Kevin Cheng

May 8th, 2019

DES 494A: Senior Thesis

Zima Mirror: Augmented Smart Mirror Technology

Abstract

This dissertation examines the impact of a smart mirror design integrated with augmented reality technology through a multi-layered study of the past smart mirror Kickstarter and augmented reality used in professional workspace and personal environments. By examining the past smart mirror Kickstarter, I have pinpointed the issues of this product that led to its absence on the market, such as not having a functionality that distinguishes itself from what a smartphone can do and a functionality that targets a specific group of people.

I conducted research on Oculus Rift and Microsoft HoloLens to identify features that made these technologies successful on the market. Through this research, I have established that the improvements to the smart mirror design will be integrating augmented reality technology to provide more interactive and practical uses. In a professional workspace, the improvement will make smart mirrors become a useful tool for product designers to better visualize their CAD models. While in a personal environment, it can help users of all kinds to visualize their choice of clothing before wearing it.

The smart mirror design consists of a frame, a large piece of two-way mirror, a computer monitor and a couple of hardware. The frame is built out of plywood with a two-way mirror installed on the frame. The program that displays basic modules and the augmented reality showcase will be uploaded to the hardware that is connected to the computer monitor to display it. Users will navigate the smart mirror by using hand gestures to prevent damaging the surface of the mirror.

Opening Statement

Science fiction movies have always shown futuristic, yet unrealistic, technologies that convince viewers that either the movie is set in a distant future or an alternative universe where technology has gone a long way. Take the movie, *Minority Report*, as an example. During the scene where Tom Cruise's character is trying to solve crimes, the movie showed the audience a highly advanced technology where a large piece of glass pane is a computer that is controlled by remote gloves that monitors the user's hand gestures (The Verge, pp.1). As we can tell from the computers that we use today are nowhere near as advanced as what *Minority Report's* computers can do, which demonstrates the endless possibilities of technology. While many people believe that technologies in science fiction movies are unrealistic and impractical, developers and engineers have been trying to make them come to life, because they believe these technologies can actually make a difference to people's lives.

In order to demonstrate this belief, I want to design and create a smart mirror of my own based on the glass pane computer that Tom Cruise used in *Minority Report*. Ever since I was little, a smart mirror was one of the technologies that I look most forward to seeing in the technology's progress. Such technology is now made possible and many people have created their own DIY smart mirrors and used them in their homes. I have always wanted to make one, because not only does it make your living space feel like you are in the future, but it is also a device that I can use to accommodate my personal lifestyle and workspace. I could not achieve this goal when I was little, but now feel like I can make it happen using my design and computer programming skills that I have acquired over the course of my education.

One of the best parts of designing your own products is that you can customize it from scratch, which means I can add additional functionalities on top of the functionalities that a

standard smart mirror should have. These additional functionalities will be determined after looking at existing DIY smart mirrors created by other people and see what improvements can be made to create the best smart mirror design possible.

Introduction

Smart mirror is a signature of the future. When a movie or an advertisement tries to demonstrate how far technology has come, they would show their protagonist brushing their teeth in front of a mirror, which would lay out their daily schedule, weather report, incoming messages, and more (Postscapes, pp.1). With our technology making incredible progress from the first-generation iPhone to 3-D metal-printing, people expected smart mirrors would come to life from science-fiction by now. However, there had not been any companies that are providing such technology on the market. There are two reasons for the absence of smart mirrors on the market: The cost of a ready-to-use smart mirror is extremely high in comparison to its benefits and smartphones can do just as much as what a smart mirror can do (Magic Mirror Central, pp.1-5). There have been a number of Kickstarter that have made attempts to get a consumer version, but it is nowhere near the technology we see in sci-fi movies and consumers are not going to pay such a high price for an underdeveloped product. At this point it is clear that smart mirrors will not be a thing for a while, but there are other technologies that were seen in sci-fi movies that came to life and were successfully sold on the market, such as Oculus Rift and Microsoft HoloLens. These technologies had undergone extensive research and development to become the product that is sold today on the market, and the smart mirrors we see today may still be within the process of development. This suggests that smart mirrors have plenty of room to improve before they become commercially successful on the market. Therefore, this paper aims to develop a smart mirror design that will make this technology cost-effective enough

companies to produce and sell it on the market. In order to find the room for improvement, this paper will start by analyzing key features that made products, like Microsoft HoloLens and Oculus Rift, practical enough for companies to mass produce and sell them on the market. Then, propose a concept design based on the key features that made these existing products commercially successful, so that it would elevate the smart mirrors to become a product suitable for the consumer mainstream.

Smart Mirror

Smart mirror is a two-way mirror with an electric display behind the glass. The display can show users different kinds of information in the form of widgets, such as weather, time, date, and more (IIT School of Applied Technology, pp.1). The idea of smart mirrors is integrating technology with furniture in a living space that we are familiar with, with the purpose of enhancing the human experience of using this particular enhanced furniture. This technology is useful for busy individuals that want to multitask and stay informed while on the go. So rather than having to pull out their smartphones or other devices, users could get informed while focusing on the task at hand.

Because of the fact that smart mirrors have the potential to enhance consumer's lifestyle, many people have tried to create a consumer version of this technology. There have been a number of Kickstarters that have made this attempt: SmartMirror by Ian Seyler, DoodleVU by AppSmith Studios, Perseus by Perseus Mirror (The Verge, pp.1). And ultimately, they all failed. Kickstarter is the world's largest funding platform for creative projects.

Past Smart Mirror Kickstarter Analysis

SmartMirror's Kickstarter

> SmartMirror's Kickstarter, created by Ian Seyler, lasted thirty days from May 25th to Jun 24th, 2015. Seyler's smart mirror has additional modules on top the standard widgets that normal smart mirrors have, such as horoscopes, cat facts and IFTTT recipes. Seyler's smart mirror's modules are all open-sourced, which means users can have access to the back-end of these modules to customize the software from scratch (Kickstarter, pp.1-2).

One of their main objectives with this Kickstarter is that Seyler needed a large enough initial order to take advantage of economies of scale. If the initial order is in the hundreds, it can pull the price per unit down enough to make the smart mirror affordable. Hence, the Kickstarter aimed for a funding goal of $74,679, but it only achieved a total funding of $10,436, which is fourteen percent of the funding goal and the project ultimately failed. In the comment section of this Kickstarter, most people commented that it was a shame that this product did not come to fruition and they hope the project will relaunch in the future. This suggests that there are demands for smart mirrors, but the number from the total funding indicates that while there are demands for smart mirrors, it is simply not enough for it to become a commercially viable product. One of the reasons why the demand for this smart mirror is low is that based on its design, a lot of the functions are extremely similar to what a smartphone can do. The smart mirror can show various information like time, date, weather, news feed and more, but so can smartphones. Unlike smart mirrors, smartphones are portable enough for people to bring around, the product's usage is not limited within their own house. In addition, the price for Seyler's smart mirror is approximately $399, while the average price of smartphones is $363.

People would purchase a cheaper product that can do just as much as what the more expensive product can do. Hence, this demonstrates that the current design of smart mirrors is not cost-effective enough to have a high demand for this product, because alternative products, like smartphones, are cheaper and can do just as much as smart mirrors.

DoodleVU's Kickstarter

> DoodleVU's Kickstarter, created by AppSmith Studios, lasted forty-two days from June 9th to July 21st, 2016. AppSmith Studios's smart mirror allows users to customize the widgets that are displayed on the mirror through logging into the user's account on their website. The Kickstarter aimed for a funding goal of $5,500, which it seems that they have achieved with a total funding of $9,176, but there has not been any progress since the last update post on November 19th, 2016 (Kickstarter, pp.1-2).

The last update stated that there was a delay in the production due to people not fulfilling the pledges, which undermined the ability to produce a product with the intended components and materials. However, people in the comments suggested that AppSmith Studios underestimated the actual cost and time needed to complete this project, and after realizing their mistakes, they decided to abandon the Kickstarter project and never gave an update to the people who pledged for this project since November 19th, 2016. This demonstrates that the cost of producing a smart mirror is a lot higher than what most people predicted. Ian Seyler's funding goal was $74,909, while AppSmith Studio's funding goal was only $9,176, which suggests that AppSmith Studio was trying to make smart mirrors a viable product on the market by reducing

the cost of producing it, so that they can also reduce the price they sell on the market. However, with lower cost of production, it would mean that the studio would have to purchase cheaper components and materials to reach their goal. Cheaper components are not necessarily the right components they need to manufacture the smart mirror, which is why they could not produce the product they wanted and resulted in the project to be a failure.

Perseus's Kickstarter

> Perseus's Kickstarter, created by Perseus Mirror, lasted thirty-three days from July 27th to August 29th, 2016. Perseus Mirror's smart mirror is one of the most developed smart mirrors, which includes key features like video streaming, personalized dashboard, camera, QR code reader and virtual jewelry & accessories. The Kickstarter aimed for a funding goal of $100,000, which they were able to raise a total funding of $100,363 (Kickstarter, pp.1-2).

The Kickstarter's potential of this smart mirror was relatively promising in comparison to other smart mirror Kickstarter, since the project's plan was thorough, and it was created by teams of experienced developers, designers and entrepreneurs. However, there were a lot of issues when it came to delivering the product, and even when Perseus Mirror were able to deliver the mirrors, many people claimed that they received shattered smart mirrors instead. Most of the people who had this problem are from outside of the United States, so Perseus Mirror worked with the shipping companies on reinforcing the package. Nevertheless, this suggests that the two-way mirror they used for the product is rather low quality and this is most likely because Perseus Mirror wanted to make a profit by lowering the manufacturing budget for

each unit. Similar to DoodleVU's smart mirror's case, it seems that many Kickstarter's approaches to starting a smart mirror business is by purchasing low quality materials to generate profit. While it is understandable that this is the correct way to approach a business, it is the wrong way to approach a startup business that they are trying to convince the world that a smart mirror can be a commercially viable product. Hence, Kickstarter should have focused on the product before thinking about profit.

Analysis for existing products used in workforce

In order to identify key functions that should be implemented to improve the smart mirror design, it is necessary to look into existing technology products on the market that have been used in the workforce. Many of these existing products are inspired by technology seen in science-fiction and many companies were not only able to bring them to life, but also made them practical for consumers to use them in professional environments. This suggests that these science fiction-inspired technologies must have undergone significant changes to transform them into consumer versions that can be sold on the market. Hence, this paper will be analyzing Microsoft HoloLens and Oculus Rift by identifying key features that prompt them to become successful products on the market.

<u>Oculus Rift</u>

Oculus Rift is a virtual reality headset that needs to be connected to a gaming desktop or laptop to work. Inside the headset, there is a pair of screens that display two images side by side, one for each eye. The user will look at the pair of screens through a set of lenses that focuses and reshapes the images displayed on the screens for each eye, which creates a stereoscopic three-dimensional image. Oculus Rift has embedded sensors that monitor the user's head

motions, which adjusts the images accordingly and creates the sensation of exploring a three-dimensional world (Tom's Guide, pp.3).

Oculus Rift's Key Feature (Unique Selling Point)

Oculus Rift utilizes virtual reality technology to create a virtual space that can be modified and interacted with. Virtual reality was created during the 1980s where users wore headsets and gloves to interact with games and virtual worlds. However, at that time, technology had no caught on to the comparison of virtual reality in science fiction shows, which did not prompt any development on virtual reality technology (The Guardian, pp.1). Until 2012, when Oculus VR was founded by Palmer Luckey and Brendan Iribe, two virtual reality enthusiasts, who managed to create a prototype that got people excited about virtual reality technology again. Luckey and Iribe launched a Kickstarter project in August 2012 that managed to raise $2.4 million dollars to create its Oculus Rift virtual reality headset for gaming (Kickstarter, pp.1-2). They distributed to developers, so the developers can start working with the device to further develop the headset's hardware that created Oculus Rift's advanced virtual reality technology. Oculus Rift had so much potential, Facebook CEO Mark Zuckerberg purchased Oculus VR for $2 billion dollars and stated that the headset "has the chance to create the most social platform ever" (PR Newswire, pp.1). Oculus Rift's advanced virtual reality technology and its endless potential made this product unique in the tech market that prompted it to become commercially successful.

Oculus Rift's Strength

Oculus Rift is backed by Facebook, which is a company that is financially capable to support Oculus VR's operations and further develop the product's hardware. For example, the latest

version of the Oculus Rift is reinforced by an external positional-tracking sensor that helps track head movements more accurately, which creates a more realistic virtual experience. In addition, due to the fact that Oculus Rift has more advanced virtual reality technology, Oculus Rift essentially has a monopoly on the VR gaming market. As mentioned previously, virtual reality technology was created during the 1980s by VPL Research, the first company to sell virtual-reality goggles (MIT Technology Review, pp.4). While the company had the advantage of being ahead in the virtual reality market, a single headset display cost approximately $100,000, which was far too expensive for the consumer mainstream (MIT Technology Review, pp.5). There were other reasons that earlier versions of virtual reality failed commercially. Nintendo's Virtual Boy was a relatively cheaper virtual reality product at the cost of $300, yet the product's life span only lasted a year. This was because people who used Virtual Boy complained that they experienced nausea after extended play. For other users, the enthusiastic sense of wonder and presence they felt inside a virtual world did not last long. This was most likely because back in the 1990s, there were not enough game developers to create new exciting virtual reality contents to maintain consumer's interest in Virtual Boy (MIT Technology Review, pp.5). However, virtual reality may be different now. Oculus VR have been developing their headsets to address the nausea experience and the company stated that their latest version has almost eliminated the problem. Furthermore, today's virtual environments offer much more content that users could enjoy and become captivated for much longer. Oculus VR has been hiring artists to create a more stimulating range of worlds, from realistic representations to abstract illustrations, so users will not get tired of exploring virtual worlds. This clearly demonstrates that the pricing and the constant development of the product drove Oculus Rift to become commercially successful and the monopoly of the virtual reality market. These are some of the key factors that should be considered to find ways to improve the smart mirror's design.

Oculus Rift's Weakness

Oculus Rift's main weakness is the device's inability to go wireless. The headset is required to be connected with a cord to a computer to fully operate. This means that the cord prevents users from truly exploring the virtual world with their own freedom. Hence, in all virtual worlds, players are moved by selecting the location they want to move to in their field of vision. Movement is one of the most important aspects within exploring a new world. If that aspect is taken away from the players and replaced with an alternative, yet unnatural, method of movement, the virtual reality experience becomes incomplete and unrealistic. For a technology that is designed to enhance users' experience in a space, the absence of the ability to move freely diminishes that experience, which pulls Oculus Rift down from being the perfect technology to experience virtual reality. In addition, Oculus Rift has been reported that the device can sometimes cause nausea and dizziness. One of the causes for nausea is because of the inability to go wireless. When users are moving through a virtual space in a way that is not natural to them, it creates a disconnection between their external sensory information and internal sensors, which will make the user feel ill and want to vomit (VentureBeat, pp.6). While Oculus Rift has been addressing this issue over the past couple of years, there are some people who are still experiencing nausea when using Oculus Rift, especially early users who have not adapted to the device's configurations. Consider that users pay for approximately $600 for a technology that would make them feel motion sickness is not exactly a product that consumers are willing to purchase (Oculus VR SWOT Analysis, pp.1). This clearly indicates that a product should be controlled the way that is most natural to the user or else it may cause potential negative effects, like nausea and dizziness, that would discourage other consumers to purchase. Therefore, the new smart mirror design should inherit some of the existing ways to

navigate a device with a large flat screen, like smartphones or tablets. This way when consumers use the smart mirror, it would feel familiar and intuitive to them.

Microsoft HoloLens

Microsoft HoloLens is a headset with a transparent screen in front of your eyes, and it wraps around the back of your head. The headset is controlled by the direction of which the user is facing, hand gestures and voice command. HoloLens allows the user to experience three-dimensional holographic images that immerse with the user's environment. The level of immersion enables new forms of computing in which the user could use their personal desktop in any space as long as there is room for them to work in (SearchMobileComputing, pp.1).

Microsoft HoloLens's Key Feature (Unique Selling Point)

Microsoft HoloLens embraces both virtual reality and augmented reality to a new reality: mixed reality. Augmented reality gives real world digital information, and virtual reality transport you into a virtual world. Between the two is mixed reality, which blends hologram with your real world. What makes HoloLens different from virtual reality headsets is that users can walk around with the headset and talk to others without worrying about crashing into walls. Furthermore, virtual reality headsets require users to use hand remotes to interact with the three-dimensional objects, but that is not the case with HoloLens. The headset has motion-sensor cameras on it which tracks the user's location in a room and their hand gestures to interact with the three-dimensional objects. This makes HoloLens unique among the current virtual reality headsets and augmented reality devices on the market (SearchMobileComputing, pp.3).

Microsoft HoloLens's Strength

Microsoft HoloLens is backed by Microsoft, which is a well-established company and known for its success in the tech market. Due to this fact, when Microsoft announced the release of this product, consumers are convinced that this technology is reliable, and the product was manufactured with quality components. In addition to the reliability of the brand name, Microsoft HoloLens is a unique product amongst the virtual reality headsets, which makes it desirable to consumers who are interested in this technology's functionality. The HoloLens has limitless possibilities in design, engineering, medical fields and more. The immersive functionality can help designers envision their designs more accurately than what they see on computer screens, and surgeons can create holographic versions of patients to provide an unobstructed view that will give more information than they traditionally had. Furthermore, HoloLens is beneficial to the environment. While the product does use energy, it prevents designers and engineers from wasting materials and resources to prototype their creations if they do not go correctly. For example, if a designer is creating parts of a motorcycle shell, instead of building numerous versions of the design with valuable metal, the designer can now achieve the same process using holographic models of the design to immerse with a real-life motorcycle without the shell parts. By introducing a new sustainable way using HoloLens for product creations, it can help make a greener Earth with less waste (Kim's Blog, pp.1). The strengths of the HoloLens demonstrate that if a product is reliable, functionally unique or able to enhance consumer's lifestyle, then a science fiction technology will most likely be able to become a commercially viable product. Hence, these are some of the key features that should be considered when designing and creating the improved version of the smart mirror.

Microsoft HoloLens's Weakness

Microsoft HoloLens' main weakness is its extremely high price. While the product is definitely unique and technologically advanced in comparison to other virtual reality headsets, it is currently priced at $3,000, which is high for a tech product. Microsoft charged at this price, because they have no competition on the market that would sway consumers to buy an alternative product. A possibility for the high price is that the components and the hardware required to produce a HoloLens is also high, hence the price of the HoloLens may have considered the high production cost on top of its unique selling point. However, even if a product has unique features that made it stand out in the market, the pricing of the HoloLens still makes it hard to convince consumers to purchase the product. After all, purchasing a $3,000 tech product is not an easy choice and there is no guarantee that it is as good as Microsoft has claimed. In addition, Microsoft created a product so technologically advanced, there will clearly be a difference in difficulty between using a HoloLens and a smartphone. HoloLens is entitled to be tech savvy, which means it requires the user to be well versed in technology to properly operate this virtual reality headset. The HoloLens has advanced and complicated applications that require specific gestures and vast-knowledge in technology in order to take advantage of the product's full capability. This creates a rather small target group as the complexity of the HoloLens is only suitable for innovators and early adopters, which lowers the demand for this product. Furthermore, like most virtual reality headsets, there could be some health implications that Microsoft may not consider yet. Since users will be wearing HoloLens to utilize it, having the transparent screens right in front of their eyes for long hours can have harmful effects on their vision. There is also the possibility that some of the holographic objects may cover wires and other objects in the room, which users may accidently trip over and hurt themselves. While it is true that most advanced technologies are meant to solve an issue and enhance our lifestyle, it is also true that there are a lot of aspects within advanced technologies that we do not

understand, which will ultimately raise new problems (Kim's Blog, pp.2). Therefore, this clearly demonstrates that the overpricing of the product, the complexity of new features and the hazards of an advanced technology may discourage consumers to purchase a product and prevent it from becoming commercially successful. These are some of the key factors that should be taken into account when considering what should be implemented to improve the current smart mirror design.

Based on the analysis on Oculus Rift and Microsoft HoloLens's strengths and weakness, this paper was able to pinpoint a couple features that the new smart mirror design should have. The smart mirror should be constantly developed by different developers to ensure that all aspects of the product are well-developed, which can be difficult to achieve if only one person is trying to cover all aspects. Furthermore, the smart mirror should have unique yet reliable functionalities that would enhance people's lifestyle and they also have to be something that a smartphone does not have. However, the user experience of these functionalities should be intuitive and familiar to users, so that everyone can use this product rather than only tech-savvy people can use it. In addition, the new smart mirror design should be safe and comfortable for users to use. While there are no recorded negative effects of using smart mirrors on users' health, we may encounter these problems, like motion sickness or damaging eye sights, during the construction process. Hence, it would be necessary to address these health issues, if it comes up, to ensure that users are comfortable to use the new smart mirror.

New Functionalities to the New Smart Mirror Design

One common feature that made Oculus Rift and Microsoft HoloLens successful is that both products targets a specific target group. Oculus Rift is primarily used for gaming in virtual reality, while Microsoft HoloLens is generally used as a tool for prototyping and assisting users'

reality. While these two products use technology that alternates users' reality to operate, their functions do not overlap one another, which allow their functionalities to be unique on their own. A smart mirror displays information like weather, time, date and more, which is often compared to a smartphone due to the fact that they share this functionality. While one may argue that smart mirrors are unique in that it uses a mirror to display information, it is not exactly a unique selling point that would convince consumers to purchase smart mirrors over smartphones. Smartphones are much more portable to carry around and they have more functionalities than smart mirrors can offer, such as calling via cellular service and millions of applications that are created by developers for users to use. Therefore, the new smart mirror design should narrow down its target group by having functionalities designed for specific uses, which smartphones do not have.

Out of the three smart mirror Kickstarter that were researched on, Perseus was the most developed smart mirror and has some interesting features. Perseus has a functionality called Virtual Jewelry & Accessories, which is an augmented reality feature that dresses the user up with virtual accessories as a quick preview of its suitability to the user's current fashion (Kickstarter, pp.4). This feature is extremely practical and has plenty of room to further expand on, which is why integrating augmented reality to a smart mirror is a possibility for improvement of the new smart mirror design.

Augmented reality is a technology that blends interactive digital elements, like dazzling visual overlay, into our real-world environment (HowStuffWorks, pp.1). Microsoft HoloLens rely heavily on augmented reality to operate the device and it has some of the most applicable uses for a science-fiction inspired product. The new smart mirror can use augmented reality technology to make this device more practical than just a mirror that displays information.

Augmented reality has many applicable uses in professional workspaces like repair & maintenance, medical training and tourism industry. Another industry that would also benefit from augmented reality technology would be design and modeling (Inc.com, pp.1-3). Whenever product designers are creating a Computer-Aided Design (CAD) model of a product, they need to prototype it multiple times before finalizing the product. The traditional way to do this would be using 3D printers to print out the CAD models to get a better understanding of what the CAD model would look like in the real-world environment. However, the problem with this is that not only is 3D printing time consuming, but it also produces a lot of waste, because most of these prototypes are going to be failed attempts and then thrown out in the trash. If multiple designers undergo the traditional method of prototyping to create their own designs, then a substantial amount of plastic waste will be created, which is harmful to the environment. Hence, the best alternative method for prototyping will be using augmented reality to display the CAD model. This is something that a smart mirror can do, and a smartphone cannot, because the smartphone's screen is too small to have this complex functionality.

The idea for the new feature on the new smart mirror design is augmented reality product showcase. To use this feature, the user will have to upload the CAD model to the smart mirror. Once it has been uploaded, the user will hold out a designed plate with a tracker file on it within the mirror’s vision. The smart mirror will have a camera behind the two-way mirror, which will scan a tracker file. If the camera finds a tracker file, the smart mirror will generate an augmented reality image of the model on the plate (Instructables, pp.1-2). The user can move the plate around to change the image’s orientation and inspect the virtual model, allowing the user to visualize their designs and rely on the smart mirror as a tool for prototyping. Furthermore, the product showcase feature can also be used in personal environment. Augmented reality is often used for retail (Inc.com, pp.3), where shoppers can view a virtual

image of a product they are interested in, before going to the shop and buying it. Since people commonly use mirrors for dressing themselves, adding this fashion feature to the smart mirror would be suitable and users will have better experiences in stylizing themselves than using a regular mirror. To go above and beyond, the smart mirror could create a CAD model collection of the user's currently owned clothes and the user can try out their virtual cloth from the collection, rather than having to go through the closet one cloth at a time. It is a more efficient way to get a quick preview of their clothing before wearing it.

With augmented reality product showcase feature, the smart mirror can serve in both professional workspace and personal environment. While this feature may seem to have a broad usage, it is specifically designed to help user better visualize products through virtual images. The feature does not involve complex background knowledge in technology, so it is appropriate for users at all age to use it, as long as they have used a smartphone before. For older people or people with disability, this feature will have accessibility that will assist these groups of people to ensure that every can use this new smart mirror design.

Construction Process and Installation

To construct the new smart mirror design, I will start by building the smart mirror, then move on to the back-end and program its functionalities.

The smart mirror will need a frame, a large piece of two-way mirror, a computer monitor and a couple of hardware for the mirror's functionalities. The frame design has not been decided yet, but it will be made out of plywood or a type of wood that is strong enough to hold the mirror, monitor and other hardware together. There are two types of two-way mirrors: glass and acrylic. The main differences between these two mirrors are price and quality, where glass is more expensive at a cost of $89.99 and acrylic is cheaper at a cost of $27, but people have complained about the final finish using acrylic mirrors. For now, and for the sake of the final

product, I will use the glass two-way mirror to build the smart mirror. There are no specifications to which brand of computer monitor to use, but there is the matter of size. The idea is that the whole mirror should be the display, so the size of the computer monitor will have to match the size of the two-way mirror, which will be determined once the ideation process begins. There are a couple of hardware needed for the new smart mirror design, such as Raspberry Pi, USB speaker, USB microphone, motion sensor and camera. Raspberry Pi is a small computer that will be used to operate the smart mirror, and USB microphone and speaker will control the input and output sound around or of the mirror. Motion sensor will be used to navigate the mirror, so users can control the device using hand gestures instead of using their fingers that may damage the mirror's surface. And the camera will be used for the augmented reality product showcase feature to capture the mirror's real-life environment (Postscapes, pp.7). All the hardware will be placed behind the two-way mirror to keep it clean and minimal. This list is only temporary, so there may be more hardware added to or removed from the smart mirror depending on the construction situation.

Once the building the physical smart mirror is complete, I will move on to the back-end and program the mirror. The operating system most DIY smart mirrors used is Android, but I will see if I can program the mirror with Java, since I do not have experience in Android applications. The application of the smart mirror will display standard information, like time, date, weather and more. In addition, I will create a separate application that runs the augmented reality product showcase, which I will integrate with the information application at the end. There is not much to write about the back-end of the smart mirror, until I figure I can program with Java or not. However, the most challenging aspect of this project is still the back-end, since there are a lot of complex functionalities that I am trying to create. Hence, if any major problem presented

itself that prevents me from completing this project, there may be significant changes to the final product.

The smart mirror is an interactive product, so in order to showcase this device, it will be displayed in an art gallery. Viewers can interact with the smart mirror, but sometimes giving viewers too much freedom to interact, they may damage the work. Therefore, placing the smart mirror in an art gallery or exhibition would be better, since viewers will tend to be more careful with a work of art when it is displayed in a closed environment than in an open space.

Conclusion

Smart mirror is one of the most highly anticipated technologies to be sold on the market, yet it seems like there has not been any progress in developing a commercially successful version of this product. Many Kickstarter have made attempts to start things up with smart mirrors, such as SmartMirror by Ian Seyler, DoodleVU by AppSmith Studios, Perseus by Perseus Mirror, but ultimately failed for good reasons. Smart mirror is one of the products inspired by science-fiction technologies, and there are many problems with new technologies that originated from science-fiction. However, that did not stop entrepreneurs and developers from bringing these technologies to real-life. There are successful products on the market, such as Oculus Rift and Microsoft HoloLens, that were inspired by science-fiction. After analyzing these products, several key features were identified and gave a better understanding on how to make a science-fiction inspired product successful on the market. The paper came to the conclusion that augmented reality would be the best option to increase smart mirror's applicability, due to augmented reality's practical uses. Hence, the new smart mirror design will have augmented reality product showcases to help users better visualize real-life products through using virtual images of the product. Whether or not augmented reality is the answer to

solving the smart mirror's problem is unclear, but this feature will definitely demonstrate that a smart mirror has more value than just a piece of mirror that displays information.

Bibliography

"4 Reasons Why You Should Build a Smart Mirror Instead of Buying One." *Magic Mirror Central*, 11 Jan. 2018, www.magicmirrorcentral.com/5-reasons-build-smart-mirror-instead-buying-one/.

"10 Real Use Cases for Augmented Reality." *Inc.com*, Inc., 30 May 2018, www.inc.com/james-paine/10-real-use-cases-for-augmented-reality.html.

"Augmented Reality Product Showcase (TfCD)." *Instructables*, Instructables, 22 Dec. 2017, www.instructables.com/id/Augmented-Reality-Product-Showcase-TfCD/.

"DIY Smart Mirrors | 2018 Tutorials and Projects Overview." *Postscapes*, www.postscapes.com/diy-smart-mirrors/.

"DoodleVU - The Smart Mirror." *Kickstarter*, www.kickstarter.com/projects/appsmith/doodlevu-the-smart-mirror.

"Facebook to Acquire Oculus." *PR Newswire: Press Release Distribution, Targeting, Monitoring and Marketing*, 30 June 2018, www.prnewswire.com/news-releases/facebook-to-acquire-oculus-252328061.html.

"HoloLens SWOT Analysis." *Kim's Blog*, green--gold.blogspot.com/2016/05/hololens-swot-analysis.html.

"How Augmented Reality Works." *HowStuffWorks*, 19 Feb. 2001, computer.howstuffworks.com/augmented-reality.htm.

"How and Why Our Experiments with Virtual Reality Motion Made Us Ill." *VentureBeat*, VentureBeat, 2 Mar. 2018, venturebeat.com/2018/02/27/how-and-why-our-experiments-with-virtual-reality-motion-made-us-ill/.

"IIT School of Applied Technology." *Smart Mirror | IIT School of Applied Technology*, appliedtech.iit.edu/smart-lab-information-technology-and-management/projects/smart-mirror.

"Oculus Rift – 10 Reasons Why All Eyes Are Back on Virtual Reality." *The Guardian*, Guardian News and Media, 31 Mar. 2014, www.theguardian.com/technology/2014/mar/31/oculus-rift-facebook-virtual-reality.

"Oculus Rift and the Return of Virtual Reality." *MIT Technology Review*, MIT Technology Review, 7 July 2014, www.technologyreview.com/s/526531/oculus-rift/.

"Oculus Rift: Step Into the Game." *Kickstarter*, www.kickstarter.com/projects/1523379957/oculus-rift-step-into-the-game.

"Oculus VR SWOT Analysis." *Oculus VR SWOT Analysis*, 1 Jan. 1970, nickyshoeman.blogspot.com/2016/05/oculus-vr-swot-analyis.html.

"Oculus VR: SWOT Analysis." *Prezi.com*, 18 Dec. 2014, prezi.com/rbmbc1kei6h7/oculus-vr-swot-analysis/.

"Perseus: The World's Smartest Mirror." *Kickstarter*, www.kickstarter.com/projects/1377326093/perseus-the-worlds-smartest-mirror.

"Smart Mirrors Aren't Happening Anytime Soon." *The Verge*, The Verge, 12 Aug. 2016, www.theverge.com/circuitbreaker/2016/8/12/12458830/smart-mirrors-arent-happening-anytime-soon.

"SmartMirror." *Kickstarter*, www.kickstarter.com/projects/513673859/smartmirror.

"SWOT Analysis on Oculus Rift." *SWOT on Oculus*, swotoculus.blogspot.com/2016/05/swot-analysis-on-oculus-rift.html.

"What Is Microsoft HoloLens? - Definition from WhatIs.com." *SearchMobileComputing*, searchmobilecomputing.techtarget.com/definition/Microsoft-HoloLens.

"What Is Oculus Rift? - FAQ - How Oculus Rift Works." *Tom's Guide*, 28 Mar. 2016, www.tomsguide.com/us/what-is-oculus-rift,news-18026.html.