The Vanishing Point

The Relevance of Traditional Art Methodologies to Digital Content Creation Pipelines

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abstract

In the ever-increasing world of digital art creation, where pipeline dependencies and asset production rely more and moreon a grass roots understanding of node-based systems, bespoke python scriptable workarounds, and optimized native code integration for shader authoring and execution, the notion that artisanship may be rapidly vanishing from this century's newest creative endeavour, computer generated imagery, may not be as far-fetched as we imagine.

As studios narrow their search for digital artists who have programming experience, technical inclinations, and a general comfort with any form of command line shell, is the cg industry inadvertently divorcing themselves from the fugue state required for an artist to become a master of their craft and placing greater emphasis on a "CBB (the art Could Be Better)" compromise in favour of those artists who can code?

How has this affected the industry? How has this affected the craft of filmmaking? As the Visual FX industry and the Computer Gaming industry face the greatest challenges they have ever faced, economically and artistically, the Vanishing Point seeks to examine the importance of an artist-centric pipeline in an attempt to combat the stereotype that digital artists are "software operators". This presentation will examine the state of the vfx industry, in terms of the Erland Tripod metaphor, the rising knowledge base requirements of CG artists vs. the lowering wages and job security, the increasing complexity of the CG tools pipeline, and how pivotal a traditional artist's analogue processes are, not just in bringing "life" to the "lifelessness" of digital art, but also in creating those masterpieces that elevate the art form to timelessness. In this way, this research hopes to stave off traditional art disciplines and approaches from becoming the vanishing point in this new digital age.

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introduction

1.1

There is a prevailing condition that seems to be afflicting this century's newest art discipline, computer graphics imagery. Upon initial consideration, it seems to emanate from an ingrained ethos of overachieving in a field that is undoubtedly becoming an underappreciated and marginalized form. Practitioners of digital art and computer graphics imagery are

Figure 1-1. "A Mix of 2D and 3D"

routinely expected to deliver high degrees of substantive excellence, across multiple specialist disciplines for an employment role within a studio system that compensates with unspeakably long hours, increasingly lower and lower wages, and creative ownership of intellectual properties whose visual bar is steadily declining into mediocrity.

Within the narrow confines of a commercial art industry, and squeezed on either side by lower budgets and decreasing timescales, there is justification to legitimately query whether the myriad digital art forms can truly have the philosophical and perspicacious investigations that characterize more traditional art forms (with their voluminous legacy of works) and question whether or not an artist's core being is even necessary during the authoring of digital content. The linear definitions of craft, when measured against the classical definitions of art, become quite murky when both commercial industries and technological evolution dictate creation paradigms.

The quintessential question of "what is art?" and the eternal conundrum of its defining characteristics and interpretation, is made therefore all the more confounding by the emergence of digital creativity as an accepted modern form of human expression with its introduction of an additional layer of abstraction, the computer, to the creative process.

While the parameters of art's constitution is the subject of perpetual, voluminous debate (Herman, 2014), it is mutually agreed upon that art ultimately requires the evocation of passion and the stimulation of emotional valence, both in its creation process and final reception. These parameters have remained, however, curiously at odds with the disciplines of the sciences, most notably computer science and graphics programming. With its reputation of impartiality and clinical objectivity, the sciences seem to live in diametric opposition to the philosophies governing art in its many forms. In a field that requires a strict adherence to the dogmas of academic rigour, there seems to be little room for the freeform, structureless fracturing of ideas and ideologies that lie at the heart of art's crucible.

"Enough storyboarding. Let's shoot something."

Figure 1-2. "Art and Implementation"

Coupled with the fact that digital art's outputs are invariably governed by the economic considerations of commercialisation and the gap between computer-generated art and its traditional brethren widens.The philosophy of "art for art's sake" (Encyclopedia Britannica, 2018) seems almost juvenile when weighed against the methodical pipeline of digital art creation, with all its dependencies, and its purposeful stride towards monetization. In fact, the strictest of those facets that govern digital content creation seem almost anathema to the reasons why art exists, and the bridge that it builds towards our humanity.

Yet the birthplace of the creative spirit, regardless of medium (whether it is digital or traditional), remains unchanged and requires a vigorous "stirring of the soul". It is this universal exploration of the human condition that strongly suggests that the notion of curating art with computer-generated art should not create cognitive dissonance but rather, be embraced as the non-partisan expression of the soul that it is.

When this study was first undertaken, it began its incarnation as an examination of the artist-centric processes in the creation of computer-generated content with the view towards reinforcing the necessity of understanding traditional, non-digital creative workflows in producing work of the highest calibre. Through the course of the last five years, the focus of the research has been recalibrated to state, unequivocally, that the artist's process is at the forefront of harnessing creative vision and the passion necessary to drive it. Technology must be an equal but invisible partner to that process. Currently, that state does not exist, with the field of computer graphics maintaining the expectation that artists be intimately familiar with a variety of technical considerations, such as the knowledge of the structure of code ("Human Condition - Wikipedia" 2017; Paxson 2017), and the fine arts disciplines erroneously viewing the computer at the heart of the authorship of computer-generated art and therefore not indicative of true, unfettered creativity.

Little has occurred in the ensuing years to encourage a re-examination of this assessment and it is the singular goal of this study to demonstrate that the subordination of traditional art processes in digital content creation pipelines (Pluralsight.com, 2018) is to the detriment of achieving the highest forms of human expression through the computer. Beyond the polarizing debate between CG animators on the need to know traditional art skills, however, is the curious consideration of the absence of desire. If CG art is truly transactional, defined in terms of need, then no, a CG animator does not need traditional art skills to do the job. The puzzling question is, why would they not want to pursue such skills? And why treat it as strictly a job, with a set of minmum requirements that need to be filled? Is this what art has become, at the hands of technology?

The observation that traditional art skills (often colloquially referred to as "2D") are still quintessential to achieving great design work is forming the basis of a new rennaisance within the professional and industrial communities as computer graphics enters a new age of maturity. Jerry Perkins, Creative Director of Dead Panic Studios and an industry stalwart, once stated "I actually found ... that basically, all the info I needed was from 2D people ... it was all 2D people that were like, 'Hey. This doesn't look good from a design standpoint.'" (Ribera, 2015)

As digital productions strive to attain the pinnacle of their craft, the sextant that once pointed to new technologies and their subsequent advancements in software is slowly beginning to re-calibrate with the artist in mind.

1.2

Art and science have often stood on opposite sides of a universal parallel. Both disciplines espouse very different philosophies in their respective approaches to elevate the human condition. Like the Montagues and the Capulets, their is an intellectual stoicism that maintains this great divide between the internal examinations of the artistic mind and the external measurements of the scientific one; however, like the proverbial Romeo and Juliet, there exists the romantic ideal to initiate a combined vision that is greater than the sum of its parts. After all, whether inspiration comes from the left brain or the right is inconsequential to the ultimate achievement of a singular vision from a singular mind.

The key to survival for this modern discipline of computer graphics ultimately lies in the unholy marriage between the meticulous exactitude of the mathematical mind with the reckless abandon of the artistic soul. The erasure of that boundary is what will form the key foundation to creating truly unique and engaging digital art.

But where is the “art” in the “code”?

Perhaps the failure to adequately address this notion is one of many reasons for the prevalence of the sheer volume of computer graphics research dedicated to the simulation of the physical world, on topics ranging from reflectance distribution functions to pre-computed radiance transfer. With global conferences, such as SIGGRAPH and GDC, renowned for their authority at the cutting edge of CG technology, centering the bulk of their discourse on advancements in the field of computer science in regards to their application to the visual arts, it is abundantly clear that the “art” in digital art is maintaining an orbital distance from the science, mathematics, and computer programming that form its nucleus.

In fact, the mere existence of the philosophical notion of "the Uncanny Valley", or the theory postulated by renowned roboticist Masahiro Mori that the closer a simulated representation of a human being becomes to actually achieving photorealism, the greater a sense of emotional revulsion from its receiving audience, seems a key indicator that the sextant guiding the field of computer graphics may be navigationally inaccurate and the siren call of using procedural computational solutions to solve expressive visual aesthetics may ultimately lead to the rocks.

An Uncanny Valley-like condition may now exist in how the industry creates the asset authoring toolsets for generating CG art as well. The more artist-centric a platform becomes and the greater the degree of experimentation digital artists engage with, the greater the jargonization proliferates within their digital toolsets. It is as if the closer we get to truly achieving stunning, astounding masterpieces, the more the CG industry must remind itself that science and mathematics are its core primary disciplines. After all, when a traditional painter wishes to achieve a moody shaft of light across a model's face, there is no requirement that they be well versed in bidirectional subsurface scattering reflectance distribution functions to achieve that effect.

Where poets, painters, and musicians can call from all walks of life, and indeed sometimes emerge into international prominence from the most unexpected and often times humblest of places, there is only one exclusive club that can produce a CG artist of repute, and its prerequisites demand access to cutting edge technology and understanding of the most elevated concepts of science and computer programming. Membership is, therefore, still quite elite.

The condition of art being subjugated to technology in digital pipelines wasn't always like this. When the flirtation first began between the artists and the computer scientists, art was very much at the forefront, staying just a hair's breadth beyond reach of the yearning programmers who, pixel by pixel sought to capture the visual world around them. As artists the world over continued the tradition of putting pencil to paper to create a line, early graphics programmers struggled with allocating memory for the various arrays and matrices that could store the x and y coordinates of screen space that would recreate that self-same line. It was through faith and perseverance, from industry pioneers such as Ed Catmull and John Lasseter, that creating art through the computer not only became viable, but a new medium unto itself. Indeed, this courtship between art and science-as-art is a ritual familiar to any new fledgling art form. After all, photography was made to weather the storm of public derision for a course before finally being allowed induction into the hallowed halls of only the truest artistic disciplines, while still managing to maintain a respectful root in the science behind its inception. "Nature, human, animal and open is no longer treated by a "rule of thumb" process, but with careful forethought and study, in which the artistic ability and soul-refining influences of the man makes secondary the use of the machines." disco(Lockington 1899). Cinematography, photography's younger sibling, was also made to endure the same level of public scrutiny, rising from the status of simple novelty, to eventual ownership of a new arena of creative expression and artistry. History would seem to dictate that art and science were never meant to be disparate, isolated disciplines, and in truth are a gestalt entity whose potential as a symbiotic unit far oustrips what each discipline can achieve on its own; yet the gap between computer scientists and artists remain though the field of computer graphics itself is nearly 70 years old.

The principles of both disciplines are diametrically opposed. Art communicates through subjectivity whilst science observes through objectivity. The visual dialogue of the artist communicates complexity whilst mathematics (the primary language of science) strives for simplification.

So how did the previous disciplines of photography and cinematography manage to negotiate a bipartisanship between these two opposing approaches long enough to achieve their own unique artistic identities? When Nicéphore Niépce first created “View from the Window at Le Gras” in 1826 or 1827, early pioneers were enamoured with the simple ability to pictorially capture the world around them, replicating the world precisely, without the filter of a painter’s interpretation. Commercial potentials were explored by this new science, and portrait photography enjoyed a financial boom, to the endless chagrin of traditional portrait

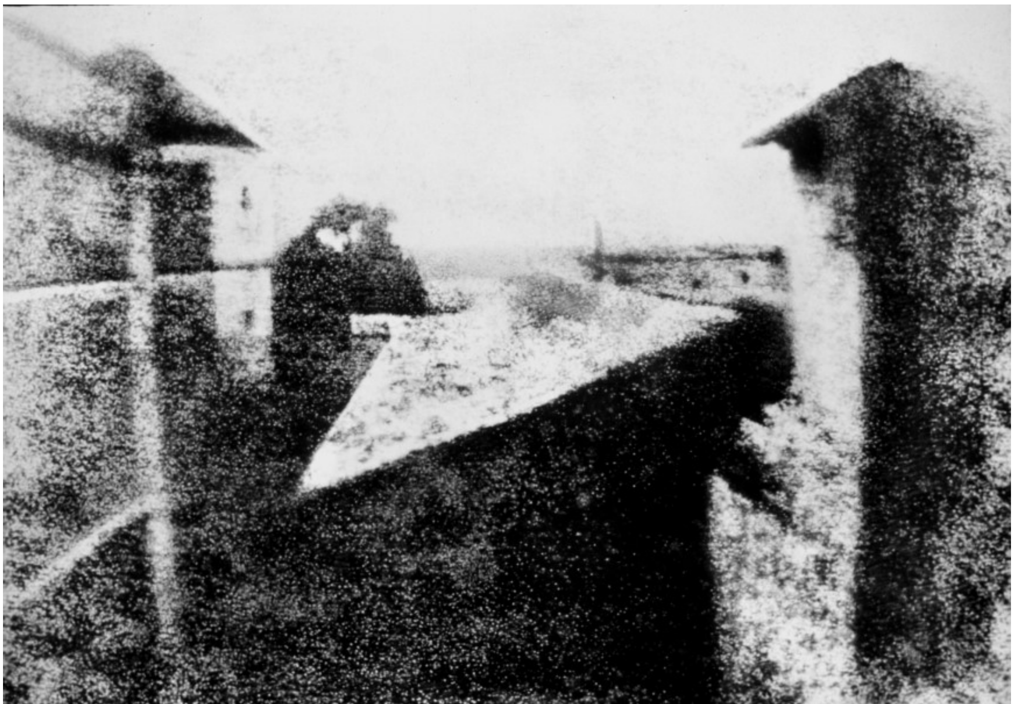

Figure 1-3. “View from the Windoe at Le Gras” Nicephore Niepce (1826/27)

painters whose very craft was under threat by this newly fashionable form of capturing an image. Discourse eventually lead to the debate of whether or not photography would replace traditional portrait painting. It would be several decades later when seasoned photographers, familiar with the process and no longer enamoured with the novelty of capturing an image, would strive to achieve more. Instead of capturing the human form, photographic pioneers sought to, instead, reflect the human condition. To achieve this, they began to examine the craft of traditional painters, honed over hundreds of years of artistic endeavour. It was through concerted study of the techniques of these old masters that photographers began to see the enormous untapped potential of their fledgling field as an art form. As Lockington so aptly points out above, the actual mechanics of photography needed to take a step back to allow the artistry to emerge. A few short decades later, the motion picture was born and replicated the trajectory of photography in its early incarnation. Its popularity was dominated by its ability to replicate in detail not only the world around us, but also to present it in motion, thus truly capturing a living, breathing, moving representation of life. When "Arrival of a Train at La Ciotat" (The Lumière Brothers, 1895) first screened in January 1896, audiences reacted in justifiable amazement at an oncoming train approaching them at speed. Again, the commercial potential was immediately explored as early films enjoyed enormous popularity at carnivals and travelling circuses. It wasn't until the early 1900s that, once the titular nature of its novelty began to fade, the notion of creating a new reality, born of creative interpretation, began to infuse itself into the early works of Sergei Eisenstein, Fritz Lang and the Lumiere Brothers; however, as photographers looked to painters for inspiration, cinematographers did not look to photographers in the same manner. When developing methodologies for lighting and mise-en-scene, early cinematographers turned to painters as well.

As computer graphics and animation have become firmly mainstream, it seems almost natural that the fascination with replicating the real world would begin to fade, taking a back seat to questions of exploring the human condition and understanding the poesy of capturing the human spirit that are necessary to elevating this century's newest art form. As was previously the case, it would be expected that. like it's photography and cinematography predecessors, computer graphics would turn in kind to an intense and dedicated study of the classical forms.

Yet computer graphics seems rooted in producing what Hollywood affectionately refers to as "VFX tentpole films", where audiences are drawn to the titular visual excitement of watching an exact replication of the real world operating under impossible conditions. It begs the consideration that perhaps computer graphics as a medium is still in the "Arrival of a Train at La Ciotat" phase, with commercial potential operating as a form of appellate

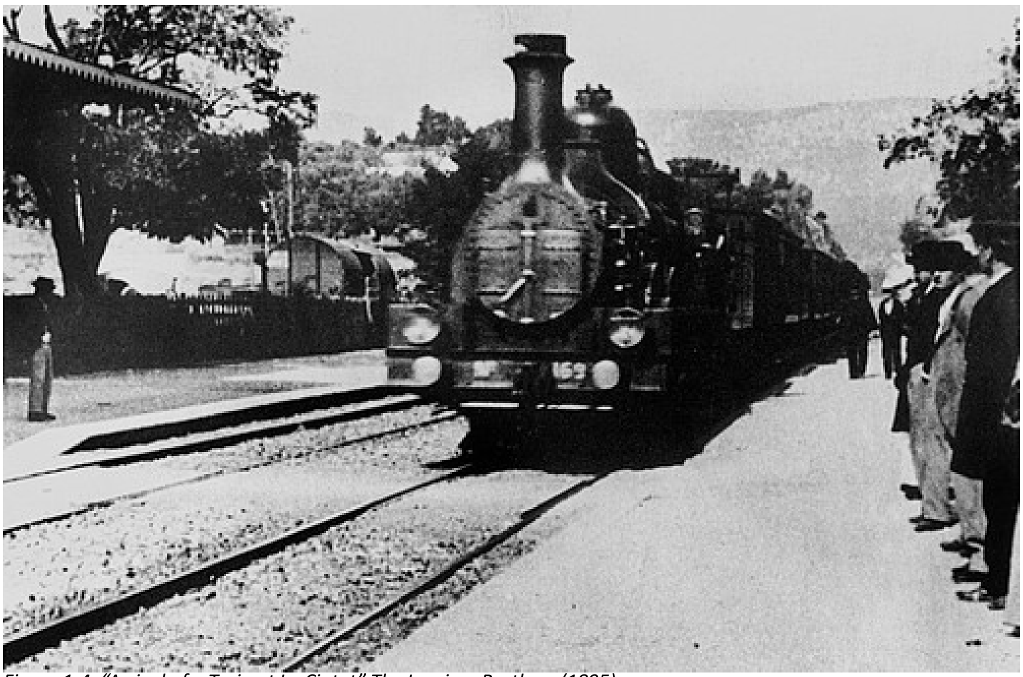

Figure 1-4. "Arrival of a Train at La Ciotat" The Lumiere Brothers (1895)

court over the progression of the art form. Indeed, some of the highest accolades from the Academy of Motion Picture Arts and Sciences are rooted firmly in the technical and scientific categories of computer graphics, whether it's the development of new solvers to create more accurate simulations of water or greater accuracy in motion solving for replication of actor facial performances on cg digital doubles, with photorealism being the presiding criteria for visual fidelity.. If not for the almost separate and distinct category of computer animation, the questioning of the artistic integrity of computer graphics as a whole would not be without reason.

The financial ecosystem that cultivates computer graphics can not be wholly ignored; as Don Bluth, one of the old masters of traditional hand-drawn animation, once stated in an interview with fellow industry veteran, Ralph Bakeshi: "What it's all about there is making money. Money's the bottom line. No one cares what they look like." (Caldwell, 2018)

Once again, the fascination with accurately replicating the real world seems to dominate any notions of interpreting it. An academy award for best digital performance (or something of that nature), awarded to the team of modellers, animators and designers responsible for creating a heart wrenching character on screen, would be a wonderful acknowledgement of the craft and artistry involved in creating computer-generated performances. This accolade, however, seems far too idealistic to entertain, and as a result, though "vfx tentpole films" enjoy an enormous commercial success, their lasting impact both culturally and historically is quite questionable when measured against films created prior to the liberal use of computer graphics.

Figure 1-5. "Siren" Epic Games at GDC (2018)

1.3

The crux of the problem associated with creating elevated forms of digital art seems to lie within the toolset given to artists for engaging in their craft. It is an incontrovertible fact that every artist is enamoured with their tools. Considering these external implements help to capture internal passions in physical form, there is little surprise that many artists have an almost ritualistic approach to their toolsets. Often times, when a young artist first embarks on their career, the questions that plague their minds are often centered on having "the right tools for the job" and engaging in the process "the correct way". Art, at it's finest, achieves perfection; therefore the process must also be perfect. In that regard, young artists will query their mentors on "what brand of drafting pens they use", or scrutinize the "tooth of a particular brand of sketchbook paper". It is a familiar series of motions that every artist engages in at an early stage, and seems almost a rite of passage. As an artist matures, there is a comfortable familiarity with the creation process itself that transcends the tools they have chosen and a masterful execution of art becomes rooted in an artist's keen observations of human behaviour, and not whether the artist has chosen acrylics or oils. This is not to denigrate the importance of tools, only to properly understand and contextualize their role in the creative process, which is to be the invisible bridge between thought and creation. Nothing can surpass the importance of the skills and experience of the artist themselves. Perkins states in his Robot Pencil stream, "It's the hands that make it dangerous … I see all sorts of random … 2D people pick up 3D and it's just … antagonizing. I'm like,... you should quit 3D, you know, because you're, you're too good off the bat … any time a painter is … picking up 3D, or … picking up ZBrush, I'm [thinking] … this person's gonna kill me." (Ribera, 2015)

When defining the role tools have to the art creation process, it is necessary to return to the earliest recorded origins of humanity's engagement with visual dialogue, namely the hypnotic qualities of the enigmatic cave painting. Their haunting beauty is evocative of the majesty of the herd and the thundering fury of the hunt, while being entirely absent from describing even the minutest follicle of visceral detail. Yet these early renderings from humanity's primordial birth are aflame with a passion that still resonates even today.

Before examining the emotional valence of our response to these crude scratchings preserved in stone, is it feasible to separate the tools and the process from the hand of the artist? There is no denying that the facilities an artist uses can rise to prominence the closer they strive to achieving realism. After all, when one is replicating the world with surgical precision, the scalpel must be sharp. The allure, as young artists desiring to perfect their craft, is to therefore seek out the sharpest scalpel. This desire to own the correct tools is the driving force for the curious young artist, embarking on their maiden voyage into that deep

Figure 1-6. "Chauvet Cave, Ardeche, France" (DRAC Rhone-Alpes, Ministere de la Culture/AP Images)

and boundless sea of creating magnificent work. Every artist thinks visually, and therefore flirts with a variety of ways to capture and maintain the visual integrity of an image itself. We study the subtle nuances of light and shadow and their intricate choreography with colour. We understand how the human eye will respond to different temperatures within an image and how high contrast can exercise a stimulus response from our audience. We precisely apply every meticulous ink stroke to each strand of hair to allow the eye to photographically preserve every minute detail.

Yet art has never been about vision, it has fundamentally been about perception. Those voluminous discussions of light wavelengths, properties of reflection and refraction, and the behaviour of certain pigments in concert with certain weaves of canvas are weighty in their sheer pithiness and are necessary discussions to engage in our craft, but they merely identify, quantify, and analyse the vision we have preserved through our art. The quality of perception, on the other hand, is all about "the lightning" or that inspirational message/moment/achievement of self-actualization that a great piece of art can stir within us. That discussion is as elusive as it ever was. It is, by far, the meaning that we derive from an image that compels and fascinates us, and not the image itself. This is why those early cave paintings continue to allure and endure. It is not in the amount of detail that is represented; it is in the thoughts that traverse our minds as our own imaginings complete the negative spaces the artist left behind. It is our own participation with the artwork that moves us.

'The most beautiful thing we can experience is the mysterious. It is the fundamental emotion that stands at the cradle of true art and true science' (Einstein, 1931)

Allowing an audience's own inherent perception to derive form and interpretation from a simplified representation of an artefact is the primary facility with which to create emotional engagement with art. This is not to say that art must be devoid of detail. On the contrary, we must harness those details to service our own ends; however, before we can proceed to manipulating the microns of our visual medium, we must first break our image down into its essential components before building them back up again with all the full, lushness of craftsmanship that time, patience, and meticulous exactitude can afford. Those essential components are gesture, rhythm, form, and silhouette. With those, we can create the Rorschach effect of ascribing meaning to simple inkblots. When successfully achieved, this will allow an artist to capture all the complexity, chaos, and power of a bolt of lighting in something as simple and as delicate as a glass bottle. This is why the thumbnailing process is crucial to design. This is why the 'squint test' (a method of blurring details when critically evaluating a composition) provides the most valued insight and feedback. This is why those enigmatic cave paintings thrum with emotional power. These are the moments when an artist can capture 'lightning in a bottle', and cannot be replicated by a technician well-versed in the subtle nuances of light perturbation across micro facets of a surface. The creation process, from the silhouette up to the final level of detail, must, therefore, never rest in the hands of anyone less than an artist. Sadly, with the advent of the digital age, this has not always been the case.

1.4

CAPTURING THE LIGHTNING

As artists, we have embarked on tumultuous times. Never before has the role of an artist been thrown into such chaotic redefinition, nor the ebb and flow of their creative process gone through such radical reinvention, as during the dawn of the digital art era.

The tried and true process of applying paint to a surface via a brush has been severely short-circuited by the increasing introduction of further and further degrees of separation between the mind of the artist and the medium to which their vision is applied. As software authoring tools become increasingly more complex, and celebrated for being so, the postulation that 'the medium is the message' (McLuhan, 1964) has now become a clear and present reality. Conversely, what is being produced by digital artists across the globe is increasingly being perceived as a function of assembly and not worthy of evaluation as a true art form. Bill Westenhofer, Visual FX Supervisor for Rhythm & Hues, stated that 'at a time when visual effects movies are dominating the box office, visual effects companies are struggling. And I wanted to point out that we aren't technicians. Visual effects is not just a commodity that's being done by people pushing buttons. We're artists, and if we don't find a way to fix the business model, we start to lose the artistry. If anything, Life of Pi shows that were artists and not just technicians.' (fxguide, 2018). Shortly before winning the Oscar for Best Visual Effects, Rhythm & Hues filed for bankruptcy. The de-emphasis on classical art skills has resulted, however directly and/or indirectly, in the denigration of the entertainment industry.

1.5

BENJAMIN FRANKLIN'S KITE: WHERE DID THE LIGHTNING GO?

#	Film	Year
1	*Snow White and the Seven Dwarfs*	1937
2	*Pinocchio*	1940
3	*Bambi*	1942
4	*The Lion King*	1994
5	*Fantasia*	1940
6	*Toy Story*	1995
7	*Beauty and the Beast*	1991
8	*Shrek*	2001
9	*Cinderella*	1950
10	*Finding Nemo*	2003

Figure 1-7. "AFI Top 10 Animated Films of All Time" (American Film Institute, 2006)

At the very heart of this discussion is the philosophy that the artist's hand must connect directly with the canvas to facilitate the flow of creative thought and technologically, it is the idea of leveraging several real-time rendering solutions to help bridge that gap. This notion is not new, unique, nor revolutionary by any means, and several exemplars (which shall be discussed and analysed) are already prevalent in the industry as production-proven methodologies towards digital content creation. It is the overall context of why they exist, and they're absolute importance to any given project, that must be sternly re-evaluated. To do this, we must cast a discerning eye to the state of CG as an art form, from a practical production point of view, and identify our justifications for doing so.

The visual fidelity of digital artistry has reached dizzying heights in terms of the levels of detail that can now be harnessed in the never-ending quest to capture our world through a piece of art. Techniques that the ancient masters could only dream of are now available at our fingertips and can be applied with the click of a mouse. It stands to reason that those art forms painted primarily with a CG brush must then have produced an explosion of classic masterpieces, at least in the past decade, of such critical acclaim and cultural impact as to be rivalled by no other time in history.

Upon close scrutiny of the film industry, there appears to be a correlation between the rise of digital technologies and the recognition of filmmaking craftsmanship, but the relationship appears to be, unfortunately, an inversely proportional one.

An examination of the American Film Institute's top 100 films of all time can be quite revealing when balanced against the commercial success of purely visual fx driven properties. The implicit relationships are quite striking when taken in context. The original figures for the AFI top 100 were assembled in 1998, with an update in 2007, and reflect a "poll of more than 1,500 artists and leaders in the film industry who chose from a list of 400 nominated movies."("AFI's 100 Years...100 Movies - Wikipedia" 2017). The criteria for selection were as follows:

- Length
- American/English Language
  (with significant creative and/or financial production elements from the US)
- Critical recognition
- Major award winner
- Popularity over time
- Historical significance
- Cultural impact

Of the various decades that are represented, the lion's share of films sit firmly in the decade of the 70s, with the ground-breaking visual fx film, "Star Wars", sitting firmly in the latter half. What is of greater interest, however, is that subsequent to the 90s, with films such as "Titanic" and "Toy Story" ushering in a new era of computer graphics in filmmaking, almost a decade passes with only one notable addition to the list: "The Lord of the Rings: The Fellowship of the Ring" (En.wikipedia.org, 2018). Every decade of american filmmaking history has quite a few candidates populating this list, except the decades that feature the burgeoning role of computer graphics in production.

1910 – 1919, 1920 – 1929	
Date	MOVIE
1926	The General
1915	The Birth of a Nation
1916	Intolerance
1925	The Gold Rush
1927	Sunrise: A Song of Two Humans
[illegible]	[illegible]

1930 – 1939	
Date	MOVIE
1939	The Wizard of Oz
1939	Gone with the Wind
1939	Mr. Smith Goes to Washington
1934	It Happened One Night
1933	King Kong
1937	Snow White and the Seven Dwarfs
1940	The Philadelphia Story
[illegible]	[illegible]
1939	Stagecoach
[illegible]	[illegible]
1931	City Lights
1936	Modern Times
1933	Duck Soup
1935	A Night at the Opera
[illegible]	[illegible]
[illegible]	[illegible]
1936	Swing Time
1938	Bringing Up Baby

1940 – 1949	
Date	MOVIE
1941	Citizen Kane
1942	Casablanca
1946	It's a Wonderful Life
1940	The Grapes of Wrath
1941	The Maltese Falcon
1948	The Treasure of the Sierra Madre
1946	The Best Years of Our Lives
1944	Double Indemnity
1945	The Third Man
[illegible]	[illegible]
1941	Sullivan's Travels
1942	Yankee Doodle Dandy

1950 – 1959	
Date	MOVIE
1954	On the Waterfront
1952	Singin' in the Rain
1950	Sunset Boulevard
1957	The Bridge on the River Kwai
1959	Some Like It Hot
1950	All About Eve
1951	The African Queen
1952	High Noon
1959	North by Northwest
1954	Rear Window
1951	A Streetcar Named Desire
1953	From Here to Eternity
[illegible]	[illegible]
1958	Vertigo
[illegible]	[illegible]
1953	Shane
1959	Ben-Hur
[illegible]	[illegible]
1957	12 Angry Men
[illegible]	[illegible]
1956	The Searchers

1960 – 1969

Figure 1-8. "AFI Top 100 Films of All Time - 1910-1959" (American Film Institute, 2007)

1960 – 1969	
Date	MOVIE
1962	Lawrence of Arabia
1967	The Graduate
1960	Psycho
1968	2001: A Space Odyssey
1964	Dr. Strangelove
1967	Bonnie and Clyde
1962	To Kill a Mockingbird
1969	Midnight Cowboy
1965	Doctor Zhivago
1961	West Side Story
1969	Butch Cassidy and the Sundance Kid
1965	The Sound of Music
1962	The Manchurian Candidate
1966	Who's Afraid of Virginia Woolf?
1967	In the Heat of the Night
1969	The Wild Bunch
1960	Spartacus
1969	Easy Rider
1964	My Fair Lady
1960	The Apartment
1967	Guess Who's Coming to Dinner

1970 – 1979	
Date	MOVIE
1972	The Godfather
1977	Star Wars Episode IV: A New Hope
1974	Chinatown
1975	One Flew Over the Cuckoo's Nest
1979	Apocalypse Now
1977	Annie Hall
1974	The Godfather Part II
1971	A Clockwork Orange
1976	Taxi Driver
1975	Jaws
1970	MASH
1975	Nashville
1972	Cabaret
1977	Close Encounters of the Third Kind
1976	Network
1971	The French Connection
1973	American Graffiti
1976	All the President's Men
1976	Rocky
1978	The Deer Hunter
1970	Patton
1971	The Last Picture Show

1980 – 1989	
Date	MOVIE
1980	Raging Bull
1982	E.T. the Extra-Terrestrial
1984	Amadeus
1981	Raiders of the Lost Ark
1982	Tootsie
1986	Platoon
1982	Sophie's Choice
1989	Do the Right Thing
1982	Blade Runner

1990 – 1999	
Date	MOVIE
1993	Schindler's List
1991	The Silence of the Lambs
1994	Forrest Gump
1998	Saving Private Ryan
1994	The Shawshank Redemption
1990	Dances with Wolves
1997	Titanic
1996	Fargo
1999	The Sixth Sense
1990	Goodfellas
1994	Pulp Fiction
1992	Unforgiven
1995	Toy Story

Figure 1-9. "AFI Top 100 Films of All Time - 1960-1999" (American Film Institute, 2007)

The list also yields only one entry in the top 10 from the '90s and the first entry to represent the modern millennium squeezes into the top 50 at the rank of 50.

Cross-referencing this with a list compiled by IMDB, The Internet Movie Database (a highly regarded industry website), Schindler's List (1993) comes in at number 2, while The Shawshank Redemption (1994) sits at number 4, and Titanic (1997) sits at number 10. The first film from the modern millennium is represented by Chicago (2002) which comes in at rank 30 (IMDb, 2018).

1910 – 1919, 1920 – 1929	
Date	MOVIE
1927	Metropolis
	1

1930 – 1939	
Date	MOVIE
1931	City Lights
1936	Modern Times
1931	M
	3

1940 – 1949	
Date	MOVIE
1942	Casablanca
1946	It's a Wonderful Life
1941	Citizen Kane
1944	Double Indemnity
1940	The Great Dictator
1949	The Third Man
1948	The Treasure of the Sierra Madre
1948	Bicycle Thieves
	8

1950 – 1959	
Date	MOVIE
1957	12 Angry Men
1954	Seven Samurai
1954	Rear Window
1950	Sunset Boulevard
1959	North by Northwest
1958	Vertigo
1957	Paths of Glory
1952	Singin' in the Rain
1959	Some Like It Hot
1950	Rashomon
1950	All About Eve

1960 – 1969	
Date	MOVIE
1966	The Good, The Bad and the Ugly
1960	Psycho
1964	Dr. Strangelove or: How I Learned to Stop Worrying and Love the Bomb
1962	Lawrence of Arabia
1962	To Kill a Mockingbird
1968	2001: A Space Odyssey
1960	The Apartment
	7

1970 – 1979	
Date	MOVIE
1972	The Godfather
1974	The Godfather: Part II
1975	One Flew Over the Cuckoo's Nest
1977	Star Wars: Episode IV - A New Hope
1979	Apocalypse Now
1979	Alien
1976	Taxi Driver
1971	A Clockwork Orange
1974	Chinatown
1975	Monty Python and the Holy Grail
1973	The Sting
	11

1980 – 1989	
Date	MOVIE
1980	Star Wars: Episode V - The Empire Strikes Back
1981	Raiders of the Lost Ark
1985	Back to the Future
1980	The Shining
1986	Aliens
1981	Das Boot
1988	Cinema Paradiso
1983	Star Wars: Episode VI - Return of the Jedi
1984	Once Upon a Time in America
1987	Full Metal Jacket
1984	Amadeus
1989	Indiana Jones and the Last Crusade
1980	Raging Bull
	13

1990 – 1999	
Date	MOVIE
1994	Shawshank Redemption
1994	Pulp Fiction
1993	Schindler's List
1999	Fight Club
1990	Goodfellas
1994	Forrest Gump
1999	The Matrix
1995	Se7en
1991	The Silence of the Lambs
1995	The Usual Suspects
1994	Leon
1998	American History X
1991	Terminator 2: Judgement Day
1998	Saving Private Ryan
1997	Life is Beautiful
1999	American Beauty
1999	The Green Mile

Figure 1-10. "IMDB Top 100 Films of All Time - 1910-1999" (IMDB, 2018)

Date	MOVIE
1981	Raiders of the Lost Ark
1985	Back to the Future
1980	The Shining
1986	Aliens
1981	Das Boot
1988	Cinema Paradiso
1983	Star Wars: Episode VI - Return of the Jedi
1984	Once Upon a Time in America
1987	Full Metal Jacket
1984	Amadeus
1989	Indiana Jones and the Last Crusade
1980	Raging Bull
	13

2000 - 2009	
Date	MOVIE
2008	The Dark Knight
2003	The Lord of the Rings: The Return of the King
2001	The Lord of the Rings: The Fellowship of the Ring
2002	The Lord of the Rings: The Two Towers
2002	City of God
2000	Memento
2001	Spirited Away
2002	The Pianist
2006	The Departed
2008	WALL-E
2000	Gladiator
2006	The Lives of Others
2006	The Prestige
2001	Amelie
2000	Requiem for a Dream
2004	Eternal Sunshine of the Spotless Mind
2003	Oldboy
	17

1990 - 1999	
Date	MOVIE
1994	Shawshank Redemption
1994	Pulp Fiction
1993	Schindler's List
1999	Fight Club
1990	Goodfellas
1994	Forrest Gump
1999	The Matrix
1995	Se7en
1991	The Silence of the Lambs
1995	The Usual Suspects
1994	Leon
1998	American History X
1991	Terminator 2: Judgement Day
1998	Saving Private Ryan
1997	Life is Beautiful
1999	American Beauty
1999	The Green Mile
1992	Reservoir Dogs
1994	The Lion King
1995	Braveheart
1997	L.A. Confidential
1997	Princess Mononoke
1992	Unforgiven
	23

2010 - 2013	
Date	MOVIE
2010	Inception
2012	Django Unchained
2012	The Dark Knight Rises
2011	Untouchable
2010	Toy Story 3
	5

Figure 1-11. "IMDB Top 100 Films of All Time - 1999-2013" (IMDB, 2018)

For a representative list that, perhaps, more correctly reflects a diversity of opinions, procedurally generated from online participant data (as opposed to a list compiled by an individual and/or panel), Metacritic's top movies of all time contains one entry from 2013, "Inside Llewyn Davis", that sits in the top 10. Within the top 30 entries, 20 titles are marked as "re-release" from an era prior to computer graphics (Metacritic, 2018).

The British Film Institutes top 100 british films of all time does not contain a single entry beyond the 90s. Although trying to conflate top 100 lists with the production of "vfx tent-pole films" is just a data correlation with no direct causal effect and can be categorized as post hoc, ergo propter hoc, it does beg the consideration that with technology advancing so far and so fast in the realm of digital imagery, and with the facility to capture the imag-

2000 - 2009	
Date	MOVIE
2007	Ratatouille
2002	Spirited Away
2006	Pan's Labyrinth
2007	Killer of Sheep
2009	The Hurt Locker
2007	4 Months, 3 Weeks and 2 Days
2009	Sita Sings the Blues
2008	WALL-E
2004	Sideways
2003	Lord of the Rings: The Return of the King
2000	The Discreet Charm of the Bourgeoisie
2000	Crouching Tiger, Hidden Dragon
2005	Frantic
2002	Amadeus
2003	Investigation of a Citizen Above Suspicion
2000	Yi yi: A One and a Two ...
2007	The Diving Bell and the Butterfly
2008	The Class
2009	35 Shots of Rum
2007	There Will Be Blood
2001	The Lord of the Rings: The Fellowship of the Ring
2001	Werckmeister Harmonies
2004	Moolaade
2002	The Fast Runner (Atanarjuat)
2003	The Triplets of Belleville
2006	The Queen
2000	Beau Travail
2008	Waltz with Bashir
2007	No Country for Old Men

2010 - 2019	
Date	MOVIE
2013	Inside Llewyn Davis
2013	Gideon's Army
2010	The Social Network
2012	Zero Dark Thirty
2013	Short Term 12
2011	A Separation
2013	Before Midnight
2011	We Were Here
2010	Carlos
2012	Amour
2012	Almayer's Folly
2013	The Girls in the Band
2010	Toy Story 3
2010	Children of Tokyo
2013	The Gatekeepers
2013	Stories We Tell
2010	a Prophet
2010	Winter' Bone

Figure 1-12. "Metacritic Top 100 Films of All Time - 1999-2013" (IMDB, 2018)

ination on screen being far greater now than at any decade in film's history, why hasn't the categorization of predominantly cg films as art kept pace? In terms of the artistry of purely animated films, an entire category in and of itself, this will be discussed in further context when this research examines the marginalization of 2D draughtsmanship skills and its direct impact to the field of CG animation.

So if we have created a better kite then the one Benjamin Franklin used in 1752, where is the all the lightning? We should be able to capture more of it, in less time than we ever dreamed. If digital technology has empowered us to create imagery that was never before possible, to capture our imagination in ways never before possible, where are those unforgettable images? After all, a decade has gone by without a single classic film being generated in the top 10 by armies of digital artists across the globe. The craftsmanship of filmmaking, for any number of reasons, perhaps in isolation or perhaps in collusion, is slowly being lost. As the level of visual fidelity in digital art continues to reach new breath-taking heights, the perception of CG as an art form has unjustifiably declined.

1.6

Whether or not digital artistry even matters is reflected in a list of another variety, compiled by IMDB, concerning the all-time USA Box Office figures for feature films, of which 6 of the top 10 are post 2000 and all 6 are visual effects driven films.

Artistry and craftsmanship aside, it would seem that computer graphics are indispensable, and indeed, a necessary formula for the success of a feature film, especially in terms of generating revenue and box office receipts. It stands to reason that if an ingredient was essential to the commercial success of a product, it would be kept close and safeguarded, nurtured, refined, and further developed. This, unfortunately, has not been the case.

Within the past decade, the state of the Visual Effects industry (and subsequently, the Games Industry) has entered a state of crisis. As technology advances and production costs skyrocket, studios around the world are collapsing under the weight of budget constrictions and large unwieldy projects. Outsourcing, once considered a solution to aid production shortfalls in minor areas, has now become the defacto standard for constructing major portions of a production's asset pipeline. More and more, visual effects is being seen as a commodity and an initially flawed business model (loosely centered around underbidding a current project to recoup its losses from a subsequent project creating an insurmountable situation of debt) has been allowed to breed unchecked until it has left behind a legacy of highly skilled and highly experienced artists working at wage compensations far below what they once were. Followed closely behind this shift in the CG industry's business model is the populist notion that if the correct software and training were provided, any studio could reproduce the same services as those created by "in-house" experienced artists, under better economic conditions and more manageable costings. With artists being relegated to human capital, across a like-for-like spectrum, and an increasing perception of their role as "software technicians", the damage has been not only to the art form itself, but also to the business model of visual fx, the quality of the work being produced, down to each individual artist's own self-perception in how they view their role and their work.

In terms of business failures, the results are palpable. Below is a list of the various studios who have filed for Chapter 11 since 2005.

1. 2013
    a. Rhythm & Hues
2. 2012
    a. Digital Domain
    b. ICO VFX
3. 2011
    a. CIS – Hollywood
    b. Kerner Optical
4. 2010
    a. Asylum VFX
    b. Café FX
    c. C.O.R.E. Digital Pictures
5. 2009
    a. Illusion Arts
    b. Pacific Title & Art Studio
6. 2008
    a. Gray Matter
7. 2007
    a. The Orphanage

8. 2005

    a. Digital Filmworks

    b. ESC Entertainment

With the rise of computer-generated imagery in film leading to the creation of so few film classics and resulting in so many studio closures due to debt, the question remains: as an art form, what has digital creativity gained?

Figure 1-13. Guillaume Rocheron, Erik-Jan De Boer, Donald Elliott, and Bill Westenhofer. (Darren Decker / © AMPAS)

Figure 1-14. "VFX Artists Protest Academy Awards" 2013

1.7

THE PROBLEMS

No one can deny that the state of both the visual effects industry and the games industry are currently in a state of flux, due in no small part to the economic climate of the past decade. The ingredients for the slow, inexorable demise of both these CG industries are as diverse and as varied as the sheer amount of blame being lobbed in multiple directions.

Upon examination of the many discussions currently being engaged online, and in industry publications ("CreativeCOW" 2017), several recurrent themes begin to emerge:

1. PROJECT ACQUISITION

   The "ends justifies the means" seems to be the prevailing motivation in how a project is acquired, and funded.

2. DEBT

   Studios, in their struggle for financial survival, are engaged in a "race to the bottom".

3. JUSTIFICATION

a. THE PRESTIGE

   Heavy losses are often seen as necessary to the attainment of accolades which result in a studios reputable status which ultimately leads to further engagements.

4. COMMODITIZATION OF VFX

   The reduction of artists and artistry to assembly line products manufactured by technicians.

5. SCHEDULING

   a. WAR OF THE WORLDS

   b. 300

   Experienced veterans and craftsman delivering under tight schedules, results in the erroneous assumption that "anyone with a computer" can replicate the same amount of work in the same amount of time.

6. SUBSIDIES

   Government subsidies (or the lack thereof) is driving demand towards certain geographic locations, and not the chosen artistry of a single studio.

7. OUTSOURCING

   With the allure of the reduced labour costs of certain countries coupled with the notion that cg and vfx artists are simply technicians, studios have been gradually expanding their outsourcing operations in the quest to reduce production costs.

8. STUDIO OPERATIONS

   Operational costs and logistics will sometimes necessitate underbidding on a contract in the hopes that a studio will suffer "less of a loss than if they didn't".

9. GLOBALIZATION

With the maturation of the outsourcing business model, what were once fledgling studios operating with very little experience to help production shortfalls have now become full boutiques and production houses with now highly experienced artists operating at a fraction of the cost of their in-house counterparts. This becomes an attractive option when budgeting a feature.

10. THE ERLAND TRIPOD

HONORARY SOCIETIES

Honorary societies are an effective way of acknowledging the artistry involved in digital creativity.

GUILDS/UNIONS

With the nomadic nature of vfx and cg work, due in large part to expanding globalization, the creation of unions that could grant cg and vfx artists a certain amount of power, seems organizationally remote.

TRADE ASSOCIATIONS

Similar to unionization, trade associations would provide vfx and cg artists a tremendous amount of buying power: however, due to globalization, this would be difficult to manage across multiple continents and jurisdictions.

Although these points will be acknowledged in a cursory context, and each topic in and of themselves would require extensive scrutiny in order to do them justice, such discussions are beyond the scope of this research. They are by no means marginalized, and play a key role in the rationale for this research.

The process of project acquisition for a visual fx house is not a straightforward process, and is mired in the usual politics and position jockeying that most businesses endure when securing contract work. The perception of the product or service being provided, however, has suffered greatly due to a legacy business model, in which vendors bid on a per-shot basis for a feature project, where the greatest qualifier is price and not quality. This single, resounding ethos has placed the burden on studios to come out on the bottom in terms of being the cheapest producer of high-quality computer graphics. This has had a tremendous trickle-down effect on how CG artists are perceived, but ultimately, in the highly cut-throat world of bidding on Hollywood projects, VFX houses have adopted the unsustainable model of bidding at a loss, in the hopes of recouping lost revenue with the next project bid. The fallacy in that approach is clearly evident and a chain of diminishing returns is inevitably created. Couple this with the massive overhead of studio operating costs, successful project bids are an exercise in desperation, and a VFX house between projects is haemorrhaging money at an alarming rate. This is a model that inevitably leads to studio debt (Squires, 2017).

There are a number of key discussion points that are in constant orbit around the issue of debt. Although it may be convenient to bring bad management practices and inexperienced business leaders to the forefront, the dilemma is compounded by the only solution a drowning studio is left with when the debt becomes insurmountable … the acquisition firm. Sometimes referred to as a "white knight", and occasionally disguised as an "angel investor", an acquisition firm may seem to come to the rescue when a fledgling VFX house is struggling under the burden of over-debt with a sizeable investment, only to use the studio as a vehicle for offloading greater amounts of debt before forcing a situation of bankruptcy. This situation occurs with such ludicrous frequency that it is now de rigueur to expect to put at least one "visual effects shop out of business" (Cohen 2007).

If it is indeed the case where feature film visual FX is a business where high quality product is demanded at low margins and fast turnarounds, and the initial start-up costs can be astronomically high, then why engage in such a volatile, high-risk endeavour to begin with? Two primary reasons spring to mind. At a personal, artist-to-artist level, CG artistry is a passion-driven enterprise driven by the same creative forces that afflict musicians, writers, painters and any disciple of the arts. This passion is the fuel that drives artists to commit emotional and intellectual resources that they would not normally expend in any other context. On an industry level, there is a certain amount of prestige attached to a feature film project that results in peer approval, patronage, and industry accolades. It is the self-same desire for recognition as an art form that has led CG artists in the opposite direction.

Although underbidding on a project, most often times at a loss, while still struggling to manage an ever increasing debt load is central to a VFX studio's inexorable march to its own demise, there is an ethos at work running like an undercurrent that keeps these bad business practices afloat.

THE CHANGE CONTROL PROCESS

Gary Marshall, a respected Visual Effects Supervisor, once coined the phrase “the consensual lie” in reference to revision and iteration on final visual deliverables. What he is addressing is what the games industry calls the “change control process”, a controlled infrastructure with which to efficiently coordinate any modifications to an existing environment while simultaneously minimizing the number and impact of those changes. In the visual FX industry, this has been handled poorly. The creative iterative process for a visual FX shot is normally under the supervision of a Visual Effects Producer/Visual Effects Supervisor team, but can often times end up in the hands of people who have little to no understanding of visual FX. Sometimes a shot change request is unavoidable, and at the mercy of a number of factors that can drive a production in a number of different directions from what was established during preproduction. From the logistics of day shots that suddenly need to convert to a night-time scenario, through to physical geographical and architectural challenges presented on location, many changes can happen on location that were not accounted for in the early stages of a production; however, there is generally no negotiable limit to the number of changes a film studio can request of a VFX house and no inherent financial obligation associated with those requests. This often leads the VFX house at the mercy of absorbing those additional resources that these iterative changes entail, and often times compounding their loss on a project, not only in terms of monetary remuneration, but also in terms of extended hours, additional studio overhead, and studio practices that are outright illegal. To make matters worse, the lion’s share of these iterative changes often times emerge during the final edit, and VFX studios often don’t get a complete shot list until after the editing process has been finalized. This has the unfortunate knock-on effect of leaving little time between the final edit of a film and its release date. All the while, the rumblings in the industry are increasingly demanding more product at higher quality, in less and less time. This leaves a visual FX studio with little choice, if it wishes to survive.

Another issue that can compound matters on a production is the shifting of shot responsibility from one department to another. The idea of "fixing it in post" often intimates at poorly executed principle photography that results in compounded work schedules for VFX artists, and is a running metaphor in terms of how visual fx artists are viewed, which we will discuss momentarily. This can sometimes occur for unforeseen circumstances that may arise, and it has on occasion been necessary to consider digital corrections for practical challenges on location, but the chief motivation for shifting shot responsibility is oftentimes a financial one. On any given production, there is an allocated budget for principal photography and a separate one that exists for post-production. As visual FX generally does not begin until after principal photography is complete, the temptation is to view that allocated budget as money that has not yet been ring-fenced, especially when principal photography looms dangerously close to depleting its resources. What generally ensues are necessary negotiations between all the creative departments to see what can be achieved "in camera" and what can be relegated to post-production. As the visual FX budget has not yet been engaged, it provides the illusion of having a tremendous amount of funds available. If production is successful in negotiating for expenditure from the post-production budget, this further reduces the capital (or man hours) available towards the end of the pipeline. Subsequently, budgets get even tighter on an already lean post-production schedule. The consensual lie that Marshall refers to takes on vocal form when a VFX house says that those shots can be executed, modified and iterated upon in their schedule and budget, outside of what was originally negotiated, when the vendor knows that they are underbidding on their allotment of shots, and are already working from a position behind the negative sign.

The metaphor of "fixing it in post" intimates not only that anything is possible in post-production, from simple fixes of operator errors, to entire set reconstructions and complex element replacements, but also falsely alludes to its simplicity. Although this naivete has long since matured, what remains of its legacy is the notion that issues in post-production can be solved by "throwing more bodies at it". This, once again, typifies the notion that visual FX artists are still viewed as technicians and not as artists, and that the execution of digital artistry can be handled by anyone.

1.8

THE PHOTOSHOP SYNDROME

No single application has had the resounding impact on the digital art world in the fashion that Adobe's Photoshop has. Although initially authored as an application for "retouching" photographs, it has rapidly entered into societal lexicon and has become an iconic cultural identifier in much the same way as the terms "Xerox", "Hoover", "Kleenex" and more recently "Google" have, especially in terms of branding and day-to-day vernacular. Beyond its social ramifications and those powerful discussions of media perceptions in the age of image manipulation, is the much simpler examination of how the digital art community, globally and en masse, have adopted Photoshop as the de facto tool for digital painting. Not only has the concept or working in layers become the defacto standard for most digital artists, but the notion of incorporating photographs into the painting process, especially for creating tactile, photo-realistic textures across imaginary surfaces. These workflow concepts, amongst others, have opened a vast new world of digital art possibilities and allowed artists to realize their imaginings with a level of meticulous detail never before experienced or realized. There is a monstrous "however" attached to this boon, and that is the notion

Figure 1-15. Adobe Photoshop CC (2017)

of "photographic retouching". Whether it is the legacy of Photoshop and its original purpose in the world of photography, or its many uses as a home hobbyist tool for the "clip art" generation, designed to cater to the world of desktop publishing, the idea of simply "removing red eye" or "applying a filter" seems to be the lasting impression that the world at large maintains over any artist versed in painting with Photoshop. This perception, rather than remaining isolated within the comfortable confines of photo manipulation, has instead "gone viral" to encompass any form of visualization using digital means. The end result is a view of compositors, digital painters, animators, modellers, and any of a variety of CG artists, as nothing more than image technicians. As technology continues to become cheaper, and more and more advanced visual fx techniques become commercially available within "off-the-shelf" software, Visual FX and those artists who operate in that field are being seen more and more as a commodity. What is slowly becoming outdated is the notion that an artist is needed to paint a straight line and it is slowly being superseded by the notion that anyone can use a ruler; therefore, if the right ruler is purchased, anyone can draft a straight line.

Every classically trained artist has experienced the exercise of designing a perspective study both through the use of a ruler and with practiced freehand strokes. There can be many discussions as to the outcomes of both techniques, whether the slight margin of error during the freehand process more closely mimics the settling of architectural structures over time, or that the ruler does not accurately represent the natural curvature of the surface of the eye, but the bottom line for an artist is that a freehand perspective rendering is simply "more organic" and "more alive" then one captured by the strict rigidity of a ruler. It is art through experiential learning, and it is difficult to convince someone who does not have a similar background that, although the ruler is quicker, easier, and (in theory) better at achieving a straight line, the freehand method will forever be more appealing to the human eye. This concept is the "hard sell" and why the field of CG Art has come to focus on the tools and the technicians to operate those tools … and not, unfortunately, the artists. This has been echoed again and again, with the introduction of each new technological paradigm. When Ultimatte became commercially available, suddenly the whole process of matte painting and bluescreen/greenscreen photography no longer required the attention of high-priced specialists, and roto work devolved from the level of "art form" to menial factory work that could be produced by anyone, so long as they procured the correct number of Ultimatte workstations. Most recently, stereoscopic cinema suffered the same misconception of technology's success for technology's sake. James Cameron, in an interview with Mike Fleming Jr in 2010, stated that "after Toy Story, there were 10 really bad CG movies because everybody thought the success of that film was CG and not great characters that were beautifully designed and heartwarming. Now, you've got people quickly converting movies from 2D to 3D, which is not what we did. They're expecting the same result, when in fact they will probably work against the adoption of 3D because they'll be putting out an inferior product." (Fleming 2010)

This cycle of technological dependency continues unabated, as studios and companies develop high-end CG applications that only a few specialists can operate and understand, achieve mind-blowing visual FX, publish an industry vetted SIGGRAPH paper, manufacture a commercial, off-the-shelf version of their high-end software that anyone can use. The specialists end up losing their jobs. The high-end software is procured for an overseas VFX house producing work at a tenth the cost, resulting in studios chasing even higher and higher technological bars to stay competitive, and the whole cycle repeats ad infinitum. The resulting rise of the technological bar, however, is failing to equate to quality, again, due to the fact that the technology and its operators are paramount to a budget, and not the artists. Audiences have responded to the spectacle, as the highest grossing box office figures have indicated, but not to the art form, as the top 100 films of all time lists from 3 different sources sadly reflect.

The true test of the synergy of technology and art is, to coin a phrase from the computer games industry, to develop a high-end application that is "easy to pick up and difficult to master". Once that has been achieved, perhaps the focus will be less on those who can operate the software, and more on those special individuals who have mastered it. After all, anyone can use a ruler, paintbrush, pencil and pen. True creative genius lies within the DaVincis, Degas, Matisses, and Rodins.

Much as can be lamented about the cyclic nature of the industry inhabited by CG artists, it is unfortunately a legacy that seems impossible to abandon. A visual FX house subsists in two primary ways. The precious research and development work that is costly, but receives validation through the recognition of excellence and thus, furthers reputation, and menial tasks such as rotoscoping work, wire removal, tracking, and chromakeying that subsequently represents consistent income and helps "pay the bills". As more and more outsourcing facilities become adept at doing the "menial work" that pays the bills, the VFX industry is scrambling to find alternate means to supplement their revenue. The idea of convergent properties with their gaming counterparts has been floating around the industry for years, with a few notable attempts from EA, joint projects between ILM and LucasArts, and most recently, Tippet Studios entering the app development arena, but these have failed to take hold for issues that will be examined further in later sections of this paper. It is in the opinion of this researcher that this avenue should not yet be abandoned. In the meantime, the only alternative left to a VFX facility is to enter into the debt cycle, which is unsustainable and results in a foregone conclusion, whose evidence we have witnessed to date.

One of the leading bones of contention within the Visual FX community is the common practice of outsourcing, which originally began as a safety net to encompass those accidental slippages of time that fell outside of production's original scheduling pass for delivering assets, and eventually devolved into the low cost labour solutions for those tasks requiring little-to-no expertise. As governments around the world offer more and more tax incentives to entice large scale production companies to invest in their local economies, and as technology gets cheaper and easier to operate, what is now being outsourced is the expertise as well. It is this troubling new development in the last 10 years that has not only begun the inevitable demise of the North American Visual FX industries, but has also affected the quality of work being produced. Beyond the hew and cry for unionization, which is a very important part of something rapidly becoming known as the Erland Tripod (which we will discuss at length in a moment), this is clear evidence of how the visual FX community is being perceived. For example, if you were charged as a conductor and a composer to lead an orchestra in a virtuoso performance, you would not suddenly outsource your first violins simply to reduce costs … even if the outsourced violinists were skilled at playing notes, and could keep the tempo. Closer to home, production companies would never replace a team of Gaffers during production with several electricians from a residential build, simply because they were cheaper. There is an artistry inherent in a chosen violinist, and chosen group of violinists that results in excellence in musicianship. With the right team of Gaffers, combined with the right DP can result in a film lit beautifully like a rare and prized Vermeer. Yet CG artists are often treated like a hundred monkeys, at a hundred typewriters with the expectation that they will eventually produce the works of Shakespeare. The cold, hard reality of the business side of the entertainment industry is the siren song of lowering costs, however, and no amount of waxing philosophical on the artistry of CG artistry will change the bottom line.

So then, let us examine the cost benefits of outsourcing work. There is a false sense of security built around any asset pipeline that utilizes the outsource model of production. Not only is the juggling of more than a dozen external vendors a management nightmare, here is a list of common outsourcing dilemmas:

1. Asset and Data Transfer

    a. This is a particular point that is generally taken for granted. If the asset and data libraries of a project were to be compared to a herd of a dozen elephants that needed to be physically moved from vendor to vendor, then suddenly the idea of outsourcing globally seems less attractive. Data wrangling is a very real, and very difficult problem for a production to solve. Fast data transfer, on a large scale, in a timely fashion requires adept choreography. Many productions have had to physically fly portable hard drives from one location to another. This also brings up the problem of data syncing and version control.

2. Communications and Change Control Process

    a. Version Control, and incorporating the approval process becomes exponentially more difficult to manage without an infrastructure in place to ensure that multiple vendors scattered world-wide have access to the same feedback and can watch dynamically changing assets in real-time to ensure the integrity of the assets they are developing remain consistently current and up-to-date.

b. Communications pipeline can also be difficult to manage, not only due to timezone issues, but also the introduction of several layers of abstraction. A production that originally began with two VFX Supervisors and two VFX Producers (one each for production side and facilities side) must now liaise with each vendor and their VFX Supervisor/VFX Producer team.

3. Knowledge/Workflow Transfer

a. Specific workflows for creating assets (and the order in which their inherent dependencies are negotiated) may be different for every vendor, and may not be in line with a particular productions methodology

b. Specific technical knowledge, which may be proprietary to a production's pipeline, will now need to be "shared" with every vendor involved to ensure consistency in the asset authoring pipeline

4. QA: Rebuilding Assets In-House

a. Consistent quality, in terms of art direction requirements, may not be met, or even be within the capability of an outsourced company, resulting in hours/days/weeks of iterative team that could result in the asset(s) ultimately being (re)built in-house.

5. Build Specifications and Guidelines

a. As visual FX techniques push the bounds of computing power, there are often times fairly stringent methodologies associated with asset authoring, to ensure maximum efficiency in the use of computational expense and to prevent costly errors. These methodologies will not only have to be communicated to an outsourced company, but also stringently monitored.

6. The Blinders of Lower Wages

a. The low cost of human resources may be misleading in production cost estimates as there are a number of mitigating factors that may end up depleting those savings quite quickly.

7. Security

a. Any proprietary tools/techniques or art assets will need to be stringently monitored. During production of the Clone Wars videogame, initial release copies of the television series were not only digitally watermarked, but access controlled via a safe and login record.

8. Investment

a. If external outsourced companies are being utilized for key work, and key positions, then the production company not only invests in the quality of their deliverables, but must also ensure the financial well-being of that company (at least, until the production expires).

9. Art Direction

a. Once again, there is an assumption that outsourced companies can produce the same quality, if not better, than that which can be produced in-house. Perhaps this is "another consensual lie"?

Many artists in the CG community have begun to discuss the notion of unionization, in the hopes of developing some sort of collective bargaining power. This notion is rapidly being perceived as a shield against the dangers of outsourcing. Yet the globalization of both the visual FX industry and the games industry beggars the question of whether or not something like this is even possible, let alone feasible as protection. Although trade associations and unionization are on the lips and minds of VFX practitioners the world over, the dilemma may be in the entrenchment of current bad practices that leave very few options to explore these avenues

"In the old days when we first started, in the late 1980s, early 1990s, there weren't a lot of us doing this stuff and we had more flexibility with the pricing structure and we were all trying to figure it out," says Barnes. "Now there is some crazy number of VFX facilities worldwide and not enough product to support all those vendors. It's a supply and demand issue." (Kaufman 2017)

Guilds, unions and trade associations feature heavily in a paper published by Jonathan Erland, a founding member of the Academy Science and Technology Council, the Visual Effects Society, as well as the recipient of numerous award, commendations, and industrial recognition for his life's achievements in the world of cinema visual effects. The paper, entitled "The Tripod Metaphor" (Digital Greenscreen, 2017), Erland identifies the necessity of 3 separate branches of non-profit, discrete entities crucial to maintaining stability within the infrastructure of the movie industry, and uses the imagery of a tripod to help illustrate the interdependencies of each. On the collective bargaining side of the tripod, Erland addresses Guilds and Unions (for personal issues such as working conditions and income) and Trade Associations (for commercial and corporate issues within the industry). The third leg of the tripod deals with Honorary Societies, and focuses primarily with the pursuit of excellence within the professional practice of CG art and Visual FX. It is this third and vital leg of Erland's metaphor that will be the philosophical undercurrent of the main themes presented in this paper.

The perception that Visual FX artists are commodities comes from the notion that the craft of CG art is more of a technical endeavor rather than an artistic one. This has been fostered over the years by the continued celebration of technology over art and has embedded the notion that the ruler is far superior to the freehand straight line. It is difficult to describe the artistic excellence achieved by 200 000 lines of highly optimized code executed using the correct mathematical settings, and much easier to discuss the wonderful command of light and exposure that Roger Deakins BSC has exercised over his body of work. Yet we celebrate the achievement of SolidAngle's Arnold, a renderer written with just over 200 000 lines of C++, when we discuss the merits of the CG work in Marvel's "The Avengers" movie, or "X-Men: First Class". Not as much press is seen to be devoted to the Lead Character Artist and Lead Animator for Iron Man, or the Hulk. Although rendering technology has given us access to some of the most astounding imagery yet seen, and this has reflected wonderfully at the box office, we are still lacking the artistic integrity of the filmmaking process that leads to the creation of a "classic".

First, let us take a quick look at how traditional draughtsmanship has been regarded since the advent of the new millennia. If we examine the AFI Top 100 Films of All Time (2007), we can see that there is a noticeable absence of films from the mid-2000s and onwards. It is curious to note that in 2004, Walt Disney studios closed its 2D Animation department indefinitely as the onset of 3D animation really began to take root in the mindshare of audiences everywhere. Michael Eisner, former CEO of Walt Disney at the time, was quoted as saying, "the 2-D business is coming to an end, just like black and white came to an end." (Ladewig 2004). This sentiment was further echoed by Jeffrey Katzenberg in an interview for the New York Times when he was quoted as saying that "the idea of a traditional story being told using traditional animation is likely a thing of the past (Holson 2003). This typifies the myopic focus on the end result, with the determination that traditional hand drawn animation is a wholly separate entity from its 3D counterpart, and the success of CG films can be solely attributed to the fact that it is a new means and a new medium. This seems to contravene the ethos for which John Lasseter founded PIXAR, and the driving force behind the success of PIXAR's films, namely that a traditional animator's sense and sensibilities are essential in underpinning CG animation for it to have the same emotional valence as other motion picture mediums. As traditional animators slowly began to lose work, and academic curriculums slowly began to drop traditional animation techniques from their syllabi, the motion picture industry was losing more than just 2D feature films from their production rosters. They were losing close to a hundred years of slowly perfected craftsmanship in the art of animation and gaining a widening gap between hand drawn design and computer simulation in the creative process. As those with classical art school training slowly become filtered out by a throng of technical people, trained on a plethora of different applications and platforms, the quality of craftsmanship is being affected at the production level and at the academic level. With the visual fidelity of replicating realism on the computer continuing to rise, a focus on artistic excellence within the medium becomes more and more of a philosophical ideal and not the application of a methodology necessary for producing the end results.

The connection between the creative mind and the creative property has always been a tight one, with the tools designed to support uninterrupted thought. Whether it involves the steps between brush, paint, and canvas, or typewriter to paper, the ability to capture the lightning quickly and seamlessly is vital in both the ideation and the creative development processes. The more layers of abstraction we supplement this process with, the more layers of distraction we introduce, and that momentary spark of inspiration can be lost when artists are fumbling awkwardly to find the correct tools, and apply them correctly. This is why, for any classical artist, the setup of their studio space is vitally important, almost religious, in terms of how art tools are laid out and how quickly the can be accessed.

In the field of CG art and animation, technology has introduced a software middleman that severely short-circuits this entire creative process, and not only fosters the notion that CG practitioners are button-pushers, but also engenders those emotional precepts from the artists, and the art teams, themselves. Any CG artist who has had to painstakingly unwrap UV coordinates, or meticulously assign weight maps at the vertex level can probably empathize with this sentiment. In an attempt to alleviate a large portion of the repetitive, "button-pushing" tasks that seemed to have accompanied the rise of CG art and animation, revolutionary technological advancements have pursued procedural responses over artistic ones. This has created controversy, where none existed before. The following debates have each served to focus disparity within its discipline:

1. Motioncapture Technology v. Keyframing Techniques
2. Photogrammetry v. Architectural Modeling
3. Procedural Shaders v. Hand-painted Textures

If we examine the first case, at a high-level, the notion that motioncapture technology provides a cheaper, easier solution than hiring a roomful of animators would at a theory level appear to be correct. After all, dress an actor in a suit, and their performance data will simply be mapped to a CG character. In practice, this has never been the case. Whereas, in the past, an animator would analyze a variety of reference material before sitting at a light table and beginning to draw out the key poses in a sequence, thinking carefully about the performance, in the process of motion capture, a large enough space needs to be acquired to allow for the necessary camera set up. An actor must dress in a black suit with optical markers and perform in an artificial scenario, devoid of environmental cues and divorced from their characterization process. The resulting data needs to be cleaned up by a roomful of animators, and the resulting performance needs to be touched up, using keyframing techniques, by another roomful of animators (IEEE, 2017).

There have been a number of seminal papers that have been written concerning this topic, and are referenced in the reading list.

To understand the relevance of an artist's process, and how integral it is to the achievement of excellence, it is necessary to explore and evaluate the "uninterrupted creative process" in a sample pipeline, and analyze its context from a craftsmanship point of view. Some major issues that will undoubtedly be encountered will be the need for artist-driven high-frequency details and its heavy reliance both on highly-skilled expertise and man hours, and the whole problem of computational expense that hangs over everything related to computer-generated imagery. We will negotiate issues such as Masahiro Mori's "Uncanny Valley" and the siren song of photorealism. The primary focus, however, is to find the right tools, processes, and workflows to help support the time honored creative workflow that has served many an artist over the centuries in achieving their visions, and we will prove that this artist-centric workflow is not only possible in a CG production context, but vital to elevate the art form. The tide must be turned, and Visual FX artists must climb the credit crawl to feature, at least, above the catering department. To do that, we must rethink what we have done, how we have done it and evaluate whether it has done justice to computer graphics, the newest art form of this century.

In this regard, we will explore a number of relationships between a number of different tools which have helped to facilitate artistic excellence.

For the traditional art process, we will talk at length about Photoshop and the Cintiq tablet, and how this perfect marriage of hardware and software revolutionized the concept art phase, despite the Cintiq being reluctantly embraced beyond its initial perception as a "luxury" item. An examination of the story/concept connection between Final Draft and Toon Boom's Storyboard Pro 3D will evolve with the incorporation of SketchUp 2013 as a tool to help facilitate the visualization process.

Previsualization will look at the asset creation process using Autodesk's Entertainment Creation Suite 2014, with Motionbuilder as the primary visualization tool. Adobe's Dynamic Link solution will be explored as a final concept-to-animatic-to-final composite solution as it was implemented in production on projects such as Clone Wars: Republic Heroes and Electronic Arts' Skate.

Traditional asset creation pipelines will be explored from a realtime context, comparing and contrasting a number of platforms, including the Unreal Development Kit, the Unity Engine, and the Cry Engine 3 Software Development Kit and how they leverage OpenGL/

OpenCL technologies for realtime artist feedback mechanisms.

For edit-based/timeline based projects, such as film and series work, the relationship between Heiro, Nuke, and ultimately, Avid Media Composer will be discussed. This will naturally lead on to data management issues and solutions in an asset pipeline. Experiments with Perforce, for realtime authoring and version control, and Shotgun, for offline edits, will be presented with resulting conclusions and the need for high-speed database solutions, such as Aspera, will be briefly touched upon as our demands for higher fidelity become reflected in ever increasing file sizes.

The pipeline that has been explored throughout the course of this research has been a framework for the production of offline, edit-based intellectual properties, as realtime solutions introduce their own set of production issues. That notwithstanding, a correlation with realtime authoring techniques and how they can be incorporated in a film-based pipeline shall be addressed further.

At the forefront of the pipeline outlined in this paper is a discussion of previsualization, how it has fractured into two separate entities, a creative and a technical previs, and how productions can leverage this phase for greater control during production. At the back end is the postvis and the postmortem, and solutions we can explore when a production eventually comes off the rails.

As a practical exercise, to flex test a number of theories postulated by this paper, 1 shot from a short film project, entitled "The Nothing Girl" was taken through a rigorous creation that involved everything from concept art to software tools development in python to final rendering and delivery in a number of production-based formats. A high level of visual fidelity was targeted during the course of this production to scrutinize how supportive it was to an artist's creative process. In this way, traditional art techniques could be compared and contrasted with the current state of digital asset authoring techniques. Beyond this rationale, the wider context of the aims of this research is to address current fx-driven properties as what they are: titular and flavorless in terms of critical reception due to the disregard for traditional art disciplines, how this is beginning to lose audience mindshare, and how refocusing on the artisanship of computer graphics will not only elevate the industry but also create an understanding that the artist is not only integral to the development and implementation of key software applications, but in fact supersedes the focus currently being placed on engineering advancements. As the dawn of High Frame Rate filmmaking and 4k resolutions begins to creep forward, with pioneers such as Peter Jackson already producing work in these new mediums, fx work will become far more demanding, both at the artist level and in terms of computational expense, and if the industry is not careful in how it emphasizes CG art, there will be volumes of publications extolling the virtues of 4k technology and how it showcases the visibility of movement in the minutiae of the cilia along the forearms of a subsurface scattering skin shader applied to a photoscanned character model, and no one asking the question how this technology has furthered excellence in visual storytelling.

1.9

When examining the socio-political framework of modern attitudes and recption towards digital art and artists, and understanding the popular context that is currently afflicting practitioners of this new craft, there are key preponderances we must investigate. Therefore, the aims of this research are:

1. What are the socio-political, cultural and generational influencers that drive the art-making process, in terms of new "digital" attitudes to creation and consumption?

    Human behavioural psychology has shaped the art creation process for centuries. It will be interesting to examine its cultural evolution in the face of our new digital ontophany.

2. Investigating a number of contemporary digital pipeline workflows, are there any commonalities, either neuropsychological and/or in terms of emotional valence associated with specific approaches that need to be identified, or is the creative process shortcircuited based on discipline?

    This research is an examination of a variety of techniques to determine if different digital discplines offer varying degrees of creative investment.

3.What is the relationship between traditional art practices as they pertain to new digital methods and are there any key influencers that can be harvested for a higher level of artist engagement with their works?

    Traditional art practices are investigated for their efficacy in a digital context, but for the artist and for their intended audiences.

What this paper touches on at a high-level, but does not expand upon due to issues of scope and focus, are :

1. Masahiro Mori's Uncanny Valley
2. Perceptual Metrics in Kinetic/Ballistic Error Sensitivity
3. Emotional Valence to Digital Stimulus Response
4. Neuropsychology/Behavioural Genetics

To help facilitate this investigation, it was framed in the context of a qualitative inquiry with a constructivist flavour. As practice-based action research work was seen to be most commonly adopted for arts-based postgraduate research endeavours of this nature, a large part of the methodological approach to this investigation would pursue experiments along that vein. In that regard, Ross Gibson, Centenary Professor in Creative and Cultural Research at the University of Canberra, helped to define the parameters of this research in his view that the thesis of an arts-based research "is not an explanation of the artwork; rather, the text is an explicit, word-specific representation of processes that occur during the iterative art-making routine, processes of gradual, cyclical speculation, realisation or revelation leading to momentary, contingent degrees of understanding. To this extent, the text that one produces is a kind of narrative about the flux of perception-cognition-intuition. The text accounts for the iterative process that carries on until the artist decrees that the artwork is complete and available for critique, 'appreciation', interpretation, description, evaluation." (Candy, 2006). To this extent, Gibson's philosophy towards arts-based research calibrates quite accurately with industry best practices and production post-mortems, as well as the ideation and approval processes of commercial entertianment design, making it a key philosophical underpinning of this research works methodological approach.

Professor Stephen Scrivener of Coventry Univeristy echoes the validity of this approach with his view that "the art object does not embody a form of knowledge. Art is not a form of knowledge communication. Art is not a servant of knowledge acquisition. Art making creates apprehensions. Art research creates novel apprehensions." (Scrivener, 2002). After all, it is that self-same novel apprehension that will be the end result of a truly revelatory creative experience. Within the parameters of these philosophies, a five stage process was undertaken to critically analyze and evaluate current production processes in light of their parent art disciplines as translated through the lens of a digital context. These stages will be outlined and explored in depth in subsequent chapters. More vital to the ethos of the research undertaken was a thorough examination of the the metamorphosis, if any, of the human behavioural psychology of the art-making routine and its socio-political impact in terms of how humanity views creativity and the arts. A powerful analytical tool in that regard was McLuhan's Tetrad of Media Effects (McLuhan, 1977) which was used to break down and articulate cultural change, in terms of digital media definitions.

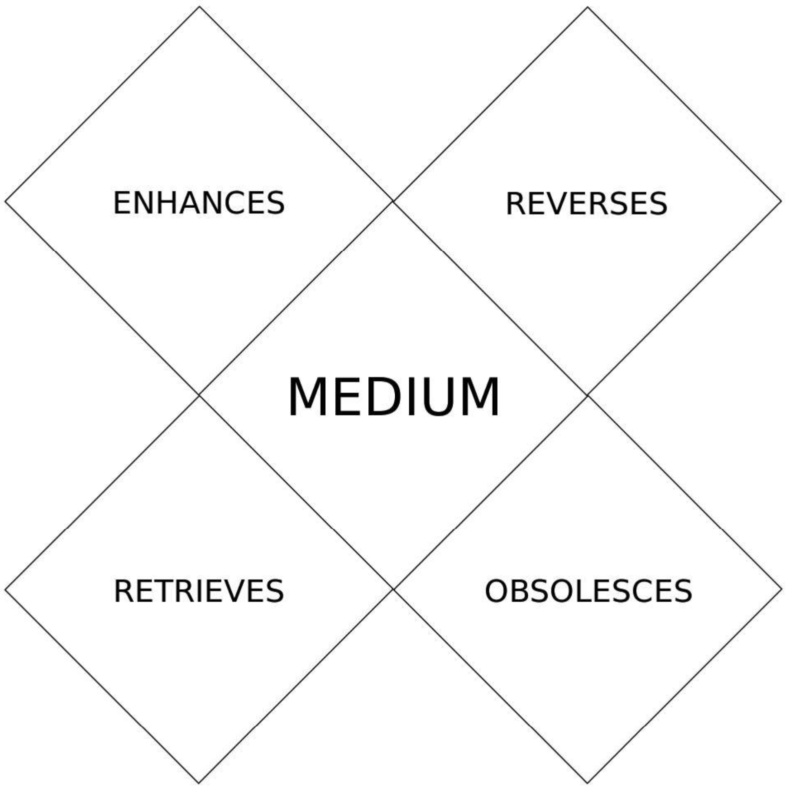

Figure 1-16. Marshall McLuhan's Tetrad of Media Effects (1977)

With the aid of McLuhan's perspective, the new medium under exploration is any media object and/or digital content asset created solely on the computer that involves simulation of its real world counterparts, whether its music, sculpting, painting, photography and/or cinematography.

1. ENHANCEMENT

Without question, digital content creation has become the great rennaissance enabler of artists this century. Without question, what once took dozens of musicians in an orchestra, or a highly specialized optical printer, or months of intense fabrication by teams of people, can now be quite easily achieved by a single person at a single workstation. Beyond that, creative visionaries can now draw upon multi-disciplinary approaches to art creation, all made available through software suites. This enhancement was tested using creation packages such as Adobe's Master Collection to see if this new creative digital paradigm enhanced the art making process, especially in disciplines once thought to be exclusively collaborative.

2. RETRIEVAL

The Davincian notion that Art and Science can occupy the same space of academic exploration and philosophical investigation was increasingly becoming muted by a world that lauded specialisms. With the combination of computer science, physics and mathematics, together with art creation, there is a return to higher level thinking, where both right and left brain activation can occur simultaneously; however, the inability to focus on a singular art objective without being able to divorce vital mental processes from computational problem solving is the root of the highest distraction for a digital artist. By adjusting the application of scientific thinking to buttress the art-making process, and not occupied by the subordinate role of technical problem solving, the experience of digital asset creation retrieves the notion of understanding scientific principles in regard to a visual revelation about the human condition through an artefact.

3. REVERSAL

Unfortunately, as the demand for more responsive and visually engaging tools increases, so do the demands for computational power. As cutting edge tools demand higher levels of resourcing, the introduction of coding is inevitable and artists find themselves slowly metamorphosing into computer programmers.

4. OBSOLESCENCE

Many traditional art disciplines are slowly being mothballed as more and more productions move to a purely digital pipeline, from cinematographers who no longer shoot on film stock, to animators who have retired their light discs and peg bars, to sculptures who no longer create production maquettes usinng clay. The danger here, however, is that technology has yet to achieve a satisfactory pinnacle for artists and the more traditional disciplines are, in fact, being retired too soon.

In an effort to isolate and examine any commonalities in those areas identified by McLuhan's Tetrad, the tests chosen ran the gamut of a purely rendered computer graphics enterprise, to a real time graphics enterprise, to one that incorporated live-action footage and ultimately one that leveraged virtual reality technology.

Of the methods chosen, those involving realtime technology, although not as graphically rewarding, provided the closest experience to their traditional counterparts. As testament to its efficacy, game engines and VR environments are now being widely adopted in film and television productions.

1.9.1

Back in 2006, while conducting character-based research at Electronic Arts: Blackbox, this researcher began exploring a number of realtime solutions and their implementations to enhance visual fidelity for the character models used in the inaugural title in their upcoming new franchise, "Skate". Having initially engaged the project during preproduction, I had the wonderful opportunity to produce concept art during the exploration period while this new franchise was seeking a visual identity. One of the more memorable design ideas that I'd proposed was an animated style of character design, which was eventually rejected for a more photoreal approach. It was then that I began to scrutinize my own creation techniques and explore the reasons behind my passionate response to ideation using traditional medium compared with the immense creative difficulties I had leveraging the technology I had at my disposal, and the inherent frustrations that occur when working between multiple applications. At the time, Adobe introduced their Dynamic Link workflow, which allowed a seamless integration between their flagship titles Photoshop, After Effects, and Premiere. This was a fortunate development as, at the time, I was charged with delivering a previsualization in a fairly short space of time. The dynamic link software support provided me with the framework with which to work quickly and maintain a level of artistic investment in the artifact. It was that primary experience that informed my decision and determination to refine an asset pipeline based on an artist's creation process, and not on solving software dependencies (although that in itself is a whole other issue that cannot be duly ignored). The philosophy that "creativity is the key" seems a concept that is self-evident given the industry that CG artists are a part of; and yet, to my surprise, I found that with each successive project, this ideal was getting lost amidst the sheen of amazing new technological achievements. As Scott Ross, former CEO of Digital Domain, pointed out in a Time magazine interview in 2010, the film industry was rapidly evolving to a state where it was "no longer about Tom Hanks or Tom Cruise. It's about flooding New York or creating blue people" (Keegan, 2010). Artistic integrity, exploration of the human condition, moving audiences with transcendent themes, and capturing the throes of creative passion on a 2D plane seem to have taken a back seat to FLIP solvers and fluid simulations. Audiences respond to spectacle, especially when that spectacle has never before been seen. Audiences have reacted this way since the Lumiere Brothers produced "Arrival of a Train at La Ciotat" in 1895. Back then, audiences rushed, screaming, from the theatre, so visceral was the imagery. For how much longer the film industry can rely on spectacle remains to be seen, but with the recent failures of "John Carter" and "The Lone Ranger" it is clearly evident that there are only a finite number of times that train can be driven into the station. To capture the magic of traditional filmmaking, we must divorce ourselves from the spectacle of visual fx wizardry as an end unto itself. If creativity is the key, then the keyhole is the "moment" and being encapsulated inside this moment.

Visual FX pioneer Dennis Muren once stated that "everybody is still in the emotional and mental zone of making the movie if you can do it in a shorter period of time. I think there are big creative wins with that." (Cohen 2007). This statement has, lamentably, led to productions justifying shorter and shorter post schedules, with the phrase "War of the Worlds" schedule being bandied about as the norm for visual fx production; however, Muren hits on a particularly salient point. An artist needs to work fast and needs to work uninterrupted when inspiration strikes. The passion must be captured quickly, and at its height. The longer an artist draws out the creation process, and the more and more distractions are introduced, the more magic that bleeds away from the final project.

This research attempts to disentangle the jumble of criss-crossed wires that computer graphics technology has inadvertently bound our wrists with and, hopefully, bring the focus back to the content creators, or more correctly, the "artists", where it should be, where it never left, and where it will always be.

I have been involved with these processes in an industrial context:

EXEMPLARS

1. General Artist Pipeline
2. EA Content Creation Pipeline

I will be expanding on some of the studio best practices I've absorbed in my professional career and using my research to develop the following processes:

EXEMPLARS

1. The Nothing Girl Pipeline: CG Animation
2. The Internal Bleeding Pipeline: Live-Action VFX
3. JCB: Mars Pioneer:
   A Real-time Application to a live production scenario
4. Gen Zero One: Implementation in a Future Project

1.9.2

ECONOMIES OF SCALE

One predominant factor that colours the creative process and insinuates itself into every digital production pipeline are prudent considerations of a monetary nature. That is, a research project of this nature would be seriously remiss if it didn't address the commercial aspects that drive most digital creative projects, whether it be a feature film or a triple A game. None of these operate in an economic vaccum and to make the assumption that the entertainment industry is purely in pursuit of artistic elevation would be dangerously naive. Inside the shells of both a profit-driven, growth industry business model and a technologically complex hardware and software paradigm, the soul of the artist, uncompromised, can exist and thrive creatively. After all, the entertainment industry did not create J.K. Rowling; on the contrary, it was her creation, Harry Potter, that spawned an industry.

If we make an endeavour to understand the atmosphere within which digital creatives operate, then we can hope to create a self-sustaining industrial ecosystem for creating entertainment art. As tempting as it may be to have frontier technology drive spectacle, as progressive discoveries and innovations in the field create stunning new visual fx, or to have a property created purely based on market and demographic analysis and controlled by a creative committee to mitigate risk for return on investment, these approaches do not generate the resounding cultural impact (and the subsequent net worth) of either a Star Wars and/or a Harry Potter franchise.

Although the former two approaches can not, and should not be wholly ignored, we must understand the single most important ingredient that does create a lasting, generational resonance from a creative new intellectual property. Ultimately, it comes down to a single creative person with vision, and the artists that help them bring that vision to life.

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chapter 2
literature review

2.1.1

Within the scope of both the feature film and the triple A games industries, computational expense (render time, simulation time, etc.) is often times synonymous with capital expenditures. It was, therefore, prudent to have artists on staff who could both maximize a system's resources and locate procedural efficiencies in a pipeline's network infrastructure. As Moore's Law continues to come into effect, however, computational power begins to free up more and more of the traditionally technical responsibilities of a CG artist, allowing them to explore their own internal processes for authoring visual assets as opposed to the more mundane data optimization tasks often necessary in the past to successfully execute render jobs, both realtime and offline. According to a recent paper delivered at ACM Siggraph in 2017, due to "significant advances in techniques and increases in computational power, path tracing has now become the predominant rendering method used in movie production, entirely eliminating scanline algorithms. Where raymarching once served as the go-to rendering method, tracking algorithms (inherited from nuclear and plasma physics) are now the norm. Pre-computed lighting and multipass techniques are now also a thing of the past, along with the methods that were used for modeling the voxel buffers and the motion blur techniques of the time. A set of ad-hoc models for light propagation have made way for rigorous implementations of physically accurate light transport, and in the process a number of "holy grail" goals have been achieved: unbiased volume rendering, along with true area light sources, multiple scattering and accurate motion blur. Effects that were unthinkable only a half decade ago are now available in o-the-shelf renderers." (Fong et al., 2017).

In that regard, a closer examination of a digital art disciplines own internal processes may yield new methodologies that more closely approximate its traditional art counterparts. As computer-generated artefacts become more and more untethered to the technology that

Figure 2-1. Unbiased Volume Rendering, OctaneRender3 and Houdini (2016)

enables their creation, perhaps we can approach the ideal psychological state for creativity, which is a single stream of uninterrupted thought that connects the artist to their creation.

To ensure that this analysis was not myopic in its focus on a singular subject matter, a number of different digital creative disciplines were examined and cross-referenced in an to attempt to isolate not only common barriers and detriments to the creative process but also to identify any interdisciplinary methodologies and best practices that can be applied universally across multiple fields.

The central challenge is how to achieve a singular vision on a multidisciplinarian creative endeavour. Individual artists, sometimes on teams of thousands, have to reconcile their own creative processes against a director's "vision" and take solace in the fact that their work will maintain the integrity of having thematic depth and nuance. In that regard, a film director or game designer does not provide a project's soul, per se, but rather the navigational star for a collection of souls travelling towards a singular destination. Of course, whether a film director and/or a lead game designer are a true auteur in their own right weighs against a number of different factors to consider, discuss and debate; however, as Andrew Sarris noted in 1962, " ... the first premise of the auteur theory is the technical competence of a director as a criterion of value. A badly directed or an undirected film has no importance in a critical scale of values, but one can make interesting conversation about the subject, the script, the acting, the color, the photography, the editing, the music, the costumes, the decor, and so forth. That is the nature of the medium. You always get more money than mere art." (Sarris, 1962)

Every discipline contained herein has, in no small measure, a creative contribution to either the digital filmmaking process and/or computer games development. Each discipline will be examined both in isolation and in tandem with a larger production pipeline with all its inherent interdependencies .

The major categorizations of digital creative disciplines contained within this analysis not only has a specific application to the production process but also offers insight into the broader digital context that governs our daily lives. Each category has its own unique processes and related challenges.

THE CATEGORIES

"Story Development"

The topic of story in and of itself is voluminous in its scope and reach, from oral traditions to modular interactive scripts for realtime cinematics. The universality of what story is trying to achieve in its overarching goals served as a powerful undercurrent in terms of uniting the various creative disciplines in a clear, singular objective. At its heart, authoring story content involves a powerful understanding of human behaviour and our own innate psychology in its profound attempts to identify and define the human condition. Retired Hollywood film director, Peter Marshall, culling from his decades of experience working in documentary, independent filmmaking and big budget features, identifies seven essential ingredients necessary for a film to have resonance. Topping his list at number one is the study of human behaviour. Directly following this is the importance of story (Marshall, 2013).

7 STEP FILM DIRECTING FORMULA

STEP 1: The Study of Human Behaviour

STEP 2: Storytelling

STEP 3: Performance

STEP 4: The Principles of Montage

STEP 5: The Psychology of the Camera

STEP 6: Basic Blocking & Staging Techniques

STEP 7: Technical

"Art"

Although having a broadly generalized term such as "Art" seems anathema in an analysis designed to evaluate the minutiae of specific processes relevant to individual creative workflows, in this case, the term "Art" has very specific parameters when taken in context with entertainment production. The areas of production design and concept art are deeply integral to the initial stages of a project. In fact, production design plays such a key role that it is widely regarded as one of the three most important roles to fill on a feature film crew's roster, alongside such luminous positions as the director and the director of photography. It is generally under this specification where the lion's share of traditional art practices falls, from production sketches to clay maquette prototypes. The early stages of a production arguably encompass the most creative processes.

> "The art department is often the largest department on a production and is responsible for all the visual elements of a film or high-end TV show. Whether its creating whole worlds of fiction from scratch or replicating period detail precisely, the art department is one of the most creative departments in the screen industries."
>
> (ScreenSkills, 2018)

"Performance"

Whilst story development internalizes the examinations of human behaviour, performance externalizes the results of those investgations and engages audiences with its breadth of human interaction. Emotional valence is critical to the success of any creative intellectual property and the truthfulness inherent in any performance is a crucial ingredient. Actors are the shepherds of any story and as John Huston once said, “I relieve myself from the rigours of directing by casting the picture correctly.” (Wikipedia, 2017)

"Production and Entertainment Economics"

Having carefully examined the more mundane aspects of project planning and project management generally associated with production departments, and having engaged in real world scheduling and budgeting considerations for CG heavy properties, it is abundantly clear that, in pursuit of a more creative artistic approach to digital asset authoring, production considerations cannot be completely ignored, and although not inherently artistic by nature, form an integral part of designing any workflow, whether on an individual artist basis or as part of a larger studio pipeline. Creative decisions need to be informed and strategic ones, with an eye firmly on the marketplace while still maintaining enough distance to allow for the truly outstanding journies of self discovery and self actualization that are necessary to create lasting social impact. In a number of different scenarios, this has not been an easy balance to maintain.

"Modelling"

Although asset construction ideally should be initiated during a project’s preproduction stages, and generally does on larger budget endeavours, the modelling of geometry, and CG assets, doesn’t properly throttle up until all initial phases have been green lit and full production begins. The largest challenge facing artists at this stage is the enormous disconnect between a 2D traditional mindset and 3D digital asset construction. Often times, the same creative considerations are repeated again while heretofore unseen design problems, only evident in a 3D contextual space, begin to introduce themselves in dramatic fashion to the production team. Bridging the gap between 2D conceptual artists and 3D modellers is the first hurdle to circumvent, and once successful, can inform a sound philosophy for production methodologies moving forward.

"Digital Sculpting"

Although digital sculpting and CG maquette creation often times exist as a separate process to asset modelling, this relatively new discipline straddles the art creation philosophies between traditional artists and digital artists. Facilitated by a few dominant new pieces of software, which will be explored at depth within this analysis, this digital workflow paradigm is the first and currently only one that caters to the needs of traditional artists. Ironically, it is due to these new applications that computer graphics have hit a new watershed of visual fidelity. By utilizing technology to cater more towards what a traditionally trained artist needs, it seems that the CG industry has raised the visual bar.

"Photogrammatry"

In direct competition with digital sculpting is a more procedural methodology that involves data reconstruction based on photographic analysis. Accurate digital reconstruction of the realworld has thrown the notion of cg artistry into a controversial new light, much the way the advent of photography challenged the world of classical painting; however, digital sampling used in the creative arts, whether in music or art installations, which has been in existence for far longer than photogrammatry, helps to inform how these new techniques can be regarded, and adopted, within a production's pipeline.

"Shaders"

The creation of shaders, whether in replicating the material properties of a given surface or simulating the photometric effects of real world light behaviours, is where computer graphics artistry begins to cross firmly over into the area of technical art and computer science. Shader writers can range anywhere from those who assemble node networks to create desired effects, and utilize high level scriting languages to do so, to graphics programmers who author those nodes from scratch. This area of a production pipeline presents a number of different challenges in terms of understanding where reality ends and artistry begins.

"Cinematography"

Recognizing that digital cinematic artists needed to understand and replicate the long tradition of cinematography, animation production teams have started turning to Hollywood DOPs to help guide their creative decisions for shot design. Although communication issues between real world cameramen and their digital counterparts has been fraught with challenges, this recognition of craftsmanship has resulted in improved cinematic work and should be regarded as a model of marrying traditional art with its digital counterpart.

"Animation and Rigging"

The art of animation and its long heritage as a well respected form of human expression is inexplicably tied to its technical counterpart in computer graphics, character rigging. It is difficult to cleanly separate the interdependencies these two discipines share. From a production standpoint, both of these areas necessitate multiple teams working on the same asset in parallel and, unfortunately, the asset in question, which is generally a performing character, is arguably one of the more difficult artistic endeavours coupled with one of the more technically complex tasks a digital creative team can face. Without question, the current state of animation pipelines requires that an animator have at least an intermediate understanding of the rigging process and the controls that drive their characters, and that riggers have an acute awareness of the artistic decisions involved in creating animated performances. Finding an artist-centric approach to this technically complex area of the pipeline is of utmost importance as performance and emotional valence with an audience ranks high in the level of importance for creating high-quality intellectual properties that connect emotionally and elevate the art form.

"Lighting"

Digital gaffering, or scene lighting, has enjoyed a number of key technological watersheds in the past decade, including the simulation of photometric lights, the use of image-based high dynamic range techniques, and global illumination. As rigging and animation are inexplicably tied together technically, so are the disciplines of lighting and rendering, also widely regarded as some of the more complex areas of a computer graphics pipeline. Although the artistry involved with effective, emotional lighting is centuries old, with cinematographers worldwide carrying a personal library of classical painters from Rembrandt to Vermeer to Turner that they often reference in their shot design, digital lighting is still mired in esoteric, overly complex technical processes. To a certain degree, the artistic processes involved in effective lighting can be clearly delineated; however, due to the relatively large role lighting plays in render calculations, lighters still need an awareness of the computational ramifications of their work.

"Rendering"

Rendering, the highly demanding, computationally intensive process of collating all final data assets, from geometry to shaders to lighting,and calculating the outputs necessary to generate a final, high resolution frame for a film and/or game, whether using offline technologies or realtime calculations, hovers over every aspect of a production pipeline. Similar to creative dependencies that traditional celluloid-based photographers faced when hampered by the lab development processes necessary before being able to review a “final print”, the computational expense of rendering often times requires digital artists to work with visual proxies, unable to view the final outputs of their work until much later in the production process. This disconnect between artists and their final vision is an area that is currently under scrutiny and investigation as more and more digital tools begin to leverage the graphics processing power of current hardware to facilitate a realtime feedback loop for artists. There is an awareness, both with software developers and production houses, that maintaining an uninterrupted visual connection between an artist and their artefact results in high quality visual dividends. This is the correct course for technological development, and needs to be the primary driving force in rendering technologies.

"VFX"

Visual FX is a broad term with a variety of definitions, and often times pertains to anything created digitally for integration with live-action elements. For the sake of this analysis, the term Visual FX will be split into the two major categories of compositing and dynamics, with dynamics itself loosely being split into physics and simulation. While compositing artists, often times referred to as 2D artists, deal primarily with element assembly, they often times come into play after final shot rendering and are considered the final stop for visual problem-solving before delivery. In that regard, compositors also need to have a high degree of technical awareness. At any given point, they may be required to dive into other pipeline disciplines, such as animation, particle physics and projection texturing, to solve visual issues in the eleventh hour. It is the compositing final renders that ultimately end up on screen. Physics and simulation, on the other hand, are firmly rooted in science and technology. This is an area that has seen very little change, in terms of artist-driven advancements; however, there is scope for "art directable" physics. Research and development departments in a number of production studios have been spending considerable resources in this area.

"SFX"

Special FX, or the real world counterpart for visual fx, generally deals with on set physical and practical effects, such as explosions, bullet impacts, fire and various other pyrotechnics. Although not part of the digital pipeline in the strictest sense, special fx does play an integral part, both during preproduction and final compositing and, therefore, requires special reference within the context of this study.

"Code"

Although different programming languages come into play during the course of production on any given aspect of the project's development cycle, two primary languages remain steadfastly at the forefront of pipeline engineering. Python, a universally adopted scripting language in the scientific community and rapidly becoming an industry standard for computer graphics, is a versatile open source language popular for authoring asset tools and repetitive task automation. For more granular, bespoke production requirements, from the creation of in-house authoring applications to proprietary shaders and renderers, C++, the most widely adopted programming language, lies at the heart of the industry. Graphical programming languages, such as HLSL and OpenGL are also widely utilised, and generally fall under the remit of the computer programmers, who are sometimes referred to as software engineers. Currently, any digital artist who has one or all of these languages under their belt will find themselves in a favourable position in any studio environment. The most coveted role, and the most difficult to fill on any production, is the position of technical artist. This caliber of candidate would have one foot firmly in each camp, as an accomplished artist and technically savvy programmer.

"Audio"

Currently, audio engineers, whether working in sound design or composition, sit firmly outside the central graphics pipeline of a production, with their own audio workflows and technical considerations. Being quite modular, with next to no asset dependencies with the visual artefact, audio engineers enjoy a modicum of autonomy; however, incorporating them early in the creative workflow has only proved beneficial and as questions of rhythm and timing govern both audio and animation finding a comfortable collaborative space between the two creative disciplines seems only natural.

"Editorial"

Every film and television pipeline leads, ultimately, to editorial. For triple A games, the closest equivalent would likely be the level designers, whose ultimate task is final asset assembly with an eye toward end-user experience. Editorial (and visual fx editorial) is, arguably, the final creative stamp on an intellectual property before general release. It is because of this that the master editorial timeline plays a key role in guiding asset interdependencies and pipeline flow. With this in mind, pipeline design should be reversed engineered from the final deliverable, much the way a game engine dictates the flow of asset libraries into the final product.

Throughout the evaluation of each of these creative disciplines, the key to helping facilitate a unified vision, and a greater degree of creative experimentation was a modular pipeline design with strong asset interconnectivity. The more exposure digital creatives receive from multiple areas of a production that lie outside their own disciplines, the greater the exchange of ideas became.

Helping to facilitate an uninterrupted flow of creative energy, outside any and all technical considerations, whether in an artist's individual workflow or designed into a collaborative space, is the goal of this research which in turn will help to reinforce the central idea that, digital context or not, the integrity of an artist's process should never be a secondary consideration to a production's final visual measure. The quality criteria that we shall use in this examination will be as follows:

1.Time and Efficiency

   It is the aim of this research to prove that by focusing on an artist's preferred processes and methodologies that efficiencies in a production pipeline actual increase.

2. Usability

   This research will also attempt to weight the creation experience against the end visual result in terms of artistic quality attained

3. Visual and Emotional Signatures

   Ultimately will a different approach to digital creative processes yield a higher fidelity in terms of a unique visual and emotional signature for a final release artefact.

The measurement of quality criteria is an unstable, variable and often contested area of evaluation for arts-based research, especially when dealing with artefact representation that is solely reliant on novel apprehensions under analytical scrutiny, two quantities that exist at diametrically opposing poles of thought. Eleni Gemtou of the University of Athens stated that the goal of arts-based research is "comprehension, seeking to ascribe meaning (via subjective transfer) to the spirit of a work of art" (Gemtou, 2010). Adding further complication to this anaylsis is the encapsulation of what Gemtou identifies within the commercial context of the entertainment industries.

In that regard, measurement of quality criteria will be industrial by nature, as this enquiry seeks to elevate the visual dialogue engaged by digital artists within a commercial medium.

INDUSTRIAL MEASURE

1. Gen Lim, Producer
2. Vicky Lam, Executive Producer
3. Gary Nicholls, Executive Producer
4. Jordi Bares, Animation Director
5. Marc Price, Director
6. Andrew Toovey, Director

2.1.3

> “ ... if I could get the simple things (which are so difficult) right, first, then I could go on to the complex details; I should have achieved what I was after; the realization of my own reactions ... I could only envisage the general architecture of a work of mine, replacing explanatory details by a living and suggestive synthesis.”
>
> (Henri Matisse, 1869-1954)

The Necessity for Simplicity

If technology has operated as a facilitator for creative people to produce at a level that once required a large degree of specialism and access to proprietary production facilities, then it would stand to reason that the price of membership be a deep computer literacy; however, technological quandaries that often plague the every day work life of anyone familiar with computers inadvertently create a mental “white noise” that can often cloud inspiration and distract from the creative process. In addition, as computational power increases with each new technological iteration, software engineers and developers become increasingly enamoured with the level of granularity that can be achieved as bit depth increases. The ability to achieve greater and greater levels of detail runs anathema to what creatives are trying to achieve in their attempts to elicit emotion. Whether through music, literature or art, the simplicity of a basic theme, shape or form is the key element that all creatives strive to achieve at a high level before anything else. To a creative, details often muddy the true aspiration of finding “the hook”, or the “perfect pose”, or the “log line”. It is the simple, yet powerful message that stirs our emotions that artists are looking to shape first, before exploring the subtle nuances that shape the individual details of an artefact. That is why concept artists when seeking to create memorable characters spend an inordinate amount of time perfecting the “gesture” drawing, a simple figurative outline that is intended to evoke the core emotion of an artistic piece.

There is a primal reason for the justification of all creative processes beginning with the simplicity of the gesture. Whether it is the “block-in” phase of sculptural portraiture, or the simple “stick figures” of the gesture drawing, or the tonal study that forms the bedrock of an oil painting, this “shorthand” for capturing reality is the key to our emotional responses. It stems from an instinctive reaction driven by the dark regions of our brain that controls our “fight or flight” decision.

Imagine a situation where a hunter hears the snap of a twig in a clearing and spies the on-rushing charge of a wolf across an empty field. With no other visual encumbrances necessary to process, the hunter reacts correctly, without thinking.

Now take that self-same situation and superimpose the hunter on a deeply overgrown wood at night. The hunter hears the snap of a twig, and desperately scans the foliage, with its myriad tangle of brambles, branches, tree trunks, and bushes. Caution is introduced to the thought process as a variety of optional responses are weighed against possible outcomes. When the wolf finally pounces, the hunter is frozen by indecision.

This is why human visual acuity is tuned for luma data (black and white tones) over chroma data (color spectrum). The simplicity of understanding depth and contrast allow us to react instinctively, at an emotional level. This is also why the pursuit of simplicity in rhythm, shape, and form is crucial in the first stages of the creative process. We, as primitive creatures, are designed to understand that a beast is crouched, ready to spring, before we even know what that creature is.

If the gesture, block-in, or tonal study does not convey at least seventy-five per cent of the emotional intent of a piece, no amount of detail can resurrect it from the cautious viewer, indecisive about whether or not a concept piece, character model, or environment design is "good" or not. Ultimately, the viewer has responded rationally, and not emotionally, and our creative endeavours will be instantly intellectualized and forgotten.

Only by eliciting a primal, emotional response can we seek to engage our audiences in an experience that is iconic, unforgettable, and life changing.

That is why many production artists are devout followers of the instant read. The ability to identify, process, and interpret visual data in the blink of an eye is key to maintaining a visceral connection with our audience, and maintains their engagement with the story.

Equally as vital to the reception of what an artist is trying to convey is the process with which the artist arrives at this emotional response. Any encumbrances that cause deviation from the fugue state an artist requires to connect with this instinctual, emotional level will also encumber the final visual artefact. In this era of digital art and content creation, the crux of the problem is, therefore, the additional layer of technology introduced to the process. While at once utilized as a facilitator of the creative arts, and an enabler for truly stunning levels of detail and visual expression, technology has nonetheless made the art creation process undoubtedly more complicated.

Emotion lives on a primal, instinctive level. It is why audiences respond to a primal drumbeat, or a looming silhouette with jagged edges. As creators, if we can evoke a tear, or a laugh, before rational thought can justify why, we have struck a deep chord within our audience using an experience they will never forget.

But manipulating emotional responses at a base, instinctual level is not an end in and of itself, but a means to an end. In that regard, what is the purpose of elevation of an art form that already enjoys an enormous amount of commercial success? If we examine the top 100 most successful films of all time based purely on box-office figures, we come across a wholly different set of rankings based on different criteria. The first dozen titles, when examining worldwide gross, are dominated by cg and visual fx heavy properties ("Box-Office Top 100 Films of All-Time", 2017). In fact, upon closer inspection, one would be hard-pressed to locate an entry that was cinematically pure in regards to digital and computer graphics manipulation. Even though the AFI Top 100 films of all time does not cross-reference well with this list, it would seem, from a business and investment perspective, there would be little adjustment necessary.

In fact, this cavalier perspective towards filmmaking artistry, and its relevance to the bottom line, can easily be expanded to encompass all the arts. In a Front Row Debate aired on Radio4 on Monday, 23rd of February 2015, Kevin McCallion, Head of Brooksbank School in Elland, said "At the moment, the Arts aren't one of the EBAC (English Baccalaureate) subjects, for example. The new accountability measures that will rank us in league tables and then be a big indicator when Ofsted visit as to how effective you are, don't include the Arts in the same light as, for example, English, Maths, and Science which are double-weighted." This exemplifies how the Arts are generally viewed, not just in the entertainment sector, but also when weighed against other disciplines in terms of their socio-economic value. Tiffany Jenkins, a sociologist and cultural commentator, stated in that same panel discussion that, " … there's been a real failure, actually, and it's not just politicians. It's come from the Arts Sector. A failure to articulate the value of the arts in non-extrinsic reasons. If you're competing with hospitals, you'll lose." Yet the value of the arts, even in an ancillary role, has a tremendous impact on human endeavours in general. "Those students that study the Arts actually end up being more successful in other academic areas. We end up with educated, interested, cultural scientists, or engineers, or car mechanics … " ("The Front Row Debate, Front Row - BBC Radio 4", 2017). With the elevation of the standing of traditional arts in our culture, and its increased importance in terms of personal development, it is without doubt that this will translate to a higher level of educational attainment for those segments of society properly exposed to it; but how does this help to drive what is essentially a profit-motivated industry and why is it necessary? The 2015 Warwick Commission Report into the Arts identifies that "the wealthiest, best educated and least ethnically diverse 8% of society make up nearly half of live music audiences and a third of theatregoers and gallery visitors." ("Final Report" 2017). It is interesting to contemplate how widening access, through cultural engagement, would affect these figures going forward; however, it cannot be viewed as a quid pro quo exchange of services in that increased awareness in the Arts will create increased audience participation. Focus on the Arts as a self-perpetuating ecosystem is what will create fertile opportunities to create lasting artefacts that resonate with ever larger audiences that enjoy commercial success that in turn inspire and inform digital artists to create further works.

For a work to illicit passion from its audience, it must be authored with that self-same passion.

Digital art creation methodologies separate artists from that passion, and like Masahiro Mori's Uncanny Valley, the CG industries create titillating spectacles that induce heady excitement, and come incredibly close to providing the life-changing experiences more familiar to its traditional art counterparts, but when these digital properties get close to becoming beacons of cultural resonance, they fall sharply off the bottom of the list.

2.1.4

The Hack Around

Figure 2-2. Realtime Wrinkle Map development for EA's Skate, Al Kang (2006)

At the outset of this research project, the primary intention was to postulate an alternative authoring method for high-frequency (and computationally expensive) visual detailing on art assets for both games and film. The initial intent was to revisit a process that this researcher developed at Electronic Arts Blackbox during the development cycle of its newest IP franchise, "Skate". In the course of researching dynamic cloth simulations in a real-time context, a technique was developed for high-frequency cloth deformations that would not require the intensive pre-simulation times classic physics engines required for detailed solving and visually rivaled anything done by offline rendering teams. The goal was to create an art directable solution that could encompass not only accurate cloth dynamics and behaviour but also allow for the flexibility to control the visual flow, contrast and density to create areas of visual focus, clean lines, and direct the viewer's eye through the strongest poses and the clearest action lines. Coupling these two requirements of technical accuracy and artistic expression through the vehicle of a standard physics-based solver was a challenge that could neither be accomplished within the production timeframe allotted nor could it be justified visually. Hence, a very important artistic consideration in any other classical medium was seen to be less than essential. Add to that a delivery mechanism through a realtime game engine at 60 frames per second and a standard cloth simulation package simply would not be able to do it. I was tasked with authoring a solution that would wrinkle character's clothing realistically, that would computationally be able to run at the required frame rate but that could also be painted by hand. Not taking into consideration (at least in the early stages of research and development) memory allocation and texture sizes, the solution that was eventually built worked dramatically well and was eventually adopted by a number of game teams at EA who, using the same methodology and philosophy, began creating their own bespoke solutions to solve their own high-frequency cloth deformations. My research for Electronic Arts would not have been possible without the contributions of David Coleman and Paul Thuriot, whose research work and tools development in EA's character rigging pipeline was invaluable in aiding my own journey.

In the intervening years, my perspective on a number of realtime asset authoring techniques, once afforded the privilege of industrial application to a commercial product in a contemporary marketplace has now been afforded the grand overview that academia can often times grant. Having a certain amount of distance from the assembly line of studio production and being able to examine every aspect of computer graphics, from an aerial view to a microscopic one, has profoundly changed my philosophy on what we are trying to achieve in the digital arts era. At its core, I fundamentally believe that we are creating convoluted "hack arounds" that are a Minos' Knossos castle of technical complexity for simple processes that artists have been engaging with for years, and although we have visually progressed, we are far, far less for it.

The notion that technology can often times interfere with the artistic process is echoed across many creative disciplines. Cinebot is a procedural virtual camera system developed by Adam Myhill, a seasoned DOP and digital cinematographer in the games industry, who states in his online CV "I created Cinebot because of my passion with cinematography and my frustration with the existing realtime camera systems available." (Myhill, 2017). Pixar created its highly regarded LPics hybrid hardware-accelerated relighting engine for production lighters because, at the time, creatively lighting a cinematic scene was "labor intensive and time consuming, primarily because lighting artists receive poor feedback from existing tools: interactive pre-views have very poor quality, while final-quality images often take hours to render." (Pellacini et al., 2005). Animation, texture painting, terrain modelling and simulation are a few of the many areas suffering from similar feedback of the digital methodologies involved in creating those assets, and descriptors of "labor intensive" and "time consuming" are commonplace with the proviso that traditionally creating those self-same assets do not suffer the same criticisms. After all, when lighting a real world set, all one has to do is physically place the light in the spot desired (an oversimplification of a craft that has its own set of technical criteria and scientific considerations, but an example that nonetheless is still far less complicated than virtual lighting).

As a case study to illustrate why this philosophy towards a new asset authoring paradigm was engaged as not only being highly desirable but absolutely essential, in the following chapters I will revisit my original work in the enhancement of high-frequency deformations by using expression-driven normal map blending that I developed for Electronic Arts Blackbox. At the time, cloth dynamics had just been redefined under a single solver architecture model in Autodesk's Maya CG authoring package and was being tested extensively at EA for its potential applications in a realtime pipeline.

2.1.5

It is without a doubt that the initial simulation provides a motion fidelity that is unparalleled in creating the illusion of dynamically moving cloth. Similar in context, however, to the controversy surrounding motion capture data acquisition in shaping dramatic character performances versus the artistry of traditional keyframe animation techniques (which this research shall explore further in subsequent chapters), the motion fidelity provided by procedural solutions and/or data acquisition only serves as a baseline for creating movement with which an artist can layer nuances of expression and intricate animation detailing. It is the two solutions working together that not only reduce computational expense but also enhance creative expression.

As high frequency wrinkle details become more and more prevalent to the feature requirements of cloth animation and the problem of collision computation overhead continues to present barriers to any elegant solutions, certain areas of focus begin to emerge within the examination of collisions themselves.

How cloth objects collide on close fitting garments involves a complexity in several orders of magnitude greater than collisions for loose fitting clothing. A tight shirt is in continuous collision contact with a character's surface mesh and creates tighter, denser wrinkles then a free-flowing skirt (Wang et al, 2010). It is in controlling these tight areas of cloth deformation that only a sculptural solution will suffice.

With that in mind, using a standard cloth simulation engine to produce blendshape targets is an excellent first stage cloth solution (in project implementations that cannot afford the use of mesh caching); however, further detailing will involve an artist's touch. Here is where the initial wrinkle map pipeline I developed ran into complications. At the time, it seemed incredibly naive to hope for a solution where character sculptors could scrub to a particular pose in a timeline, sculpt the effect they needed from the character's posture, then move to the next key pose.

In the intervening years between my initial work at EA to the time of this research, a small piece of specialist software, called Marvelous Designer, originally intended as a digital tool for the fashion industry, has grown into global prominence as the de facto cloth simulation engine for games, films and anything computer graphics related. The key to Marvelous Designer's initial success was a steadfast adherence to procedures and terminology familiar within the textiles industry and tools that were comfortable for fashion designers. Coupled with an excellent simulation engine, designers no longer had to worry about particle behaviour when applying spring constraints to a high density mesh, all designers had to do was "insert an elasticated waistband into their skirt model". When designing the initial clothing geometry, artists were presented with a garment window where they could assemble patterns that were based on actual textiles industry templates, making it all too familiar (and subsequently, creatively comfortable) for fashion designers. This ethos served two key functions on a character team. Cg artists had a common lexicon with which to communicate criteria and feedback to any realworld fashion designers on a multi-discipline team, as on a live-action feature film, and the simplification of the creation process meant that designers comfortable with a traditional workflow could simply create, with very little technical distraction. Marvelous Designer achieved industry respect and dominance, not through clever marketing, nor through incessant touting of its technical and scientific achievements (of which it deserves all its accolades), but by simply adhering to one resounding principle. To listen to the artists, experts in their own fields, and bend technology to suite their needs with a tool that inspires them.

Marvelous Designer is not an isolated anomaly, but an exemplar in a field of software developers who are putting the artist first. As this research has discovered, this simple tilting of the scales, bringing the artisan forward and shifting the engineer back, has had a resounding impact on digital art creation within this decade.

2.1.6

Two overarching areas of concern rise to the fore when considering the digital toolsets available to artists in most production pipelines. The first is the perception that any entity, graphical or feature-driven, that is designed with the express purpose of creating a comfortable and familiar working environment for a digital artist is considered frivolous, inefficient and unnecessary. In fact, the less technically adept a digital artist is, the more contemptuously they are viewed, which begs the question of what an artist's primary focus should be. It would stand to reason that generating the most passionate, visceral and evocative imagery would take precedence over qualifications as a software technician. This is precisely the point that Bill Westenhofer emphasized in 2013 in discussions with Bill Desowitz (which will be further expanded upon within this research) (Desowitz, 2017). The second, and far more disturbing area of concern is what I previously referred to as "The Photoshop Syndrome", wherein a digital artist is not perceived to be the inherent author of their own works but rather, they are collectively viewed as "software operators" responsible for applying procedural operations where the computer does the majority of digital manipulation. Adobe Photoshop has been the single most influential piece of digital art software within its almost 30 years of existence since its incarnation in 1988 at the hands of Thomas and John Knoll (Schewe, 2018). Originally perceived as an image manipulation tool for photographers (hence its name), Photoshop's impact has been felt far and wide, affecting many creative disciplines from the aforementioned photography, to graphic design, to concept art and digital painting. It's relevance to society is such that the very term "photoshop" is now used in colloquial conversation as a verb and its usage has now sparked fiery discussion over the sociological and psychological impacts of digital image manipulation, calling into question not only ethics but legal ramifications as well. Of primary import for this century's crop of aspiring (and established) digital artists, however, is the lasting impression that current software has invariable made the process of image manipulation and image creation "easier", therefore de-emphasizing artistic qualifications in favour of technological considerations, such as how powerful a workstation's specifications are and/or how recent the software engineering is. Although Photoshop is pinnacle in changing and affecting our perceptions on digital art, it is only a precursor to a larger problem of optics for digital creation software in general and has affected disciplines from cg modelling and animation through to visual fx and compositing. Yet not all creative disciplines have been affected as resoundingly as the visual arts, although a few have travelled similar paths.

There was a time when synthesized music suffered the same perceptions as digital art and electronic instruments weren't not regarded in the same way as their classical counterparts. Now we have complete orchestral scores presented in theatres, plays, films and recitals that, if not partially, are solely created digitally. The electric guitar and the electronic keyboard are both listed in the top ten instruments of all time, alongside the piano and the violin ("Best Musical Instruments - Top Ten List - TheTopTens®" 2017). The moniker of "digital music" or "electronic music" no longer seems applicable to modern usage and the terms themselves seem outdated, or indicative of a past generation. If we were to make a parallel analogy to creative writing, when an author drafts a screenplay, stageplay or novel in Microsoft Word, they are not colloquially referred to as a "digital writer". Yet the distinction remains in common parlance between an "artist" and a "digital artist", with the word "real" used as a common emphasis for clarification when referring to a traditional medium, or physical, artist. As in, one can be categorized as a "digital artist" or a "real artist". This distinction, although upon surface examination may seem to be addressing a point of pride or as a simple plea for recognition, but the ramifications of this categorization run deep, damaging both the industry and its deeply flawed economic model, and culturally, in terms of the enrichment of the art form.

So the general public perception of digital artists needs to change, in terms of their cultural contribution and their level of craftsmanship. To accomplish this, we need to understand the second issue at work, which is the usability of the toolset provided to art teams and what entity, or entities, are essential for bringing out the best in digital creatives.

Consider the statement "Adobe Photoshop VS. Corel Painter" (Breathing Color Blog, 2018). Both are digital image manipulation tools that are designed for 2D work, and both are widely in use as concept art/production design tools. The inherent fallacy in comparing the tool platforms is based on the assumption that both applications are equal and designed to achieve the same things when in actual fact, the application of the tool (as with all digital tools) depends solely on what the artist is looking to achieve. In fact, many discussions indicate that Painter is slower, and less efficient … this demonstrates a lack of understanding of the artist's process and brings the discussion around to technological requirements and resource allocation within a workstation ("Which Is Better at Digital Painting: Corel Painter or Photoshop?" 2017). In fact, it seems that general discussions on the topic tend to arrive at the conclusion that "traditional" artists prefer painter and "digital" artists prefer photoshop, which only compounds the issue. Corel's recent development of the ParticleShop plugin for Photoshop identifies what really needs to be recognized, and that is that the digital process has come into its own and cannot be ignored for its contributions to the process. Yet leveraging technology to incorporate more traditional feeling tools demonstrates an understanding that this new way of approaching art creation borrows heavily from both sides of the aisle, while being exclusive to neither. Herein lies the answer.

Remaining exclusively reliant on a technological approach is detrimental, as demonstrated by a statement from Ron Fedkiw, Professor of Computer Science at Stanford University, which states, "Cloth simulation has become a staple in the special effects industry, with simulation being able to achieve realistic looking cloth with varying material properties, realistic folds and wrinkles, and robust self and object collisions. However, cloth simulation is also incredibly expensive, making it difficult to use in the film industry, and impractical to use in games and other real-time applications." (Selle et al., 2009) As well, incorporating robust simulation engines on the cutting edge of scientific research into a pipeline designed to be staffed by animators poses further challenges, as noted by Jos Stam, Principal Research Scientist for Autodesk. He states, "Ask animators and VFX artists what was the most challenging part of their work and the answer is invariably: cloth and liquid, and don't even try to create hair that looks and reacts properly. And then there is the painstaking task of getting the various animated objects and characters to interact properly." (Armstrong, 2007) The conundrum of using highly technical solutions that offer the flexibility of creative interpretation in an art pipeline is never more demonstrable than when examining how something as complex as fluid simulation needs to be retrofitted for art direction. "Providing animators control over the behavior of a liquid interface when creating a directed performance has proven to be elusive. Natural liquids generally exhibit a characteristically "sloppy" behavior as discussed in [FM97a], which one would like to maintain while at the same time providing for explicit control in regions of interest. In the past, liquid actors such as those in 'The Abyss" and "Terminator 2: Judgment Day" have been created with realistic rendering, but without the desirable "sloppy" liquid behavior. In both cases, the liquid actor was directed via control vertices placed on the liquid surface. For complex large scale liquid animations, this approach quickly becomes infeasible." (Rasmussen et al. 2004) As fluid effects are arguable the most computationally complex areas of environment animation, it effectively illustrates the difficulties of working between technology and art.

The toolset is the bridge that can effectively add a steering wheel and pedals to an undeniably complex piece of machinery. But in creating the black box to allow artists to interact intuitively with the software, two distinct camps have arisen and the polarisation between both sides is palpable. On the one hand, there is the notion of "node coding" where the graphical interface and data operations closely approximates the structure of a programming language, making it leaner and more efficient in terms of working with large datasets. The central drawback to this philosophy is that artists who drive these types of tools will either need experience working with code, or at the very least, a basic understanding of programming logic. It is undeniable that the applications and tools that use a programming paradigm in terms of how they structure and process scene data are amongst the most powerful in the industry, with notable applications such as SideFX's Houdini, and ThinkBox Software's Naiad being tasked with some of the more difficult, calculation intensive fluid simulation and fx scenes in Major Hollywood blockbusters. Houdini artists have often jokingly been referred to as "Masters of the Dark Arts" and their technical prowess engenders industrial respect; however, there is another camp that champions the idea of making the highly technical invisible to the artist, allowing for a greater deal of immersion into the creative process. To the "black box" camp, technology is an enabler that should support, and not hamper, the speed and fluidity of the creative process. This sentiment is not exclusive to the visual arts. Renowned composer for high-budget films and videogames, Trevor Morris, spoke at length during an exclusive Bioware interview of the key benefits that music technology has imparted to musicians and composers the world over, and how digital audio tools, such as Apple's Logic and Avid's ProTools, have allowed individuals to create fully orchestrated, rich movie soundtracks without relying on the resources necessary in the past, namely the hiring of an orchestra (Dragon Age: Inquisition Making the Music with Trevor Morris, 2014). Similarly, concept designer Harald Belker has worked in the movie industry for a number of years, designing everything from the Batmobile to Tron's lightcycle, and has incorporated a package called SketchUp in his own workflow that seamlessly provides 3D construction tools that require little-to-no technical training in computer graphics and provides an intuitive digital toolset reminiscent of architectural drafting tools. "Sketchup is very fast. It actually allows me to move quickly and fluently in 3D, sometimes faster than I would in 2D … If I had to draw it and set up the perspective and render each one, it would have taken me 2 more years to even come close to a finished look," (Hollywood Artist Harald Belker Discusses SketchUp, 2011).

Without a doubt, a digital artist must understand their medium, which exists entirely within the computer. It is the question of to what degree should that technical involvement entail that vexes the digital creative and, arguably, short-circuits the creative process.

In the following sections, this analysis will be closely evaluating current best practices in the film and games industries from the perspective of traditional creative development techniques and how they apply to a digital context.

2.1.7

Although the first three tenets of Peter Marshall's 7 Step Film Directing guideline form the crucial basis an entertainment property's success and must be first and foremost for all creative discussions moving forward, they focus solely on the intellectual property, whereas we shall jump forward slightly into production. Creating a framework, or organizational container, is an important consideration for project development. After all, how can a creative team effectively "capture the lightning" if there's no container to put it in?

What has plagued many productions in the past was the disconnect between the three main phases of a film and/or game pipeline, mainly 1) Preproduction, 2) Production and 3) Postproduction. Although Production and Postproduction have, by necessity, been more closely tied together, whether through asset pipelines or studio communications, Preproduction has classically existed as a satellite, outside the main production pipeline. This has been primarily because the preproduction period contains the most wildly creative and anarchically experimental phase of a production that cannot be neatly compartmentalized and/or harvested. A very large drawback of existing outside the main trunk of production is that preproduction work is often considered "discardable" and many times, final visuals that have been arrived at through sometimes gruelling months of creative iteration, will be (not in all cases) reinvented by the Production team until it no longer resembles what was arrived at during the "design phase". This was a situation that was more prevalent in game pipelines than film, and was due in large part to the fact that a game's technology and gameplay are in flux almost until the Beta deadline in many cases. It stands to reason, however, that the most creative and experimental phase of a project will likely yield the most passionate vision and should, really, inform the rest of the project's execution. Sadly, this is far more ideological than what is actually in practice.

During my time at Electronic Arts Black Box, I was afforded the opportunity to help develop new IP and new franchises to engage with ever growing markets in EA's expanding stable of genres, and because our initial team was quite small, it allowed me the opportunity to evaluate and experiment with creating a more tightly integrated preproduction to production process. This meant creating a tighter change control process with the team's producers and involving the production artists in creative development far earlier than was usually the case. The results of those earlier experiments (and subsequent applications in simulated studio environments here at the University) will be expanded upon in detail in the Methodology section of this analysis.

Firstly, we must examine a typical case studio pipeline scenario. The most significant area of organizational challenge is the main Asset Management Pipeline. This pipeline will feed the Content Creation workflows of all the art teams and must be flexible enough to accommodate the review and Change Control Processes. Isa A. Alsup, an industry veteran CG Supervisor and Senior Compositor identified in an article written in 2010 for The Art of CG Supervision (Alsup, 2018) that a CG Pipeline can be classified as:

Production (Task)

Material (Data)

Approval (Metadata)

He further outlines 3 structural elements inherent in a CG Pipeline:

Personnel

Tools

Procedures

I would argue that this intermingling of the Communications pipeline, the Data pipeline and Asset Creation methodologies could be further dissected for greater flexibility in accommodating an artist's process. A few logistical issues in the early stages of laying out a "network road map" for digital data travelling from initial creation to final implementation is how individual artists organize their workspace and how that maps to a studio's organization of a project.

How an artist organizes their personal digital workspace can oftentimes be culled from the primary authoring tool that they use. Each dominant piece of software for every discipline is "pipeline" aware, and often has, as part of its feature set, an initialization process that involves setting up, at the very least, local dependencies. Whether it's Autodesk's Maya creating self-contained directories within an overall project structure (with inherent dependency mapping to relative locations), or Avid's Media Composer setting up a set of system-wide dependencies on any workstation where it is installed, understanding how data moves within an artist's own workspace mapping is incredibly important if a pipeline engineer wants to intuitively connect them to the rest of the studio.

An individual artist's visibility to the rest of the production team (in terms of assets being developed) is incredibly important for maintaining a cohesive vision across teams. Again, in the Methodology section, I outline a simple server/workstation structure that helps to accommodate both art team visibility and production integration starting right at the initial ideation stages of the project.

What complicates matters is the physical location of the artist and/or art teams.

In terms of production logistics, there are two main locations of a picture:

Production-side

Facilities-side

For a triple A game team, the production logistics are similar, only reversed in order of importance.

Facilities-side artists tend to want the flexibility of either working at the studio, or working from home. In the past, this was accomplished by two means, either a portable storage medium (which would require that version control be placed in the hands and the memories of each individual artist) or through VPN access, where an artist could simply remote commandeer their workstation from home over a wide-area network (but also introducing various security concerns). Organizationally speaking with either solution, we have introduced layers of asset tracking:

Main Pipeline Assets (Studio LAN)

Studio Workstation Assets (Local - Connected)

Portable/Home Workstation Assets (Local - Disconnected)

Couple that with the emergence of two new technological paradigms. Mobile computing (smart phones/tablets) and cloud-based computing introduced a new way of contemplating data, both in terms of access and device convergence. The universal paradigm that many tech companies competed to pioneer was the idea of a single data source accessed by multiple connected devices. What ended up actually disseminating across both the film and games industry was a plethora of new productivity and asset authoring tools that were bespoke and proprietary to the devices an artist would be using at any given time, with asset data spilling across various cloud drives and network locations (both at home and in the workplace), compounding the confusion and creating further divisions between the creative processes.

When examining creative considerations in pipeline design, the ultimate end goal of establishing a creative digital framework is to :

Allow for an artist to work quickly and passionately

Have the work visible to the team

Have the work integrated almost immediately into the final deliverable
(for "Big Picture" analysis)

Allow an artist to iterate quickly
(and refer to points 2 and 3 above)

When examining organizational considerations in pipeline design, it is important to understand an individual artist's needs as well as the needs of individual departments and ultimately the entire team. When dealing with teams of artists, all working on the same intellectual property (sometimes on the same central asset itself), there are a few key production considerations to keep in mind:

Version Control

Feedback Loop and Communications Pipeline

Asset Referencing

These considerations need to be comprehensively analysed at the earliest possible stages of a project. As asset lists begin to grow, any confusion in communications will be compounded exponentially.

Production tracking tools have been around for over a decade now, although primarily following the server/workstation LAN configuration and based largely on a software development model. The games industry have generally worked with 3 main version control systems:

Subversion (SVN)

Alienbrain

Perforce

Each of these packages essentially controls the same aspect of production, namely the organization and control of asset versioning, and controlling permissions in terms of how multiple artists work on a single asset.

Newer asset tracking systems have recently found wide-spread adoption in both the games and film industries, with a primarily online identity that helps to facilitate multiple devices and a cloud computing methodology.

The Foundry's FTrack

Shotgun

Both FTrack and Shotgun not only track asset versioning, but also help to track the feedback loop and communications (Staff 2014).

To a lesser degree, Google Drive (and it's ancillary services) is a wonderful collaborative space for the exchange of ideas. It's support for Youtube, G+, GMail, Google Docs and Google Photos (amongst others) makes it a great "one-stop-shop" for online communications and development. Unfortunately, a lot of the initial project set-up and basic pipeline connections need to be created from scratch, by hand, creating an enormous amount of up-front preparatory work and management before a project can be engaged. As the cloud drive is a subscription-based model that provides various plans based on the data storage needs, costs can quickly rise as asset libraries begin to build up.

The Foundry's FLIX (although currently available on an ad hoc, per-project basis) seems like a more cohesive solution that couples not only the ethos of a Perforce version control pipeline but also the review, approval and communications of FTrack whilst also integrating a creative, story-based workflow (The Foundry, 2017). Although not commercially available, this is one of many solutions that seeks to unify pipeline management and asset tracking in with the creative processes.

The philosophy of having a framework in place ahead of time, as a scaffolding for creativity, is a notion that seems to be gaining traction in the CG industry. As Mike Griggs notes, "In my experience, when tooling up for a new project it's better to decide on your project asset and tracking workflow before you decide on your creative apps, because this can save so much grief later down the project pathway." (Creative Bloq, 2014).

This is the primary reason why these types of production discussions are front-loaded, not only at the top of this analysis' literature review, but also for many of the projects that this researcher has been personally involved with.

To throw yet another metaphorical spanner in the works, each phase of a project, whether it is Preproduction, Production or Postproduction, has slightly different pipeline requirements, just as they have slightly different artistic philosophies in terms of how you approach them.

All of this needs a clever, intuitive and clear management system that remains invisible to an artist's process. This invisibility is crucial, as will be demonstrated in the following chapters.

Invisible technology will empower artists and an empowered artist will design with passion. Beyond investor relationships, beyond profit sharing and return on investment, and ultimately beyond product development, every astute business enterprise understands that at the very centre of financial success is passion. In December 1985, at a retreat in Pebble Beach California, Steve Jobs, whilst addressing his fledgling new company at the time, said this " … one of the things that made Apple great was that in the early days, it was built from the heart. Not by somebody who came in and said, 'I know how to build a company. Here's w hat you do. … ' It wasn't built that way. It was built from the heart … we're doing this because we have a passion about it." (Jobs, 1985)

This, it is safe to say, is a sentiment shared by artists, both traditional and digital, the world over. To create memorable, culturally impactful experience that not only generate revenue but affects people's lives, we need to first create passion.

2.1.8

Of utmost importance to any artist during their creative process is the maintenance and integrity of uninterrupted thought. It is vital to maintain a connection with your creative visions when inspiration strikes, and chase down those ideas before they escape into the ether. This is greatly evidenced by the writing process, and ironically, an example that serves as an outstanding metaphor for other creative disciplines. After all, writing is a personal process that everyone has undergone at some point in their life, and consequently, the difficulties that plague the writing process is a trial that everyone can understand. As this is generally considered the first stage of creative development, it generally sets the tone for all creative discussions that follow and as it is a process that a vast majority of the general public will understand, regardless of industry, it is an excellent frame of reference from which to understand how technology affects workflow when, indeed, it should be the other way around.

Take, for instance, two very innocuous objects: 1) the pen, and 2) the scrap of paper. Incredibly powerful in capturing ideas, from story notes to thumbnail sketches to entire strategies, whether business or political. The urban legend of ideas being born on a napkin during dinner are based largely in fact due to the very simple power of these two objects. It is, however, not the objects themselves that are key here. It is their immediate availability for capturing an idea while it is "still fresh" that is important in this context. in fact, two significant questions need to be addressed during any initial ideation phase:

1) Where can I capture my idea, and

2) Where do I keep that idea for later.

The simplicity and immediacy of the scrap piece of paper is why the cue card/bulletin board methodology of a writer's process is crucial here and why this has become a proven way of approaching story construction. A writer need not strictly adhere to these iconic tools. Methodology variations could include multiple small piles of printed text, annotated with post-it notes and spread across a tabletop and/or bed. The key concepts here are the capturing of emotionally charged, bite-sized chunks arranged in a broad overview to gauge how the pieces dynamically fit within a "bigger picture". The answer to the second question during an ideation phase of "where do I keep that idea for later?", the bulletin board/ tabletop/bed represents an overall structure that, while malleable at the outset, will prove essential when the ideation process involves a team. There is a commitment and sense of permanence when capturing ideas in this manner which a whiteboard, the most common industrial tool for creative ideation, cannot seem to replicate. This is a problem that companies have tried to address by adopting electronic whiteboards that capture any ideas created upon its surface digitally for referencing later, but the core of the whiteboard problem is a question of approach, and not necessarily the tool itself. Although many articles offer insight into the advantages and disadvantages of whiteboards themselves (Ramani 2017), it's the cultural impetus that the symbol of a whiteboard evokes, namely a collective environment where spontaneity is eschewed for creativity on demand. Many discussions abound online on the harm of the act of brainstorming to the creative process (McGuinness, 2009) and whether or not true creativity can be encapsulated in a brainstorming session, the central problem still exists in production work, where a deeply personal process that evokes and mirrors the subtlest of human behaviours, and is most effective when executed by one or two individuals engaged in deep introspection, is now forced out into the open, under a bright light, and involving hundreds of creative people. It is difficult to bare one's soul whilst lying in an operating theatre undergoing cardiac/thoracic surgery. Companies who operate in this fashion will often times be victim to "story-by-committee" or game design by

"Chinese whispers". Yet in a film or game production, collaborative creativity between large groups of people is the central modus operandi of daily studio life. Herein lies the answer to how technology can take a deeply introverted creative process and give it the extroverted bully bull-pit it needs to communicate in a team environment. We will examine a few of the ways in which technology serves as a stable support for creative, "napkin" discussions.

During practical, in studio brainstorming sessions, very rarely (other than by an appointed minute taker) are laptops and other digital devices engaged. This is due in large part to the sometimes cumbersome nature of technology in these highly creative sessions. Contextually speaking, when ideas are raging around a room, thick and fast, there is very little time to wait for an operating system to index drives and prepare your desktop. Boot sequences in several operating systems can sometimes take up to five minutes, let alone the time it takes to locate files in a folder and/or wait for an application to load. In that span of time, a creative discussion can easily have moved on, or the brief flash of an idea may escape memory. Steve Jobs, ever the champion of a continuous stream of uninterrupted thought, understood this as a significant obstacle to digital creativity, and designed a generation of devices that you could simply "wake up" and continue where you left off. He had existential reasons for why he didn't want Apple devices to have an "off" switch, as noted by his biographer (Isaacson, 2013) but perhaps, on a product usability level, Jobs understood that technology had to be an enabler. Perhaps he understood that creative people are never "off" and always need an outlet for their ideas, one that has the immediacy of the pencil and scrap piece of paper that they can store anywhere and retrieve on anything at any time.

To answer the question of how this fits into a larger scale framework, with multiple people, Adobe, ever the champion of the publishing industry, took a long hard look at how their digital suite of tools were helping to bring creative teams together. In a publication scenario, multiple designers, copywriters, editors and layout artists would often times be engaged with a single publication and communication was essential as in most instances, multiple people could be working on a single page in parallel. To alleviate cross-communications and issues with linear dependencies (ie. layout department waiting for completed copy before allocating space), the developers took the concept of "file referencing" or "live linking" assets and coupled that with the pre-existing document "track changes" work methodology to try and reduce the amount of time writers and designers spent in the operating system (hunting for files and latest versions) and increase their time inside an application engaged in the creative process. What they developed was the "Incopy Collaborative Workflow" (Concepcion 2017). What is unique about this workflow is the idea of a live master document that dynamically updates in realtime as people work. This allows high visibility on the final, overall end product while maintaining the close, personal environment of an individual writer's workstation. So successful is this integration that the structure has, itself, been adopted for the authoring of this thesis document.

Documentation is at the heart of every film and games production (in terms of communications, reporting and creative development). Whether it's the authoring of a "design bible" or an "investor's' annual report", the need for a large project document library is ever increasing. This demand often times leads to an enormous amount of repetition of work. Often times, a graphical rendering will be needed for producer updates, artist "welcome packs", marketing reports, advertisements, and ancillary products (such as "making of" art books) simultaneously. A connected document library that accesses artist network resources can keep in step, in realtime, with production art teams. Once a layout "philosophy" is established at the outset of a project, writers and artists can work autonomously, knowing that their work will always be current and accurately represented in all project documentation going forward, without the necessity for creative teams to take time out from their busy production schedules to assemble said documentation. With a master document dynamically replicating to a cloud drive, that "live" project documentation will always be available in its most current state to everyone on the team, anywhere there is a internet connection.

With that framework in place, the nonlinear, chaotic process of ideation no longer needs to be isolated to its allotted section of the pipeline and project schedule. Take for instance a key writer and story artist working in tandem on a sequence of events. Using the philosophy of cuecarding, a writer can map out a story based on snippets of ideas, or social vignettes. This is very similar to a story artist's initial phase of thumbnailing out visual ideas. Couple the two creative minds working together (not necessarily in the same location), with complete visibility of what each of them are doing, and writers can then solve very difficult scene dynamics visually, whilst the story artist can understand the dramatic pacing and flow required by the emotional beats with far more clarity.

If this process is tied to a story development document controlled by InDesign, than the writer can operate as layout designer, shifting story elements around in the timeline to suit their needs, with the art automatically updating to reflect timeline changes and immediately communicating those changes to the story artist.

Although final scripts are generally authored in Final Draft (or similar .fdx format authoring packages, such as WriterDuet) with final boards generated in ToonBoom Storyboard Pro (which are themselves connected), initial creative exploration can utilize Adobe's connected workflow to better capitalize on creative collaboration.

Adobe has also pioneered a Dynamic Link Library system that connects Photoshop/After Effects/Premiere in the same fashion, which will be further discussed in subsequent chapters.

Two case studies will explore this union of creative disciplines in depth:

Thesis Authoring

GenZeroOne: A Design Bible (Animated TVS Proposal)

By bringing together the disciplines of writing and story art, a more comprehensive visual exploration of human behaviour is possible. Future work will explore how this collaborative pipeline can work with CG modellers to aid with contextualizing 2D work in a 3D volume (which can sometimes introduce its own set of challenges).

A collaborative workflow eliminates creative “blind spots” by introducing perspectives previously unavailable. For a writer, blind spots in their creative process may be, as an example, in acting space, camera and actor choreography, and dramatic staging, which can oftentimes change the way audiences perceive dialogue and human interaction. For a 2D artist, blind spots may be in weight, mass, overall scale and volume considerations that are not readily evident in a 2D design.

Connecting these disciplines, especially during the story development phase, can aid in preventing the repetition of work later on down the pipeline, where sometimes even entire sequences require a reevaluation in face of new visual information gleaned by the next phase in production.

In fact, major Hollywood studios are beginning to lean quite heavily on visualizations tools and methodologies to help with production planning, evidenced by the rise of both Previs and Postvis as necessary and now staple parts of the production process (Romanello, 2015).

Ultimately, the writing process starts as a deeply personal experience. Stephen King, world renowned American author, states that in the beginning of the process, writers need to create for themselves, and to fulfill a deeply personal need (King, 2014). This is a necessity for getting to the heart of the human experience and a modicum of privacy is required at this stage. From a business perspective, however, (and entertainment after all is about the bottom line), a producer and an investor require constant updates. A digital structure, located in the cloud and outside a writer's study, can offer a window into the writer's process for the rest of the team (if agreed upon at the outset), whilst leaving the writer to explore their own dramatic boundaries. This relationship of communicating with a creative team becomes more prevalent after the first draft of a story. King also expounds on this in his book "On Writing" by stating that the second draft is often written with "the door open" (Macpherson et al. 2013).

On a collaborative creative project, the luxury of choosing to be an introvert or an extrovert is not readily available, as it is often required to be both simultaneously. How we set up our digital space helps us accommodate this necessary dichotomy.

The actor's process, which is also centred around the study of human behaviour and, in a similar context to writing, is a deeply personal experience. To arrive at the core of a profoundly life-changing experience, we need to understand how performance is the delivery mechanism for creative ideas and how actors are the shepherds for any narrative and/or interactive experience.

2.1.9

The creative process, not just with actors but as a whole, must be dissected, not only to determine the causes and effects of this deeply mysterious ritual, but also to cleanly separate it from the audience's perception of what it entails. Once we can achieve an understanding of those processes that are essential to distilling down to the core of a deeply moving and emotional artefact, we will be one step closer to creating nuanced, memorable, and life-changing experiences.

The craftsmanship of acting is rooted in the study of human behaviour, and although there is the public perception that actors (especially Academy Award winners) are the greatest liars, this notion could not be further from the truth. In fact, the concept of "the truth" is the metaphorical workshop inside which actors hone their craft (Ploski 2017). The process that an actor engages is an emotionally difficult one, but necessary to identify the myriad feelings that can sometimes traverse the soul during an emotional moment that they are trying to capture. The end goal of that process, for an actor, is to be "in the moment" speaking the greatest truths directly from the heart.

Due to its long history and tradition, theatre actors are well-versed in finding this within themselves during rehearsals. Film actors, although engaging in a slightly different craft, are also intimately familiar with this process. However, until recently, this process bore little significance in the production of triple A game titles. VFX tentpole films that allotted large commitments of time to performances in a motioncapture studio and/or in front of a greenscreen also, initially, failed to adequately understand the needs of an actor for crafting riveting, emotionally engaging scenes. As with many of the traditional entertainment crafts that have existed for decades, when the digital era blossomed, technology shot to the forefront and an almost messianic belief came with it. It was the belief that the new tools would supplant any need for manual and/or practical techniques from the past. Old methodologies for creativity were considered archaic. Software engineers were the new film editors, and what they ultimately crafted in the end was what mattered in terms of entertainment value.

Actors performing in front of a greenscreen were often simply expected to craft high quality characters with very little visual guidance and often without props, set dressings, or even fellow actors to help with their visualisation process. Sir Ian McKellen once stated, during the filming of The Hobbit: An Unexpected Journey, that filming on a greenscreen set was "... so distressing and off-putting and difficult that I thought 'I don't want to make this film if this is what I'm going to have to do' … It's not what I do for a living. I act with other people, I don't act on my own." (Pulver 2013). Similar scenarios often afflicted actors commissioned to do voice-over work for videogame characters, where scripts are generally authored based on player choices and random snippets of emergent gameplay. Where actors normally find the rhythm and cadence of a line of dialogue within the dramatic context of a scene (with the overall throughline of the entire film driving their characters forward), early gameplay scripts were structured with lines of dialogue that were out of context and non-linear, making it incredibly difficult for actors to find the height of an emotionally charged delivery during their recording sessions (Stuart 2010). The process of motioncapture, prevalent when an actor is called upon to drive a fictional CG counterpart on screen, also suffers from the problem of isolating an actor in a motioncapture lab, wearing a data acquisition suit that could not be further from the character's skin that an actor is expected to inhabit. Productions are currently making strides to allow an actor's process to be part of the development of purely CG sequences, as evidenced by the pioneering effort of the VFX team on Pirates of the Caribbean with Bill Nighy's characterisation of Davy Jones (Daly 2006). Performances self-contained in a motioncapture studio, with an actor isolated from the rest of production, often led to poor "wooden" performances because, as noted in the Entertainment Weekly report " … the actors typically had nothing physical to work off of, since every part of the scenery and the CG-creature supporting cast was put in later."

As technology changes the needs of a dramatic performance that we place upon actors and that need is shaped more by engineering considerations opposed to dramatic ones, CG productions are looking to actors to become ever better liars, when in essence, digital creativity should exist to help facilitate an actor's quest to discover higher truths. To be so invested in the creation process, to the extent where the body is acting before conscious thought can take control, is a state that every artist, no matter what discipline, desires to achieve.

Herein lies Peter Marshall's third most important consideration to crafting an exceptional feature film: Performance. By analysing the process undertaken by actors, once human behaviour has been dissected and cross-referenced against the story, we can begin to understand the essential ingredients that may perhaps be missing from the CG development pipeline.

There is a clear delineation between theatre performance and film for many actors. Although techniques can sometimes cross over. Michael Caine, Academy Award winning actor, once compared theatre acting to an operation with a scalpel, and contrasted that with movie acting which he subsequently compared to an operation with a laser (Caine, 2012). So precisely captured by the film lens are the subtle little movements of an actor's performance, that audience perception of film acting is a much more deeply personal experience. For an actor to craft that "minutiae" of facial expression requires a rigorous amount of emotional control. This is why an actor's preproduction process, so often times ignored by CG heavy projects, is absolutely essential for increasing a film or games emotional resonance.

Ivana Chubbuck, a celebrated Hollywood acting coach, identifies twelve tools that are universally accepted as industry standard for film actors when they engage with a script breakdown and begin constructing a memorable character (Chubbuck 2004). The tools consist of the following:

Overall Objective

What character wants from life more than anything

Scene Objective

What character wants over the course of an entire scene

(closely related to Overall Objective)

Obstacles

Barriers to Overall and Scene Objectives

Physical

Emotional

Mental

Substitution

Using someone from your own life to recreate the emotional framework

for your fictional life

Inner Objects

Visualizations -

Pictures that form when speaking/hearing about:

Person

Place

Thing

Event

Beats/Actions

Beat = change of thought

Action = mini-objectives for every beat

(Scene/Overall Objectives must be satisfied)

Moment Before

A place to move from, physically and emotionally, before a director calls "Action!"

Place/Fourth Wall

Endow a character's physical reality with attributes from a real life place

Create:

Privacy

Intimacy

History

Meaning

Safety

Reality

Doings

Handling Props

Producing physical behaviours

Inner Monologue

Thinking of incredibly clever things to say, and choosing not to say them

Previous Circumstances

Backstory

Comparing their backstory to that of your own

Let It Go

Don't intellectualize

Absorb the 11 techniques, then allow instinct to interpret them on a subconscious level

Of particular note is the amount of introspection required while preparing for a particular role. A large part of the steps that actors engage in involves tapping into personal memories and experiences and part of the Director's role is to psychologically explore those personal, intimate moments. If we take, for example, the step of "Previous Circumstances" which is more commonly known as "back story", this all important analytical phase for an actor is often regarded as an academic exercise in most game production pipelines, and only serves to help define visual style for things like set dressing and character wardrobe. Very rarely is backstory considered an essential tool for characterization and often it is disregarded in favour of "visual moments". Having spent a number of years working as a senior concept artist at Electronic Arts, this was a practice I had witnessed at the forefront of game development, and at that time, none of us on the core team were familiar with the intimacies of an actor's process, to what I believe sincerely was our creative detriment. This cavalier attitude towards what is an essential element of story development and characterization has followed computer graphics into the movie industry, and as vfx and digital artistry has grown in feature films, the growth of the actor's process has been inversely proportional. Mark Hamill, known for his role as Luke Skywalker in the Star Wars franchise, stated at a Star Wars Celebration event in Orlando, Florida that " … actors like to write their own backstories, you know. You want to figure out what you've done and where you've been … but I realised that wasn't really important to the story of [Star Wars] Force Awakens. I still made it up myself. And … I tried to show it to J.J. [Abrams] and he, you know, was accommodating, but basically, patted me on the head, gave me a cookie and made me go away." He continued to reiterate that, as an actor, " … I have to relate to things that are real in my own life to understand where Luke is at this point in his life." (Hamill, 2017). Mark Hamill's comments are a good indication of the receding value of emotional depth in a performance in the face of tighter deadlines and higher budget CG spectacles.

In terms of Inner Objects and Substitution, an incredibly important tool that allows a performer to emotional equate a character's experience with one similar to their own, and thus create emotions that are not just believable, but are also (to a certain extent) actual, a large part of workshopping a script until that point is arrived at is not necessarily being circumvented, only interpreted, perhaps, in inaccurate ways.

Take, for example, an animator's process. Animators are often referred to as "actors with pencils", or in a modern day context, "actors with mice". In that regard, animators often rely heavily on motion and performance reference materials and although a number of approaches have been developed over the years to hone the craft of animation acting, it has not grown significantly beyond the traditional use of a mirror at an animator's desk as an aid to study and capture the animator's own expressions and movements. The significant problem with this approach is that simple mimicry (of movement and of expression) has taken the place of emotional exploration. Actors use Inner Objects and Substitution in the hopes of creating new emotional experiences that happen "in the moment" and are surprising revelations of human behaviour.

If it is universally accepted that all compelling storytelling begins with the study of human behaviour, then we would not necessarily need to invest so heavily in the preparation and study of backstory and inner objects; however, I would argue that it is the unexpected human behaviours, the ones that give us a surprising new insight into ourselves and our world around us, that leave a lasting impression.

This process of edifying the deep emotional experiences that ultimately manifest themselves as a character's behaviour plays itself out in the beats of a script. Beats are also a familiar tool for both game developers and CG animators and are used to identify a thought change, or a dramatic twist to an alternate direction; however, actors tie this to "actions", which in this case refers to "mini objectives" that are related to the "Overall Objective" of a character. They are the moment to moment reactions a character has, both physical and vocal, to the presentation of new information in a scene that requires a significant shift in thought. The gameplay mechanic of "emergent challenges" runs along the same lines of beats and mini-objectives, only with the audience tasked with shifting their thought patterns and not the performers. If executed well, in both videogames and film, this creates the spokes of of interest in the ever rotating wheel of an entertainment property's overall experience, catching audience member moment-to-moment and unfolding an overall scene and/or level.

The key to creating high drama exists in the volatility of "what will happen next". This is inherent in the challenges of a fast moving game level, but it also exists in the dynamic of story emotion and dramatic choice. The fact that actors try to live "in the moment" so that their weeks/months/years of preparation will manifest themselves in unexpected physicality that is genuine when cameras begin to roll, so do gamers want to find themselves unexpectedly responding to challenges, emotionally and physically, in ways they never thought possible.

In the early years of game developers seeking to create the “playable movie”, or the videogame that successfully recreated the “cinematic moment”, there was the idea that mimicking what feature films accomplished visually , in terms of lighting/set design/cinematography, would suffice. There was, and still exists today, the notion that gamers want to act the part of the hero in movie-like gaming experiences; however, it is the unexpected human behaviour that gamers crave, just as fanatically as their cinema-going counterparts. Gamers don’t want to act the hero, but instead, want to be surprised and delighted to discover that, when called upon, they can be heroic by doing the impossible subconsciously.

Gamers play each passing moment of an interactive experience. Actors try to live them while they happen in front of the camera. Each experience is not a series of actions being performed linearly, but reactions that emerge from a primal emotional response to each changing beat of new information being delivered by the medium. This is what creates genuine drama. To help achieve a high level of drama in performance, actors need to first build the emotional firmament that will help them get there. By perparing the emotional environment for storytelling drama beforehand, unexpected and astounding performances can occur spontaneously. It is the process of building that emotional environment that seems to be slowly vanishing in an ever-increasing, results-based approach to creating digital art, where emotional intensity is being substituted with procedural digital operations and artistic mimcry has taken the place of the quest for creating unique experiences and profound revelations.

The equation is simple: the stronger and the more genuine the feelings in the actor, the stronger the feelings in our audience.

2.2.0

The key creative force present and driving both the story development process and the performance exploration period is the immediacy of what is produced and the emotional response associated with it. The performing arts enjoy the unique position of being an artistic discipline where the creation process and the actual end result can occur simultaneously, whether on stage or in the studio. The craft of writing, whilst introducing a more traditional iterative development pipeline, can also enjoy sporadic moments where the creation process yields the final result. These are the inspired moments where, instinctively, creators may experience the emotional thrall of what they've created. It is sometimes colloquially referred to as "goosebump" moments, and oftentimes translates into an entertainment property's most powerful emotional beats. The process of arriving at these moments involves an enormous amount of foundational work in constructing fictional buttresses that may never actually appear in either the narrative or the performance, but are nonetheless crucial for emotional grounding.

With Peter Marshall's first three tenets explored, namely that of human behaviour, story and performance, and the emotional thrust of a narrative clearly identified, it now falls upon the Production Design team to begin fashioning a visual interpretation of the fictional world the first three stages have constructed. The visual interpretation must be as resoundingly powerful as the emotional core that it is meant to represent. It is also the first of the creative disciplines in our pipeline that will not enjoy as much creative autonomy as the processes preceding it. While being developed to create powerfully emotive visuals, it must also remain faithfully responsible to the story's intent and the characters that the cast have created. With a great, core creative production team, there can be quite a bit of development crossover, and ideally this would be encouraged. Failing that, production design must successfully build on the emotional core created in the first few stages and amplify what is there.

One of the first stages of production design is the generation of concept art which can be used in one of two different ways. Concept art and the production of “Look Books” can be used to pitch and sell a particular intellectual property to either a production company or a board of independent investors who have a key interest in understanding a proposed design for a film script and/or game design. Concept art can also be used as an initial “proof of concept” for a production under way.

In general, three primary areas of development are the following:

- Characters
    - Costume/Wardrobe
    - Hair
- Environments
    - Set Design
    - Locations
- Props
    - Weapons
    - Vehicles
    - Etc.

There is a fourth category that deals with cinematic style, but depending on the production, this generally rests in the hands of the Director of Photography and Digital Intermediate Colorist wherein they explore not only the emotional impact of lenses and lighting, but also discuss the contributions of film grain and film postprocessing effects (amongst other factors which we will explore in depth further on).

During the concepting phase, there is often the same level of research and background work that characterized both the writing process and the actor's process and this is often necessary to create a grounded, believable reality for an entertainment property, but there is also a fair amount of design problem solving, as the core creative crew begins to encounter visual and spatial problems that may not have been considered during story development. Classically, concept art has spearheaded the preproduction phase of project development and has uniquely been a non-linear, explorative process as well. With productions moving more and more towards previsualisation being the primary goal of preproduction, and computer graphics pipelines insinuating themselves into a traditional artist's explorative period, there is an increased risk of creative teams locking down a look "too early", with very little room to adapt to creative changes. Preproduction exists solely to encapsulate visual experimentation in an effort to remove it from the production period, where creative changes are astronomically expensive and can introduce tremendous delays. The general rule of thumb is that films are made in preproduction, executed in production, and polished in postproduction; however, as any seasoned production veteran can attest to, this is rarely ever the case. One aspect of the concepting phase that can slot in either at the beginning of the design phase or closer to the end is the process of storyboarding, where the compositional framing of the film is chief amongst the visual problems being solved. The storyboarding process aligns itself very closely to the emotional targets set by the writers and concept artists work very closely with the core creative team to ensure that key story elements are resoundingly amplified.

The stages of development for the majority of concept artists and production artists worldwide have remained relatively consistent over the past decade. The process is similar during both the linework phase and the digital painting phase:

1. Thumbnails and/or Silhouette
2. Roughs and/or Tonal
3. Detailed Rough and/or Base Color
4. Clean and/or Finishing

The one part of the process that relies on the same emotional core that affects both the discipline of writing and the craft of actingis the thumbnailing process. During this phase, an artist works quickly and instinctively, creating designs that are small and fluid (hence, the name "thumbnail" which is in reference to the initial size of the design). One of the key visual design goals is the creation of an "interesting silhouette value" which will later inform the rest of the design. It is vital to note that the principle behind this approach ties back to our primitive response mechanism to visual information.

If we examine the construction of the human eye (in brief) and attempt to dissect the sensory process whereby visual information is conveyed to the brain, we can understand why concepts such as silhouette, negative space, and contrast are vital design choices to make at the early stages of visual concepting.

Visual acuity, much like a number of physiological processes in the human body, derive their primary functionality from the primitive instinct for survival. Information, during a high-stress situation, must be rapidly processed to aid the "fight-or-flight" mechanisms to activate appropriately. Within the human eye, rods are the photoreceptor cells responsible for scotopic vision, which aids in low-light conditions, and these cells are strategically placed along the side walls of the eye. This creates a situation where human peripheral vision is much sharper in darkness than direct sight. It is also designed such that luminance sensitivity, or changes in light and intensity, is far stronger than sensitivity to color changes. From a biological point of view, this makes perfect sense, and is the primary reason why we react to shadows before we see the objects casting them. In fact, our primitive response to luminance data is so powerful that digital camera chroma subsampling algorithms provide the greatest amount of image resolution to the luma channel, with the chroma channels (or color) being subjected to various compression algorithms (of which we shall explore in depth further in this chapter). Our emotional response to black and white is deeply rooted to a primitive, instinctual response, and therefore an effective silhouette or value design will evoke a very human response.

This initial design phase is not simply isolated to organic designs per se. It is a technique employed in the entertainment industry, from vehicle and prop designers such as Scott Robertson (Roberson, 2017) and Harald Belker (Belker, 2017), to environment specialists such as Feng Zhu (Zhu, 2017) and James Paick (Paick, 2017), to character artists such as Richard Lyons (Lyons, 2017) and Lois Van Baarle (Van Baarle, 2017). The application of the thumbnailing process is universal across entertainment properties, including games, animation, and feature films.esign

The key problem encountered during the ideation phase is it's non-linear structure, as often times a particular wardrobe choice may be inspired by subsequent set designs or in other cases, a vehicle design may alter an environment design's layout. In certain cases, a core creative team may like elements from disparate designs and request an amalgamation across visual ideas. This makes locking down designs and structuring an approval process particularly challenging.

What is interesting to note is that this particular creative paradigm is reflected in several stages further along the pipeline. Character modellers have a similar process of "concepting mesh" with emphasis on "asset silhouette". Animators, likewise, place an inordinate amount of importance on key poses and their silhouettes during the initial animation block out pass.

As this process seems to form the bedrock of a number of digital artistic workflow across disciplines, it is imperative to investigate its inherent worth to the objectives of this study.

As preproduction moves out of the design phase, the general deliverables expectation is a "Look Book" followed closely by a Show Bible. This will, ideally, contain the blueprint for the entertainment property moving forward. Considering that the subsequent disciplines to follow are categorically in "full production" and the technical complexity jumps in ever increasing orders of magnitude, it is incumbent on preproduction to ensure as many questions are answered and as many visual problems mitigated as possible.

2.2.1

Having examined the three most volatile creative processes, both in terms of organisational tracking and development, and passionate, inspired ideation, the subsequent stages of production are, by necessity, far more rigorously regimented. Not only do technological interdependencies begin to starkly upscale, the window for creative interpretation begins to narrow as the singular vision of the entertainment property begins to come into focus.

At this stage, a production pipeline template, already constructed and in place, begins to ramp up in importance, as a core team begins to ramp up with larger teams of digital creatives. At this point, a hardware backbone becomes more of an essential piece of the anatomy of a production. Up until this point, writers, performers, and designers could operate with a certain level of both creative and technical autonomy (which is not ideal, but manageable). Once a modelling department and animation department start to ramp up its key people, an operational structure most definitely needs to be in place (even if the initial stages have recruited freelancers and outsourced boutiques). Key areas that need to be in place from a facilities-side examination are: the network, the servers, artist workstations, and the renderfarm. Not only does this framework need to be in place, but it also needs to be flexible enough to allow for growth. A simple framework will be modelled during the practical portion of this research.

What logically develops at this stage is the long and laborious task of asset creation which generally begins with the art of CG modelling. As modelling teams generally look to concept art and production designs for visual guidance in terms of the assets they need to create, the relationship between modellers and designers, in terms of communication and asset sharing, is a close knit one.

Although a number of CG packages exist, offering a number of approaches to asset creation (many of which are investigated here), the heart of all digital modelling springs from a handful of applications that have dominated the market for decades. Chief among these are Maya, 3D Studio Max, XSI, and the increasingly popular Modo. The first three applications were eventually acquired by a company called Autodesk and have been part of their stable of digital creation tools since.

Born from the heart of mathematical models, two dominant approaches to surface creation, polygonal modelling and nurbs (non-uniform rational b-spline) modelling, proliferated, joined shortly by a third technique, subdivision surface modelling. All three techniques exist today and are widely regarded as the bread-and-butter of asset creation. The newest modelling paradigm, voxel modelling, is rapidly coming into its own and will be examined as this research gradually approaches an ideal modelling workflow.

Closely coupled with cg modelling techniques are surface shading models (which, from a production standpoint, exists as a separate discipline, both departmentally and schedule-wise). These shading models are not only calculated in parallel, for realtime visual feedback on computer monitors, but also during offline rendering processes that exist towards the end of an asset's development life cycle.

Lighting, surface properties, and texture maps share a number of computational dependencies at render time that sometimes make it difficult to cleanly isolate these workflows. As almost all CG visualisations tend to be reducible to light calculations based on surface normals, with screenspace scanline renderers producing pixel color values at rendertime, an inordinate amount of resources generally tend to funnel towards both the lighting and shading pipelines, which will also be closely scrutinized later in this chapter.

In terms of the construction of visual assets, this is the first identifiable split with traditional art approaches. Before a CG modeller can engage with any of the available digital tools on the market, the first key concept they need to become familiar with is the notion of working with packets of data called "nodes". A clear understanding of how data passes, via attributes from node to node is so fundamental to how the major CG asset authoring tools operate, that key texts often open with a comprehensive description of this architecture before even engaging in discussions about the actual digital art creation process (Palamar 2015). This is understandable, as software generally doesn't not have the robust flexibility to deal with the chaotic, emotional, non-linear experimental process that typifies a heightened creative state. To understand the underlying behaviour of the application used for asset authoring is essential for diagnosing problems that may arise later on in production. In popular discussions, this familiarity has been likened to the necessity for an artist to "know their brushes", but it is an erroneous metaphor as, generally, familiarity with a package such as Autodesk Maya may take weeks, months, and even years, whereas an understanding and utilization of a paintbrush happens in moments.

Couple that with the guidelines to avoid technical errors that often accompany the creation of digital assets that is both platform and application agnostic, but also governed by the computational model of computer graphics geometry. In Andrew Paquette's Siggraph Asia 2012 presentation (Paquette 2012), the rules governing proper 3D modelling and construction are rigidly outlined and have not deviated in the ensuing years, being relevant to construction pipelines and workflows today. In his abstract, he clearly states that "artists who are technically proficient are prized above those who are not." This is a sentiment that continues to this day.

A number of modelling paradigms have surfaced in recent years to address issues of balancing artistic expression with technical implementation and the greatest paradigm shift for digital modelling is the emergence of digital sculpting, pioneered primarily by two flagship applications: Autodesk's Mudbox and Pixologic's ZBrush. Although computationally quite expensive, this new shift in how digital asset authoring is approached has, unsurprisingly, dominated the CG arts community worldwide and elevated the visual quality of computer graphics by once again allowing the computer to support and enable traditional sculpting approaches. This unique shift in how modelled assets are produced was made partially possible by new developments in graphics adapter technology. With a generally shift from vertex shader pipeline calculations to pixel shader pipeline ones, the sheer amount of vertex detail that can be displayed on monitors was increased by several orders of magnitude, allowing for a hitherto unforeseen level of high detail in CG models. In parallel, a number of hardware technology companies were beginning to expand their research and development into interactive input devices to allow for a more comfortable interface with digital art creation, taking data entry beyond the traditional mouse and keyboard and exploring more organic approaches to working with software. Tablets, haptic devices, and touchscreens soon proliferated the market as tech companies began to explore a new standard, with Wacom rising quickly to the fore for art communities with their pen and tablet devices being quickly adopted. Both the digital sculpture revolution, coupled with a new hardware standard for digital artists, will be explored in depth in the methodology section of this analysis.

Beyond being able to "sculpturally" interact with a digital model, the advent of these new software tools led to the advocacy of a different philosophy towards static geometry asset creation whose chief antagonist, surprisingly, was entrenched tradition. In 2004, during the development of new IP projects for Electronic Arts Black Box, this researcher was involved in the company's internal character creation research and development group where new "sculptural" workflows were explored and discussed at length. At the time, the standard modelling creation workflow consisted of the following:

1. Geometric Construction of Assets
    - Polygonal modelling techniques (primarily)
    - NURBS (or higher order surface creation) techniques
2. UV Unwrapping (a method of preparing geometry to accept texture data)
3. Texturing
    - Color Map
    - Bump Map
    - Specular Map
4. High Resolution Geometry Construction
    - Subdivision Surface Modelling
    - High-Frequency Detail Transfer
    - Normal Maps/Displacement Maps
5. Optimization
    - Often times involving revisiting any of the above steps
6. Collision & Supporting Geometry

Of the steps outlined above, perhaps the most time-consuming and interdependent stage of this particular workflow is the one involving the task of UV unwrapping, in which an artist manually unfolds and flattens out a model to accept linear projections for texturing information. This would often times involve physically moving individual UV points. When a geometric asset contains a UV count numbering in the thousands, this could potentially lead to days of repetitive, monotonous work. Coupled with the fact that any geometric changes during an assets optimization phase would necessitate repeating the UV Unwrapping stage (and all subsequent stages) until an asset reached its final, optimal state. As this process typically occurred during the art creation process, it not only represented a large time dependency, but also necessitated that an artist interrupt the creative process to engage in a more technical one before attempting to reinsert back into the initial creative flow. Although this workflow was not ideal, it was nonetheless a process that art teams globally spent years becoming comfortably familiar with.

What was being proposed by myself and my colleagues has been alternately referred to as either the "retopology workflow" or the "resurfacing workflow", whose driving ethos was "let the artist be an artist". Its guiding principle was to ensure that the artist maintained a high level of creative engagement for the longest period of time, before having to consider technical aspects of asset implementation, either in a game pipeline or the standard offline rendering pipeline typically used in film and television production. The proposed workflow was the following:

Digital Sculpting of High Resolution Assets

Digital Painting of High Resolution Textures

Retopology of High Resolution Assets

The Creation of Low Resolution Asset Variations

Optimization

UV Unwrapping

High-Frequency Detail Transfer

Collision and Supporting Geometry

The first two stages outlined above can be taken to final visual asset sign-off, or finished and polished model, before the subsequent more technical stages need to be engaged.

The largest benefit that was being evaluated was the impact of maintaining the creative, artistic connection with the asset for as long as possible. The guiding ethos was that, given an uninterrupted workflow from conceptualization to final polished model game teams would see a significant rise in visual fidelity for all the art assets being produced. This way, art teams could maximize the creative period of asset creation, and compartmentalize the technical optimization work for further down the pipeline with the possibility of perhaps assigning those tasks to far more technically minded staff members. Of greatest impact was Pixologic's ZBrush and its non-linear dependency to UV unwrapping. By creating a situation where UV unwrapping did not necessarily need to occur before texturing, this process could be shifted further up the schedule and allowed for far more versatility in designing an artist-centric, non-linear pipeline.

Although the proposed new art workflow met with a considerable amount of resistance in the beginning, it has become the defacto standard on all CG asset creation pipelines to date.

Although digital sculpting has helped CG teams understand the importance of traditional art creation processes, the technical aspects of asset creation could not cleanly be decoupled from artist-centric processes. Both an artistic approach and a technical one could not be mutually exclusive, and as digital art creation is fundamentally a new artistic discipline in this century, should not be.

As further research has revealed, digital asset creation needs to utilize the best of both worlds, and capitalize on what computational power can give us. The elimination of the repetition of tasks, the simulation of minutiae in terms of detailing, and the ability to enhance traditional media in new and wonderfully unexpected ways are just a few examples of where an artist needs technology to step in. In a talk delivered at Siggraph 2012, Daniel Seddon, Daniel LeTarte, and James Kirk from Method Studios outlined one such scenario for Wrath of the Titans where the creation of CG lava was a two-stage process that involved both simulation and art-based sculptural enhancements (Seddon et al, 2012). This marriage of fluid simulations and sculptural techniques is still lauded by industry experts to this day, with a paper published in Siggraph 2016 by Tuur Stuyck and Philip Dutre of KU Leuven in their discussion on "Sculpting Fluids" (Stuyck and Dutré 2016). As fluid simulations are notoriously unpredictable and difficult to control, allowing experienced traditional fx animators to control key stages of a fluid simulation (without having to build out the natural noise produced by the minutiae of organic movement) allows for very dramatic, artistic shapes. The resulting movements for the CG effect still retains the "looks and feel" of a naturally occurring fluid, while also taking the form an artist desires. This notion of "art directable" effects has rippled through all of the traditionally physics-based CG asset authoring pipelines, affecting how artists produce cloth, hair, and destruction; however, the marriage between simulation and sculpting remains an unstable and tumultuous one, with heavy dependencies on hardware and, at the time of this writing, perpetually error-prone.

Although the sculptural solution is best suited to artist-centric workflows and seems a foregone conclusion for generating higher levels of quality in visual assets, there is still the question of hardware limitations and the enormous amount of processing power needed to facilitate this approach.

2.2.2

As discussed in the previous chapter, the introduction of the asset modelling process heralds (within the context of a studio pipeline) the onset of a more technical approach to generating art and one that invariable requires a broadening scope of computer science and geometry knowledge. As the reliance on software proficiency begins to expand, so does the inherent dependency on hardware.

As studio's begin to weigh their overhead and operating costs against the visual bar that a project sets and the budget allocation they've been awarded, consideration is heavily skewed in favour of internal workstation and server technology. Whether it's a high-speed Aspera data server or simply increasing the specification of graphics adapters within artist workstations, the budgetary eye is invariably cast towards rendering power. Indeed, CG studios spend an inordinate amount of their internal operating costs on the establishment and maintenance of a render farm. As this is the bread and butter of delivering high standard visuals to clients in a timely fashion, every spare resource is generally dedicated to increasing a render farm's technical capabilities.

One of the more revolutionary hardware developments in the past decade for digital artists, however, has been the introduction of Wacom's line of Cintiq products. At the time the Wacom Cintiq was introduced, tablet devices had already saturated the market becoming the defacto interface device between an artist and their digital artwork. In the late 80s and early 90s, two companies vied for dominance in what was then referred to as the "digitizing tablet" market: Summasketch and Wacom. Wacom quickly became the market leader and their Intuous line of hardware has enjoyed several years as the "standard" art input device;

however, there was a central issue with the Intuous tablet in that an artist would have to co-ordinate drawing on the tablet's opaque surface, generally placed on a horizontal desk-top, whilst simultaneously observing and controlling the results on a vertical display. Artists could not directly interact with their artwork on screen and had to control, by proxy, a dis-embodied cursor disconnected from their drawing implement. This resulted in the necessity for artists to "retrain" their hand/eye co-ordination to compensate for the hardware. It was not an ideal situation for digital art creation, but the pen and tablet allowed for a more tactile interaction, using familiar implements, than could be afforded by a simple mouse. This adjustment, one every artist had to endure, was the accepted price of entry to be able to draw with a pen that could capture thousands of levels of pressure sensitivity. In addition, the standard Wacom tablet wasn't cost prohibitive, and production studios found that they could arm teams of artists for a relatively low cost-per-unit with an astronomical rise in visual fidelity. As with any new artistic implement, over the course of time it was mastered and digital artists weaned on Wacom were producing phenomenal artwork. Hanging over the Intuous, however, was the inescapable disconnect between the artist and direct interaction with their art.

Wacom understood this and developed a computer monitor that you could draw directly upon, with the same levels of control and sensitivity as their Intuous tablets. The Wacom Cintiq quickly became the most sought after digital art creation instrument. There was a barrier to entry, however, as the Wacom Cintiq retail price was in the thousands, making it resoundingly cost prohibitive. As a result of this, although many artists would lobby for the necessity of having that direct interaction with their artwork, most studios productions considered the Cintiq either a "luxury" wish list item and not necessary for producing high quality digital art, or only invested in units reserved for team art directors and production designers.

The workhorse artist was left to contend with their drawing hand located several feet from their actual drawing, and wrestling with the co-ordination. In this regard, mastery of the tool masked the fact that mastery of the art form had not been fully realized. Coupled with this was the curious fact that younger generation digital artists, who were trained almost exclusively on Intuous-style tablets, found actually drawing on a screen quite a difficult transition to make. The phenomenon of younger generations of digital artists actually preferring a disconnect with what they are creating is a worthy investigation outside the scope of this research and will not be addressed beyond a cursory note here. The principle takeaway is that companies like Wacom began to understand that there was a need for recreating the tactile feeling of traditional art processes, and that the hardware itself may play a large part in elevating an art form. The rising popularity of digital art interfaces, like the Cintiq, began to inspire research in haptic input devices, force feedback peripherals, and a number of other extraordinary ventures exploring the possibilities of interacting with digital data in another form. This idea of tactile, sensory input computer hardware was not confined to the discipline of digital art by any means, and the past decade has seen touchscreens become a wonderfully new way of interacting with digital devices, from tablets to smartphones, which the general public has responded to with great passion. The importance of varying sensory input, and the incredible emotional boon it gives to the creative process, is only now becoming a serious consideration of developing an art creation pipeline. Cintiqs are now commonplace in game studios and film production houses and research and development departments are now beginning to embrace virtual reality technology as a means for fast visual prototyping and redefining the art creation process itself.

Early experiments conducted by this researcher have yielded some fantastic dividends which will be expanded on in depth further on, as this analysis seeks to explore future interactions with the entire digital art creation process itself.

2.2.3

With the representation of 3D geometry in a computational environment introducing a complex series of mathematical operations that occur behind the scenes, effective design of both an application interface and a hardware data input solution go a long way in creating an end-user experience that encapsulates an artistic process while being devoid of higher-level mathematical thinking. From a purely static geometry asset point of view, digital artists are only loosely introduced to the concepts of global space and local space in a cartesian coordinate system. Many of the underlying operations are masked by these layers of hardware and software abstraction.

Of crucial import to graphics programmers is the utilization of space, and understanding how to link what is essentially the illusion of 3 dimensions across a proscenium plane (Alamia, 2017). In fact, 3D space in the field of computer graphics can be broken down by the following:

1. Model Space
    (often referred to as either Object Space and/or Local Space)
2. World Space
3. View Space
    (or Camera Space)
4. Clip Space/Projection Space

Each successive space allows for the compartmentalization of keys types of data for specific calculations.

Model space deals with data and mathematics the deal specifically with an object's shape dynamics, and is represented in Autodesk's Maya as the calculations that center primarily around the shape node. Although model space has a transformational matrix for positional information, the calculations are relative to the object itself. This allows for complex hierarchical relationships where object calculations can be based off of an external parent object. World Space, however, is a fixed coordinate system with a grid origin point that remains constant within an application's virtual environment. All transformational data is calculated based on this fixed, absolute point. In Autodesk's Maya software, these calculations (in a general sense) drive the transform node's calculations. These two transformation operations form the heart of a Maya geometric primitive, as every object created will invariably be assigned both a transform node and a shape node. Both local and global transform matrices contain data for translations, rotations, and scale in 3 axis, the x, y, and z. To a certain extent (and because it they contribute to visual geometry asset manipulations), digital artists have become quite familiar with these systems. An additional layer of calculations are involved before this set of 3 dimensional mathematics can accurately be represented on a 2D plane. Graphics engines need to then subsequently calculate the View Space, or Camera Space, to understand the relationship between the geometry, its location, and how we are navigating around it in this virtual environment (in addition to acquiring computational data for ray casting and a variety of other dependency calculations further down the rendering pipeline). Finally, these calculations need to be translated into clip space or projection space, which gives us our final 2D image on our screens. 3 Matrices of calculations occur in a fraction of a second. World matrix data is calculated based on model space and world space. View matrix data is calculated based on world space and camera space. Projection matrix data is what finally gets output into screenspace.

Within the graphics adapter itself, an internal 3D graphics programming pipeline is run, processing the data provided from the points outlined above, and involve further calculations, such as tesselation, occlusion queries, stencil tests, scissor tests, alph blending, and a whole host of ancillary calculations needed before a final draw call sends the results to the screen.

Couple the above calculations, being run several hundred times a second, with the variety of primitive and surface types calculated by higher order mathematics (such as polygon primitives, parametric objects, subdivision surfaces, NURBS, and Implicits) and there is a considerable amount of complexity that has been introduced to the digital sculptor's asset creation process, with a lion's share of those calucluations having precious little to do with creating art itself. Computer graphics science has made enormous strides to alleviate this burden with dynamic tesselation recalculations and voxel-based technologies that ultimately leave an artist (armed with a Wacom Cintiq and/or haptic device) manipulating "digital clay" and removing the need for an artist to consider any of the issues discussed above. There is still a prerequisite for digital artists to be somewhat aware of the underlying graphics concepts, but slowly technology is beginning to remove the necessity to directly interact with the data.

This is not an accurate reflection of the current state of computer graphics animation. Once kinetic motion and performance are introduced, the complexity rises by several orders of magnitude, and not without good reason. Calculations that involve a composite transformation need to adhere to an order of operations for a number of key reasons. The accepted convention for these types of transformation calculations is to solve them in this order (from left to right): scale, rotate, and translate (or SRTs for short). Reversing this order will produce visibly different results. The two calculations that cause this variance are the scaling and rotational calculations, as they reference the origin point of a coordinate system, either locally or globally (Microsoft, 2017). Translations, which are generally additive in nature, simply locate a point in space based on the triangulation of the three dominant axes and is generally calculated last. Of the three transforms, however, the most problematic calculations are the rotational ones. This leads to the primary affliction of all computer graphics based animation workflows, a concept known as "gimbal lock" (Nasa, 2017).

Gimbal lock is a calculation limitation for rotational transformations that use Euler angles for solving complex movements. At its core, gimbal lock occurs because of a hierarchical dependency on axis calculations, where at any given point during a complex movement, two of the three rotational axes may align losing one free axis of movement. Although in the context of this paper, we are examining this through the lens of entertainment science, gimbal lock is also an affliction of of a number of related fields in mechanical engineering, most notably in aviation. For CG animators in particular, gimbal lock results in an animated character flipping around erratically as a solving algorithm tries to rotate around an axis that is no longer available and compensates by counter rotating those axes that are.

This is not an easily solvable limitation of rotational transformations (although there is another system of rotational calculations available, which we will cover subsequently). The core of rotational calculations lies in our ancient, antiquated mathematical system, designed around a linear numerical system that, in 1572, needed a new set of rules to deal with calculations across a plane. This became the birth of imaginary, or complex numbers that did not gain popular acceptance until the research work conducted by Leonhard Euler and

Carl Friedrich Gauss made a rigorous examination of these concepts (Rozenfeld, 1988). At the heart of Maya's rotate plane solver is the system or rotations named after Euler. In 1843, this concept was extended to encompass mechanics in three-dimensional space by William Rowan Hamilton, an Irish mathematician, who extended complex numbers using a system he defined called quaternions, which is also implemented in Maya (and most CG packages) as quaternion rotations, an alternate system of rotation evaluations designed to alleviate most gimbal lock situations. It would seem to stand to reason that if quaternion rotations are a system of calculations that generally avoids a gimbal lock situation that this would be a universally adopted methodology. Unfortunately, quaternion values are generally counter-intuitive to the most popular and widespread understanding of rotational mechanics that involve a pivot point and a radial movement calculated between the finite values of 0 and 360 degrees. This is a system that is easily visualized, and has been in practice in both drafting and technical art for centuries. Quaternions, on the other hand, use a complex system of calculations that use the x,y, and z values to calculate a fourth curve, w, which represents the final rotational offset. It is not a popular system for understanding rotation, and is likely unfamiliar to the vast majority of the populace. This makes it awkward to work with, both individually and in a team production environment. Finally, from a graphics programming standpoint, working with rotational calculations in radians is preferred over degrees simply because the results produced are mathematically cleaner; however, as with the concept of quaternions, radians are a system of calculating rotations that is not in widespread use. This makes it difficult to immediately adopt on the artist level and on a studio-wide level. Of course, all of this presupposes individual rotational operations on a per object basis. Once hierarchical dependencies are introduced in the form of limbs, then a robust solution is needed to control how each individual rotation compounds on the last. For this, animation engineers have developed two key solutions. Forward kinematic rotations involve rotating each limb dependency separately. In the case of a character's leg, the upper leg would be rotated first, then the lower leg and ultimately the ankle. This method is generally quite labour intensive, and does not account for an end joint needing a certain degree of stability, as in when a foot is firmly planted, or a hand is locked into position. Inverse kinematics allows for direct manipulation of a hierarchy of limbs (or joint chain) by directly positioning either the ankle or the wrist and having the rotation of the dependent limbs occur procedurally. This technique, while considerably faster than forward kinematic posing, requires the addition of an up vector calculation for knee and elbow positioning and the specification of a preferred angle of rotation.

Once the final vertex transformations of a character are calculated, those values can simply slot back into the realtime 3D graphics pipeline (the identical one used for static geometry assets) and the results can be quickly drawn on screen. The complexity, however, remains two-fold. Rotational calculations must be cleanly evaluated by the software and the end-user (in this case, the animator) needs to have a methodology of practices in place to minimize the complexity being sent to the system. The latter of these two is of primary import to the intent of this research in that when a CG animator seeks to rotate a character's arm, to perhaps reach for a pint of beer, they must first ensure that the rotations are occurring in their appropriate sequence in the SRT order of operations. They must then choose which system of rotations they wish to engage, whether they are Euler rotations or quaternions. As animators generally prefer working with Euler rotations, they must also be wary of the rotate order set on the limbs and be careful that two axes do not align during key posing. Once the process of animation begins in earnest, the animator must invoke either forward kinematics or inverse kinematics in their work (sometimes switching between the two). All throughout the animation process, they must be cognizant of the degrees being set (preferably staying within the 0 to 360 degree range). In addition to this, animators must be wary that the geometry collisions and intersections are not visibly destroying and/or detracting from the performance, all while remaining faithful to the emotional intent and narrative thrust of the scene. This can hardly be characterized as an emotional "fugue" state.

By contrast, a traditional animator focuses solely on the emotional intent of the pose in relation to the performance as they move from key drawing to key drawing. They find the position that best describes that emotional intent and taking into consideration perspective, timing, proportion, and a number of other traditional compositional rules, they simply draw it in.

This loss of emotional creative power in the 3D animation process has not escaped the larger production facilities, such as Disney Research Zurich, who have devoted a number of research papers towards engaging in a more traditional art approach for working in a computer graphics context. In a recent paper presented in the proceedings of the 14th ACM SIGGRAPH/Eurographics Symposium on Computer Animation (Hahn et al., 2015), the researchers state that "In classic 2D animation, artists draw each pose of a character by hand using pencil and paper. This tangible connection is a powerful interface that gives artists direct control over a character's shape. ... a production character rig may employ hundreds or thousands of different rigging controls, varying in complexity from blend shapes to skeletal deformation to complex procedural functions. Naturally, navigating this huge parameter space is a challenging task that can tax even the best animators." These experiments, whilst well-intentioned, have been pursued for over a decade. Research work conducted in 2003 as a joint venture between Stanford University, the University of Washington, Microsoft Research and the Honda Research Institute USA identified that traditional animators, in the initial phases of exploring a performance, can work faster in capturing motion than 3D animators, who are often encumbered by digital tools that "are not well suited for rapidly posing articulated figures." (Davis et al. 2006). They go on to state that, in most cases, a CG animator will begin their process by first hand drawing key poses on paper before engaging with the complex digital processes necessary to execute their vision within the computer. The key observation to make is the unanimous understanding of the value of maintaining that "tangible connection" for creating emotional impact but the failure in the ensuing years to develop an adequate solution for animators.

To date, a number of revolutionary rigging solutions have been introduced and adopted (including the HIK, or Human IK, rig) in various productions from triple A games to feature films, but they still follow the standard model of Euler vs. Quaternion rotations systems in a Forward Kinematic/Inverse Kinematic workflow.

By contrast, the discipline of geometric modelling has gone from "the manipulation of control vertices on non-uniform rational b-spline higher order surfaces using a mouse" to "using brush tools on a Cintiq monitor to paint on digital clay".

Developments towards a more emotionally impactful, artist-driven digital pipeline is not occurring in parallel, and some areas prove to be more challenging than others.

As animation is directly related to performance for digital characters, and as we have seen from earlier chapters, a finely crafted performance is essential for creating the kind of drama that can have lasting cultural resonance, it is of vital import that a lion's share of resources be devoted in improving the techniques and the technology involved with bringing digital characters to life. If we continue to trudge through this "uncanny valley", enamoured by our own ingenuity in creating technology, performances will continue to be frankensteinian and the art of animation will never move forward.

2.2.4

By understanding the processes behind some of the more traditional art disciplines and comparing that with their digital counterparts, it becomes evidently clear that an additional layer of technical expertise comes into play, but a number of traditional filmmaking roles are, in and of themselves, technically complex enterprises to begin with. Although not largely centred around digital literacy, disciplines such as traditional cinematography and lighting often require at least an informal relationship with the sciences and offer a wholly unique set of different technical challenges. Basic understanding in light wavelengths, lens and optical characteristics, film emulsion sensitivities, and color science (amongst others) are routinely called upon during the daily routines of on-set live-action film productions. By examining both the craft of cinematography and lighting and understanding their common language with their digital counterparts, it becomes abundantly clear that, not only is there a necessity to capture the traditional, emotional connection with the art form, but there is also a need to bridge the gap from the "physically" technical world of cameras, lenses and filmstocks to their "digitally" technical counterparts in both a 3D content creation platform and compositor.

The stages of investigations are as follows:

- Cinematography
  - Film Stock
  - Digital CCD
  - Physical Lenses/Lens Behaviour
  - Film Stocks

- CG Cameras
    - Maya
    - Shaders
    - Rendertime FX
    - Post FX
- Nuke
    - Post FX
- Unreal Engine 4
    - Realtime Lens Shaders

As top Hollywood cinematographers are incredibly familiar with using a highly technical skillset to fashion incredibly artistic visuals, a common dialogue and understanding of scientific principles, such as light behaviours and lens physical properties, can be shared with CG Layout artists, shader writers and rendering software engineers who, by the very nature of their disciplines are well-versed in these self-same principles.

In the heyday of CG cinematography, camera focal length was primarily a constant and animation was either positionally keyframed or locked to a NURBS (Non-uniform Rational B-Spline) curve or motion path. This resulted in visually delivering mathematically accurate camera transforms with an unnaturally error-free smoothness that was often too perfect. Renderings from these cameras were also pin sharp, pixel perfect images with no chromatic and/or lens aberrations and no barrel distortions, resulting in visuals that were too clean and too perfect. Thus, many of the early attempts at incorporating CG elements into live action films could not be successfully done, in regards to visual discontinuities, without either heavy stylization or isolating the CG elements as separate visuals from their live action counterparts. Two early examples of this are Tron (1982), Disney's first heavily stylized feature film using computer graphics, and The Last Starfighter (1983), a live-action film with separate, intercut cg sequences. Both of these productions demonstrate the first concerted effort to move away from vector-based, wireframe graphics that were beginning to see widespread use in the entertainment industry, towards the first polygonal surface shader representations in 3 dimensional space using a z-buffer to create the illusion of an object's depth and solidity.

With the success of the first computer generated visual fx being incorporated into feature films, the 80s and 90s saw a rising boom in computer graphics related research, particularly in the arena of display systems and antialiasing algorithms. The research work, by proxy, involved investigations into virtual camera systems.

In an early paper on virtual camera oversampling, published in the CG International '90 Conference Paper by Frank Van Reeth, Rudi Welter and Eddy Flerackers, the computational models necessary to transfer any 3 dimensional calculations to a 2 dimensional plane, such as a computer display, would involve the creation of at least 3 "cameras". This model roughly illustrates the layers of necessary computations in a graphics pipeline, in terms of accounting for a "camera space" (Van Reeth, Welter, and Flerackers 1990).

Virtual Camera

- Transforms
- End-user Blackbox
- Panning
- Tilting
- Tracking

Zooming

Spinning

Region Camera

Regional Divisions of Screenspace

Polygon Lists

Pixel Camera

Final Rasterization

Anti-aliasing Calculations

The three identified cameras roughly characterize the three subsets of calculations that need to pass data from one to the other in order to accurately draw a 3D visual representation on screen.

The Virtual Camera represents the “End-User Blackbox” that primarily concerns itself with a camera transformational matrix, or its scale, rotate and translate data, using an interface familiar to a non-technical creative end-user and introduces the first layer of “cinematographer-centric” technical terms for camera movement, such as panning, tilting, tracking, zooming and spinning. It is within this high-level layer of abstraction where traditional cinematographers and their digital counterparts will spend the most time conferring. In addition to this, the virtual camera also defines a normalized viewing volume, based on the screen size and the position of the camera in virtual space.

The Region Camera operates as an analysis of the object data present within a Virtual Camera's viewing volume and consists primarily of data lists, populated with polygonal and/or vertex data and calculations for any operational preprocessing, prior to final scanline rendering, that needs to occur with objects detected within this volume. Final screenspace is subdivided into regions based on the number of polygons in the scene.

The Pixel Camera constructs pixel lists based loosely on polygons detected by a scanline analysis of the regions created in the previous step and subsequently, antialiasing algorithms are applied for final, per pixel image creation on a display.

These "cameras" are intrinsically tied to the vertex shader and pixel shader pipelines that form the basis of all standard rendering pipelines, which we will examine further in the upcoming section on rendering; however, the problem still remains of creating a comfortable and intuitive bridge between non-technical camera operators and virtual camera systems. This has been an overarching goal since even before the inception of modern movie computer graphics. In fact, in the fall of 1968, in an article co-authored by J. Citron and John H. Whitney ((Citron and Whitney 1968), the researchers clearly state that their primary goal was to "avoid dependence upon the user's knowledge of mathematics, geometry, and programming logic" in their design of computer assisted production tools. They identified that their end-user would be "expected to have the
sense and sensitivity of an artist in manipulating given geometric figures" and thus, "while the mathematical and logical program necessary to perform this processing may be complex, the language seen by the user must afford control over all the technical flexibility available in the program, but from the user's non-technical standpoint."

After over thirty years of computer graphics virtual camera development, there are still a few key computational characteristics that anyone involved with digital cinematography must inherently understand (Staff 2014). Due in large part to hardware limitations dictated by the computational requirements for analysis and processing of all 3D constructs in a given scene, which is often times measured crudely by floating point operations per second, those disciplines that directly interact with CG camera placement and animation, such as layout artists, cinematics artists, matchmovers and compositors (to name a few), need to familiarize themselves with these core concepts.

Cinematics Exclusive

The Frustum

Horizontal/Vertical

Cinematographer Crossover

Aspect Ratios

Normal View

Cinematographer Exclusive

Film Stock

Lens Characteristics

Pulldown

Light Wavelength/Throw

Exposure

As the CG industry moves closer in terms of collaborative exchanges with traditional film production houses, a fairly large part of the nomenclature that evolved with the computer graphics animation industry, due to its origins in its traditional counterpart, is being supplanted in favour of a more live-action film hierarchy and structuring system. This is due, in no small part to the sheer freedom of camera placement and movement available to layout artists that were once deemed impossible, or at the very least, cost prohibitive in traditional layout departments of the past. However, CG camera layout is both a hybrid of traditional animation techniques coupled with live-action film production whilst simultaneously being neither. It is therefore not unreasonable that certain production houses still maintain 2D animation categories and terminology whilst other facilities adopt a more film-based nomenclature.

So for facilitating a wonderfully intuitive and creative cinematic authoring process, which approach would be the most ideal? Do we reference each new camera set-up as a scene, as commonly used in animation, or do we break scenes based on location with every new camera setup categorized as a shot, which is the convention used in film? Are CG camera animators layout artists, cinematics artists, or digital DOPs? As traditional animators consistently seek to replicate the visual dialogue created by film, it seems only natural to begin migrating tools, processes, workflow and pipelines towards a more filmic approach and indeed, there is every indication that the entertainment industry is moving in this direction.

Figure 2-3. Sharon Calahan, Pixar, First Computer Animation ASC (2014)

The key factor to be constantly regarded is the versatility of the digital camera space and its potential to define its own artistic identity. For example, Epic, the developers of the realtime development platform Unreal Engine, have created a "Level Sequencer" tool that adopts a lot of the features and terminology of live-action cinematography cameras, yet at the same time is an encapsulated set of digital data that can be treated as a separate "actor" or manipulatable entity. It can be layered, chained, and triggered by other data events inside the Unreal engine development environment, granting it features that live outside both animation and film. This opens up the potential of a very different approach to digital filmmaking that the industry is only just beginning to understand.

The feature film Rogue One (2016) was the first successful demonstration of using Unreal technology to create feature film level computer graphics to be integrated with live-action elements., heralding a very different approach to authoring visual fx content.

Figure 2-4. Rogue One and Unreal Engine (2017)

2.2.5

The subject of animation is not only voluminous in scope and content but is quite possibly the first subject heavily reliant on computational computer science as it pertains to CGI. Not only does animation have its roots in a heavy tradition of classically derived, hand crafted techniques, it also severely tests the limits of engineering mathematics not designed for the free flowing, expressive chaos of certain animation techniques and is quite demanding in a computational pipeline.

It is no surprise, then that majesty of this century's newest art form is now heavily mired in specialist technical knowledge. A traditional animator who would once only consider how a character would anticipate a key moment, now also has to consider whether joints would need to rotate using Euler mathematics or quarternion solutions during that anticipation.

Before examining the current state of animation procedures and techniques, it is apropos at this point to present a snippet of a colloquial exchange on an internet forum that best exemplifies the prevailing mindset surrounding computer animation in this day and age.

In a forum posting on Oculus' home website, a user identifying themselves as "IsoMacintosh" posted a humble query for "... the easiest animating software?" (Oculus, 2017). Although, at the time of writing, a number of solutions exist that offer a gentle, art-centric introduction to the core principles of animation, certainly from a creative point of view (from very rudimentary 2D applications such as 'Pivot Animator' currently bein introduced at the primary level in schools, to Geppetto by Masters of Pie, a VR animation package geared towards novice users), these were not the solutions proferred in this discussion.

In fact, the latter example of Geppetto would have correctly addressed the question being asked by "IsoMacintosh"; however, the recommendations began with professional level, high-end production packages and quickly moved on to some of the most highly technical software used in the industry. A forum user identified as "mrdr" kicked off the conversation by first intimating that good animation was not possible without 10 years of training and then proceeded to recommend both Autodesk Maya and 3D Studio Max, both requiring a certain degree of specialist knowledge. Although "IsoMacintosh" reiterated that they were not interested in production level specialist software and/or modelling and rendering, the discussion quickly degenerated into recommendations far above and beyond the reach of a novice attempting animation for the first time. A forum user named "Imaceleighton" recommended Houdini and ZBrush, both incredibly difficult pieces of software to learn without any foundational knowledge in CG. A forum user named "nosys70" then proceeded to recommend full body ranged scans (using a modified XBox Kinect camera) and re-topologizing the resultant mesh data, both highly technical processes and neither of which addressed the original concerns of simply animating a character. The conversation continued along this vein, rapidly deteriorating into a discussion of "which software package was better" and what is the correct pipeline for processing digital assets for a game engine.

Although this is only a singular example of prevailing attitudes towards animation in the CG industry, the internet is resplendent with with similar sentiments and virtually identical exchanges. As CG animation presents a uniquely complex mathematical model for solving complex rotational mechanics, this particular digital discipline presents the largest ideological chasm between itself and its traditional counterpart. Due to the technical complexities associated with properly deforming a geometric character with the same freedom and fluidity of its hand drawn counterpart, animators for the first time in entertainment history are faced with a plethora of new computational problems to solve. Rotational solvers using both quaternion and Euler mathematical models, inverse kinematic and forward kinematic solution for complex movement, gimbal lock errors, deformation anomalies, inherited transformation data, and corrective blendshapes for deformation anomalies account for a small sample of what a CG animator must face in their pursuit of the perfect emotionally-driven performance. By contrast, a traditional animator need only focus on honing their draftsmanship abilities, developing their basic understanding of physics as it pertains to motion and learn to explore their own inner thoughts and emotions to mine them for soul-stirring ideas and revelations of the human condition, which they can subsequently channel through a pencil.

It is no surprise then that the digital context for animation, in its pursuit of technical excellence, has somehow managed to miss the point. After all, an easy toolset does not equate to a less professional context. After all, one can't get any simpler than the pencil. So why is the pursuit of the "easiest 3D animation software" so vital? The less time an animator spends puzzling through mechanical engineering problems, the more time they can devote to pursuing emotionally charged performances.

The interesting conundrum here is that the actual process of animation has not deviated much, in terms of workflow and best practices in over decades. The essential usability concerns don't rest in the process of animating itself, but rather in the processes directly preceding the animation pipeline. It is the process of "character set up/rigging/character technical direction" where an animator's primary concerns can be directly addressed with innovative solutions prior to character manipulation. Although the process of "rigging" is a discipine (and a studio department) in and of itself, as it is intrinsically tied to animating, it is the primary focus of this chapter.

In terms of mapping large watersheds and/or innovation-driven paradigm shifts in animation rigging, aside from a handful of notable milestones, the workflows of rigging and animation, for better or worse, have remained relatively unperturbed. Inverse Kinematic joint chains, adopted from the study of robotics and in widespread use in computer graphics since the 80s, is still de rigeur for modern production pipelines today, as are simple mathematical concepts such as parent-child hierarchies and transformational constraints. Although implementation of rotational solvers varies from package to package (from 3D Studio Max's TCB Controller to Maya's dual quaternion solution) with variations in either left hand or right hand coordinate systems, the underlying technology has changed very little.

A few key developments in animation toolsets are the following:

Muscle systems

Motionbuilder's Human IK Rig

Endorphin, human behavioural motion synthesis

Auto rigs

Animation layers

Screenspace-based deformations

Although the introduction of these innovations have had a powerful impact on CG animation, with arguably the animation layers and the Human IK rig having the largest impact on an animator's workflow, the essential creative process for animation has not changed and the concerns of rotational mechanics, gimbal lock and deformation anomalies still persists.

Perhaps animation software being “easy” is an erroneous descriptor. Animation software needs to shift emphasis away from the technically complex and refocus on the creative process of delivering performances.

2.2.6

The process of geometric modelling and its various surface types has been around almost since the inception of computer graphics. Although "modelling", as it is colloquially referred to, has often suffered from the same technical considerations that hampered the animation process. As CG modelling is a relatively new art discipline, with tenuous connections to architectural modelling and classical sculpting, it has enjoyed an evolutionary process free of reinventing existing legacy processes and techniques.

Unlike its animation counterpart, however, modelling has experienced 2 evolutionary watersheds of note. One was the introduction of subdivision surface modelling as an additional surface type to the existing polygonal surfaces and NURBS (non-uniform rational b-spline) surfaces. This allowed CG modelling artists to work with low polygon models that would render with point interpolation and create smooth, rounded surfaces as a final visual result. It was a technique widely adopted, as it seemed to marry the best practices of polygonal modelling, with its low resolution cages, and NURBS modelling, with its smoothly interpolated surfaces. Of note was the first implementation of subdivision surface modelling in a high profile, Hollywood feature film in the character of Gollum, from the Lord of the Rings trilogy. Although subdivision surfaces (subdivs, sub-Ds) started to create a more sculptural visual feedback mechanism for digital artists, it still suffered from the same inherent technical considerations/limitations of its predecessors. Artists still had to be wary of surface normal directions, lamina faces, non manifold geometry, and a plethora of other technical and mathematical challenges.

The second, more profound development was the introduction of digital sculpting. In terms of modelling, this would have a resounding impact across the globe in every production pipeline, from games to film. Although mired in its own set of technical encumbrances, digital sculpting platforms such as Mudbox and ZBrush presented a set of digital art tools that replicated the processes and workflows of its traditional art counterpart. Digital sculptors felt, for the first time, like sculptors.

In 2006, this researcher was fortunate enough to have worked with Dave Cardwell (Cardwell, 2017) during his tenure at Electronic Arts, one of the co-founders and creator of (then Skymatter's) Mudbox, one of only 2 existing 3D sculpting and painting tools at the time. Although voxel-based geometry manipulation techniques had been on the scientific radar since the mid-90s (Wang and Kaufman 1995), with a number of research teams looking to address a more artistic methodology for the creation of geometric digital assets, it is only during mid-2010, with the release of ZBrush 3.1 followed shortly thereafter by Mudbox 1.0 that digital sculpting started to become widely adopted by digital creative teams in production houses ranging from ILM (Industrial Light and Magic) to EA (Electronic Arts). It was during several discussions with Dave Cardwell that the prevailing ethos behind the authoring of these toolsets started to solidify into the understanding that, in a digital asset pipeline, software must allow "artists to be artists first" and technicians afterwards. Removing a large number of technical considerations from the asset creation process, including polygon counts, surface normal calculations, and illegal geometric modelling techniques (non-manifold geometry/lamina faces) allowed modellers to focus solely on achieving a high level of visual aesthetics based on traditional art principles. This focus on bringing sculptural techniques and a new methodological software interface "has enabled artists to create models far more quickly and with much greater detail than previous approaches." (19 Scientific And Technical Achieveme...) and Dave Cardwell and his team subsequently won an Academy

Award for Technical Achievement in 2014.

It is without a doubt that shifting the focus to traditional creation methodologies, at least in the field of digital modelling, has not only achieved raising the bar in terms of visual fidelity, but it has also had a resounding ripple effect throughout the computer graphics industries.

In a related field, texture painting of digital assets is also experiencing what this researcher believes will be the next digital art paradigm, which is the introduction of particle simulation based brush painting. The central tenet of this new area of technical development is to create digital brushes that behave organically, with paint spattering and obeying the laws of physics, and being driven by realtime particle simulations. At the time of writing, two painting packages sit at the forefront of this new ethos, The Foundry's Mari and Allegorithmic's Substance Painter, and both currently require a high level of system hardware to properly mimic real world materials. Already, this new methodology of painting on digital models is receiving high praise from art teams across the globe and resoundingly echoes the philosophies that drove the creation and implementation of their digital sculpting counterparts.

It is without a doubt that software developers who refocus on the artist's experience will subsequently raise the bar on the quality of digital asset production.

2.2.7

Of the remaining pipeline disciplines in CG production, namely the fields of lighting, rendering, and dynamics, the level of technical proficiency sharply rises. It is due to the highly intricate marriage between real-world physics and advanced computer science that these disciplines require that they often come to the quick attention of the Academy of Motion Picture Arts and Sciences and are often awarded their highest accolades for technical achievement. As lighting and rendering are intrinsically tied, it is often difficult to discuss one without framing it in the context of the other.

At the base of all lighting and rendering pipelines is a fundamental problem of gamma correction. This is due in large part to the real world behaviour of light which, due to the nature of how colour science and lighting is calculated in the computer, is often not accurately replicated by existing digital lighting tools. Couple this with the fact that legacy image file formats and older display systems treat gamma calculations differently, most lighting and rendering technical artists must have an awareness of a content creation package's method of controlling gamma versus any legacy gamma devices and file formats versus the correct gamma behaviour under real world lighting conditions. As most lighting and rendering artists are constantly converting between different colour spaces, this can amount to an ultimately confusing baseline with which to begin crafting a beautifully lit scene or sequence. In the methodology section, we will discuss at length the requirements of a linear light workflow and study in depth its ramifications to the creative process. For now, the central issue with digital lighting is the same one that afflicts digital cinematography in that digital lights are mathematical quantities with a high degree of computational accuracy in terms of controlling illumination but have no real world equivalent. Examining the problem inversely, real world lights, their behaviours and idiosyncratic aberrations, do not exist inside a digital context and must be authored manually.

As a lighting TD responsible for creating a variety of "filmic" lighting tools during production of Star Wars: The Force Unleashed, this researcher was faced with the task or replicating real world film set lights, from 4k HMI's to 2k Blondes and 1k Redheads using digitally perfect point lights, directional lights and spotlights. One of the more recent developments to standard CG lighting pipelines, the introduction of photometric lights and the simulation of their goniometric throw patterns, was a step in the right direction in terms of replicating real world cinematic lights; however, any further additions to a light rig, such as gobos and cuculoris, or any addition of a custom light shader, would exponentially raise the calculation times required for both realtime and offline rendering. This meant that any complex light rig would be outside the scope of use in a realtime lighting session. Lighting artists would often have to hypothesize illumination outcomes will building and placing lighting solutions, based on a rudimentary realtime lighting model displayed through their viewport, approximate their final light placements and then subsequently wait for an offline rendering before visually analyzing the results of their work for critical feedback. The process of offline rendering would often take hours, and the disconnect for lighting artists was difficult to work with, and the subsequent investment in time required to achieve a high visual aesthetic was oftentimes prohibitive for most creative pipelines.

Although research in both realtime and offline lighting solutions have been exhaustive, Pixar was the first studio to practically address the problem of lighting design during production and in 2005 implemented a working solution sitewide. Researchers at Pixar understood that the process of lighting was "labor intensive and time consuming, primarily because lighting artists receive poor feedback from existing tools: interactive previews have very poor quality, while final-quality images often take hours to render." (Pellacini et al. 2005). They subsequently authored the Lpics relighting engine for use in the production of 2 feature length animated films, successfully leveraging advancements in realtime graphics processing hardware.

Similarly in 2007, ILM (Industrial Light & Magic) developed "an automated approach for high-quality preview of feature-film rendering during lighting design." Using an identical technical strategy, ILM capitalized on realtime rendering hardware to "use a deep-frame-buffer shaded on the GPU to achieve interactive performance. " (Ragan-Kelley et al. 2007).

The intuitive toolsets and interactive visual feedback mechanisms were a powerful boon for lighting artists.

Slightly prior to the creation of production-ready lighting tools with realtime feedback mechanisms, computer graphics scientists were rapidly moving from a direct lighting model and exploring the indirect illumination that occurs when light "bounces" around inside a virtual environment. Rendering technologists sought to replicate the reflectance properties of light emissions by developing radiosity models and two massive leaps forward in that regard were the introduction of both Global Illumination (Whitted 1979) and Final Gathering (Jensen 2001), both of which used a simulated photon emission engine to calculate light bounces off a variety of varying surface materials in an attempt to more closely approximate real world light behaviours. It is, however, the pioneering work of Paul Debevec in 1996, in the fields of both photogrammetry and Image-based Lighting, that presented another leap forward in rendering technologies (Technology Review Web Development Team). In 2010, he received an Academy Award for his work. With Debevec's processes, lighting artists could simply photograph a surrounding environment and use the illumination data from the photograph to effectively light their scenes. The result of this process produced startlingly real illumination models and would quickly become de rigeur for both feature film and game productions.

A complex and comprehensive analysis of the development of CG lighting models from their inception is beyond the scope of this paper; however, the toolsets that have evolved to aid in lighting design will be further explored in the Methodology section.

As the art of CG lighting matures, several packages have appeared in recent years that capitalize on parallel CPU processing and OpenCL libraries that are beginning to gear themselves towards a more artist-centric approach to lighting design, now more commonly referred to as "Look Development". Two primary packages are being adopted in film production houses. One of them, The Foundry's Katana, is still very much a specialist piece of software requiring a large breadth of technical knowledge. The other, Isotropix's Clarisse, is a more user-friendly approach to look development and lighting design. Both represent a step in the right direction, in terms of a custom toolset driven by the needs of lighting artists; however, both packages are still in their infancy, hampered in large part due to the tremendous processing power required in a lighting pipeline.

Sneaking somewhat stealthily into the world of look development for film are packages such as Unity and Unreal, realtime game engines and development environments. The power of realtime visual feedback to the artistic process in development of a CG property is beginning to be realized. John Knoll, a visual effects supervisor at ILM, spoke at length in 2017 at a Game Developer Conference about the crucial role realtime game engines played in their feature film vfx pipeline for Rogue One: A Star Wars Story (Alexander 2017). It is the harnessing of realtime tools (and advancements in GPU hardware) that will be explored in depth, in terms of their value to the artistic process.

The final area of technical concern is in the field of dynamics, whether it concerns rigid body dynamics, fluid/particle simulations, and hair and cloth. The defining characteristics of the technical challenges incumbent in these areas is their utilization of two separate calculation engines. One is the simulation framework that is used, whether it is a FLIP solver, nucleus solver and/or Finite element Analysis and their subsequent mesh conversion calculations. The other is the rendering framework used subsequent to final simulation calculations. In general, most simulation based assets require three stages before final implementation. Assets need to run through their simulation, then they need "meshing" (a process that converts the simulation point data into geometry), before final being rendered out for final implementation. As the visual fidelity of most simulations is reliant on the number of points being calculated (ie. the denser the point cloud, the more inherent detail in the asset), each of these stages are resource intensive and can potentially command a large portion of offline production time.

Couple this with the fact that designing most physics-based dynamic and simulation assets usually involves the manipulation of real world physics to achieve desired results, whether it be adjusting gravity, mass, temperature and/or wind, there is very little control that a simulation artist can exert over their asset. Regular iteration generally involves a lot of experimentation, sometimes with unpredictable results. Couple this with the processing power needed and the resultant drain on production time is tremendous.

In 2007, with the release of Autodesk's Maya 8.5, computer graphics researchers began attempting to implement "art directable dynamics" into a vfx simulation pipeline, in the hopes that the ethos of returning control to the artist in terms of how a simulation ultimately looked, would not only reduce simulation iteration time, but also result in a higher level of aesthetic quality and artistic expression in everything from wave splashes to flame licks to hair sway.

To most effectively illustrate the challenges faced by this part of the CG pipeline, the following chapter will explore my early research work and pipeline implementation of a cloth simulation solution for Electronic Arts' flagship skateboarding franchise, "Skate" and the primary inspiration behind my research work. In it, I hope to shed further enlightenment to the difficulties faced in a highly technical CG pipeline and the processes I helped to author that created a more artist-centric workflow which ultimately contributed to Skate's success as EA's newest franchise.

2.2.8

> 'Although nature begins with the cause and ends with the experience, we must follow the exact opposite course, namely begin with the experience and by the means of it investigate the cause.'
>
> (Leonardo da Vinci, 1512: 1)

Although there are key areas of simulation work that this researcher is familiar with, including early fluid dynamics work in both Realflow and Naiad, destruction simulations using Voronoi fracturing in Houdini, and explosions created using Maya fluids and the nucleus framework, cloth simulation has classically been under the remit of character animators and has often been viewed as an artistic extension of character performance. Not only is clothing fascinating from a design point of view, with cultural relevance and emotive resonance, its movements can both be unpredictable and choreographed. More often, from a creative perspective, cloth is used to accentuate and punctuate an animted character's performance. It is in this regard that an examination of cloth simulation in a character pipeline, as an exemplar to the challenges faced in a simulation pipeline, is relevant to this analysis. Before understanding its impact to a digital pipeline, it is first important to understand why an artist's process is vital to the emotional impact of clothing on a character's performance. History is resplendent with humanity's fascination with the undulating, wraith-like supple movements of cloth. There is a mystery behind the soft folds and iridescent sheen of drapery that captivates the eye like fire and water. Perhaps it is the elemental chaos of natural phenomenon that exhibits itself in the random crests and valleys of a fallen sheet of satin that draws us hypnotically to the study of it. Perhaps it is the allure of a provocatively hung gathering of silk whose thin barrier holds a subtle hint to the secret promise held tantalizingly beyond reach. Perhaps it is cloth's intriguing ability to hide and reveal the very heart of who we are that we find fascinating and provocative.

Our love affair with the material we use to cover our bodies extends to the most infinitesimal details of its color, tone, cut, flare, and texture. It extends beyond the inward scope of being our closest companion and most accurate personal reflection to the outward study of its inherent divinity by generations of obsessed artists attempting to capture its fleeting, gossamer beauty in the cold hardness of granite and the sharp brightness of brass. It has ensnared the scientific mind deep into the lifelong study of its deformations whose inherent ability to create patternless patterns defies the ordered sets of its mathematical definitions and baffles all attempts to engineer its clone.

It is woven into our very identity. It is celebrated in our art. It is scrutinized by our science, and it is worn every day.

Cloth Simulation

Traditional animators are innately familiar with the aesthetics and the physics of cloth in motion, and have been for decades before cg scientists ever cast a discerning eye upon its inherent mysteries. Directly tied to at least 2 of the 12 Principles of Animation, and bringing voluminous life to a fluid performance, the study of drapery in animation is now staple to the emotional force of an animated character. In some cases, particularly upon examination of techniques widely adopted in Japanese animation studios, the emotional valence of dynamic cloth animation supersedes the character performance animation that forms its base, with animation frame counts being sacrificed at the performance level only to be supplemented by additional clothing animation.

CG scientists, back in the early incarnations of cloth simulation, spent years studying the movement of cloth and its inherent properties. Although the textiles industry had been analyzing cloth properties from a geometric perspective from as early as the 1930s (Pierce, 1937), the first serious work from a computer graphics perspective began in the mid to late 80s, coalescing around a purely geometric method, as pioneered by Weil in 1986, and eventually evolving into the three basic classifications for cloth simulation today: geometric methods, physical methods, and particle/energy methods (Wikipedia, 2011).

Weil (1986) examined the visual nature of cloth deformations without strict adherence to the replication of accurate physical properties; however, his initial research continues to form the basis of all cloth simulation techniques to date. Procedurally driven, his solution in its distilled form is to represent draping cloth as a simplified grid or series of points and the application of certain restraints to more closely approximate a material's behaviour. Weil's approached excised the artist cleanly from the process and began the cycle of research, in earnest, of a wholly computational solution to replicating cloth dynamics. At this time, John Lasseter lay the foundation for the first dedicated CG animation studio by releasing the award-winning short, Luxo Jr.

The evolution of physical techniques for cloth simulation led to the utilization of an equation originally applied to the theory of elastic plates (Feynman, et al., 1996). Feynman used a multi-grid technique to help identify the behavioural characteristics of a material's inherent properties itself, such as wool and silk. In isolation, a number of resulting visual tests produced not only a measure of physical accuracy but of visual believability as well. Within a single year, Lasseter and Pixar would be bringing the ground-breaking CG film, Toy Story to the screens and into the annals of cinematic history. The question of collisions with a third party object outside the simulation scope, however, still remained, providing a number of research challenges that would be circumvented in the next, and final model of cloth simulation and modelling.

It was not until Breen (1996) that cloth simulation saw its final maturation into a particle-based model, with its first incarnation of a spring-based system of grid-distributed particles still in use in digital content creation packages, such as Autodesk's Maya native cloth module and standalone commercial solutions such as Syflex.

Then, in 2007, Autodesk released Maya 8.5 and unleashed the nucleus unified framework on an unsuspecting world. The brainchild of Autodesk Senior Research Scientist, Jos Stam, the nucleus framework represented an expansion of thinking in terms of an inclusive solution. Dynamic solvers would no longer be operating in isolation, fine tuned for specific effects, but be part of a greater cohesive whole. Individual dynamic solvers, each with their own uniquely coded behaviours would often times necessitate an order of operations, of sorts, if different solutions were called upon to interact with each other. The idea behind the nucleus framework was to remove that dependency and create a robust environment of mutual interactions. This was facilitated by Stam's move away from the spring-based model to one that combines simple constraints to help describe how cloth will stretch and bend (Stam, 2009). The conceptual anchor for Stam's approach was the theory of simplicial complexes that allowed for the approximation of any surface by a triangular mesh to any arbitrary precision. The resulting implementation of the nucleus simulation framework within Maya provided CG artists with a new module called nCloth (later revised to nMesh) which allowed for more robust cloth simulations that had a higher fidelity collision model and allowed for multiple dynamic solutions to interact with each other as part of a universal solution.

And here we are.

As a commercial, off-the-shelf solution, Maya's nCloth quickly gained favour in both the art communities and as a production ready implementation. In fact, in addressing the production benefits of nCloth, Stam (2009) is quick to point out that the specification of material properties and definition of external forces is far more efficient than the pose-to-pose, time-consuming, man-hour dependent approach of traditional keyframe animation techniques. From a production standpoint, and a technical implementation perspective, Stam is not incorrect. Unfortunately, from an art direction standpoint, this approach, along with the history of cloth simulation approaches, is most definitely putting the cart before the horse. If you query a traditional 2D special fx animator on the validity of accuracy of material properties and external forces versus aesthetic control of the final visual outcome of a specific effect, the weighting of importance would most definitely shift to the latter, and not the former. As reinforced by da Vinci (1512: 1), all artists, including those that count science as part of their library of media, strive to create the experience first before investigating the causes. Manipulating a cause, to achieve an effect, to create an engaging experience is a particular process that is anathema to the creative one. When examining the process of creating an nCloth object, compared to a sculptural approach, this philosophy becomes readily apparent.

The nCloth Process

While it is incontestable that the traditional pipeline is detrimental to the singular factor of time during a production, the benefits reaped from a purely simulation-driven workflow quickly balance out against the massive overhead of the myriad other factors involved with trying to shoehorn a creative process into an iterative simulation pipeline.

As an isolated solution, removed contextually from the plethora of art assets from different creation methodologies required to construct a scene, a purely simulation driven solution yields a variety of visually strong and emotionally evocative results. In terms of the creation process itself, it is also inarguable that hand-crafting visual assets is not only time-consuming, but carries a large, unpredictable dependency on the abilities and experience of each individual artist in a production department. A simulated solution is not only predictable, but measurable and visually pleasing.

However, whereas a sculptural solution simply requires an artist to have a firm foundation in visual aesthetics (reinforced by iterative development, of course), an nCloth solution requires a Maya operator to understand active and passive rigid body dynamics, particle systems, edges and cross-links across a polygonal face, nucleus-based gravity, air density, wind vectors, stepped calculations and substeps, iterative collision solving, self-collision, attributes of bounce, friction, stickness, stretch resistance, compression resistance, bend resistance, shear resistance, restitution angle, rigidity, mass, lift, drag, tangential drag, dampening, field magnitude, linear interpolation, density, vorticity, and more (Palamar, et al., 2011). Moreover, the addition of a scientific skillset radically changes the qualifications of a special fx animator and de-emphasizes the requirement for aesthetic skill in favour of application operational experience. This new found focus is detrimental to the longevity of CG films as an art form, which we will discuss shortly.

To control visual outcomes in a 2D production pipeline involves simply creating the correct visual aesthetic at the correct frame for maximum emotional impact at that time. Within a simulated solution, because of its recursive calculation process, relies on creating the correct physical conditions for a particular effect to occur and crossed fingers during the simulation calculations in the hopes that the effect would take the shape, form, rhythm and silhouette that the artist(s) required. It would be akin to placing a series of fans around a piece of cloth in the hopes that the resulting forces would sweep the material up into the correct shape and balancing that against the weight, mass, and type of material being used, as opposed to simply sculpting the material into the desired shape. Add simulation type to the iterations necessary to test against a variety of different materials, with a variety of different forces, and the creative turnaround time approaches the manhours necessary to simply create and animate the final form.

Simulation time alone, in an isolated scenario, presents few challenges that are insurmountable. With the nucleus framework implemented in current versions of Maya, even multiple dynamic solutions interacting with each other, within a single shot, can still be manageable. Couple that with the variety of assets that need to be balanced against the simulations, in terms of asset types, shader complexity, and specific renderers and their requirements, the final processing time of all elements rapidly becomes a question of mitigated visual fidelity and diminishing aesthetic returns. High frequency deformations in a cloth simulation that creates the look of wrinkles, exponentially increases simulation times and quickly becomes prohibitive to production. The benefits reaped from a simulation workflow rapidly become a case of artists making visual sacrifices to maintain a processing overhead. This compromise is not only contrary to da Vinci's philosophy but also reduces the digital creation process to a series of implemented operations.

The harrowing alternative of relying on a simulation-only solution, and its impact on an artist-driven workflow has not escaped notice from the frontline of major Hollywood productions. John Knoll, a veteran ILM Visual Effects Supervisor, commented recently on the production of Mission Impossible 4 on the importance of a visual effect "looking right" over its mathematical and scientific correctness (CG Society, 2015). Director Brad Bird reinforces this requirement by reiterating the necessity for creative teams, no matter the discipline, to think visually.

Simulation, by its own definition, seeks to replicate nature, and the conditions of nature, to create an experience and this, again, contravenes the mantra for artists that da Vinci so eloquently articulated. According to Henri Matisse, an artist's sole desire is to achieve "the realization of my own reactions" and to replace "explanatory details by a living and suggestive synthesis" (Matisse, 1869-1954). Art by its nature is not about the "how" and never has been, but conversely, this is what defines the very essence of science. We are on the cusp of achieving fantastic, mind-boggling leaps of computer science in terms of CG visualization, and it is an exciting time growing in fervour. We are also very much in danger of diluting an art form.

ENTER THE ARTISTS: Recognition of the Artist's Pipeline

> "Alright, so what Gus is saying is that we've got to change things around here. He's saying that we are pilots. And we know more about what we need to fly this thing than anybody else. So what we have to do is alter the experiment" (Deke Slayton, The Right Stuff)
>
> ------------------------
>
> "What about a hatch?"
>
> "Hatch?"
>
> "We need a hatch with explosive bolts, that we can open ourselves."
>
> "There's something you don't understand. This is the final form of the capsule."
>
> "We want a window."
>
> - The Right Stuff (01:34:25 – 01:35:38)

Eagerly awaiting in the wings, CG artists and animators were not oblivious to the growing developments occurring in the world of dynamics and simulation. At every opportunity, animators adopted existing cloth solutions into their workflow in the hopes of bringing a larger sense of artistic detail into their work. The animation of minutiae (Jones, Chuck Amuck, 1999) being an essential ingredient to punctuate certain emotional moments, or areas of artistic focus, the ability to integrate cloth dynamics simply and easily into an animated context generated a resonating buzz within the animation communities and growing excitement in the CG industry. In practical terms, cloth simulation was ready for production implementation as early as the 90s.

The minute the pilots entered the hangar bay, and came face-to-face with the tiny capsule that would be atop the gigantic rocket, there soon emerged a very large shadow of doubt. It appeared that cloth simulation operation required some relevant scientific qualifications that were beyond the scope of most traditional animators. As well, the simulation workflow did not seem to have the support considerations for the iterative process most familiar with animators. At its surface, it seemed that most cloth simulation solutions involved defining a set of parameters, for both material properties and external forces, and then simply hitting a switch. There was no area for implementing and refining keyframe targets, solutions were applied uniformly without support for areas of detailed focus, timing adjustments could not be made without affecting the recursive calculations needed for the simulation to be "correct", and there was no hatch. Apparently.

It was not the first time the traditional animators had to assert the relevance and validity of their unique art form to a stubborn and reluctant community of computer graphics specialists. It was in the early years of computer graphics visualization for feature film that a young Disney animator became enamoured with the ability to create animation in a virtual 3D space. Not only was he convinced that the medium could go beyond architectural and mechanical shapes and forms, but it could also capture performances utilizing the same 12 principals of animation that brought Disney to the height of animated storytelling. For his vision, he was subsequently terminated from the Disney corporation. When he partnered with a computer graphics scientist by the name of Ed Catmull, he was not acknowledged as an animator, but rather, as an "interface designer". Despite the resistance to his ideas, John Lasseter, this young animator who steadfastly pursued CG animation from the viewpoint of a traditional animator staying true to the tenets of the art form, eventually founded Pixar.

It is only natural, then, that it becomes prudent to examine the fallout of cloth simulation pipelines implemented in production from the trenches of Pixar, and subsequently, Dreamworks Animation, the two studios at the forefront of CG animation as an art form and the universally accepted masters of the craft today, from both a scientific perspective and an artistic one.

WHEN WORLDS COLLIDE

In the intervening years, between 1998 and 2003, cloth simulation entered production in earnest, growing from a novel feature for specific implementation to an absolute necessity for character-driven performances. Beyond the original promise of simulation techniques being far more efficient, far more accurate, and far less labour-intensive than traditional techniques, it became quickly apparent that implementation of these techniques in a large scale production was rapidly proving to be far more cumbersome and unwieldy than was originally stated on the back of the box.

"To achieve visually flawless results, early adopters of cloth-simulation technology have resorted to extensive pre-simulation tweaking of simulation parameters, collision geometry, and animation, as well as a variety of post-simulation fix-up techniques. All this extra work has made cloth simulation very expensive and painful as an animation tool." (Baraff, et al., 2003) The problem did not lie with the simulation of unrestrained cloth and the achievement of certain material looks, which had proven successful time and time again in a number of instances and research examples (Terzopoulos, et al., 1987; Terzopoulos and Fleischer, 1988; Carignan, et al., 1992; Breen, et al., 1994; Provot, 1995; Eberhardt, et al., 1996; Baraff and Witkin, 1998; DeRose, et al., 1998; Meyer, et al., 2001; Choi and Ko, 2002). The problem lay in the collision models implemented for cloth simulations in that the structure of the algorithms were not designed to adapt to the needs and wants of a production animator. The primary visual feature responsible for breaking most collision models, and a feature that all production animators need for good cloth draughtsmanship, whether it be the swish and swirl of a pleated skirt, the crumpling blanket of a restless night, or the tension lines when a sword is drawn, is the non-intersecting pinch at high velocity. Couple that with the calculations necessary to determine collisions between cloth and cloth, cloth and self, cloth and props, cloth and character, and cloth and secondary character, it is no great surprise that simulation times can quickly go through the roof.

The problem lay in how to make thousands of tiny objects hit each other and respond accordingly.

In 2002, Robert Bridson and Ronald Fedkiw of Stanford University, together with their industry colleague John Anderson from Industrial Light & Magic, endeavoured to solve this major production "bottleneck in cloth simulation" (Bridson, et al., 2002) Unlike traditional rigid body simulations that generally solved for relatively few collision points per object due to a manageable number of vertices, a cloth object, whose average mesh budget during production could easily be twenty thousand vertices or more, gave rise to an exorbitant amount of collision calculations per frame based on variable strengths and speeds. Interpenetrations and self-collisions were the first area of examination. Clothing needed to fold over on itself, very fast, in numerous locations, without going through itself or the character underneath. Although the collaboration of Bridson et al resulted in a fairly robust geometric treatment of collisions combined with developments in repulsion forces on a vertex by vertex basis, a fairly important problem still remained. When a cloth object becomes trapped between two solid deformable (or rigid) bodies, unexpected behaviours would result from collision calculations attempting to establish the correct repulsion. At the time of publication of their paper (Bridson, et al. 2002), there was no way to determine at a particular frame in time, in a local co-ordinate space, what side of a collision line a particular particle occupied.

With a physically accurate and realistic scenario, calculations on a per particle basis, using a history-based approach to determine a particle's location relative to a collision surface, poses no significant degradation of a cloth simulation. Unfortunately, animators are governed by laws that quite often cross the threshold of physical accuracy, and geometric interpenetrations occur on a frequent basis during an animated sequence, as necessitated by the demands of the art form. As a result, cloth becomes pinched between character mesh boundaries, resulting in permanently tangled cloth. In a practical illustration of the issue, when a forearm is animated into an exaggerated position, where the geometry penetrates through the bicep during an elbow bend, the cloth particles that simulate along for the ride become hopelessly confused as to where they should be situated in terms of the character geometry underneath. In the spirit of Pixar's founder, researchers attempted to solve this collision issue "without placing unacceptable constraints and artistic limitations on the animation process" (Baraff, et al., 2003). Their subsequent research, building on prior work from Bridson et al.(2002), resulted in two distinct takeaways. In terms of character geometry interpenetrations, a technique called collision flypapering was developed that helped to carefully control trapped or pinched vertices during simulation. The second technique that was developed dealt with self intersections within the cloth object itself, and was coined global intersection analysis (GIA) for its ability to avoid local calculations based on history. The stability and fidelity of these two approaches were production tested during the creation of Pixar/Disney's Monsters, Inc. and produced fantastic results with a relatively "small number of simulation runs" (Baraff, et al., 2003); however, animators were still required to iteratively resimulate based on art direction feedback instead of controlling the cloth animation keyframes directly, and even with the implementation of the collision flypapering and GIA algorithms, high quality cloth animations could not be achieved without a skilful and experienced simulation operator who is, once again, familiar with the underpinning science driving the illusion. Vertex budgets, in a particle driven solution, still needed careful management on both the art level and code side and visual details would still need to be mitigated against simulation times. As of yet, the desire for animators to craft a high level of detail and meticulous craftsmanship into their cloth animations would still remain an unrealized dream.

A WRINKLE IN TIME …

In the same year as the release of Monsters, Inc., Bridson and Fedkiw returned to the problem of high-fidelity cloth simulations, this time with Sebastian Marino of Industrial Light and Magic, with the sole determination of attacking high-frequency deformations. This time, there was a distinctive tonal shift colouring the research that for the first time, hinted at what could be achieved in cloth animation as an art form.

Whereas Bridson et al.'s abstract in 2002 began with the statement, "We present an algorithm to effectively and robustly process collisions, contact and friction in cloth simulation", the paper released one year later began with the following statement:

"Clothing is a fundamental part of a character's persona, a key storytelling tool used to convey an intended impression to the audience. Draping, folding, wrinkling, stretching, etc. all convey meaning, and thus each is carefully controlled when filming live actors. When making films with computer simulated cloth, these subtle but important elements must be captured." (Bridson et al., 2003)

Two areas of particular interest to examine in their resulting research is the development of detail in areas where tight contact occurs, therefore necessitating a wrinkling solution, and a collision model for both the clothing and the character that "preserves folds and wrinkles". The introduction of artist-sculpted features as an important consideration in designing the solution earmarked a shift in thinking in scientific circles vexed with the problem of creating a simulation that fulfilled both the aesthetic principles of art and the correct physical behaviours of accurate real-world cloth. This sentiment is prominently mentioned in Baraff, et al (2003) where "in production animation cloth behaviour must be plausible but strict physical accuracy is not a requirement". It is echoed again in Bridson, et al (2003) where the conclusions of their research included the incorporation of non-zero rest angles to allow for sculpted animation key poses and dynamic sticking constraints that offered another layer of controllability, and therefore, directability. The net result of this paradigm shift was that detailed animation was no longer being scoped out of a production schedule in favour of a simulated solution, but rather the opposite. Accurate simulations were not as crucial as getting the look right. The horse was finally before the cart.

One thing yet remained. The computational expense of high-frequency simulations still presented a large production overhead.

With the orientation of research goals into high-frequency cloth simulations adjusting to include a more artist-driven pipeline,

Cutler, Gershbein, Wang, Curtis, Maigret, Prasso, and Farson (2006) presented a "kinematic system for creating art-directed clothing and skin wrinkles on CG characters used in the production of computer-animated feature films." Prominently stated within their abstract was the very promising line: "An artist creates wrinkle patterns in an interactive application that is intuitive to use and accommodates iterative art direction." Their research was tested and implemented with a measure of success during the production of Shrek 2

(Dreamworks, 2004). The most interesting aspects of their research were the decisions to deliberately deviate from pursuing a purely simulation-based solution, and their critical analysis of existing solutions at the time of writing. Cutler et al express an understanding of the reliance of most production environments on dynamically simulated cloth, and extend a courteous acknowledgement to the amazing developments made in the field, in terms of speed and stability, that allow large scale productions to adopt simulated solutions with a high degree of visual return; however, echoing the sentiment of animators in the production trenches, and the humble opinion of this researcher, the practical reality of production implementation on a large scale, with hundreds of animated characters, belies the steadfast belief that a simulation-based approach is both a conservative approach and a less labour-intensive one. They identify that the history-based approach to iterative work on most simulation workflows runs counter-intuitive to the frame-by-frame process of creating successful animated sequences. They also correctly identify that, although great strides have been made in terms of collision models, contact collisions and self-collisions have not adequately resolved themselves into a pipeline friendly solution. Based on collision artifacts, animators are often called upon to restrict their range-of-motion, a catastrophic detriment to animation as an art form, and additionally, supplement their character deformation work with corrective sculpting in areas of high self-collision were cloth artefacts are likely to occur. The resulting workflow of animating and correcting and animating and correcting is a process commonly referred to as "counter animating", a process that computer animation, at its inception, was heralded to eliminate. Most importantly, simulated solutions retain their difficulty to adequately art direct, resulting in creative pipelines being modified to accommodate simulated solutions. Cutler et al identified five major goals in their research. They wanted a system that would allow frame-by-frame iterative work without the computational overhead of simulation, a smoothly transitioning system for capturing high-frequency wrinkles (including silhouette edges), an artist-driven process, a layerable solution easily integrated with existing techniques, and finally, a scaleable solution for large scale production. Upon examination of the creation process itself, it is without a doubt that the primary goal underpinning their research objectives was to create an artist-driven workflow. The techniques they developed for Shrek 2 centered around working with keyframes and reference poses, a process familiar to all traditional animators, and allowed for the wrinkle solution to be built around those poses and not vice versa, as previous solutions required. In their system, the clothing was being controlled by the artist and not the other way around. Although the techniques presented by Cutler et al were not map-based solutions (they had briefly discussed displacement map implementations before abandoning them in favour of geometric deformations), the results of their system veered dangerously towards eliminating the need for a simulation solution altogether. This is directly addressed towards the end of the paper indicating that future work would result in an amalgamation of the two approaches. They also identify the crux of using a blended library approach with set reference poses, namely that of limited variants and blending artifacts. Their proposal of expanding existing blending libraries and separate suggestion of testing their techniques in tandem with standard simulation methodologies seem surprising that the obvious connection was not made. With the inclusion of simulation techniques, a variant is introduced that may well negate the need to expand on an asset library of existing wrinkle types. This supposition is tested within the scope of this research.

Although production implementation has revealed a number of areas of improvement, the results achieved by Cutler et al brought the artist back to the forefront of the animation process, in terms of clothing and secondary action. Their approach was intuitive to the animation process, requiring little to no knowledge of the fundamental science behind material properties, particle systems, and the manipulation of dynamic forces. Results were immediately viewable and art-directable, allowing for the rapid iteration and change control process that traditional animators are inherently familiar with. Their system was robust and scalable, and eliminated the need for hand-tweaking or various other forms of "counter animating". In terms of computational expense, Cutler et al had this to say:

"In comparison to a simulation approach, the fast computation and low memory overhead of these algorithms allowed us to have hundreds of characters with animated, wrinkled clothing with virtually no impact on rendering performance." (Cutler et al., 2006)

Looming above the distant horizon of dynamic cloth simulation solutions, two very important beacons hove into view.

An Artist-driven Workflow

High-Frequency Details with Low Computational Overhead

With these objectives gaining momentum within the CG industries, it was obvious that considerations for the craft of animation were beginning to lead development cycles in the world of dynamic cloth simulations, and not merely the scientific objectives for replication of a real-world phenomenon. After all, recent trends in television programming aside, it is very rare that an animated film or videogame seeks to engage an audience in reality.

It is no surprise that parallel research was beginning to take shape in the world of realtime CG and games development. With the advent of the next generation of games consoles in late 2005, realtime computer graphics was poised to approach, and in certain cases, equal the graphical experience of film and television for the first time in computer and videogame history. Many of the developments occurring in the film industry, including new lighting models, dynamics, simulation, and rendering technologies, were quickly being absorbed and explored for implementation in a realtime context. From realtime depth of field, to convolution motion blur, to precomputed radiance transfer lighting techniques designed to mimic radiosity rendering, graphics programmers and CG artists in the games industry were keeping closely abreast with their older sibling in the film industry.

Research into realtime wrinkle solutions was engaged in by the author of this paper in 2005, during the preproduction phase of Electronic Arts' new intellectual property, Skate (2007). The research objectives stated by the author at that time were not dissimilar to those set out by Cutler et al in 2006. Driven by the compositional choices of the camera design, and the orientation of a tight shot through a fisheye lens to more closely approximate the look and feel of an independent underground skate video, it became imperative that the "animation of minutiae" (Jones, 1999) become a core visual device in heightening the sense of speed and adrenalin. To that extent, flapping clothing and rippling fabric in concert with the character animation was a signature visual target, to be at all times governed by the 12 Principles of Animation (Johnston and Thomas, 1981). The objectives outlined were as follows:

- Artist-driven workflow,
  - coupled with existing digital content creation packages currently adopted in production
- High degree of detail
  - in unison with visual expectations tied to the proximity of the game camera
- Easy integration into existing asset creation pipelines
- Low computational overhead

Initial research began with offline rendered examinations of ClothFX, 3D Studio Max's integrated cloth simulation solution and 3rd party solutions such as Syflex, in terms of setting a visual prototype and/or exploring the possibility of integration into a content creation workflow as a target model shape generator.

After numerous tests, it became evident that the computational costs did not balance satisfactorily against the visual outcomes, and therefore an alternate method needed to be developed. It was at this time, the author was invited to participate in the Character Creation Group at Electronic Arts, a collective think tank of artists and technical artists from a number of franchises within the studio, where he met with Roger Chamberlain, Research and Development Lead for Realtime Hair Production, and David Coleman, Senior CG Supervisor. Although their research focus was primarily centred on realtime hair implementation, it was their expression driven joint offset technology that first inspired the notion of a normal map blending solution for high-resolution wrinkles. The author designed and successfully tested a simple integrated workflow for high-frequency deformation authoring in a cloth animation pipeline. Using standard normal map authoring tools and processes, a 6 stage creation process was defined.

1. Wrinkle Sculpting

    Target Geometry bridged to appropriate sculpting package
    (ie. ZBrush, Mudbox) for wrinkle creation process
    Wrinkles sculpted using color texture maps as visual guides

2. Normal Map Generation

    ZBrush and/or Maya Surface Transfer Utility
    used to generate normal maps

3. Wrinkle Quadrants

    Photoshop dissection of normal map into areas of influence to be
    blended by ancillary joint controls

4. Layered Shader

   Utilized for Normal Map blending to allow for a high degree of control over the animated appearance of the normal map wrinkles.

5. Character Offset Rig

   Joint with an expression-driven offset is built into the existing character rig to control blending functions and blending amounts.

6. Remap Value Node

   Spline-based control over eases in the blending function to be controlled by the animator

As this was designed from the ground up to support realtime implementations, certain visual considerations were not prioritized, including topological silhouettes.

Shortly thereafter, AMD researcher Christopher Oat presented a solution for realtime "Animated Wrinkle Maps" at SIGGRAPH 2007 that discussed a similar process with a more defined methodology and tighter integration with a shader authoring approach. Again, the primary considerations for Oat's investigation were independent control of multiple wrinkle regions relinquished to the control of the animator, and utilization of current programmable graphics hardware to leverage realtime rendering visual feeback and reduced computational overhead. Although the case study in his example used wrinkle maps to augment facial animation, the layered approach, combined with morph targets and region-based normal maps with wrinkle masks, was contextually similar to this author's wrinkle research at Electronic Arts. Final implementation in Oat's research was as an HLSL shader authored for immediate implementation in a realtime environment, which represents the logical culmination of where the author's initial investigations concluded. Due to the nature of realtime applications for wrinkle maps, and the driving factor of framerate optimizations, there is a noticeable degradation of visual fidelity in comparison to feature film techniques, most notable in edge silhouettes, composited passes, level of detail, and blending animation; however, a complementary cross-section of techniques derived from both realtime investigations and offline rendering solutions may yield acceptable visual results.

Although the methodology and technology utilized in the process of realtime wrinkle map blending was markedly different to those of Cutler et al. in 2006, very similar problems were encountered during the investigation and it is the hope of this research to explore a combined dynamic simulation, blendshape topology constrained, and normal map blended solution.

2.2.9

As the state of technological development begins to accelerate in terms of providing the graphical power for more complex and intricate visual representations, it would seem a foregone conclusion that an artist-driven process would be at the forefront of any and all tools considerations for new software advancements. Yet in addition to the case studies discussed here, front line experiences at multiple studios corroborated

Figure 2-5. "Animation and Games Industires Giants"

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chapter 3
methodology

3.1.1

One of the primary areas of polarization in the CG industries often occurs during industry panels at the academic level when industrialists are confronted by student questions on how they should present their work to potential studios. One camp firmly presents the arguments for specialization while the contrary opinion states that a more generalist approach is preferred. While larger productions can afford to address specifics in their digital pipelines, smaller boutique studios need the versatility of a generalist to be able to shift into various roles as needs arise.

Although specialization is key in larger productions to address the myriad minutiae of technical issues that may arise, it engenders three disadvantages:

1) the danger of myopia
   (and disconnection from the overall artistic vision)
2) a loss of substantial creative ownership
3) a fierce protectionist elitism over specific areas within the pipeline that leads to the elevation of technical complexity over intuitiveness.

CG pipelines have not erroneously been metaphorically construed as symphonic orchestras, with each specialist being compared to musicians who are virtuosos in their chosen instrument; however, CG specialists very rarely, if ever, receive exposure to the symphonic melody as a whole, and thus can passionately drive their instrument through a tide of harmonious melodies with the clear understanding of how their passion contributes to the piece as a whole.

Make no mistake. Specialists are preferred, and necessary, when vfx teams number in the hundreds, and they do not lack in the passion and creative drive that their generalist counterparts have. Indeed, as most specialists began their career as generalists, their passion and creative drive will often times be more refined and of a higher quality. The goal is to create an environment where a specialist has the same exposure and creative ownership that a boutique generalist experiences so that the sense of authorship and artisanship is much greater. After all, artists should not feel like all they do is create wheel rims but rather that they created the astounding vehicles for a phenomenal film/game.

Although the perfect digital creative pipeline is a fallacy, as it would have to ignore considerations for how an individual artist approaches creativity, and the permutations are as countless and as diverse as individuals and their personal experiences, there are commonalities in philosophy between art disciplines that can help foster creativity.

In the following chapters, a multidisciplinary pipeline was designed and presented from the perspective of a singular artist's methodology. Heavily favouring traditional means, these methodologies will grant preferential treatment to enhancing creativity over facilitating technical fluidity.

As computer science, in regards to entertainment arts, is a volatile, rapidly evolving field, many of the findings are presented with the limits of being driven by specific authoring packages and their release dates, with concepts of a software agnostic approach being presented when and where possible.

As artist-centric digital pipelines are a dream that many productions share, it is assumed that this examination is taking place concurrently, and in parallel with a number of research teams across the globe. Where applicable, any current technology and research in that regard will be duly accredited here.

Figure 3-1. "An Artist's Workspace"

3.1.2

Of the voluminous tomes that have been devoted to digital art authoring techniques, a wide range of literature has covered the gamut from inspirational thought processes right down to specific functions and classes needed to execute code bodies to achieve desired effects. There have been very few that specifically addressed the commercial context within which digital creativity must take place. A similar metaphor would be the topic of gardening not properly addressing the chemical makeup of certain soils. Although entertainment economics and finance would, at first glance, seem the furthest removed from an artist's creation methodology, it is the soil where all projects begin. This researcher's experience with pitching triple A game titles, animated television series and feature films will be discussed in terms of how a broader understanding of what investors are looking for can sometimes be the first pilot light for guiding creative direction, and not necessarily in the negative context that is most commonly associated with making a creative vision "commercially viable" and "marketable". Too often, investment and finance is viewed in the context of creative limitation, and too often this readily available cliche has been proven to be true; however, gearing a creative property towards a certain market and a certain direction can also be an exhilarating part of the creative process. Venturing off in a direction with no idea of the destination can be very exciting, but it does not make a planned journey to a specific place any less so.

When presenting an idea to an executive producer (or a potential investor, for that matter), there is a tendency to assume that they are not also a consumer of entertainment media and therefore not affected by emotional elevation. It is true that entertainment financiers are concerned with Return On Investment and Capital Gains, but if that was purely the motivation then there are far easier and more profitable avenues to explore than entertainment. Executives look for passion as well, and in enough quantities to create cultural impact. They are equal parts clinical banker and soulful artist. If a presentation targets only one of those two aspects, it will fail.

On a full length feature film project, the most important relationship that happens on the creative side is the one between the Director, the Director of Photography and the Production Designer. The writer is also key to these relationships, but we will address that subsequently. On the business side, the important relationship is between the Director and the Producer. It is here that the creative vision is not only tailored, but it is also designed to reach as many people as possible (ie. remuneration). In the simplest, most generalized terms, the Director seeks to craft a unique vision, then worries about visually communicating that to as large an audience as possible with startling clarity. The Producer, one might say, works in almost the opposite context. They seek out what has visually communicated to the largest possible audience in the past, then worries about crafting a vision to encapsulate it. These statements are not designed to encapsulate those roles in convenient stereotypes and create further polarization, but rather, to understand that both approaches are not mutually exclusive and wholly necessary for creating a successful creative property.

One of the greatest compliments that the driver of a successful creative venture can receive is the acknowledgment that they have their “finger on the pulse” of populist culture. There is the subtlest of implications in that statement of divine intervention, as if a true understanding of the ebb and flow of populist culture comes, not from scholastic endeavour, but rather from a primal, instinctual place. Stanley Kubrick, often regarded as one of cinema’s finest auteurs, was such a student of film and all its aspects that he was intimately familiar with the minutiae of film financing and distribution. It was rumoured that those aspects of filmmaking he was unfamiliar with, no matter how seemingly inconsequential, he devoutly studied. It is with Kubrick's exemplary discipline and academic rigour that all commercial creative endeavours should seek to achieve.

In terms of understanding how intrinsically tied the creative processes are with entertainment financing, we will begin by examining two perspectives:

1) the key considerations for financing and distribution, and
2) the economic perspective of the entertainment industry as a whole.

After all, in this age of intellectual property convergence and market cross-pollination, a creative pioneer must understand not only the impact in their chosen market but ancillary markets as well, if they wish to maintain creative control over their vision. After all, Star Wars action figures are just as important a part of the Star Wars universe as the films themselves, and up until recently, George Lucas maintained sole creative control over both the narrative products and the commercial merchandise by judicious control of licensing (Serwer, 1997). This research will begin with an analysis of the economic perspective before endeavouring to understand how financing not only fits into this climate but also helps to define it. After all, a creative property not only derives its value from popular culture, it is also a contributing factor to the influences that help shape its direction.

Understanding the economic climate of an intellectual property's release takes more than just a simple analysis of demographics. As a triple A game title can run anywhere from 8 months to 2 years in development before public release, with an identical production time for films, and a tendency for most popular trends to fluctuate, sometimes with a wide standard deviation in as short a time as 3 months, there is a certain amount of probability and projection necessary to determine if a property will be "successful" at the time of release. To ensure that financial projections have the greatest accuracy, it is important to understand trends, and the more socioeconomic and sociopolitical factors that can be analyzed, the greater the probability of success. As dry as the last statement sounds, in entertainment economics, this is all about studying people and understanding the dynamics of behaviour, which should already naturally fascinate authors of creative fiction in all its permutations. In a lot of cases, determination of demographics and understanding popular media can be revelatory and fascinating in helping us not only understand what influences are shaping our society but also what drives us as human beings.

Economic perspectives

Table 1.4. *Leisure time on an average day, 2012*[a]

	Minutes	% of total
Watching TV	168	54.9
Socializing and communicating	39	12.7
Playing computer games	25	8.2
Reading	20	6.5
Other activities	18	5.9
Sports, exercise, recreation	19	6.2
Relaxing and thinking	17	5.6
Total	306	100.0

[a] Includes all persons age 15+ and all days of the week.
Source data: U.S. Bureau of Labor Statistics, http://www.bls.gov/tus/charts/leisure.htm.

Figure 3-2. "What is our audience doing?" (Entertainment Industry Economics, 2013)

Before accurately understanding and evaluating market trends (in terms of commercial entertainment properties), it is vital to engage in a measure of demographic analysis. When examining capital investments in a commercial product, a careful analysis of consumer income expenditures in terms of cost can help identify spending patterns and determine an appropriate pricing model weighed against household budgets. When analyzing entertainment properties, however, the cost association may not necessarily be monetary. As consumers generally evaluate entertainment properties in terms of a personal investment in their cultural and social identity, the pricing model is often a secondary consideration when measured against a commitment of time, therefore creating a new transactional relationship with consumers of entertainment. If a property has an intrinsic cultural value, and a consumer has apportioned a segment of their leisure time towards their chosen platform of entertainment, cost (although a strong consideration) is not a driving motivator for investment. The consumer transactional model is not cost versus return necessarily, but rather time spent versus positive emotional valence. In that way, most entertainment assets enjoy a certain measure of "price inelasticity", for a measure of time while the asset enjoys a "must see" and/or "must have" honeymoon period upon release. Populism, of course, fuels the cul-

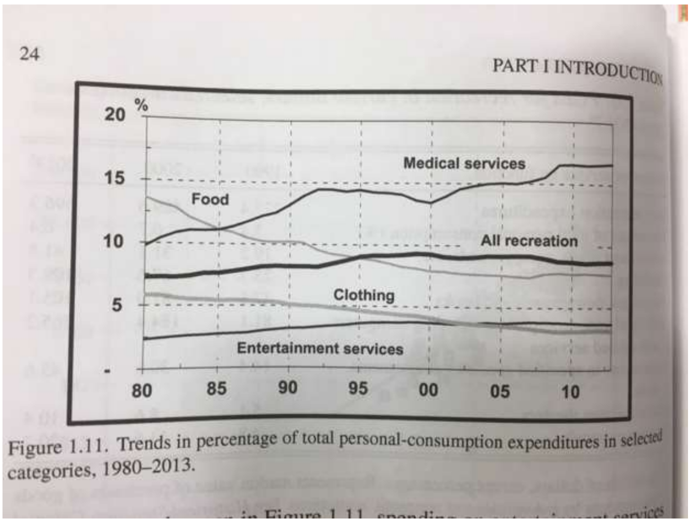


Figure 3-3. "What are our Priorities?" (Entertainment Industry Economics, 2013)

tural need for an appropriately positioned product, but cultural impact can greatly increase an entertainment property's price inelastic period, and therefore maximize a high profit period. With more people willing to spend more time engaged with an intellectual property, it is incumbent upon digital creatives to engineer an engaging and unforgettable experience during a consumer's allocated leisure time. To be appropriately effective, a demographic analysis in terms of time must first create that division between work and leisure time, as leisure time can be further broken down into the two categories of

a) recreational, and

b) entertainment.

Economic perspectives 23

Table 1.6. *PCEs for recreation in current dollars, selected categories, 1990–2013*[a]

Product or service by function	1990	2000	2013[b]
Total recreation expenditures	227.4	489.6	696.3
Percentage of total personal consumption (%)	5.4	6.7	6.4
Amusement parks, campgrounds, etc.	19.2	31.1	41.8
Gambling	23.7	67.6	109.3
Magazines, newspapers, and books	47.3	81.0	105.1
Video and audio equipment, including computers and related services	81.1	184.4	265.2
Admissions to specified spectator amusements, total	14.4	30.6	45.6
Motion picture theaters	5.1	8.6	10.4
Spectator sports[b]	4.8	11.6	20.7

[a] In billion of dollars, except percentages. Represents market value of purchases of goods and services by individuals and nonprofit institutions. See *Historical Statistics, Colonial Times to 1970*, series H, pp. 878–93, for figures issued prior to 1981 revisions.

[b] Includes professional and amateur events and racetracks.

Sources: U.S. Bureau of Economic Analysis, *The National Income and Product Accounts of the United States, 1929–1976*; and *Survey of Current Business*, July issues.

Figure 3-4. "Recreation" (Entertainment Industry Economics, 2013)

As the landscape of entertainment consumer products has radically evolved, broadening to provide new means of delivery (including downloadable/streamable digital content) across multiple platforms, the battle for consumer leisure time has intensified; however, when measured against the steady reduction of average weekly employment hours over a large cross-section of time (10 years to 25 years), and the resultant expansion of leisure time trending steadily upwards in recent years, the age old adage popularized by entertainment producers that "content is king" is still very much apropos.

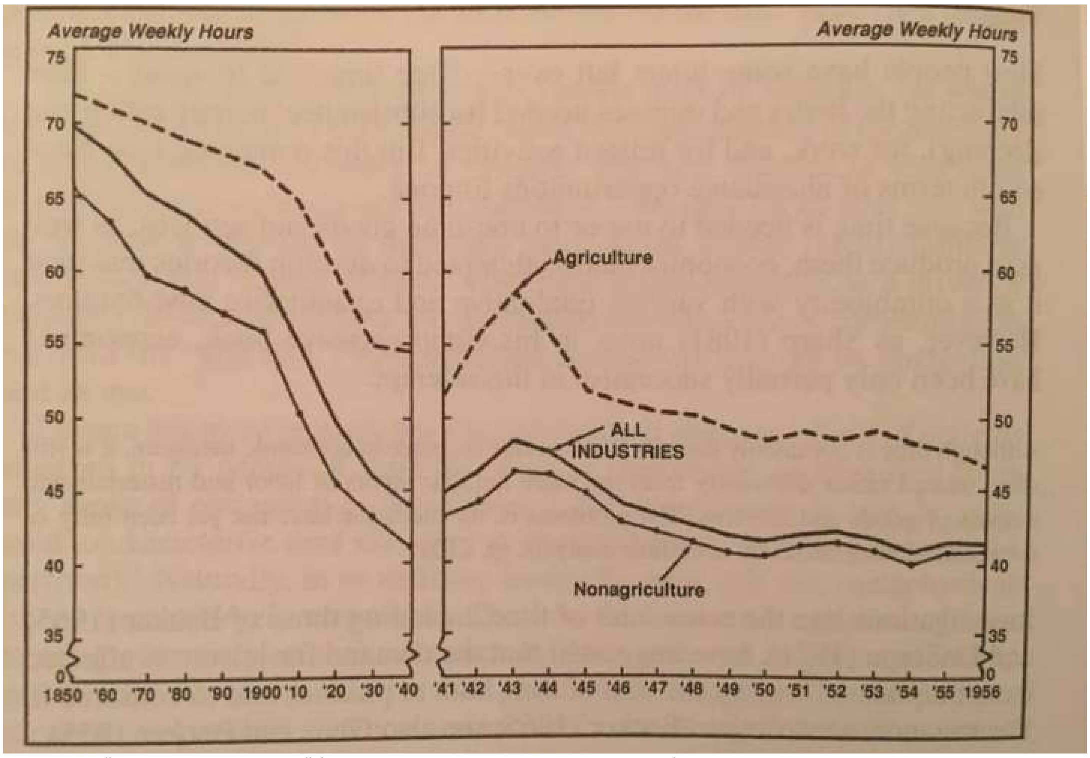


Figure 3-5. "Work Hour Reductions" (Entertainment Industry Economics, 2013)

When breaking down time spent by adults on selected leisure activities across a number of delivery platforms, such as television, radio, newspapers, music, magazines, books, movies, spectator sports, gaming, and cultural events, it becomes abundantly clear that television viewing hours has been, and still is, the primary investment of entertainment leisure time by adult consumers. The rise of streamable digital content, accessible on multiple delivery platforms, is a shift of tectonic proportions whose resultant influence will be the first to significantly impact television's reign at the top. Higher wage earnings can significantly impact growth in leisure time, and the resultant increase in demand (although this can be countered by leisure time investment in further work to create additional income). A further granular analysis of specific age ranges within the adult consumer demographics can also identify greatest market potential for entertainment properties (for example, the over 30 age group generally places a greater emphasis on recreational expenditures of time over sedentary entertainment pursuits). This becomes a significant consideration when weighed

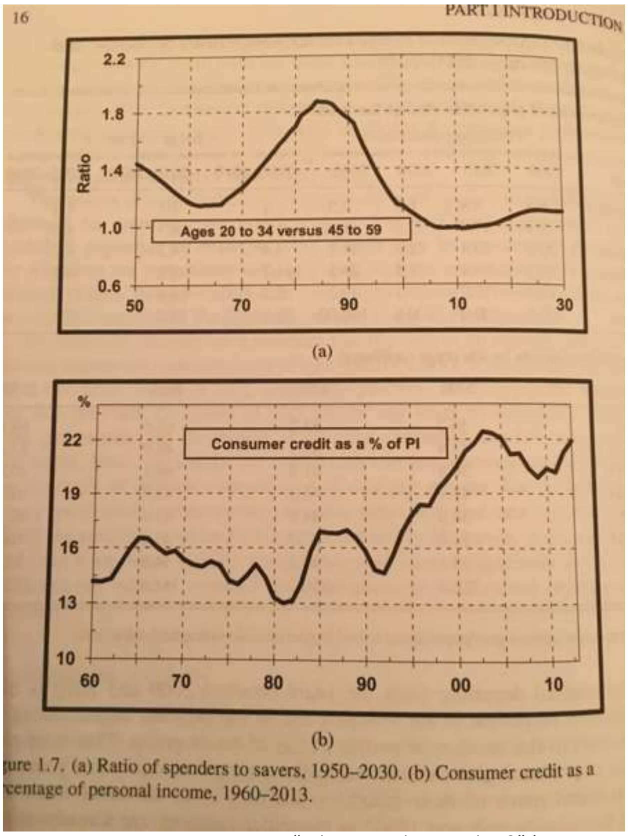


Figure 3-6. "Where are the spenders?" (Entertainment Industry Economics, 2013)

against population trends, which predict a larger increase in the 35- to 64-year-olds, over the 18- to 34-year-olds that typify a demographic known for spending. Those in the older category generally display behavioural patterns tending towards monetary accumulation and future thinking in terms of financial planning.

From a creative content point of view, the decision then becomes a question of whether to strategize expanding markets into a younger age bracket, or try to entice the older group towards consumer spending. This may be one of many reasons for the rise in nostalgic intellectual properties, known franchise reboots, and sequelization. It is a proven strategy to attack both age brackets by continuing to feed spending trends in the over 34s and expanding a consumer base by appealing to a “new audience”.

To create a new intellectual property that strikes both of these key demographics would require something with equal resonance as the Harry Potter franchise, whose global influence was not only an enormous surprise, but also an understandable phenomenon. J.K. Rowling’s superb encapsulation of childhood misadventure helped to ensnare a large, younger audience whilst her subtle nod to Tolkien-esque mythos won the hearts of older readers. In fact, the same generalization can also be applied to the success of the Star Wars franchise.

Understanding activity and time investment in ancillary entertainment leisure time, such as in books, can help determine if a product can cross-pollinate across different delivery platforms, and if so, can also inform a strategy in terms of distribution and scheduling. As certain key entertainment assets generally have a fairly long incubation period before any return on investment starts to pay dividends, such as in films and games, it is crucial to examine additional revenue generators that can operate both as pre-advertising and “buzz” creation, as well as an early revenue stream that can potentially be tapped while the primary asset is under construction. This research documents a live case study of designing a commercial entertainment entity with this particular strategy in mind.

One key revenue generator usually associated with broadcast properties is advertising, as consumables (either on television or the internet) usually follow a subscription service model and therefore necessitate a large portion of creative planning and programme planning devoted to advertising strategies. As this often necessitates a co-ordinated campaign between producers of a creative property and the product branding most suited to its target audience, whilst adhering to the demographic marketing strategy of the central product(s) themselves, the questions then become "who will advertise with us" and "who will we advertise with"?

Basic elements 61

Table 2.1. *Top 12 advertising spending categories in the United States, 2009*

	$ millions	Newspaper	Television	Cable networks	Internet
Retail	17,160	5,719	4,942	1,203	765
Automotive	15,609	3,529	7,006	1,273	666
Telecom, Internet	10,101	1,554	4,192	1,173	1,338
Financial services	9,664	1,899	1,964	882	2,944
Medicine and remedies	8,687	215	4,053	1,472	281
General services	8,547	2,437	2,303	498	574
Food, beverages, and candy	7,820	79	3,180	1,633	124
Personal care	6,029	19	2,341	941	101
Restaurants	5,616	221	3,255	1,146	68
Airlines, hotels, travel	5,174	1,199	854	448	467
Movies, video, music	5,110	886	2,295	1,223	135
Media	4,722	1,310	201	165	516

Source: Advertising Age, December 28, 2009.

Figure 3-7. "Advertising Spends" (Entertainment Industry Economics, 2013)

If products and services ancillary to an entertainment asset's primary product are considered early enough in the creative development phases, then not only can a strong, single-voiced campaign strategy be designed, but also a fluid, multi-dimensional and versatile digital creative pipeline. With enough forethought, there is no reason why game assets can't be used to generate toy prototypes while forming base level assets for a feature film's CG department at the same time.

Convergent intellectual properties, such as the Marvel Cinematic Universe and the Transformers are a few of the models that demonstrate how this philosophy could be practically executed. Of course, ensuring the success of a creative property across multiple platforms and products requires an increased capital investment at greater risk with properties such as the Matrix as cautionary tales of spreading out too thinly across mutiple product lines. Of course, what makes any decisive path through an entertainment property such as film resoundingly more difficult is a curious and seemingly unstoppable trend downwards. We may see the demise of movies as a primary spectacle for escapism in our lifetimes.

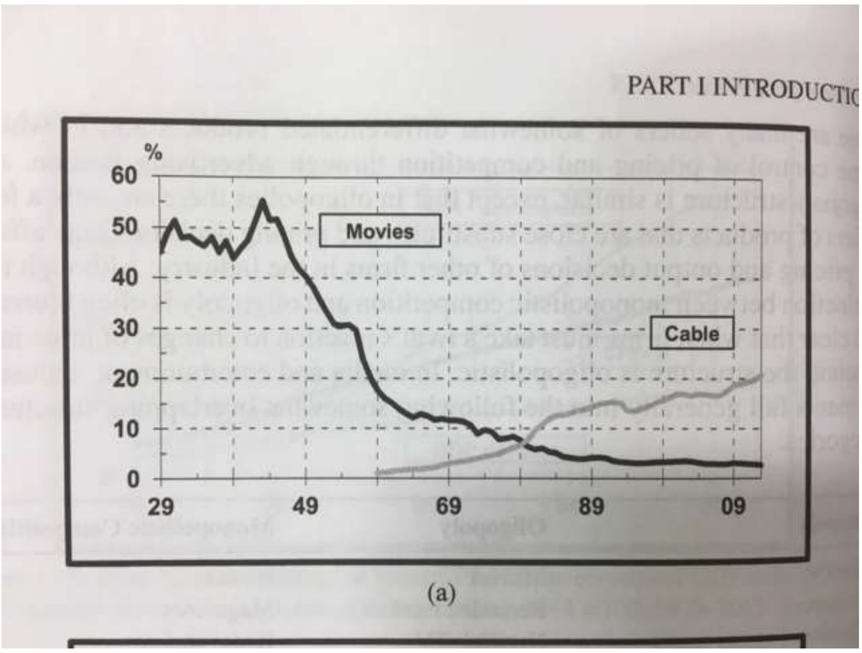
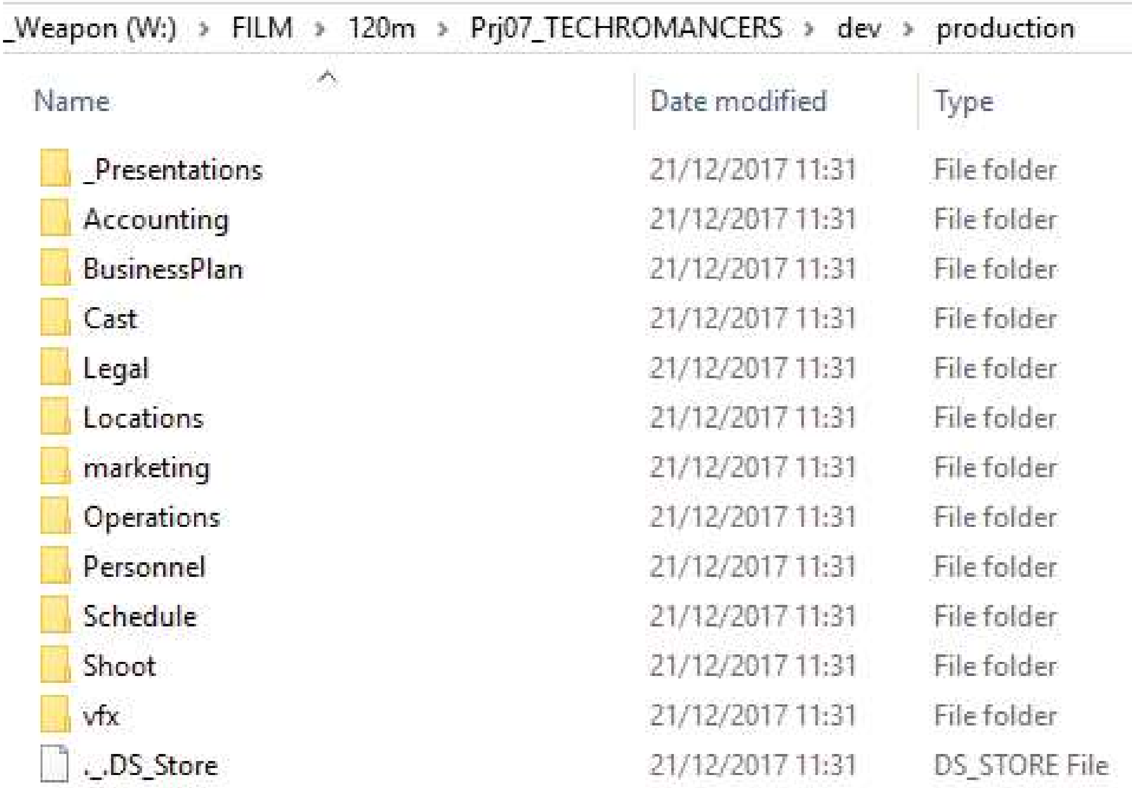


Figure 3-8. "Movies' Downward Trend" (Entertainment Industry Economics, 2013)

3.1.3


_Weapon (W:) › FILM › 120m › Prj07_TECHROMANCERS › dev › production

Name	Date modified	Type
_Presentations	21/12/2017 11:31	File folder
Accounting	21/12/2017 11:31	File folder
BusinessPlan	21/12/2017 11:31	File folder
Cast	21/12/2017 11:31	File folder
Legal	21/12/2017 11:31	File folder
Locations	21/12/2017 11:31	File folder
marketing	21/12/2017 11:31	File folder
Operations	21/12/2017 11:31	File folder
Personnel	21/12/2017 11:31	File folder
Schedule	21/12/2017 11:31	File folder
Shoot	21/12/2017 11:31	File folder
vfx	21/12/2017 11:31	File folder
._.DS_Store	21/12/2017 11:31	DS_STORE File

Figure 3-9. "Production Directories for Gen Zero One (Techromancers)" (Al Kang)

Generally, in any visual commercial entertainment industry property, the writer is the first auteur, commanding a vision that seeks to unify various divergent and sometimes opposing facets of the human condition into a singular emotional experience. The mantra in Hollywood that best exemplifies this is: "Everything starts with a script!" However, it is prudent to investigate in the beginning the enivronment that would need navigation if a commercial idea is to survive. After all, the life of a project doesn't begin with a script. It begins when a potential producer picks up a script, and that producer carries with them an inherent knowledge, bolstered by experience, of the tumultuous waters that await. The process outlined here is an attempt to edify a Producer's experience before we engage with the writing process.

Of note in the timeline provided is the development structure of the writing process, which follows a tradtional path, regardless of the financial picture.

The slow and somewhat organic evolution of a feature film pitch is one that defies any attempt at a structured approach. In mid-to-late 2015, I was fortunate to be at the forefront of a joint Welsh/China/Malaysia Feature Film project from the early stages of its development. During that time, I became acutely aware of how truly powerful the written word was throughout this entire process, and how the writing process itself needed to be preserved in its most traditional form to survive the rigourous stages it would subsequently undergo. Of the many digital assets that were created in support of this venture, from concept art to 3D previsualizations, it was the script that everyone involved eventually came back to, and it was the script that did the creative heavy lifting when it came to creative inspiration. The following 3 figures charts the timeline of Gen Zero One's preproduction process, from pitch inception to preproduction greenlight. At each stage of the process, it was vitally important

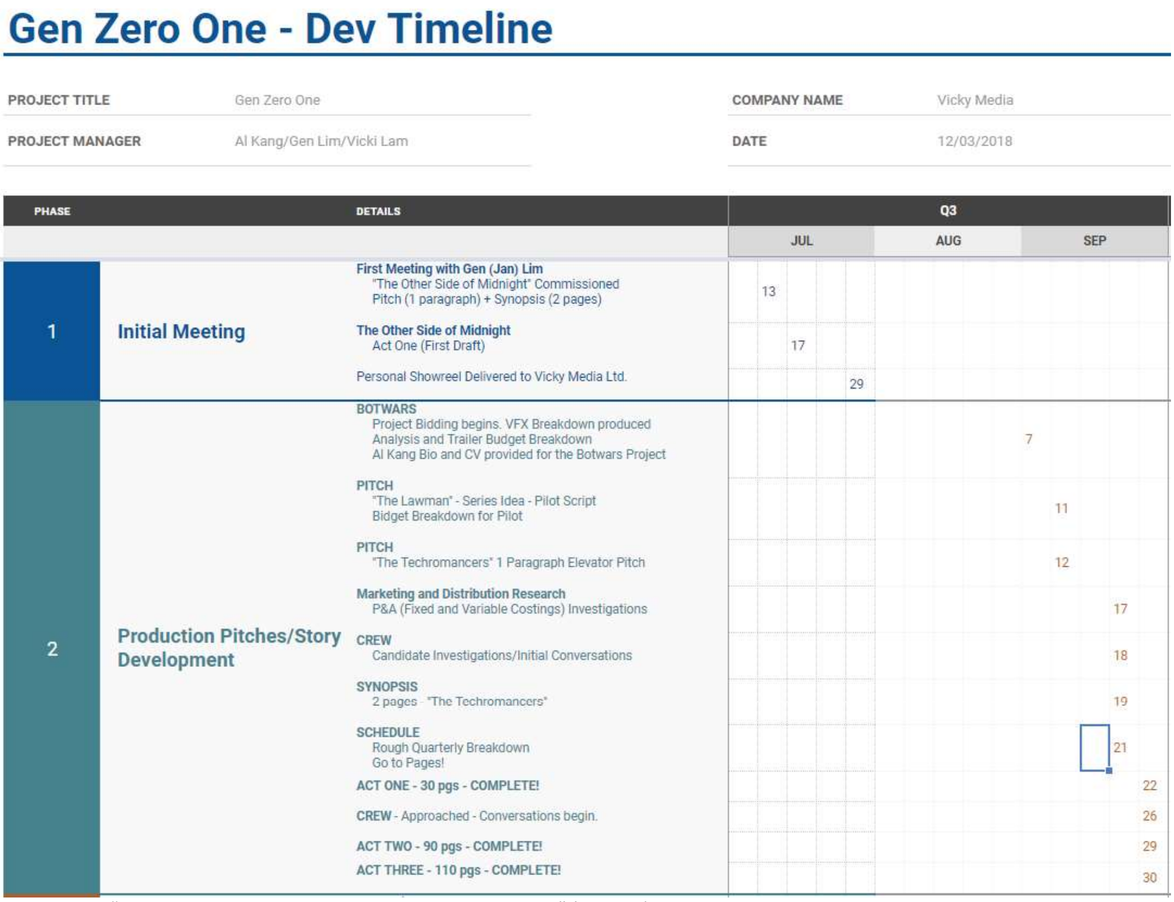


Figure 3-10. "Gen Zero One - A Development Timeline - July 2015" (Al Kang)

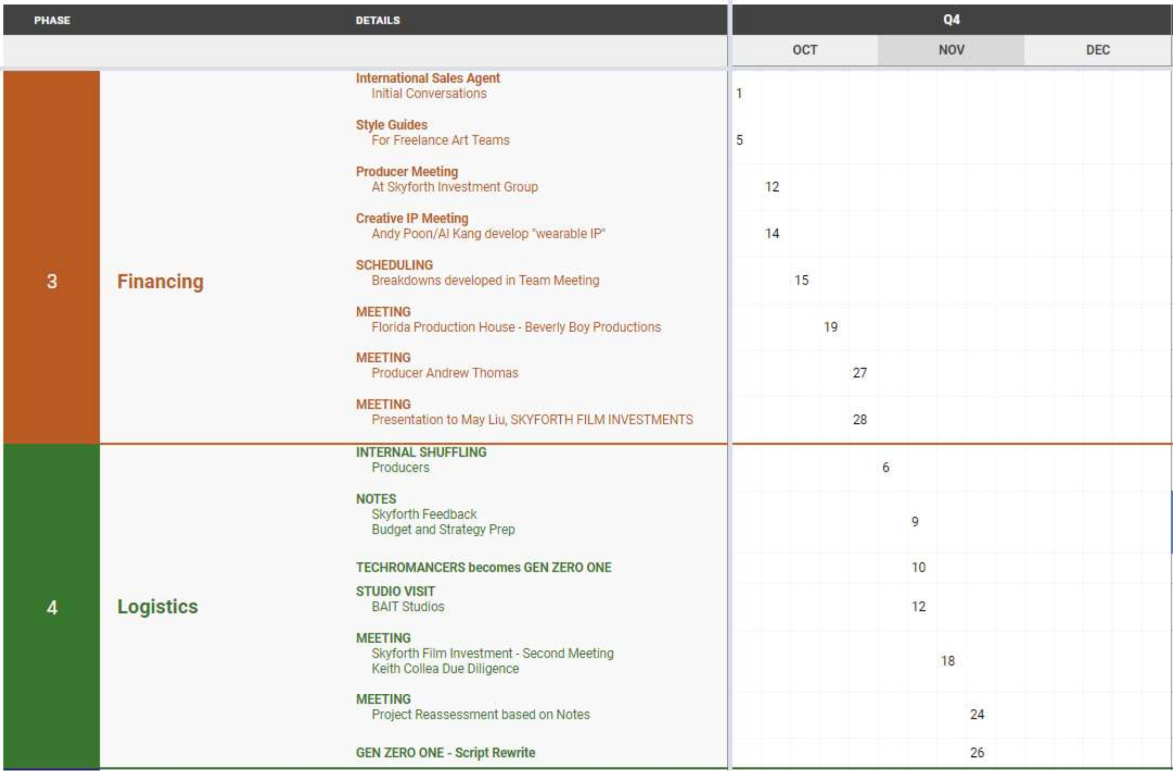


Figure 3-11. "Gen Zero One - A Development Timeline - October 2015" (Al Kang)

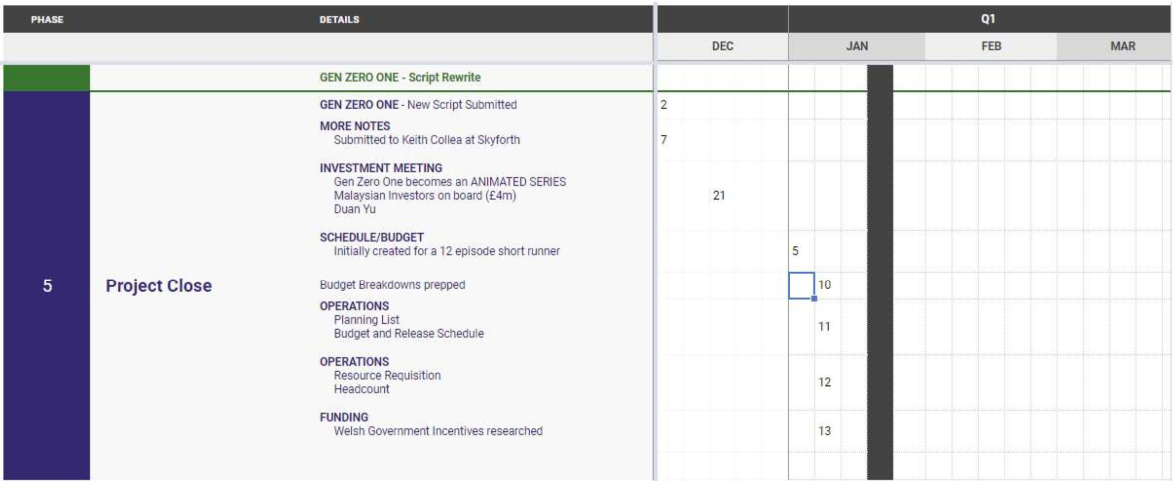


Figure 3-12. "Gen Zero One - A Development Timeline - December 2015" (Al Kang)

that the parties involved remain engaged, inspired and confident about the project. This required an artist's utmost abilities to elicit emotion. There was very little dependency on the actual craftsmanship or execution of any of the production disciplines that followed. Emphasis on assembled crew and collective experience was a mitigating factor during discussions, but of primary importance, overriding all considerations, was the strength of the high concept and the execution of the story elements.

Figure 3-13. "Vicky Media - Company Profile" (Vicky Media, 2015)

Once an Executive Producer has "buy in", or shows a considerable amount of interest in developing a script as a feature film entity, they will begin to engage Agents, Production Managers, and a plethora of agents that begin exploring the commercial connections to help execute the project.

Vicky Lam, of Vicky Media Ltd. in Hong Kong, whoes profile extends to a number of television and feature film properties in China, including the number one reality TV series of all time with over a billion viewers, began the preparatory work to engage investors. Once

VICKI MEDIA

- 电影名称：《科技罗曼史》
- 总预算：人民币3亿（不含宣发）
- 题材：科幻冒险剧情片
- 出品方：
- 海外制作：Vicki Media
- 发行方：
- 制片人：Vaughan Sivell, "Gennaker" Roger Burnell, "It's My Shout!" Steve Clark-Hall, "Skyline Films"
- 编剧：AL KANG，
- 监制：
- 导演：AL KANG， Trent Opaloch, "Captain America:Winter Soldier" Stephen F. Windon, "Furious 7"
- 主演：Florence Pugh , Dylan Minnette, 廖凡， Ryan Gosling ……
- 开机时间：

Figure 3-14. "Chinese Presentation Materials" (Vicky Media, 2015)

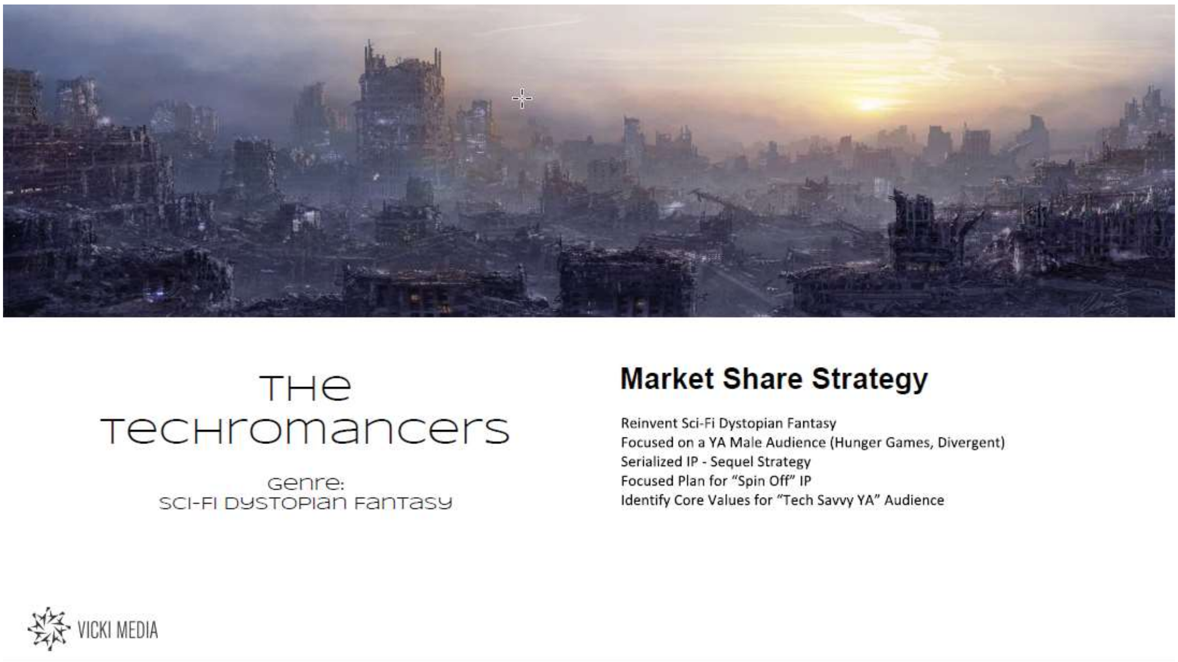


Figure 3-15. "Market Share Strategy" (Al Kang, 2015)

the creative property has elicited the emotional response necessary to generate finanacial interest, the next stage is to identify the market and the customer segments. Ideally, an outside firm is usually commissioned to do an in depth marketing report, but in this case, intial research was conducted by our team.

For obvious monetary and ROI (Return On Investment) concerns, creators vying for external funding will often times need to justify their creative decisions in terms of the acquistion of the broadest possible market share and largest consumer base, which ultimately translates to lower risk and higher rate of return; however, this fits very much in line with how Shaun McNiff, a University Professor at Lesley in Cambridge, identifies as a goal of arts-based research. He encourages arts-based researchers to study how "art has served as a primary agent of change in the world." He also goes on to emphasize how important the understanding of human behavioural psychology is by observing that "it has been said writers are profound psychologists; the same can be said of artists as researchers." (McNiff, 1998). This is key to a conversation that I had with Hanno Lemke, the then-General Man-

Figure 3-16. "Genre Analysis" (Al Kang, 2015)

ager of Electronic Arts Blackbox at the time. When approached by the notion of my ideas for expanding our market share, he replied that he was single-minded in his goal to affect cultural change. He then went on to emphasize that by affecting cultural change, market-share becomes, while still quite necessary, a secondary consideration. After all, as philosopher Alfred Wolfsohn once observed, "theater" is "a form of art that gives existence greater meaning." (Salomon, 1981)

For too long, the commercial aspects of art-making have been ringfenced as a wholly undesirable, yet necessary evil; and yet, understanding the underlying motivations to launching a commercial entertainment venture gives clear perspicacity on how intrinsically tied commercial ventures are to deeply profound expressions of humanity and that entertainment is not merely marketing an intellectual property, but instead is an offering of spiritual catharsis and an opportunity at transcendence. These seem, at cursory glance, as lofty ideals best left outside the boardroom, when in fact it is the sole reason for the meeting to take place.

3.1.4

Engaging with the scriptwriting process was very much a tried and true exercise in participating in a tradtional creative discipline with a historical record of success that stretches back through the generations. I was humbled by how powerful the simple written word was, and how much a simple script could move people before any visual designs were commissioned.

Using the feedback and approval process of various Producers, I gauged my quality criteria around the subsequent notes, revisions requests and approvals I received from them, that were, in turn, formulated by their experience and their own personal successes in the entertainment industry. They were also driven, in no small part, by the successful eliciting of emotional response from the page.

The discovery process at this stage mirrored, quite accurately, the impetus of McNiff who in his own research work "shifed away from experimenting on human subjects and toward the more direct examination of the artistic process." He wanted to "emphasize how even though these artistic expressions may come from within me, I nevertheless attempt to study the art objects and the process of making them with as much objectivity as possible ... the examination is both heurisitic and empirical and thoroughly artistic." (McNiff, 1998).

What intrigued me about the process of selling a feature film is the opportunity to see how the art-making processes translate through such a large, collaborative endeavour.

One key consideration to note, from a philosophical standpoint is that, even though screenwriting is often engaged on computers, laptops, tablets and mobile devices and is heavily reliant on specific software paradigms, never in popular culture do we bestow the moniker "digital writer" on a writer. Yet the term "digital artist" has seeped its way into our vernacular.

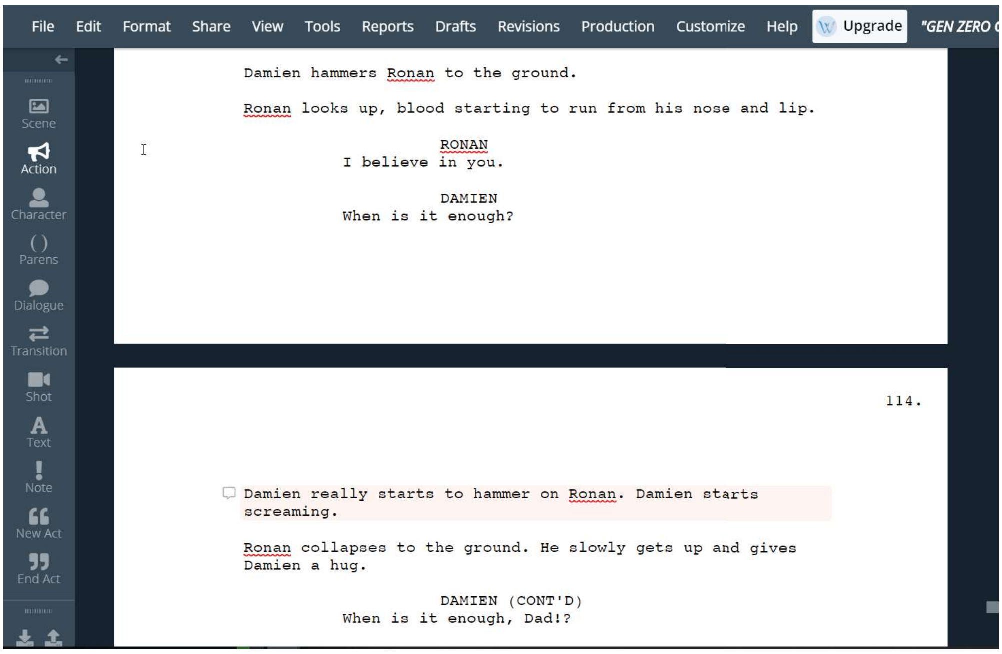


Figure 3-17. "Gen Zero One - Excerpt" (Al Kang, 2015)

3.1.5

The most vital aspect of initiating any digital creative endeavour is the careful construction of the computational foundation that will allow for rapid prototyping and the ability to facilitate multiple iterative experimentation and development at the creative concept level. There is a metaphor that an artist's pencil serves as an "extension" of their arm. This intimates that the creative tool is directly linked to an artist's thoughts and is subsequently invisible. The digital space that is created for an artist must, therefore, also be intuitive and invisible. The connection that an artist feels with their work must be direct, uninterrupted, and instantaneous. Inspiration has often been metaphorically referred to as a "lightning flash", and the resultant illumination lasts for seconds at its brightest intensity, fading rapidly into obscurity. Tapping into that inspirational flash in a digital environment is challenging, and the greater the computational expense required to visualize that moment of revelation, the longer it takes an artist to "capture the lightning". The resultant delay may mean that the most inspirational conceptualizations will irrevocably vanish as artists and creators "wait for the loading bar". It is primarily due to this reason that the success and/or failure of any digital project relies heavily on the construction of a robust and invisible pipeline, that not only supports an artist's creative process but also nurtures the freeform experimentation that is a necessary part of inspired invention.

In previous chapters, we examined case studies of "production death marches" and project "trials-by-fire". We analysed production "best practices" and those pipelines that worked where others had failed in an attempt to identify, not those key areas that failed to facilitate rapid delivery of product, but those that short-circuited the creative process required to achieve artistic excellence.

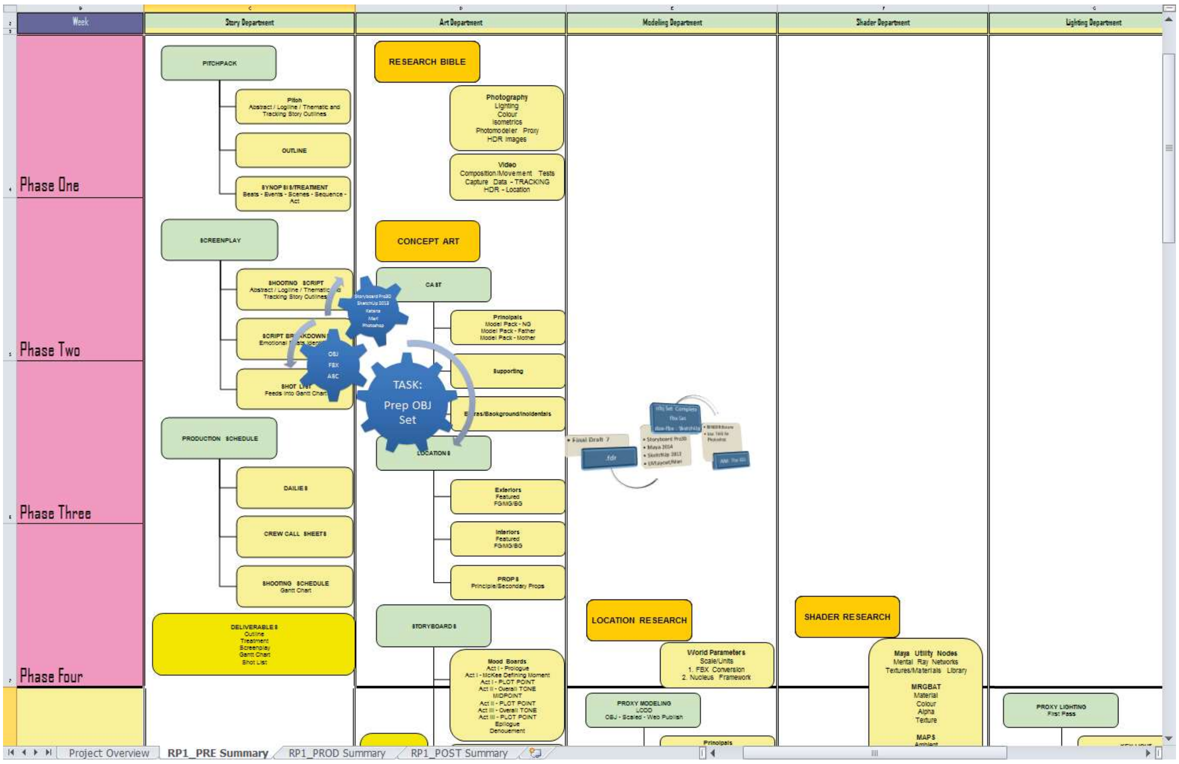


Figure 3-18. "Pipelilne Planning"

More often than not, the ability to design an effective pipeline is reliant on a previous project's culmination, and its post-mortem report, as best practices are harvested and pitfalls are identified. The process of pipeline design very rarely has any allotted scope at the outset of a project due to the demands of delivering assets almost immediately and the rapid ramping up of various departments and their staffing requirements. If a pipeline is not in place when this process initiates, individual teams will begin designing their own pipeline branches, bespoke to the assets each department is responsible for. As artists begin to seek out "digital space" to which they can begin uploading their daily work, pipelines can rapidly become entangled as server space becomes a premium. Necessity is the mother of invention, and as artists need to start delivering work, they will start inventing places to put it, and within a studio environment, this can prove detrimental to daily operations.

In an attempt to circumvent the myopia that results from individual departments solving individual workflow issues within their own branch of a project pipeline, it is essential to examine all aspects of a collaborative digital project (albeit at a relatively manageable scale for this research). To determine how best to facilitate an artist's creative process, not only in their individual roles within their own departments, but contextually within the scope of the entire project as a whole, 3 different case scenarios were undertaken during the course of this research and the commonality they share within the various 3D digital asset creation disciplines was closely scrutinized. The overarching goal was to design a modular template that could be adopted for any project, with very little built-for-purpose modification. As every project requires a pipeline to be flexible enough to adopt project-specific issues that may arise, the pipeline template will also encompass a minimum and maximum scope. As this is a digital pipeline as well, technological developments within each discipline's respective field must also be taken into account.

These projects were as follows:

A CG Animation Project

A Game Development Project (Game-side)

A Short Film Project (Live-Action with VFX)

Each of these projects posed their own inherent problems and challenges requiring their own creative solutions. For each of these projects, however, the one common practice that suited all initial pipeline design phases was the identification of two tiers of design: the high level pipeline and the detailed artist workflows.

Within the high level pipeline overview, two distinct courses needed to be charted:

The Overall Creative Pipeline

The Creative Ideation Process

The Discipline Pipeline

The Overall Asset Pipeline

The first point identifies the creative vision and charts its development; the other point discusses how multiple departments will be interacting in the digital asset creation process.

The "Overall Creative Pipeline" itself encapsulates the Ideation Process, which is ethereal and inherently intellectualized, followed by the development of a process for generating tangible assets. The creative ideation process itself cannot be adequately quantified, or designed in any sort of linear fashion. In fact, inspiration necessitates the cross-referencing of radical, sometimes diametrically opposed ideas and notions, and by its very nature, needs to be fluid in its chaotic incarnation. The type of workflow necessary for the initial creative conceptualizations of a project run anathema to the structured, linear needs of a set schedule, with set and defined deliverables. The only way to encapsulate this elusive, initial phase is by loosely defining "phases" that allow a large measure of freedom for exploration and experimentation.

The "Creative Ideation Process" encapsulates both the writing discipline and the arts, in terms of loosely defining an idea and then slowly refining it through several iterative passes. These three stages are as follows:

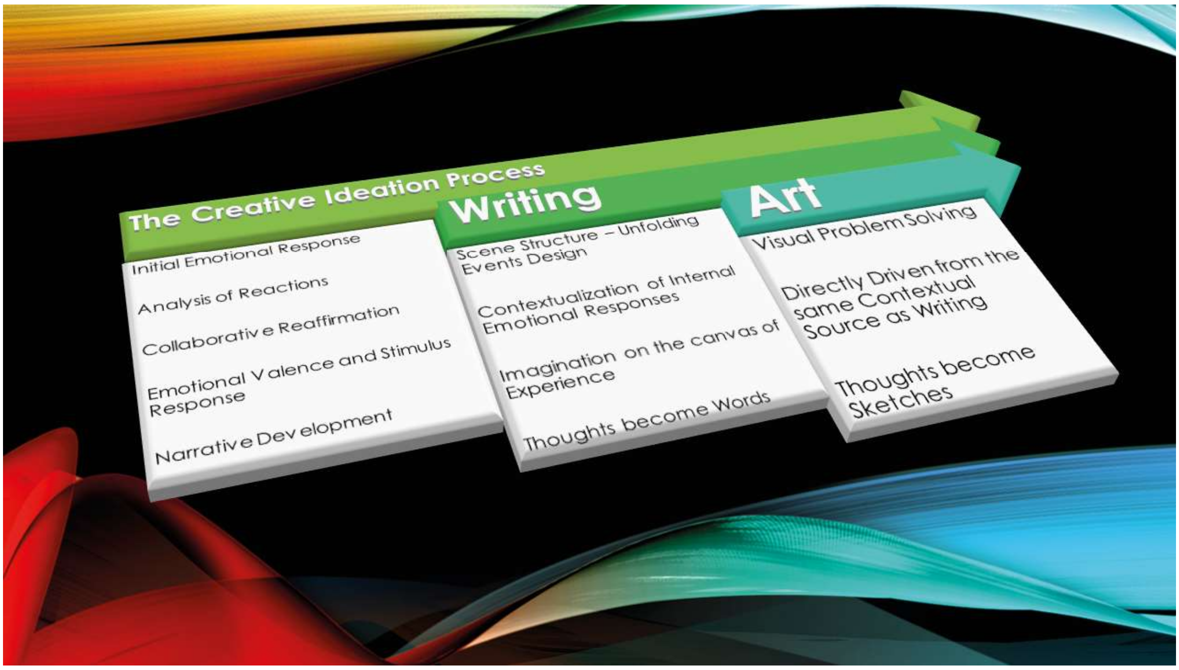


Figure 3-19. "The Creative Ideation Process"

IDEATION

Inspiration

Driven by a single moment of clarity.

Built from individual experiences.

Identification of a Universal Truth.

Initial Emotional Reponse

Analysis of Reactions

Collaborative Reaffirmation

Emotional Valence and Stimulus Response

Verbal Narrative Development

Director-driven Peer Review

WRITING

Emergence of Scene Structure

Unfolding Events Design

Contextualization of Internal Emotional Responses

Imagination on the Canvas of Experience

Thoughts become Words

A writer writes.

ART

Visual Problem Solving

Directly driven from the same contextual source as Writing

Thoughts become Sketches

Don't talk it up. Mock it up.

The "Ideation Phase" and the creative processes involved cannot be adequately encapsulated within the scope of this paper, but its distillate form, in terms of the process of digital content creation, can be touched upon at the outset of analysis of the Overall Creative Pipeline. The concept of "inspiration", what the general public perceive as "divine intervention", can actually be scrutinized on an analytical level, in an attempt to design a process that can feel "truly creative" within the confines of a digital delivery mechanism. Inspiration is often mistakenly identified as the onset and culmination of a truly innovative and original creative idea, when in actual fact, it serves merely as the catalyst for the hundreds of iterations that follow in the process of carefully carving out true divinity in an artist's digital works. Even though the ideation phase kicks off with that single moment of clarity generally perceived as "inspiration", there is a large quantity of refinement work that must follow to prevent creative ideas from stagnating and becoming cliché. An artist's moment of inspiration is often built from within their individual experiences and contains emotional power due to an overt and/or subtle identification of a universal truth. To be able to understand the creative emotional journey that an artist will endeavour to build, it is incumbent upon them to first identify their initial emotional response and analyse their own internal reactions. This is vital in terms of understanding why an idea "works", on both a visceral and an emotional level. Once the powerful emotional core of an initial idea is identified, often an artist, creator and/or writer will seek out collaborative reaffirmation from peers and co-creators. The initial idea is then refined in the subsequent feedback loop, based on emotional valence and stimulus response, creating a more developed level of complexity to the initial emotional responses. It is at this stage that a verbal narrative development begins and very shortly will transform into a more tangible incarnation. Writers and artists alike generally exit this phase using a shorthand for their ideas that exists either as handwritten cue cards, in the case of a writer constructing their narrative, or thumbnail sketches, in the case of an artist exploring shape, gesture and form.

The writing process is generally engaged first (with a few very rare exceptions) and is inarguably the most valuable step in creating a cinematic narrative creative property, whether it's a digital animation or a VFX-based live-action feature. It is during the writing process that the initial narrative scene structure begins to form. A writer begins to peel back the unfolding events that lead to the heart of the initial idea and begins to contextualize all the internal emotional responses that surround that moment. Imagination is often painted upon the canvas of our experiences, and as thoughts become words a writer is suddenly afforded a perspective of their original idea that begins to take root in the real world. Experience helps to paint the subtle details of an imagined fiction that lend it believability and nuance.

The writing process culminates in a final shooting script that generally passes to the art department, where the process of "visually problem solving" the narrative begins. Many of the same considerations that an artist confronts will also be part of an artist's process, as they try to interpret from the same contextual source as the writer. Thoughts are engaged in a visual medium, most often times as simple sketches and ideas are quickly iterated upon in a very exploratory, experimental fashion.

Both the writing process, and the concept art process, are generally executed in serial when it comes to cinematic narrative projects, whereas a parallel development model is often used in games development.

When the relationship between writing and visual conceptualisation culminates in a concrete vision, the structure for building assets and delivering shots begins to coalesce around a set of defined disciplines. These disciplines can generally be grouped into sets (based on shared assets) and generally follow each other in a more structured manner, compared with the initial ideation phase.

Figure 3-20. “Essential Early Disciplines”

The Story Department, Art Department, and Technical Art Department generally begin a concurrent relationship. As narrative moments develop, concept artists find visual ways of communicating and solving certain narrative issues. Any sizeable technical issues that can be foreseen during the concepting phase can be red-flagged and passed to the Technical Art Department for further research and development. As simulation times and render times are generally merciless during deadlines, having a core group of technical artists dedicated to a variety of problem-solving endeavours, even at this early stage, is a wise course of action, especially for a VFX heavy property.

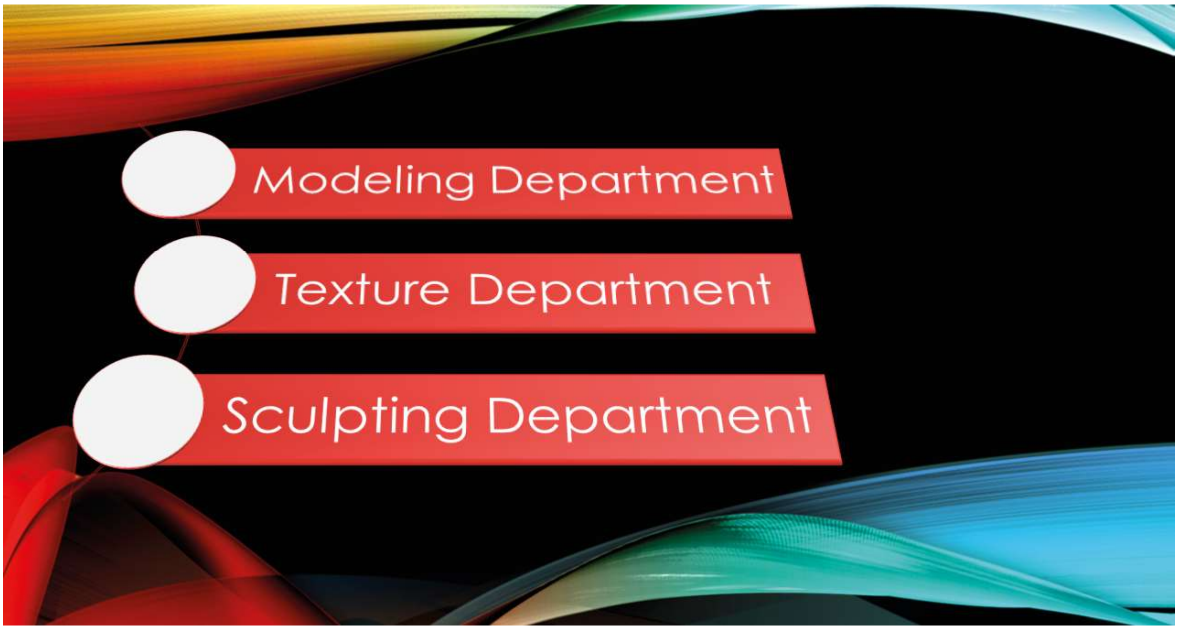


Figure 3-21. "Sculptural Art Asset Pipeline"

The Modeling Department, working closely with texture artists, begin working on tangible, trackable assets based upon final designs received from the Art Department. Occasionally, a production will have a separate Sculpting Department, where high-end artists begin digital maquette work, which can range from being digital doubles to creature work.

Figure 3-22. "Look Development"

In the past few years, the Shader Department, Lighting Department and Camera Departments have, in one incarnation or another, formed a collective discipline loosely defined as “Look Development”. As more and more bespoke tools designed for creating a uniform visual signature become commercially available, the discipline of Look Development is slowly maturing. The ethos behind look development, or “Look Dev”, springs from an art team’s desire to create “On Target” visuals, in the digital medium of their choice, with the ability to see their final work as it will appear in the finishing application. It must also be noted that the Shader Department has a close foothold in the texturing discipline, in terms of bringing surfaces and materials to life in a final render.

The Rigging Department (Creature TDs, Character Set-up Artists), Animators, and Simulation Department are generally responsible for bringing kinetic life to those things that exist solely within the imagination. It is, ultimately, the performance of these digital characteri-

Figure 3-23. “Characters/Performance”

zations that will harken back to the emotional core so carefully nurtured during the writing phase of a production.

Figure 3-24. "Characters/Performance"

Working closely together on shot methodology are the Rendering Department, Compositing Department, and ultimately, the Editing Department. It is in these disciplines that the heart of a truly effective shot delivery pipeline can be created.

Figure 3-25. "Audio"

Finally, Sound Production and Design, working closely with Editorial, bring a finally narrative layer to the production that could not be possible in any other traditional narrative medium.

Together, these departments create a skeletal structure for the Discipline Pipeline. Once these are loosely identified within a studio, the identification of inter-departmental dependencies and format strategies for digital delivery can be further broken down. At this point, the pipeline being designed is purely theoretical, and rooted heavily in projects the preceded it. It is only when assets are delivered through this structure that those problems can be identified. This will be further expanded on during discussions of the preproduction phase, and incorporating its classically isolated pipeline into the overall studio structure.

Communications and Change Control are vital ingredients to any effective studio structure, especially in terms of creating an effective feedback loop with multiple art departments; but before we can discuss how each department will communicate, we need to understand what the topic of conversation will be. In that regard, having a generally idea of what each department, during each phase, will be responsible for is an important initial discussion to have at the outset of any project.

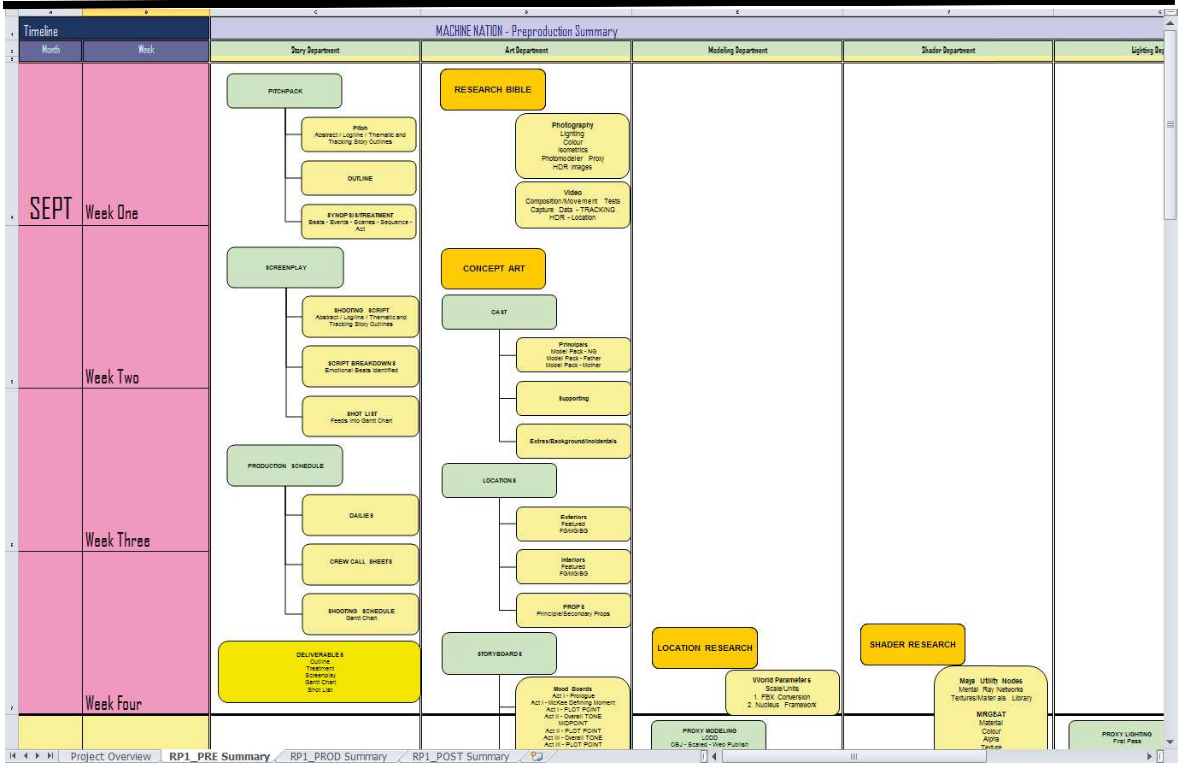


Figure 3-26. "Typical Studio Environment"

If we take a look at a generic breakdown of each department in a typical studio environment, we can see at a glance what are the known deliverables and when in the timeline they generally begin development.

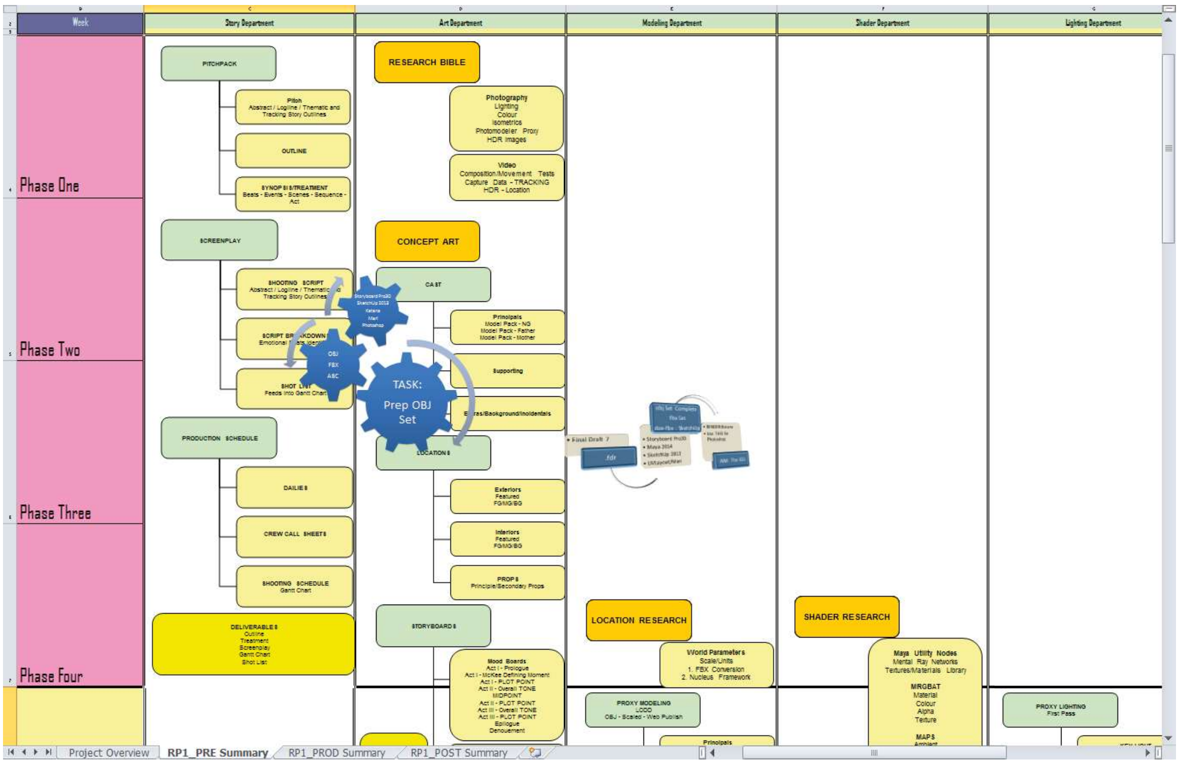


Figure 3-27. "Data Bridges"

If we then overlay this investigation with discussions of what file formats can best support data interchange between disciplines, we can start to develop an understanding of how best to set up a digital development environment.

THE FDR WORKFLOW

The digital workflow from script to storyboarding to our eventual shotlist and master gantt chart is an exemplar of how this connectivity between disciplines can aid the creative process during preproduction. The adoption of Final Draft's .fdr file format by Toon Boom's Storyboard Pro has helped to smooth the transition to the Art Department and the use of the .fdr file format by mobile-based screenwriting packages, such as Scripts Pro means that the writing process is constantly available to the screenwriter, wherever inspiration may strike. As an intermediary, Storyboard Pro also has the facility to export timeline based .edl files, another universally accepted file format, which allows any non-linear editor to build a shot-based sequence automatically.

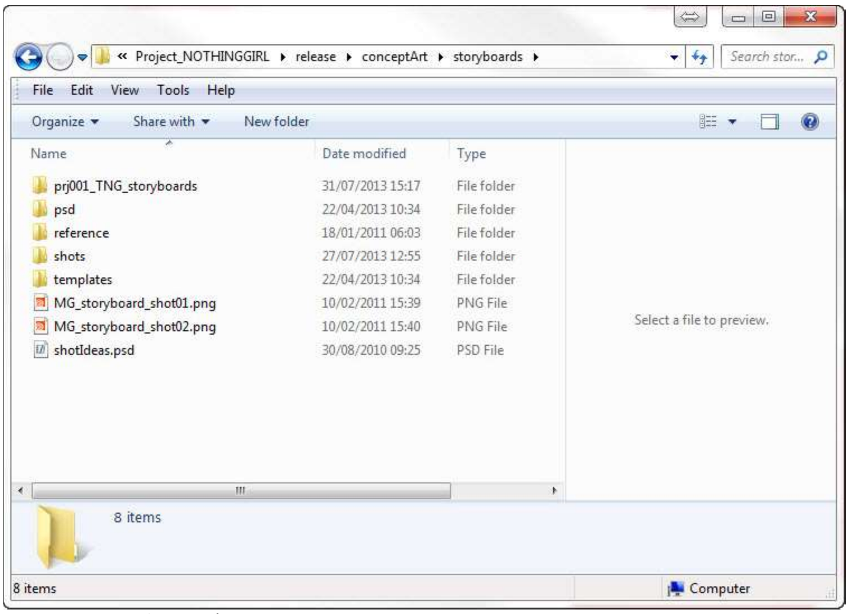


Figure 3-28. Setting Up the Directory Structure

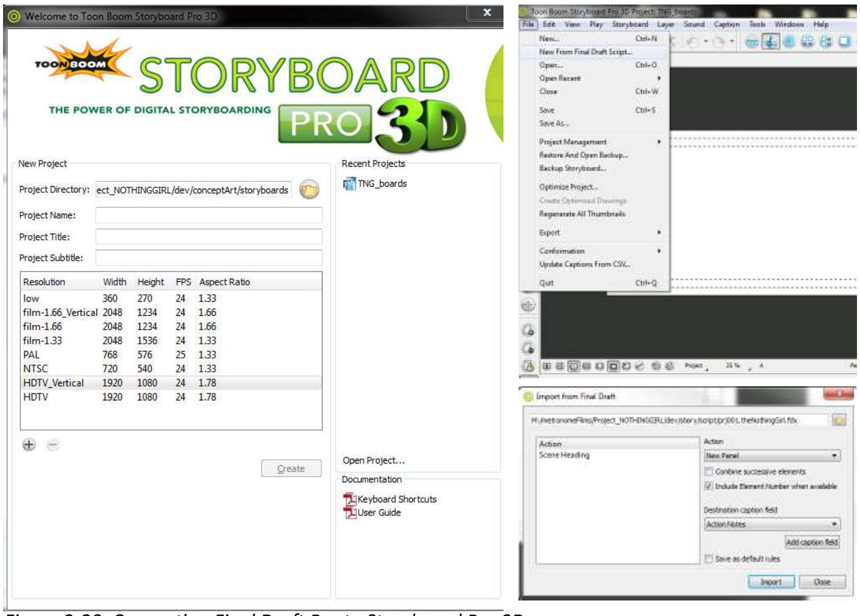


Figure 3-29. Connecting Final Draft Pro to Storyboard Pro 3D

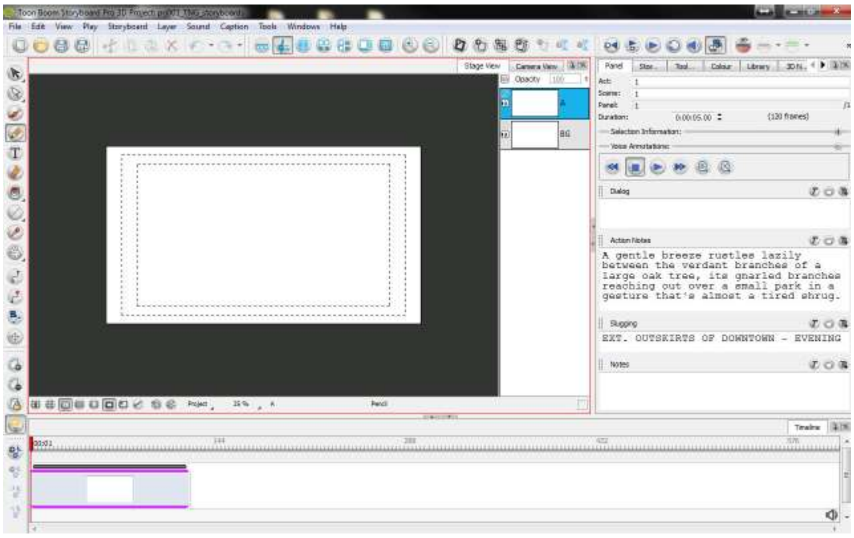


Figure 3-30. Script in Storyboard Pro 3D

Creating a seamless software relationship between Final Draft and Storyboard Pro (coupled with a universally located and accessible version control server) automatically connects the writing team to the concept art team, removing the processes of notification, delivery, acquisition and ingestion that would normally need to take place and affords a cross departmental overview, where creative changes can be seen instantly, is vital in the two disciplines that are, arguably, the most creatively volatile.

THE ADOBE INDESIGN WORKFLOW

Project documentation is likewise facilitated by the adoption of Adobe's content authoring suites. In particular, the InDesign/InCopy workflow cleanly separates the discipline of layout and editorial from writing, yet maintains a live connectivity between the two disciplines via a software engine that continually keeps file versioning up to date from both departments, across a network, and feeding directly into a single document template.

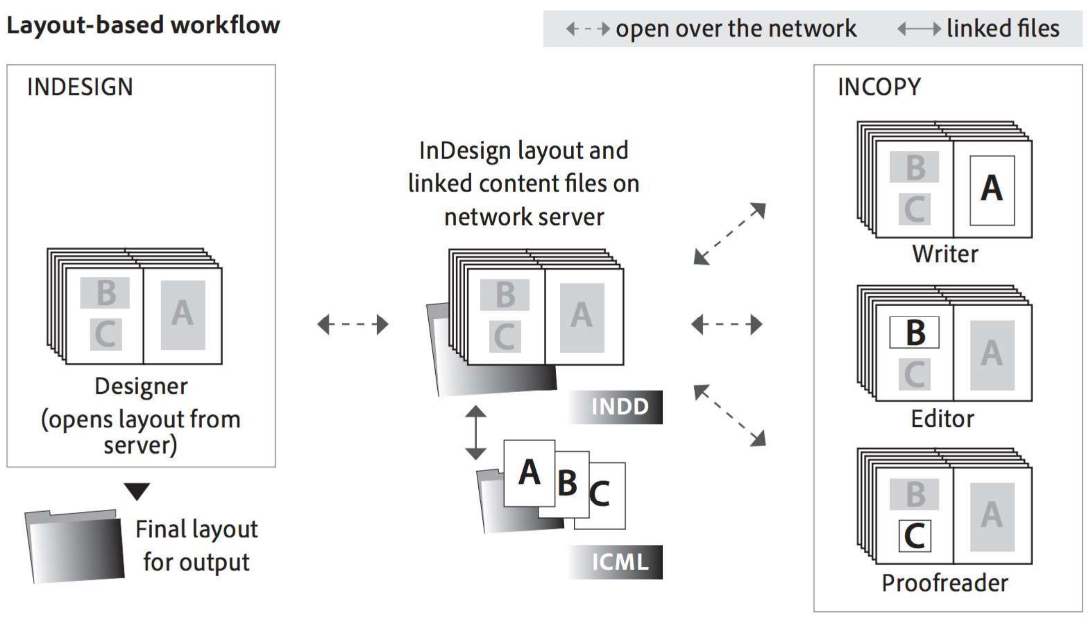


Figure 3-31. The InCopy/InDesign Workflow (Adobe, 2017)

Similar in philosophy to the connection between Final Draft and Storyboard Pro, the InDesign/InCopy workflow significantly advances the complexity of joint collaborative document creation by also maintianing links to graphical and animated elements (auspiciously connecting art departments to the cohesive whole).

THE AVID CONFORMING WORKFLOW (EDL-Driven Design)

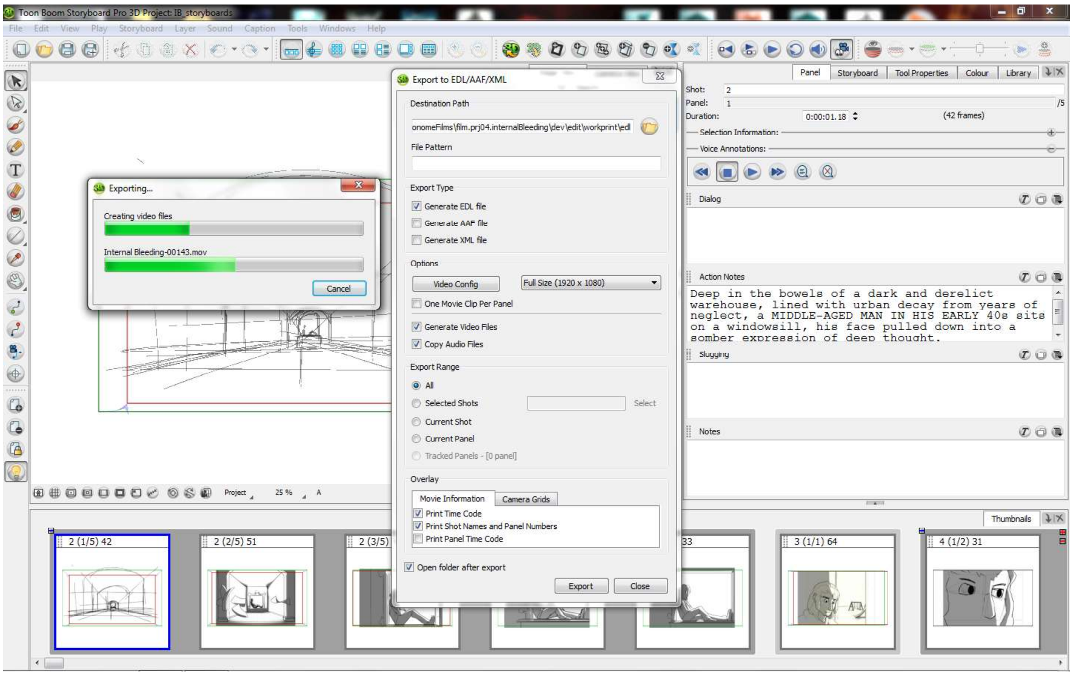


Figure 3-32. AVID/Storyboard Pro Workflow (Al Kang, 2015)

To test the efficacy of including the editorial disciplines into a connected, collaborative engagement, the adoption of the EDL file format in the daily exports was thoroughly tested. Although there was not facility to maintain a live connection (with immediate file updating across the network), storyboards could be delivered to an Avid editorial suite for immediate and painless ingestion into a progression timeline.

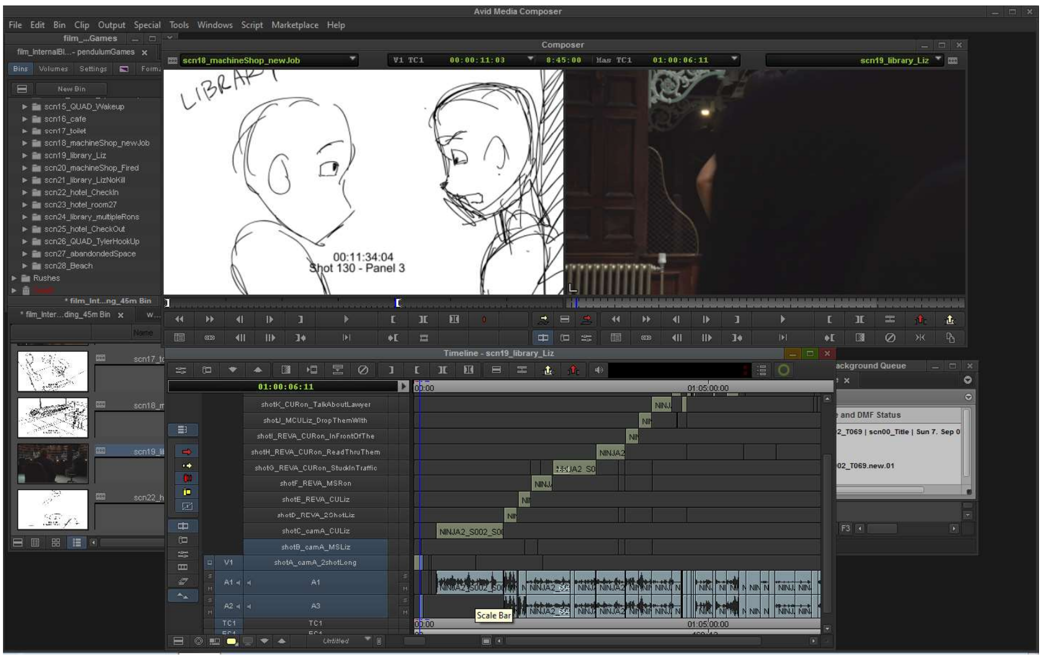


Figure 3-33. Storyboard Ingestion into AVID MC (Al Kang, 2015)

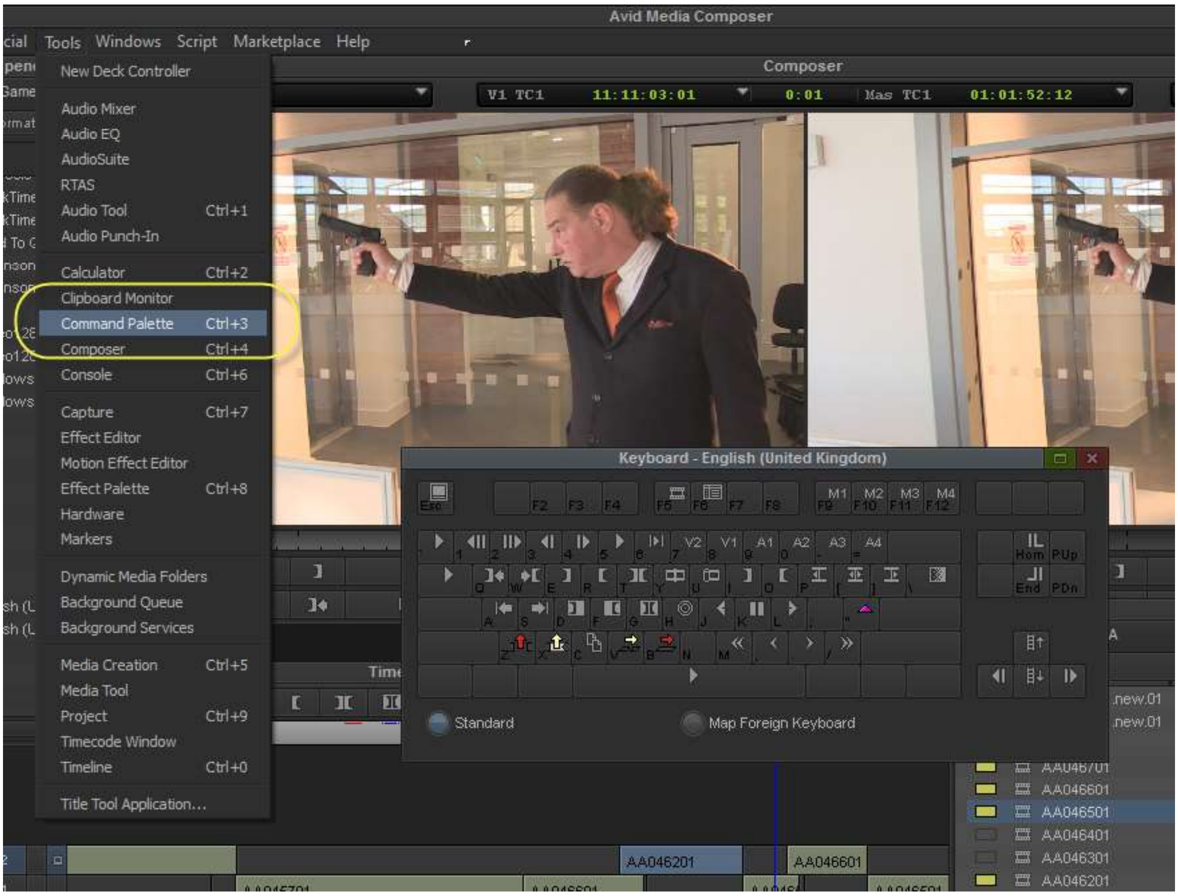


Figure 3-34. Inside the AVID (Al Kang, 2015)

Once an AVID editorial suite is involved, however, pipeline connectivity design increases in complexity by several orders of magnitude. We will delve into the specifics of how to integrate the script-to-board-to-shotlist pipeline momentarily. Editorial needed to be set-up with a forward thinking shot compositing conforming pipeline that would need to include both After Effects and Nuke. Thankfully, The Foundry, creators of Nuke compositing software, developed a trimmed down NLE (Non-Linear Editor) called Hiero that could ingest an EDL and, by way of macro, create ready made compositing files directly connected to its timeline with live updates. A VFX editor, working inside of Nuke, would then have instant visibility on what a team of compositors was producing.

This chain of connected software was tested during the production of the short film, "Internal Bleeding" and successfully created a quick and efficient environment for shot ingestion, editorial and compositing work. Having various artists working synchronously on a project where assets are visible across the creative spectrum created a synergistic feedback mechanism where everyone involved could easily interpret and implement the visual style of the director's vision.

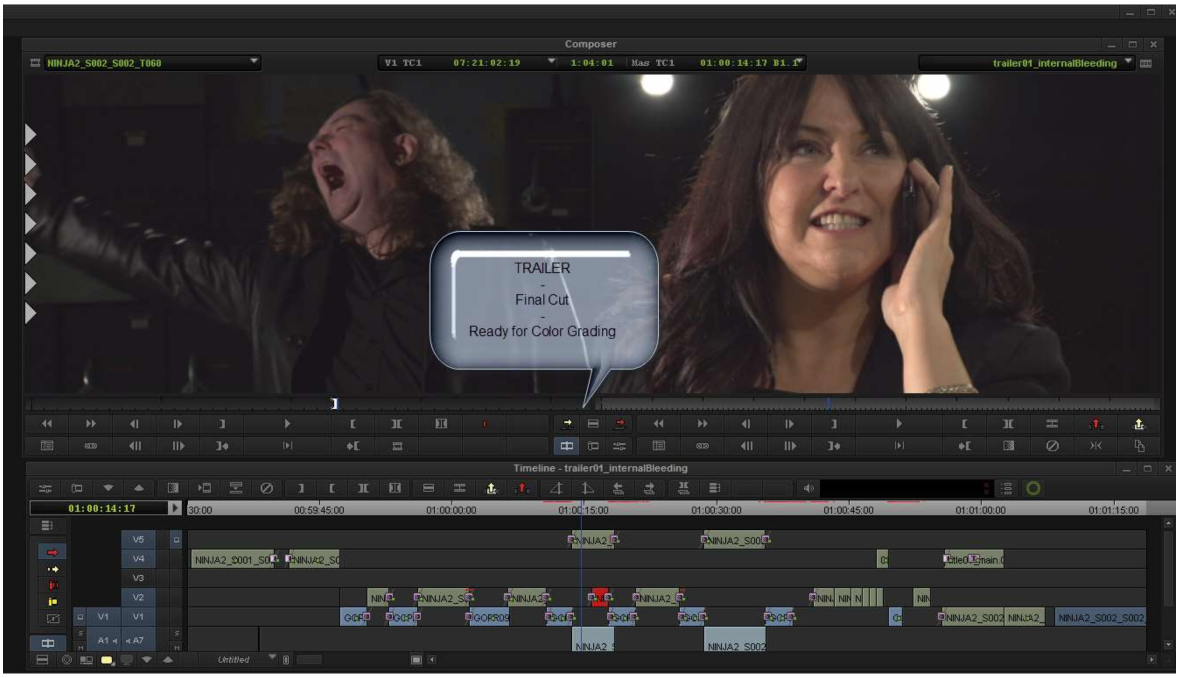


Figure 3-35. Timeline Prep for Export (Al Kang, 2015)

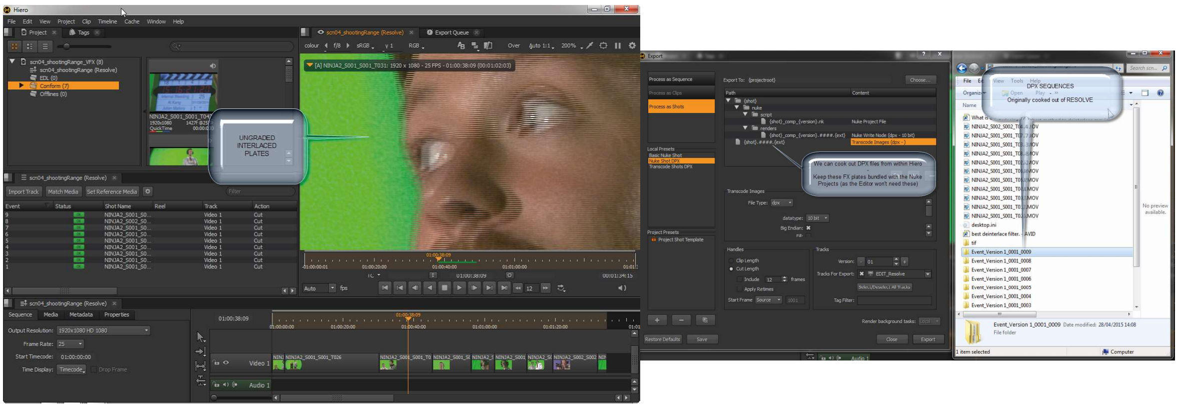


Figure 3-36. Conform Pipeline: Hiero to Nuke (Al Kang, 2015)

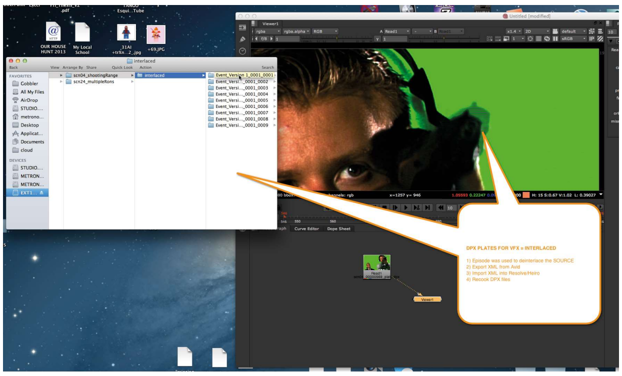


Figure 3-37. Footage in Nuke (Al Kang, 2015)

Once a high level understanding of how assets will travel from one department to another is established, a working development environment can be constructed using placeholder content for all known variables.

Although it seems quite logical to build a production infrastructure linearly, from start to finish, balancing variables along the way and integrating as many existing best practices on a per department basis into the overall pipeline, this methology lends itself to a production that loses sight of the end goal. As a production evolves ever closer to the point of generating tangible, trackable assets, the Overall Asset Pipeline needs to be designed. Arguably, the mechanisms for this should already be in place, with the Art Department delivering the first viable workflow tests. Preproduction also affords a creative team their first opportunity to implement and test their change control process and communication/feedback model, but this relies on the foresight of treating a preproduction cycle in the same context as a "mini production".

Examinig the live-action VFX film case scenario, two experimental design models were utilized. All production materials, schedules, document assets and team communications were shifted from the standard server-based network model to a cloud based paradigm and the asset production pipeline was created back-to-front, with the final deliverable controlling the pipeline's overall structure.

The inclusion of online repositories for the communal access, uploading and editing of project files is a relatively new addition to the content creation pipeline, and one that is rapidly gaining favour in the creative community. Not only are relevant files accessible anywhere a wifi signal is available, but these self-same assets are also accessible by a multitude of different digital devices.

To contrast the standard server/workstation studio pipeline, an alternative project set up was engaged for “Internal Bleeding”.

Two very important considerations were scrutinized at the outset of the design process:

Identification of the Primary Delivery Medium

Identification of the Central Controlling Application

In the case of the live-action VFX short film, the Primary Delivery Medium would be the cinematic narrative, delivered in a variety of broadcast formats, with AVID Media Composer as the central controlling application, or the finishing application.

EDL-DRIVEN DESIGN

Connect

Avid

ProTools

Hiero

StoryboardPro

Maya Camera Sequencer

RENDER PIPELINE

-

Katana

Nuke/Mari

Arnold

With Nuke effectively sharing a relationship with an editorial timeline, the only connection left outstanding for “Internal Bleeding” was the Katana-based rendering pipeline and its inherent connectivity to the post-production editorial workflow.

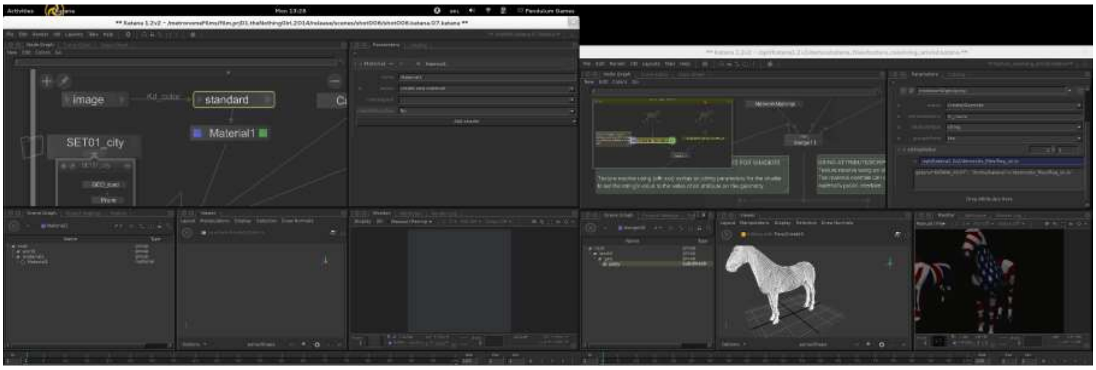


Figure 3-38. Katana (The Foundry, 2015)

Once the production landed on the lighting stages inside of Katana, all creative endeavours came to a screeching halt for two immediately discernable reasons:

1. The Technical Complexity of Katana
2. Exclusively Available on the Linux Platform ONLY

Cloud-based Workflows

The inclusion of online repositories for the communal access, uploading and editing of project files is a relatively new addition to the content creation pipeline, and one that is rapidly gaining favour in the creative community. Not only are relevant files accessible anywhere a wifi signal is available, but these self-same assets are also accessible by a multitude of different digital devices.

3.1.6

The Elegance and Fluidity of Working in the Cloud

Sometimes evolution is attributed to happenstance, and a series of chronological, unrelated events may bear all the hallmarks of an accident, when in actual fact, their development may have been a foregone conclusion at the outset. Take, for example, how the writing process has evolved inside of the digital hemisphere and the mishmash of content creation packages that have built up around the process itself. At first glance, this conglomeration may appear somewhat haphazard; but once we understand the process, we can see that software designers have been building towards a rigorous, consistent process.

The writing process best exemplifies an evolutionary step in digital content creation. Driven solely by the needs of the creator a whole infrastructure has evolved to support this essential creative process. Digital authors have not been unduly saddled with effectively understanding the inner gears and plumbing of software at a technical level (with a few notable exceptions which shall be addressed herein), but rather, software engineers have supported the writing process by understanding the needs of writers and creating effective software design solutions. This frees up digital authors to focus on the excellence of their craft, which is the business of writing.

With the emergence of so-called “cloud technologies” and “smart devices” the writing process has not suffered several orders of magnitude of complexity, as has happened with other notable digital creative processes, but quite the opposite.

Although it can be argued that digital content creation, and the assets they generate, are at a computational level never before seen in the world of computing, whereas the text files generated by the writing process have remained relatively unchanged, the time-honoured traditions of creating music, art, and literature have a refined process that dates back further than any digital process to date. Authoring digital literature, and the inherent workflow it presents, should be an exemplar of how process must drive software design if we are to create tools that will allow the specialisms we desire to rise to the surface.

Two major forms of writing have been undertaken during the course of this research. The first being the authoring of this paper for the purpose of academic discourse and publication and the second being the creation of a short screenplay for the purpose of independent production.

While the academic writing process has rigorously tested the digital document creation pipeline popularized by the Adobe InDesign/InCopy workflow, the creation of the screenplay identifies the strength inherent in a universally accepted standard file format and the versatility that that provides to the creative process. The file format in question is Final Draft's .fdr extension.

Both of these factors have contributed to a creative writing process that, even in lieu of persistent technical shortcomings that still linger, proves to be the most seamless and unencumbered workflow of all the digital creative arts. The Adobe workflow necessitates the adoption of Adobe's creative suite of tools while the .fdr file format is a standard which companies have developed around. We will eventually see a reflection of this dichotomy in the CG creation process when we examine both Autodesk's suite of tools in comparison to universally adopted file formats, such as the once-stable-now-volatile .fbx file format and the open source ILM openEXR initiative.

Given the cloud-based workflow discussed in a previous chapter, a relevant anecdotal example of the seamless integration of technology and the creative process is the ability to engage a writing project on a desktop workstation, continue its development inside a mobile computing device, refine and reiterate the content on a mobile phone, and continue developing the property on another desktop workstation. This process encapsulates the creative process, allowing it to continue, unabated, and encumbered only by the slightest of technical considerations.

3.2.1

To effectively understand how the digital creative industries are trending, in terms of art creation philosophies, it is necessary to examine the intense struggle of early attempts at diverting a technical pipeline towards a more artist-centric one, the problems encountered and how, ultimately, the end result adequately demonstrated that this shift in focus produced a greater level of visual fidelity. In this case study, practical experiences garnered by this practitioner while engaged in industrial work at Electronic Arts are particularly relevant for a number of key reasons. Electronic Arts, at the time of writing, is the world's fourth-largest gaming company in terms of revenue behind Tencent, Sony and Microsoft, and is appropriately positioned to deliver triple-A level gaming experiences on a global scale. In terms of cultural impact, Electronic Arts has contributed its fair share to popular culture and its design philosophy in that regard is worth investigating. In addition to Electronic Arts' position in the market, this researcher was recruited to develop new intellectual properties for Electronic Arts, some of which became enormous commercial successes, including Need for Speed Most Wanted and EA SKate, their newest game franchise. As this researcher was a practitioner on the forefront of creating new and exciting international brands, the pipelines and artist workflows developed during production provides an excellent springboard from which to examine a common methodology for harnessing the highest level of creativity from both individual artists and various art teams.

Electronic Arts' Skate franchise was an excellent proving ground for EA Black Box (a satellite studio located in Vancouver, British Columbia) who had, up until this point, never engaged in any character-centric game titles. Suddenly tasked, not only with creating a strong, character-centric new title, but also building a digital creation pipeline from scratch, would not have been possible without a shift in focus to artist-centric creation methodologies.

The largest philosophical paradigm shift came in the area of preproduction which, up until that point, was considered an optional luxury for game teams without any relevant applications to the main production team. The establishment of EA's first previsualization teams on Most Wanted, Skate and NBA Street helped to create a new philosophy that would radically alter the landscape of how game teams approached creative ideation.

Figure 3-39. "EA New Franchises"

3.2.2

EA's SKATE: A Prototype Workflow

Figure 3-40. "Game Previsualization" (Al Kang, 2006)

One of the primary goals of the Previsualization Department at Electronic Arts, Black Box Studio, was to develop completely visceral experiences, creating the sensations of a living breathing synthesis of energy, emotion and adrenaline purely by manipulating visual aesthetics alone. Stimulus response was a thing of the past, and several development teams, including the senior art team from titles such as The Need for Speed: Most Wanted, Skate, NHL07, and a number of covert creative teams developing new intellectual properties, began to adopt the term "unique visual and emotional signature" (UVES).

The net result of UVES was that it would offer a meticulous attention to detail that was

Figure 3-41. "UVES: EA Skate" (Al Kang, 2006)

heretofore never achieved in realtime CG properties. Of vital importance to the conceptual art and previsualization teams were the finer intricacies and high frequency details of game assets. The Need for Speed: Underground art teams developed light streaks created from long exposures, while the Most Wanted team focused on shifting apertures and bleach by-pass effects, and the Skate team began in earnest to investigate the interaction of cloth with dynamic character movement.

It is upon the results of early research and development engaged in by the previsualization artists of the Skate team that the primary focus of this research has been built. It is therefore fitting that all further discussions begin with a review of the techniques derived from Skate's preproduction period. Upon examining final execution of Skate's clothing solution as a case study, further investigations into refinement of that methodology in terms of convergent intellectual properties and applicability to offline rendering solutions has resulted in the development of a more intuitive artist-centric workflow with applications to all areas of visual asset development.

The primary justification for developing cloth enhancements for realtime execution lay in the observation that flapping, whipping clothing was often used, to high effect, in action films to enhance fighting sequences and foot chases. As the primary in-game camera in

Figure 3-42. "Previz To Release: EA Skate" (Al Kang, 2008)

Skate would afford a view of the character that was closer than that seen in previous titles within the genre, it became vital to enhance the subtle nuances that this new viewpoint would reveal. Coupled with the fact that the driving principle behind the project was to maintain the authenticity of the experience, without resorting to unrealistic exaggerations of physics and heightened levels of animation, creating an experience that was larger than life would entail focused study on how to amplify the minutiae.

Two governing goals guided the conceptual design phase: high-frequency details needed to be authored at the artist level to allow for greater control of design, and animation principles needed to be applied to create a greater sense of dynamic movement.

It was clear from the outset that the traditional solution of cloth deformations, namely verlet integration in realtime vertex-based cloth simulation, which would basically push and pull geometry at its vertex points based on force calculations, would not be adequate at the distances required by the camera. The high-frequency details needed to create clothing folds and wrinkles would have to be implemented using normal maps: a method of capturing topological detail in the X,Y and Z axis in an RGB image map that would alter the reflectance distribution function of any light source based on normal direction to the surface. Although normal maps were in widespread use at the time of Skate's development for capturing static high-frequency details, solutions for map-based animation were either non-implementable in a realtime context or existed as a High Level Shading Language (HLSL) programmatic solution which was generally inaccessible to art teams, and often times not designed to produce the desired visual results of more organic CG elements.

In view of these limitations, research into a potentially new solution was broken down by myself and the senior artists on the Skate team into these categories:

Asset Creation: Base Mesh

Asset Creation: Normal Map Authoring

Shader Creation

Rigging: Ancillary Effectors

Expression Authoring

Animator Controls

Asset Creation: Base Mesh

Three primary software packages were chosen for the development of the new cloth creation pipeline: Adobe Photoshop CS2, Alias Maya 8.5, and ZBrush 3.1. It was a conscious decision to develop a process using the tools that were common to art teams in the games and animation industries, and that avoids specialist software.

The first phase of asset creation would begin in the foundation 3D package, in this case, Alias Maya 8.5. Within this environment, character artists could use familiar polygon editing tools to develop a properly quadrified, game-ready base geometry that at any point could be implemented into a game engine for realtime playback. This mesh would be exported into one of two different 3D exchange formats supported by the pipeline, either obj or fbx file format.

Asset Creation: Normal Map Authoring

Inside ZBrush, map authoring on both the albedo map (a term to delineate a texture's base colour with no light and/or shadow information) and normal map would begin in earnest, either by the character artist or a subsequent texture artist and would involve the meticulous sculpting of intricate details at a high-level of geometry resolution.

Once completed, normal maps would be generated either in Maya, using the Surface Transfer utilities, or in ZBrush, using the ZMapper plugin.

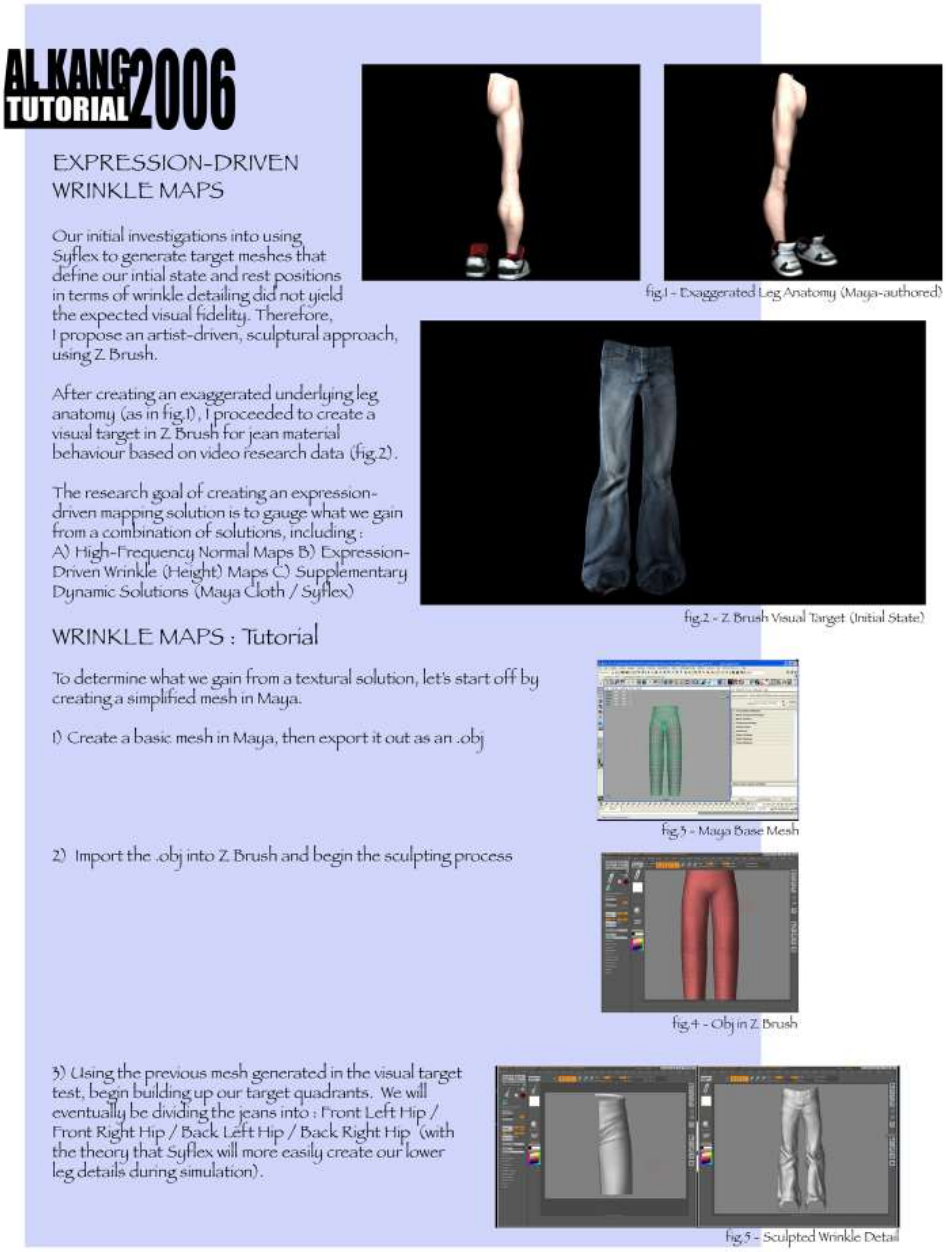


Figure 3-43. "Asset Creation: Normal Maps" (Al Kang, 2006)

A final clean-up of the resulting texture files is a two- step process. The base geometry would be brought back into Maya, where the normal map would be reapplied as a standard colour texture to refine and eliminate any artifacting, or weird visual anomalies and errors, created by the map-generation process. Once completed, the normal map is exported into Adobe Photoshop, where deformation quadrant maps could be defined by slicing up the normal map texture into four pieces that would each control front, back, left and right details that would appear on the model. A blending fall-off to smoothly transition the four areas would generally be painted in by the artist as alpha channels.

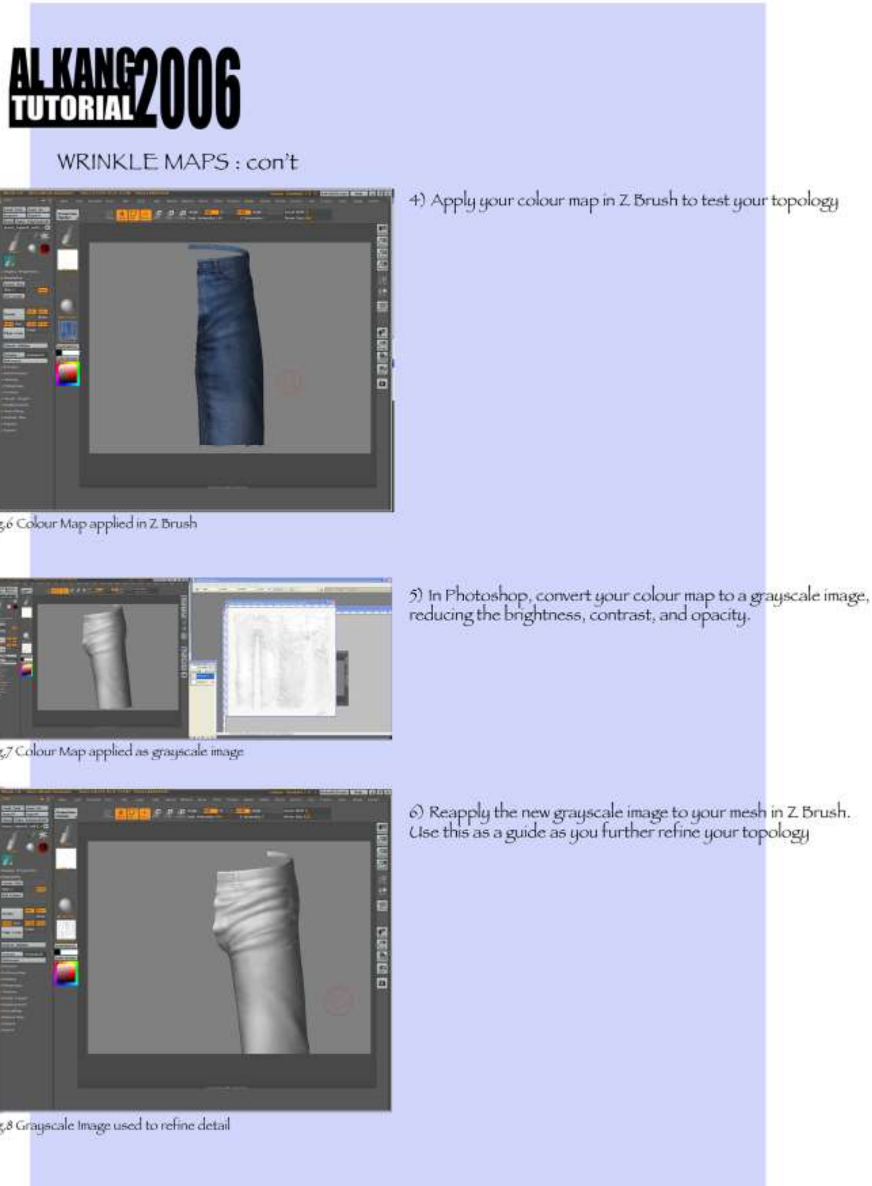


Figure 3-44. "Asset Creation: Wrinkle Sculpting" (Al Kang, 2006)

Shader Creation

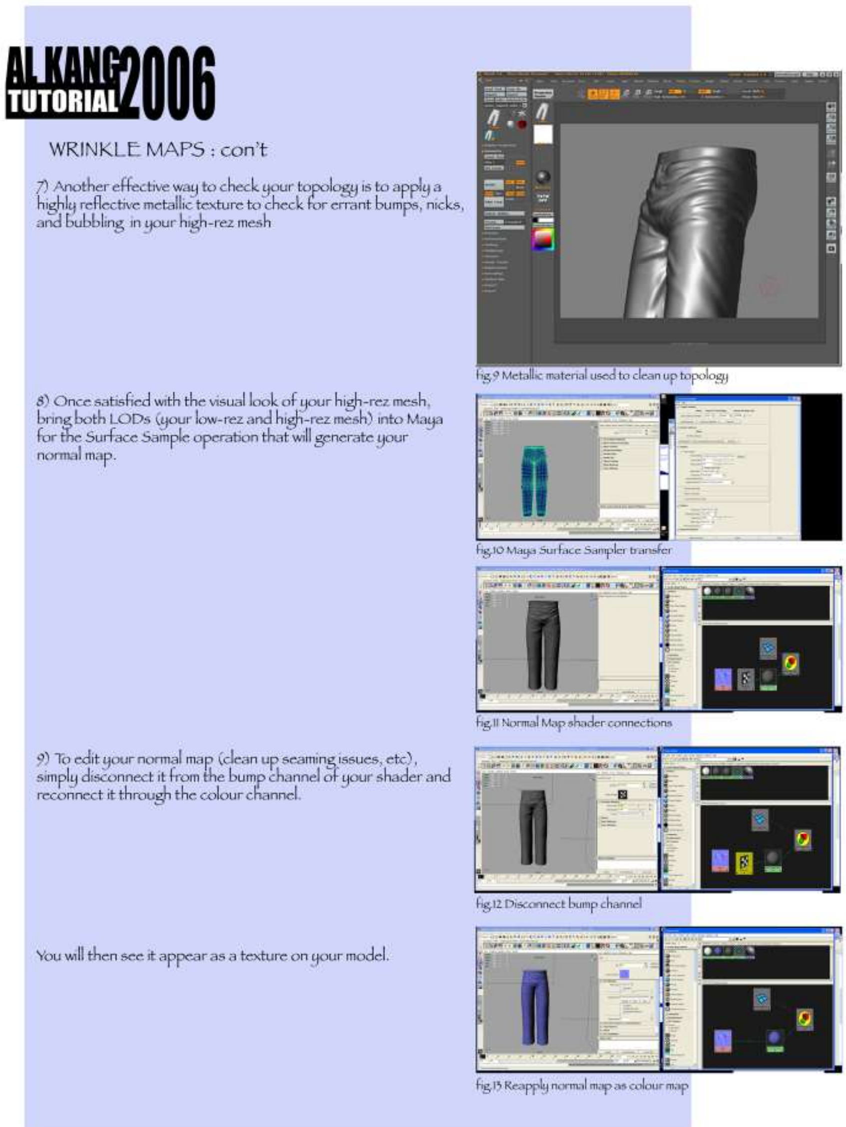
Once the normal maps are complete, Maya's hypershade feature enables a layered shader to be created to control the alpha blending, or the smooth seamless transitioning, of the various normal maps so the topological detail could be controlled based on identified areas. In the test case scenario, these areas were identified as follows:

Front Right Pelvis

Front Left Pelvis

Rear Right Pelvis

Rear Left Pelvis


AL KANG TUTORIAL 2006

WRINKLE MAPS : con't

7) Another effective way to check your topology is to apply a highly reflective metallic texture to check for errant bumps, nicks, and bubbling in your high-rez mesh

fig.9 Metallic material used to clean up topology

8) Once satisfied with the visual look of your high-rez mesh, bring both LODs (your low-rez and high-rez mesh) into Maya for the Surface Sample operation that will generate your normal map.

fig.10 Maya Surface Sampler transfer

fig.11 Normal Map shader connections

9) To edit your normal map (clean up seaming issues, etc), simply disconnect it from the bump channel of your shader and reconnect it through the colour channel.

fig.12 Disconnect bump channel

You will then see it appear as a texture on your model.

fig.13 Reapply normal map as colour map

Figure 3-45. "Asset Creation: Maya Hook-up" (Al Kang, 2006)

User-defined controls driving the alpha gain, or how intensely the details would blend together, within the layered texture allowed for wrinkles to appear gradually in any of the four regions of the pelvis, with the artist again controlling the intensity of the effect.

Rigging Ancillary Effectors

As the skeleton objects used to create character movement use joint chains that end in "effectors" (such as the tips of fingers, etc.), additional "effectors" can be added to help control "ancillary" movement not directly under control of character anatomy, such as scarves, shoe laces, shirt sleeves and skirts. These "ancillary effectors" can easily be "rigged", or attached, to a character's main skeleton.

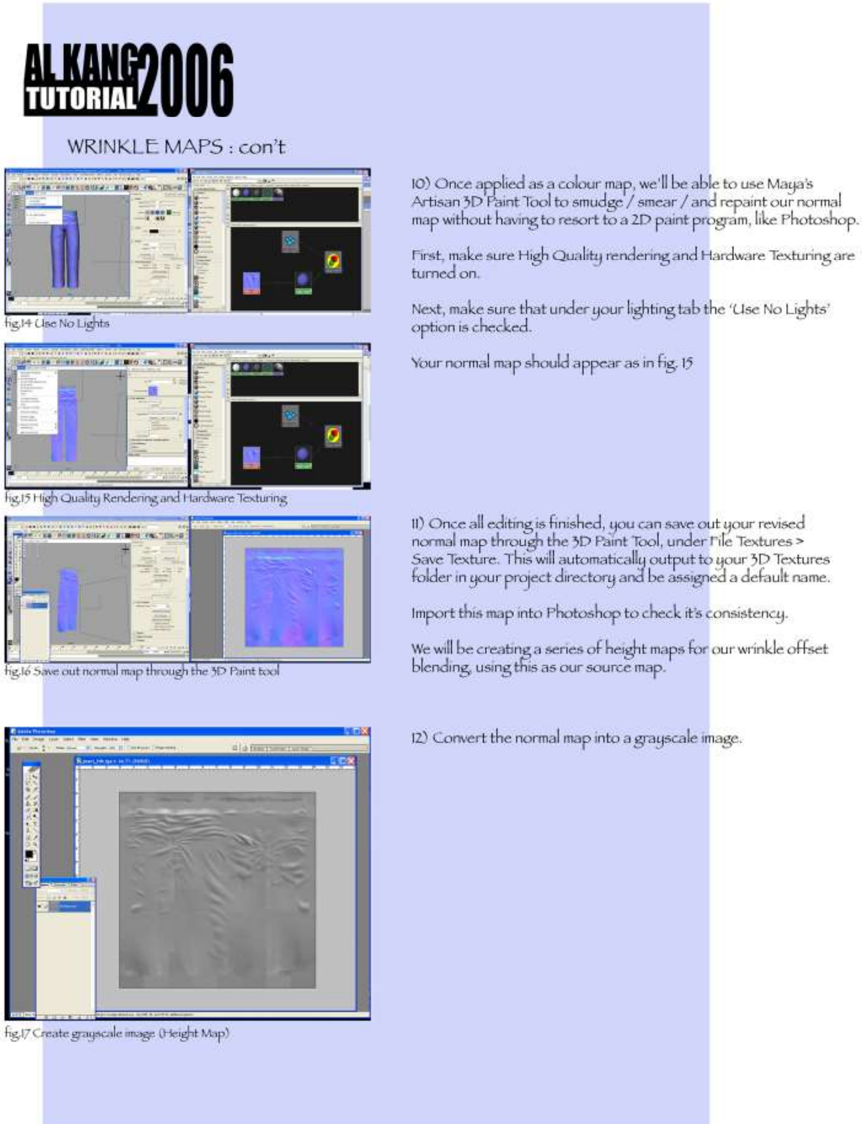


Figure 3-46. "Asset Creation: Normal Map Fixes" (Al Kang, 2006)

To help facilitate animator or artist control over the timing and intensity of the wrinkling effect, the creation of additional effectors are necessary in terms of driving the map blending changes over time; however, because these effectors will not be active deformers, they can be stitched into the overall character rig after the fact, with no knock-on dependencies, either to the rigging or the modelling pipelines. The central benefit to this dissociation is that not only can the map blending effectors be implemented at any team, but a separate artist or art team can be free to work on these assets with a degree of creative autonomy. The rotation values of these effectors will feed into the blending values of the layered shader: i.e. when the effector rotates by 1, the map's alpha value will increase by 1. The effect of

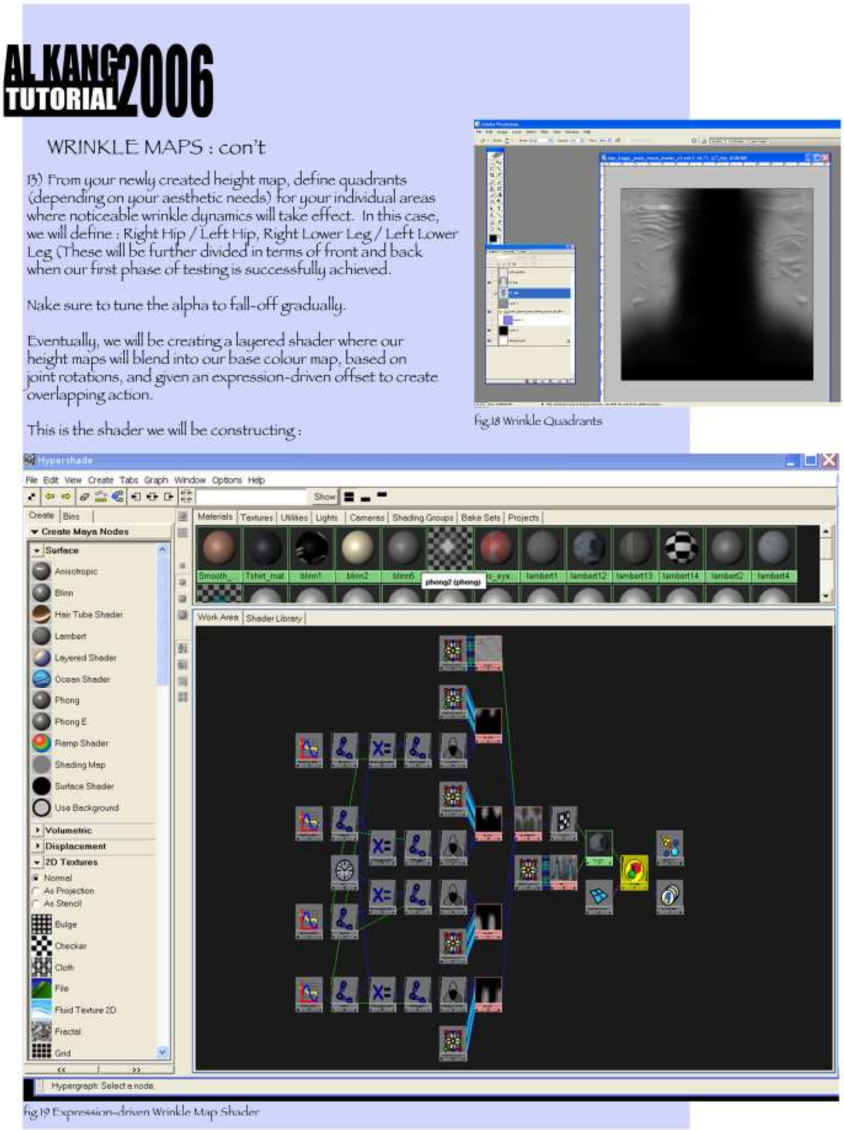


Figure 3-47. "Asset Creation: Normal Map Quadrants" (Al Kang, 2006)

this is that once the normal maps are created and "rigged" into the central character, they no longer need any physical adjustment or manipulation by an animator, and thus are automated to a certain degree. When an animator rotates a leg, the effector will also rotate and the clothing the character is wearing will "wrinkle" according to how much the normal maps have blended together.

As rotation values are generally not normalized (or converted to a value between 0 and 1), a standard Maya remap value node will be inserted between the effector and the map blending channel to ensure that any rotational values remain within the 0 and 1 value range. Now, once the maximum and minimum rotation values are determined, these figures can

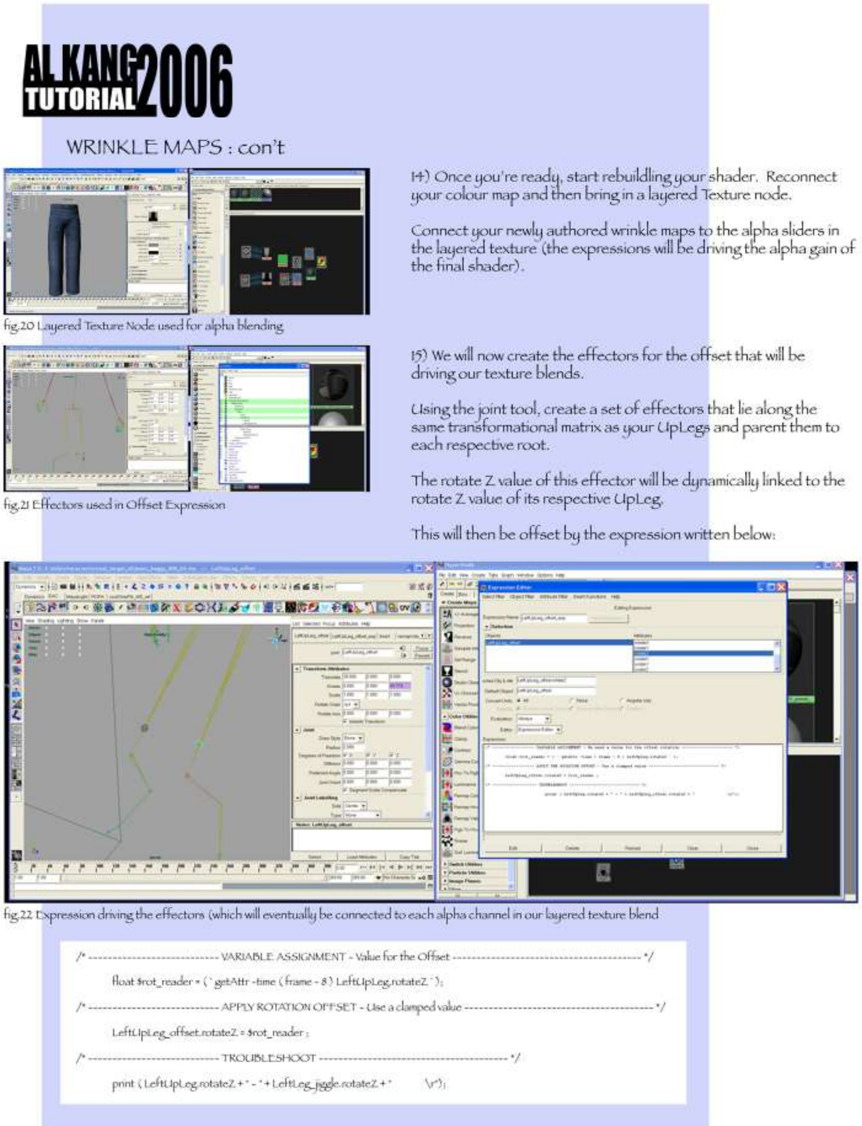


Figure 3-48. "Expression Authoring" (Al Kang, 2006)

be applied onto the remap value node to be normalized . If the min and max range values are -63 to 54, the remap value node converts this to a floating point scale between 0 and 1. If the furthest our effector ever rotates is between -63 and +54 (based on animation testing) then we can quite easily state in the remap value node that -63 equals 0 and +54 equals 1. The remap value node will pass this information on to the 0 to 1 alpha gain slider inside the layered texture node. The end result of these connections processes is a rotating effector that blends in the wrinkles on a character's clothing based on how it moves. How the effector moves, will be based on a timing offset driven by a standard set of joints, which in this case are the character's leg joints. As each leg rotates, the effector will also rotate, but with a slight offset that will create the appropriate secondary and overlapping action required by the second governing goal: the application of animation principles for a greater sense of dynamic movement. This offset effect will be driven independently by an expression, as outlined in the next section.

Expression Authoring

For the animation expression to function properly, the effector labelled as "LeftUpLeg_offset" needs to receive values from the leg joint, labelled "LeftUpLeg".

First, we will assign a variable to contain our rotation data.

```
/* --- VARIABLE ASSIGNMENT – Value for the Offset --- */

float $rot_value = (`getAttr –time (frame – 8) LeftUpLeg.rotateZ` );
```

Here, we are considering the rotation of the leg, and at its location in the timeline, it is offset by -8 and assigned the value to a float variable called "$rot_value".

Next, that value is passed to the offset effector.

```
/* --- APPLY ROTATION OFFSET – Use a clamped value --- */

LeftUpLeg_offset.rotateZ = $rot_value;
```

Based on the range of values received from this operation, the range of values may or may not have to be clamped. The LeftUpLeg_offset.rotateZ values are passed to the remap value node inside Maya.

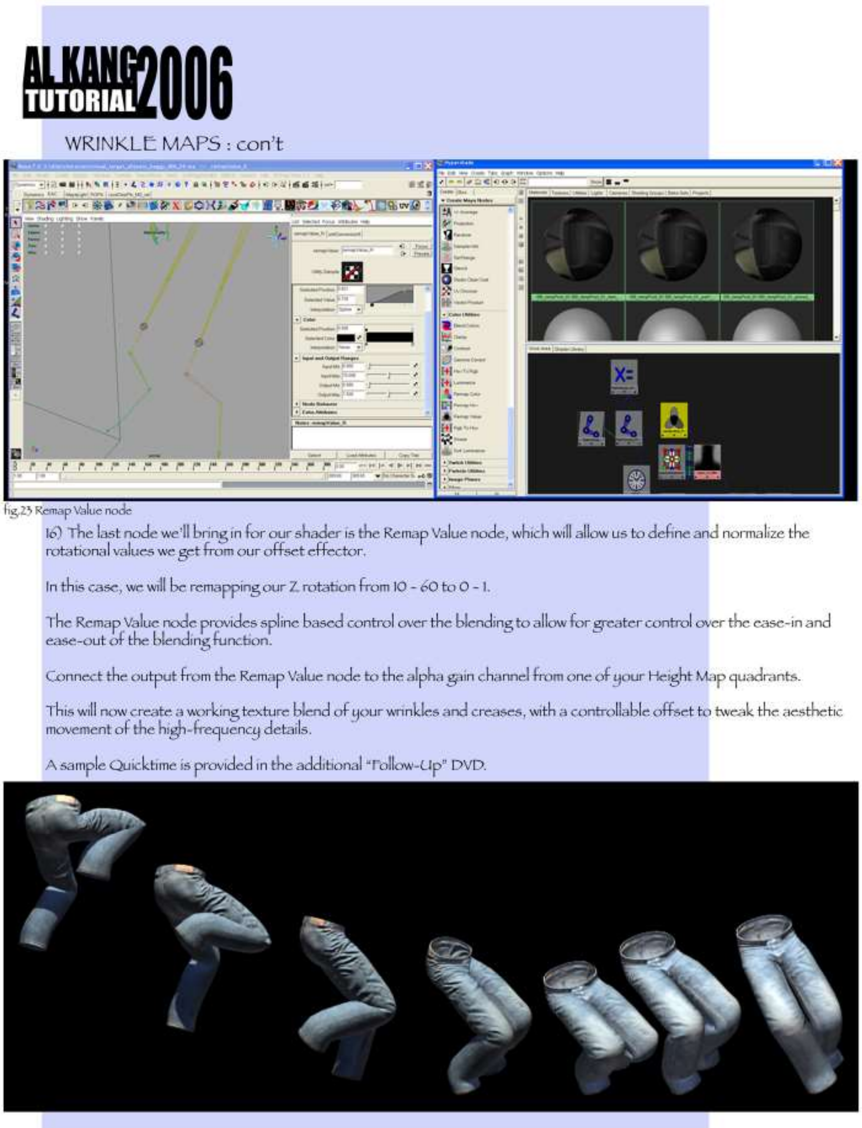


Figure 3-49. "Final Realtime Wrinkle Map Implementation in EA Skate" (Al Kang, 2006)

By creating another variable in the expression, an additional attribute in an animator's control set can be queried to define the offset. In this case, an offset of -8 is hard-coded, but by adding an additional attribute into the animator's control set, freedom to dynamically alter this value is provided.

The final submission of the wrinkle rig presented to the production team at EA was well-received, and a realtime version was eventually implemented in the game engine.

Although standard artist tools were adopted for this particular workflow, a number of different workflow optimization opportunities presented themselves during prototyping and improvements to the methodology, as well as an expansion of its inherent application, are discussed within the context of this research.

3.2.3

In lieu of the effective implementation of a realtime solution without any appreciable degradation of visual fidelity as demonstrated by the EA Skate case study, this research will attempt to undertake a layered approach, combining a variety of offline and realtime rendering solutions.

Residing at the heart of any discussion concerning the production of digital art assets, the greatest point of conflict seems to arise when any procedurally generated solution, with its inherent high computational cost, is measured against an artist-driven approach, with its own associated cost … namely, labour-intensive man hours. The debate has raged between advocates of motion capture technologies and traditional animators. It has reared its ugly head for shader writers and texture artists. From 3-point-lighters to physical-sun-and-skyers, the essential crux of the argument can be distilled down to the skill of the hand versus the speed and accuracy of the computer.

One thing is for certain, as is classically the case with such a heated debate, we can safely ascertain that beyond the obstinate reasoning of each side's myopic view, the truth of an optimal solution may not rest exclusively with one side of the argument or the other. It is in the spirit of a collaborative approach that the following workflow will be tested:

- 4 LAYERS OF CLOTH DEFORMATION
  - 2 Low Frequency Solutions
    - nCloth (simulation/high-computational cost)
    - Blendshapes (artist-driven/low-computational cost)
  - 2 High Frequency Solutions
    - Displacement Maps (artist-driven/high-computational cost)
    - Normal Maps (artist-driven/low-computational cost)

3.4.1

Prestidigitation is at the heart of all grand spectacles that awe and inspire.

From the simplest of Victorian illusionists whose sole instrument in the manufacture of the fantastic is the manipulation of smoke and mirrors, to the meticulous precision of a single diaphragm opening and closing every 24th of a second to expose celluloid emulsion to carefully controlled slivers of light, prestidigitation is all about controlling what the audience sees.

What the audience sees is the physical world reacting to light. To control what people see, the illusionist must control that light. Once that is successfully achieved, the grand spectacle begins and the audience no longer questions what they see.

This manipulation of light to create magic is at the heart of 2D normal maps, a type of image that is designed to create the illusion of depth. It is the primary technology doing the heavy lifting of high-frequency detailing, and can be produced either as a result of procedural operations calculated based on physical properties, or through sculptural means via an artist's interpretation, or a combination of both. Most importantly, 2D normal maps can be created relatively quickly.

At its core, a normal map is simple a red, green, and blue image or texture. As illustrated below, it is simply a picture containing colour values. The fast speed at which it computes these values is due solely to the fact that the only data it contains are the colours for red, green, and blue. No transformational information (in terms of position, rotation, and scale), nor UV data is stored in a normal map file. An example is shown in Figure 3-1.

Figure 3-50. "An Example of a Normal Map" (Al Kang)

The colour information in the image is what is utilised to simulate high resolution geometric details and it does so by adjusting a surface's inherent response to light.

Bouncing Checks (or Reflectance Distribution Function)

To better understand how a normal map works in terms of bouncing light to achieve geometric detail, it is essential to understand the normal map's heritage, beginning with its predecessor, the bump map.

The two primary ingredients in any CG recipe are the calculation of light rays and the corresponding behavior of the surface it comes into contact with. How light is reflected, or absorbed, by a surface will greatly affect how that surface is perceived.

In order to define a surface's properties in a simulated 3D environment, the ingredients that need to exist in this environment are:

Raytracing

A method for determining spatial relationships, occlusions and reflectance properties within a 3D scene

Vector Rays

Rays cast from a camera's position

Rays cast from a light's position

Normals

A measurement of a surface's angle to the light

Vector

A ray that points away from a polygon surface at a right angle

These two important concepts represent one of the very first CG 'illumination models' in that it was a description of how light rays interact with an object in a virtual world. In fact, these two core concepts are still referred to, and used quite widely today. Unfortunately, the calculations of a ray being cast into a virtual world and the resulting normal calculation when that ray intersects a surface was confined primarily to an individual polygon face, made up of two triangles. There was no calculation in place to help describe how light transitions from one polygon face to the next. This resulted in polygonal faces exhibiting a surface characteristic known as 'faceting', or the hard-edged transition from one surface to

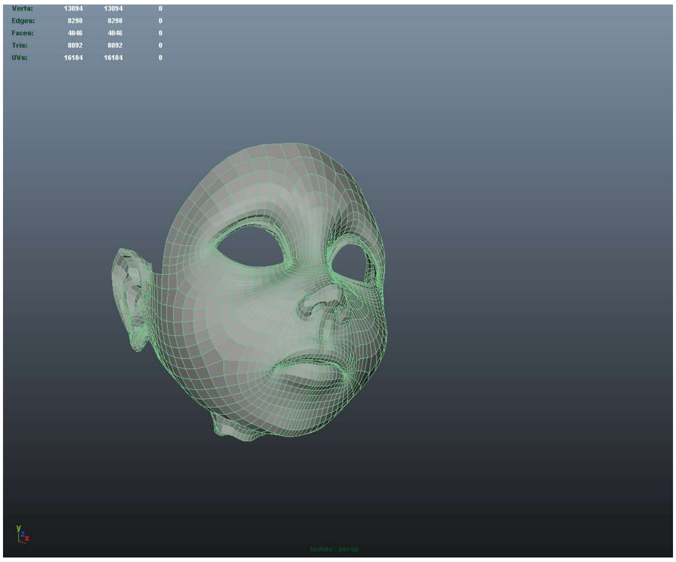


Figure 3-51. "Highlighted Surface Topology"

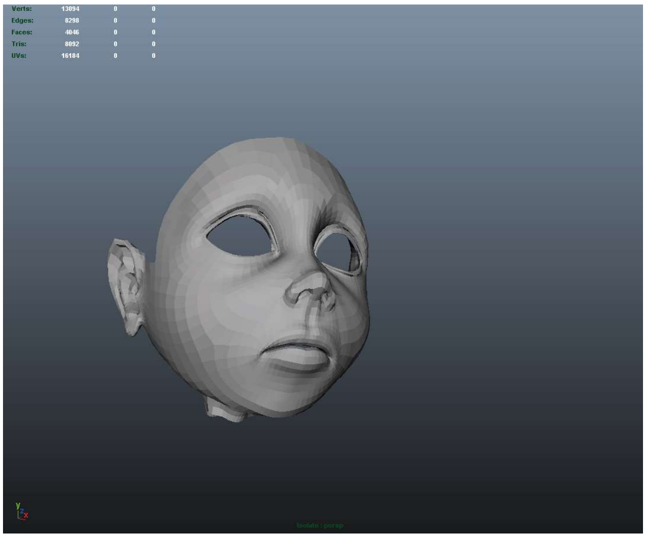


Figure 3-52. "Polygonal Faceting"

the next (see Figure 3-14 and 3-15).

The only available solution to correct these inadequate results was to simply add more geometric subdivisions, creating smaller and smaller polygonal surfaces in the hopes that the surface detail would appear smoother. As a result of this, geometric objects needed to have

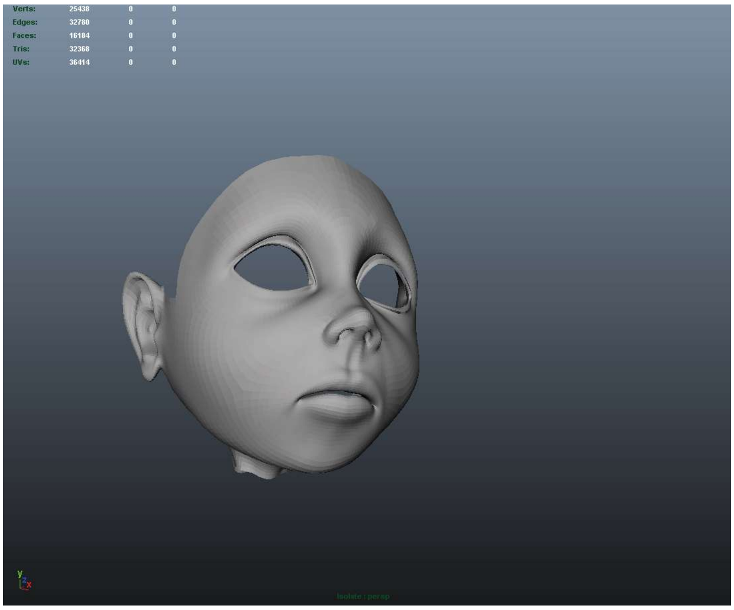


Figure 3-53. "High Polycount - Faceting"

extraordinarily high polygon counts to a modicum of smoothness (see, for example, Figure 3-16).

Even with the addition of extra polygonal faces, faceting was eliminated completely from these earlier illumination models.

In 1973, a scientist by the name of Bui Ton Phong discovered that by bending the normals along the edges of connecting polygons, light vectors themselves would transition gradually and the illusion of a smooth surface was attained. Two notable results evolved from this observation (Phong 1975).

$$I_p = k_a i_a + \sum_{\mathrm{m} \in \mathrm{lights}} (k_d(\hat{L}_m \cdot \hat{N}) i_{m,d} + k_s(\hat{R}_m \cdot \hat{V})^{\alpha} i_{m,s}).$$

Figure 3-54. "Equation for computing the illumination of each surface point"

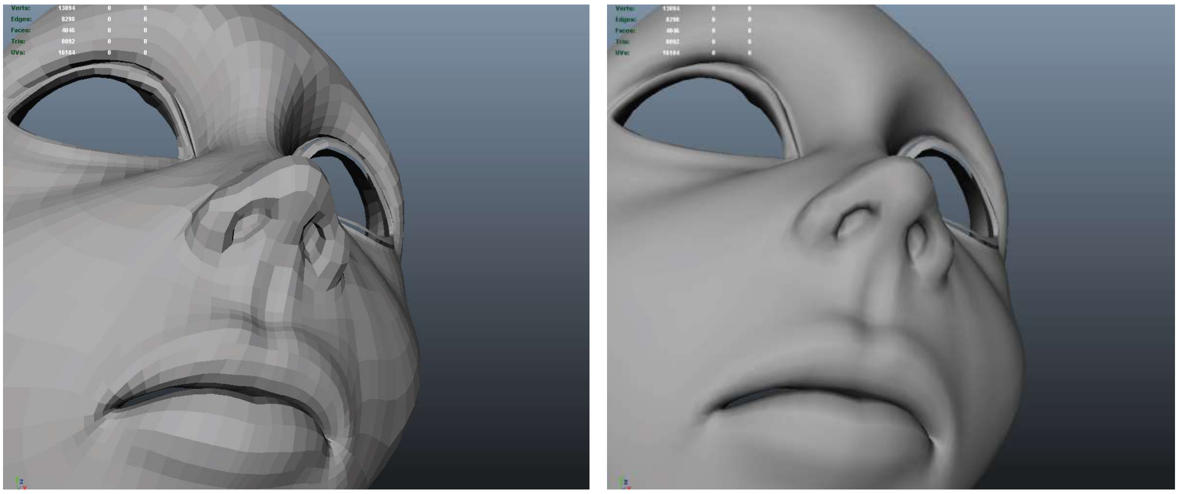


Figure 3-55. "An Illustrative Example of the Phong Effect"

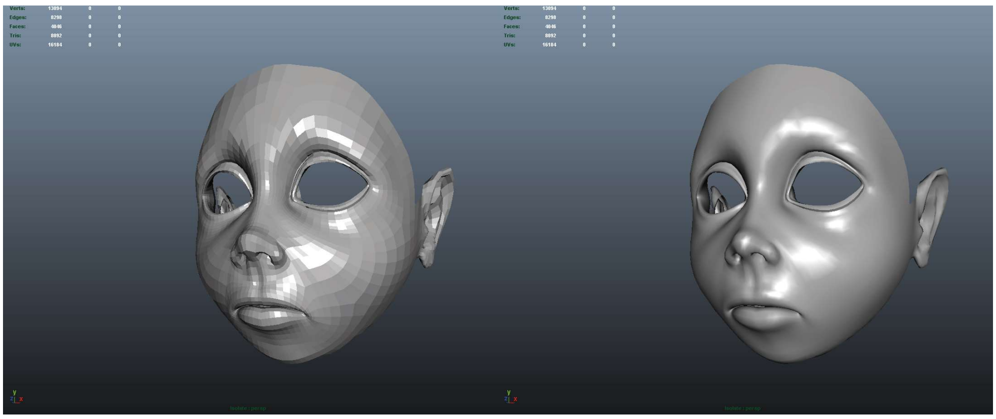


Figure 3-56. "The Phong Shader in Action"

It was at the University of Utah that a young researcher by the name of James Blinn took Phong's initial research one step further. Blinn began to experiment with 'wiggling' the normals to manipulate light and shadow across a polygonal surface. He soon discovered that recreating surface relief was a simple matter of adjusting these surface normals using data captured in a simple black and white 2D image, where black would represent impression and white would represent surface relief. The illusion of detail was so effectively implemented that the technique is still very much in use in CG studios today (see Figure 3-20).

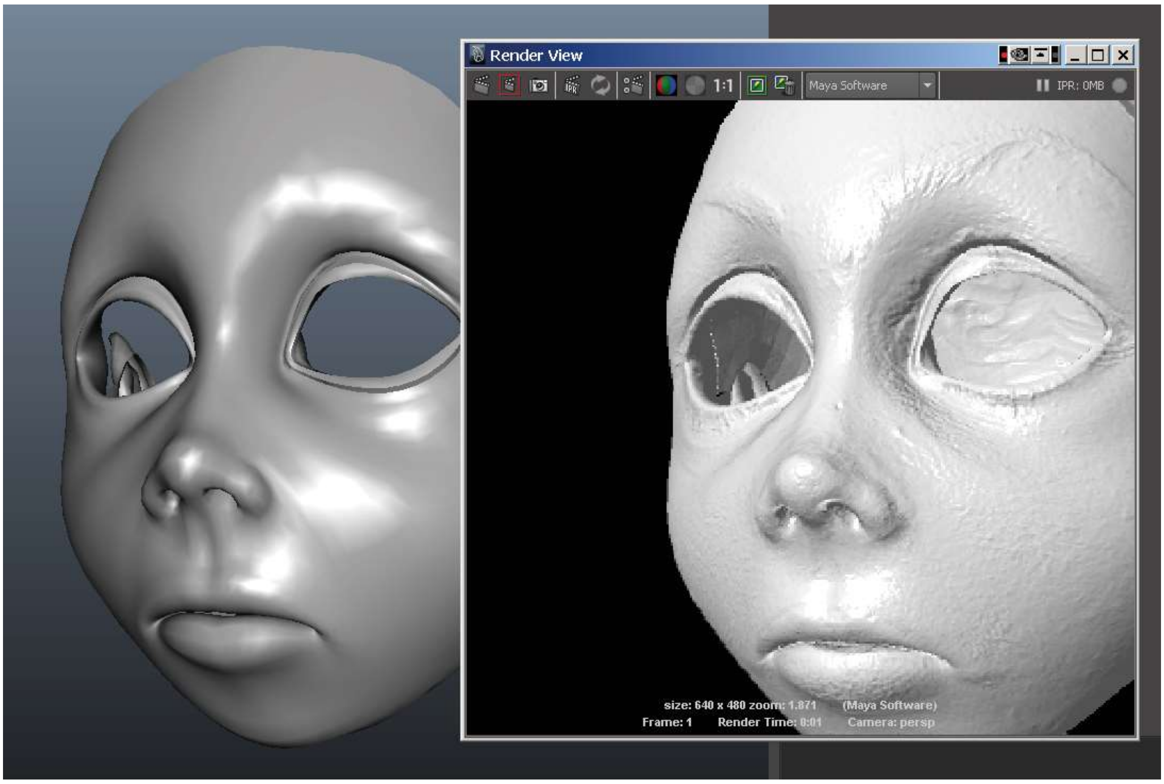


Figure 3-57. "Phong v. Blinn"

As effective as bump mapping is, in terms of capturing surface relief, the visual fidelity of the illusion can only be sustained at certain distances from the object or subject. As can be observed in the initial test examples below (Figures 3-22 and 3-23), the surface detail of bump maps only represent a height value (or up and down perpendicular to the surface normal's orientation) and the black and white image can only hold a single channel of data containing 256 numerical values. This data limitation is what gives the bump map its characteristic ‘plastic’ look.

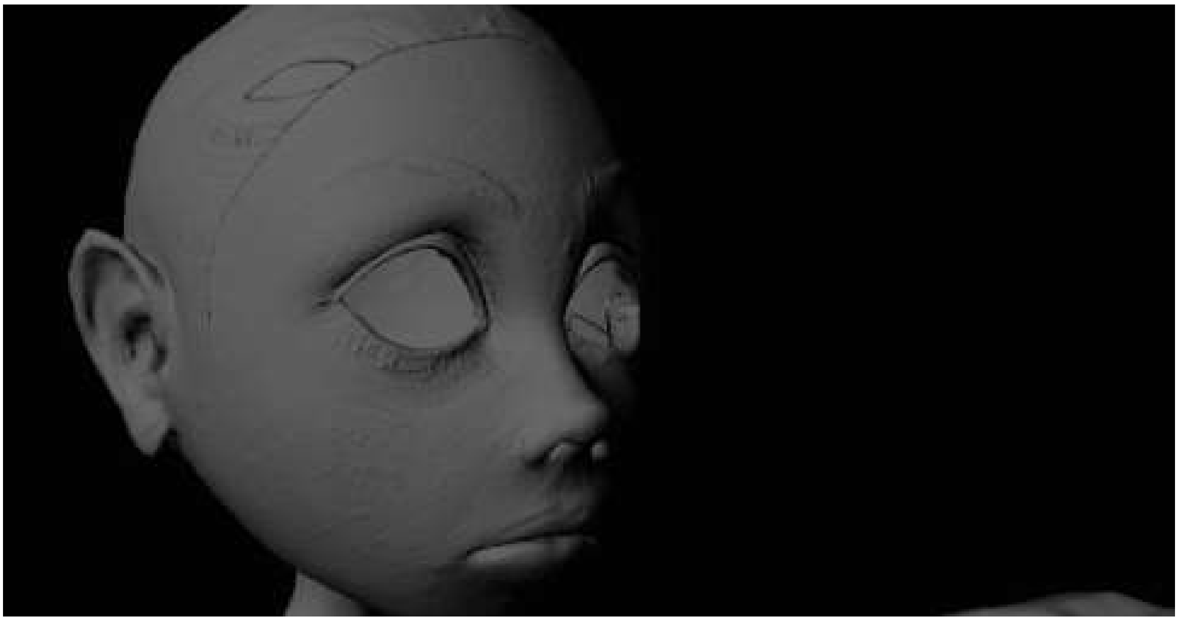


Figure 3-58. “Bump Map Limitations - Medium Close Up”

Figure 3-59. “Bump Map Limitations - Close Up”

By contrast, a normal map is a red, green, and blue image that can contain three separate channels of data, each channel containing its own value set of 0 to 255, resulting in a combination of 16,777,216 different values. Where the bump map can only contain data representing a height value for topological detail, the normal map can capture three co-ordinates of topological data, namely the x, y, and z co-ordinates of a location in 3D space. More precisely, each pixel of a normal map contains the normal data of a high resolution geometric model, and the direction that each of those normals face in a Cartesian co-ordinate system. Each colour in a normal map is effectively 'wiggling' the normal. When this 2D image is applied to a low resolution geometric model, each pixel will act as a face normal, controlling how much light each one will receive. It is the colour channel/co-ordinate relationship of each pixel that will determine which direction that pixel normal will be facing.

Red = x

Normal Direction: left → right

Green = y

Normal Direction: up → down

Blue = z

Normal Direction: perpendicular to the face

It is this resultant bending of the light that fools the eye into seeing more detail than actually exists along the surface of a polygon.

Normal Map Flavours

The most commonly used type of normal map does not just rely on the map alone. The second stage of surface relief calculation combines the 2D image with data that exists inherently in the geometric model. Two calculations are therefore combined to create the illusion:

2D Image Pixel Information

Tangent Basis

Vertex Normal Information

The information contained in the image, combined with calculations stored in the model's vertices contribute to the final image in all its glory. Of the 2D image maps themselves, there exist three distinct flavours:

World Space Normal Maps

Object Space Normal Maps

Tangent Space Normal Maps

Each type of normal map has its own distinct advantages, given a certain set of circumstances.

WORLD SPACE NORMAL MAPS

Static Objects.

Requires the model to remain in its original orientation.

No transformational matrix and no deformations.

OBJECT SPACE NORMAL MAPS

Static Objects.

Also called Local Space or Model Space.

Rotations, no deformations.

Characterized by rainbow colors, making it difficult to edit manually.

1-to-1 ratio of geometric object to unique object space normal map

Difficult to tile

Difficult to mirror

High quality curvature

(ignores crude smoothing of low poly vertex normals)

Harder to overlay painted details because of variations of base colors

Harder to manually edit

TANGENT SPACE NORMAL MAPS

These will serve our purpose.

MAP + VERTEX DATA = Tangent Space Normal Map

2 DEPENDENCIES

The 2D Texture Map

UV Shell Orientation VS. Actual Geometry Orientation

UV Coordinates

The important visual contribution of tangent space normal maps is that it visually represents surface relief in realtime rendering permutations. With painting packages helping to facilitate the authoring and customization of these normal maps using art-driven techniques combining with realtime rendering calculations sent to the screen for rasterization, the net result is that artists no longer need to wait for offline rendering calculations to complete before they can inspect and analyze their results, an intermediary process that could often times take hours.

With realtime normal map calculations cheating light evaluations in realtime, artists could truly see what they were creating and make changes they knew would ripple to the final visual artefact.

This realtime feedback loop became vital for the many EA art teams' iterative processes and informed the tools and workflow I developed for dynamic realtime cloth authoring for EA's Skate, which I shall outline in subsequent chapters.

In addition, realtime technologies and contributions from the world of videogames would greatly impact the creative processes of feature film production teams the world over until it culminated in its zenith with the release of Star Wars: Rogue One, the first feature film to include final rendered elements created in Unreal Engine 4, an industry standard triple A game engine (Alexander 2017).

3.4.2

Although replacing the high end calculations of cloth simulation with a sculptural approach allowed for a more synergistic approach to character creation and design, there was still an enormous technical back-end in place for implementation, making the entire process dependent on a large degree of technical knowledge.The primary aim is not simply to render obsolete the simulation process in favour of supplanting it with a purely sculptural approach but rather an attempt at delineating exactly when and where computational simulationi can be utilized and how we can capitalize on the designer's creative process in the most visually advantageous way.

Marvelous Designer, a relatively new tool adopted in production, presents a unique solution in the way it favours, not digital artists, but fashion designers and their preferred modus operandi. Strictly positioning itself as simply a wardrobe design tool, it has very little in the way of competition. With a robust simulation engine underpinning its architecture, and a lexicon and workflow derived entirely from the fashion design industries, it's easy to see why artists the world over have gravitated towards it.

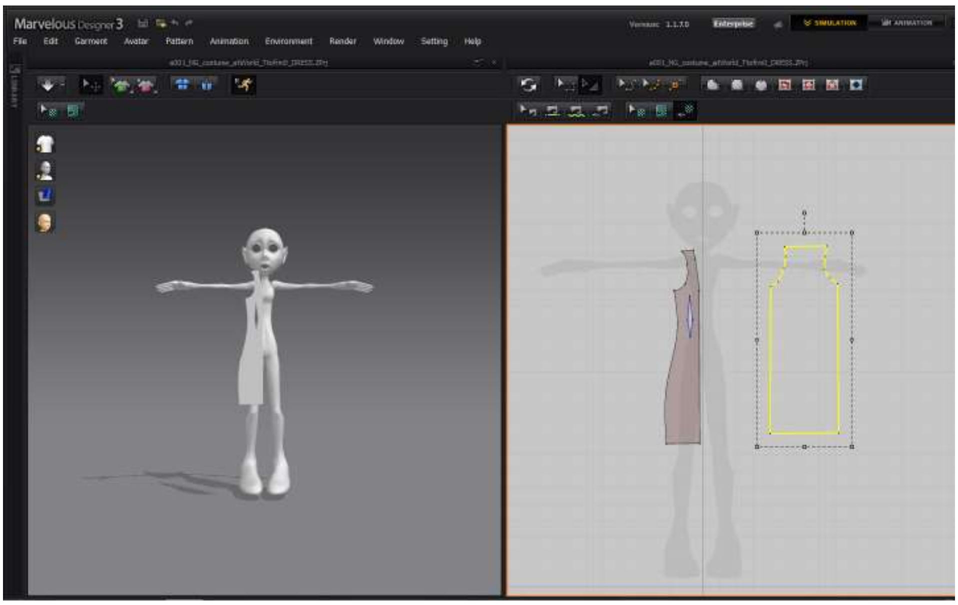


Figure 3-60. "Nothing Girl Project: Inside Marvelous Designer"

Using the base geometry of the Nothing Girl character to compare and contrast the clothing design and simulation alternative that Marvelous Designer offered, it's somewhat clean UI and interface was instantly, visually inviting. Tools terminology, such as normal facing vertex welding, was replaced with seam sewing and pattern making.

Figure 3-61. "Sewing Tools"

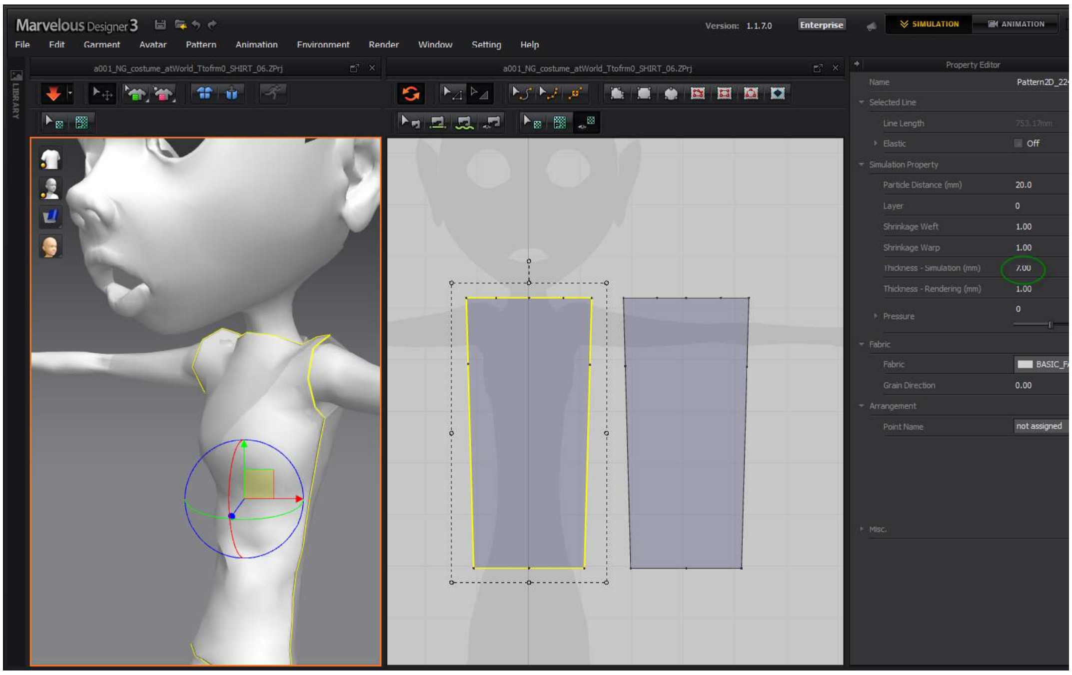


Figure 3-62. "Fast Simulation Engine"

The speed and the responsiveness of the simulation engine was also a key factor, as during the pattern design process, the physical properties of cloth dynamic behaviour was less on the forefront of artistic consideration as creative focus was almost exclusively dedicated to pattern design and drapery study.

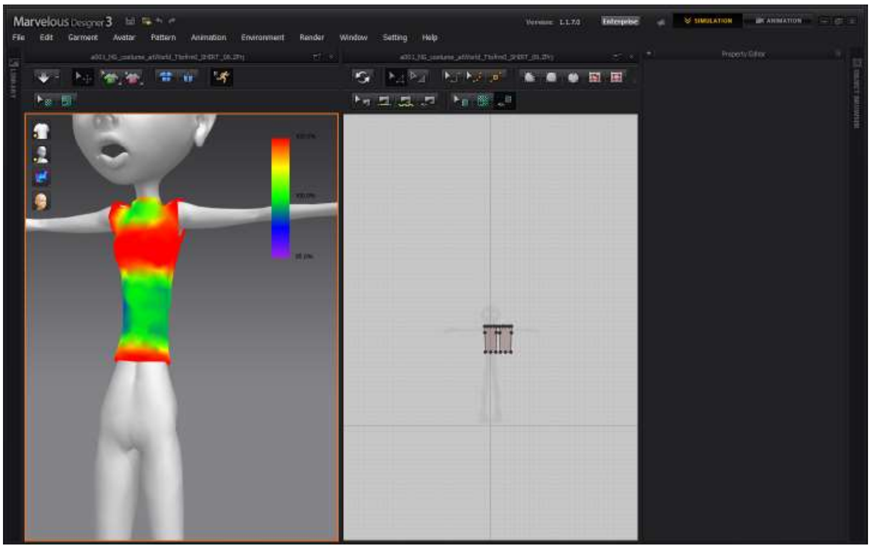


Figure 3-63. "Heat Map Tools"

As with all digital toolset, Marvelous Designer allows you to get as technical as you need to, providing tools such as heat maps to gauge fabric tension in key areas of the model. As the framework supporting the cloth simulations are encapsulated in a dedicated application, there is very little resource overhead normally associated with master packages, such as Maya. This frees up the technology to allow for very intricate, computationally heavy clothing designs to be easily managed by the artist. Here, the design for an asymmetrical, multilayered skirt was created quite easily.

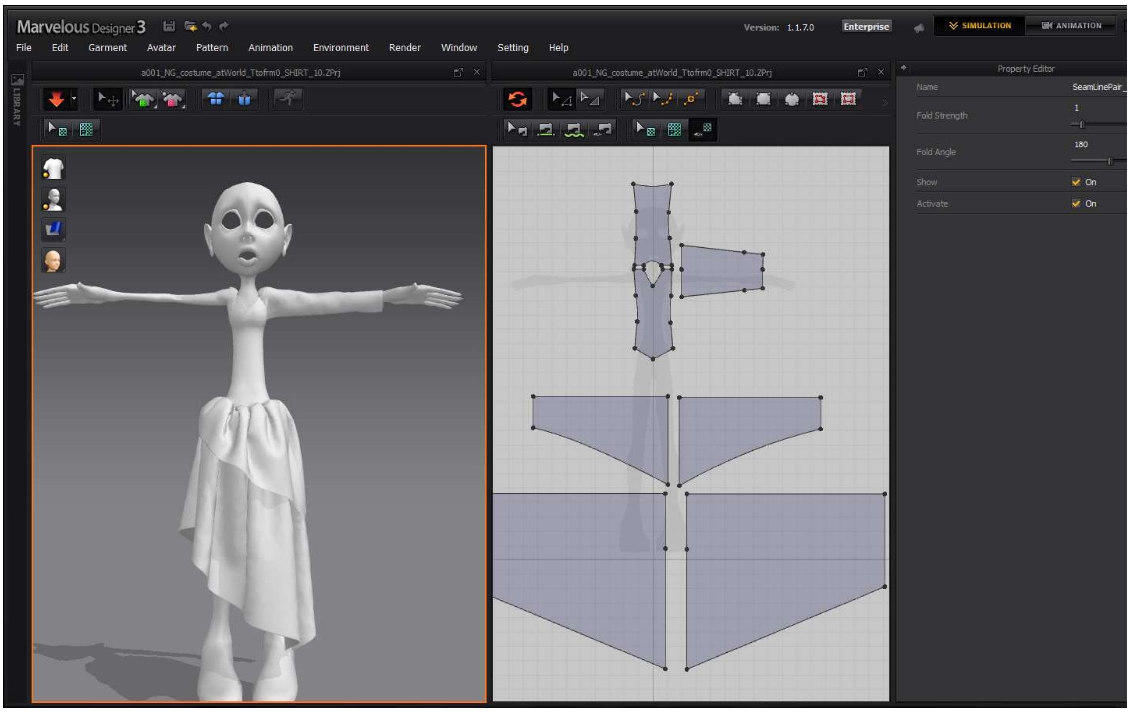


Figure 3-64. "Intercollisions: For fabric layering"

The only difficulty currently presented by Marvelous Designer is its rather inefficient workflow in terms of moving CG assets between packages. In that regard, examples moving from script-to-storyboard-to-editorial were far cleaner and more efficient . Moving large amounts of data seamlessly and invisibly is a key factor in maintaining a direct creative connection with an artist and their digital works.

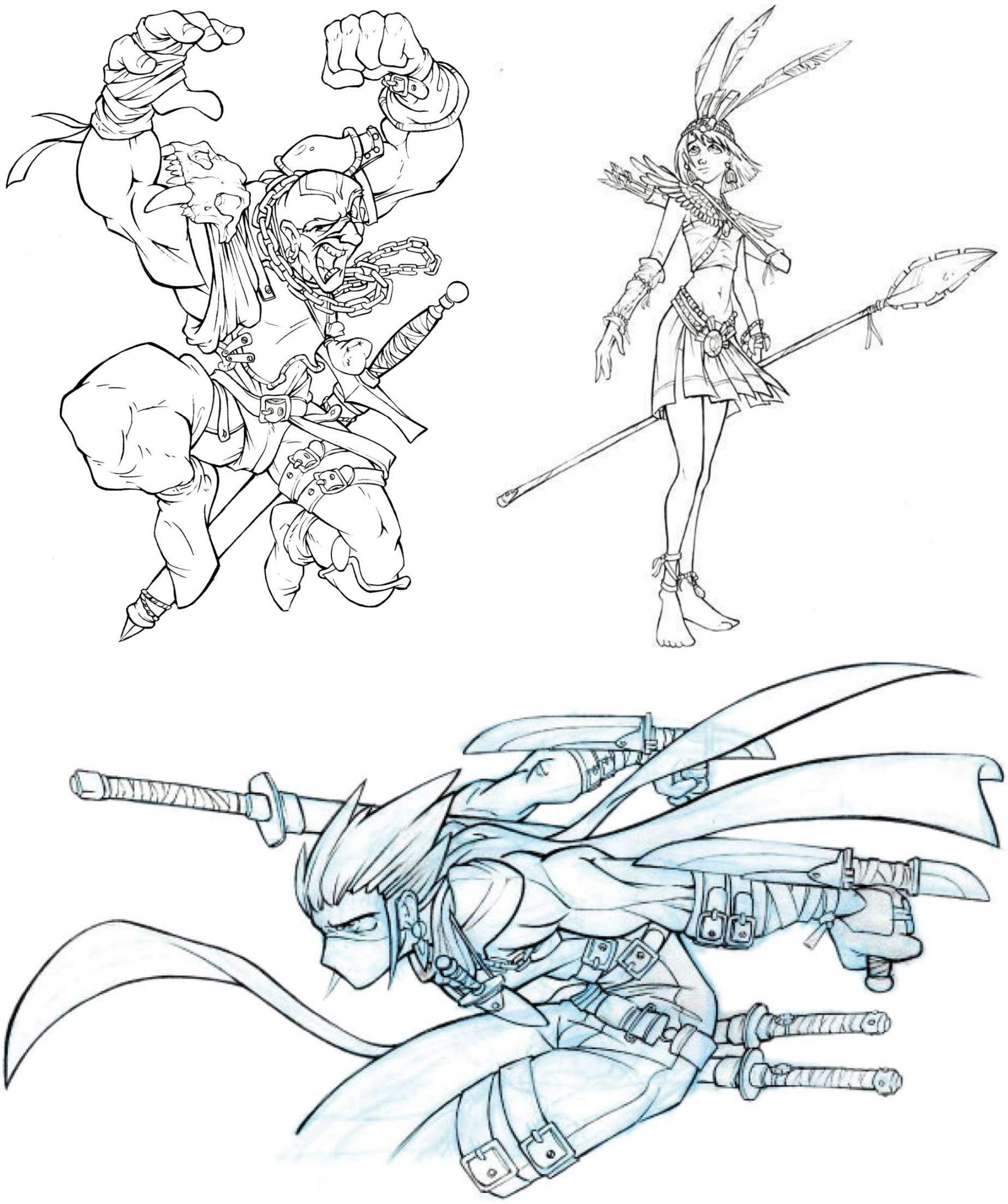


Figure 3-65. "Traditional Character Designs" (Al Kang)

In terms of traditional pencil and paper costume design, there was still an immediacy that seemed, somehow to be elusive; however, the experience with manipulating digital patterns was definitely a process that felt far more creative then it had in the past.

To further investigate the creative use of simulation technologies in a visual artist's work-flow, set assets and front end logos were built using two key pieces of technology. The first was a powerful and robust fluid simulation and flip solver dedicated environment called Naiad, which was eventually purchased by Autodesk and retooled inside of Maya as their BiFrost Engine. Another dedicated utility that allocated all of its resources to simply solving fluid dynamics, Naiad was wonderfully responsive and fast. It's primary interface to the data was, in the fine tradition of Nuke and Maya, a node-based paradigm.

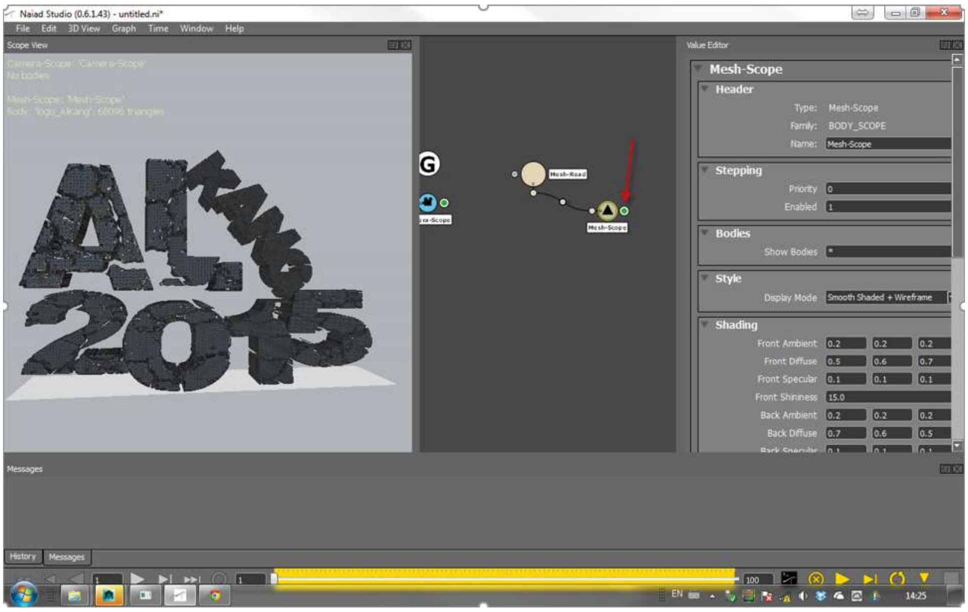


Figure 3-66. "Naiad" (Al Kang)

Naiad proved problematic, however, as its interface, attribute editor and node graph were designed primarily with the assumption that its user would have a breadth of scientific and programmatic knowledge and would devolve from manipulating visual elements to exclusively working with numberical values.

Photomodelling and photogrammetry software was also being widely adopted as a procedural modelling and texturing solution. Using a library of individual photographs, taken under certain restrictions, applications such as Photomodeller could create geometric reconstructions based on the photographic data whilst simultaneously projecting colour pixel data culled from the images into the vertices of the geometric asset.

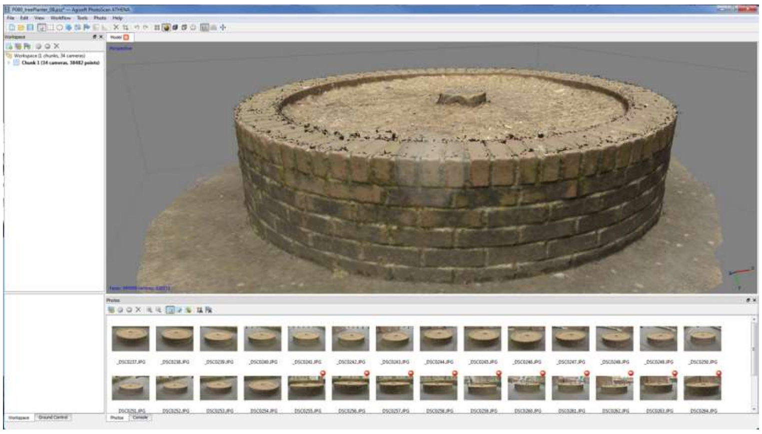


Figure 3-67. "Photogrammetry" (Al Kang)

Again, the UI in most popular photogrammetry tools are quite clean and uncluttered, with a fairly simple and intuitive approach to the data processing. The only strict conditions with which an application such as Photomodeller imposes upon an artist is the number of dedicated photographs, and in what order they are shot, that the software needs to effectively reconstruct an asset.

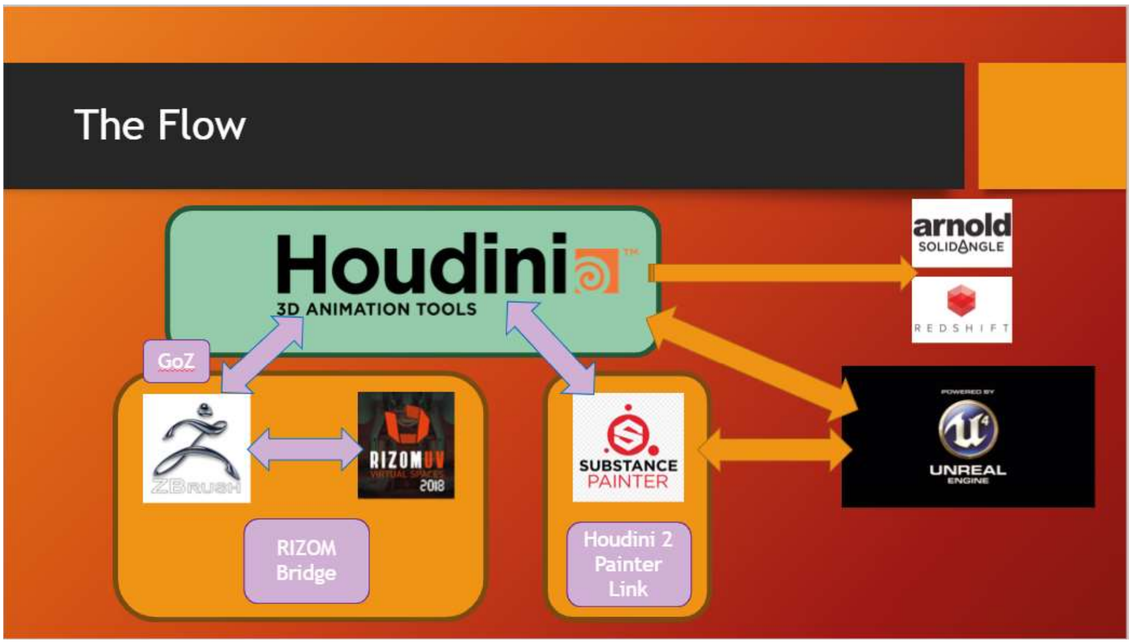


Figure 3-68. "The Flow" (Al Kang)

By predesigning a workable asset flow, based on realtime updates and live connectivity, a more synergistic creative digital environment can be established, similar to a self-contained ecosystem of visual development.

In another character-based project, development centred around an eventual Houdini render master deliverable and an intricate network of interdependencies was established using primary asset authoring tools.

Figure 3-69. "Asset Sculpt in ZBrush" (Al Kang)

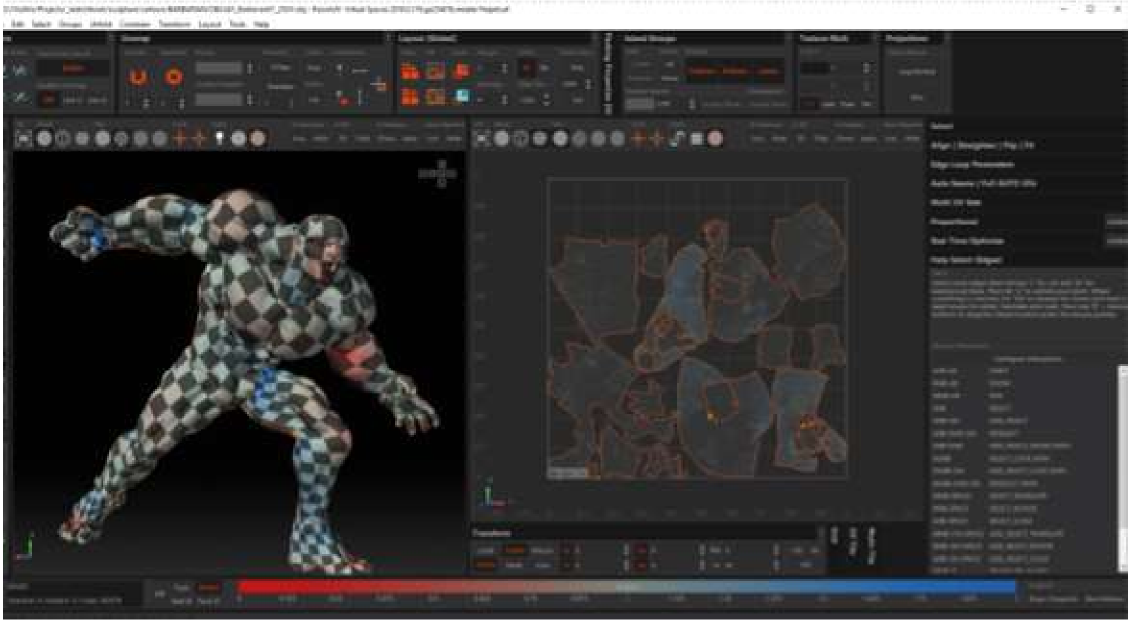


Figure 3-70. "Asset UV Unwrapping" (Al Kang)

Once an asset is carefully sculpted inside of ZBrush, it is connected to the UV Unwrapping process, in this case using the utility called RizomUV.

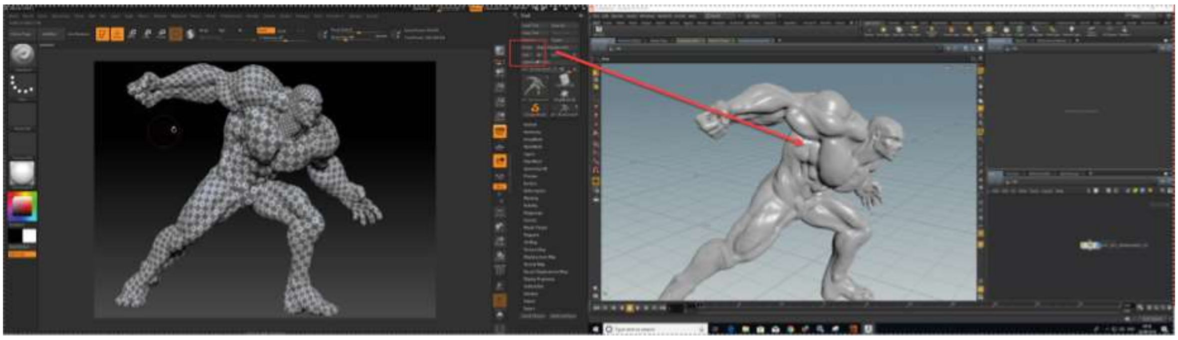


Figure 3-71. "ZBrush to Houdini Bridge" (Al Kang)

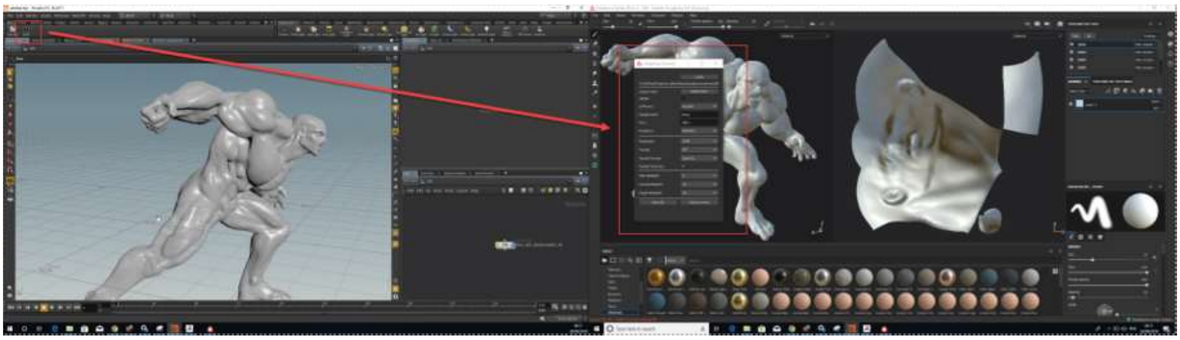


Figure 3-72. "Houdini to Substance Bridge" (Al Kang)

Figure 3-73. "Houdini Arnold Render" (Al Kang)

From within the UV unwrapping software, the character asset is then "bridged" over to Houdini for inspection before getting "bridged" again to Substance Painter for shader design and implementation.

The character asset will eventually "bridge" its way back to Houdini for the final render deliverable.

This series of software connections, designed and planned out in advance can create a workflow where 4 separate tools can feel like one contiguous environment. In a complex studio environment, staffed by hundreds of artists,with many disciplines interacting with a single asset simultaneously, this can feel like a veritable Minos' Knossos castle of balanced interdependencies. Therin lies my version of the total perspective vortex and my theory that multiple artistic endeavours can be governed by a singular creative philosophy.

But the data connections need to work if this notion is to operate successfully. A very important first step is to deconstruct an existing asset pipeline into its various disciplines and find the dependencies, both process -wise and data format reliances.

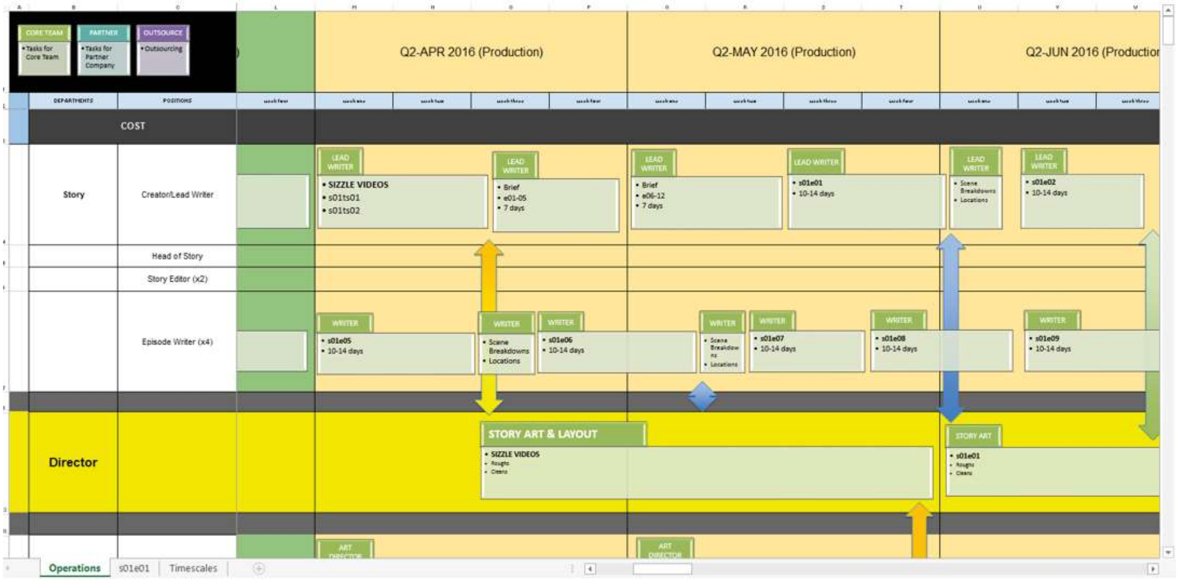


Figure 3-74. "Interdepartmental and Discipline Dependencies"

Once the primary dependencies are identified, then a set of theories are postulated, informed by creating "asset bridges" but motivated solely by placing art creation before technical work.

In a classic asset modelling pipeline, and image plane is used to guide the modelling process before the asset is eventually shipped to uv unwrapping and texturing.

Figure 3-75. "Visual Feedback mechanisms first"

However, several tests carried out in production, and eventually disseminated in a teaching context, flipped that model so that the texture was utilized first, allowing environment artists to build out towards a strong visual cue and creating a process that was far more visually stimulating from the outset.

Figure 3-76. "Architectural Model" (Al Kang)

Engaging with this process for my architectual modelling allowed me to reduce my asset production time considerably, and I was able to build out a proxy set in no time.

Figure 3-77. "Set Visualization Process" (Al Kang)

With a number of rough, working pipelines in place, with all the key creative departments connected, it allowed for a faster and more versatile production relationship to develop with real world clients on live industry-facing briefs.

Since instituting both a revamped digital art creation pipeline throughout UWTSD's Games and Animation Programmes and recalibrating a new philosophical approach to digital art creation applied at both the academic and industry facing levels, I have achieved a high degree of success on a number of projects of varying scope and purpose.

Figure 3-78. "ADVERT: QQ Watch for Kids"

Working directly with Chinese company QQ on a new line of digital watches for children, I was able to deliver a CG animated commercial in under two weeks and supported by this new art-centric pipeline. QQ appreciated the fact that they could see a close to final visual quality almost immediately and maintained a high level of engagement due to the speed with which visual prototypes could be delivered.

Figure 3-79. "Lucky Legend"

Student researchers were engaged for a live brief that entailed a traditional 2D animation project called Lucky Legend. Charlotte Preston, a Level 6 BA (Hons) 3D Computer Animation student researcher was involved in delivering the final animation to the client and the new production pipeline had an opportunity to be tested against a slightly different digital creative property.

Travelling to the polar opposite of the cinematic entertainment property category, a short film project called "Internal Bleeding" was produced involving 2 student researchers:

Dean Cummings, BA (Hons) Music Tech - First Class Honours

James Penhallurick, BA (Hons) 3D Computer Animation - First Class Honours

Using the same technology pipeline, it was surprising to see how versatile the framework was for encapsulating projects of different themes and digital media.

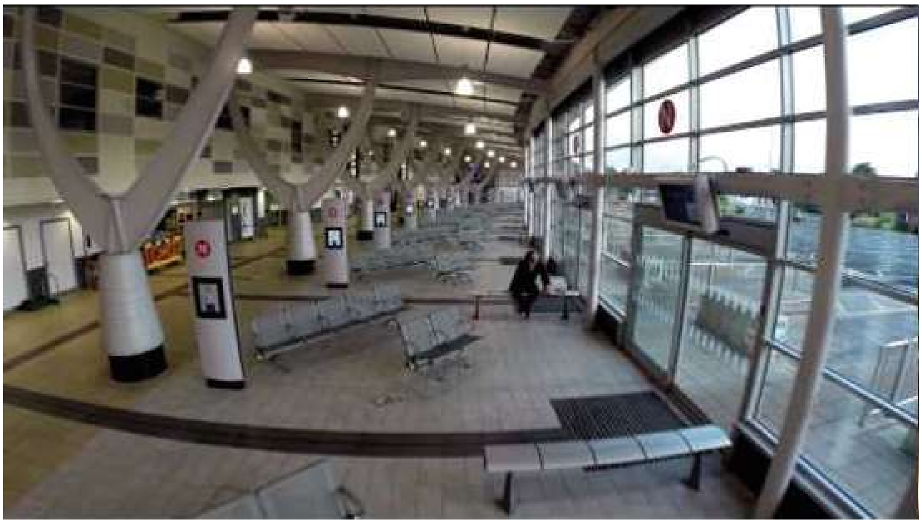


Figure 3-80. "Internal Bleeding"

Our numerous successes on a very small scale allowed me to slowly and gently ramp up the scope of our network infrastructure and layer in a few more disciplines into our asset pipeline. This eventually put us in an excellent position to work in partnership with Atomicom Games in Liverpool on a game property for JCB called Mars Pioneer.

Figure 3-81. "JCB Mars Pioneer"

Figure 3-82. "BFI/Ffresh/UWTSD/Bait Studios"

Looking beyond simply industry-facing engagement, with an eye towards reaching wider, I brought my tools and techniques to the BFI/Ffresh youth VFX Adjacent Education Workshop, involving sixth form students, to successful completion in 2016, 2017 and again in 2018. Engaging with local actors and director Marc Price, a Swansea native, the students had a wonderful opportunity to develop additional skillsets in a digital environment where emphasis was resoundingly placed on art-side creative skills over software mastery.

Figure 3-83. "BA (Hons) Creative Computer Games Design 2015-16"

Integration of my practice-based research philosophies concerning digital art engagement had a surprising ancillary benefit on the BA (Hons) Creative Computer Games Design Programme at UWTSD, resulting in consistent cohorts passing, without failure, since its institution in 2012.

Examining both the rich history of production pipeline development and balancing that against my own practical experiences, I found the journey of the traditional artist as they navigate this new digital ontophany an incredibly rich and compelling narrative, one that continually returned to a profound understanding of human behaviour, and how the art creation process itself is steeped in a rich history of emotional examination. The digital era introduces a conundrum unlike any technological paradigm of the past.

Within that context, I developed a 5 stage process for my research:

- STAGE ONE
    - Define the Needs of the Creative Process
- STAGE TWO
    - Case Study Analysis
    - Comprehensive Look at Industry Best Practices
- STAGE THREE
    - Change Control Process/Asset Tracking/Version Control
    - Designing an Effective Artist Pipeline
- STAGE FOUR
    - Localized Implementation
    - University-wide Curriculum Development
- STAGE FIVE
    - External Industry-facing Application
        - Vicky Media/Shenzhen Entertainment Group
        - Atomicom Liverpool
        - NoWhereFast

Each stage was successfully engaged and helped to inform the subsequent stages.

But what about a broader commercial context? Can this emphasis on an artist-driven pipeline be viable on projects with global scale?

Figure 3-84. "Jens Hansen, BSc (Hons) VFX and Ryan Morgan, BA (Hons) 3D Computer Animation"

Two students, Jens Hansen and Ryan Morgan, whom I've had the wonderful opportunity to teach the concepts of both an artist-centric pipeline design and unlocking full creative potential in a digital context, both went on to win Oscars for best Visual FX for their contributions to The Jungle Book (2016).

Although this practice-based action research only engages with the very small sliver of the commercial wing of the creative arts, and explorations further afield into wildly experimental areas such as generative art are well beyond the scope of my research, I hope to expand my philosophies outwards and eventually engage many different artists, using many different media, within our growing digital scope.

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chapter 4
experiments

4.0.1

The phase that houses the greatest degree of fluctuation in the creative processes is undoubtedly the preproduction period, ranging from the onset of the writing process to the culmination of storyboard design. It is within this crucible that ideas collate, germinate and any impurities that do not speak to the emotional core are eventual seared away.

What will eventually become a singular examination of human behaviour in a dilemma context must first begin with the human. A character exploration will sometimes (but not always) begin with an exterior perspective as a creator than slowly begins to peel back the layers of psychology to discover the delicate wounded shielded beneath.

Applications such as Persona allow for the freeform development of a character within a template structure where each compartmentalized category can be dealt with in an almost modular fashion.

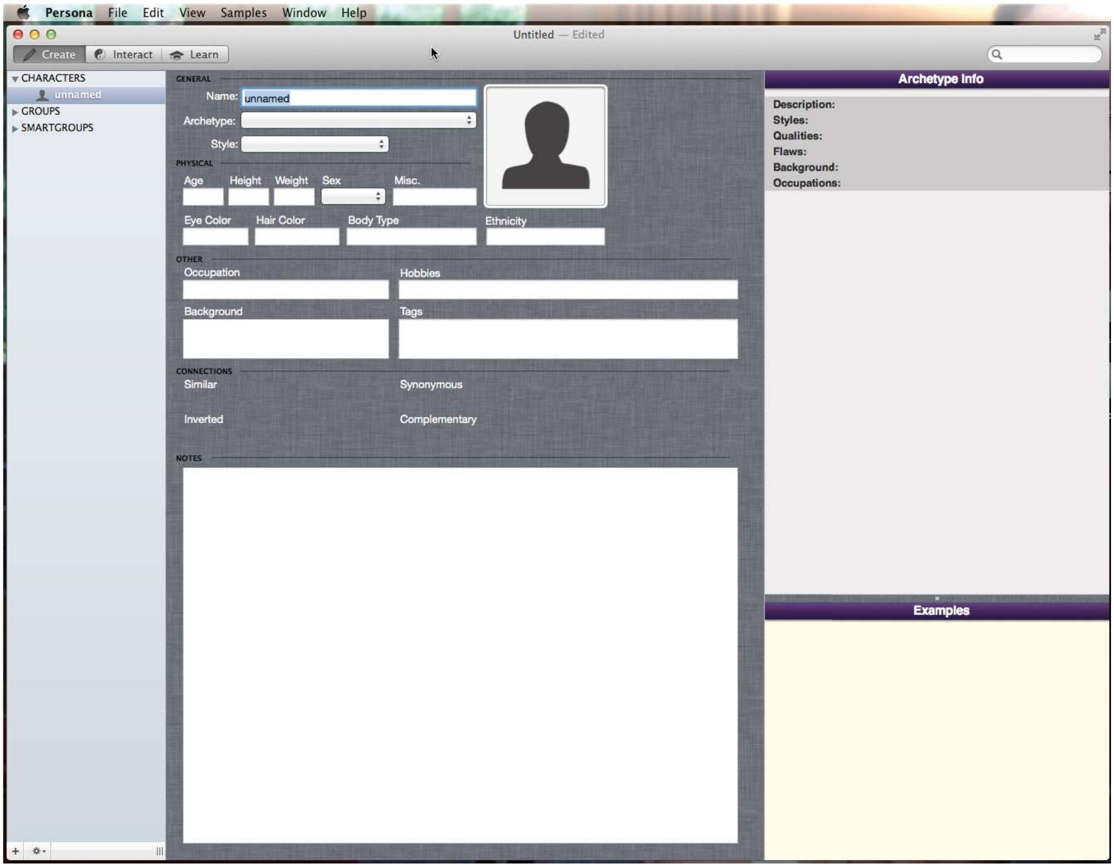

Figure 4-1. "Persona"

What makes Persona useful is it's availability in both a desktop and mobile app format, with data links that connect to a single workspace and a single working file. As creating the physical and mental likeness of a person will often require the engagement of observations of the populace, inspiration will often strike a writer at the oddest times while they are out and about, sometimes in the oddest of circumstances. The fact that Persona is available both in the cloud and on mobile platforms creates an incredibly available platform for instant ideation and brainstorming. Capturing the lighting requires that a bottle be available at all times and in all places for when opportunity avails itself.

Although most commonly associated with an actor's craft, writer's will need to mine the inner most depths of their characters once the surface details have been negotiated.

A very good place to start would be to utilize the 9 central questions that every performer must ask of their character that was developed by Uta Hagen, a prominent figure in the acting world.

UTA HAGEN'S "NINE QUESTIONS"

1. Who am I?
   (character-search for character's life prior to play's/scene's beginning)

2. Where am I?
   (environment: location, conditions)

3. What surrounds me?
   (persons, objects, color and texture)

4. What time is it?
   (hour, minute, date, year, century, era)

5. What are the given circumstances?
   (those events, facts, and conditions occurring before or during the play/scene that affect the character and /or action)

6. What is my relationship?
   (to all of the above and to other characters-solid or shifting?)

7. What do I want?
   (Objectives or Intention –includes the overall character objectives as well as more immediate beat-to-beat intentions).

8. What's in my way?
   (Obstacle)

9. What do I do to get what I want?
   (ACTION – VERBS; physical, verbal, psychological)

This process is a profound first step in being able to isolate and amplify the powerful core emotion that can connect both the entertainment property and the audience engaged with it. From this philosophy springs a number of schools of thought all related to the identification process a creator must go through to "flesh out" their characters. Whether through classical doctrines established by Stanislavski and Vakhtangov, or via contemporary meth-

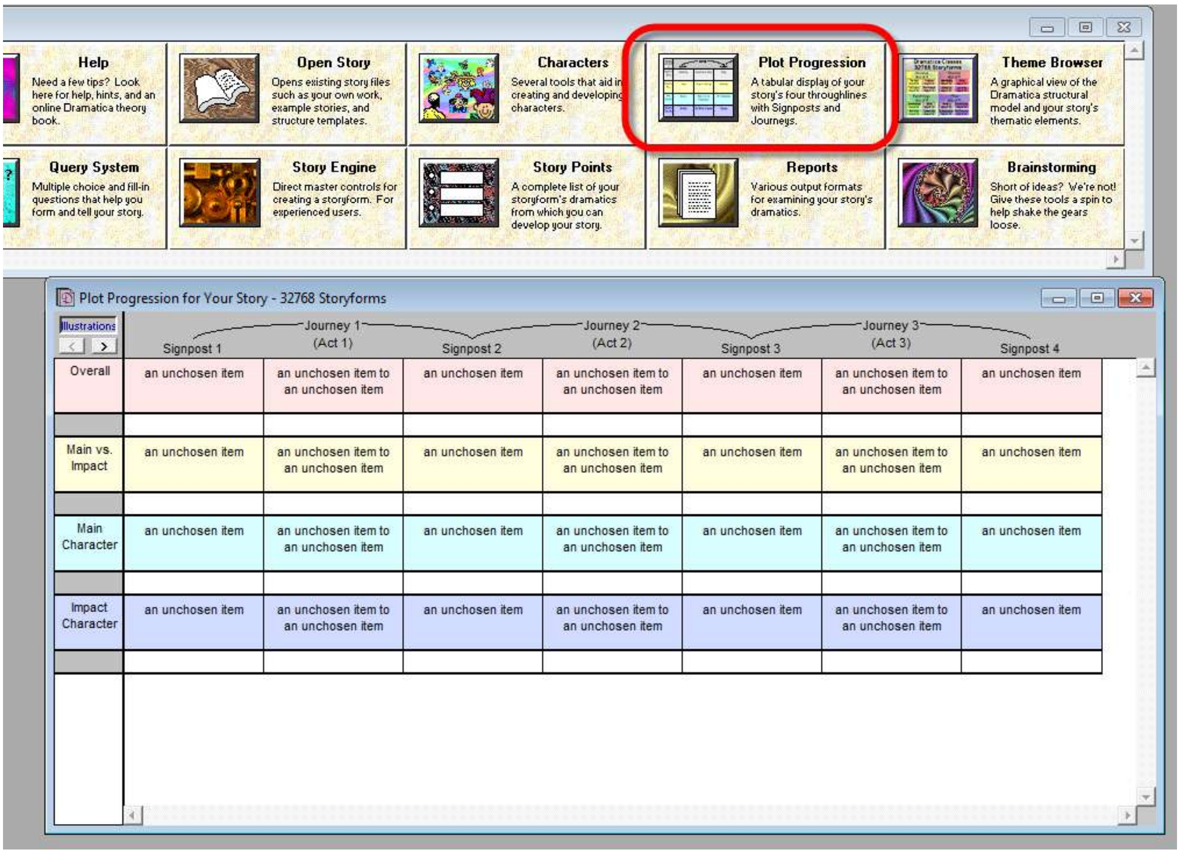

Figure 4-2. "Dramatica Pro"

ods such as those proposed by Ivana Chubbuck in her "Power of Acting".

Unfortunately, quite a number of character development tools and breakdown sheets suffered the problem of being self-contained, without the clairvoyance necessary for big picture oversight that a writer often needs. Dramatic Pro is one such story planning tool that offers a much broader vista of the creative journey a writer is attempting to craft. Not only does it explore a singular character, but also provides the context of a cast of characters and how they dovetail with story events.

As a creative story planning tool, packages such as Persona and Dramatica Pro have yet to capture the same synergistic energy as it's cuecarding/post-it note brethren, in that certain software functions in terms of navigating the interface robbed many creative discussions of their momentum. Whereas the traditional approach of arranging cuecards on a story wall still had the immediacy of tacking an idea straight into the context of the big picture. Story events could be shuffled around with relative ease and new ideas could be immediately jotted down and examined against the larger vision of the film. The downside to this process, of course, is that all information would eventually need to be collated for dissemination down a digital production pipeline.

Once a story plan is prepped, and ready to "go to pages", a film industry euphemism to begin the writing process in earnest, connections within a digital production pipeline context become more robust.

During the screenwriting phase, of the many tools that were available, two quickly rose to the fore, in terms of either supporting the creative process and/or the digital production pipeline.

1. Writer Duet
   A relatively new online utility built for collaboration
2. Final Draft Pro
   An industry standard screenwriting application that enjoys tenure.

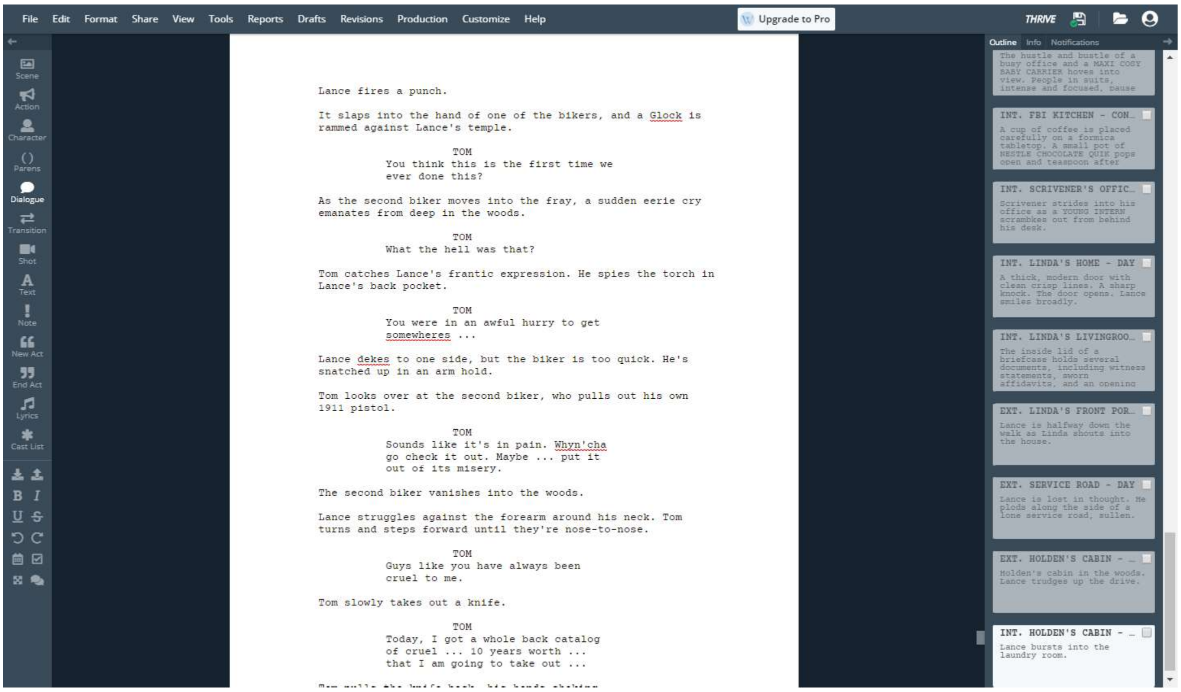

Figure 4-3. "Writer Duet (online)"

Writer Duet, due to its online platform, was the primary tool in helping to achieve a high standard quickly and helped to facilitate the timeline of events outlined earlier. As the Gen Zero One project moved relatively quickly through development stages from initial concept, right up to a meeting with Skyforth Film Investment Group, the tool had to be quick, easy and relatively unencumbered with either UI navigation and or technical considerations.

Writer Duet's relatively clean and simplified UI created an open and inviting visual work-space, and its online platform, accessible from anywhere, on any device, helped to facilitate my ability to write anywhere. Bus stops, coffee shops, in the livingroom and in the study were all places I could now utilize for writing when inspiration struck, making for an in-stant connection with my ideas.

Although restricted to traditonal workstations, which themselves are tethered to desks and offices, Final Draft Pro offers a depth of features that connect it firmly with subsequent stag-es of production. The ability to tag certain elements in a script and have those tags feed into production reports (and eventually connect it to industry standard budget and scheduling packages such as the Movie Magic suite) make it an invaluable part of the toolchain.

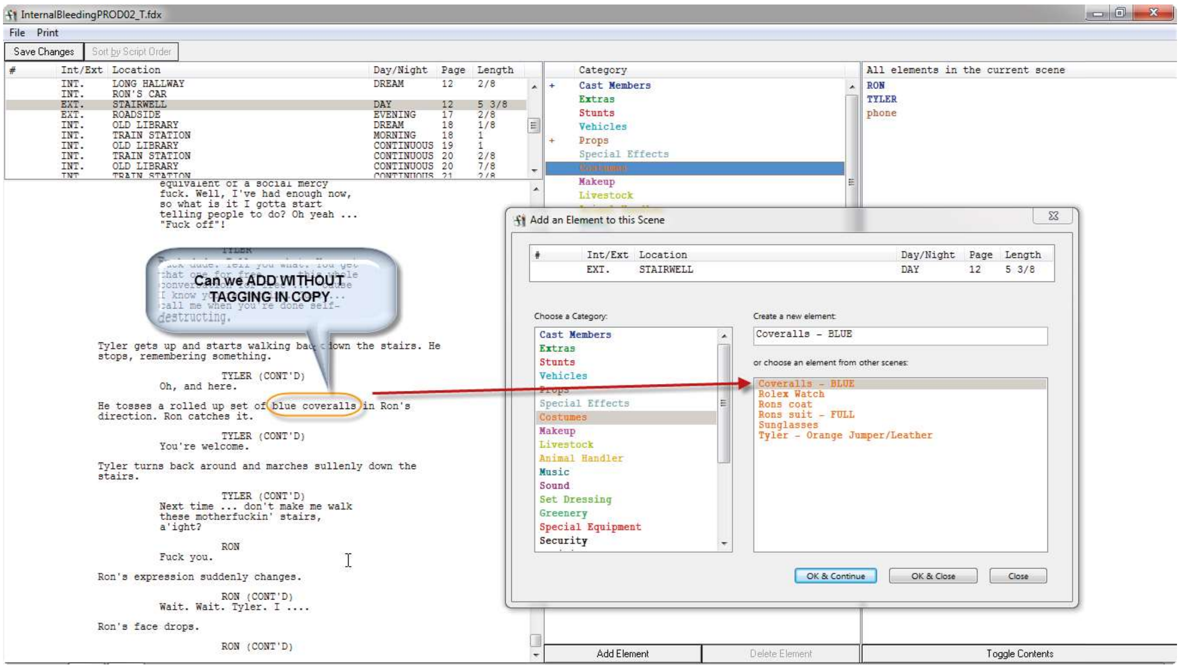

Figure 4-4. "Final Draft: Scene Tagging"

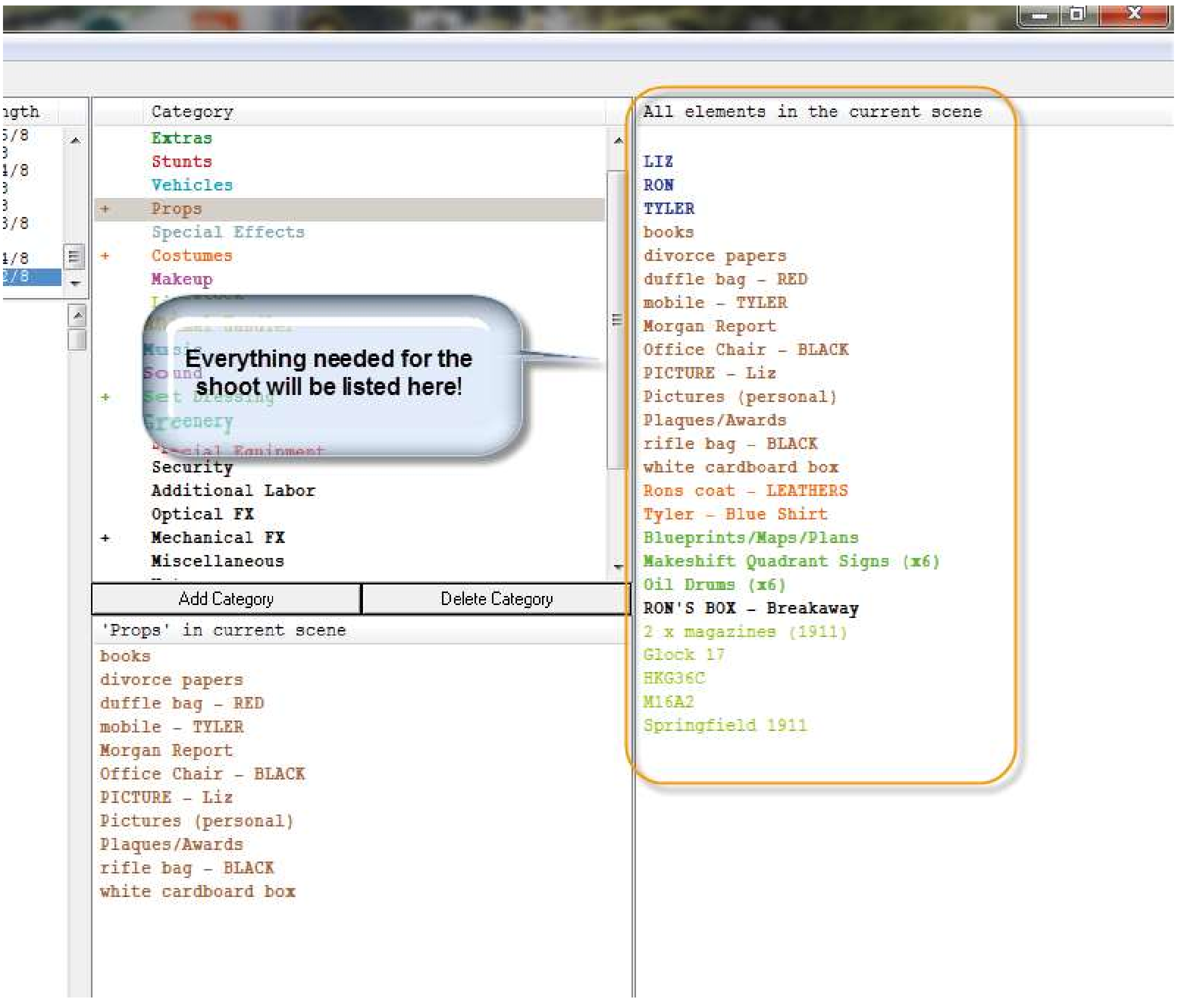

Figure 4-5. "Final Draft: Preproduction Planning"

4.1.1

The creation paradigm for digital artists is beginning to dynamically shift in favour of the artistic process. As coined by the developers behind the revolutionary new content creation package Clarisse iFX, the CG industry is moving rapidly away from “physically-based rendering” and inexorably towards “artistically-based rendering” (Staff 2014). As esoteric a concept as that is, “artistically-based” approaches are beginning to take serious precedence over the usual considerations of emulating physical real world properties, in areas of production that have classically been reserved for these technically biased processes, namely “multi-pass rendering” and “high-level compositing”.

Beyond the marketing hyperbole and rhetoric of claims from CG application developers that their tools can help artists to “work at the speed of thought”, there still exists the irrefutable real world example of placing a traditional paintbrush against a traditional canvas to intercept any notion that creating digital art is in any way shape and form faster and easier than traditional means. This stands anathema to the raison d’etre of digital technology in the modern world. There are numerous, justifiable reasons for this condition to exist that are inherently technological, but there is no justification for this condition to continually propagate.

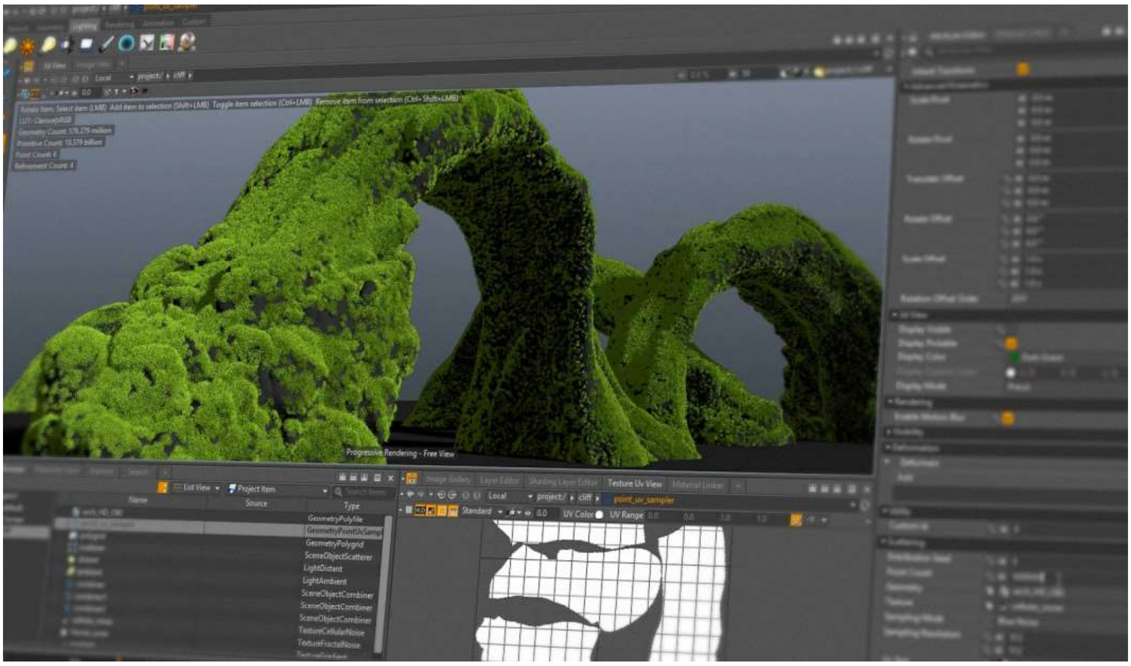

Figure 4-6. “Clarisse IFX”

The struggle to breathe new life into the digital creation process is beginning to gain momentum, and of particular note in the past year is the prominent emergence of a number of outstanding, production-proven third party tools.

Examining classic bottlenecks in a production of a creative property, such as a film or computer game, there are intimations that a number of the challenges that exist live in areas that require artistic expertise, and yet necessitate a more rigid, technically-minded operator to oversee. Dynamic simulations of real world phenomena is one area that typifies this conundrum, with its heavy reliance on physics and computer science. The field of computer graphics rendering is heavily rooted in mathematics and physics. Even compositing requires a rudimentary understanding of colour mathematics.

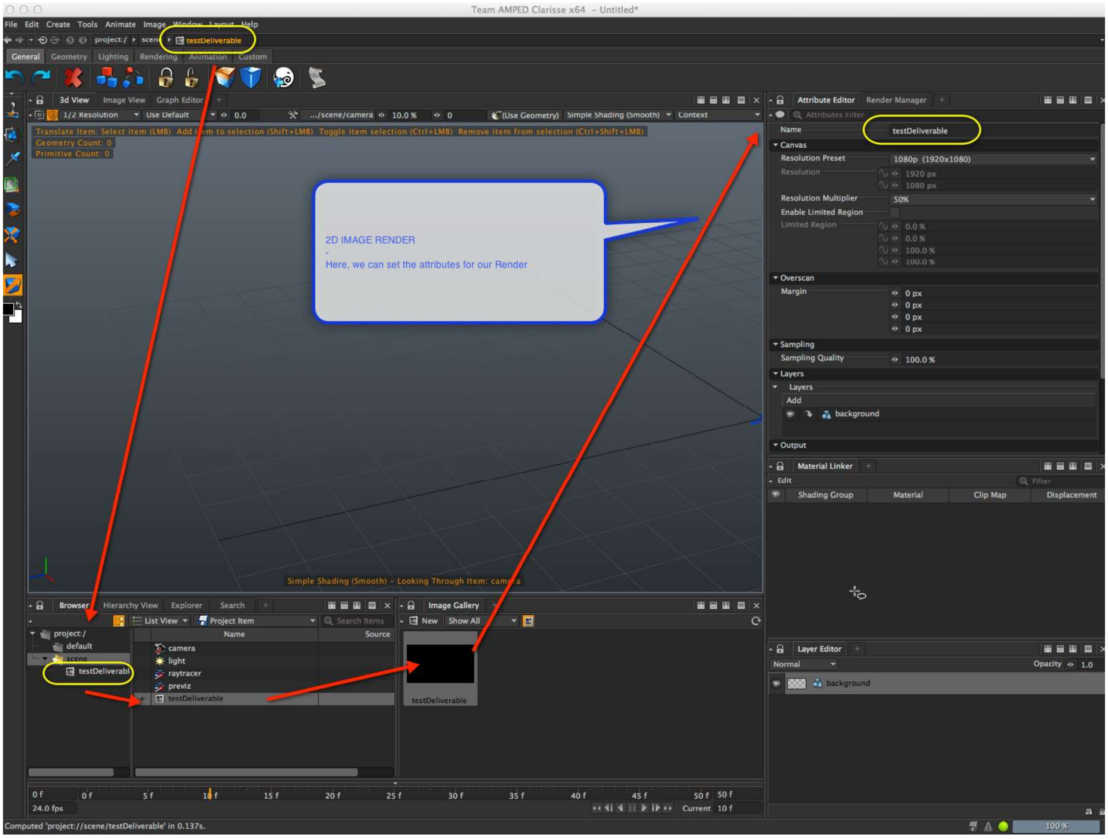

Figure 4-7. "Clarisse IFX: Workspace"

An accomplished senior animator, with exceptional draughtsmanship, who can wonderfully, expressively capture the ebb and flow of a lustrous lock of hair during a character animation keyframe pass, counterpointing the mood of a performance beautifully, can no longer incorporate that in their creative process. In fact, by sheer technical necessity, that part of the creative process has been surgically removed and relocated to another department. The same condition exists for clothing animation, for facial animation, and for props.

To help combat this, a number of independent developers have released a variety of solutions that, to some degree, focus largely on the interface between the artist and the underlying technology, in an attempt to "return to the roots" of classical-driven techniques for creating art.

MODELLING

At the ground floor of CG asset creation is the manipulation of primitive object types. Traditional creation of non-uniform rational b-splines through the manipulation of iso-parms, and the construction of subdivision surfaces based on the Catmull-Clark standard algorithm for higher order surfaces has now made way for traditional sculptural approaches when examining the process of creating models, whether organic or hard surface. Packages such as Pixologic's ZBrush and 3DCoat utilize modern day graphics adapter technology, the pixel shader pipeline, and volumetric pixels to represent a simulated "clay" that traditional artists can manipulate in a familiar, tried, and tested process. No longer are artists required to understand the ramifications of certain boolean operations, not only on proper quadrification, but also on proper UV map distribution. With the advent of digital sculpting packages, artists can now properly concern themselves with effective techniques using the rake tool in scraping a wonderfully textured feel across an area of built up clay.

CLOTHING ASSETS

Wardrobe and fashion design, which at one point, devolved into simply "cloth simulation" in a CG context, has now found its way properly back into the creative process as fashion design once again. "", the developers behind Marvelous Designer has taken a process that used to involve an acute understanding of the nature of the forces of shear, resistance, friction and their relationship to a collision physics model, and turned it into a process more familiar to tailors and traditional seamstresses.

Figure 4-8. "ZBrush: Fibremesh and Grooming Tools"

HAIR

Based on the same simulation model as cloth dynamics (which is largely derived from the curve-based principles that drive follicle dynamics), the creation of realistic looking human hair is a traditionally convoluted and calculation-intensive process. From follicle creation, to dynamic simulation characteristics, to the physical styling of the hair itself, the creation process of CG hair is so far removed from any classical painterly or sculptural approach, that it is not surprising that proper art direction and iteration for character-driven hair is prohibitive for many productions.

Three recent developments are quite noteworthy in this regard. One tool exists as an integrated plugin within ZBrush itself, while the other two can be voluntary incorporated into the working environment of Autodesk's Maya for seamless addition to an existing pipeline.

The first solution, labelled "Fibremesh", is Zbrush's integrated solution, and presents the most intuitive and response set of hair design tools of any package. What once took several days to establish, in terms of creating even a baseline simulation with which to iterate from, can now be authored in ZBrush within hours, with greater visual fidelity and a fantastically visceral artistic feedback mechanism. Incorporating proper design tools, using recognizable lexical referencing removes the unnecessarily difficult and unapproachable technical terminology and immediately places an artist at ease. With "Shave and a Haircut" and "Yeti", both hair authoring plugins available for Maya, their immediate benefit present themselves in the iterative process, which can often times be quite time-consuming when dynamic, non-recursive simulations are involved. Yeti, being the more recent of the two, introduces a visual node-based editing system that allows isolation of an attribute and its characteristics which is valuable when tuning the visual "look" of a particular effect.

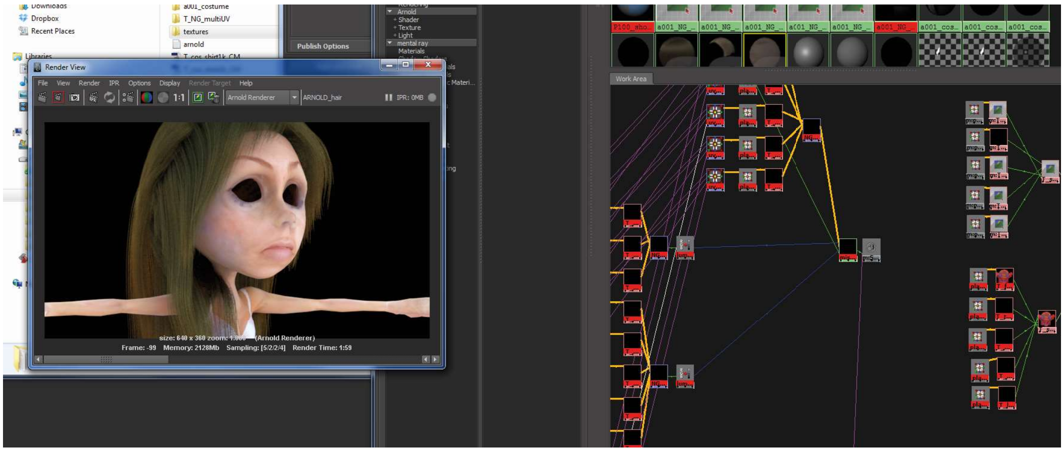

Figure 4-9. "Final Shader Set Up in Maya"

PROCEDURAL ASSET CREATION

SPEEDTREE

Although procedural solutions generally tend to imply the removal of any contextual artistic interpretation in favour of a purely mathematical solution for a visual dilemma, a package called “Speed Tree”, from developers “”, presents a delicate balance between artist-driven techniques and a purely procedural core. Using a node-based editing system, artists can organically “grow” vegetation assets in a logical, hierarchial manner. Node naming in Speed Tree presents the concepts of “trunks”, “branches”, and “leaves” that by their obvious nature, removes unnecessary technical clutter, allowing an artist to focus more importantly on the “silhouette”, “pose” and “gesture”as they creatively grow and prune their digital assets. No longer do artists need to familiarize themselves with L-systems, curve-based rendering, and fractal distribution. Artists can simply create trees. Procedural operations that drive tree creation are largely invisible, and exist purely to eliminate the mundane aspects of the creative process.

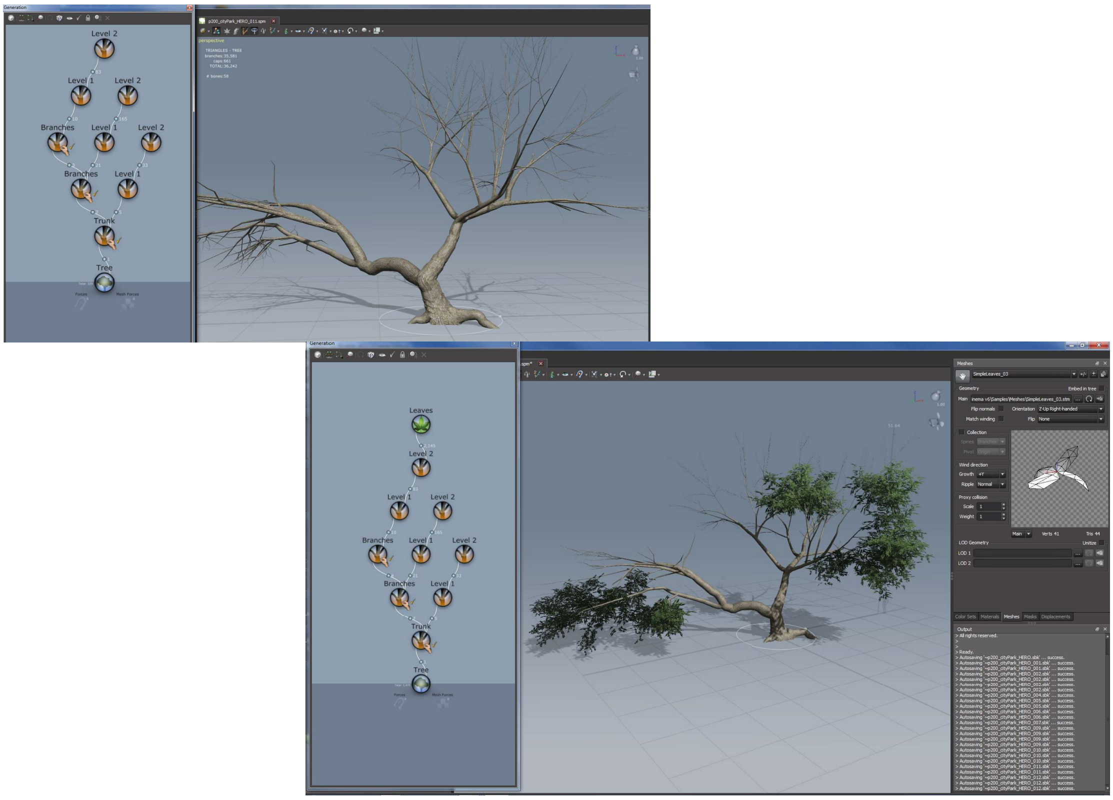

Figure 4-10. “SpeedTree: Hand Crafting Nature”

RENDERING: ARNOLD

Standard Material

Rising quite rapidly into prominence in the field of rendering is Sony's once proprietary "Arnold" renderer. Although a number of advancements can be addressed in evaluating Arnold as a whole, one key example worthy of note is Arnold' introduction of a single material. Where shader artists and texture artists in the past have had to work with Blinn shaders, Phong shaders, Lambert shaders, and Anisotropic shaders, Arnold presents one unified "Standard" Material. With a single shader definition, artists can create everything from metal, to plastic, to complex skin.

4.1.2

Enter The Nucleus

The world of dynamic simulations is deceptively simple.
The age old question of what would happen when an immovable object meets an irresistible force is sophistry when measured against the world of computer graphic simulations. For all intents and purposes, things generally tend to move when pushed, and continue to move until they collide with something. In the world of dynamic simulations, when an immovable object meets an irresistible force, something has got to give. That 'something' is the basis for the application of classical mechanics. Newton's Philosophiae Naturalis Principia Mathematica (1687) posits three physical laws of motion :
The velocity of a body remains constant unless the body is acted upon by an external force.
The force of an object is equal to its mass times its acceleration.
Any action between two bodies has an equal, opposite and collinear reaction.
These principles represent the foundation of all active and passive rigid body dynamics, which in turn forms the basis for how cloth dynamics can be visualised.

For a very cool dynamic simulation to occur, an active rigid body (i.e. something moving, preferably with a bit of force) must come into contact with a passive rigid body (something to bump up against). Active rigid bodies can be acted upon by a variety of different types of forces, including gravity, wind, and turbulence. They cannot, however, by animated in the traditional sense, with an artist controlling its location in space using keyframes. The passive rigid body, on the other hand, is completely manipulatable by the animator but remains irresolute against any external forces. The passive rigid body's raison d'être is to simply be something to collide against; hence, its more common moniker of 'collision object'.

From these very simple roots comes another layer of complexity when introducing particle systems. A particle system, at its basic core, is simply a swarm of active rigid body objects that can be acted upon by forces and that can collide with passive rigid bodies, or collision objects. If one imagines a particle system comprised of 500 particles, each an active rigid body, colliding against a passive rigid surface, what ensues is a lot of dynamic calculations for a simple simulation. Imagine calculating Newton's physical laws 500 times per every frame every second (not including substeps, which will be discussed later).

The situation increases in magnitude once cloth is introduced. If we take a garment, such as a shirt, and sculpt it to what may be considered as medium resolution scale, we would have a CG asset with between 10,000 and 50,000 vertices. The essence of any cloth dynamics solution works on the simple principle of tying a particle from a particle system to a vertex location on a polygonal object. What we now have is between 10,000 and 50,000 active rigid body objects colliding with a passive rigid body, and that same number of calculations per every frame every second. At a standard film setting of 24 frames a second, we are beginning to encroach upon the law of diminishing returns, and as computational time increases, the validity of having high-frequency details comes into question.

Commercial Solutions: Maya's Nucleus Framework

The introduction of the Nucleus Solver system for dynamic simulations to Autodesk Maya's framework represents the most significant change to application embedded simulation solutions. In an attempt to corral the rising costs of introducing a variety of simulations into the animation pipeline, Autodesk engineers created a universal simulation engine to centralise many of the core dynamics calculations into a single node: the nucleus node. Acting as a 'dynamics globals', the nucleus solver not only succeeded in shaving time off simulation calculations but also made it possible to integrate a variety of dynamics systems into a single fully interactive environment.

In the past, dynamics systems were designed in isolation. Particle systems, cloth solutions, hair systems and the forces necessary to drive each of these effects had to be compartmentalised and solved on their own. If effects needed to interact with each other, they would have to do so indirectly and with careful planning. The nucleus node allowed these elements to combine with each other in a unified environment allowing for a more integrated development process, and ultimately, a better looking solution.

That notwithstanding, the computational cost for running a cloth simulation solve is still prohibitive for high-resolution polygonal objects.

Production Solution: Low Frequency Simulations and High Frequency Maps

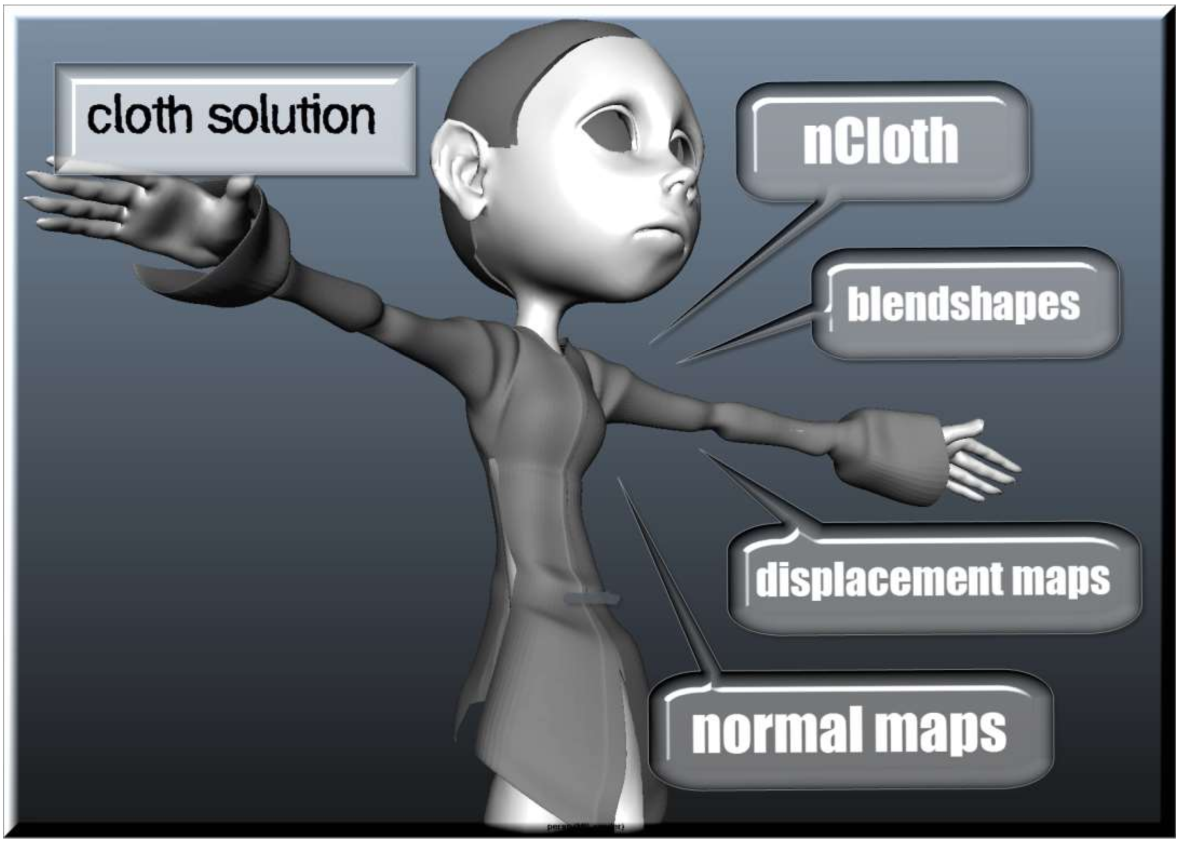

Figure 4-11. "The Recipe for Cloth"

Cloth simulations cannot be entirely written off, as the central movements that result from a low fidelity simulation are undeniably accurate in recreating motion. They will, however, be supplemented by three legacy animation techniques that continue to be utilised in the CG industry, and demonstrate not only a faster turnaround time in producing high fidelity cloth effects, but also the need for an artist-controlled asset creation pipeline.
The four stages for the creation of high-frequency wrinkle deformations are as follows:

1. nCloth: Nucleus-based low-frequency simulation
2. Blendshapes: Directable dynamics and Sculpted Keyframes
3. Displacement Maps: Rendertime mid-frequency details
4. Normal Maps: Realtime high-frequency details

4.1.3

The Shirt - nCloth

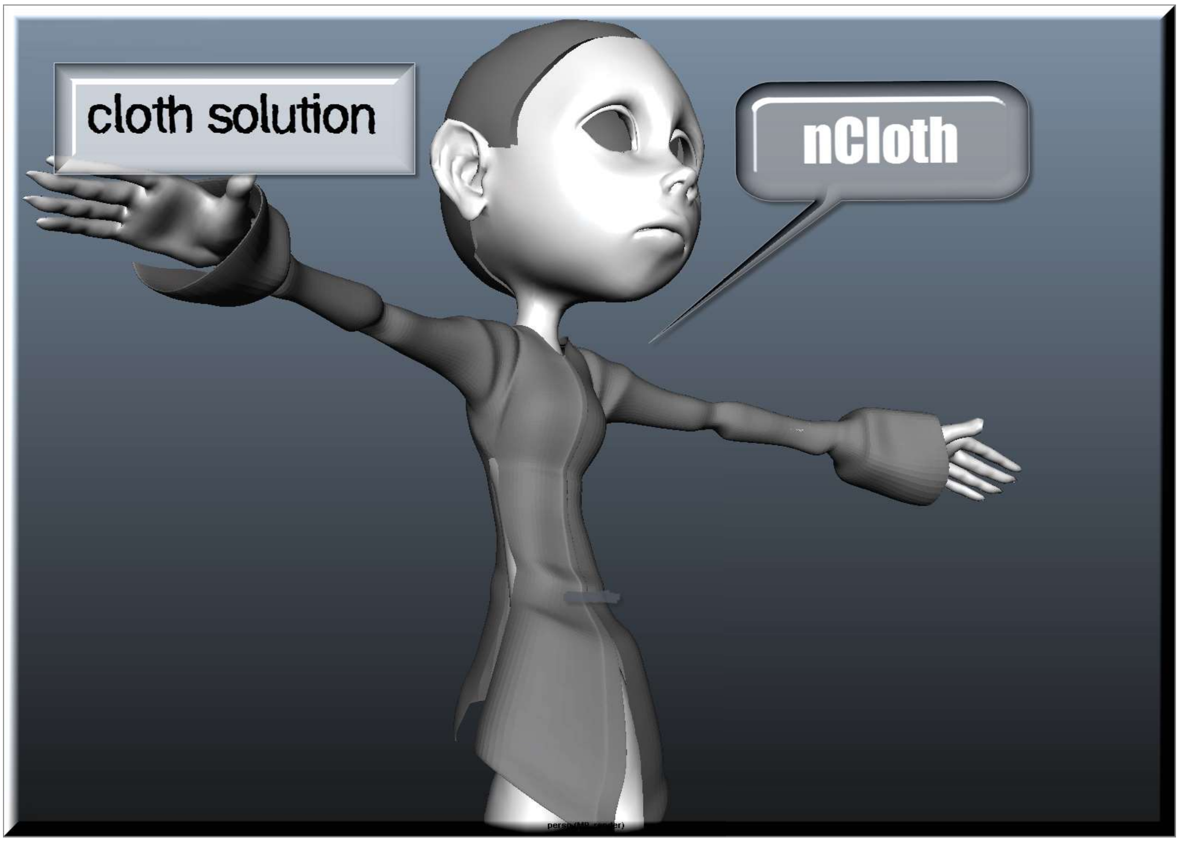

Figure 4-12. "nCloth - The Basis"

The Assets

From the outset, the creation of clothing assets for the central character in The Nothing Girl made several assumptions in terms of artist/user profile. The first and primary assumption, and in the estimations for this research, was that the artist's approach derived heavily from a classical sculpting background. The second assumption was one of knowledge base for the artist. Beyond moderate user knowledge of the operating system and intermediate user knowledge of the requisite 3D asset creation tools, no programming expertise or mathematics for computer graphics knowledge was assumed.

In terms of power users, no work arounds, hacks, or to a certain degree, simulation-based optimisations were employed.

Using Maya's nCloth feature, based around its nucleus dynamics framework, polygon-based clothing assets were authored for direct, simulation-only implementation.

The primary character's shirt was constructed from 32,133 polygonal faces and 33,104

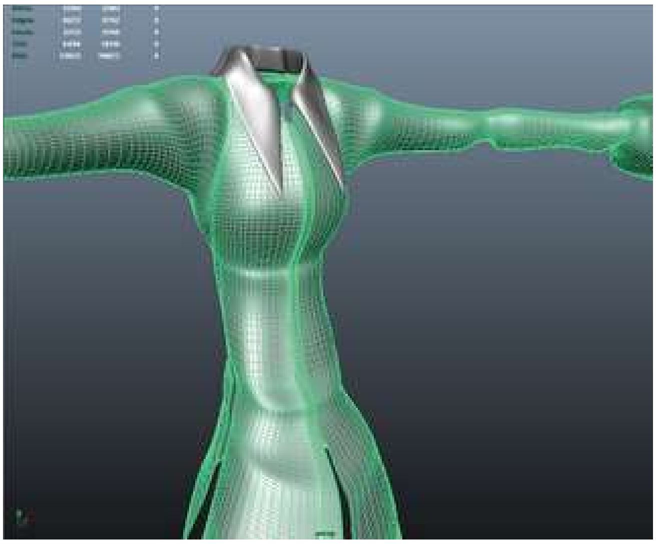

Figure 4-13. "Base Polygonal Structure"

vertices (see Figure 4-3). Although the density of the geometry represents a relatively high number of polygonal faces for simulation calculation, it does not represent a significant challenge for a standard CG production pipeline. From a visual standpoint, the number of vertices representing the surface detail is adequate for simple folds and wrinkles.

To help accommodate the texturing process, the shirt asset was UV mapped using a process called 'pelting', the results of which can be seen in Figure 4-4. Although the concept behind UV mapping and its relationship to texture space is inherent to this process, a discussion on the various projection methods involved is beyond the scope of this dissertation. The procedure itself is mentioned here, in terms of its impact on the artist's overall workflow.

Simulation Pre-Roll

Setting up nCloth assets for character clothing simulation is a two stage process. The first stage involves 'settling the cloth' which allows the dynamic solver to get 'comfortable in its

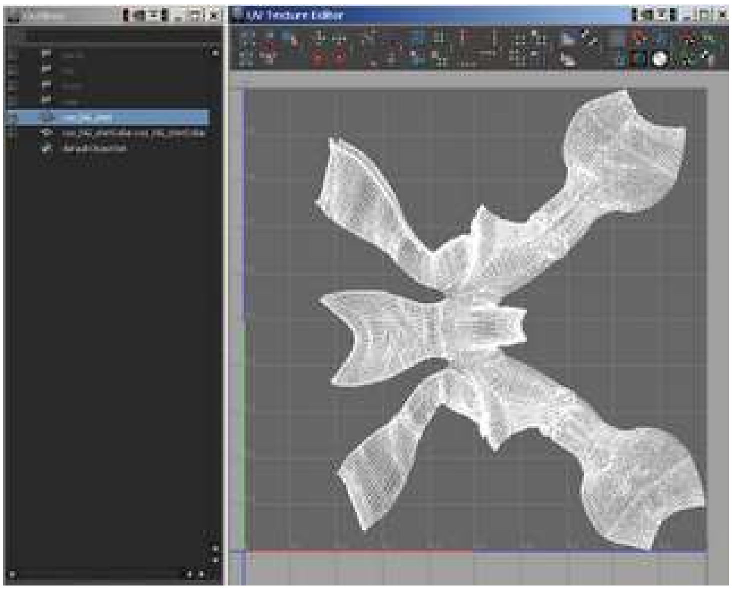

Figure 4-14. "Pelting"

clothes'. The second stage is to match the clothing with the first key pose in an animation sequence.

1) T-pose Initial State (Figure 4-5
   a) Settling the Cloth
      i) With the character scene file loaded, the character presents itself in the standard T-pose. The modeled shirt asset is also created at the T-pose.
      ii) The timeline is adjusted to include negative numbers, in this case -40 to 0. This space to the left of the timeline is an area normally free from any keyframe animation data and will allow time to settle the cloth onto the character.
      iii) As the simulation plays out, the clothing drapes itself across the character, as if being suddenly dropped from a suspended position. Once complete, an initial state is stored for the nCloth object.

2) Pose 01 Initial State
   a) The First Pose
      i) Once the nCloth object has been settled, it will need to simulate from the T-pose to the first pose in the animation sequence.
      ii) The animation sequence used in initial testing is a basic walk cycle. An animation blend must now be employed to morph the character from the T-pose to the first contact keyframe in the walk cycle.
      iii) As the character blends from a T-pose to pose 01, the nCloth object must move and simulate into position.
      iv) Once that simulation cycle is completed, another initial state is stored on that nCloth object.

The entire two-stage process for preparing a cloth simulation object for rendering and testing is generally referred to as a simulation pre-roll.

Observations

At this point, a number of problems presented themselves in terms of artist workflow and visual fidelity.

The primary concern was time, in terms of simulation processing. On a standard Intel Core2 Quad Q6700 running at 2.66GHz with 3.25 GB of RAM, the simulation pre-roll from frames -40 to -30 took 5 minutes.

Considering a standard pre-roll takes between 30 and 60 frames, this translates to a potential 30 minutes of preparation time before an artist can even begin to tweak, test, adjust and modify the simulation results.

From Figure 4-5 above, it is clearly evident that several attributes need to be adjusted to get the cloth to drape correctly on the character. Each adjustment will require a 10 frame roll (at the very least) to observe and evaluate the visual fidelity of the results. Considering that an artist may make over a dozen changes, this will equate to a fair amount of time just to get the cloth into a workable state.

In terms of On Target Look Development, the central flaw to this common approach of isolated testing not only prevents an artist from accurately gauging how much of a visual impact wrinkles would have in contributing to the final look of a fully textured character and environment, and how key lighting setups would react and interact with the movement of the clothing, but it also prevents an artist from accurately estimating the production cost in terms of processing time to the overall production pipeline. If testing were to continue on an isolated piece of clothing against character geometry, a set of values may be arrived at that would indicate a reasonable amount of processing time balanced against a satisfactory visual return, but once the asset is incorporated into the final environment, with multiple articles of clothing intercolliding with each other, coupled with muscle simulation calculations of the character rig and dynamic hair systems interacting with further collision objects, the amount of accumulated simulation time necessitated by a simple 10 second shot is a harrowing prospect.

Not only is On Target Look Development an important consideration for art direction, but from a technical standpoint it is a necessity, especially in terms of estimating the sheer number of calculations involved in delivering a shot.

The first test case scenario of a simple untextured shirt simulating against a character's untextured body resulted in a 60 frame simulation, what amounts to a little over 2 seconds, equating to 30 minutes of calculation time. At this point, the first visual sacrifice had to be made. The shirt asset was retopologized (see below) to allow for a faster simulation turnaround time. It was abundantly clear that high-frequency wrinkle deformations, on a purely simulation level would equate to an exponential increase in development time, without an appreciable gain in visual fidelity. In an art pipeline for a CG project, this would represent a massive overhead that few studios could readily afford.

Retopology

The process of retopologizing a polygonal object involves creating a new topological surface by manually redrawing polygons across the existing surface of the asset to be retopologized. This process is often employed in a studio pipeline to reduce the number of polygons in a given asset, or to create a low level of detail collision object. There are a number of methods available to a CG artist to resurface an existing piece of geometry. After a number of tests involving a few industry-standard practices, ZBrush 4.0 was ultimately employed for this task. Its retopology tools represent the most preferred method (outside of standalone tools) for CG artists in a standard production pipeline.

The process itself is 3-fold :

EDGEFLOW GUIDES

In this process, an understanding of how the underlying mesh objects will ultimately deform is absolutely essential in determining where to draw in the new polygonal shapes.

Painting The New Topology (Figure 4-7)

Using any number of vertex-based painting tools, it is a wise idea to map out visually how the new topology will conform to areas of high deformations.

GIVING ENOUGH VERTICES: In this case, the shirt mesh is brought into ZBrush and subdivided to create enough vertices to allow us to paint on.

POLYPAINT: The shirt asset then has all uv-based texture information removed and the "colorize" feature is activated to allow the artist to paint directly on the model.

Notes:

Draw = black/Erase = white

Hotkey: V – swap foreground and background color swatches

Sketch: draw in the major loops then progress to the minor loops

RETOPOLOGY TOOL

Within ZBrush's TOOL menuset, we will be using the following features :

- ZSpheres Tool
- Adaptive Skin Pallette
- Rigging Pallette
- Topology Pallette
- Projection Pallette

Switch to a ZSphere

- If the ZSphere draws a connecting joint from its origin to your new topology, you want to delete that!
- Hold down ALT (with the DRAW TOOL) and click that line

In the Rigging Pallette:

- Select Mesh > shirt object
- Scale down the ZSphere
- Minimize the Rigging Pallette

In the Topology Pallette:

- Edit Topology
- Activate Symmetry
- LMB – draw joints
  - There is a directional rhythm to drawing joints
  - NEW ROW = Clockwise/counterclockwise
  - ADDITIONAL ROW = Corner/Join/Corner/Join
- CTRL+LMB – to start at a new joint
- SHIFT+click on a point
- PreSubdiv Slider > 4: Increase this to grab more detail

In the Projection Pallette:

- Projection
- Press A – Previews Adaptive Skin
- Projects Polypaint

In the Adaptive Skin Pallette:

If the PreSubdiv Slider in the Topology Pallette is maxed out at 4, and more detail is required …

Increase Density to 4

PROJECTION

We need all our textures, details and UVs back again!

Create a High and a Low that lineup:

Make Polymesh3D @ 5 divisions (our new TOPO)

This will SOAK UP the detail from your original sculpt underneath

Make Polymesh3D @ 1 division

Export both

Switch to ZSphere

Import Low

Subdivide to the same number as the high

Import High to replace it

As an exemplar, this is a small sampling of the convoluted process in “preparing a mesh” to adequately accept a full cloth solution. One of the key requirements for an artist during this process is a keen understanding of underlying topological considerations, as each vertex can directly affect computational overhead.

The ideal situation is a creation methodology where artists can work “polycount free”.

When comparing the multi-faceted process outlined above, in terms of using a more technical approach to wardrobe design, it is easy to see why the methodological paradigm of using artist-centric platforms such as Marvelous Designer was eventually adopted in its stead.

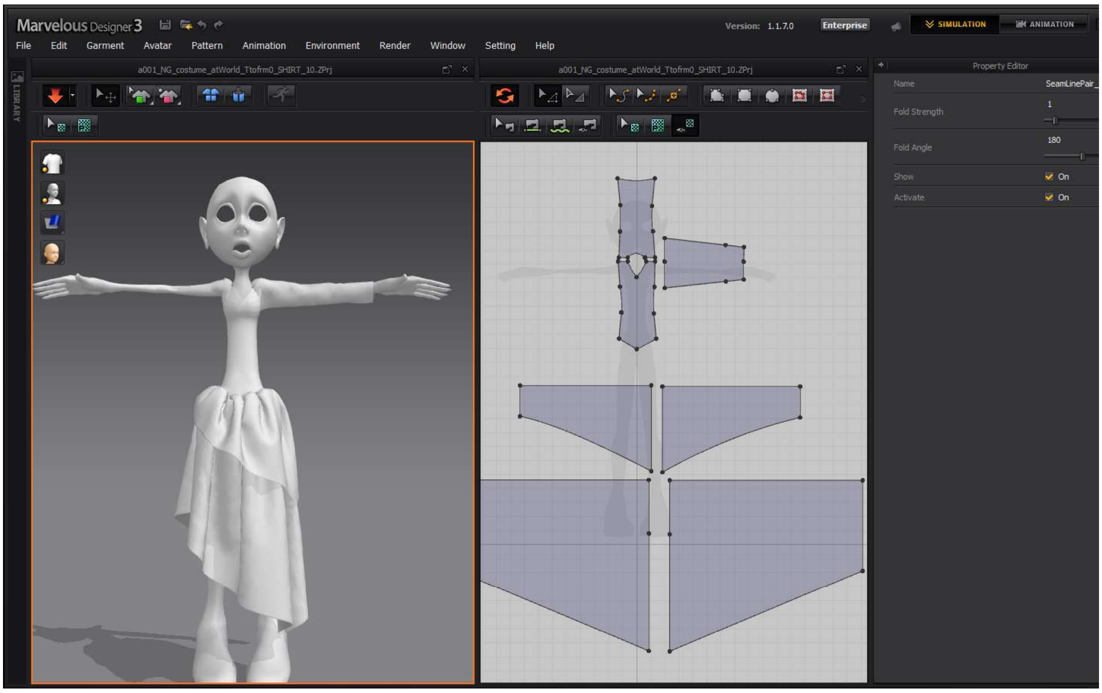

Figure 4-15. “Marvelous Designer and the Nothing Girl”

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chapter 5
analysis

5.0.1

The isolation of the precise neurological and/or behavioural conditions and processes involved in art-making is essential in divining, not the validity of the contribution of traditional art practices in being able to dictate the outcome of a particular piece of work, but rather in determining the quantity of involvement the traditional means have in terms of influencing an artefact.

As necessary as it is to delineate between what constitutes craft against what constitutes art, it is equally fundamental to understand creativity's role in art, and whether or not the two are engaged symbiotically, or are mutually exclusive. Human beings have an immense capacity for being creative, without necessarily having command of the arts, but can the opposite condition exist, where one can create astounding works of art without necessarily being creative? It is an accusation occasionally levelled at the entertainment sector from popular critical review, but the role of creativity is a powerful one in every discipline of the arts. The goal is to determine if there are factors at play within the scope of a digital context that may be contributing, adversely or not, to the peak capitalization of a "creative" moment. In fact, the entire concept of buttressing creative processes would be null and void if its lack of relevance to art-making could be evidenced. In fact, creativity and the creative processes themselves may seem, upon cursory inspection, not to be entirely relevant to the operation of our daily lives.

The emphasis on classical education models have always centred on the edification of the quantifiable, in terms of knowledge acquisition, in linearly measurably progression paths, through the subjects of mathematics, law, science and engineering to name a few. Whereas their immediate application is readily apparent in the broader context of practicality, creativity (most notably, through the arts) does not share the same regard, as McCallion noted when he observed that new academic accountability measures in the UK "don't include the Arts" (McCallion, 2015).

Yet humanity has always intuited the importance of creativity to any endeavour, and the source of that intuition may be attributable to genetic favourability towards variability, one of the chief determinants of evolution according to Darwin. In an essay entitled, "Artistic Creativity and the Brain" by Semir Zeki, professor of Neurobiology at University College London, art is explored as one demonstrable expression of this variability. Zeki acknowledges that "variability confers huge advantages: it enriches our cultures immeasurably and is a key factor in the further evolution of human societies" and thus, attributes wide-ranging social and cultural ramifications to its development. He then proceeds to expand on its significance by stating that when "neurobiology starts charting the neurological foundations of variability, the results will affect profoundly our social organization at all levels, including educational, political, and legal" (Zeki, 2001). Creativity, in a sense, could be considered an outward manifestation of internal variability characteristics in terms of cognitive processes. If that variability, exhibited through creative expression, demonstrates a sufficiently elaborate and sophisticated range, there could be a genetic impetus that draws audiences towards the Arts and the need to celebrate its outstanding achievements.

From an artist's standpoint, what neurological activity is triggered by the creative processes involved in art-making and, more importantly, what are the ideal conditions that facilitate the greatest amount of emotional investment in a work of art? In a study published on January 16th, 2018 that examined the correlation of creative ability with brain functional connectivity. The neurological activity they discovered, through a number of fMRI scans under controlled tasks, demonstrated that a "high-creative network exhibits dense functional connections between core nodes of the default, executive, and salience systems - networks that typically work in opposition - suggesting that the creative brain is marked by a tendency to simultaneously engage these large-scale circuits to a greater degree than the less creative brain." By contrast, "the low-creative network was largely comprised of subcortical, cerebellar, and sensorimotor brain regions." (Beaty et al, 2018)

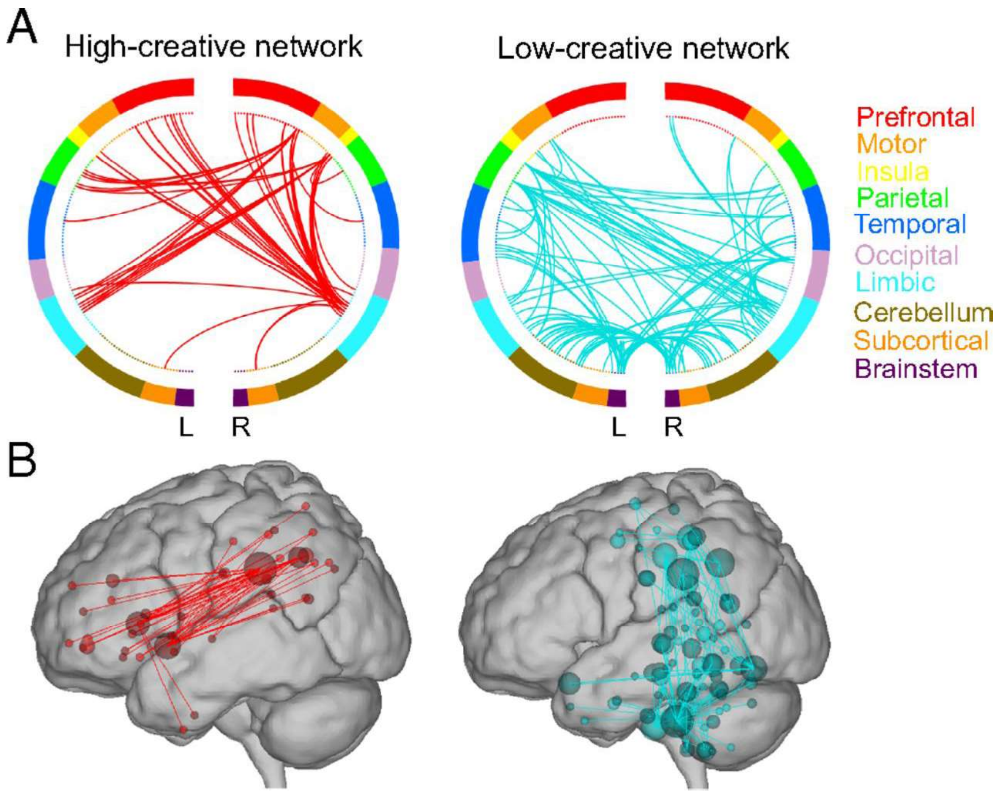

Figure 5-1. Creative Networks in the Brain (Beaty et al, 2018)

Upon further examination of neurological activity in computer programming, specifically the "ability to bias a particular response from many possible choices", a process frequently engaged by programmers, the prefrontal cortex played a dominant role in providing the "cognitive and executive control" needed for complex coding tasks. In fact, the prefrontal cortex is theorized to be at the heart of "rules, plans, and representations for tasks". (Parnin, 2010); however, an interesting neuroimaging study of artistic expression conducted by Charles Limb and Allen Braun demonstrated the possibility of highly creative moments requiring the deactivation of the prefrontal cortex (Limb and Braun, 2008).

It would seem that, although the creative brain can simultaneously engage a variety of systems in the brain, the one primarily responsible for computational thinking may not necessarily be relevant to the creative process, and indeed could quite very well interfere with its maximum potential.

Upon closer examination of research conducted in the areas of mental engagement with traditional art and how it influences levels of the neurotransmitter, dopamine, there seems to be an interesting relationship to investigate and analyze. As stated in a journal article about dopamine and the creative mind, researchers concluded that their findings supported "the idea that dopamine levels in multiple brain areas affect human creativity, with an interaction between frontal and striatal dopaminergic pathways" (Zabeline et al, 2016) It is interesting to note in some of their findings the contrast with dopamine levels extant in the brain during engagement with the sciences.

Table 1

Correlation matrix and descriptive statistics of ATTA fluency, ATTA originality, and ATTA total scores, CAQ arts, CAQ science, and CAQ total domain scores, and SAT/ACT scores.

	ATTA Fluency	ATTA Originality	ATTA Total	CAQ Arts	CAQ Science	CAQ Total	SAT/ACT
ATTA Fluency	—	.26*	.66**	.09	.00	.08	.29*
ATTA Originality		—	.90**	.25*	-.08	.17	.18
ATTA Total			—	.23*	-.06	.17	.27*
CAQ Arts				—	.14	.89**	.04
CAQ Science					—	.57**	.16
CAQ Total						—	.09
Mean	14.46	7.30	29.06	10.36	3.64	14.00	98.00
SD	3.71	3.12	8.04	9.58	5.25	11.55	2.23

*Note. ATTA = Abbreviated Torrance Test for Adults; CAQ = Creative Achievement Questionnaire. *p < .05

**p < .01.

Figure 5-2. ATTA (Abbreviated Torrance Test for Adults) v. CAQ (Creative Achievement Questionnaire) , 2016

As can be readily observable in Table 1, a small and by no means comprehensive example of the tests undertaken, there is a noticeable decline in the creative processes for brains engaged in the sciences. This is by no means an indicator of lack of creative problem solving in the sciences, but rather a simple reflection of the thought processes generally engaged in one activity over another.

Also lacking in scope when analyzing the neurobiological factors contributing to the maximization of creative potential are the profoundly influential environmental conditions that shape artistic development. As any discussion of the advantage of traditional art forms over digital must invariable examine how artists interface with their work, tools and environment are very much part of the equation, as companies such as Oculus and Wacom deeply understand.

With the goal of activating certain systems in the brain and facilitating the release of certain key neurotransmitters, such as dopamine and understanding how they may contribute to creative potential, it seems a logical progression to examine how external tools and environments for digital art-making processes have evolved over time. There is a concerted effort to explore haptic feedback as a further bridge between digital experiences and the tactile satisfaction of the craft its digital counterpart is meant to replicate.

Research undertaken at University College London set out to determine whether or not simulated tactile feedback supported creativity. "Haptic interfaces in art-related applications have been reported as being able to improve users' performances and enhance their creative processes (Baxter et al., 2001; Kim et al, 2003; Shillito et al., 2001; Yeh, et al., 2002). However, work to date has focused on the realism of the haptic sensation, rather than on understanding the role of haptic feedback in creating a positive user experience for art-related applications, or on how users might choose between alternative haptic sensations in interactions." In their study, Sulaiman and Cairns have "provided evidence that haptic feedback can enhance artists' creative experience with computer-based drawing applications" (Sulaiman and Cairns, 2010).

From here, it takes a very small deductive leap to reason that, with the necessity of simultaneously engaging several disparate neurological systems to engage creative thinking and activate the neurotransmitter dopamine on a significant scale, bolstered by multiple sensory pathways of stimulation as evidenced by the relevance of tactile interaction with art making, a combination of neuromuscular coordination with cognitive processes not normally accustomed to simultaneous activation, yields the secret to unlocking full creative potential.

The best exemplar for this process in action is evidenced by musicians. Any musical endeavour requires a unique and simultaneous co-ordination between a variety of neurological and neuromuscular systems, reacting constantly and instantly to sensory feedback every milisecond and making necessary recalibrations during a performance. Henry B. Newton, in his book entitled "The Neurology of Creativity: Focus on Music" examines these complex relationships in the context of musical performance. Newton acknowledges that "the most recent theories suggest that the major lobes of the brain, in particular interactions between the frontal lobes and temporal lobes, are critical for maximizing the potential for creative endeavors. The neural circuitry of the limbic system, as well as catecholaminergic neurotransmitter pathways and their lobar interactions, is also important in the process. Music is one of the most creative and complex of all human activities and appears to involve numerous regions and pathways within the brain" (Newton, 2015). This seems to reinforce early research emphasizing the importance of co-ordinated neurological systems and the nuerotransmitters associated with them. Music industry professionals have recognized, whether through deliberation or via intuition, this necessity for generations. They recognize the relevance of creating the conditions, whether in a rehearsal space or during a performance, of tapping into this sophisticated form of neurological co-ordination.

Whereas a traditional artist can entertain a number of tactile experiences, from the soft maleability of clay to the slippery subtlety of paint, in a wide variety of different environments, from an art studio with all its associated visual, auditory and olfactory sensations to en plein air exterior locations, by contrast a digital artist entertains only one form of interaction, the mouse and keyboard, and only one environment, the desktop computer workstation.

Behavioural adjustments, driven by the stress of enivronmental changes never yield as satisfactorily a desired outcome as creating an environment to nurture a particular behaviour.

Prof. Robert Sapolsky, in a series of video lectures hosted by Stanford University on human behavioural psychology, discusses the impact of environmental conditions on genetic differences in certain cognitive aptitudes. In his example, he cites mathematical aptitudes across genders and cross-references it with a United Nations Human Development Report to determine, not if, but how much impact certain environmental conditions play in early learning development. It is interesting to note that the basis for his comparison springs from a reaction to a study conducted at John Hopkins by Camilla Benbow and Julian Stanley and published in Science magazine ("Sex Differences in Mathematical Reasoning Ability: More Facts", 1984). In the Benbow Stanley study, a huge generational cross-sampling from a pool of 40 000 participants beginning at the age of 13, harvested data from applicants who took the College Board Scholastic Aptitude Test in the mid-Atlantic region of the United States. In their data analyses, Benbow and Stanley examined the difference in math skills between males and females of the same age to gauge if there were sex-based influencers to performance outcomes. The rationale for using middle school children was based upon consistency in the maths curriculum, with very little differentiation. With an identical math curriculum and identical educational environments, what they found at the highest end of the specturm was a 13 to 1 ratio of male performance versus female performance. This led to explosive publications in Time magazine and Reader's Digest that labelled their findings as "The Math Gene" and discussed at length the male genetic predisposition for mathematical aptitiude. Of course, what Prof. Sapolsky correctly identifies is that their control factor, namely their environmental conditions, was not a constant and social conditioning most likely was a mitigating factor. Sapolsky continues by bringing up three very important societal factors that have been studied in the past, in terms of investigative research: a) boys are more likely to be called upon than girls for math problems, b) for identical correct answers, boys were more likely to be positively praised over girls, and c) by the time they reached junior high, guidance counsellors were already differentially advising, by sex, who should be taking additional maths tutelage. Even taking implicit bias into account, would a considerable reduction in attitudes towards gender bias profoundly impact Benbow and Stanley's original study? Or is that an idealistic approach to what should really be considered a meritocracy, where participants must rise to the challenge of their existing environments and social conditions, regardless of praise and misguided guidance counsellors? Sapolsky directly addresses these considerations by then citing a United Nations Human Development Report that processes and collates a massive global study, involving over 480 000 participants, across multiple nations, into a gender inequality index, and in it, its findings seem to refute the notion of a male-dominated "math gene". According to Sapolsky, what the study found was that their was a direct correlation between gender bias and performance in mathematics. The greater the degree of inequality in the sexes, the greater the ratio of aptitude in maths between male and female. In those countries that consistently scored the lowest on the UN indices that measured quality of life across several bands, with demonstrably discriminatory practices towards women, the study measured the largest discrepancy in maths performance between the sexes. As the data approached western nations, such as Canand, the US and the United Kingdom, ratios began to approach the Benbow and Stanley results. Curiously, however, as the study approached the Scandinavian countries, where social influencers towards gender inequality are greatly reduced, the ratio for mathematical aptitude between men and women approaches zero. One surprising finding is that in Iceland, where gender equality scores quite high, women actually surpass men, ever so slightly, in mathematical aptitude. This seems to strongly favour the notion that creating a supportive environment can positively influence human potential.

Ironically, the popular notion that adversity creates a more resilient constitution and therefore longevity and a greater quality of life is also challenged by Sapolsky. In his talks, Sapolsky discusses the stress hormone, cortisol, one of the chief hormones tied to our fight or flight response mechanism, in terms of its heritability over successive generations. Exposure to aggression and stress lead to higher levels of cortisol, which has shown in a number of studies to lead to shortening life spans and an increased sensitivity to pain (inherited over generations). It also leads, coincidentally, to a natural revulsion towards ambiguity. In terms of the experimentation process of creative artists, ambiguity would almost seem a given in terms of an artefacts discovery process. In addition, higher levels of cortisol seem not to be ideal for maximizing creative potential and could actually be a strong detractor to the creative process.

A key inducer of stress in the modern workplace is the computer. In a report published in 2016 in South Korea, there was a notable "association between computer use at work and self-reported depressive and anxiety disorder (DAD) in a nationally representative sample of South Korean workers" (Kim et al, 2016). As well, in a report commissioned by the Canadian government in 2002 on the effect of computers on workplace stress found that the task of learning new computer skills ranked third amongst the stressors identified, on par with poor interpersonal relations and outranked only by increasingly longer work hours, which itself is, ironically, a byproduct of the introduction of computers in the workplace (Lin et al, 2002). As this is a contributor to rising levels of cortisol, these studies would seem to indi-

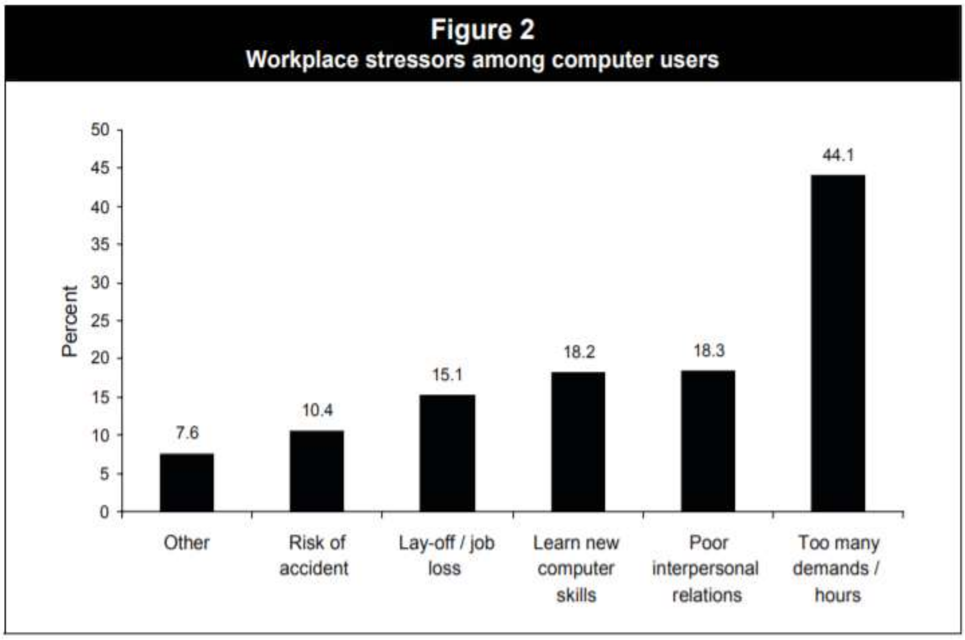

Figure 5-3. Workplace Stressors Among Computer Users, Government of Canada (2002)

cate that that a tradition computer workstation environment may not be the most conducive to the neuropsychological processes necessary during the art-making routine; however, this would need to bear further investigations to determine a correlation, if any, between the studio enivronment, neural activity, and final creative output.

There are many instances, however, that aptly illustrate the art-making routine being consistently interrupted by the known stressors of computational problem-solving, on a highly technical level, on a frequent basis, most noteably during offline rendering and simulation.

5.1.1

There existed, almost an entire generation ago, computational graphic workhorses specifically engineered to handle visual fx. They were created by a company called Silicon Graphics and one of their key mottoes was harnessing the ability to “work at the speed of thought”. These giant work stations were slow, cumbersome and priced beyond the reach of average household incomes. Prior to the era of Silicon Graphics workstations, films that required heavy digital effect often had to queue up for data crunching time on a Cray X-MP supercomputer behind Nasa, the Department of Defence and its ongoing analysis and evaluation of meteorological conditions around the globe.

Then the world became fascinated with playing games.

Consumer’s of this newest escapist entertainment property, once relegated to text-based, decision-tree gaming on early motorola-based CISC (Complex Instruction Set Computing) processors, where visualization relied solely upon imagination, suddenly developed a ravenous appetite for pixelation. The demand for graphics to accompany a gaming experience grew exponentially and hardware developers jumped on creating “daughter cards” (as they were referred to at the time) that would considerably boost the the graphic capabilities of standard computers. Companies such as Matrox and 3DFX soon became industry standard, producing graphics adapters capable of complex realtime rendering tasks. It did not take long for Hollywood to notice, and as household gamers’ demands for more and more realistic visuals pushed the hardware industry, resulting in cheaper, consumer level graphics cards, so too did the need for high-priced, bespoke graphics workstations become harder and harder to justify.

Eventually, the common market Intel/Mac PC would supplant the Silicon Graphics workstations globally as the digital artist’s tool of choice and graphics adapters originally intended for computer game entertainment would serve double duty as award winning CG content production hardware.

Whereas gamers demand high fidelity, low latency graphics experiences, where virtual worlds look photoreal while running at 60 frames a second, the digital art community demands high performance, low latency art tools, where brush strokes have the fine granular details of real world media and a natural responsiveness to the quickest brush strokes, with “no lag”. In this way, it is now the digital art community that has come to the fore, joining the erstwhile gamers in pushing for greater hardware performance.

Creativity has always required an enormous amount of computational power and it is at this technological altar that most artists wait and pray, hoping for the day when digital creativity can truly operate at the speed of human thought.

Indeed, new technologies emerging on the horizon have taken the digital art creation process into new realms, with virtual reality applications rapidly gaining credibility as a new asset creation platform; however, the price of entry to a virtual art creation experience is an even higher demand on hardware specifications, and the race between computational power and creativity is accelerating.

5.1.2

It is now November 2018 and Emmy Award season in the United States. Adam Myhill and his colleagues have been awarded an Emmy for "3D Engine Software for the Production of Animation" and Adam's work on Cinemachine, his realtime camera system, has been pinnacle to that achievement. In an interview for MCV UK, Myhill describes some of the key benefits for creating a camera system in CG that references traditional camera work and provides instantaneous visual feedback. "Blade Runner, Lion King, Jungle Book; they used Unity for pre-visualisation, they had a camera on a motion capture floor and it's a real camera, it's a real thing you hold, it has a screen on it and you record into that, it gets beamed to Unity, which renders the shot and puts it back. So you can be in an empty dusty mo-cap floor but when you look around it's lions and tigers or sunsets. And directors are using this to craft their stories, move the sun over there, move the camera faster and make all the mistakes there. And we're hearing directors who worked on these amazing projects say things like: 'I get to put my hands on the lens again'. " (Myhill, 2018). So profoundly has the development of cg cameras into digital replicas of their real world counterparts affected the process of digital cinematography that more and more productions are moving towards utilizing them, at least during the preproduction and previsualization phases.

In an Alex Stolz industry podcast, Academy Award nominee and two time BAFTA Award winner, Habib Zargarpour discusses how he implemented the "technologies and strategies he developed in games to revolutionise the storytelling process in film ... to empower storytellers like Steven Spielberg (for READY PLAYER ONE) Jon Favreau (THE JUNGLE BOOK) and Denis Villeneuve (BLADE RUNNER 2049)." (Stolz, 2018). Zargarpour discusses how his original project preferred outcomes stumbled upon a process that profoundly affected how certain types of art assets were created in CG. "We thought we were just making the process faster and easier but it changed the outcome for every artist on the project." (Zargarpour, 2018).

Essentially, Zargarpour identified the core of the issue and its inherent solution simultaneously. Digital art tools simply need to be faster and easier, but within the context of an artist's creative workflow. Further defining the concept of a toolset being "faster" generally equates to visual feedback mechanisms and the ability to iterate and review, with very little technical distraction. Defining "easier" in this context is purely the intuitiveness of the digital toolset in reference to familiarity with its real world counterpart.

The crucial section of Zargarpour's statement, however, is articulated by his observation that his realtime technologies "changed the outcome for every artist". When a toolset responds quickly and an artist can design with the speed of inspiration, it isn't surprising that maximization of creative potential is readily achieved.

chapter 6
discussion

6.1.0

Craftsmanship

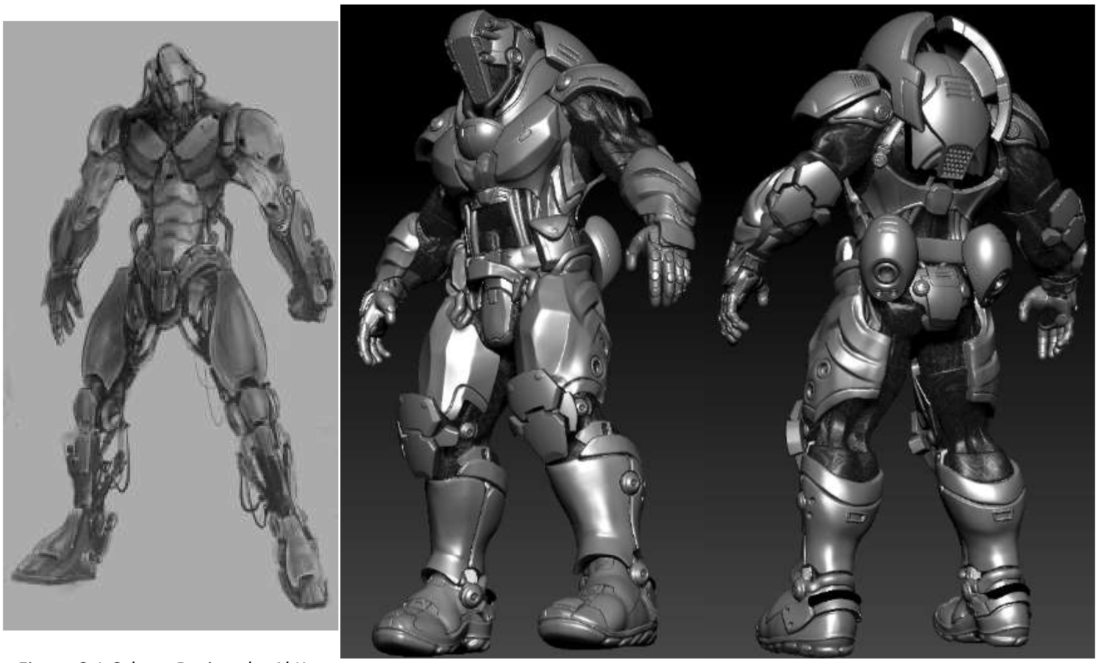

Figure 6-1.Cyborg Designs by Al Kang

The entertainment industry's primary market model of needs identification and fulfillment, as typified by its central marketing approach of identifying customer segment demographics and psychographics, is one that lends itself to excellence in craftsmanship and not necessarily evocative of the emotional transference and self actualization of the more traditional tributaries of artistic expression. The relegation of computer graphics from art form to craft is a polarizing debate in the arts communities and remains a moniker that is difficult to shed. Yet the battle to remove the demarcation line between craft and art is a fray that is joined on many sides, by many disparate entities and practitioners. Gwendolyn Magee, a reknowned Canadian textile artist, encourages aspiring artists to engage confidently with the art world by addressing issues of her own legitimacy. She freely acknowledges that her work is the craft "from which the type of art that I create began" but implores those who engage with her works to "think of me as someone who uses textiles and threads as paint, who creates brush strokes using a sewing machine, who can manipulate the materials with which I work into sculptural configurations ... " (Magee, 2005). Whether it is through the deliberate manipulation of various textile surfaces or a carefully controlled sequential charging of an array of lights produced on an LCD surface, the notion that art and craft co-exist on opposite sides of an imagined demarcation line seems an oversimplification of a truly symbiotic relationship between the two disciplines. Art, in this regard, seems to be an evolutionary progression of craft, which itself is an evolution of necessity. Once an artisan has distilled their craft of creative solutions, the only path that's left is one of creative expression, and innovations lead to novel apprehensions.

It is this perplexing redefinition of what constitutes art in an increasingly digital age that prompted the Canada Council for the Arts to publish its "Arts in a Digital World" follow up to their 2016 strategic plan, "Shaping a New Future" (CCA, 2016). The report recognizes the urgency of identifying the place of the digital in the arts world and the need for reassessing accepted terms and definitions in that regard. Andre-Louis Pare continues along this line of thinking in his editorial entitled "Sculpture in the Digital Age" where he not only cites the initiatives of the Canada Council of the Arts, reinforcing the need to put "into perspective this important study of the arts in the digital age, especially since the survey of artists and arts organizations highlights the community's wish that digital technology be considered as a means and not an end" but also contributes that "artists have always been technophiles, but it is creative freedom that enables them to think critically" further sectioning an artist practicing their craft in service of art-making from the tools of the craft themselves. Stephane Vial, Associate Professor at the University of Nimes, France, defines this new age in art creation as a "digital ontophany" and suggests there is actually little that separates the "real" from the "virtual" in his assessment of the phenomenology of the digital revolution (Vial, 2018). This would be a welcome prognosis as, in the words of Sherry Turkle, "We have learned to take things at interface value." (Turkle, 1995).

Indeed, machine learning would seem to reinforce that our behavioural patterns have adjusted to our new digital ontophany, reinforcing Turkle's sharp observation, but the entertainment industry could very well be at the heart of marketing imagery that extends no further than the "interface" in terms of meaning and interpretation. It is, therefore, understandable that, for digital artists to emerge from out of the shadows of artisanship, and from being viewed as merely union members of a craft assembling the modular parts of an image, they must battle from a defensive posture. Coupled with the fact that large productions often employ thousands of artists to execute a singular vision from an accredited auteur, the redefining of artistry within a digital context, which itself is sandwiched within the confines of commercial entertainment, becomes an erudite challenge, but a challenge not without precedent in historical tradition. Mass production of artefacts at the helm of an auteur is not exclusive to the digital age. The key precept to untangling this cacophony of interpretations is Vial's assessment that the definitions of "virtual" space are irrelevant to engaging with art creation, interpretation and ultimately, appreciation. From this precipice, our vantage point on traditional art methodologies would seem to indicate that they are not relevant to digital content creation, but rather a foregone conclusion of the art-making processes involved. After all, when the convenient definitions of a technical nature are cancelled out after reduction, what we are left with is a process that every artist recognizes.

The questions of authorship vs. auteurship that have arisen during this investigation, creating an understandable debate on how powerfully a singular human experience can be encapsulated in an artefact manufactured by many hands, and this debate is made all the more confounding when considering the contributions of computational calculus. When a landscape artist must take a back seat to L-systems and smart geometry instancing using predictive ecosystem generation, is there true compositional design at work or has the commercial art world accepted a small sacrifice in image control, in favour of brevity and expediency? Or has the creative responsibility shifted up the proverbial food chain? There is a certain amount of credence to the notion that, although a chef demonstrates culinary mastery in preparing and presenting a signature dish, there is also a tremendous amount of creative power invested in the authoring of a recipe that can be disseminated amongst a number of chefs to reproduce en masse the original creator's signature dish. To a certain degree, there is an avenue of acknowledgement for resultant knowledge embodied in an artefact and the processes that drive it to fruition, as discussed by Prof. Ross Gibson of the University of Canberra (Candy, 2006:9) where he discusses the value of examining the "representations of processes that occur during the iterative art-making routine, processes

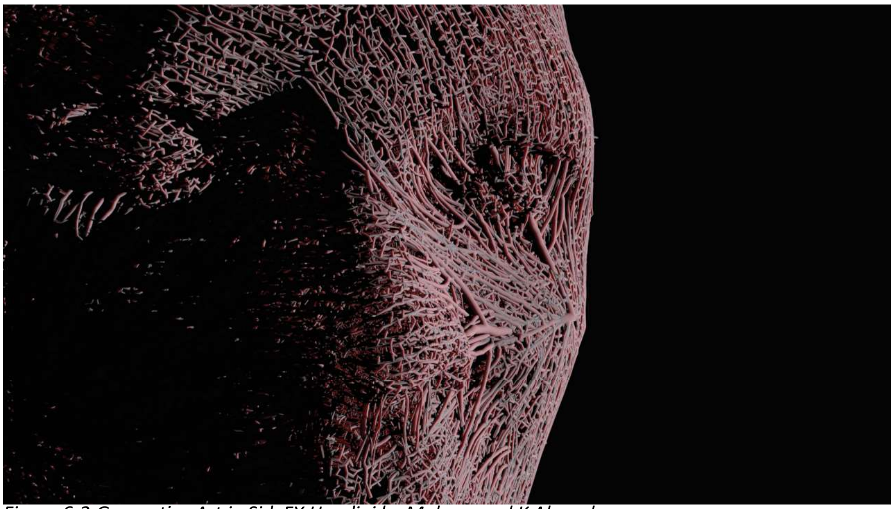

Figure 6-2.Generative Art in SideFX Houdini by Muhammad K Ahmed

of gradual, cyclical speculation, realisation or revelation leading to momentary, contingent degrees of understanding." Herein, Gibson emphasizes that the process of creating art has a certain degree of validity in being analyzed within the context of the whole. He further states that understanding the "narrative about the flux of perception-cognition-intuition" can often times yield revelatory insights into the creative process. In that regard, procedural solutions, engineered at a machine language level, is not entirely devoid of the kind of authorship normally attributed to a "creative" endeavour. In fact, algorithmically driven visual artefacts have been openly embraced as another splinter in the diaspora of forms birthed at the inception of computer graphics and categorically labelled as "generative art". Characterized by its modular component parts and adaptive use of systems (amongst other classically data-driven approaches), the field of generative visual art featured early works from pioneers such as Francois Morellet (1926-2016) who utilized abstract moire patterns as the basis for his visual foundations, and Joseph Nechvatal, a post-conceptual digital artist who utilizes custom authored viruses in modelling his computer-assisted creations. In 1988, Michel Bret discussed "Procedural Art with Computer Graphics Technology" in a journal article authored for the MIT Press, where he observed that "while traditional tools enable visual artists to work only on objects, the computer gives them access to the processes and sources of creative activity. Through dialogue with the model, the artist is no longer limited by the material constraints or the irreversibility of real actions. By emphasizing the process rather than the object, the computer enables formalizing of the creative act and the application of formal categories of discourse. Graduating from the hand to the brain and becoming "intelligent", the tool gives new meaning to the concept of artistic creation ..." (Bret, 1988). Whether authored by many hands, or by none (and therefore entirely data driven), or purely for the sake of commercial enterprise or entirely in the service of elevating the human condition, the notion that craftsmanship exists somehow as a diametric counterpart to artistry seems an oversimplification of a uniquely large, intricate and symbiotic process that draws upon both mental and physical dexterity while sacrificing very little in the way of passion and emotion during its execution.

Originally adopted for its expediency, production pipelines that have utilized procedural solutions to complex graphical problems have simply subsumed these programmatic solutions into the rich tapestry of visual techniques that characterize computer graphics artistry. Auteurship, once a staple characteristic of directors in the film industry, has begun to appear in the games industry with the likes of Hideo Kojima, creator of the Metal Gear Solid franchise, and John Carmack, founder of id and creator of signature titles such as Doom and Quake. The question of whether or not proceduralism can be considered art could almost be viewed as taken entirely out of context in this regard.

Figure 6-3.John Carmack at GDC 2010; Hideo Kojima at Japan Expo 2010 in Paris (Images Courtesy of Wikipedia)

6.1.1

What is the Procedure Here?

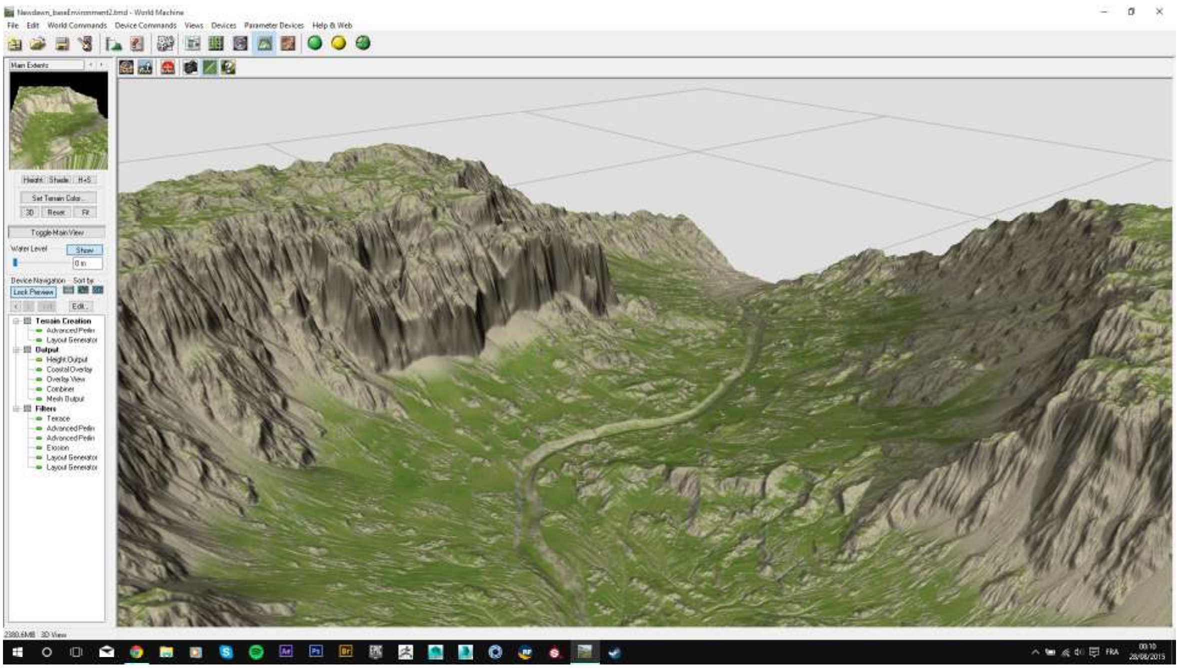

Figure 6-4. "World Machine -Procedural Terrain Generation"

Capturing reality has always been, and shall always be, the holy grail for computer graphics science. Yet, since the advent of the very first pinhole camera, the novelty of simple capturing the world around us does not captivate our imaginations for very long. Aboriginal tribesmen may think that a simple photographic device ensnares the soul, but artists know that, without the interpretive force of creative vision, what is captured in that little black box is relatively soulless.

The simple fascination with being able to reproduce the world around us predates the advent of a new art form and would seem to almost be a necessary part of any technical paradigm shift. As a case in point, that little black box that captures the soul is now a respected classical art form. This black box evolved into the Zoetrope, a simple parlour device that could now capture movement as well, and delighted audiences for 30 years before the Lumiere brothers stepped in and attempted to land a man on the moon Technical achievement is something to be marvelled at, and with good reason. After all, in attempts to reproduce the world around us, artists are attempting to understand and replicate nature. In a sense, it is a case of "man doing God's work".

The reality is, however, that mere replication cannot be considered divine. It is the process of creation that is considered inspired, in any field and in any art form. Ultimately, it is the hand of the artist that elevates reality to a whole new level.

In the field of computer graphics, this evolutionary process is only now beginning to emerge from its phase of simply being fascinated with replication to the much larger conundrum of how to create an art form, a truly respected classical art form, with the visible "hand of the artist" resident within the work. The legacy of an old and tired debate in CG, namely that of simulation versus artist is now being revealed for its fundamental fallacy. When photography was first born, it seemed destined to eliminate the need for painting, and in terms of portraiture, there were advocates on both sides of the line on which was the preferred method for this particular form of art, a debate that seems quite irrelevant and misguided in the modern age. It took quite a while before artists began to ask the more important question: how do we paint with photographs?

Within every simulation or procedurally driven solution for CG visualisation, this philosophy is beginning to emerge and the argument of which is better, faster, or of higher quality, the artist or the simulation, is being looked at in the same light as the photograph versus the painting.

6.1.2

World Machine

The procedural generation of environments has been a source of fascination for mathematicians, environmental scientists and computer scientists for decades, and is a dedicated discipline in and of itself. Commercial packages (such as Vue and World Machine) have been used in production to quickly calculate and generate mountain ranges, islands, hilltops and deserts. Although a number of different applications exist for generating environments, including Bryce and Vue, a relatively smaller application in its second versioning is rapidly gaining in popularity for cg artists in both the film and games communities. The World Machine application and its design philosophy very much encapsulates the artist as a necessary part of the process.

"When working in World Machine, your role is to determine the overall appearance and characteristics of the terrain, and then allow the generators and effects to create and detail the appearance of your world. This way of working and thinking at a higher level takes some getting used to, but the rewards are huge: You can create impressive terrains with relatively little work … The tradeoff in computer graphics for [procedural methods] is usually a lack of control over terrain feature placement; but WM2's Layout Mode allows you to work in a

Figure 6-5.Building Landscapes by Dylan Yarbrough (Image Courtesy of Pluralsight)

more artistic fashion, plotting out terrain as roughly or precisely as you like. The ability to determine for yourself the level of control you wish is one of the great new abilities available to you as an artist." (Schmitt 2017)

Sketch Up

Architectural design and rendering has always been functionally tied to engineering, mathematics and the science of perception. The craft of traditional draughtsmanship must be closely married to ellipse templates, protractors and a plethora of measurement tools in terms of conceptualising architectural form, and the advent of computer-aided design (CAD) has not necessarily alleviated the need for artistic interpretation to be compartmentalised into small mathematical boxes.

Understanding the needs of the artist, or in this case the draughtsman, is key in understanding how to make available a wide range of traditional drafting tools through the limited interaction of a keyboard and mouse, an interface that was primarily designed for textual interfacing with the computer.

Early implementations of CAD visualisation software, most notably through the industry standard application AutoCAD, relied heavily on traditional architects learning new skill sets and abandoning familiar tools in favour of inputting the correct data into the visualization software to achieve the desired rendered result. Often times, days, weeks, and months were spent in trying to achieve a simple baseline, let alone facilitating any creative experimentation.

Google's Sketch Up first arrived online as a simple previsualisation tool for casual designers and hobbyists. Its core philosophy was to provide a simple set of comfortable and familiar tools to the general public to allow them to build houses, buildings, products and general all-purpose industrial designs with relative ease.

With Sketch Up's simplified interface and limited exposure to the core computer graphics principles necessary to drive more sophisticated software, it rapidly grew in popularity, finding a foothold in the prosumer and hobbyist markets. Concept artists and previsualisation artists, in both the games and film industries began to adopt Sketch Up in their design workflows. As its simple philosophy and clean interface began attracting more and more designers, it became evident that the software itself was designed not to interfere with an artist's creative process. In fact, Sketch Up was exemplary in demonstrating that the software must develop according to the skills of the artist, the software must adapt to provide the artist with familiar tools, and the software must ultimately work for the artist, not the other way around.

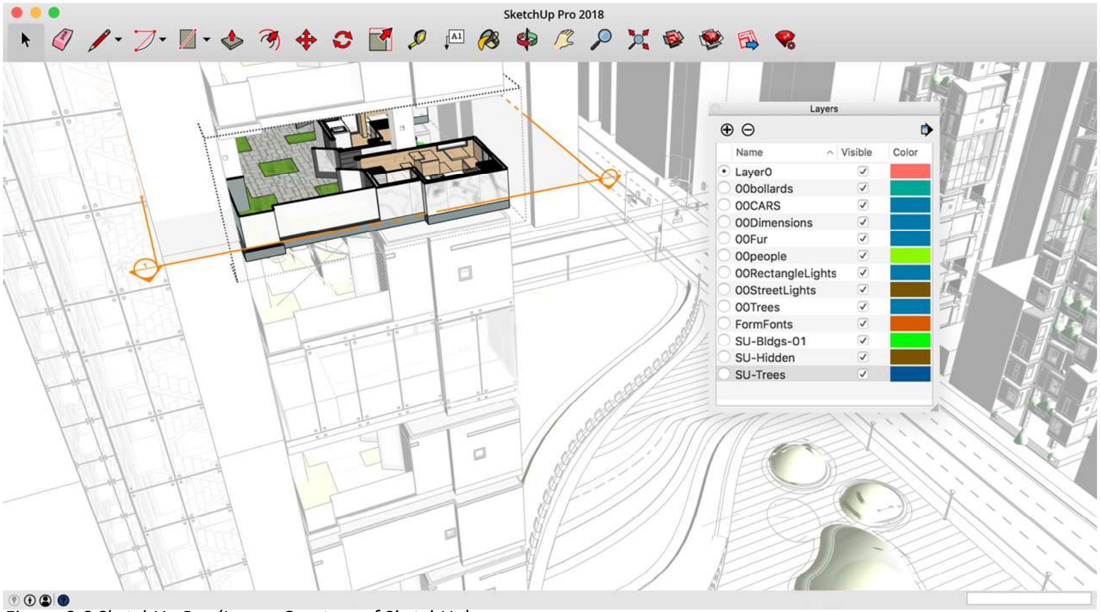

Figure 6-6.SketchUp Pro (Image Courtesy of SketchUp)

Digital Sculpting (Mudbox/ZBrush)

The modern day graphics adapter has seen its share of evolutionary turmoil, and its adoption as a serious scientific tool saw a staunch period of reluctance. Once associated strictly with videogames and computer games it was disregarded in the world of computer science in favour of 'specialised hardware' for computer graphics simulations and rendering. Graphics adapters had two distinct categories: the computer graphics adapters and the gaming cards. As graphics adapters evolved, vertex shader pipelines gave way to pixel shader pipelines, and suddenly, realtime visualizations had a fidelity heretofore never seen in the world of computer graphics on common, affordable platforms with publicly accessible software. With the sheer amount of visual detail being developed in the games industry, which in turn pushed the development of better and better hardware solutions to display those visuals, it was only a matter of time before computer graphics artists began to yearn for a tool with realtime visual feedback not tethered to the long render times needed to preview and assess high resolution details.

Out of the furnace of standard CG authoring tools, and the manual manipulation of polygons necessary in packages such as XSI, 3D Studio Max, and Maya, came the birth of digital sculpting, a new and innovative approach to authoring CG art that, at its heart, replicated the sculptural process of traditional artists.

Figure 6-7.Concept Sculpt in ZBrush (Al Kang)

Developed at Weta Digital as an in-house production tool, ZBrush was the first of these new forms of digital asset creation. Leveraging the inherent power of the modern day graphics adapter, artists now had the ability to manipulate millions of polygons on screen, in realtime, with a pen-based tool, carving and moulding a high resolution geometry object with relative ease.

Mudbox became the second of these new sculpting tools, and ZBrush's primary competitor. It was obvious that a new paradigm in the world of computer graphics was beginning to emerge.

Figure 6-8.Concept Sculpt in Mudbox (Courtesy of Autodesk)

Quill and Brush (WACOM)

Hardware has not been sheltered from the shifting paradigm of artist-driven approaches to interfacing with the digital world. Pen and tablet based tools, once considered a desirable luxury, are now standard design tools in labs, universities, production studios and art departments worldwide.

The central issue with pen and tablet input devices, although providing a far superior means of digital visualization than the keyboard and mouse, is its disconnection of proper hand and eye co-ordination for the artist. While the artist must view the results of their brush strokes on a vertical monitor, the must also offset their hand by 90 degrees to manoeuvre a digital pen across a digital sensory board placed on a desktop or horizontal plane nearby. In general, an average artist requires approximately two weeks to acquire the new skills necessary to work in this fashion, which I had the opportunity to personally observe on a number of different projects. Ideally, an artist should be able to look directly at what they are creating, to the very point of their sculptural or drawing tool.

Enter the Cintiq tablet, a pen and monitor input device that allows an artist to draw, sculpt, and paint directly on the screen, removing any necessity for acquiring a new skillset and/or training new motor skills.

Currently regarded in the industry as a desirable, but unnecessary luxury, it can be predicted to become an essential industry digital art tool.

In the Driver's Seat

The shifting paradigm of creating an art-based ethos is progressing forward, albeit at a lacklustre pace and the understanding that the technical side of the software needs to be invisible is not currently in fashion. Whether it is the stubbornness of software designers, with a stereotypical response for requests to make the software easier to use being "RTFM" (or "Read The Manual"), or simply the limitation of current graphics hardware in dealing with the astronomically complex programmatic solutions to make an artist-friendly workflow possible, one thing is evidently clear. History has proved time and again that the technological advancements of a visual medium pale in comparison to the artists and the artwork that reside in that medium. Granted, any mastery of a medium requires a fair amount of technical knowledge of the tools of that medium, whether it be a Director of Photography who understands coluorimetry in designing a shot, or a classical painter who understands intimately the viscosity and consistency of a variety of different oil paints, technical mastery encompasses processes prior to and directly preceding the creative process. Activating a shutter, and stroking a sable brush across canvas, in the intimate moment that art is born, is an act unencumbered by technology. In those terms, in computer graphics alone, we are not there yet.

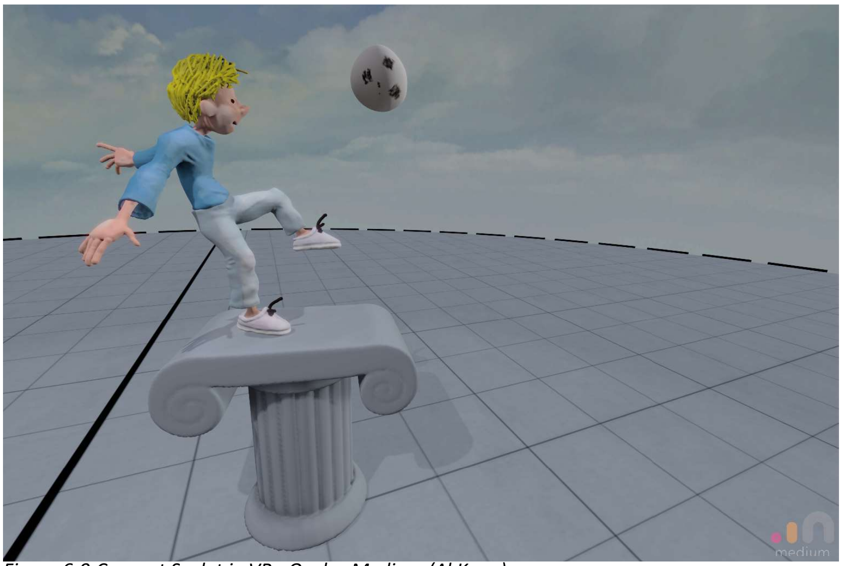

Figure 6-9.Concept Sculpt in VR - Oculus Medium (Al Kang)

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chapter 7
conclusion

7.1.1

Every heartfelt entreaty by the artistic communities aimed at technocrats to foster the facilitation of passionate simplicity is not a petition drawn up by luddites to regress a progressive digital context for art creation to a more primitive state of being. It is, rather, a sworn fealty to the elevation of increasingly more sophisticated forms of media representation for the human condition. The desire to simplify the encapsulation of passion within a digital context was driven, in part, by a desire to pursue more perspicacious visual artefacts. By facilitating the creative spirit, artists would simply subsume higher forms of technological edifice, as the desire to create would feed the hunger to learn.

A central tenet that was in widespread adoption at Electronic Arts, and first attributed to Nolan Bushnell, the founder of Atari, stated simply that "all the best games are easy to learn and difficult to master." (Bushnell, 1971).

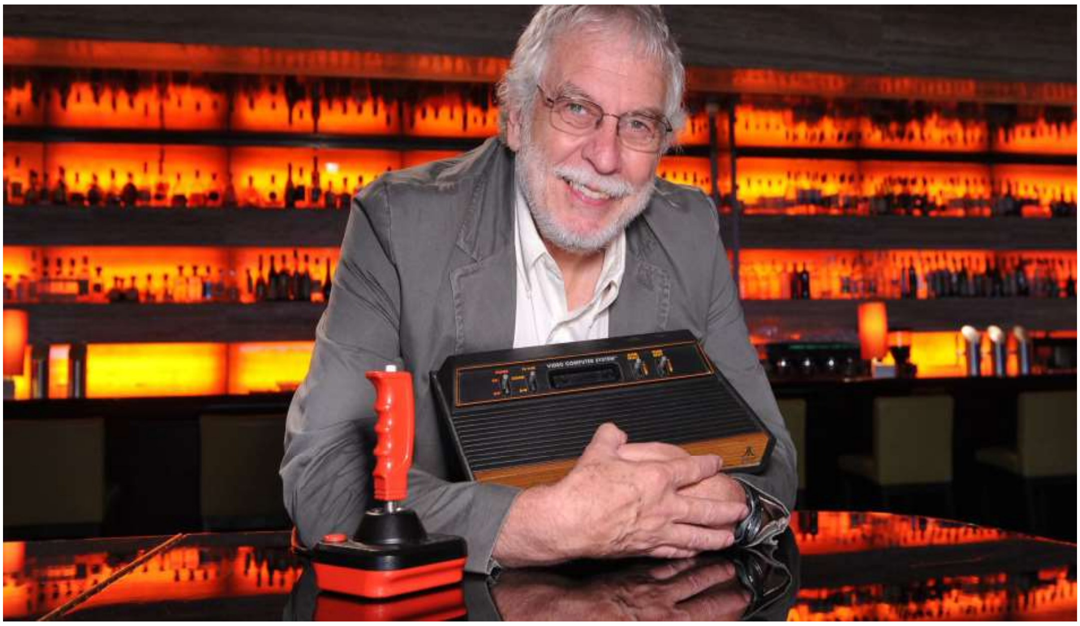

Figure 7-1. "Nolan Bushnell, founder of Atari, 2010." (Adolph | ullstein bild | Getty Images)

What this denotes is the idea that a control system must be so intuitive and feel so natural that the controller is rendered invisible in the hands of the player. Instead of the game mechanics interfering with gameplay, the experience must always feel, at a visceral level, like a constant state of play. This creates a condition of immersion, freeing the player to focus on ever increasing challenges, puzzles and complex problems encountered within a game loop's fiction. To assume that the immediate solution presented itself readily in a hardware design iteration and that a simple examination of haptic stimulus response would yield ideas for a more effective controller interface to the experience would be a positivistic philosopher's response. The concept that "only that which can be scientifically verified or is capable of logical or mathematical proof" (Oxford Dictionary 3rd Edition, 2010, p. 1386) can be applied to an engineering design solution for immersion pays short shrift to a universe of noesis and insightfully nuanced intuition, which ironically is crucial to scientific creativtiy and innovation. Michael Polanyi, a Hungarian-British polymath, argued that postivistic approaches supplied a false accounting of knowledge, emphasizing that "the intuitive powers of the investigator are always dominant and decisive" (Scott, 1995). Lady Drusilla Scott, in 1995, in her examination of the powerfully intuitive common sense approach of Polanyi to deciphering complex mathematical and scientific conundra, quoted his view that a "terribly mistaken understanding of what science is has distorted our whole outlook and alienated man from their own powers of understanding the world" (Scott, 1995) Feeding intuition, therefore, on a base, primitive level facilitates the higher order thinking necessary to interpret and translate cognition into computational algorithms and complex computer modelling, and due to its recursive nature, cannot be approached inversely with the same degree of success. A game that is "easy to play" will necessitate a desire to master the difficult to progress forward. Intuition, or in this case an intuitive system, ultimately contributes to the immersion necessary to create the desire for needs fulfillment that will push an audience member to this end. In "A Grounded Investigation of Game Immersion" (Brown and Cairns, 2004), researchers discovered that "gamers who did not feel total immersion talked of lack of empathy and the transfer of consciousness." The same can be said for the art-making process.

Feature film has a similar philosophy regarding the proscenium space in that no camera technique, nor filmmaking embellishments must ever detract, even for a instance, from the central narrative thread (with the notable inclusion of narrative techniques involving the eradication of "the fourth wall", which in and of itself defines a contextualized narrative space inclusive of audience experience and participation).

To achieve true escapism, both games and film understand and respect that the cognitive connections created must not be in the remotest disturbed until the culmination of that entertainment experience.

This is essential for achieving a state of psychological transportation, tapping deeply into our imaginations, resonating with our emotions and ultimately leaving us with a sense of fulfillment. In fact, a guiding design ethos driving story development in the feature film industry requires a clear and intuitive understanding of A.H. Maslow's theories behind human motivation (Maslow, 1943). In the pursuit of achieving self actualization, or the harvesting of maximum human potential, artists must understand at what point their audience engages with a given creative property and at what level of satiation they initially bring into the narrative contract. Only then, can a creative seek to indulge the individual pursuit for greater levels of fulfillment with the hope of achieving self actualization. This, in turn, will feed symbiotically into a significant sense of fulfillment at the societal level.

In a study undertaken at the University of Illinois at Urbana, researchers concluded "that need fulfillment needs to be achieved at the societal level, not simply at the individual level Although Maslow focused on individuals, we found that there are societal effects as well. " (Tay and Diener, 2011). The communal ritual of attending a film screening to engage in transient escapist fiction may therefore be an empirical example of Maslow applied on a larger scale, especially when observing the cultural impact of blockbusters. Again, individual engagement of a creative property to a high degree of emotional investment seems to resonate on a global scale.

As every new technological paradigm insinuates itself further and further into our sociopolitical identity and entertainment becomes more intrinsically tied to our day-to-day interactions with consumer technology, the compartmentalization of entertainment categories, along with the boundaries of their traditionally accepted delivery mediums becomes further blurred. The Actor-Network Theory, postulated by Latour (2005) proposes a unified system of both social and technological networks. The notion of technological objects belonging to the same network as people is a readily available visual metaphor in this day and age, where routine social interactions that are driven by "smart" phone technology and apps such as "Facebook" and "Twitter" are de rigueur. Technology wordlessly abbreviates our complex emotional behaviours, leaving us to desire greater levels of Maslow-esque fulfillment whilst seamlessly removing the technological barriers of "what software" on "which device". Technological immersion, therefore, becomes less of a commercial objective and more of an emotional, social imperative operating on a needs fulfillment level as society becomes increasingly well-versed in this new digital lexicon.

The creative process, in many respects, is identical in its objectives to not only engage an artist at a very high level of emotional and intellectual investment, but to also seamlessly blend the psychological and technological for digital content creators. When considering the narrative contract entered into by an artist and their intended audience, it is not difficult to ascertain why.

For artists to achieve that self-same fulfillment, they must feel that their own methods have successfully transported them, undisturbed, to that area of their soul that contains the purest and most powerful forms of expression. This is key to an artist producing their best, most profound works. This is also key to an artist being prolific as the perfect resonance between an artist and their work creates an elation that is addictive. This addiction translates down to an audience member who, seeing how much of an artist's passion has, undiluted, shaped a vision, will desire to see the next work, and the next, ad infinitum. Even in the age of digital computer graphics, the passion imbued by production artist on a creative property not only guarantees its success but also its timelessness as audiences are continually drawn to the emotional resonance contained within a work that cannot be defined by a simple collection of geometric objects. Canadian artist and Virtual Reality pioneer Char Davies, in her "Virtual Seminar on the Bioapparatus", laments just this possible outcome of a digital social condition, where "our culture may consider the simulated bird (that obeys our command) to be enough and perhaps even superior to the real entity. In doing so we will be impoverishing ourselves, trading mystery for certainty and living beings for symbols." (Davies et al, 1991). In fact, the philosophy of encapsulating an artist's organic art-making methods within a digital context reinforces Davies' world view that "working with this technology involves subverting its conventions and the ideology behind them in order to make images that can act as antidotes, reaffirming our organic participation in, rather than our separation from, the world." The greater we engage in esoteric computer science categorizations of art, the greater the danger of separating the artist's real world experiences from their computer graphics representations of it.

As Blake Snyder categorizes it in his structural analyses of feature film screenwriting, the "Promise of the Premise" (Snyder, 2005) is an active re-examination, within the context of the narrative, of the themes presented at the outset of a film. This defined category within the structure of screenplay development must deliver a fulfillment of the escapist promise tantalizingly proposed by a film's chosen genre and its conventions. It is within the spirit of that ethos that this conclusion examines one of the newest developments in realtime computer graphics animation and digital artistry: Unreal Engine 4's Level Sequencer cinematic toolset.

Figure 7-2. Unreal Engine Logo and Splashscreen

7.1.2

The “promise of the premise” for cinematic design in the Unreal Engine’s realtime rendering workspace is the opportunity for artists to directly connect with their artefacts, without the painstaking process of offline rendering, the single largest visually abstraction layer hampering artists who work in CG. Realtime calculation benefits also filter into areas that capitalize on physical simulations, making early cloth and particle visualizations possible.

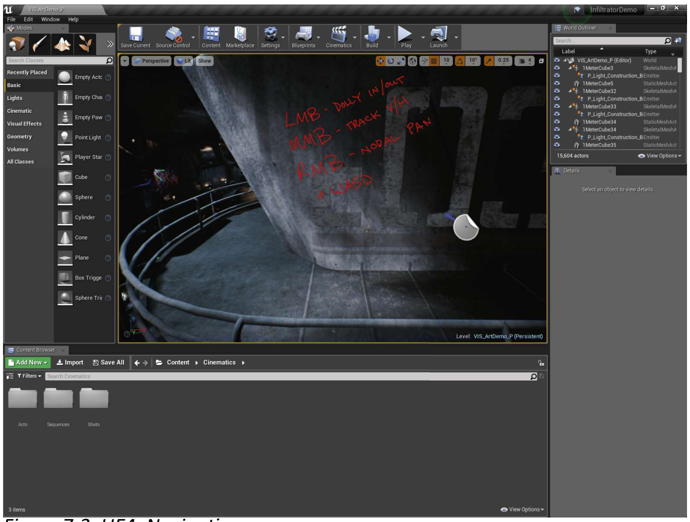

Figure 7-3. UE4: Navigation

Inside Unreal Engine 4’s development workspace, navigational controls within the game environment relies solely on 3-button mouse interactions, removing the necessity for simultaneous hotkey operation and freeing up a hand for additional tasks. It’s minimalist UI presents a colourfully graphical interface with the key toolsets immediately available, and it’s modular, non-modal window construction allows for quick customization of the UI to suit the most punctilious of workflows.

- Master Sequence
    - Shot 1 (Level Sequence)
        - Shot 1 Lighting (Level Sequence on Subscene Track)
        - Shot 1 Camera (Level Sequence on Subscene Track)
        - Shot 1 Skeletal Animation (Level Sequence on Subscene Track)
        - Shot 1 FX (Level Sequence on Subscene Track)

Figure 7-4. Shot Hierarchy Set Up for UE4

Designed from the ground up with both a feature film pipeline and an animation layout department workflow in mind, Unreal's 4.19 release introduced an new object called the "Level Sequencer". Built from Unreal's actor instantiation model, each level sequence asset exhibits bizarre behavioural characteristics that doesn't completely preclude the necessity for understanding game engine frameworks, however, and therein lies the crux of its

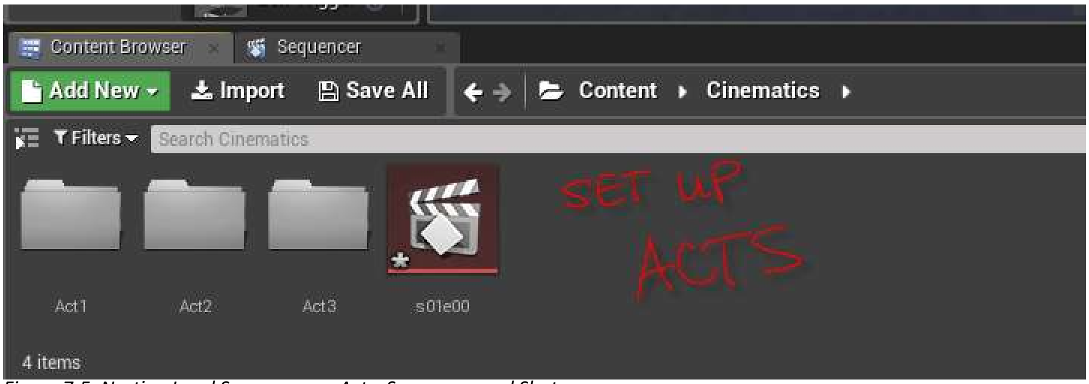

Figure 7-5. Nesting Level Sequences as Acts, Sequences and Shots

deficiencies.

Within each level sequence object used to build a structure for containing a film's various narrative categories, subscenes can be further assigned to encapsulate individual art departments, from lighting to animation. On one hand, this facilitates a dynamic, multidiscipline workflow feeding into a singular final artefact, yielding a tremendous sense of individual ownership whilst sharing a collaborative development art space, it still requires a recalibration in terms of adjusting traditional footage-based film workflows to understand that live

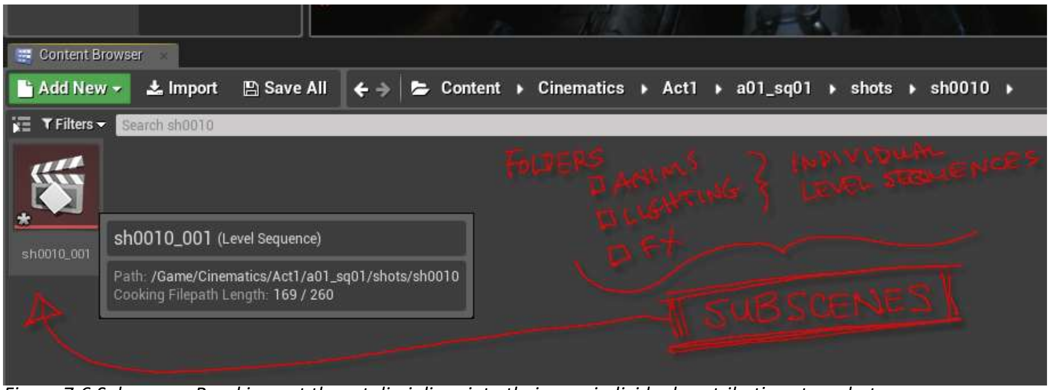

Figure 7-6.Subscenes: Breaking out the art disciplines into their own individual contributions to a shot.

objects are being manipulated within the editorial timeline in modular data capsules.

In a number of ways, a metaphor that would be appropos to digesting this new way of approaching filmmaking is to imagine that each clip on an editorial timeline is the entire cast and crew for that shot. They are creating the footage live inside each edit segment.

In addition to recalibration conventional wisdom for structuring a cinematic workflow in a classic studio structure, the best exemplar of how digital innovations can sometimes introduce peculiarities that never existed prior to their introduction arises when working with a multi-location, temporally inconsistent narrative. As Unreal was originally constructed to execute a level-based, asset streaming continuum, there is no real context for a camera cut to a new time and location (unless the narrative story world takes place in a singular, uniform region. Cutting between interstallar locations would be computationally prohibitive. As a result, to execute a dynamic location change, Unreal Engine's level sequencer has a level visibility control track where set pieces would dynamically be hidden and revealed between cuts, and thus, create the illusion of a temporal camera change.

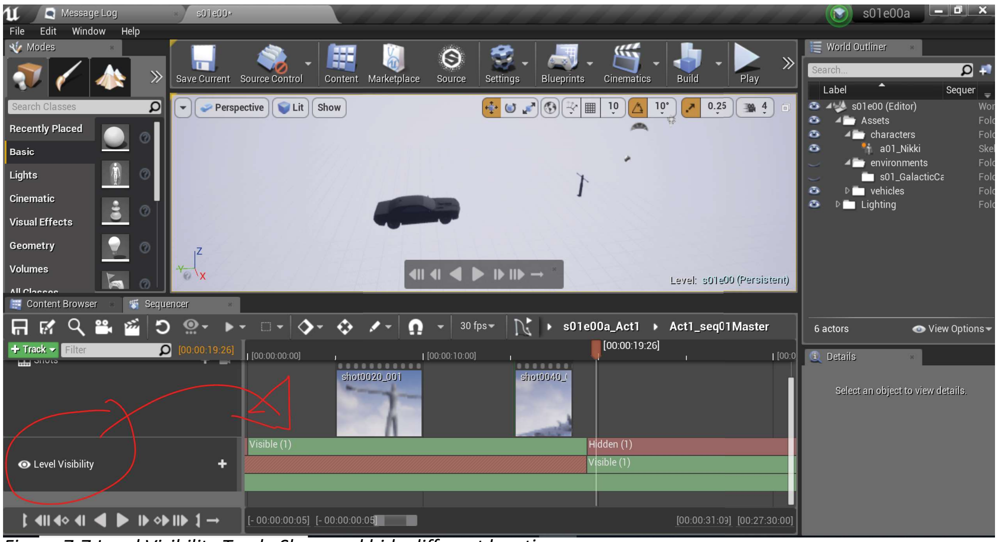

Figure 7-7.Level Visibility Track: Show and hide different locations.

This method of controlling asset visibility by assigning location set pieces with a numerical array locator is demonstrably unlike any process for cutting shots in either the digital filmmaking and/or animation industries and best exemplifies how, as digital tools seek to cater to the best of art-making processes, the digital context still insinuates itself as a technical requirement of engagement.

To paraphrase Dickens, "It is the best of times, it is the worst of times, it is the age of wisdom, it is the age of foolishness," where innovation which strives to move us towards a more meaningful exchange of ideas in our digital conversation, inadvertantly creates a layer of abstraction and subsequently, a layer of distraction from our intended message. Unreal's Level Sequencer technology pays homage to the notion that "the content of any medium is always another medium" (McLuhan, 1964, p305), requiring that a new understanding of a toolset involved in traditional art-making techniques will often times also require a continued understanding of the technologies that preceded it.

Pursuing a more intuitive approach to clothing design in computer graphics, Marvelous Designer continues to pursue its development from the vantage point of fashion designers, tailors, and clothing manufacturers.

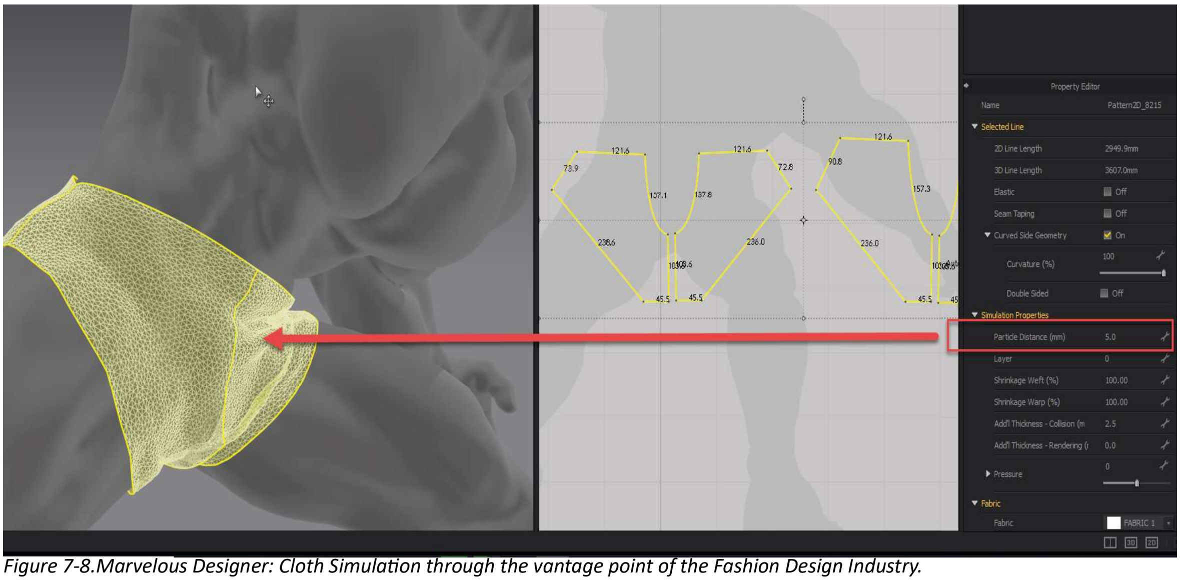

Figure 7-8.Marvelous Designer: Cloth Simulation through the vantage point of the Fashion Design Industry.

As software development for digital content creation begins to steer ever so slowly towards an intuitive workflow and a lexical standard more attuned to the creative process, rather than a strictly technical one, we will see, with greater frequency, visual milestones and creative watersheds in digital art production. As ZBrush's clay tools, Substance Designer's physically-based shaders, or Photoshop's particle brushes demonstrate, when a digital art tool strikes the perfect storm of hardware, visual and tactile responsiveness and intuitive workflow, the results raise the standard for what artists can create and what audiences can perceive.

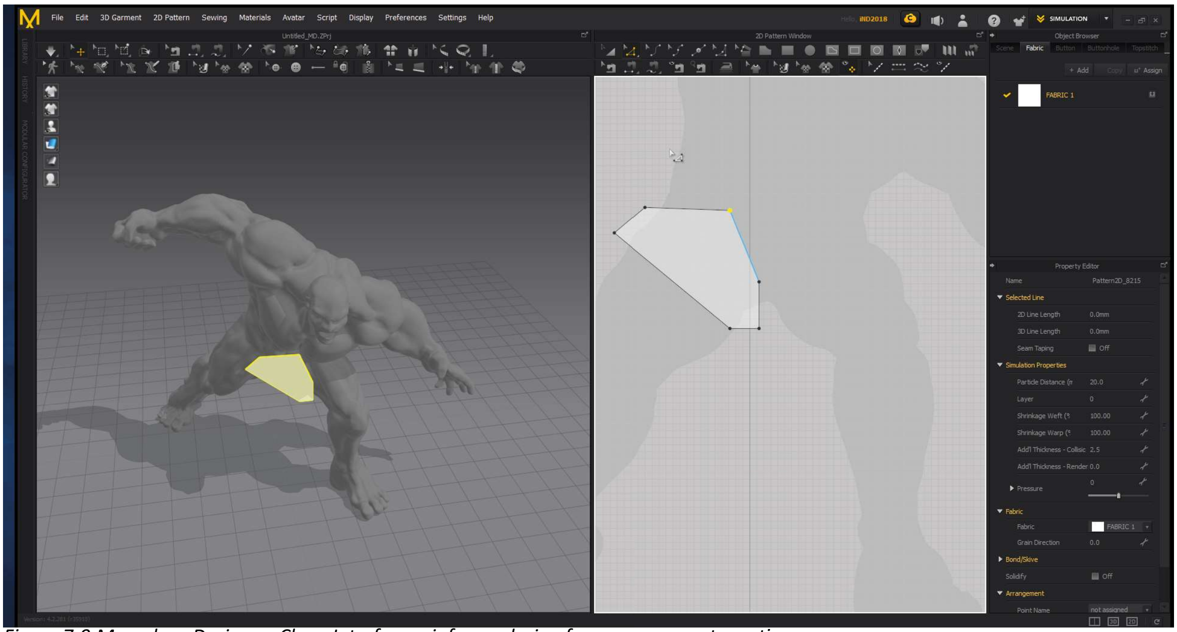

Figure 7-9.Marvelous Designer: Clean Interface reinforces design focus on garment creation.

The most astounding avenue of exploration in this regard is the emergence of realtime sculptural tools in a number of virtual reality platforms. Digital art-making tools, such as Medium and Gravity Sketch, that are exclusively available for Oculus Rift and HTC Vive offer an immersive experience for a creative artist that removes a signature layer of hardware abstraction to the creative process, namely the keyboard and mouse.

As evidenced by the influence virtual reality technology has had on researchers such as Davies who seeks to "rethink the technology, not as a means of escape but of return, as in a returning of attention, to our own being", there is an inherent desire to see beyond the technology to effectively utilize it. If a new technological paradigm presents itself as the content within another technological paradigm, there is the risk of feeling suffocated under the sheer weight of each new abstraction layer, if we continue to calibrate our viewpoint towards external factors. Perhaps Davies is correct in understanding that the true meaning of art creation in a new digital content paradox is to turn the all seeing eye inward, to investigations of our internal selves, both as consumers of commercial technology and creators of those experiences.

As McLuhan so prophetically observed, "one of the peculiarities of art is to serve as an anti-environment, a probe that makes the environment visible" (1969:252). If our environment, as artists, is currently being co-opted by callback functions and code instantiation, then it is incumbent upon art to reveal humanity in sharper relief, in finer detail, and in the unabashed perspicacity afforded the creative mind in its abilities to observe the actual and the factual from any conceivable vantage point, whether real or imagined.

In that way, the preservation of the vanishing point de-emphasizes meaning encumbered by digital trappings and emphasizes a renewed focus on the various ways throughout history we as humans have observed one another, and indeed, the world around us.

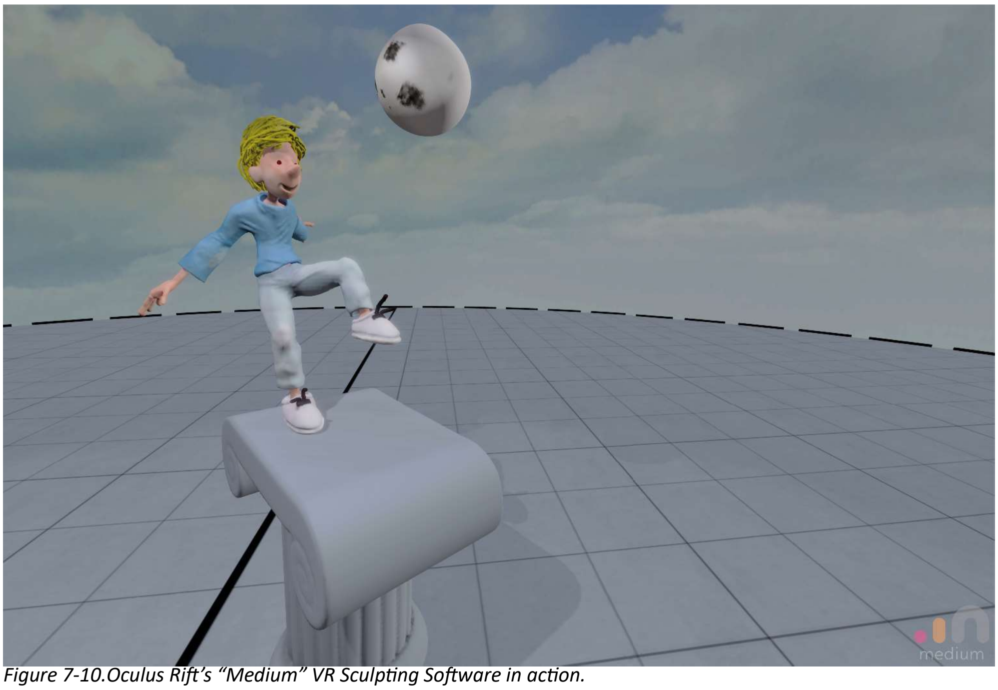

Figure 7-10.Oculus Rift's "Medium" VR Sculpting Software in action.

chapter 8
future works

8.1.1

A software engineer once approached me during a development cycle at EA and asked me to provide her with a list of art tools that would benefit one of the sub teams. When we engaged in a raucous discussion of the various types of additional tools, both off the shelf and bespoke proprietary technologies, she then proceeded to ask me why I needed them. I didn't fully comprehend her meaning and replied that these were our requirements, assuming from the context of her question that she was implying our sub teams were over indulgent. Programmers generally tend towards an efficient, reductivist nature. She further expanded, however, by explaining that as a tools programmer, she wanted to create the quickest, leanest, most comfortably intuitive toolset for her end user but being a programmer, she did not understand the processes involved for creating high level, visually stunning art. she wanted to know, intimately, why an artist chooses one particular tool over another and how that decision impacts their creative process. It was then that I realized that programmers are not simply clogging an artist's creative chakra with needless technical kludge, but that artists were also partially responsible for the frustrations of a production pipeline. An art team's failure to adequately communicate what they need to the engineering staff is very much part of the problem. It is a key reason that one of the most important roles in production is the technical artist. Being both familiar with art creation and the intricacies of coding languages, they can effectively mediate between two largely disparate disciplines; however, as harnessing both technical and creative skills requires utilizing both left and right brain thinking simultaneously, the technical artist role is one that is understandably difficult to fill.

As a result, the general iterative process in early studio pipelines involved a technical framework being constructed, artists being trained within that framework, an art team requesting a tool (or set of tools) that are created by the engineering team, and then subsequent requests submitted by art teams (as feature requests) to address the technical limitations of each digital tool. in this way, an art tools pipeline inches along by trial and error towards a vague notion of the perfect set of digital art tools.

In examining prospective concepts for potential digital art tools, identification of an artist's experience should be the primary consideration to which technology can serve as the envelope. Instead of bolting a sable-haired paintbrush to a chainsaw and teaching an artist the intricacies of a two-stroke motor, researchers need to instead discern how to integrate the power of the chainsaw into the sleek wooden handle of the paintbrush, invisible to the artist.

From the outset, at a very high level, an artist requires their toolset to have the tactility and responsiveness of traditional media. Many short lived experiments with haptic devices have sought to address this need, including Claytools and the Omni arm developed by Phantom, which sought to replicate the solidity and pliability of real world surfaces through force feedback mechanisms in their hardware. Indeed, Wacom devote a large amount of research to the granular texture of the surface of their drawing tablets in a concerted effort to mimic the "tooth", or grain, of paper. In fact, a newer product line features the ability to place a sheet of paper overtop of the Wacom's surface and illustrate normally with traditional methods, with the tablet simply interpolating the data for reconstruction digitally.

Ideally, digital data being captured during a session with traditional media is the ideal scenario. If, for example, a sculptor could work with a special type of treated clay, beaded (perhaps on a microscopic level) with sensors that could relay positional data based on a set of root co-ordinates, then they would be free to engage in their most creative workflow, with the sensors relaying triangulated volume data for digital reconstruction at a later point in the pipeline.

Although this concept suits a traditional sculpture, from a hardware and software development point of view, this represents a considerable commitment of time and resources to research and development.

On the inverse side of examining where technological development could possible endeavour, the idea of leveraging existing technologies in a more profound way is a more attractive approach, in terms of being somewhat hardware and software agnostic and removing the commitment to develop new technologies. As this research has continually emphasized, the essential core of the creation experience is a form of unbroken escapism and fugue state that every artist must engage in to create their most powerful work. With that in mind, companies have already developed software plugins that facilitate "bridging", where an asset developed inside one package, for one stage of production, can immediately be "sent" to another application, which will automatically open and load the asset for the next phase of visual development. Essentially, this removes the necessity to engage in save, exit, close, open and load operations to move a visual asset down a pipeline, and creates a wonderful feeling of continuous connection to an asset; however, their is still a visceral disconnect between an artist's eyeline and their asset during the bridging process.

In this modest proposal, there is an understanding that most cartesian co-ordinate systems and cg camera space calculations share a commonality in mathematical orientation to their virtual environments. Barring right hand vs. left hand co-ordinate systems (and the conversions they require), the principle concept of one possible future investigation is to see if it were possible to, rather than load an asset into an application, have an application load around an asset, maintaining that assets scale and orientation relative to the viewer during the asset transfer process. In this way, as an artist moves through stages of development, the necessary tools simply appear around the asset they are working on.

To visually demonstrate how this might work, an artist may begin character development work inside a package such as Adobe Photoshop, seen here in Figure 8-1, and continue concept development through to Figure 8-2.

Once the artist is ready for CG conceptualization, then the required toolset (in this case, Autodesk's Maya) can simply open up around the image and the artist can continue seam-lessly developing their asset.

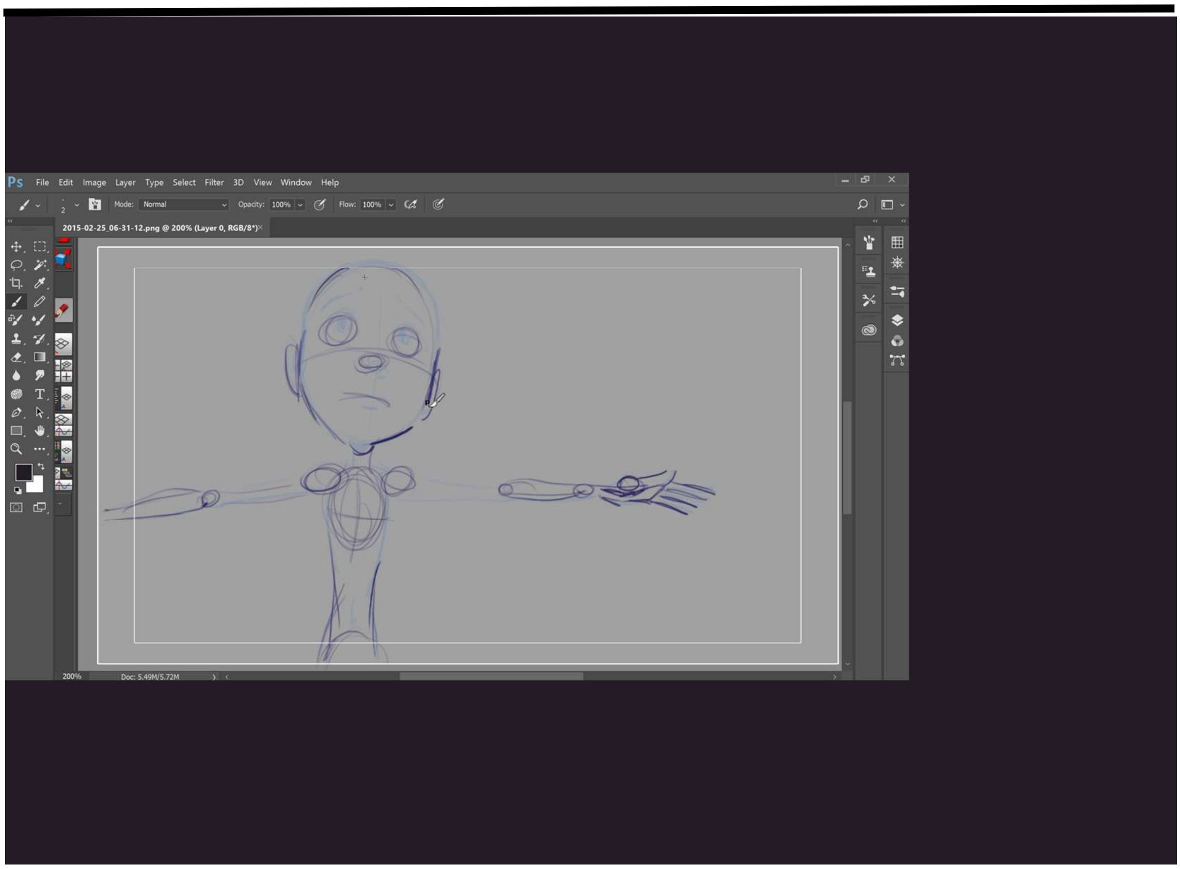

Figure 8-1. "Rough Outline"

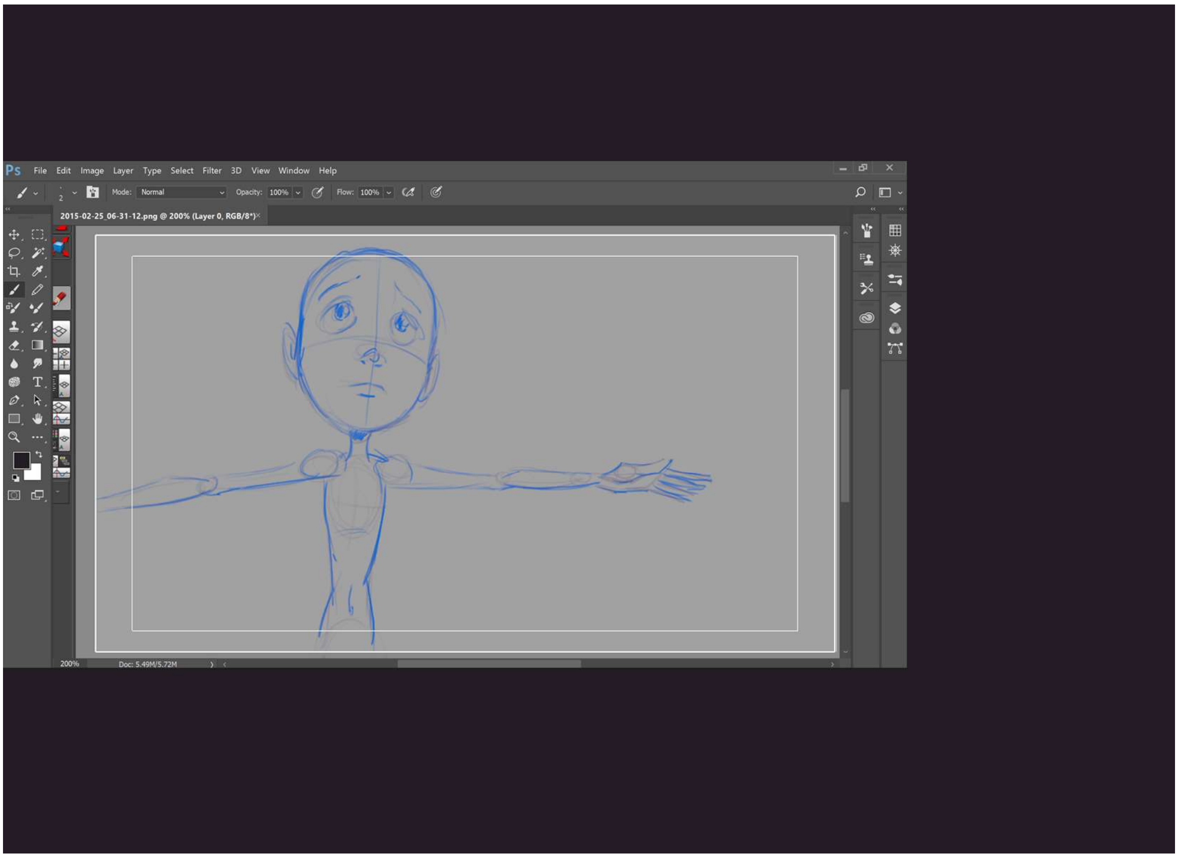

Figure 8-2. "Minor Detailing"

Inside Autodesk's Maya context (Figure 8-3) digital artists can create skeletal rigs based on

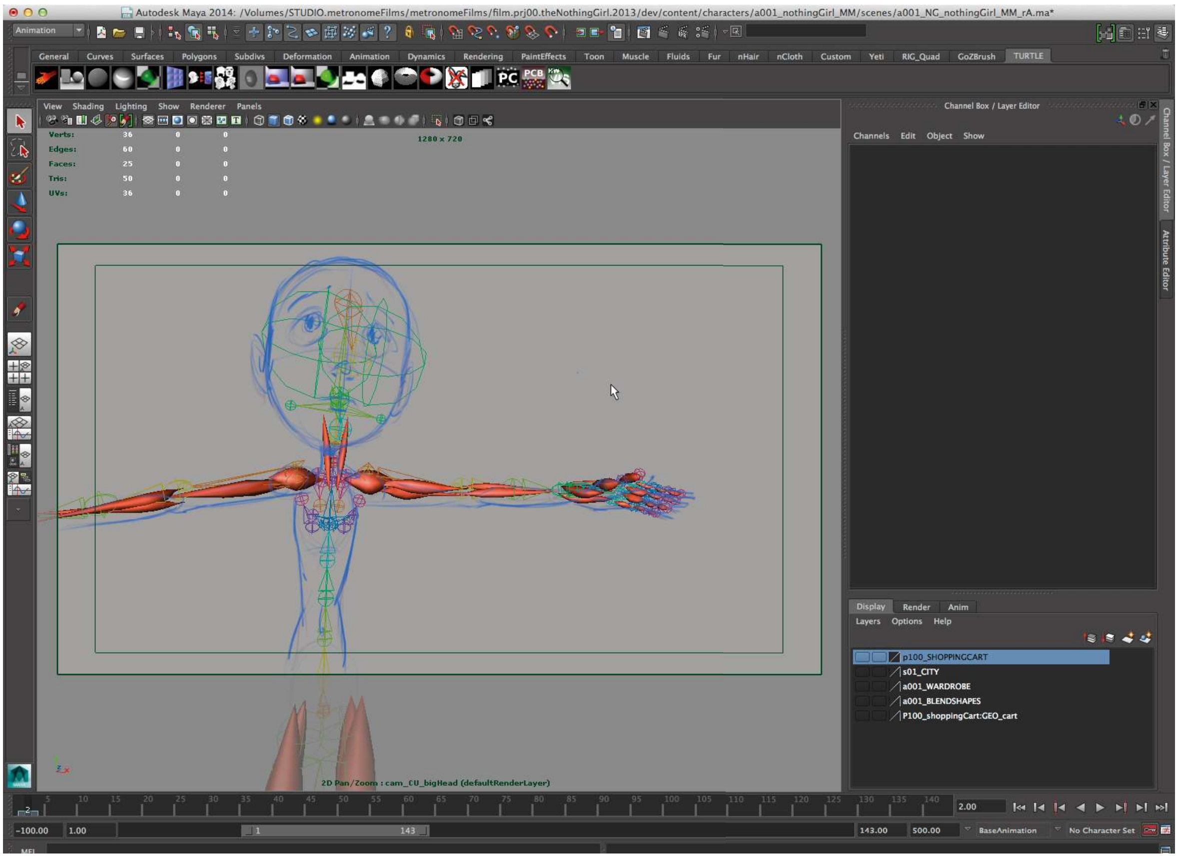

Figure 8-3. "Base Rig"

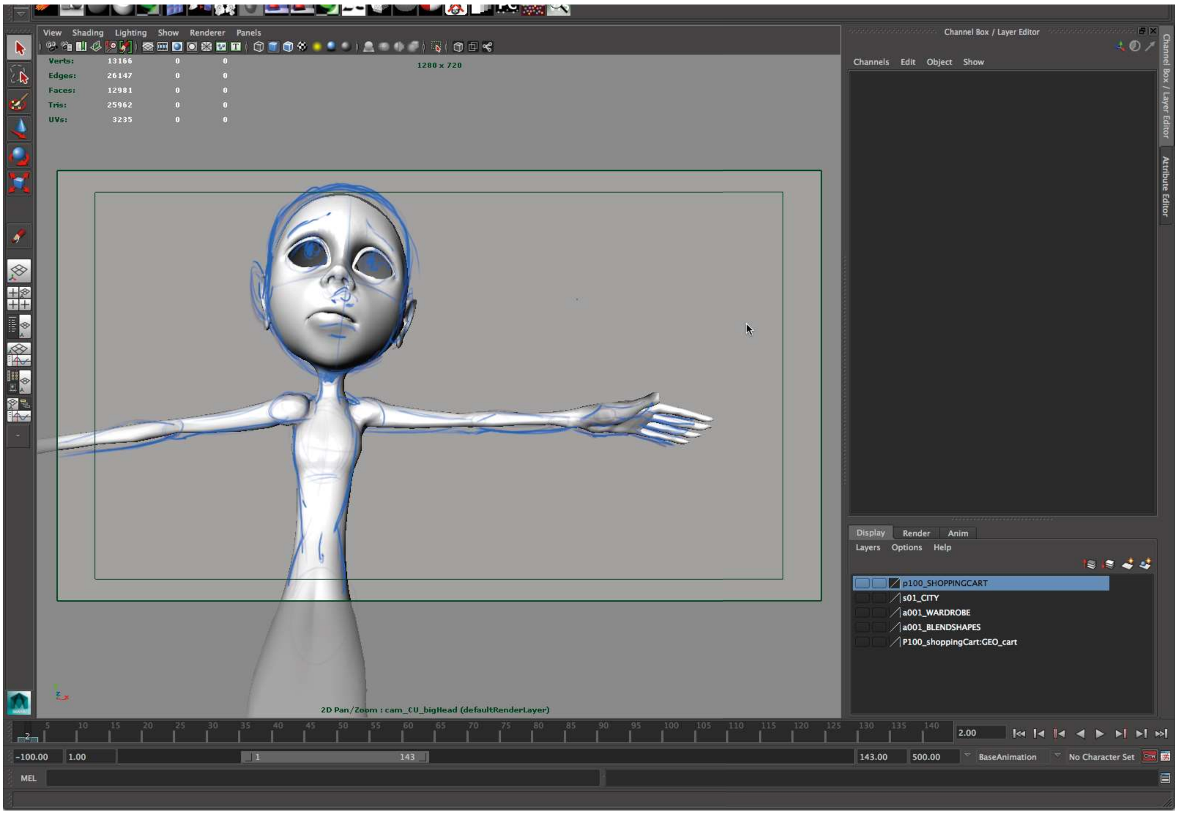

Figure 8-4. "Geometry"

their design or (Figure 8-4) 3D geometry.

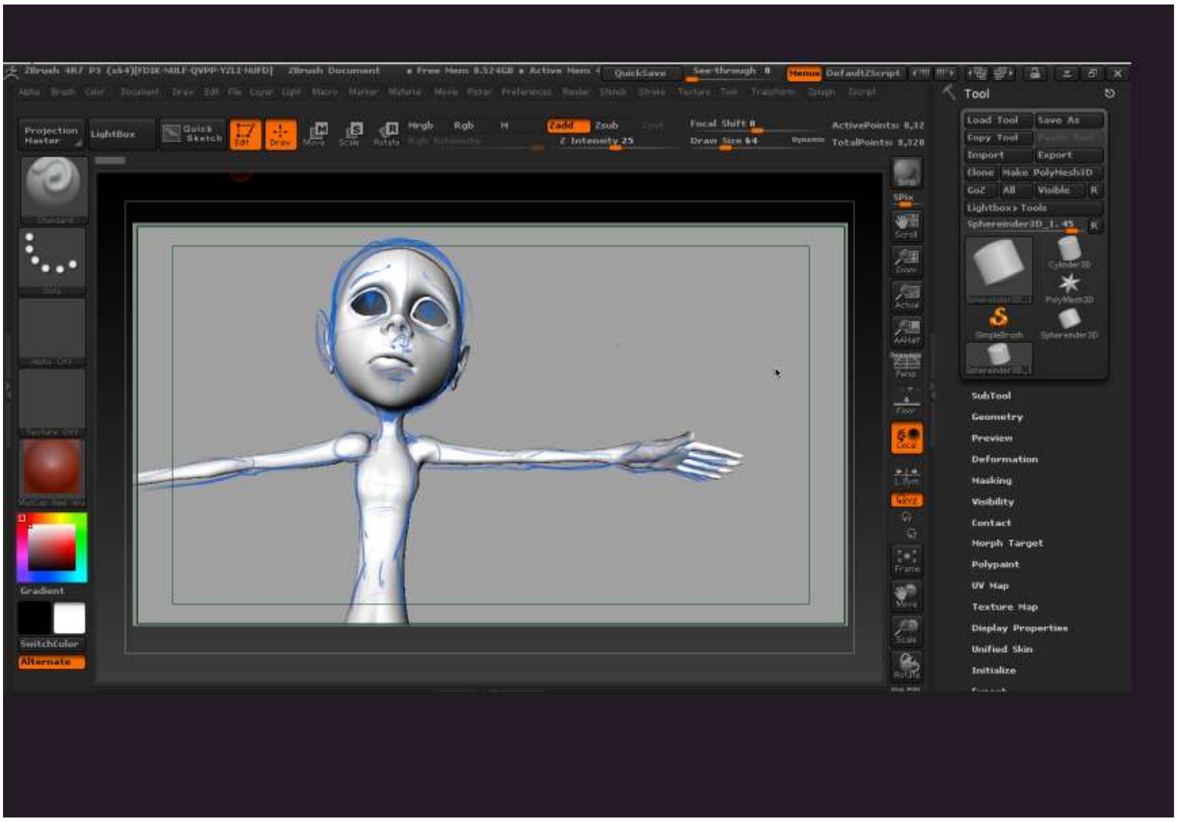

Figure 8-5. "Sculpting"

If further digital sculpting is required, then the toolset for ZBrush loads in around the asset, and the artist again continues to work on the asset, irregardless of what software toolset currently envelopes the asset.

The powerful notion that a digital artist will always remain connected to their work taps into the same channel of creative energy utilized by a painter constantly surveying their canvas, or a writer glued to their page, or a sculptor continually tracing the contours of their model.

The notion of total, unbroken immersion by an artist into their work will be compounded by the newest developments in the field of virtual reality and various experimental tools where an artist can truly be engulfed by their canvas. With Oculus releasing their prototype art creation tools, Quilll and Medium, for drawing and sculpting respectively, to be used inside a VR development environment, we are truly on the cusp of providing digital artists with a wonderfully inspiring and powerful creative space with which to author passionate and profound masterpieces.

After all, if Auguste Rodin can recreate the suppleness of human skin in marble, using nothing but a hammer and chisel, the digital world presents a profound opportunity for artists to truly explore the elevation of the human condition in ways never before seen in the world of art.

chapter 9
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All character sketches, concept character models and film footage, unless otherwise noted, are the sole creations of Al Kang.