Ambient Animation:

Technological Determinism and the Advent of Ubiquitous Animation

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Declaration

I declare that the work described in this Research Paper is, except where otherwise stated, entirely my own work and has not been submitted as an exercise for a degree at this or any other university.

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Summary

The field of animation has long been tied to the field of technology, as technology is needed both for the creation and presentation of animation. As such, shifts in technological development have resounding effects through the field of animation. This paper aims to explore how ubiquitous animation, pervasive animation that goes unnoticed by design, has arisen as a result of developments in technology. This paper examines animation both in historical and contemporary contexts, in conjunction with the state of technological development that has either facilitated or hindered its progression towards ubiquity. The paper will primarily be focusing on three manifestations of contemporary, ubiquitous animation - video special effects, video games, and web and mobile animation; tracing the transformation of each from novelty to ubiquity.

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"Images don't move on their own. They have to be made to move - or appear to move - by technology, invented and developed by human beings with the purpose of tricking the human brain into thinking that it sees a continuously moving two-dimensional (or in some cases, three-dimensional) picture. No technology = no movement." - Leo Enticknap

1. Introduction

The field of animation is a field that, while allowing for limitless creativity with possibilities bounded only by the confines of the human imagination, is also one that is inexorably tied to the technology necessary for its creation. From its origins, animation has been a product of technology - with scientific conjectures as to the workings of the human eye spurring on its initial developments. Both the creation and presentation of animation are wholly dependant upon the technologies that possess the necessary capabilities to successfully produce animation's inherent illusion. As Leo Enticknap points out in his book *Moving Image Technology,* technology is essentially what allows animation to exist (Enticknap, 2005). With such a close bond between animation and technology, it is reasonable to think that changes in one would lead to alterations of the other.

In this paper I will be exploring how the role of animation has been fundamentally altered due to the driving force of technological change; transforming from a static novelty into an adaptive and pervasive medium. Through the lens of technological determinism, I will be examining animation both in historical and contemporary contexts, in conjunction with the state of technological development that has either facilitated or hindered its progression towards ubiquity. I will be focusing my study on three modern incarnations of ubiquitous animation - video special effects, video games, and web and mobile animation - and examining how their current state of ubiquity has come about through developments in relevant technologies.

Chapter two of this paper will give the reader an overview of the underlying concepts with which the remainder of the paper will be dealing - providing a working definition of animation, giving a brief overview of the history of animation's development as a medium, in addition to introducing the concepts of technological determinism and ubiquitous animation.

Chapters three, four and five will each discuss one of the three previously mentioned manifestations of ubiquitous animation; investigating both its historical and current trends in relation to its coinciding technologies to determine how the medium transformed from novelty to pervasivity.

Chapter six will present my conclusions on the relationship between ubiquitous animation and technology based upon the information discussed in the previous sections.

2. Overview

2.1. What is Animation?

We all inevitably have some basic understanding of what animation means. Whether we see billboards for the newest Pixar film or are watching Saturday morning cartoons, the notion of animation in its popular embodiments has become a part of our common vocabulary. However, the precise scope of what can be encompassed by the word 'animation' for the purposes of this paper is something that needs to be defined. In addition to the popular conception of animation in terms of Disney style animated films and Hanna-Barbera style television cartoons, the term 'animation' must be also understood on its own, detached from its specific applications in any particular media.

From an etymological perspective, the word 'animation' itself finds its roots in the Latin word 'anima,' meaning spirit, with 'to animate' meaning 'to give life to' (Atkinson, n.d.). One way we can therefore understand an animation, in its most broad sense, is as something that possesses qualities that in some way reflect those of the living - something that has been given life. According to this broad sense of the term, even Frankenstein's monster - given life by his creator - can be considered a piece of animation. This definition, while very general, gives us an idea of the general aims of animation, to give the illusion of life. The prevalent manner in which animations are endued with this sense of life, and the manner with which we are concerned for the purposes of this paper, is through the representation and conveyance of motion - particularly through the medium of a two-dimensional plane. This conveyance of movement can be accomplished through numerous techniques and media, predominantly relying on the rapid switching of images to give the static images the illusion of movement (Cavalier, 2011).

The exact mechanism by which this rapid succession of static images is interpreted by the human mind into fluid motion is still not fully understood. The prevailing view during 19th century attributed the illusory phenomena solely to retinal persistence of vision, the

idea that the "an impression made by a pencil of rays on the retina, if sufficiently vivid, will remain for a certain time after the cause has ceased" (Roget, 1825) - a view that is largely associated with the works on the subject by physician Peter Roget and physicist Joseph Plateau, with the thought being that these after-images left on the retinas would fuse with the new image presented and give the viewer the illusion of movement (Anderson and Anderson, 1993). Although persistence of vision is often cited, even in modern writings on film and animation, this explanation of the perception of movement in animation has, for the most part, been replaced by the understanding that the phenomenon can be attributed to the human brain's inability to process the images with the same frequency as they are presented in animation and film, rather than to 'retinal memory' (Galifret, 2006).

It is this semblance of life imbued to non-living objects, particularly through the creation of an illusion of movement, that we will consider animation for the purposes of this paper. In addition to encompassing traditional notions of what is generally thought of as animation - the Saturday morning cartoons and Disney films - this definition also includes a much broader array of animated mediums - from web animations, to video special effects, and video game animations.

2.2. A Brief History of Animation

In order to fully understand how shifts in technology have affected animation as a medium and have brought about its current state, it is important that we have an understanding of the various forms that animation has taken throughout history as well as their associations with the technology of the day. I will therefore give a brief account of the history of animation, from its prehistoric precursors to the rise of what would be considered the popular conception of animation.

2.2.1. Animation's Ancient Ancestors

Although the invention of what would be considered animation by our modern definition would not come about until the nineteenth century, humans' desire to represent life and

movement pre-dates not only this, but also the majority of modern civilisation. Some of the earliest manifestations of mankind's wish to somehow convey representations of motion can be seen as early as the Palaeolithic era. As discussed in Marc Azéma and Florent Revère's paper, Animation in Palaeolithic art: a pre-echo of cinema (Azéma and Rivère, 2012), the foreshadowing of animation can be seen in cave paintings. A feature of Palaeolithic art noted by Azéma and Rivère is the propensity of the artists to attempt to capture the motion of their animal subjects in the static mediums of stone and paint. To accomplish this, the artists would either overlay multiple images of the same animal in different stages of movement in the same space - producing representations such as horses with several sets of legs, showing the gait of the animal in motion - or juxtapose multiple images of the animal in various stages of motion side by side - giving a film strip effect. Thousands of years later, circa 180 AD, another indication of mankind's urge to represent and recreate motion emerged in the form of Chinese inventor Ding Huan's spinning apparatus (Day and McNeil, 1996). Now referred to as a zoetrope lamp, the device bore sequential images that, as the lamp was spun by the force of rising hot air through its vanes, would suggest the movement of the figures. The difference between this device and the later *zoetrope*, is that Ding Huan's device provided no distinction between the 'frames' of animation - meaning that one sequential image does not seamlessly replace the previous within the same physical space, therefore not allowing for an actual illusion of movement to take place. These instances of pre-animation, while not animation in illusory sense with which we are familiar, exemplify humans' urge to portray motion, in addition to the constraints placed upon this desire by the available - or indeed lack of available - technologies with which to realise it.

2.2.2. Victorian Animation Contraptions

Regardless of the validity of the persistence of vision explanation for the illusory qualities of animation as discussed in section 2.1, it was undoubtedly the emergence of this theory in the early half of the nineteenth century that was the catalyst for the rise of early animation technologies that occurred concurrently (Cavalier, 2011). In the beginning of the 1830s,

three scientists - Joseph Plateau, Simon Stampfer, and Peter Roget - seemingly simultaneously and independently invented what would come to be known as the *phenakistoscope*, the first example of what could be considered animation by our definition (Leskosky, 1993). The device consists of a cardboard wheel that has sequential images along the periphery. Above each image, a narrow slit is cut out of the cardboard. In order to achieve the illusion of movement, the viewer would stand in front of a mirror and hold the phenakistoscope in front of their face, with the illustrations facing away from them. The device was then spun in front of the viewer's eyes. Because the slits in the cardboard would only line up with one sequential image at a time, the *phenakistoscope* was able to rapidly, and distinctly, alter the image before the viewer's eyes - attaining for the first time the illusory nature of animation that is key in our understanding of the concept. Following the success of the *phenakistoscope* technology, numerous other related animation contraptions began to arise (Cavalier, 2011). In 1834, William Horner created the *daedalum,* an adaptation of the *phenakistoscope* into a drum-like form that eliminated the need for the user to look into the mirror during use. The *daedalum* gained further popularity when it was renamed the *zoetrope* in the 1860s by William F. Lincoln. This technology was even further improved in 1877 with Charles-Emile Raynaud's invention of the *praxinoscope*, which replaced the *zoetrope*'s vertical slits with a central, faceted mirror to provide the device's frame-distinction. These objects, while generally treated as novelties, were the first incarnations of what would qualify as animation according to the definition provided in section 2.1. The simplicity and novelty of the animations produced by these objects highlights the constraints put upon the medium by the technologies of the time. The fascination with the representation of movement was still present, as it has been since the palaeolithic era, but without the technological advancement necessary to realise its greater potential, animation was relegated to a mere curiosity on the shelf of the Victorian era.

2.2.3. The Rise of Cel Animation

The next major advancement in the field of animation would give rise to forms of animation that are more comparable to those with which we are familiar. Facilitated by the

inventions such as the incandescent light bulb by Thomas Alva Edison and developments in film and projection technologies by inventors such as the Lumiere brothers, animation was able to branch out to never before seen expanses (Dirks, n.d.). With the ability to record and project moving images, animation could now develop past the several-framed novelty that it had become during the nineteenth century. While the animation objects like the *phenakistoscope* and *zoetrope* necessitated the animations they represented to be short and looped, the advancement of film technology allowed animations to be much longer and more complex - providing animators the opportunity to introduce into their animations the narrative element with which we are familiar in many modern incarnations of animation. Some of the earliest examples of animation utilising this new film technologies arose out of the so called "chalk-talks," popular vaudeville shows in which a cartoonist would quickly draw and change figures on a chalkboard (Smith, 1977). *Humorous Phases of Funny Faces* is one such animation, where the animator creates each frame of the animation on a chalkboard, just as was done for the live shows, however the intermittent footage of the artist drawing each frame is not included, giving the impression that the drawings were moving on their own (Humorous Phases of Funny Faces, 1906). The next major step towards the development of animation as we know it today was the rise of cel animation technology. Spearheaded by animators John R. Bray and Earl Hurd in 1913, cel animation involves the illustration of each frame on a transparent or semi-transparent media (Wells, 1998). This new technique not only facilitated the creation of more smooth animation - by allowing the artist to easily align each new frame with the previous - but also allowed for static, constant backgrounds to be created and overlaid with each new animation frame (Dobson, 2009). The result of these advancements was the ability of animators to create higher-quality animations more quickly. This animation technique was adopted and popularised by animation such as Disney and Warner Brothers. Though hand-painting of individual animation cels has largely been replaced by digital technologies, it is the aesthetic created by this technique has become most strongly associated with our conception of animation (Dobson, 2009).

2.3. Technological Determinism and Animation

We can see through this brief overview of the history of animation that the human desire to capture and represent motion has been a motivating factor for artists and scientists over the centuries, if not millennia. From conveying motion in paintings on stone cave walls, to creating spinning animation curiosities, artists have been striving to depict life and motion by whatever means they have at hand. The major roadblock to - as well as catalyst for - the advancement of animation as a medium has always been the technology available to realise the artist's conception. As soon as a new technology arises that facilitates the creation of animation, the medium is allowed to expand in previously unfathomable of directions. This powerful influence that technology exerts over the role that animation plays is reminiscent of theory of technological determinism; whereby technological innovations serve as the impetus for further developments (Smith and Marx, 1994). This theory highlights the important role that technology plays, not just with regards to animation, but in wider society. While a new technological development may not actively bring about changes to an existing media, its advent can open up a floodgate of potential innovation predicated on its existence. Likewise, while the inventions of the incandescent light bulb and video projection technologies did not *necessitate* the invention of cel animation, they certainly shaped the direction in which animation would develop; steering the medium away from its existent role as a relatively limited novelty, and opening up animation's potential to become a multifaceted and wide reaching medium.

One approach we can take to understanding how technological developments affects the course of animation's continued progress is to use a metaphor of a glacier and a river. A river originating at the top of a mountain will flow downwards, winding along around obstacles that block its course. As the glacier moves across the land, it carves out a trough in the earth - tearing up boulders and terrain in its wake. If the glacier's path crosses that of the river, the channel carved by the movement of the glacier will undoubtedly change the course of the river - tossing aside impediments and providing a new path of least resistance for the flowing water. It is in this way we can comprehend developing technology's influence on developments in animation. As technology progresses, it removes obstacles impeding the

progress of animation, allowing animation to evolve in a new directions that were previously impossible. Advancements in technologies have thus shaped the path that innovations of animation technologies have been able to take, and consequently have sculpted the current forms of animation.

2.4. Ubiquitous Animation

As the interconnected nature of the disciplines of animation and technology would suggest, as new technologies develop, even to this day, new possibilities for the realm of animation are made possible. This interconnectedness has lead to developments in the role of animation that parallel concurrent evolutions in technology. One of the major trends in technological development since the early 1990s is the shift from desktop computing towards ubiquitous computing (Weiser, 1991). The idea of ubiquitous computing, also known as pervasive computing, describes the technological trend of 'computing' moving away from taking place on devoted computers, to distributed and pervasive devices - everyday objects start to become computers in and of themselves, seamlessly incorporating computing into our day to day life while simultaneously diminishing our awareness of it (Greenfield, 2006). It is a process that we can see unfolding all around us. Not all that long ago, in order lookup a piece of information on the internet, we would have to log into a desktop computer and sign on to dial up internet. This function has since been transferred over the years from desktop computers, to laptops, to smartphones. Our access to the internet is becoming both more diffuse and pervasive. As Mark Weiser stated in his 1991 article on the future of computing, "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" (Weiser, 1991).

Technology's push away from overt to ambient, from conspicuous to inconspicuous, is mirrored in contemporary incarnations of animation. What was once a distinct and spectacular novelty - a tangible, twirling object brought out to fascinate guests, or an afternoon out at the cinema - is now following the same trajectory as technology, tending

towards ubiquity. Rather than being a medium that we knowingly and purposefully consume, animation has evolved into an omnipresent medium that goes unnoticed by design. While overt pieces of animation - pieces meant to be noticed for their animation - are still very much in existence in the form of animated television shows and Pixar feature films, animation that does not call attention to itself is gaining traction; animation that I will refer to as ubiquitous animation. We see these pieces of ubiquitous animation on a daily basis, and do not even recognise their existence. Rather than existing for animations sake, these examples serve a utilitarian purpose. They exist not to be noticed, but to illicit a subliminal reaction from the viewer - to create a mood, to establish an atmosphere, to emphasise a message, to give an illusion. Such ubiquitous animation can be seen in advertisements, web design, video game worlds, video special effects, mobile apps - essentially anywhere you find a screen, examples of ubiquitous animation can also be found.

For the remainder of this paper, we will be focusing on the history, trends and motivating technological factors in three instances of prevalent, ubiquitous animation - video special effects, video game environments, and mobile and web design.

3. Video Special Effects

Our first example of ubiquitous animation ironically takes us back into the context of the cinema. Present in nearly every film shown in theatres these days - particularly in action films - video special effects in live action films are becoming increasingly integral to our movie going experience. It's easy to see why so many films are relying so heavily on the use of special effects - not only do they allow the film makers greater creative freedom to produce stories that could never be filmed in reality, the inclusion of well done special effects can also be very lucrative for the film makers. According to IMDb's all-time USA box office records, the vast majority of the top grossing box office hits in America have extensively featured special effects (IMDb, 2015). The field of video special effects relies heavily on animation to create the spectacular effects for which it is known. The animation utilised in the effects, however sensational, is generally not meant to call attention to itself. Seemingly counterintuitively, although special effects animation is often used to bring stunning, unbelievable visuals to life, its success is often measured by how imperceptible it is - how convinced the audience is that everything they are seeing could have been filmed by the camera, that there is no animation.

3.1. Video Effects History

3.1.1. La Voyage Dans La Lune

Animation's ability imbue life into anything - to give moving form to things that do not and cannot exist in reality has made it an invaluable tool for special effects artists throughout the history of film. The history of animation being used to expand the possibilities of live film is just about as old as the histories of both mediums. One of the earliest examples of animation being used to enhance the aesthetics of live action film can be seen in George Méliès's 1902 film *Le voyage dans la lune*. The film tells the story of a group of astronomers who, through the use of a gigantic cannon, are shot to the moon (Le voyage dans la lune 1902). Evident of its role as one of the pioneering pieces not only in special effects, but in film making in general, the spectacular effects created in *Le voyage*

dans la lune rely primarily on established theatrical trompe-l'œile techniques - making use of a highly intricate set, elaborate props and forced perspective (Gunning, 1991). George Méliès, seeing the opportunities that the new media of film could afford his production, used these traditional theatrical tricks and combined them with stop-motion animation - a method of creating the illusion of movement by photographing physical objects in slightly different position for each frame. This combination of techniques allowed for the film to achieve never before seen visual effects. Perhaps due to the limitations of its time, aesthetically, *La voyage dans la lune* was a highly stylised piece, which worked to its advantage. Because of the rudimentary nature of the effects that were possible to be created using the technology of the time, a realistic aesthetic would not have been feasible to achieve. By deliberately choosing such a stylised atmosphere for his piece, George Méliès was able effectively disguise any disconnect between the live action actors and visual effects. Méliès's groundbreaking approach to film has had a resounding impact on the perceived possibilities of the medium (Gilland, 2009).

3.1.2. Cel Animated Effects

The early history of special effects is not only relegated live action films. Much of the early innovation in special effects can be traced back to Walt Disney Studios in the 1930s (Rickitt, 2000). During the production of *Snow White and the Seven Dwarfs*, Walt Disney strived to create an animated environment that was naturalistic, while still in keeping with the style of the rest of the picture. As a result, Disney brought together a team of animators who studied the movement of natural elements - water, rain, fire, wind, etc. These artists were instrumental in bringing life to the background elements of the film - lending a sense of believability to the world that the animated characters inhabited, while simultaneously producing animation that purposefully does not call attention to itself but rather subtly complements the main action of the film (Rickitt, 2000).

3.1.3. Rotoscoping

A major aspect of the historical usage of special effects is the use of rotoscoping. The Rotoscope was developed by Max Fleischer in 1917, originally intended to be a device to aide creating smoother, more naturalistic animations (Seymour, 2011). The rotoscope was a device that allowed an animator to trace over top of a projected piece of film in order to create more true to life animations. An actor would be filmed acting out the role of the animated character. The resulting film would then be projected onto a surface for the animator to trace on top of. The rotoscoping technique eventually found applications outside of the field of animation. The ability to trace directly over each frame of a video allowed afforded animators the opportunity to create pieces of animation that could interacted seamlessly, frame by frame, with the live action elements of the film. This technique has since been used to create post-production special effects such as lasers, sparks, lightning, etc. - drawing the effects overlaid on top of the projected film frame by frame (Rickett, 2000). Perhaps one of the most iconic usages of rotoscoping would be the creation of the lightsabers in the *Star Wars* films (Turnock, 2014). Over the years, with the development of computer software, rotoscoping has moved away from being an analogue process to a digital one, allowing for quicker production time, the implementation of more advanced effects, and greater flexibility (Seymour, 2011).

3.1.4. Three Dimensional Animation

Although created with the intention of being used simply to help animators animate more efficiently, perhaps one of the most crucial technological developments that has shaped the special effects industry into what it is today was the emergence of three dimensional animation in the early 1970s. One of the early pioneers in this field was Ed Catmull, who would later go on to become one of the founders of Pixar Animation Studio (Price, 2008). In the early 1970s, although he was limited by the power of the available computers, Catmull wrote a program that could not only create three dimensional representations of objects, but was also capable of producing the world's first three dimensional animations. Although computer technology was still in its infancy at this point, and computer

animation was not readily adopted by many artists due to its complexity, this technological breakthrough paved the way for the three dimensional effects that would eventually come to be featured in films such as *Looker* in 1981 and *Tron* a year later in 1982 (Kerlow, 2004).

3.2. Current Trends

The development of special effects animation throughout the majority of its history has been tied primarily to the analogue technology of film and cel animation. The effects that could be represented on screen were limited to what the animation artists could manually create. The goal of special effects has always been to complement the main action of the film, to augment the environment in which the action takes place with visuals that would either be too expensive, too dangerous, or simply impossible to recreate before the camera. Ever since the time of *Snow White and the Seven Dwarfs*, special effects artists have struggled with creating believable worlds and natural effects that, while spectacular, did not seem out of place. The major hindrance to the advancement of special effects through the early half of the twentieth century, a hindrance that prevented special effects from being the commonplace element of film that they are presently, was the lack of technology to effectively and efficiently meet these aims. However, with the advancement of computer technology in the second half of the century, the possibilities of what could be accomplished through the use of special effects expanded rapidly - with many obstacles to creating the realistic, yet stylistically compatible visuals sought after for decades being removed. The trends we saw emerging throughout the history of video special effects have continued to mature and develop as technology has advanced in a manner to facilitate it.

It only takes a quick look at the top box office hits from the past year to see how far the special effects technology has come and h0w instrumental the development of this technology has been in shaping our current movie going experience. Eight of the top the top ten box office hits in the United States during the year 2014 were live-action films that heavily featured the use cinematic effects - from *Guardians of the Galaxy,* to *The Hunger Games*, to *The Hobbit: The Battle of the Five Armies.* What's more, the remaining two films

in the top ten list are far from being devoid of computer generated effects. They are, in fact, the wholly computer generated animated films, *The Lego Movie* and *Big Hero 6* (IMDb, 2015). The ability of film makers to cater to this evident demand for special effects by the viewing public is largely due to technological advances allowing for the supplementation of manually created - frame by frame - effects with computer generated content. Notable examples of this trend can be seen in crowd simulation and performance capture.

3.2.1. Crowd Simulation

Possibly one of the most visually striking things that we can see on screen is the representation of a massive crowd of people. The vast expanse of bodies visible on screen can give a sense of scale to an epic tale, making for an effective film. While extras can be employed by film makers for the creation of expansive crowd shot, as has been the practice for decades, this can be a logistical and financial nightmare (Rickitt, 2000). The ability to utilise manageable yet autonomous crowds - without having to pay each individual - is an ideal situation from a film production perspective. As a consequence, one of the most visually impactful forms of computer aided special effects is virtual crowd simulation. In the early days of three-dimensional animation, the processing power of the computers available was limited, thus limiting the number of figures that could be rendered at any one time. As computer technology has progressed, computer processing power has risen exponentially. By the year 2000, computer processors could perform roughly one thousand times better than they were able to in the late seventies (Edwards, 2012). This increase in processing power, in addition to progress made in three dimensional animation software, afforded special effects artists not only the power necessary to render thousands of figures in a single scene, but to also program their behaviour. A prime example of this technology is the *Massive* crowd simulation software for the three dimensional animation program, Maya. Originally developed for use in the *Lord of the Rings* trilogy by Peter Jackson, *Massive* allows for the creation and animation of large numbers of figures in a shot, each with their own programmed logic to determine their behaviour (Massive Software, 2015). Now, rather than manually animating each and every figure in a crowd - a process that would be

prohibitively expensive and time consuming - special effects artists can give each figure the ability to autonomously chose their own actions given their surroundings based on pre-programmed and animated behaviours. This autonomy allows crowds to be created on a scale and to a degree of realism never before seen. Because the the program is so capable of deciding how each figure should act without direct input from the animator, the resulting animation unfolds in an organic manner - with the calculated decisions of each of thousands of individual figures interacting with one another and their surrounding terrain (Rickitt, 2000). Due to the resulting naturalistic behaviour, the crowd simulated figures become almost indistinguishable from life action performers, reacting intelligently to their environment and surroundings.

3.2.2. Performance Capture

Central to the current ability to create visual effects that are seamlessly integrated into their surrounding worlds is the capability to accurately track and capture motion. This desire to replicate realistic motion was evident in the previously discussed technique of rotoscoping. However, with advances in computing technology and the growing popularity of three dimensional graphics being used to create special effects, there was a need to devise a way of tracking motion in three dimensions in a way that could be applied to these graphics, giving rise to the field of performance and motion capture. "*Motion capture* is the process of recording a live motion event and translating it into usable mathematical terms by tracking a number of key points in space over time and combining them to obtain a single three-dimensional representation of the performance. In brief, it is the technology that enables the process of translating a life performance into a digital performance " (Menache, 2011). One of the early predecessors to the field of performance capture as it is known today was the *Dinosaur Input Device* created by the visual effects team working on production of the 1993 film *Jurassic Park* (Rickitt, 2000). This device was essentially a moveable, stop-motion dinosaur puppet with sensors at each joint. The device was hooked up to a the 3D animation software which was being used in production and transferred the movements of the physical model to the virtual model. The principal of this technology was later applied

on a human scale. Instead of sensors, actors would wear suits covered in reflective dots. These actors would then be filmed acting out their roles, and the positions of the dots later triangulated to calculate the movement of the body (Gray, 2014). The first film that utilised this technology in a major way, and to limited success, was the 2000 animated film *Sinbad: Beyond the Veil of Mists* (Reber, 1999). Unfortunately, the production of the film was plagued with many technical and budgetary issues, leaving the film makers to find themselves without the technology at hand to track facial expressions, and a lack of tools to allow for the real time puppeteering they endeavoured to employ (Menache, 2011). The film's attempt to use performance capture technology in isolation from additional supporting technologies is glaringly apparent in the final piece of animation produced. Instead of the seamless integration with the surroundings leading to a consistent animated environment, we instead see motion that is not consistent even within one character's body, let alone with the character's environment. Rather than creating a piece of animation whose process goes unnoticed, the technical troubles experienced during production come to the forefront - ultimately detracting from the viewing experience. However, the real potential of performance capture technology was revealed a few years later with the release of *The Lord of The Rings* trilogy. By integrating the performance capture technology on set rather than isolating it in, and having the support of an adequate tech team behind its production, the motion capture used to create the creature Gollum allowed for the creation of a character that was not only visually consistent with its environment, but whose actions and movements gelled with those of the actors with whom he interacted on screen (Gray, 2014).

3.3. Conclusions

Following the path carved by the development of technology, visual effects animations have - like technology itself - morphed from being a conspicuous novelty into a pervasive omnipresence. The two examples discussed above are indicative of the larger trend in the realm of visual effects; a trend towards visual effects animation being at least partially generated procedurally rather than by direct frame by frame manipulation by an animator. This trend allows for greater naturalism, in addition to facilitating a greater number of

effects to be added to a particular film. The individual instances of animation are enabled by the development and increased availability of computing power to blend so well with their surroundings as to go unnoticed by the viewer in the context of the film.

4. Video Game Animation

The second instance of ubiquitous animation that will be discussed in this paper is that of video game worlds. The animation contained within video games shares many commonalities with that implemented in video special effects - the major difference being the interactivity that video games necessarily provide. Not only do the animations implemented in video game worlds have to have an air of believability about them, they also have to allow for player interaction. Therefore, unlike animation created for video special effects - which can be minutely choreographed frame by frame - video game animation is a medium that necessitates adaptation - to allow the player to exert meaningful influence on their surroundings. The context of video games lends itself particularly well to the notion of ubiquitous animation. One of the primary goals of video game producers is almost always to create a game world in which the player feels immersed, identifying with the main character and accepting the virtual environment. In order to maintain this level of immersion in the game world, it is necessary that the animation contained within it is visually appropriate, responsive, and does not call attention to itself; to be effective at conveying the reality of the world created by the producer, while remaining unobtrusive to the illusion they endeavour to create.

4.1. Video Game Animation History

4.1.1. Tennis for Two

Because animation of some kind is necessary for representing the kind of interaction that takes place in video games, the history of video game animation is as old as the history of video games themselves. As far back as the creation of the first video game, a two player ping-pong simulator developed by physicist William Higinbotham on an analogue computer at Brookhaven National Laboratory in 1958 (Office of Scientific and Technical Information, 2011). The game, dubbed *Tennis for Two,* was displayed on a tiny oscilloscope. Confined by the rudimentary nature of the analogue computer on which it was run and the oscilloscope on which it was displayed, the lone piece of animation present

within the game is that of a dot representing a tennis ball - which travels in various arcs depending upon the input from the players - while the entirety of the game environment is represented by two perpendicular lines - one representing the ground, and the other the net. The decision to construct a game which utilised these animated arcs can be, once again, traced directly back to the technology used to create it. As Higinbotham explained "the instruction booklet that came with this analogue computer described how to generate various curves on the cathode-ray tube of an oscilloscope, using resistors, capacitors and relays;" a prime example of how the capabilities of the analogue computer literally shaped the animation of the earliest video game (William Higinbotham as quoted in Christie, 2013).

4.1.2. Early Arcade Games

Two decades after the creation of *Tennis for Two,* video games had gained considerable popularity within the context of the arcade. Facilitated by the development of the microprocessor by Intel in 1971, computers became simultaneously cheaper and smaller (Allan, 2001). As a result of the new found attainability of computing power, the video game as a medium was allowed to expand; soon becoming a commonplace fixture in arcades across the country. However, when compared to the computer and display technology available today, the processing power and display abilities of these systems were extremely limited. One of the most popular early arcade video games was released by Midway Manufacturing Company in 1978 - *Space Invaders*. Fairly comparable with other arcade video games of the era, *Space Invaders* utilised an 8-bit 8080 CPU, in addition to an industry standard 336 x 240 resolution raster, monochromatic cathode ray tube display (Arcade-museum.com, 2015). Acknowledging the constraints placed on *Space Invaders* by the available technology, creator Tomohiro Nishikado observed "Space Invaders, like all microcomputer-based games of the time, was heavily impacted by hardware limitations and slow processing speeds, so development was a struggle" (Nishikado as quoted in Betters, 2013). These restrictions manifested themselves in the in-game animation. As a result of the low resolution of the CRT screen, the designs of all the elements on screen are kept very

simplistic, and the animation of the elements is minimal - with each alien alternating between two frames of animation as they snake across the screen. Perhaps one of the most unexpected effects that the restraints of the hardware had on the gameplay animation was effect the limited processing power had on the speed of movement of the aliens. Now considered to be an important feature of the game, the increase in the frame rate of the moving aliens each time an alien is killed resulted from the inability of the game's processor to quickly move the fifty five on screen sprites in unison (Smallwood and Cantrell, 2011). As the number of the enemies were depleted, however, the computer was able to move the remaining aliens incrementally more quickly.

4.2. Current Trends

Since the naissance of video games, computer processing has progressed significantly. Where many arcade video games were created using 8-bit processors, the newly released game console, the Sony PlayStation 4, utilises a 64-bit processor (Playstation, 2015). This enormous increase in available processing power coupled with a simultaneous shift away from Cathode Ray Tube television screen to high definition LED screens opened up many opportunities for the realm of video games. This increased availability, and subsequent affordability, of superior technology not only facilitated the advancement of more advanced and intricate in-game animation, it also perhaps changed the context in which video games were played. With such high performance technology available, and affordable, to an average individual, a shift from video games being a novel medium that valued quick gameplay - to accumulate as many quarters as possible from players (June, 2013) - to one that could be implemented in homes - where the player could use the games uninterrupted for hours on end if they so wished. This technologically driven transformation of the medium is evident in both the types of games manufactured, and in turn, the animation contained within. While early arcade games featured quick, novel play with similarly novel, simplistic animations - as seen in *Space Invaders* - modern console and PC games often feature expansive, naturalistic, and immersive game worlds, a trend exemplified in popular titles such as *The Elder Scrolls V: Skyrim* (2011) and *The Last of Us* (2013). Because this genre of games places such a heavy emphasis on absorbing the player into the game world,

it is especially important that the animation they include effectively creates the illusion of a believably 'real' feeling environment, while remaining unostentatious.

4.2.1. Character Animation

Arguably the most significant piece of animation a player encounters in a video game for embodying this new, immersive role of the video game as an is that animation which portrays the movement of the main character. In order to achieve the level of player immersion that many modern games strive for, the character's motion - as with that of all the non-player characters who inhabit the game environment - ought to be concurrently naturalistic in a manner which is suited to the reality of the game world, while also being responsive to both the player's actions in addition to any in-game elements with which it interacts. The naturalistic portrayal of human motion is a particularly difficult task to undertake. As noted by Bruce Nesmith, lead designer for *The Elder Scrolls V: Skyrim,* "part of [this difficulty] is because you and I see people every day. We are intimately versed in what a real person is." (Nesmith as quoted in Behind the Wall: The Making of Skyrim, 2011). As such, any deviation from what we would consider lifelike human behaviour, would promptly negate the illusory nature of the game. The characters must respond in a way that the player expects given their surrounding circumstances in order to maintain the carefully crafted illusion of the virtual environment. As discussed with video effects, one major movement that has been seen in the area of video game character animation in order to efficiently create animations that are both responsive and naturalistic is the replacing of much of the manually created animation with animation that has been extrapolated from data. Again, similarly to the field of video effects animation, this often takes the form of motion capture - allowing the animators to accurately capture nuanced human movements more accurately, precisely, and efficiently than would be possible through traditional, frame by frame, animation techniques. Numerous different sequences of these motions are captured, perfected, and stored for each character.

These highly naturalistic character animations are further given life through the capability of modern gaming machines to simulate artificial intelligence and virtual physics. Instead of encountering a static non-player character and experiencing a predetermined, pre-animated interaction, in-game artificial intelligence facilitates a more dynamic and believable exchange, "the game has now responded to something you've done in a way that makes sense, and feels like the natural world" (Nesmith as quoted in Behind the Wall: The Making of Skyrim, 2011). Likewise, characters can be imbued with digital simulations of physical properties - such as centre of gravity, mass, and momentum - that, when amalgamated with similar properties present in surrounding virtual world objects, can be used by the software to calculate and simulate a reasonable facsimile of a real physical interaction (Geijtenbeek and Pronost, 2012). When the game is played, the program is able to decide, using a combination of the action requested by the player and the constraints of the surrounding environment or interactions from other characters, which set of motions to display (Grounded: Making of the Last of Us, 2013). Essentially, huge portions of the creation creation of the final visual representation are being generated not necessarily by the animators, but instead by a combination of motion capture, programmatic decisions, and player input. The result of all of these factors coming together to create the character's animation is a character that feels real - a character who presents all the nuanced, responsive qualities of life, rather than those of an artificial, obviously animated, entity.

4.2.2. Environmental Animation

Yet another extremely important occurrence of ambient animation present in modern day video games is that animation that comprises the virtual environment. In conjunction with the character animation, it is the believability of this virtual environment that allows the player to be engrossed in the game world. Perhaps even more so than character animation, environmental animation in video games exemplifies ubiquitous animation. Animated environments envelop and complement the games' characters - conveying the context of the game while fading into the background. In order to achieve this effect, the animation must be both subtle and omnipresent. As you walk through a forest on a breezy day, you do not

necessarily perceive each individual instance motion that surrounds you - the swaying of the branches, the dappled light filtering through the rustling leaves, the dandelion seeds floating through the air, or the birds flying overhead - but it is the amalgamation of these small, subtle samples of motion that come together to comprise the visual experience of the environment. This sort of animation would have once been impossible for game creators to create due to the massive drain on performance such an inclusion would bring - as evidenced by early video games such as *Space Invaders*' inability to properly represent even fifty five pixelated elements on screen at once. However, due to the increase in availability of gaming computers and consoles with ever improving technical specifications, game developers are now able to put more focus on creating and animating such subtle environmental elements.

One of the primary draws to the 2011 cross platform game *The Elder Scrolls V: Skyrim* was the expansive and convincing game world - populated with innumerable animated world elements - from grasses swaying in the breeze, to swirling snow, to the dancing Aurora Borealis (The Elder Scrolls V: Skyrim, 2011). The environment was considered such an integral part of *Skyrim*'s gaming experience that the game's director, Todd Howard went so far as to say that "the world is our main character" (Howard as quoted in Behind the Wall: The Making of Skyrim, 2011). Yet another spectacular example of a video game that highly prioritised the creation and animation of its immersive virtual environment is the 2013 game created for the PlayStation 3, *The Last of Us.* In addition the creation of animated environmental elements as did *Skyrim* - such as plants, trees and floating fungal spores - arguably the most effective form of animation utilised in *The Last of Us* comes from the production's emphasis on lighting design. The world of *The Last of Us* is lit by numerous different qualities of light sources, from soft light streaming in an open window, to the warm evening sun, to the harsh light of a nearby flashlight. As characters move about the game world, they interact with varying qualities of light and cast appropriate shadows - hard, soft, large, small - that are calculated and projected onto nearby objects in real time (Bierton, 2013). It is conceivable that these lighting effects and the procedurally generated shadow animations that they produce go unnoticed by all but the most technically minded

players, however, the effect that this - and indeed all - environmental animations has on the player is a subconscious affirmation of the environment's reality; these things behave the way real things do, therefore this place may be real.

4.3. Conclusions

Much like animation is self, the role video games play is inexorably tied to the technology that is essential for its existence. As a result of this, progressions made in the technological sphere have echoing ramifications for the video game industry, and in turn nature of the animation utilised. These technological shifts not only affect the type of animation that it is possible to produce within video games, but also affect the nature of animation that is in demand. The arcade era, limited by the technology of what was a relatively new medium, was home to video games that demanded flashy, novel animations in order to lure in quarter-carrying players to try their luck on the cabinets for a few minutes at a time. Today, spearheaded by the driving force of technological progress and the at-home gaming experience that it facilitates, there has been a surge of video games that emphasise the total immersion of the player within the video game world. The animation present in these immersive games quite clearly reflects the qualities of ubiquitous animation. Each animated element in isolation - from the character's movement to the swaying of the grass - generally goes unnoticed. However, the amalgamation of all these animated elements mesh together seamlessly to form a unified and authentic game world.

5. Web and Mobile Animation

Perhaps one of the most recent emergences of ubiquitous animation that we see in our day to day lives is animation that has been tailored for the web and mobile devices. It is easy to see how this new avenue for animation has evolved. In the last two decades, the internet has risen from the ranks of a curiosity to being an integral part of our lives. According to the Pew Research Center, between the years 1995 and 2014, the number of American adults using the internet has risen from 14% to 87% (Pew Research Center's Internet & American Life Project, 2014). In addition to this, people are more spending more time consuming digital media on mobile devices than on desktop computers, and the margin is increasing (Perez, 2014). The plethora of screens we sit at, carry around, and wear throughout the day, have provided an abundance of platforms for animation to infuse itself even more deeply into our life. As technology has allowed computing itself to become more and more ubiquitous - fragmenting away from a discrete interaction at a distinct computing terminal to smaller, stickier screens that accompany us every waking moment - animation on the web has followed suit.

5.1. Web Animation History

5.1.1. Early Web Animation - The Age of the GIF

At the onset of public adoption of the internet, the usage of animation in the context of the web was just about as novel as the internet itself. After Tim Berners-Lee's brainchild, the World Wide Web was opened to the public in 1991, the internet began to slowly garner popularity (Elon.edu, n.d.). Accessing the internet at this point in history, however, was a particularly discrete and isolated process, with the technology of the time not allowing for the kind of infusion into our daily lives as is seen today. Rather, reaching the internet required access to an often times static computer, accrued costly bandwidth charges, and even precluded the use of a the telephone while browsing - factors that ensured the internet of the early nineties would monopolise limited portions of the users' lives (Eppink, 2014). At this stage, the amount and type of content that could be displayed on the internet was

severely limited by the both the computing power of the average personal computer, in addition to the profusion of slow, screeching, dial-up internet modems. Keeping these constraints in mind, the vast majority of web pages were meanly designed to allow them to be downloaded as quickly as possible. As a result, the first incarnations of animation on the web took the form of looping, animated GIF files. The GIF, or Graphics Interchange Format, was a mem0ry-saving image file format originally developed by CompuServe in 1987 (Eppink, 2014). Although the format was born out of a practical desire for a memory efficient digital image file format, the GIF gained popularity for its ability to represent animation, and its initial implementations were anything but subtle. The GIF soon found its niche on the popular web hosting service, GeoCities, where it was used copiously. On sites such as GeoCities, where anyone had the ability to create their own web page, the GIF was used as an almost sticker-like adornment - decorating pages with dancing babies, marching hamsters, sparkling letters, and 'under-construction' signs (Alfonso III, 2012). Quite contrary to the notion of ubiquitous animation, these GIFs were created to be, and used as, animation for animation's sake; existing to be noticed - to call attention to themselves. They reflected the limitations of the technology while embracing the novelty of the new medium of the internet. Echoing the state of the internet technology through which they were implemented, early web animations blossomed out of this new medium in a similar fashion as the very first incarnations of animation - ostentatious curiosities reminiscent of the Victorian zoetrope.

5.2. Current Trends

The last two decades have seen a rapid and profound shift in the role computers play in our lives. Instead of a succinct, open and shut interaction with a single-purpose machine, our daily usage of computers has matured into an amorphous and continuous interaction that, through the ever expanding platform of our innumerable screens, interleaves itself harmoniously with our daily routine - with people spending on average over 61 hours per month browsing the internet on some manner of digital device (The Nielsen Company, 2014). These interactions are also becoming increasing meaningful - facilitating everything

from social contact to online banking. This new-found ubiquity of digital technology, compounded with the ever increasing power of increasingly small devices has provided new pathways into which the medium of animation can expand - trending away from the novel applications as seen in the early years of the internet.

5.2.1. Web Animation

Although the GIF format is still utilised quite frequently on the web, its role has been predominantly changed from being a strictly decorative novelty to being a, usually humorous, piece of user generated content. New developments in the field of web animation, on the other hand, have switched directions completely from the nineties' extravagant use of conspicuous animation. The focus of web animation as moved from being a distinct object on a web page, to being integrated into the source code of the web page itself, "these kinds of animations contribute to the overall experience, but they are seldom the focal point of the design" (McNeil, 2015). While the animated GIF occupies space within the body of a web page, web animations are increasingly being created programmatically through the use of programming languages such as CSS3 animations, JavaScript, and JQuery. This manner of creating animations ingrains them into the very essence of the web page, where they become an intrinsic part of the page itself. The result of this is animations that, as seen with the creation of virtual worlds in the realm of video game animation, that fade into the background, coming together to form, to some extent, a virtual environment - animations that, if skilfully produced, can go completely unnoticed by the user. Aside from generally being implemented more subtly than its GIF predecessors, modern web animation tends to be motivated by a certain pragmatism. According to the suggested use cases offered by the World Wide Web Consortium, also known as W3C, these web animations can be used to communicate crucial information to a user (W3.org, 2014). For example, a web animation applied to a menu button may cause the button to slide out slightly like a drawer when the user hovers the mouse pointer over it, indicating that more options contained within that can be revealed, or a password input may shake side to side when a an incorrect password has been entered, mimicking a shaking head and

quickly and efficiently communicating to the user that the information they provided was wrong. These subtle, interactive effects can not only aide the viewer in gaining information about the web page, but help transform the web page from giving the impression of a static, unmoving page, to feeling like an adaptive, responsive virtual environment, catering to the needs of the user.

5.2.2. Mobile Animations

Perhaps the screen that the majority of people spend most of their time interacting with is some manner of mobile device. From tablets to smart phones, these mobile devices are our constant companions and as such provide another opportunity for ubiquitous animation to permeate our lives. Animations designed for display on mobile devices have to be particularly well designed due to the physical limitations of the device. With a screen less than a quarter of the size of a laptop screen, it is essential that these animations make the most of the available resources. The animation generally created for present day mobile devices tends to be following some of the same routes as animation for the web - with many animations being designed, not simply to make an individual app appear more appealing, but particularly to enhance the overall user experience (Johnson, 2012). As with web animation, animation for mobile devices serves to craft a live, and interactive virtual environment.

5.3. Conclusions

In what might be one of the most rapid shifts away from novelty to ubiquity, aided by the quick development of internet and computing technologies in the last twenty years in conjunction with the vast increase in web and mobile usership, web animation has morphed from a purely decorative, eye catching curiosity, into a hard-coded user experience aide. Transforming from the very picture of animation for animation's sake, to an unnoticed, element woven into the structure of the web page.

6. Conclusions

In this paper I have discussed only a few of many manifestations of what I refer to as ubiquitous animation - the sort of animation with which we are inundated and yet somehow manages to pass beneath our notice. Animation that is created not for the sake of animation itself, but rather to serve a purpose. It should come as no surprise that animation has been tending towards ubiquity - as Mark Weiser stated, "the most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" (Weiser, 1991). Animation, a means of giving the illusion of life to the lifeless, is an incredibly profound technology in and of itself; drawing on the millenniums old human desire to capture the living spark of the world that surrounds us. Animation, however, cannot exist on its own in isolation from other technologies, it requires a medium not only to convey its motion, but to construct it - either mechanically, digitally, or otherwise.

Because animation is so inexorably dependant upon technology for its very existence, it follows that advancements in technology would have concurrent ramifications for animation. We can see through the examples discussed in this paper how animation, the representation of life through motion, has experienced a pull towards pervasivity. The simulation of life is slowly progressing towards achieving the height of convincing mimicry: seamless integration into our real lives. This pull of pervasivity pull being like the pull of gravity on a river flowing downhill. This path of development is changed and sculpted as technology progresses, removing impediments and opening up new avenues through which animation can approach ubiquity.

For as long as technology progresses, which we can most likely be safe in assuming will be as long as humans continue to endure, I believe that animation will continue to realise its tendency towards ubiquity - seizing each new opportunity afforded to it by new technological mediums to continue on its progression from conspicuous novelty to pervasive ubiquity.

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