SPATIAL DICHOTOMIES: RESEARCH INTO THE DEVELOPMENT OF 3D REPRESENTATION

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ABSTRACT

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Spatial Dichotomies: Research into the Development of 3D Representation

Chair of Committee: Robert Spahr

This research paper covers how 3D technology influences different industries over time. Key points within the research find that over time humans consistently gravitate toward increasing their ability to recreate depth, texture and image. Industry leaders in education, film, medical, television, and the Web will find literature and discussion of how to adjust their modes of production and manufacturing in the future. Each of these industries will be reviewed throughout the report. The data in the report identifies 3D technology in two sections: object and screen-based technology. Each chapter contains social and financial elements that assist and react to new technology in the market. Additionally, to help show the effects on the different industries there are trends and time lines to show how individual industries develop. In each industry, there are multiple ways that 3D technology can be effective and ineffective. The research goes over transitions in early media to compare to transitions in modern mediums of art and science. After covering a short history on the transformation that society has had with the image, the paper covers public demand for new virtual settings in education and entertainment. Image-based research indicates that users will on average continuously desire more depth and interactivity in content.

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CHAPTER 1: INTRODUCTION

The arc of depth and perspective behind imagery has progressed substantially since the personal computer revolution in the 1980s. In contrast to 2014, this report takes a look at personal 3D printers entering the market. Individuals have been recreating screen and object-based images for centuries through sculpture and paint. Artists, engineers and philosophers have worked together to provide society with new ways of looking at data. These industries each have a variety of individual companies that make up their subject matter. Examples include Sharp with television industry; Google and Apple in the personal computer and tablet industry, and how both the computer and television industries connect on the Web. This section is one of the areas reviewed, and is an example of how multiple areas of business have been merging with specific industries to compete for potential customers. Advanced computer-generated imagery in the film and television sectors has progressed well domestically and in developing countries. The film industry, for example, has seen increases in average revenue generated from 3D technology beginning in 2004 through 2013 (MPAA, 2013). 3D printing has started to materialize digital content, revolutionize the retail industry, and has created a new level of social empowerment that is unparalleled to the other industries analyzed in this study. The reason that the 3D printing section contains more weight is due to the positive and intended results that 3D printing has had in comparison to 3D graphics on screen-based systems. The social, financial and user benefits of 3D printing provide individuals with the power to produce products they have only been able to consume in mass market during past generations. The primary thesis is to show how 3D technology, financially and socially across several industries, is effective and, at times, ineffective.

Effective can be defined as producing a desired or intended result. Research in this study expands upon intent by researching the differences in open source and closed source software. Additionally, examples are provided showing when three-dimensionality is effective and ineffective for each area of business.

The theory that media producers can predict when multidimensional design is cost effective, and socially beneficial for their audience is possible, but it is especially difficult to predict audience demand. A similar baseline theory can be compared to how Thomas Kuhn, American philosopher, viewed the transitions in various scientific revolutions. His theory displays insight on the paradigm shifts that occur in science. Kuhn (1962) states, “These transformations of the paradigms of physical optics are scientific revolutions, and the successive transition from one paradigm to another via revolution is the usual development patterns of mature science” (p. 12). When we review the mistakes and successes from the past, it can be easier to pinpoint when to implement new 3D technology for different industries that interact with complex systems of computer science. This paper details the effectiveness that screen and object-base 3D technology has within different developed markets.

The introduction of the study provides background on what has been researched. It also provides data on the main topics discussed in the paper on the social and financial effects that 3D technology has had in a positive and negative manner. A historical transition in painting is covered to identify the continuous arc of social demand to view items, objects and images with greater depth and perspective than in previous generations. Historical analysis is used to display the trends that have taken place in imagery and the shifts in representation from physical to more digital base content.

CHAPTER 2: LITERATURE REVIEW

Scholars all over the globe have covered research on the rendering of images over time. Artists and engineers continue to merge and build new industries to produce changes socially and financially. Each chapter will review the demand for user-generated content. 3D technology, when referenced in this paper, means screen-based systems including computer generated graphics, as well as object-based items, such as printed materials produced through a 3D printer. Three-dimensional printing is a relativity new process of layering and printing materials, such as plastic, glass, and metal into physical objects. The data collected for this study focuses on two specific time periods of transitions within imagery. First, there is review and discussion of the renaissance movement's shift in perspective physically and metaphysically. The second transition in three-dimensionality is currently taking place within the print, motion picture and manufacturing industries.

This paper is structured chronologically to help identify the enlightenment era in Europe that relates to the current transition in computer graphics. Computer generated imagery, also known as CGI, represents all computer-based imagery, including 2D and 3D graphics. CGI is covered and reviewed to show the progression of computer-aided graphics in media. The use of CGI is most commonly used in screen-based systems. There is an exciting potential for crossover within computer-generated images to be used in 3D printing projects.

The proposal of this study is to show the social and financial benefits, as well as the drawbacks produced when 3D technology is brought into new industries such as the film, medicine, and manufacturing. These benefits can be seen differently from a user and a producer's point of view. The term "render" in this study refers to the process in which an image is

developed into a finished product. Examples of this include paint drying, film development, and the digital rendering of computer-based images. Discussion is held on the rendering of paintings from the Medieval to the Renaissance period in connection to the rendering of digital images on screen based systems. Furthermore, there is review on modern technical developments that relate back to the way users see and have interacted with content before computers.

Medieval & Renaissance

Christiane Paul writes for the Massachusetts Institute of Technology Review, and notes the a shift in perspective within the audience and the artists during the transition into the Renaissance period. Her point of view illustrates conceptual and perspective shifts that took place for consumers and artists. Paul (2008) notes, "The parallels between the development of realistic perspective in late-medieval art and in video games, as well as the transition between the two-dimensionality of painting and the real-time three--dimensionality of computer games" (pp. 1-3). Paul's reference here supports the overall arc behind the need and desire for humans to seek additional depth and perspective in imagery. Paul analyzes a similar connection between the transition of art in the Middle Ages, and the contemporary transition in 3D technology that is currently taking place. This example is used to display metaphysical shifts with the audiences' ability to relate to subjects in art. Additionally, this example gives a visual comparison between the two art periods that have been researched for this dissertation. Next, there is review on the data gathered from the Renaissance movement on the evolution of imagery.

Visually, this paper uses two examples from ARTstor online. Niccol di Segna's *Saint Lucy,* a Medieval painting produced with tempra in comparison to Leonardo da Vinci's *Last*

Supper, displays piece of transitional artwork to the Enlightenment era. The visual shift of using different oil paints created a mental shift in how individuals perceived art.

Textually, Dr. Beth Harris and Dr. Steven Zucker analyzed, and added to the collective conversation on the materials used by Leonardo da Vinci in the *Last Supper*. Da Vinci's piece represents the transition of the time by his use of oil and tempra. His style of painting was to layer a nontraditional fresco with dry plaster, (Harris & Zucker, 2013). These pieces of work provide juxtaposition between the two time frames, materials used for creating images, the rendering time, as well as the social and financial demand from the public. Historical examples support the progressive arc behind the social demand from the audience toward additional depth, lifelike likeness, and unique styles representation of objects within art.

Public demand continued to push for a faster rendering time on artists to complete their paintings. In transition for paintings to photographs, artists experimented with new methods in producing artwork. Camera obscura became a transitional medium for artists to render images by hand with the use of a projector. The still base camera would allow producers to create imagery without drawing by hand.

Motion Picture

Modern imagery has seen leaps in advancements from a 2D, imagery that is two-dimensional, to creating additional layers of illusion graphics to represent depth in a 3D format. The first reference, used to show the visual 3D effects in film, covers on the Wachowski siblings. Andy and Lana (formerly "Larry") Wachowski wrote and produced The Matrix in the 1990s. Jens Schroter points out the mode of operations used to produce the film that was shot in 2D, and also provides insight on the manner in which post production editors can add frames shot 360

degrees around the subject, to mock a 3D environment. Schroter notes the spatial differences within transplane imagery, and the structure to adding space as an illusion of depth (p. 136). This idea is reviewed to elaborate on the spatial representation of images, and the means by which filmmakers mock or recreate the images.

After reviewing the state of 3D content in the 1990s, the study moves forward to visually display the progressive nature that Hollywood has had in the past 10 years in producing 3D films. A group of researchers with Motion Pictures Association of America provided statistical information on the financial impact that 3D technology has had in the past decade. Their research indicates that the amount of 3D films produced each year has consistently increased on average since 2008, (MPAA, 2013).

Transitionally, 3D technology is in a constant state of flux. This study helps identify the current state of computer graphics, when they are effective and ineffective on a social and financial level, and the perspective from a user experience point of view. Michael Rougeau provides insight from Sharp on their plans for television production in 2014. Earlier this year Rougeau noted, “Sharp expects 8K TVs to hit the market within the next few years" (Rougeau, 2014). This example connects with the collective dialogue covering the transition toward 3D visual rendering in electronic manufacturing.

Web & Education

Screen-based systems makeup a large section of research gathered in this study. Scholars and industry professionals share their points of view, as well as the advantages and disadvantages of 3D technology. Ben Shneiderman’s piece titled, *A Step Beyond Programming Languages* within *The New Media Reader,* provides a point of view from an early age of demand for

advanced human-computer design. Shneiderman (2003) states, “The tremendous growth of interest in interactive system design issues in the research community is encouraging” (p. 497). His excerpt supports research in developing digital products and services for the Web.

Jaron Lanier’s *You Are Not A Gadget* covers open source content, described in this study through the lens of 2D and 3D computer-based code, as well as design and intellectual property open to the public to consume and reuse at the users’ discretion. Closed source content, software and hardware is a proprietary form of commerce with restrictions to the user, but whose promulgation is more financially viable for private tech firms. Lanier states the current issue that separates these two ideologies in 2010: “The new century is not yet set up to support its own culture" (p. 132). This piece from his book is reviewing Spore, William Wright’s latest published project that has witnessed a negative reaction from media producers, partially a result of adding restrictions to user-generated content. The open source and closed source debate continues amont advocates and producers of 3D printing.

The Future of 3D

Literature in this study also covers 3D printing in the medical industry. It helps provides a look forward into 3D technology. Alexandra Morris, writer for MIT Technology Review, begins the section with socially vital information on how 3D technology is shaping cancer cell detection, and how doctors are diagnosing patients. Morris provides beneficial data on the latest 3D technology in the field of medicine, but lacks a counter perspective on the cost for the equipment to the company that indirectly, and invariably, gets passed along to the consumer. The increase in cost can be seen as a negative change; however, the balancing of cost and reward when considering 3D medical devices adds yet another layer to the discussion.

3D printing is an emerging an empowering medium that allows users to customize their goods. The growing list of products available with 3D printing technology includes glasses, braces, prosthetic body parts, and organs. User interaction with desktop 3D printers, such as the Makerbot model, provide the user with additional functions and controls when producing new products. Makerbot is another example of a company that had operated with an open source mentality prior to making a similar decision to move to a closed source mode of production, such as William Wright and the Spore team.

Matt Ratto and Robert Ree published a Web article for First Monday on 3D printing. The authors noted that, "In our environmental scan, we found that current uses of 3D printing seem to empower people in several distinct ways, including: fashioning custom tools to accomplish specific tasks; extending or connecting disparate forms, systems or structures; visualizing problems that difficult to picture virtually..." (Ratto and Ree, 2012). Ratto and Ree's scholarship shows the social benefit of empowering individuals to manufacturing their own goods.

The final section of research reviews upcoming trends in 3D technology with tablet and personal devices being a a focus of attention moving into the next decade. Emerging technologies have shown to have functionality that not only allows users to see in additional dimensions, but to interact with those dimensions handsfree within the software and hardware.

Project methodology is shown to provide insight on the process in identifying the positive and negative effects that 3D technology has had on developed markets. There is a financial and social effect that is taken into account to make up this data. In the next section, there is more on the process taken to review and add to preexisting research.

CHAPTER 3: METHODS

Research collected in this study consists of three main approaches to identify past patterns and transitions in different mediums of art. The methods of data analyzation include theory-based, applied and community-based research. These methods show how the image has made many spatial and dimensional transitions since the Medieval time period. After reviewing past research on 3D design and technology, the data also shows the parallels between transitions in content production. Canvas art from the fifteenth century is one of the first examples examined in the report. Second, some visualizations are provided to show the revenue generated from 3D technology at different time periods. It will parallel with adption rate (the rate at which a particular technology is adopted, not the rate at which babies are adopted), and data collected will also reflect the amount of interaction between the user and the product. The data used in this study builds a visualization for ways individuals can adapt new technology.

The primary goal of the research paper will statistically and visually illustrate how and when 3D technology is being used within developed markets. Each section will analyze the financial makeup of emerging multidimensional technologies. The cost of the content will be reviewed, as well as the social significance to the value of the financial cost. In the television and film section, there is review on how 4K, (horizontal resolution of 4000 pixels) content is disrupting the 3D market for screen-based systems.

A secondary purpose to the report is to create a discussion of how and when digital content should be converted to a multidimensional design. It will also cover how devices that project imagery in multiple layers when producing 3D content, such as the Nintendo 3DS, Oculus Rift, smart televisions, and IMax Theaters. This study covers screen-based systems where

3D technology has created new business opportunities and problems for technological companies. Multi dimensional screens are generally defined herein as involving several dimensions of viewing projected imagery. The time periods researched in this report show an interest to develop or create depth in visual formats. Examples of the dimensions and aspects in the Renaissance period include: the oil paint, canvas, tablets and thin sheets glass. Different modern interfaces in the paper reviews: touch-base screens and command-based interfaces. These different formats to display data can be seen as different devices in the market, or different mediums of art. Data collected in the study is setup to help professional media producers narrow down time frames to begin transitioning to a new medium. A methodology to this problem is to review past transitions and trends, in connection to current social demand.

The first two industries reviewed in this report are film and television. Three-dimensional film can be identified and produced in more than one way. 3D imagery in this paper includes 2D and 3D content. 3D imagery is best defined by example: all converted film from 2D, content that was originally shot with multiple 3D cameras, stop motion animation, polarized 3D, computer generated imagery, and autostereoscopy, (glasses free 3D viewing experience). James Cameron, director of *Avatar,* and *Deepsea Challenge 3D,* is one of the successful examples of acquiring 3D image-based content to his work over time. A second example on 3D content in motion picture is by the Wachowski siblings, and their direction of *The Matrix* family of films.

An element to this study is how the paper defines 3D technology within each industry, and within each reference. As noted, research shows how 3D film can be broken down, and in our 3D printing section, data provides information on how to distinguish the terminology within 3D technology.

Overall, the research gathered in this study indicates that the healthcare industry will see a vast amount of opportunities to work with financially and socially from 3D scanning, advanced computer graphics, and the combination of these functions with 3D printed materials.

In retrospect, this paper can be compared to showing the methods and modes of production when adding color to advertisements and content on domestic television in the 1950s. Richard Gil and Ryan Lampe reviewed this transition in 2012. They noted that American film fully converted to sound within three years. In comparison, Hollywood's conversion to color film lasted more than three decades and ten times the length in adoption rate. "Between 1954 and 1957, the proportion of color movies even fell by 27 percent after surging by 38 percent between 1950 and 1954" (p. 2). This mirrors public demand for 3D films in the early 2000 era.

Research gathered at MIT by Douglas Lanman and a group of screen-based computer scientists provides context on the screen-based systems for 3D technology. "Stacked LCD monitors can now provide a glasses free experience" (Lanman, 2010). This collective point of view supports research on modern monitors that, while requiring no glasses or headsets, are also not yet available in developed markets.

There is additional theoretical discussion to support the positive and negative effects that have taken place in the still and motion picture industry. The amount of time one needs to wear 3D glasses is key when developing effective content. Historically, stereoscopic imagery required individuals to wear viewing glasses to experience additional depth. Research presented in this paper has been collected and analyzed to show the positive and negative elements behind the digital transition. Furthermore, data in this study features the progression of 3D technology, as well as a brief history of recreating subject.

CHAPTER 4: HISTORY OF THE (3D) IMAGE

History of rending images connects to the big picture within adding depth and perspective to an image digitally and physically. Imagery connects with technology in each generation starting back with cave paintings. Perception of how one is represented within an image has evolved over centuries of time. History behind the evolution of the image adds to the discussion of how technology affects industry. Before investigating different industries, this study looks at how inventions in technology, (machinery and equipment) fuels the platforms, also known as physical areas in which content is distributed, to provide unique perspectives on different mediums that later become industries. One counterpoint to that view is that the demand of society fuels the technology being produced. In order for any medium to become successful, it appears that there needs to be a balance between the demand from the public, and the abilities of the current technology to fulfill the demand. The first example inspects the evolution behind the transition from Medieval to Renaissance paintings.

Initially, representation of imagery can be considered an applied science. The knowledge of how an artist represents objects on caves and walls can be one of the earlier methods of capturing an image on a shared surface. Applied science can occur when artists acquire others work and use it for inspiration to create their on work. Individuals would use different forms chalk and gradient to give objects the illusion of depth on a 2D mediums. Chalk would be exchanged for paint, and paint or ink can be seen as contemporarily being traded out for computer code within hardware. Each transition provides the chance for artists to question the bias behind the equipment in use. Next is a brief examination of artists using different materials to represent objects on shared surfaces.

Case Study: Medieval & Renaissance

Artwork covered in this section reviews two styles of painting images that have similar and unique functions to them. In the first example, a piece titled *Saint Lucy* is exhibited to show the tempra material used to create images and portraits. Next, there is Leonardo da Vinci's the *Last Supper* to visualize the fresco style of painting mixed with plaster and oil paint. The second example provides a transitional view to rending artwork with different materials of paint.

Christiane Paul provides support on the transition of perception in viewing canvas art between the Medieval to Renaissance time periods. After the fall of the Roman Empire, and around the fifteenth century, there was a massive transition in ideology which created new opportunities and changes in perspective. Within Paul's reference is bolstered with additional scholarly support from Brody Condon. He notes the effects technology has had on game development. His work supports the transitional view that occurred when painters started using living subjects within the current generation, in comparison to producing artwork with subjects from the afterlife. The financial transition of acquiring oil paint was an issue, but recreating living subjects in real time, instead of looking at subjects primarily in the afterlife, left a profound transition in ideology that has evolved through modern times.

Paul (2008) states the following theory:

> The term "Early Netherlandish" refers to a group of painters--from Van Eyck to Gerard David--working in the Netherlands in the 15th and early 16th centuries and representing a particular moment: the zenith of the Middle Ages and the transition to the Renaissance, an era when perspective--the technique artists use

> to mimic how three-dimensional objects appear to the eye--developed in several stages. On a formal level, Condon's work draws parallels between the evolution of perspective and realism in medieval art and the evolution of 3-D computer graphics in games. (p. 2)

On one level Paul is talking about video games, but one can see it applies to most CGI as well. Advancements in object and screen-based three-dimensional technology both have had their impact on different industries. This study separates these two mediums to help identify the differences in physical and digital content. This first example shows the connection between taking a physical object, including: a canvas, egg yolks, oils and the brush to create an image within a frame. 3D imagery is an extension of the physical canvas. It can be seen as the digitization of an image that is rendered to a computer screen.

Time is another element that is identified when reviewing 3D imagery. After the fifteenth century, artists started focusing on alternating the time within the subject matter in the painting to modern day events. Textually, one can note that there was a shift in ideology and perspective during the transition from Medieval to the Renaissance era. Visually, the differences between these two styles of painting are easily recognizable.

On a financial level, these pieces of work tended to be bought and paid for by religious organizations, such as the Roman Catholic church. They were socially effective in the sense that images provided a narrative to those that may have not understood a particular language. Each painting produced by hand would have taken longer to render, but as a consumer, the product would have been more valuable in a sense of rarity, but also in the sense of decay. In a

transitional sense, these two examples give an opportunity for readers to compare the two images together and critique which painting you find more effective in a sense of relating a message.

Figure 1 Saint Lucy by: Niccol, di Segna. Medieval painting from 1340. Retrieved from http://art.thewalters.org/detail/38525/saint-lucy/.

Saint Lucy by Segna uses tempera and gold leaf on a panel surface to illustrate the image. The rendering time that it would take for this image to be completed once, and possibly

duplicated would be considerably longer when compared to producing an image with oil paint. Furthermore, the material of oil paint also provided a change in the way individuals perceived the living and afterlife in artwork. Segna is using a single female, known as Lucy, which is holding a dagger that she was murdered by according to ARTstor. The deeper layer of this image is that the main subject is apart of the afterlife, and adds to the discussion of depth within an image.

One perspective shift that occurred between Medieval and the Enlightenment period was the subject matter within the painting. The use of physics and detail added to subject matter in paintings, and is an early example of one of these shifts. A second shift was the visual perspective change. It shifted to a linear view with gravity-based objects within an image. The continuation of adding depth and illusion to make an image look as lifelike as possible, will continue to progress as we move forward.

Carmen Bambach, curator in the Department for Drawings and Prints at the Metropolitan Museum describes *The Last Supper* by Leonardo da Vinci as a piece of art that, “Had already begun to flake during the artist's lifetime due to his failed attempt to paint on the walls in layers (not unlike the technique of tempera on panel), rather than in a true fresco technique” (Bambach, 2002). Bambach adds that da Vinci was using the head of Christ as a vanishing point toward which all lines of the perspectival projection of the architectural setting converged. The message within the materials used for the portrait can be related to a later subject reviewed in this study on *The Matrix,* and the approach of crafting the message with current technology. This form of a perspective change is a visual form of transitioning that da Vinci helped create during the early stages of the Renaissance.

The addition of depth and perspective can be seen as benefits that were created from layering paint in comparison to tempra. There was a perspective change and a rendering change that took effect during this transition: both examples relate back to the acquisition of 3D visual content available on digital devices, as well as object-based content produced from 3D printers.

Figure 2 The Last Supper by: Leonardo da Vinci. Renaissance painting from 1495-1498. Retrieved from http://www.artres.com/c/htm/Home.aspx.

Da Vinci worked with subjects in the present day, as well as working with subjects from the afterlife. Da Vinci is a good example of an artist that helped bridge the Medieval and Enlightened art. It can also be noted, he helped increase rendering speeds by his style of production. This can be related to our research on James Cameron, and his constant state of acquiring new forms of technology. This paper is structured to help share information on

developing new ways of looking at visual data and imagery, as well as how it connects to historical art.

This second example of a classical painting shows an emotional moving scene from the users point of view in comparison to prior versions of the same painting. Bambach noted that the perspective in which a viewer would see this painting is 5-10 feet below the bottom of the painting itself. This connects to research on how viewers experience 3D movies differently at IMax Theaters. The screen-based system in 3D theaters has different viewpoints when watching a film. In the perspective of the user, it can be seen as a drawback to not have an ideal viewing position to consume the content. This point can also been seen as a variable to influencing user demand for visual products, such as film and television.

When viewed from a historical perspective, the evolution of technological equipment and tools can be more readily dissected and analyzed. The research gathered from past technological revolutions helps pinpoint the manner in which current and future revolutions will take place. In the next section, there is review and discussion of the benefits that 3D technology has in education, the downsides that it has had with ESPN 3D, and the converging possibilities on the Web.

In the next section, discussion continues regarding the progression of digital rendering of images. Each time period provides a set of materials and techonology that gives each generation opportunities to shape and mold society in positive and negative ways. Modern 3D Technology takes a closer look at how people currently interact with digital interfaces. As the paper continues to progress; there will be additional review on possible tools and equipement in 3D technology that may be used in the near future.

CHAPTER 5: MODERN 3D TECHNOLOGY

In 2014, the state of 3D technology within different industries is mainly controlled by demand from the audience. From still photography to the motion picture, audiences have consistently been drawn toward visually stunning imagery. In this second section of review, three-dimensional design is shown to provide insight on the continuous state of influx that has become an issue for media producers. The method in this study is set up to better understand the influx, and to review how transitions historically in paintings has mirrored the transitional era of digital production near the end of 2014. First, the research in this study analyzes the influence on the development of materials in paintings, and the effect it has had on perspective of depth. Now, the paper separates the motion picture industry into two categories, film and television, with an additional section for tablets near the end of the report. Second, we look at the a case study that is reviewed within the television industry on how ESPN has transitioned their platform, along with other mainstream television and film companies, in their transitions from 2D to 3D content. That case study looks at some of the negative effects that have taken place with 3D technology and the television industry. Third, the modern era of 3D technology is converging on the Web and within the education systems. That section of the study uses examples on how these industries have incorporated advanced screen-based systems to view content.

The motion picture has seen stereoscopic photography evolve from the early 1900s with the evolution of cameras and equipment to develop content. 3D films can be shot in 2D and converted in post-production to 3D. They can also be shot with 3D camera that is usually paired together in a similar fashion to shooting film in 2D. The tools behind the content help the artist create new work, but those tools also need to be questioned to be able to build new equipment or

technology with unique functionality. James Cameron is an excellent example of a director that is also pushes the boundaries an inventor.

A segment in the film section of this study examines a set of filmmakers from Chicago, Illinois. The duo has worked on *The Matrix* trilogy, as well other large-scale projects like *V for Vendetta* and the upcoming *Jupiter Ascending*. It helps identify the era of 3D motion picture during the late 1990s and early 2000 era. This example is used to identify a financial success and failure of adding additional depth to an image and storyline. Socially, the Wachowski siblings brought the downsides of a shared virtual reality to the masses with their franchise of *Matrix* films. They were able to narrate a message in their film on technology taking control over the human species, as well using vanguard camera equipment to glorify their message.

Jen Schroter, writer of *3D History, Theory and Aesthetics of the Transplane Image,* examines the visual 3D effects that the Wachowski siblings added to *The Matrix* produced by: Warner Brothers, Village Roadshow Pictures, Groucho II Film Partnership and Silver Pictures. The film approximated cost according to IMDb was $63 million in 1999, and grossed $646 million worldwide. It pushed the boundaries of what was currently available in 2D and 3D technology at the time. The Wachowki siblings would receive larger budgets for the sequels, but lacked the financial success of the first film. This can be a sign that content and story lines within entertainment engages audiences more than visual effects with a remastered plot structure.

One well-documented caveat by Schroter points out the symbolism that occurs when the Wachowskis use the advanced transplane imagery in their film. It also reflects on the overbearing reach of technology in combination with stunning visual 3D effects. This is an example of how

the medium contains and perpetuates the message of the film in a sophisticated manner. Schroter provides insight on the need and demand of spatial data.

Schroter (2009) states the following theory:

> This means that transplane imaging technologies not only have a function for rendering information on space in order to make it controllable and manageable, they also serve to transform space into a spectacle and thus make it commercially viable. (p. 136)

The viewpoints that Schroter shares on narration within multidimensional technology is an excellent way of connecting something that is visually entertaining with industrial technologies that can be medical beneficial, educative, or emotionally engaging with new audiences. This idea of using the 3D environment as a piece to the story is still developing for the film and television industry. The virtual reality and video game industries on the other hand have adapted quicker to allow users to adjust and manipulate the virtual worlds to create new story lines and narration.

3D animation continues to evolve with computer-generated imagery within the film and television industries. The Web and education section of this paper is setup to review Viewpoint software. This new software is making 3D modeling more cost effective for interfaces on the Web and available on personal digital devices. This is a positive example featuring benefits socially for disable students, and for the user experience.

To meet the demand for 3D content there will need to be inexpensive ways to produce short films and movies. One example by Bernard Mendiburu, writer of *3D TV and 3D Cinema,* published in 2012, indicates how broadcast business will continue the transition from 2D to 3D, or from standard to high definition content within television and motion picture industries. “For the years ahead, distributed content will have to make its way through 2D channels, until the industry agrees on 3D standards and upgrades equipment” (p. 123). His view on transitional platforms fits the pattern on upgrading television from analog to digital in 2009. The snapshot of his perception of 3D content in 2009 is a good example of the optimism that filled the market until the end of ESPN 3D in 2013. Since that moment, users have accumulated to viewing 3D television as an additional function instead of a driving force behind 2014 televisions being marketed.

In comparison to the decline of ESPN 3D, the motion picture industry has seen steady growth in demand and production in 3D films. Figure 1.3 represents that statistically data from the motion picture industry from 2004 to 2013. A group of collective writers with MPAA provided data on how many 3D films had been produced each year. The data is setup in a timeline to visually show the increase in demand. Their data also suggests that the film industry has made more money on average each year, but has also increased the average price of admission to view 3D featured films. In 2014, the business model for releasing feature films has started to redirect. The options provided for video on demand streaming on opening day for feature films has continued to shift to home entertainment. The chart symbolizes ten years of 3D films being produced for domestic audiences nationwide.

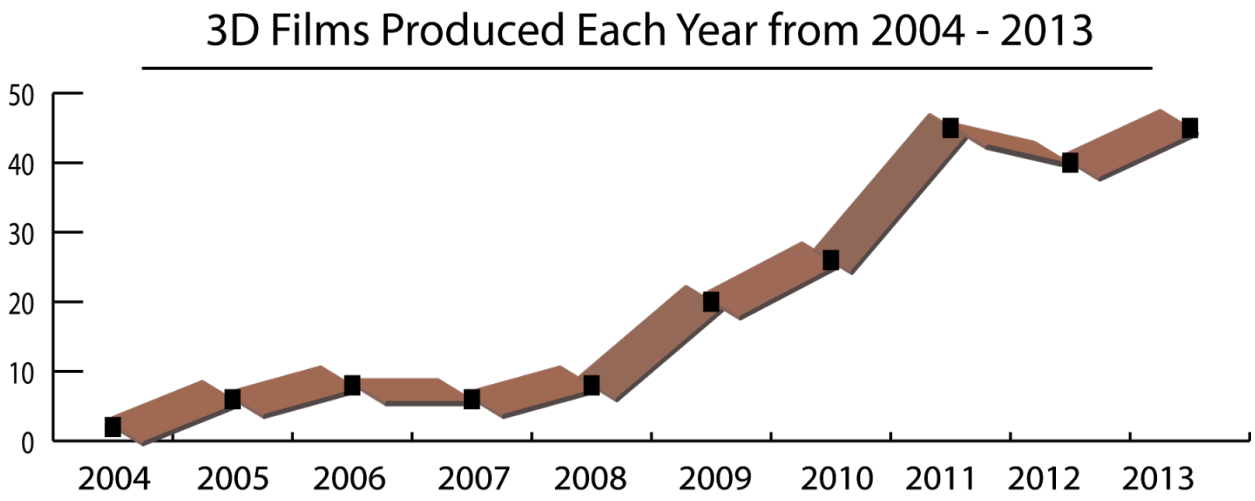

Figure 3

Data source from: *Theatrical Market Statistics* written by multiple authors with the Motion Pictures Association of America.

Another factor to 3D technology is how it is marketed and distributed to users in different areas. In the future, technology-based companies will be looking to continue trailering their products to different generations of users. The next section of the paper reviews the current state of the television market regarding how users interact and consume content on 3D, 4K and 8K televisions. Additional discussion to 3D television, and the personalization of content is covered to show the intent of the user when interacting with 3D screen-based systems.

James Wall, senior lecturer at Southern Illinois University Carbondale, has over 20 years marketing and sales experience in the broadcast industry and provided insight on the viewing experience for 3D. During a conversation he pointed out the way the short time frame that most users are willing to wear glasses to experience three-dimensional content. He noted that watching

a televised newscast is 3D would not be as effective in comparison to a featured film. The viewing experience itself became a reason to why the different platforms have different adoption rates, and one main reason the large technology companies are rushing to develop 3D content that is glasses free.

As three-dimensional digital content evolved in the late 1990s, new methods of building 3D became a new frontier for filmmakers. Transplane imagery combined with freeze-frame photography provided a unique approach to producing still and motion pictures. After seeing the image evolve in the twentieth century, technology that is based on Moore's law indicates that the need to produce more data with additional layers of depth to imagery is the current arch that most developed countries seem to follow. It can be noted that technology in undeveloped parts of the world will take longer for larger penetration rates. According to research from 2006 by Menzie Chinn and Robert Fairlie on the digital divide, they have noted that, "Relative to developed countries in which there are 0.57 computers per person and half of the population uses the Internet, developing countries have a long way to go to close the gap. As noted above, there are 3.7 computers per 100 people and less than 6 Internet users per 100 people in developing countries" (p. 3).

This example is brought into conversation to demonstrate the uneven balance that occurs between different countries. Adoption rates for new technology can be determined by the current interaction with a device or interface. The primary focus for research in this study covers the how the United States has created, distributed and viewed advanced computer graphics. It can be noted that the digital divide continues to prevent all human subjects from experiencing new forms of technology. Cross-referencing our data later on 3D printing, it can be noted that the

digital divide that has kept information open for some, and closed off to others. This physical divide becomes more stark with the addition of 3D printing physical objects in healthcare for those needing rare organ transplants. These new technologies will likely be socially effective in regards to health, but also likely financially ineffective in comparison to two dimensional computer graphics.

Modernly, three-dimensionality as a screen-based system has progressed from producing content in 2D to advancements in equipment, and providing opportunities to film and create in 3D. The financial cost to producing cinema in 3D is also comparative to providing in depth computer graphics in healthcare. Socially, it can be seen as imperative to saving lives with 3D technology, but may lack substance when viewing and interacting with entertainment.

ESPN 3D is the next case study that is reviewed in the study. It provides an ineffective example of unattended results with 3D technology. The quick rise and fall of the content distribution was noted to failing due to a lack of demand, but this next case study goes over some of the other factors that played in the canceling the 3D programming on ESPN.

Case Study: ESPN 3D

This section helps guide predictive elements on 3D television, and the timetable behind the structure of when it will become mutually beneficial for consumers and producers. In juxtaposition to the other industries reviewed; this portion will take a look at the downsides to 3D technology and slower adoption rates with consumers.

A connection can be drawn to Gil and Lampe's research on the addition of color in motion pictures to how the film industry is currently finding ways to add 3D technology into

content. In this next example, the study displays how one of the largest networks in television has reacted to the social demand from the marketplace.

Andrew Dodson, writer for TvNewsCheck.com, spoke with ESPN CTO Chuck Pagano, in the summer of 2013, on the future of 3D content development with the company. Pagano stated that he predicts 3D will evolve when companies can mass market a truly lenticular lens, a lens in the shape of an eye, that can be placed in front of the set that in which one can watch content without glasses. His point of view connects with the scientists at the MIT Media lab. They indicate that dual-stacked LCD screens can provide additional depth perception without having to wear the glasses. Their research notes that applying non-negative matrix factors to the input field, and displaying a dual-layer display to the audience obtain the content-adaptive parallax barriers. This helps show the progressive nature behind autostereoscopy imagery.

Furthermore, Michael Rougeau, writer for techradar.com, reported in early 2014 on plans that Sharp has in store for their televisions. The excerpt shows the expected future of production for products over time. “Sharp Senior Product Manager Tony Favia told TechRadar that although its two 8K TVs (the 3D and non-3D) are definitely still prototypes, Sharp expects 8K TVs to hit the market "within the next few years" (Rougeau, 2014).

One of problems that this study attempts to answer involves identifying the more effective transitions in 3D technology. Collective research shows an impending evolution of high definition sets, from 4K to 8K, with optional design for 3D viewing experiences. That transition appears to be critical for television stations in comparison to producers for the Web. As traditional media producers continue to work on transitioning to digital content for the Web, producers that work online are currently looking for ways to interact with the physical world.

Web & Education:

The Internet is one of the most expansive platforms regarding the exchange of content from sender to receiver. In this case, content producers will need to be even more aware on how to effectively communicate their products to online audiences. Multidimensional systems can connect interactive features with audiences on the Internet. These features create a user-centered experience that relates to deeper levels of engagement.

In this section, literature is analyzed to find out more on how education has been effected by advanced computer-aided graphics, virtual reality, 3D modeling, multidimensional interfaces, and interactive content. Educational and research communities also have had plenty of opportunities to gain with the 3D technology transition. In contrast to education,

Ben Shneiderman, featured writer in *The New Media Reader,* envisions the need and demand of interactive content in 1983. He goes into commercial and industrial design on different interfaces regarding advanced computer graphics. The point of view from the early 1980s helps show the progression that interactive systems has made in the past thirty years. Shneiderman (1983) stated, “The tremendous growth of interest in interactive system design issues in the research community is encouraging. Similarly, the increased concern for improved human engineering in commercial products is a promising sign” (p. 497).

Shneiderman points out the emergence of new research and interest being centered on engineering new products which are contemporarily called devices. This is in comparison to his point of view from thirty years prior. It adds a point of view on increased user demand interactive design from the 1980s era of technology development. Schneidermann’s work aids in elucidating interest in the social point of view from the research community.

Next, the study examines the effects that 3D technology has with online education. They point out that 3D blackboard is a module that provides 3D visualization and interactivity for more in depth knowledge delivery. Wang, Li, Chang expanded upon that idea by showing that the term, interactive *3D* media*,* is used to emphasize its capability of presenting 3D content via interactive means.

They tap into the concept of interactive 3D technology, and how it provides more capabilities and functionality in comparison to preexisting platforms in education. The three professors continued to show how interactive three dimensional interface design can produce learner-centered constructive environments that can provide deeper levels of engagement. From a social and users point of view, it can be noted that 3D technology has the potential to be highly effective online within the education system.

Cemenasco (2004) states the following theory:

> The Viewpoint format offered the best interactivity (to move, label parts and control the animations, plus the possibility to cover surfaces with textures) with an incredible size reduction (more than 20 times in comparison with the VRML format). (Cemenasco, Bianchi, & Tornincasa, 2004)

Additionally to Wang, Li and Chang's work, a group of professors from Italy also evaluated three-dimensionality within the higher education industry. The international visionaries tested the following formats: VRML (virtual reality modeling language), Spinfire (.3D) and

Viewpoint (XML) software on 3D modeling to find out that the Viewpoint format offered the best interactivity.

This study provided depth on the production side of the advanced computer aided graphics. It also provides context on interactive content on the Internet, and within the healthcare industry. Along with the change occurring in the healthcare industry, education is also acquiring the benefits from 3D technology. The research group from Italy expands on their reasoning to support three-dimensionality interface design for students learning a variety of courses outside of computer science.

> Cemenasco (2004) states the following theory:
>
> By now it is evident how much the communication runs through the Internet and how much the three-dimensionality is supplanting the traditional two-dimensional iconography. It is also the opinion of the different authors that Web courses have the potential of changing the face of higher education, due to the demands in medical education for greater globalization... (Cemenasco, Bianchi, & Tornincasa, 2004)

Furthermore, there is discussion on Jaron Lanier's view on how multidimensional design in new media can be less effective financially and socially in connection to ownership of the content that is produced. Lanier looks at William Wright in his book, *You Are Not A Gadget*. His work is featured to show the process users take when interacting as digital producers. The last case study reviews the ideology shift that William Wright decided to take with his Spore project.

Case Study: William Wright

Lanier opens the conversation on open source and close source information on the Web. He goes over virtual and interactive environments that he envisioned the Web to produce over time. In connection, Lanier shows how his reality is different then how he envisioned environments by using William Wright as an example. Lanier (2004) states, "Will Wright, creator of The Sims and Spore, is certainly creating new-media forms...Wright's work is something new, but his life is of the previous century. The new century is not yet set up to support its own culture" *(*p. 131*)*.

Lanier points out that Wright is working outside of a technological paradigm in his work. This connects my view to why multidimensional design is not yet effective on the Web, but the time for a self run society is not far away. It also connects with the open and close source debate that is behind the growth of the Markerbot personal 3D printer.

Lanier (2004) states the following theory:

> When Spore was introduced, the open culture movement was offended because of the inclusion of digital rights management software, which meant that it wasn't possible for users to make copies without restriction. As punishment for this sin, Spore was hammered by mobs of trolls on Amazon reviews and the like, ruining its public image. (Lanier, 131)

The Web played into the temporary defeat in producing effective 3D technology by a poorly run management team. In most industries, there appears to be a reoccurring trend of

opposition for new technology in each industry. Furthermore, disruptive technology can be seen as potential positive and negative opportunities socially, financially, and from the users point of view. One of the debates this paper goes into is how the content is produced and the intent of the producers for the finished product, such as software, hardware, graphics and shared interaction. Lanier (2004) states, "Some other examples are the iPhone, the Pixar movies, and all the beloved successes of digital culture that involved innovation in the result as opposed to the ideology of creation" (p. 132).

This excerpt indicates the mentality behind the intent of different media producers. Lanier provides a layered message containing breakthroughs in new technology that were also faced with a preexisting paradigm or medium of content production. This message connects back to the Kuhn example on the reoccurring trend of scientific revolutions.

Lanier and Kuhn's work reflects and mirrors the open source nature of creating medical records in comparison to creating records of code for a computer game, Web platform or any other coding system created with an eye to monetary gain. Currently, individuals often seem complacent when dealing with copies of their medical records in comparison to copies of data they created in an online environment.

That separation of medical records versus Web records helps show reasoning behind the effectiveness of 3D technology more in medical than in digital environments online. This idea has an interesting parallel into the Makerbot evolution that took place in 2012. Their transition from an open source company to a closed source company heavily had an impact on the 3D printing universe in a negative manner. Again, the users of the Web sided with open source model to help make the content more accessible.

This section has shown how multidimensional interface design can still be an expensive cost to any company. In modern 3D technology there is multiple businesses competing for the attention and support from an audience. On an internationally level, countries that have gone through industrial and technological revolutions will be the first communities to evolve to computer aided technology. On the Web, in the classroom and when consuming any content the data from this section supports the positive and negative aspects to using advanced computer graphics to relate information.

The concluding section of research in this report takes a look into the future of how 3D technology will affect digital and manufacturing industries. In this section, there is vital research covering the importance of 3D technology within the medical industry. In addition to being effective visually, 3D printing in healthcare is also becoming socially valuable. For financial success, the 3D software and hardware will come with large up front costs, but as noted with Moore's law, the cost of technology will decrease over time. The following section of research contains a look at what is to come with 3D technology moving forward.

CHAPTER 6: THE FUTURE OF 3D

After looking back at what has happened, and conducting research on current technologies, it is now time to perceive the future of three-dimensional screen-based systems, as well as object-based systems. The report's concluding section provides new opportunities for older industries in computer science and multidimensional design. In this area of research data, there is analyzation on advancements in cell reproduction, mammography, and printing 3D structured parts to the human body. The first area of data reviewed is tomosynthesis, (also known as 3D mammography) is a revolutionary screening and diagnostic tool designed for early detection of breast cancer that can be done in conjunction with a traditional 2D digital mammogram.

Alexandra Morris, writer for MIT Technology Review digs into biomedicine with the positive effects that advanced computer imaging is opening up for the medical industry. The ability to pinpoint caner cells with additional precision has become an invaluable connection to social change behind new 3D technology.

Morris (2014) states the following theory:

> Some doctors say 2-D mammography isn't going to be retired, since it's better at detecting the tiny calcium deposits that are evidence of ductal carcinoma in situ (DCIS), one of the earliest forms of breast cancer. Instead, the two technologies may be combined. Hologic's newest scanner, approved by the FDA in 2013, creates both 3-D and 2-D images from the same set of x-rays. (Morris, 2014)

Morris references the June 25 issue of the Journal of the American Medical Association. In this study, researchers found that 3-D mammography, in combination with traditional x-ray screening, was linked to a 41 percent increase in the detection of invasive cancers as well as a 15 percent drop in the recall rate. This helps show the social and user benefits to the addition of 3D technology in comparison to the current financial burden to accessing the cutting edge technology.

Research conducted by Morris at MIT referenced a report by JAMA. That original report goes into additional detail to the precision in detecting cancer cells with more multidimensional graphics in tomosynthesis in comparison to traditional mammography. Their research pinpoints the 2.8 increase to the cancer detection rate being recorded with patients.

Morris (2014) states the following theory:

> In an analysis of 7292 screening examinations, Ciatto et al18 demonstrated a significant increase in cancer detection rate from 5.3 to 8.1 cancers per 1000 women screened, with 20 of 59 cancers seen only after addition of tomosynthesis to conventional digital mammography. A 17% reduction in recall rate was also reported. (JAMA, 2014)

These two sets of references indicate the precision within tomosynthesis, in comparison to traditional 2D mammography. A group of doctors in various fields collectively produced an article to show the social benefits currently taking place in the medical industry, as well as projections for the future. Their study aids to our argument of when industries can plan to start

the 3D conversion. In this case, the healthcare industry is currently in a transitional period to keep up with revolutionary breakthroughs in modern 3D technology.

Dr. Larry Donoso is the main correspondent on the next project we review. He currently works in Department of Ophthalmology at Wills Eye Hospital in Philadelphia, Pennsylvania. Another one of the doctors is from the Salt Lake City area. This is an excellent time to display the penetration rate within smaller markets, in comparison to larger cities with more resources. Most of the technological breakthroughs take place on the East and West coast, and by the time the reach the middle of the country, most of them are already outdated.

An element that is going to level the playing field includes printing materials and consuming products that would have had to been shipped, cost additional funds, and mostly likely would have not been cost effective. The personal printer is now starting to redefine the bell curves for adoption rates.

Donoso's research connects with the shared dialogue from other scholars on the effectiveness in smaller production runs that go into making products. If a company cannot make gains on their products in mass quantities, normally, they would remove that product from the line. Now, with 3D printing, past items that have been unable to be shipped to larger audiences, can now be available for individuals and companies to easily print smaller batches of products.

Donoso states the following theory in 2009, "NASA just produced a fuel injector for one of their rockets at a third of the cost and two-thirds of the time compared with traditional methods and plans to have a 3D printer on board in their next space flight" (p. 159).

NASA is not technically within the medical industry, but it is within the science industry. The main point is the cost effectiveness when companies use 3D products in precise situations.

That point directly connects to the need from medical industry to have individual items being tailored to patients.

Next, the study critiques some of the findings that Larry Donoso and his team found the social and financial advantages for the healthcare and pharmaceutical transition to 3D printing for their delivery method, and during the administration process. The researchers found that cutting down the cost in delivery will not only save resources, but open up additional resources to add to the production cycle, in which, will also be socially beneficial.

Donoso (2013) states the following theory:

> This means of drug distribution would radically change the present delivery methods and would most certainly be less costly. In a similar manner, it will be possible to print out a patient's living tissue as a strip which can then serve as a test site for administering a variety of medications to find the most efficacious one to treat for the particular illness. (p. 160)

To follow up on that point, Donoso's teams show the connection between the benefits that 3D printing has on the medical industry. Donoso and his team goes into detail on how 3D printing is starting to slowly aid non-functioning organs. They indicate that new 3D printed organs are reshaping defective organs. It goes beyond traditional medicine. The biggest finding out of their research shows the shortage in shortage of organ transplants. Donoso notes that 120,000 people in the U.S. alone are waiting for an organ transplant. They help guide the path for 3D printing, and where the healthcare industry is headed in the upcoming years. Donoso states,

"Part of the paradigm in this treatment is that organ transplantation involves finding a tissue match. This issue could potentially disappear if organs could be printed and grown using cells from the patient's own body" (p. 160).

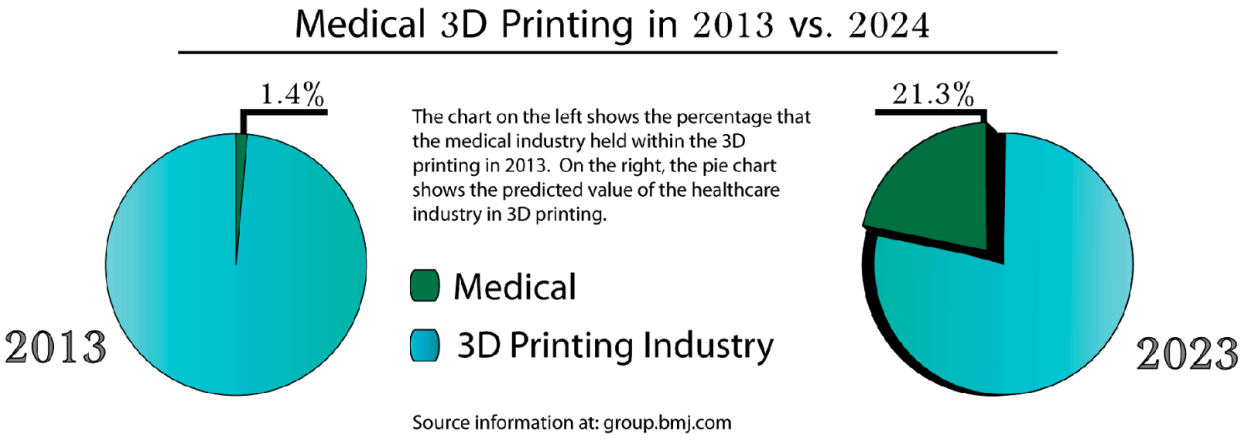

Figure 4

These two pie charts displays data from the Donoso research conducted in 2013. The increase in value visually shows the financial effect that is predicted to take place in the next decade.

Lastly, we report the financial impact that Donoso and his group predict with the potential growth in the 3D printing industry in connection to healthcare. They note that they current influence that 3D printing has on the area of business is still reasonable small, but holds a value of $770 million dollars in 2013. In (figure 1.4), there is visual data to compare the current and projected budgets for 3D printing in the medical field. As we move forward, the group of doctors added that in the next 10 years the 3D printing industry would grow to $8.9 billion with $1.9 billion projected for medicine. That is a growth of 17172.73% in ten years. This prediction is also close to other scholars that have made financial predictions to the medical printing industry in the upcoming years.

3D Printing:

3D printing is a convergent medium, similar to the Web. Both industries are reasonably young, and have both been made widely available shortly after the expansion of the personal computer. Each of them as an industry has have made major changes in their short existence. These two industries merge content and spatial information into one medium. Their functionality is one reason to describe them as multidimensional.

Recently, Forbes has reported that the cost for 3D printing is expected to decrease over the next three years. Moore's law supports this theory. It can also help lead to larger penetration rates across developed countries. At first, one may not immediately connect 3D printing to social change. In our first example on printing, there is three dimensions shared the social benefits by Ratto and Ree.

Ratto and Ree (2012) states the following theory:

> In our environmental scan, we found that current uses of 3D printing seem to empower people in several distinct ways, including: fashioning custom tools to accomplish specific tasks; extending or connecting disparate forms, systems or structures; visualizing problems that difficult to picture virtually; expressing their aesthetic taste; individualism, community affiliation or 'brand'; and, of course, having fun making their own toy. (Ratto and Ree, 2012).

On a financial level the 3D printing industry is quickly becoming more available to the mainstream market with prices ranging from $350-$250,000 according to Rayna and Striukova

in 2013. “While 3D printing technologies were, originally, intended exclusively for industrial use, the constant decrease in cost has put them within reach of SMEs and individual entrepreneurs. With desktop 3D printers now available for less than $1000 (the cheapest printer, the Buccaneer, costs $350), 3D printing is progressively becoming a technology any business, small or large, can afford and a number of companies have already started to integrate 3D printing in their business model” (Rayna and Striukova, 2013).

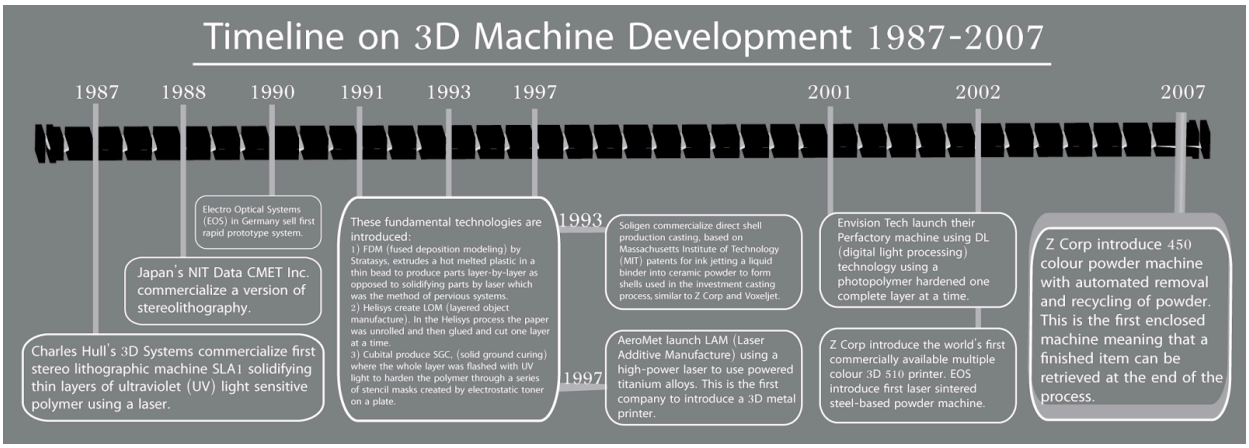

Figure 5

The timeline for figure 1.5 covers 20 years of development in 3D printing. Original source information: *3D Printing for Artists, Designers and Makers* by Stephen Hoskins.

In this past section, data has reviewed the changes taking place in 3D printing. As individuals look forward into the developing world of 3D interface design, this paper helps show the progress within tablets, in connection to interaction design within gaming and motion picture industries. The 3D tablet industry, along with other handheld devices, is the final section of research covered in this study. Data on the tablet industry helps identify future forms of interaction with 3D content.

3D Content on Tablets:

There is an emerging field of new 3D technology in the works at Apple and Google within their tablet department. This industry is one of our main screen-based topics that we critique, in comparison to physical based interactions with 3D technology. Google is leading the pack on developing new technology in the tablet industry. Interactive media is becoming an industry standard, and companies are trailering their products to advanced computer users. In an article written for Computerworld.com by Sharon Gaudin on Google's approach to advancements on their next generation tablets. Gaudin stated, "Johnny Chung Lee, Google's Project Tango lead, said Google is teaming with LG Electronics to build a 3D tablet that is scheduled to go on sale sometime in 2015" (Gaudin, 2014).

Google's ATAP-Project Team is pushing the boundaries of screen-based systems similar to the ambition produced by the Wachowski brothers on The Matrix films. The difference with Google is that is uses an open source method to creating immersive interactive environments in comparison to the studio method of professional filmmaking. The open source method for generating content can be seen as a positive way to keep costs down on building 3D content. Furthermore, intellectual copyrights can also be seen as a large factor when dealing with open source content.

Project Tango at Google has been described as a way to interact in full 3D motion with software built in C/C++ on their Android platform by Johnny Lee. The team has found ways to calculate millions of 3D measurements every second with the code they created in the software and hardware. This advancement of having computers create the content from code, is a developing breakthrough that quantum computing is also on the cusp of breaking into as well.

The United States Patent and Trademark Office, along with Mikey Campbell with AppleInsider, has also reported that Apple has acquired patents from their upcoming tablets to have additional three dimensional interface design elements. To better understand how this process will work, I have referenced Campbell's notes on what the patent office has confirmed.

Campbell (2014) states the following theory:

> First, the image being projected is digital and not a reflection of a physical object. Apple describes a system in which infrared lasers, or other light emitting devices, project an image into a medium such as a non-linear crystal. The medium itself may serve as an optical frequency up-converter for light passing through. When configured correctly, the medium can mix and up-convert infrared laser light to the visible spectrum, thus creating a primary 3D image. (Campbell, 2014)

Tablet and cell phones users can expect this new technology to arrive in stores in the next two to three years. The company has just acquired the patent, and the production process should take at least a year. In connection to film and television; media producers will need to start planning now to have content ready for the new platforms. ESPN tested the waters before the viewing devices were produced. As more cable companies cut the cord, the time for Internet television being viewed on different devices is becoming a reality. The computer and tablet industries are already working to provide as much interactivity to their content as possible.

In a time period filled with technological advancements, there is continuous influx to finding new solutions to century old questions. When a company expands their computer

software, it does cost resources, but as in healthcare and education in comparison to media, those costs usually are outweighed by unprecedented functionality that advanced computer systems provides different industries.

The future of 3D technology is filled with opportunities and obstacles for companies to either find effective or ineffective for their companies. 3D printing is a cross-platform industry that continues to grow. Research in this study points to a large increase in demand for 3D printed materials in the healthcare industry. Tablets are another emerging industry that is set to build more interactive content with additional layers of depth in the future. Both of these industries require 3D technology to develop effective content. Public demand for new technologies plays an equal role in this study. When new technology is available in developed markets, a bell curve of an adoption rate is usually generated. Desktop 3D printing continues to redefine standard bell curves of adoption rates for new technology. The future of how individuals acquire computer-generated content is in a state of transition. This paper has shown that different industries react in a unique manner when adding 3D technology to products and content.

CONCLUSION

In summary of how 3D technology effects different industries, advanced computer graphics and 3D printing continues to produce new ways of interacting with physical and digital content. It has been noted that not all industries have reacted in the same manner to the advanced computer systems that have evolved since the mid 1980s. The different industries reviewed in this paper reflect the different developed countries that have been going through their own technologic revolutions. 3D content development on television has hit a major roadblock, along with open source content that was later transitioned into closed source content. In comparison to television, three-dimensional films have shown to be financially effective over the past decade. 3D technology within the Web and medical industries has a financial hurdle to overcome, but also have immense social and user benefits to provide for future generations.

Finally, the research points out how each industry has taken shape during this digital transition. The film and television industry is separated and split into two categories. Research from the MPAA indicates that the film industry has shown the trend of producing more 3D films each year on average since 2004. Additional research has shown that the film industry, on average, has made more revenue each year in comparison to the previous year for the past ten years of film production. Additionally, research from the MIT Media Lab provided subtext to understanding how glasses-free viewing is possible in 2010. Their data helps identify the current key issue in viewing 3D screen-based content.

This paper has defined effectiveness as the intended result from a finished product. Research was conducted to illustrate the visual, physical and metaphysical differences and changes that occur on computer-based projects.

One of the overall goals to this study was to pinpoint time frames on when media producers should begin their transition to three-dimensional content. After conducting research and discussing the topic, it can be noted that unlike Kuhn's drastic revolution between mediums, the transition to 3D content is a slow and gradual change. A new theory has been built around how the transition in the film and television industry will take shape. Before autostereoscopy becomes mainstream, additional degrees of higher definition content appears to be in the immediate future for screen-based technology. Along with the technology being updated, the functionality of the eyewear will also continue to evolve.

On a social level, the effects that 3D technology has had on each industry are different. There tends to be less social benefit from the film and television industry, but the education and healthcare industries each provide new ways to increase modes of production when teaching disabled students with virtual reality, the physical benefits to producing and printing 3D organs, and opening up new possibilities to connect with individuals in undeveloped markets. This paper primarily provides data on how developed markets currently use 3D technology.

After reviewing collective data, the arc of demand behind 3D technology appears to not be always be driven by the technology that is available. This connects with the theory that individuals steer technologic revolutions, and not the equipment that is available. A deduction to those two theories, is shown by balancing the demand from an audience, with new forms of technology, that provides necessary functionality to the user.

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