3D model management for e-commerce

Joel Toivainen

HAAGA-HELIA
University of Applied Sciences

Author(s)	
Joel Toivainen	
Degree programme	
Information and Communication Technology	
Report/thesis title	**Number of pages**
3D model management for e-commerce	**and appendix pages**
	33 + 3

The overall purpose of this thesis was to investigate the usage and management of 3D models in e-commerce. The objective was to research how 3D models were used in e-commerce and evaluate their impact and benefits they bring to consumers as well as merchants.

The theoretical framework is an overview of 3D models and e-commerce in general. The aim of this section is to give the reader enough information to understand the research. E-commerce refers to the buying and selling of products over the internet. Unlike in traditional commerce, where customers can inspect their product, in e-commerce consumers must rely on images to make their purchase decision.

The use of 3D models in e-commerce allows consumers to inspect products from all angles and distances. This helps provide more information on a product to the consumer. The aim of this study is to analyze the use of 3D models in e-commerce more thoroughly to define its benefits as well as its challenges.

The chosen research method is quantitative and consists of interviews with experts in the field. This research method was chosen to get the most recent and reliable information in a field that is constantly evolving and shifting, resulting in the relevance of researches to decay fast. With the data collected from these interviews, I will conclude the benefits and challenges of 3D models in e-commerce.

Keywords

3D model, e-commerce, 3D visualization, computer-graphics

Table of contents

1   Introduction

E-commerce has been growing rapidly, and it is shaping the way we transact. Unlike in traditional commerce, in e-commerce customers do not get the opportunity to inspect the physical product before purchasing it. Instead, they rely on product information in the form of text, photos, and videos to make their purchase decision. This lack of information leads companies to try new innovative ways of displaying their products for a better sensory experience for the customers. One of these ways is the use of 3D technology.

The usage of 3D technology has been evolving rapidly, and this has enabled it to be used broadly in e-commerce platforms. The use of 3D models in product visualization allows customers to view the product from any angle and gives a more complete and accurate view of the product. There are a few ways to display a product in 3D, but this research will focus on virtual 3D modeled products. Also, the evolution and development of Augmented Reality (AR) technology allow for 3D models to be displayed anywhere. I believe 3D visualization to be fundamental in the future of e-commerce.

1.1   Research goal and structure

The goal of this research is to go in dept to the usage and management of 3D content. To find out how and why 3D models are used in e-commerce platforms. How does the management of 3D models work? How does 3D visualization effect e-commerce? Does it give value to the product, or does it remove value? I find the topic of research to be highly relevant and exciting.

This paper's structure goes as followed. Sections two and three will provide relevant background information of 3D modelling and e-commerce for the research. I chose to use interviews as my source of data and in section 4 I will explain how the research was carried out and what data it produced. In section 5 will be discussing the findings of the research and the data will be compared with the background literature. Then I will provide the conclusion of the paper, in section 6.

1.2   Client

The client of this paper is a Finnish start-up Sayduck, a platform that helps companies to engage and inspire their customers through 3D and Augmented Reality (AR). It was founded in 2012 and has ever since worked for the development of 3D and AR.

Their main product is their real-time 3D viewer which can be embedded on external websites. With this interactive 3D viewer, companies can display their products in 3D in their websites. Furthermore, it also offers 3D modeling for companies as well as an app that allows products in Sayduck Platform to be displayed in AR.
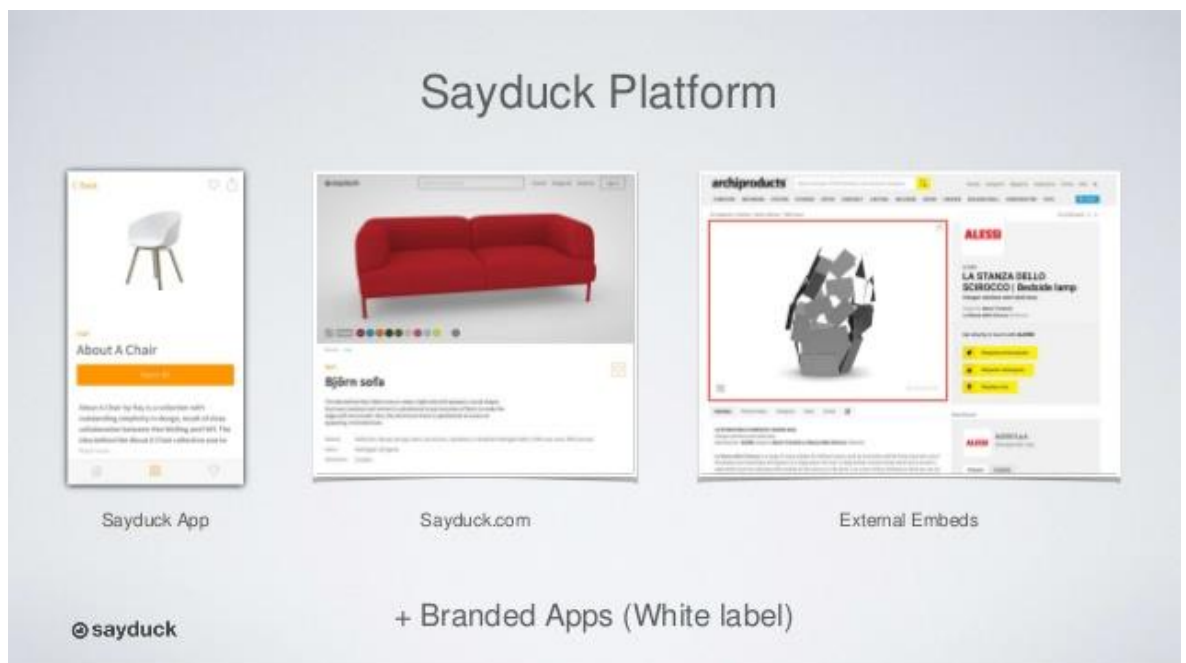

Figure 1 Sayduck Platform (N. Slotte 2016)

1.3 Key Concepts

3-dimentional (3D) model is a mathematical representation of an object with the use of 3D computer graphics.

3D viewer refers to the technology that allows 3D models to be displayed on the web.

Augmented reality (AR) is a technology that allows computer-generated objects to be generated to the real world for users to view them.

Computer-graphics refers to computer-generated image data created with graphical hardware.

E-commerce is the activity of buying and selling products over the internet.

Online shopping is an activity belong to electronic commerce where consumers can buy directly goods or services from an online seller through Internet browsers.

Personal Computer (PC) is a computer that is cost-effective, intended to be used by a single person and does not require special expertise to be used.

Rendering is the process of converting 3D wire frame models into 2D images displayed on a computer.

Texture map is a two-dimensional image file that can be mapped on to the surface of a 3D model to display colors, textures or other forms of details.

USDZ is an AR file format, for devices with an operating system used for mobile devices developed by Apple Inc., that can be used to display 3D models in AR with their AR Quick Look feature.

Virtual Reality (VR) is a computer technology used to create simulated virtual environments.

2   3D Model

2.1   Computer graphics history

The roots of computer graphics can be found in the 1960s. In this decade computers started to evolve from strictly calculating devices into tools with user interaction devices and software that allowed for creation and changes in real time. (A. Beane, 2012, 11)

The creation of the term computer graphics (CG) was credited to William Fetter in 1960. In his work at Boeing, he used a computer to create 3D models of objects and of a human body, that were used in the planning of the Boeing airplane cabins. The first 3D model of a human became known as Boeing Man (A. Beane, 2012, 11)
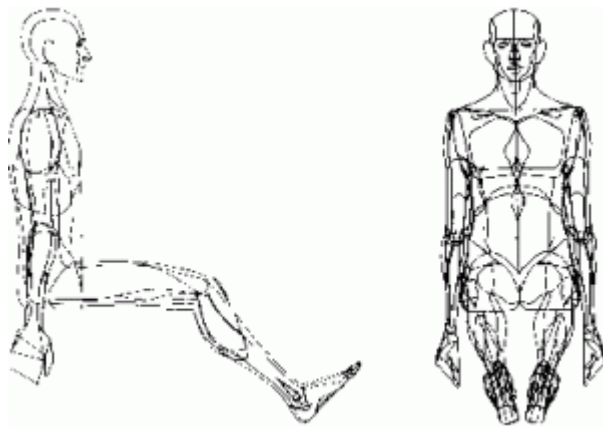

Figure 2 Boeing Man

In 1962, the first video game, Spacewar, was produced. This was done by Steve Russell and a team from Massachusetts Institute of Technology (MIT). Note that these first achievements were done with computers lacking any graphical user interface. With only a black screen and a blinking cursor, users needed to fully understand the system and memory to access any information. (A. Beane, 2012, 11)

The first graphical interface for computers was created in the form of a drawing program. It was created by Ivan Sutherland in the 1963. This program employed a light pen and was used to draw simple shapes. The light pen used for this system was also one of the first human input devices after keyboard, switches, and dials. The computer mouse, we all are so familiar with, was also created in 1963 by Douglas Engelbart. (A. Beane, 2012,11-12)

2.2 3D Computer graphics

In 1970s, the idea of 3D virtual surfaces began to emerge, and with the development of microprocessors in 1971, a transition towards personal computing began. Many key features of 3D computer graphics, such as shading and rendering, were invented during this decade. Advancements in this decade made 3D graphics achieve realism not seen before. (A. Beane, 2012, 12)

Up to this point, the flat shading of polygons could only provide you with 3D objects that looked faceted and blocky, but an algorithm that enabled hidden surfaces to be rendered on to the surface of the 3D object was produced by researchers in the University of Utah. With this algorithm Henri Gouraud create Gouraud shading in 1971, which rendered these surfaces smooth (see Figure 3). (A. Beane, 2012, 12)
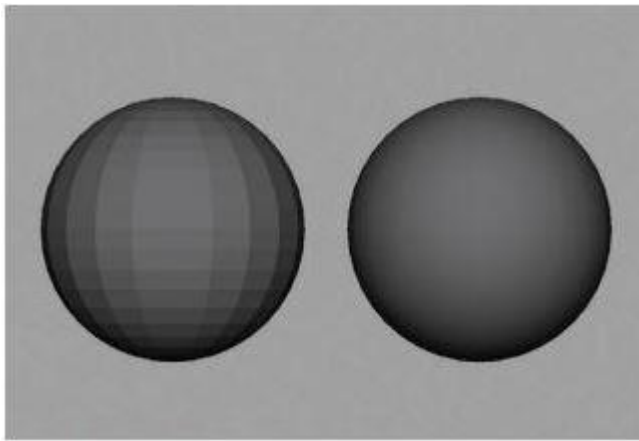
Figure 3 Same model with flat shading on the left and Gourand shading on the right. (A. Beane, 2012)

The developed of texture mapping, in 1974, brought 3D graphics realism to a whole new level. It was developed by Ed Catmull, who later went to create advancements in anti-aliasing and z-buffering. With this new technology, the surface of a 3D object could be manipulated in a whole new way. This allowed James "Jim" Blinn, in 1978, to invent new texturing techniques, such as bump-mapping and environment mapping. Bump-mapping allowed bumps, bulges and dents to be rendered to the surface of the 3D models and environment mapping allowed objects to be rendered as they were in different environments. These new rendering algorithms were tested with Martin Newell's Utah teapot (see picture). (A. Beane, 2012, 12-13)

Figure 4 Utah teapot in 3ds Max

In 1975, Bill Gates created Microsoft. In 1981, IBM released its IBM PC with an operating system created by Microsoft. Also, in 1976, Steve Jobs and Steve Wozniak founded Apple Inc. to develop and sell personal computers. Before this, computers were only available for universities and the government. Computers required a lot of knowledge and were not ready for common households, but these new personal computers were low cost had user interface so that they could be used by common people. (A. Beane 2012, 14-15)

In 1982, the companies Silicon Graphics (SGI) and Autodesk were created. Silicon Graphics focused towards making computers more efficient in 3D graphics, mainly for 3D animation. Autodesk on the other had released AutoCAD for these personal computers and played a huge role in the move from specialized computers to the personal computers for computer graphics. Autodesk is also still the leading company in 3D modeling software. (A. Beane 2012, 15)

The real revolution of 3D computer graphics started in the 1990s, and 3D graphics began to have a significant impact on domains such as movies and computer games (Pletinckx, 2014). New dynamical systems started to support forces in animations such as collisions, gravity, friction and more. Motion capture became a widely used method for generating animation sequences. The new graphics effects allowed the production of movies such as Terminator 2, Jurassic Park and Toy Story. (A. Beane 2012, 17-18)

2.3   3D modeling software

Autodesk is a company that specializes on making software services for 3D design. They are most well-known by their first product, AutoCAD, but have since then developed over

80 products aimed toward different industries. AutoCAD is a 2D and 3D drawing software, that is mainly used to conceptualize ideas, produce designs and even perform simulations. At first it was targeted towards mechanical engineers, but has since evolved into other fields, such as, architecture and animation. Another notable software Autodesk have made are Revit, Inventor, Maya and 3ds Max. All these software function as 3D modeling software but are designed to function better in their targeted fields. (Bethany, 2017)

Revit is a building information modeling (BIM) software mainly used by architects, structural engineers and designers. This is because this program allows users to build structures and components in 3D, but also users can add notes in form of a 2D draft and access the building information from the model's data. Inventor, however, is targeted toward mechanical designs, because it has specifically designed product simulation tools as well as top-grade 3D mechanical design and documentation. These two programs focus towards building simulation model. (Bethany, 2017)

Maya and 3ds Max, however, are targeted more towards building visual models. Maya is a 3D modeling software perfect for 3D animations and has played a key role in many Hollywood movies, most notably Avatar. 3ds Max also former known as 3D Studio, is the most flexible software, when it comes to 3D modeling. It is used for 3D animations, models, games and in fields like architecture. (Bethany, 2017)

The first and well-known free open source 3D modeling software was Blender. It was developed by Ton Roosendaal with the help of the animation studio NeoGeo. Not long after the first public release of Blender in 1998, NeoGeo was dissolved. However, Roosendall would not so easily give up on his program and founded Not a Number (NaN) company to further develop Blender. In 2002, NaN went bankrupt, but with the help of a non-profit Blender Foundation and crowdfunding, Roosendall was able to release the Blender source code. Today blender is a free 3D modeling software with a huge community around it and the capabilities to rival other 3D modeling programs. (Blender 2015)

2.4   What is a 3D model?

Three-dimensional (3D) model is a mathematical representation of an object in a 3D software environment. To represent an object, one requires three components: a 3D scene description, a light source and a description of the camera that views the scene. The scene is the collection of all the individual parts or models that make up the 3D environ-

ment or object. In this scene, each model contains two descriptions: a mathematical representation of the shape and structure, and a way of figuring out how that shape would look if illuminated. (N. Badler, A. Glassner, 2009)

2.5   Model Structure

The model structural description follows the principles of geometry. By calculating the location of each part of the object in a 3D space, we can determine where the object is, and where it is not. Think of it as freezing an object in the air, and the structural description is that object's every molecule. (N. Badler, A. Glassner, 2009)

There are primarily two different ways of representing 3D models that are used by companies. These models mostly differ in the form of their creation and manipulation. These models are NURBS Surface and polygon models. (J. Slick 2018b)

A Non-uniform rational basis spline or NURBS uses Bezier curves (3D version of a pen tool in 3D Paint) to create a smooth surface model. Control points define these curves. An individual point does not represent the location of that surface, and it is instead averaged by with the surrounding points to create a curved surface. When working with control points, the surface of the model cannot be edited directly. The models from many individual NURBS objects and are laid out to look like a single object. (J. Slick 2018b)
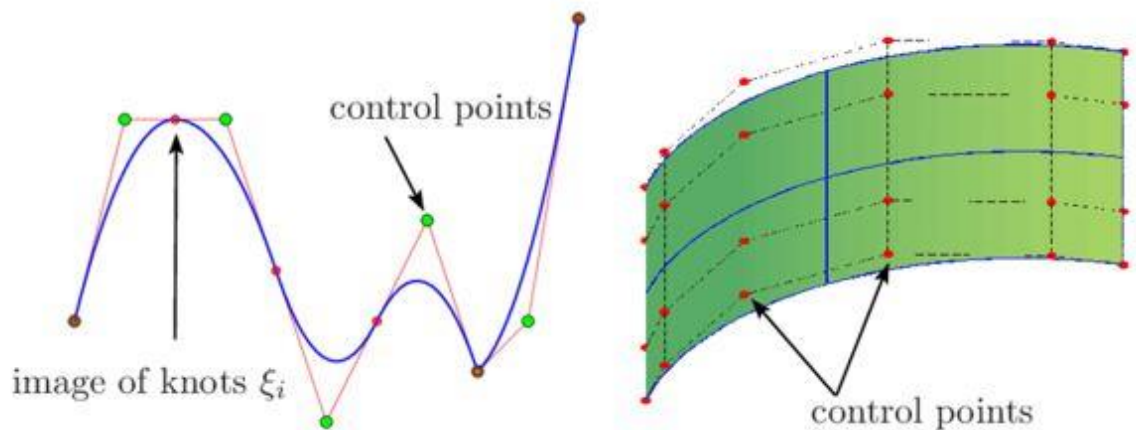
Figure 5 NURBS model (V. Nguyen, etc. 2013).

The other form is a polygonal model. These models are often referred to as meshes and are comprised of faces, edges, and vertices. Vertices are points in the 3D environment. Drawing a line between two vertex points makes up an edge. Connecting three or more edges produces a polygon, also known as a face. The surface of a mesh is made of faces, that are usually three or four-sided, but there is no limit to the sides a polygon can

have. Polygons with *n* sides are known as *n*-gons. By interacting with vertices on the x, y, and z-axes, the model is shaped to its final form. Polygonal model is the most common form of a 3D model. (J. Slick 2018b)

Figure 6 Polygon model (R. Khan, 2016).

2.6 Model Appearance
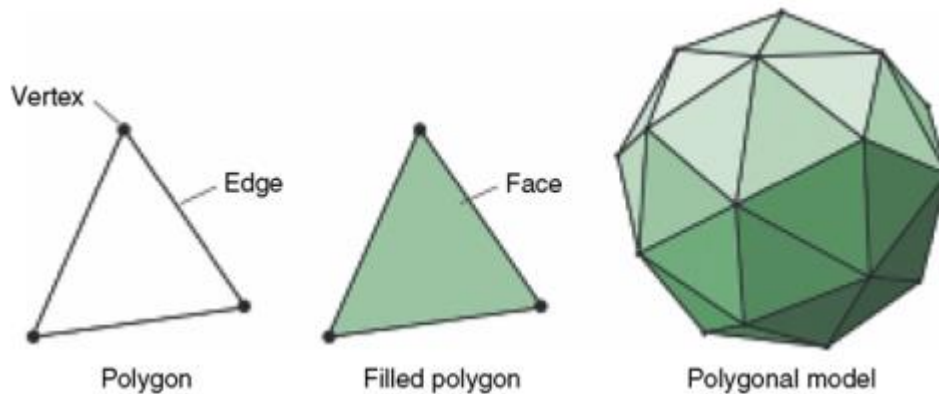
A central part of making realistic looking 3D models is the surface description. It defines the physics of how the surface interacts with light. For us, it means determining the models surface appearance, such as color, shininess, and transparency, but it also includes other details added to the surface, such as adding little bumps or scratches. (N. Badler, A. Glassner, 2009) Mainly these descriptions are applied through materials, that consist of texture maps and shaders.

Texture maps are flat 2D images mapped to the surface of a 3D object. They are mainly used for defining what is drawn on the surface of the 3D object, like the color, but can be used to describe other factors like adding bumps to the surface or making it metallic. The different maps are diffuse, albedo, ambient occlusion (AO), normal or bump, metallic, reflection and roughness. (M. Rouse, M. Haughn 2016)
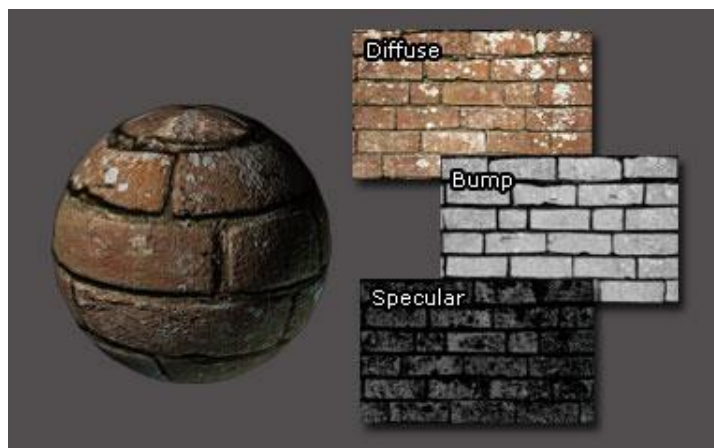

Figure 7 Texture maps applied to a 3D object.

Shaders, on the other hand, define how the textures are drawn on the surface of the 3D models. This is done by defining how the surface interacts with light, its reflectivity or roughness. Shaders can be applied to the 3D models with mathematical values (0 to 1) or with the using a specific grayscale (black to white) texture maps. (M. Geig 2013)
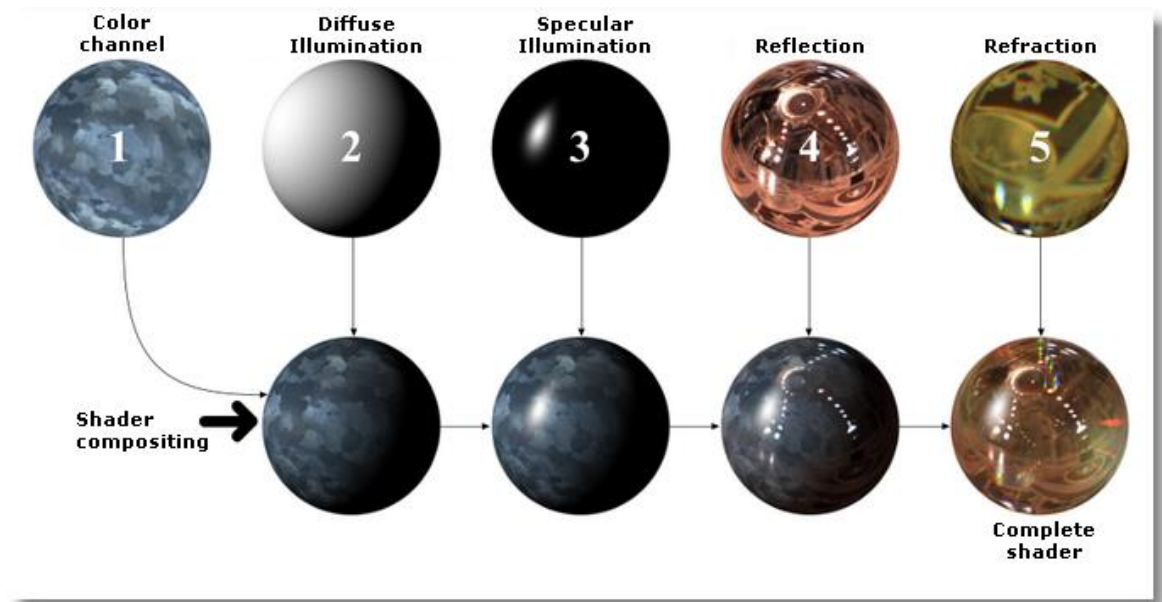

Figure 8 Shaders and their effect on a texture.

2.7 Rendering

Rendering is the process of turning the 3D scene into the finalized 2D image that we see. During this process, the rendering engine calculates the entire scene's information to determine the color values, object location, and lighting of the finalized image. It is used in, for example, architecture planning, video games, and animated movies. There are two kinds of rendering processes: pre-rendering and real-time rendering. (Techopedia 10.12.2018)

Pre-rendering produces high quality and definition images, but the process takes longer. This sort of rendering gives for the best result in quality, but the rending process must be done beforehand. Its primary use cases are photogrammetry, animations, and visual graphics. (Techopedia 10.12.2018)

Real-time rendering takes away from the quality of the images but significantly increases the phase the images are produced to simulate a movie like an effect. This form of rendering is used when the models need to be presented in real-time speed, but this allows factors, such as interacting with the results. Real-time rendering's primary use case is in

video games but has also allowed for real-time interactable 3D models in product presen-tation. (Techopedia 10.12.2018)

2.8 How are models used?

There are many ways to use 3D models. They can be used for visual product designs and at the same time to show these designs in a different environment or different lighting. They can also be used to determine the structural costs, volume or area needed for the machinery or to observe the relationships of other machinery to learn how they function or fit together. However, primarily 3D models can be put into two categories: simulation and visual models. These models are structurally similar but work towards different goals. (N. Badler, A. Glassner, 2009)

Visual models aim toward visual quality. These models need to look realistic and focus on the areas the eye can see. They need to be a sufficiently accurate representation of the object they are portrayed as but pass convincingly to the viewer as the real object. There-fore, in these models, there is a high emphasize towards optimizing the visual details re-quired with the lowest amount of data necessary to produce it; what makes this hard is the fact that its viewer depicts the model's quality. (N. Badler, A. Glassner, 2009)

Models used for simulation on the other hand aim towards structural accuracy and are not required to look good, but to be structurally the best representation of the object they need to simulate. These models are used for simulations, such as testing the durability and strength of the roof of a new stadium in different weather conditions or the structural func-tions of an airplane wing. In these simulations, it is vital that the model has the same structure as the portrait object if we want to learn anything useful before building them. (N. Badler, A. Glassner, 2009)

3 E-commerce

3.1 Market size of e-commerce

E-commerce or Electronic commerce refers to the act of buying and selling of product and services through the internet. In large, it also includes the entire online process of devel-oping, delivering, marketing, selling, servicing and paying for products and services. (S. Ahuja, 2011).

The e-commerce market is growing rapidly. From 2014 to 2017 the retail e-commerce sales worldwide rose almost a trillion US dollars, making 2017 sales 2.3 trillion US dollars

(see chart 1) (Statista 2018). This worldwide growth is projected to 4.88 trillion US dollars in 2021. In 2017 e-commerce made up approximately 10 percent of U.S. total retail sales (Statista 2017), in China 23 percent (Statista 2017b) and in Japan 8 percent (Statista 2017c).

Amazon is currently the biggest and most significant e-commerce platform in the world. In 2018, it reached 1$ trillion in the market cap and net sales of 232 billion. Its share of the global e-commerce market has increased from 20 percent in 2013 to 28 percent in 2018. (N. Levy, 2018) The empire of Amazon's founder Jeff Bezos is not only in e-commerce these days, but include industries in retail, newspapers, and others. (S French, 2018) Amazon has even stepped over Google in the U.S. as a search engine for products. According to R. James research, in 2017 52% of the people picked Amazon as their first choice for product search. (B. Beck, 2017)

3.2   E-commerce strengths

3.2.1   For customers

Unlike traditional commerce, e-commerce does not limit its marketplace to a physical location to transact. E-commerce has the ability to function just about everywhere. It enables consumers to shop from their desktop at home or work, and with mobile e-commerce, the only limit is the internet connection. This ability to transact from anywhere solves serious problems of traditional shopping in reducing the ability, the time and the transaction costs consumer use to travel to participate in a market. (K. Laudon, C. Traver 2014, 12-13) Consumers do not need to waste their time and energy going from store to store finding their products. Based on a survey, 35.7% of consumers believe that online shopping saves time and energy, while 53.9% believe that online-shopping is of convenience due to home-delivery services. (L. Milong 2011)

Most of the e-commerce platforms have built their websites so that all product information is easily accessible and have their own search engine, which help allows customers to find products. Making prices and product descriptions easily accessible for all results that product and price discovery is fast, accurate and straightforward, which in turn speeds up the whole transaction process. It also gives customers the ability to find and buy anything that is available in the whole world, regardless of where it is. (K. Laudon, C. Traver 2014, 14)

Online stores have lower operating costs and access to more commodity channels, which allows them to cut out a lot of additional costs and makes them function more efficiently.

However, online stores built on Internet technology which dictates commodity prices by the laws of supply and demand are less affected by regional differences and business marketing strategies. These two variables make the commodity prices online cheaper than sold by traditional way, resulting in that consumers can buy their goods cheaper. (L. Milong 2011)

3.2.2 For merchants

All e-commerce platforms use the same technological standards shared throughout the internet. These universal standards make e-commerce more accessible to merchants by lowering market entry costs. (K. Laudon, C. Traver 2014, 14) This also equals the playing field by cutting the amount of money required to start a market. Merchants do not need to invest in facilities or spend money for renovation, instead, they hire a web designer for a fraction of the cost. (L. Milong 2011)

With the internet merchants are immediately enabled to the target audience on a global scale. This global reach strips the regional, national and cross-cultural boundaries more efficiently than traditional commerce and allows for a market size roughly equal to the world's population (estimated internet users 4 078 881 100) (internetlivestats 2018). (K. Laudon, C. Traver 2014, 13-14) This allows merchants to sell their goods in a significantly larger scale and the time slot between ordering and distribution helps them manage their inventory much better. (L. Milong 2011)

E-commerce produces significant amounts of valuable information that merchants can use to target their message to specific market segments and individuals. Based on this information, they can adjust their messages directly to the individual consumer by adding names, interests and past purchases to their message. They can adapt their behavior based on a user's preferences and prior behavior. Allowing them to target individual consumers needs even better and market them the things they are interested in. (K. Laudon, C. Traver 2014, 14-15)

3.2.3 For the market economy

E-commerce as a network economy is a lot root flexible compared to other economic forms. It unites the world market under one room and releases countries from economic isolation because online trading depends on unity. As e-commerce continues to grow and develop, it brings forth tremendous market opportunities for related industries such as advertising and other service providers. (L. Milong 2011)

Using e-commerce dramatically increases the quality and amount of available information. This increase in accessible information also affects the costs of information collection, storage, processing, and communication. Resulting that information becomes more accurate and of higher quality, which in turn makes it more useful, but less expensive. It also makes the market more transparent in consumers eyes. (K. Laudon, C. Traver 2014, 14-15)

3.3   E-commerce weaknesses

3.3.1   For customers

Shipping times and costs also effect to the e-commerce shopping experience. Because of the delay between purchasing a product and receiving it, consumers do not get the immediate gratification that one would get from traditional commercial. (M. Kaplan, 2013) This delay also raises uneasiness when purchasing from new e-commerce, and one might question its safety, making it essential for new e-commerce to build up a trust for their platform. (L. Milong 2011)

Unlike a traditional commercial experience, in e-commerce, consumers do not get the opportunity to inspect the physical product or the quality of service before making their purchase decision. Consumers rely on limited visual modalities of text, videos, and 2D graphical images, that may limit the information of the product. (S. Hewawalpita, I. Perera 2017)

With online shopping, also comes the risks of information leakage. Consumers are required to provide personal information such as email address, mobile number and even more sensitive information, such as a credit card number. This opens the possibilities that this information will be mishandled or stolen. (L. Milong 2011)

3.3.2   For merchants

In online shopping, consumers are given the option to choose their vendor for the same commodities, which increases the competition in the online markets and makes it harder for merchants to accumulate consumers. This increase in competition forces merchants to take extra measures to get noticed and leads some to use untrue or exaggerated ways to market and sell their products. (L. Milong 2011)

3.3.3   For the market economy

E-commerce is slowly making traditional commerce obsolete. The benefits that e-commerce offers force offline retailers to conditions on which they are unable to compete. The

low prices of online shops attract all consumers which makes offline retailers lower their prices to levels that are not cost-effective. They are also unable to maintain a large variety of stock because it will result in huge losses for them. To attract customers, they must put more money to advertisement. (M. Dahiya 2017)
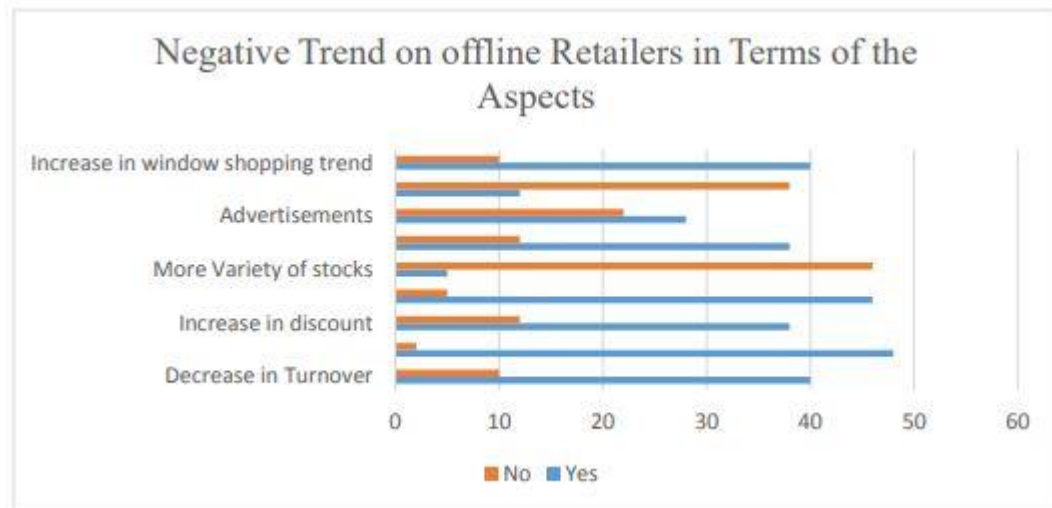

Figure 9 Impact of e-commerce on offline retailers. (M. Dahiya 2017)

3.4 3D visualization in e-commerce

In e-commerce one of the defining factors of success is the method and way product information is displayed. Of these methods, the form of sensory information is found to be one of the most defining factors in the success of the e-commerce platform (R. Ramanathan 2010). To find the most effective method of showcasing their products, online retails are continually searching for new innovative technologies to integrate into their platform. Of these methods, 3D visualization is a more effective method to enhance consumers' product understanding and limit possible sensory mistakes, than static 2D images. (Z. Jiang, I. Benbasat, 2007)

3D product visualization, also known as product rendering, is a technology for the viewing and manipulating of 3D models. It allows merchants to display their products through a 3D viewer on their websites. For this, one needs a 3D model of their product and a 3D viewer. Merchants can be acquired these components either by designing them their own or by outsourcing it to another company. 3D product visualization can also be done by combining a series of photos from every angle of the product into a 360° product view. Understanding that when creating 3D visualization, it is essential to consider all options and to build mutual understanding between each party involved, which in turn can save time and

expense by neglecting the possible misunderstandings regarding the product's design, functionality or purpose. (M. Jensen, 2018)
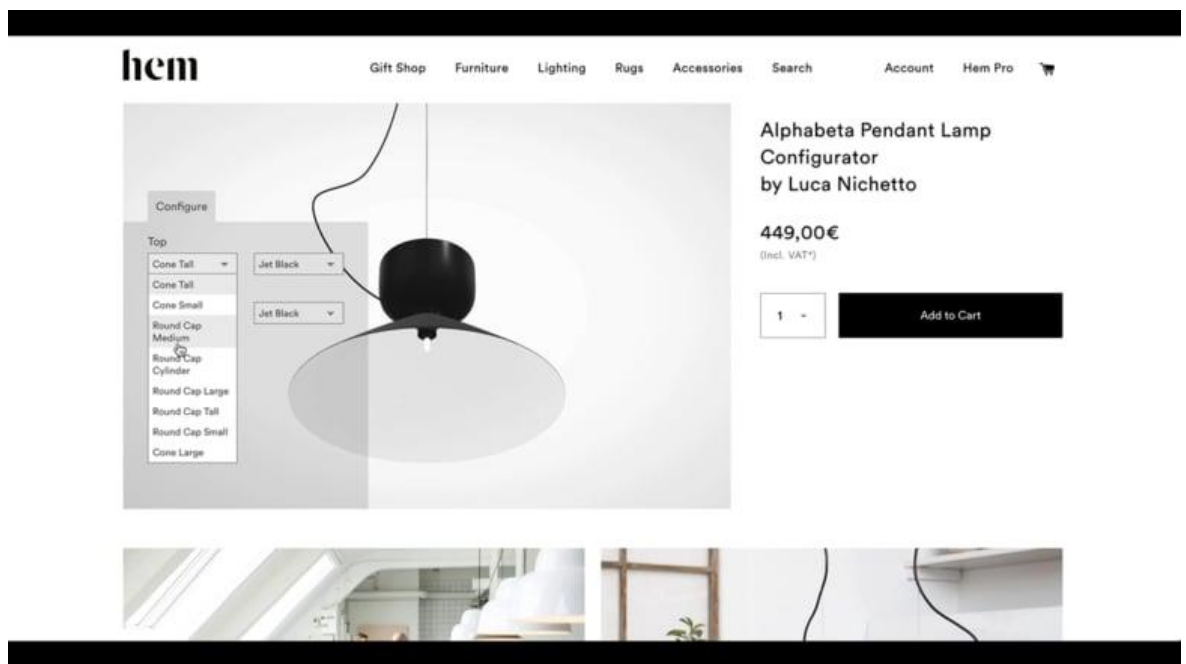

Figure 10 3D visualization with a 3D model.

The use of 3D visualization gives consumers the ability to explore and inspect the product freely. Giving consumers control over information has been found to positively affect purchase intentions and the understanding of a products attributes, features and characteristics (D. Ariely, 2000). This free navigation and inspection of the information of any part of the product have also been found to increase the chance that consumer will experience a heightened sense of presence (H. Li, T. Daugherty, and F. Biocca, 2002). While interacting with 3D products, consumers tap into past experiences, memories, and feelings, giving them a positive sensory experience (T. Daugherty 2001). Consumers interacting with 3D products become more involved and encourages them to seek additional information regarding products characteristics (Fiore, 2005).

In research (A. M. Fiore, etc. 2005) made explicitly the effect of interactive image technology (IIT) in which the product can be viewed from different angles and distances. It found that this technology positively affects the customers' ability to gather information and allows customers to get complete and accurate information about the product. This in turn not only effects the customers' willingness and attitude to patronize the online retail but also their willingness to purchase from the online retail. Later research (A. M. Fiore, etc.

2007) found a higher level of IIT such as virtual 3D models to positively affect the customer's enjoyment, shopping involvement and their desire to stay. Therefore, they suggest that 3D models be more suitable for online retailers.

Another research (F. Moritz, 2010) has found interactive 3D modeled products do not reach the level of quality to pass a realistic presentation of the product and they are only good for products that can be customized (colors, parts). It also found the 360° product view to be a favorable option by the consumers due to realism. (S. Hewawalpita, I. Perera 2017)

The effect of 3D product visualization has been shown to vary with demographic factors. In (R. Algharabat and C. Dennis 2009), researches indicate that females perceived the total effect of animated 3D products better than males. They support this on females' ability to understand and use nonverbal cues better than males and to the ability of the animated graphic to increase females' understanding and learning. They also found a link between education and the effectiveness of product presentation. It shows that consumers with a higher level of education are less affected by product presentation.

4 Research

4.1 Research topic

The topic of this research was the management and usage of 3D models in e-commerce. The goal of this research was to find out why 3D models are used in e-commerce and the effect their usage has. This research focused on e-commerce companies that use 3D models in their product presentation.

This research was done by interviewing three companies that use 3D models. Companies consisted of e-commerce platform, manufacturer and a web store. Each of these companies was interviewed and gave their own experiences and view on the usage of 3D models. After that, the collected information from the interview was compared to various researches and scientific articles to see the correlation between them. The goal of this is to conclude the effect 3D models have on e-commerce.

This form of research meets the qualifications of qualitative research because it was done by interviewing experts on the field. This research used the Delphi method with the goal to find the effect of 3D models in e-commerce based on the knowledge of experts. (M. M. Grime, G. Wright, 2016) Each of the participants was interviewed only once and were asked questions about the management and usage of 3D models and of the effect 3D models had on their platforms. The questions differed between the participants based on their knowledge and expertise in the subject, and each participant was encouraged to respond freely.

4.2 Interview

I contacted five e-commerce companies that use 3D models in their platforms. Three of the companies agreed to give an interview. Two of the interviews were done through a call and lasted for 15 minutes, and one was a 30 minutes face-to-face interview. The first interview was with the head of the virtual and augmented reality of e-commerce platform Shopify. The second was with a manufacturing company. The third interview was the face-to-face interview with the director of development of a web store Finnish Design Shop. The questions in each interview differed based on the knowledge and expertise of the interviewee and with the answers they gave.

4.3 Results

4.3.1 E-commerce platform

When comparing to various product showcase methods, such as 360 photos and 2D photos, he saw real-time 3D models to be most effective. Because unlike photos, 3D models can be viewed from any angle without restrictions, for example, one can zoom in and out to see all the details. Also, 3D models can also be used for different ways aside just showcasing a product on the web. They can be used for AR/VR experiences and product photogrammetry for a fraction of the cost.

The tricky part is still defining the effect it has on conversion, and he would argue that there still is not enough data to state with certainty that 3D converts more than for example 2D images. There have been studies made, but many of them seem dated or have scientific methods that he questions. Right now, they do not possess the data to state that 3D models would convert better than images but are researching it. However, what he can say, is that anecdotally merchants that use 3D are not that focused on the conversion and instead see them as more of a marketing tool or a way to involve themselves in the future of e-commerce. When e-commerce platforms explore new technologies, it makes their brands look better, and their customers are noticing it.

The main issues of the 3D technology right are that there is an upfront cost to it and that the 3D cannot be done without the skills in photogrammetry or the use of 3D software. The lack of knowledge of the cost and processes makes some merchants more hesitant to invest especially to a technology that is still missing data of its effectiveness.

There have been many studies that show that every megabyte added to the website correlates to a drop in the conversion and increase in bounce rate, and this makes companies hesitant when adding larger 3D files. They did, however, do a test with a 3D model that was approximately the size of a photo of a product and did not see any decrease in conversion or the interaction. He believes that people using photos or 3D models do not optimize their file size and that to be the cause of large MB files. The challenging part is when dealing with larger MB files with a higher level of detail, due to the complexity of the product or to the requirement of the merchant. When dealing with these larger files, one needs to be smarter how they load it in the page; they can, for example, load the data in the background while displaying just a photo and then swapping them.

He viewed 3D product visualization to be an instrumental part in future e-commerce, in the same light that photos and videos used to be. First by 3D product view in websites and

then evolving to AR experiences than to VR immersive experiences and that the key to power all of this is the 3D models. The primary challenge of 3D is that merchants do not have an easy way to obtain the models.

4.3.2 Manufacturing company

Finds the use of 3D models in product visualization to be highly relevant in today's e-commerce. Especially with the development of AR and VR. However, there is a technological barrier in the use of this technology and that its use is not easily understood. When comparing 3D visualization to 2D photos, the 3D visual presentation allows users to get to know the product better and for them to get the full picture of that product. The use of real-time 3D models is good in products with lower quality materials like wood, but in products, with high-quality materials and unique designs 3D visualization through 360° photogrammetry is better, for example, glass in not good in 3D models. However, there are privacy issues in the use of 3D models and must be careful what products to use in 3D.

There are two main things that 3D product view offers. It creates excitement in customers, and it increases the time spent on the website. However, these effects are still not significant enough to see the real impact of 3D, and because of this, they can only guess.

The 3D visualization will play an essential role in the future and not just in e-commerce. In e-commerce, it is important that customers understand and get a full picture of the products. Development of technologies, such as AR and VR, further helps this cause by allowing products to be viewed anywhere. A big thing for this technology was the iOS AR update. It removes the need to download software for AR and makes AR more accessible. Hopefully Android will be something similar.

4.3.3 Web store

To give customers, the best description of the product, they mainly use a combination of photos and product information in text format. They had active customer support and based on the questions and requests of their customers they improve their product information. They do also display some products in 3D, but mainly the shopping process takes place with 2D photos. He believed 3D models to be a great tool to provide consumers that extra bit of information and help them to visualize the product better, but they did not have any data of their effectiveness. He felt that the interaction with 3D models helped consumers to get to know the product better but that it also might take the customer mind away from the actual shopping process.

The main issue he sees in implementing 3D is the acquiring of the 3D models. He would want there to be more 3D models available for them to use or that the product manufacturers should make their 3D files more accessible but recognizes their fear of publishing their 3D model's due privacy issues. When adding 3D models into their web store, they must be careful because an increase in loading time of the page results in a decrease in conversion and increases bounce rates. When using 3D models, they use different methods to combat this, such as loading it in the background and not having the 3D view in the first view of the page.

He sees that in the future of e-commerce 3D model will play a more significant part and that AR is an excellent tool for designers.

5   Discussion

All the interviews recognized 3D visualization through 3D models to be highly relevant in today's e-commerce but interview two found that there is still a technological barrier to be solved. They agreed on the positive effect that use of 3D models have compared to images in their customers, mainly giving them more information and helps them with mental visualization, which is also found by studies (D. Ariely, 2000, H. Li, T. Daugherty, and F. Biocca, 2002, T. Daugherty 2001). Also, the first interview found the use of 3D models as a new technology to positively affect consumers image of company's brand and the second interview found 3D models to positively impact the shopping process and increase the time spent on websites, this supported by (A. M. Fiore, etc. 2007).

When comparing different forms of product visualization, there was some difference in opinions. The first interview, however, found 3D models to ultimately be the best form of product visualization, because it allows users to view product from any angle, which is backed by studies (A. M. Fiore, etc. 2005), but also because 3D models can be used for AR/VR experiences and product photogrammetry for a fraction of the cost. The second interview found 3D models to be best used for lower quality products and the 360 visualizations to be suited for quality products. This view is also supported by a previous study (F. Moritz, 2010, S. Hewawalpita, I. Perera 2017). The third interview found 3D models to be effective in terms of providing additional information but also saw the interaction with 3D models to negatively affecting the shopping process.

Most interviewees recognized the problem with adding additional data into a website to slowing loading time and this to result in increased bounce rates. However, they did find ways to tackle this with different methods, such as loading 3D models in the background. The first interviewee was the only one not experiencing this. He recognized the studies made regarding this effect but found in their tests well optimized 3D models did not show any effects to the conversion rates.

The main issue with 3D models is that they come with an upfront cost and require a skilled hand to produce. So, acquiring 3D models requires an investment and companies are not willing to make this investment with the limited amount of information of the straight effect 3D models have in conversion. The first interview found that companies willing to make this investment is not looking for a direct impact on conversion, instead, they see it make their brand look good and create excitement for their consumers. Interview three also noted that they would use 3D models if there was an easier way to acquire them.

Another issue of the use of 3D models was privacy. This was an issue brought by the manufacturing company in interview two. 3D models embedded on a website can be stolen with the right tools. This is an issue mainly for manufacturing companies and makes them more hesitant to use 3D models. They must choose carefully, which product they want to endanger to this.

There was unanimous consent of the fact 3D models will play a significant role in the future of e-commerce. First by 3D product view in websites, then to AR and VR experiences.

6   Conclusion

This section will go through the goals set for this paper, the conclusion and debate the reliability of the research and findings and in the end. Then it will go through what the author has learned through this research.

The goal of this research was to study the usage and management of 3D content and to find out how and why 3D models are used in e-commerce platforms. It found that the use of real-time rendered 3D models in product visualization provides additional information by allows consumers to view the product from all angles. This helps consumers to get a more complete and fuller mental picture of the product.

This research could not provide any data of the direct impact 3D models have to product sales, conversion or to the value of a product. It did, however, find the use of 3D models in e-commerce provide excitement to customers and increase their time spent on a website. It also found that companies using 3D are not as much looking for a direct impact on conversion, but instead experimenting and using new innovative technologies creates a positive image of a company in consumers eyes. It also found that there are still arguments to be made towards other forms of displaying method.

3D models display the product as they are, without the bias that is created by edited product photos. However, it must be noted, that when it comes to 3D models used in e-commerce, there is a limiting factor that depict the quality and realism of a 3D model. This limiting factor is the data that a 3D model requires. Products with high quality materials and complex structure require more data and more data in a website results to slower loading times, which in turn impacts conversion. This opens the question, is it better to use 360 photogrammetry to produce the 3D effect rather than 3D models or simply stick to product images.

In my research I obtained different opinions on various product displaying methods in e-commerce, but in the end all interviewees leaned towards the use of 3D models with this data limitation in mind. This limitation, however, is not a limitation on 3D technologies ability to produce these 3D objects, but on our devices ability to render them properly and in real-time. Knowing this factor, the question regarding whether we should use 3D models shifts to when we should start using them.

Ultimately 3D models should be optimized so that they pass convincingly as the object they are representing and with the minimal amount of data required to produce this. The

problem is that the quality is depicted by the viewer not the modeler. This vague standard of quality result some companies use maximum quality of a model, which in turn increases data requirements, resulting in a decrease in conversion. With our current hardware's limitations, companies must consider what they are using the 3D models for and what is enough realism. Based on the research a well optimized 3D models were shown to have no negative impact on a website's conversion. Therefore, if the goal of 3D models is to provide additional information and help customers visualize products, then they are the best way display product, due to the fact, that 3D models can be viewed from any angle without restrictions.

Another argument for the use of 3D model, is that they are a lasting resource that can be used for many forms of product displaying methods aside from product visualization on a website. One access to an 3D model, merchants have access to endless amounts of product photogrammetry for the fraction of the cost. They can also be used to create AR and VR experiences. The value of this feature is further boosted by the continues development of easily accessible AR technology. Most notably by Apples AR Quick Look feature that allows iOS devices to open 3D models packed into a USDZ file format in AR.

Based on the research the central restricting factor on merchants use of 3D models is acquiring them. There are still no easy methods to produce 3D models. Their production requires skilled hands and usually come with an upfront cost, which means that to acquire 3D models an investment with minimal information regarding their effect on conversion must be made. This restricting factor leans more toward companies with only webstores than manufacturing companies, because in most cases manufacturing companies have access to 3D models of their products. They in the other hand must deal with the second issue, which is privacy.

3D models as well as photos that are embedded on a website can be, with the right tools and technical skill, be pulled out. This mean manufacturing companies need choose careful on the products they want to expose to this danger. There is still no ultimate way to protect from this danger, which makes it a defining flaw of the technology and that still turn companies to use photos and 360 photogrammetry instead of 3D models.

However, all the interviewed companies recognized that 3D models will play an important role in the future of e-commerce. The use of 3D models will revolutionize the way e-commerce functions in the same light that photos did. They will also bridge the gap that still exists on traditional commerce to e-commerce, that is the ability to carefully and thoroughly inspect products before purchasing them. As the technology evolves, there are still

challenges to dealt with and more research to be made. The benefits of the use of 3D models as a visualization tool in e-commerce seems to be well understood, but there needs to be made more studies made of the impact 3D models have on conversion for merchants to confidently be willing to shift from photos to the use of 3D models.

6.1   Reliability

The subject of the research is continuously evolving, and this causes the credibility of studies to decay fast. The information in this thesis is aimed to be the most reliable and of the newest sources as possible. But due to the lack of research, the credibility of some studies can be questionable.

To tackle this, I decided to interview companies with expertise in the use of 3D models and with this get the most reliable form of information. Their knowledge of the field, however, also different based on the interests of each company and none of the companies had any measurable data to back their view on 3D models. All the interviewed companies agreed that more research is needed.

6.2   Author's learning

The author set out to this project in the with the tools and knowledge that he had received in my internship in Sayduck. This allowed him to seek out interviews with companies at the start of the project. He sent out requests to five companies from which three accepted. He knows now that this was an error on his part, because he conducted these interviews with very limited amount of information of the complexity of 3D management in e-commerce. He thought that with the information he had received from my internship, gave him enough background information of 3D to ask the right questions. He did not take enough time to form the right questions, but in his luck, the companies he interviewed had the knowledge and experience to cover up his mistakes. They answered his questions broadly and with additional viewpoints, which gave him the information to conduct this research.

At the beginning he set up goals and proceeded accordingly, which resulted that his paper proceeded forward constantly, but as the paper began to form, he stated to loosen up planning, which impacted his writing phase and the whole process. Without proper planning and project management, finishing this paper began to be harder and harder. He kept feeding his mind with the idea that the paper was almost finished, which did not help him, but in turn it drove him away from one the most important factor of project management, finishing the project.

Writing this paper has been a journey that has taught the author many valuable lessons in project management, information gathering, conducting of interviews and about himself. However, the most important lesson he learned was the importance of carrying out the project all the way to the end.

References

A. Beane, "3D Animation Essentials" 2012, 10-18p, Read: 28.04.2019 http://dl.soft-gozar.com/Files/Ebook/3D_Animation_Essentials_Softgozar.com.pdf

A. M. Fiore, J. Kim, and H.-H. Lee, "Effect of image interactivity technology on consumer responses toward the online retailer," J. Interact. Mark., vol. 19, no. 3, pp. 38–53, 2005. Read: 08.01.2019 https://www.researchgate.net/publication/229514297_Effect_of_image_interactivity_technology_on_consumer_responses_toward_the_online_retailer

A. M. Fiore, J. Kim, and H.-H. Lee, "Influences of online store perception, shopping enjoyment, and shopping involvement on consumer patronage behavior towards an online retailer," J. Retail. Consum. Serv., vol. 14, no. 2, pp. 95–107, 2007. Read: 09.01.2019 https://www.researchgate.net/publication/229349202_Influences_of_online_store_perception_shopping_enjoyment_and_shopping_involvement_on_consumer_patronage_behavior_towards_an_online_retailer

B. Beck, "Amazon is the new Google for Product Search," 2017 Read: 30.11.2018 https://www.digitaldoughnut.com/articles/2017/november/amazon-is-the-new-google-for-product-search

Bethany, "Autodesk – Everything You Need To Know," 2017, Read: 28.04.2019 https://www.scan2cad.com/cad/autodesk/

Blender "History," 2015 Read: 17.05.2019 https://www.blender.org/foundation/history/

D. Ariely, "Controlling the information flow: Effects on consumers' decision making and preferences," 2000, J. Consum. Res., vol. 27, no. 2, pp. 233–248 Read: 13.12.2018 https://pdfs.semanticscholar.org/0b78/e7721318637d85e3b87d345725beaa825287.pdf

Digital School "A History of Computer Graphic Modeling" Read: 5.12.2018 https://www.digitalschool.ca/a-history-of-computer-graphic-modeling/

eCommerceDB "Top online stores by revenue: Global eCommerce Market" Read: 18.12.2018 https://ecommercedb.com/en/ranking/ww/all

F. Moritz, "Potentionals of 3D-Web-Applications In E-Commerse - Study about the Impact of 3D-Product-Presentations," in 2010 IEEE/ACIS 9th International Conference on Computer and information Science, 2010, pp. 307-314. Luettu: 22.11.2018 https://www.computer.org/csdl/proceedings/icis/2010/4147/00/4147a307-abs.html

Figure 2, Boeing man. 12.05.2019 https://grayfire93.wordpress.com/2015/12/07/3d-computer-animation-in-the-60s/

Figure 7, Texture maps applied to a 3D object. 12.05.2019 https://www.reallusion.com/contentstore/iClone/pack/3DTextureMaterial/General/General.aspx

Figure 8, Texture maps applied to a 3D object. 12.05.2019 https://wiki.mcneel.com/brazil/shaders

Figure 10, 3D visualization with a 3D model. 12.05.2019 https://vimeo.com/sayduck

Internetlivestats, Internet users in the world 2018" read: 23.11.2018 http://www.internetlivestats.com/watch/internet-users/

J. Slick, "What is 3D Rendering in the CG Pipeline" 2018 read: 22.11.2018 https://www.lifewire.com/what-is-rendering-1954

J. Slick, "3D Model Components — Vertices, Edges, Polygons & More" 2018b read: 22.11.2018 https://www.lifewire.com/3d-model-components-1952

K. Laudon, C. Traver "E-commerce business. Technology. Society." 2014, New Jersey Pearson, pp 12-16 read: 23.11.2018 https://sabraz.files.wordpress.com/2017/05/e-commerce-laudon.pdf

L. Milong, "The Analysis of Strengths and Weaknesses of Online-Shopping" 2011 read: 12.05.2019 https://www.researchgate.net/publication/293021886_The_Analysis_of_Strengths_and_Weaknesses_of_Online-Shopping

M. Dahiya, "Study on E-Commerce and it's Impacts on Market and Retailers in India," 2017 ISSN 0973-6107 Volume 10, Number 5 (2017) pp. 1495-1500 read: 12.05.2019 https://www.researchgate.net/publication/326829709_Study_on_E-Commerce_and_it's_Impacts_on_Market_and_Retailers_in_India

M. Geig "Working with Models, Materials, and Textures in Unity Game Development" 2013 Book "Unity Game Development in 24 Hours, Sams Teach Yourself" read: 20.11.2018 http://www.informit.com/articles/article.aspx?p=2162089&seqNum=2

M. Jensen, "Understanding the Basics of Product Visualization", 2018 read: 08.01.2019 http://steensolutions.com/2016/11/understanding-basics-product-visualization/

M. Kaplan "SWOT Analysis for Ecommerce Companies," 2013 read: 30.11.2018 https://www.practicalecommerce.com/SWOT-Analysis-for-Ecommerce-Companies

M. M. Grime, G. Wright "Delphi Method," 2016 read: 06.01.2018 https://www.re-searchgate.net/publication/305909817_Delphi_Method

M. Rouse, M Haughn, "3D Model," 2016 read: 22.11.2018 https://whatis.tech-target.com/definition/3D-model

N. Badler, A. Glassner "3D Object Modeling," 2009 read: 22.11.2018 http://gamma.cs.unc.edu/courses/graphics-s09/LECTURES/3DModels_SurveyPaper.pdf

N.E. Coviello, R. Milley, and B. Marcolin, "Understanding IT-enabled Interactivity in Contemporary Marketing", 2001, Journal of Interactive Marketing, Vol. 15 No. 4, pp. 18-33. read: 19.12.2018 https://www.researchgate.net/publication/229886128_Understanding_IT-Enabled_Interactivity_in_Contemporary_Marketing

N. Levy "Amazon's impact on e-commerce, smart speakers and streaming quantified in Mary Meeker's massive tech report" 2018 read: 30.11.2018 https://www.geekwire.com/2018/amazons-impact-e-commerce-smart-speakers-streaming-quantified-mary-meekers-massive-tech-report/

N. Slotte, "AR as Part of The Consumer Shopping Experience," 2016 read: 12.05.2019 https://www.slideshare.net/Mindtrek/niklas-slotte-ar-as-part-of-the-consumer-shopping-experience-mindtrek-2016

Pletinckx, D. 2014. Virtual reconstruction. [www-sivu]. wordpress.com. read: 5.12.2018 https://enameabbey.wordpress.com/2014/06/09/virtual-reconstruction/

P. Evans, T. S. Wurster, "Getting Real About Virtual Commerce," 1999, Harvard Business Review read: 19.12.2018 https://hbr.org/1999/11/getting-real-about-virtual-commerce

R. Algharabat and C. Dennis, "3D product authenticity model for online retail: An invariance analysis," 2009. read: 15.12.2018 https://www.researchgate.net/publication/42599966_3D_Product_authenticity_model_for_online_retail_An_invariance_analysis

R. Algharabat and C. Dennis, "Using authentic 3D product visualisation for an electrical online retailer," 2010, J. Cust. Behav., vol. 9, no. 2, pp. 97– 115 read: 13.12.2018 https://www.researchgate.net/publication/49402323_Using_authentic_3D_product_visualisation_for_an_electrical_online_retailer

R Garlington, "What are the different texture maps for?" 2018 read: 21.11.2018 https://help.poliigon.com/general-information/what-are-the-different-texture-maps-for

R. Oppenheimer," William Fetter, E.A.T., and 1960s Computer Graphics Collaborations in Seattle," 2018 read: 5.12.2018 http://www.historylink.org/File/20542

R. Ramanathan, "E-Commerce Success Criteria: Determining Which Criteria Count Most." 2010, Electronic Commerce Research 10 (2): 191–208. read: 13.12.2018 https://www.researchgate.net/publication/220480754_E-commerce_success_criteria_Determining_which_criteria_count_most

R. Khan, "3D Modeling in 3D Production Pipeline," 2016 read: 12.05.2019 https://animationjedi.wordpress.com/2016/10/16/3d-modeling-and-its-stages-in-3d-production-pipeline/

R. H. Tsiotsou, M. Vlachopoulou, "Understanding the effects of market orientation and e-marketing on service performance" 2011 Marketing Intelligence & Planning 29(2):141-155 read: 19.12.2018 https://www.researchgate.net/publication/233595369_Understanding_the_effects_of_market_orientation_and_e-marketing_on_service_performance

Statista, "E-commerce share of total retail sales in United States from 2013 to 2021," 2017 read: 29.11.2018 https://www.statista.com/statistics/379112/e-commerce-share-of-retail-sales-in-us/

Statista, "E-commerce share of total retail sales in China from 2014 to 2019," 2017b read: 28.11.2018 https://www.statista.com/statistics/379087/e-commerce-share-of-retail-sales-in-china/

Statista, "E-commerce share of total retail sales in Japan from 2014 to 2019," 2017c read: 29.11.2018 https://www.statista.com/statistics/379122/e-commerce-share-of-retail-sales-in-japan/

Statista, "Retail e-commerce sales worldwide from 2014 to 2021 (in billion U.S. dollars)," 2018 read: 28.11.2018 https://www.statista.com/statistics/379046/worldwide-retail-e-commerce-sales/

Statista, "Amazon - Statistics & Facts," 2018b, read: 11.05.2019 https://www.statista.com/topics/846/amazon/

S. Ahuja, "Significance Of E-Commerce In Today's Scenario," 2011 read: 21.11.2018 https://www.uberdigit.com/significance-of-e-commerce-in-todays-scenario/

S. French "All the companies in Jeff Bezos's empire, in one (large) chart," read: 30.11.2018 https://www.marketwatch.com/story/its-not-just-amazon-and-whole-foods-heres-jeff-bezos-enormous-empire-in-one-chart-2017-06-21

S. Hewawalpita, I Perera, "Effect of 3D Product Presentation on Consumer Preference in E-Commerce," 2017 J. Advert., vol. 31, no. 3, pp. 43–57, 2002. read: 22.11.2018 https://www.researchgate.net/publication/317281781_Effect_of_3D_Product_Presentation_on_Consumer_Preference_in_E-Commerce

T. Daugherty, "Consumer Learning and 3-D Ecommerce: The Effects of Sequential Exposure of a Virtual Experience Relative to Indirect and Direct Product Experience on Product Knowledge, Brand Attitude and Purchase Intention," 2001. read:22.11.2018 http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.194.5651&rep=rep1&type=pdf

Techopedia "Rendering" read: 10.12.2018 https://www.techopedia.com/definition/9163/rendering

V. Nguyen, P. Kerfriden, S. P. A. Bordas, "Isogeometric cohesive elements for two and three dimensional composite delamination analysis," 2013 read: 12.05.2019 https://www.researchgate.net/publication/236688075_Isogeometric_cohesive_elements_for_two_and_three_dimensional_composite_delamination_analysis/figures?lo=1&utm_source=google&utm_medium=organic

Z. Jiang, I. Benbasat, "Investigating the Influence of the Functional Mechanisms of Online Product Presentations," 2007, Information Systems Research Vol. 18, No. 4, pp. 454–470 read: 14.12.2018 https://pdfs.seman-ticscholar.org/ee8e/20cfa8a6ef39492667f30505d1e445d3e88c.pdf

Appendices

Appendix 1. Interview

15 minutes interview with Shopify:

- A study done by F. Moritz in 2010 researchers indicate that consumers preferred a 360° product view of a product over 3D models due to the realism, has this changed through the improvement of 3D technology? Which displaying method do you prefer and why?
- What are the main issues you see in 3D and its effect in conversion?
- Have you seen issues with the 3D model file size effecting conversion?
- What role do you believe 3D models will have in the future of e-commerce? and what is still required of the technology?

15 minutes interview with the manufacturing company:

- A study done by F. Moritz in 2010 researchers indicate that consumers preferred a 360° product view of a product over 3D models due to the realism, has this changed through the improvement of 3D technology? Which displaying method do you prefer and why?
- What measurable data is there of the impact 3D-models have on the consumers purchase decision or to product sales in e-commerce? and what are your views on their effectiveness?
- What are the main issues you see in 3D models?
- What role do you believe 3D models will have in the future of e-commerce? and what is still required of the technology?

30 minutes interview with Finnish Design Shop:

- What methods do you use to ensure that your customers get the most accurate view of your products? And how do you measure this?
- Have you seen difference in your measurements regarding products with 3D models to those without? And what are your opinions on their effectiveness?
- Have you done any measurements specifically to products with 3D models?
- How many of your users are mobile?
- What is your personal take on the use of 3D models in mobile compared to computers?

- What is your opinion on 3D models compared to images in e-commerce? And what is your overall opinion of the benefits 3D models bring to e-commerce?
- Has the 3D model size file effected conversion?
- What role do you believe 3D models will have in the future of e-commerce? and what is still required of the technology?
- How do you see AR effecting e-commerce?