Healthy Eyes, Healthy Life:

The Viewing Distance Monitor

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A thesis presented to OCAD University in partial fulfillment of the requirements for the degree of Master of Design in Digital Futures

Abstract

As we enter the era of technological advancements, our lives are becoming more convenient and connected than ever before. However, the health problems caused by technology must be addressed. In daily life, many people have the unhealthy habit of staring at screens for prolonged periods of time, which can lead to various health issues. These problems arise from two main issues: prolonged screen time and improper distance between the eyes and screen.

To address these issues, I have designed a distance monitoring system. This computer-vision-based system monitors the viewing distance of users in real-time and alerts them to maintain a healthy distance from the screen through prompts.

Acknowledgement

I would like to express my gratitude to my primary advisor Dr.Alexis Morris. In the process of refining my thesis project, you gave me a lot of insights. Especially when I encounter technical problems, you always carefully explain the possible solutions for me. With your encouragement, I conquered one problem after another. And I also would like to express my gratitude to Dr. Cindy Poremba. Thank you for your detailed advice on my thesis paper and for finding the framework that I had overlooked in the midst of so much information. Most importantly, I would like to thank you for your guidance during this period of time as both program director and secondary advisor.

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1.Introduction

In today's digital age, the consumption of digital content has become pervasive, with individuals, including children, spending prolonged periods of time in front of screens. However, this excessive screen time has been linked to various health risks, such as heart disease, eye strain, and myopia (Tatiana et al., 2010; Demirayak Bengi et al., 2022; CW Pan et al., 2012). This is especially concerning during childhood, as it is a critical time for forming habits that can have long-term impacts on health and well-being.

1.1 Toward the Era of Technology – Health Concerns

In today's digital age, the widespread use of digital technology has changed people's behavior, with increased reliance on devices for social networking and virtual interactions (Pandya et al., 2021). These interactions have become essential for human well-being as they facilitate communication and socialization (Ahn et al., 2020). However, the rapid emergence and evolution of digital technology have also resulted in prolonged screen time, raising concerns about the potential health effects of excessive exposure to digital media (Liu, 2005).

One often-overlooked health issue associated with digital media consumption, especially during childhood, is unhealthy viewing distance, which can lead to myopia, obesity, and even mental disorders (Marumoto, 1999; Dong et al., 2019). It is essential to understand the potential health risks associated with overconsumption of digital media and take necessary measures to minimize the adverse effects.(Twenge, Jean et al., 2018) Therefore, it is important to develop interventions that promote healthy viewing habits and positive reinforcement strategies to address the issue of unhealthy viewing distance caused by prolonged digital media consumption.

1.1.1 Unhealthy Proximity

Childhood is a critical time for forming habits, and positive reinforcement is central to creating healthy habits (Gardner, Benjamin, et al., 2012). According to a study conducted by Demirayak and colleagues in 2022, people who spend a prolonged amount of time looking at a screen may experience eye strain (Demirayak, Bengi et al., 2022). This condition causes the eyes to work harder to keep focused (Demirayak, Bengi et al., 2022). One of the most common reasons why people tend to get injured while using a screen is due to its proximity (Ming, Zhiyong et al., 2004). Holding one's shoulders and neck awkwardly can strain the muscles (Ming, Zhiyong et al., 2004). Also, getting too close to a display can result in poor posture, which can negatively affect one's overall health (Ming, Zhiyong et al., 2004). People who habitually hunch over a screen can experience various health problems, including breathing difficulties and back pain (Ming, Zhiyong et al., 2004).

Early intervention is crucial, as some research suggests that spending too much time in front of screens, particularly at a young age, can increase the risk of myopia or nearsightedness (Finlay Shonah 2022).

Lastly, staring at a screen too closely, particularly before bedtime, can disrupt sleep (Hale, Lauren et al., 2015). The blue light emitted from screens can interfere with the production of the melatonin hormone, making it harder to fall asleep and stay asleep (Esaki Yuichi, et al., 2016). By providing positive reinforcement for maintaining a healthy distance from screens, my thesis project can also contribute to better sleep quality in children.

While longer screen time can harm the human body, there are already many screen time monitoring software options available on the market. Therefore, the focus of this project is on addressing extreme proximity to screens, especially among children, by utilizing computer vision technology to promote healthy viewing habits.

1.2 Research Summary

1.2.1 Problem Statement

In the era of technology, intelligent devices have become indispensable to modern humans. While technology brings numerous benefits, unhealthy usage habits of smart devices can lead to physical problems (Pandya, Apurvakumar et al., 2021). Childhood is a critical time for forming habits(Gardner, Benjamin, et al., 2012). Therefore, it is essential to address these unhealthy habits early in life, focusing on either children or parents, to prevent long-term adverse effects on health.

1.2.1.1 Prolonged Screen Time

Excessive screen time can lead to various physical health problems for children, such as eye strain, headaches, neck and shoulder pain, and back pain (Falkenberg H K et al., 2020). Being sedentary for prolonged periods can also increase the risk of obesity, diabetes, and heart disease(Warren, Tatiana Y. et al., 2010). Furthermore, exposure to the blue light emitted by screens can disrupt children's circadian rhythms, affecting their sleep quality

(Dong K. et al., 2019). And the quality of sleep directly affects kids' physical development. (Gruber, Reut, et al., 2010)

In addition, too much screen time can lead to a range of mental health issues in children, including anxiety, depression, and poor self-esteem (Akulwar-Tajane, Isha et al., 2020). Social media, in particular, can lead to unfavorable comparisons and feelings of inadequacy (Akulwar-Tajane, Isha et al., 2020). Over-reliance on screens can also hinder the development of social skills, which are crucial for developing empathy, communication skills, and the ability to read non-verbal cues (Dutta Sanchari Sinha 2020).

Excessive screen time can be addictive, especially for children and adolescents (Child Mind Institute 2021). The constant need to check social media, play video games, or watch online videos can lead to compulsive behavior and interfere with daily life (Child Mind Institute 2021).

It is important to note that screen time itself is not necessarily problematic for children. The issue lies in the excessive and uncontrolled use of screens. To address this issue, it is essential for parents to set limits on screen time, prioritize real-life social interactions, and engage children in physical activity (Child Mind Institute 2021). Additionally, being mindful of the content children consume and its impact on their mental and emotional well-being is crucial (Child Mind Institute 2021).

1.3 Research Question

This thesis aims to explore the following question: **How can individuals be effectively reminded to maintain a healthy viewing distance from their digital screens while consuming digital content?**

This research question is particularly relevant in today's digital age, where many kids spend a significant portion of their time using digital devices. In order to address this question, several sub-questions need to be considered. For instance, *how can confusion among users be avoided when the video pauses due to unhealthy viewing distance?* This is an important question as the current prototype's only alert to users is to pause the video when the viewing distance is below a certain threshold, which may lead to confusion for the user. Another sub-question is *how to improve awareness of distance while watching?* This question focuses on finding a method to reflect users' viewing distance and increase their awareness of it. Ultimately, these research questions aim to identify effective strategies for promoting healthy digital habits. By finding ways to effectively remind individuals to maintain a healthy viewing distance, the project can help prevent eye strain and related problems and promote long-term eye health and overall well-being.

1.3.1 Potential Impact on Children

While the research question, "How can individuals be effectively reminded to maintain a healthy viewing distance from their digital screens while consuming digital content?" addresses the general population, this study places a special focus on children. The rationale for this emphasis on children is multifaceted. Children's eyes are still developing and may be more susceptible to eye strain, fatigue, and other health issues resulting from prolonged screen time and unhealthy viewing distances (Jones-Jordan et al. 2011). Addressing this issue early on can help prevent long-term negative impacts on children's eye health.

Habit formation is a critical aspect of this research, particularly in the context of children. By introducing effective strategies for maintaining a healthy viewing distance early in life, children can develop good habits that will carry into adulthood (Bener et al. 2010). Habits are formed through repetition and reinforcement, and by incorporating these elements into the proposed solutions, the aim is to instill lasting behavioral changes that contribute to better eye health and overall well-being throughout their lives (Lally et al. 2010).

With the increasing use of digital devices for education and entertainment, children today are exposed to screens for extended periods (Kabali et al. 2015). This exposure makes it essential to find effective solutions for ensuring that they maintain a healthy viewing distance while using digital devices.

Children often become more engrossed in digital content, making it difficult for them to notice when they are too close to the screen (Chassiakos et al. 2016). A solution that effectively reminds them to maintain a healthy distance can help counteract this challenge.

By focusing on children and habit formation, this research aims to explore solutions that are particularly suited to their needs and abilities, offering potential benefits to their eye health and long-term well-being.

1.4 Hypothesis

Context awareness may provide a solution to this problem, as it has the ability to understand and respond appropriately to its current environment and situation. A context-aware monitor is a monitoring system that can collect and analyze data in real-time, taking into account the context of the monitored environment to provide more accurate and relevant insights. Therefore, incorporating context-awareness into the monitoring system may help to effectively remind children to maintain a healthy viewing distance, ultimately promoting healthy digital habits and preventing eye strain and related problems.

1.5 Goals & Objectives

The ultimate goal of this project is to develop a system that effectively promotes healthy viewing distance among children of digital screens. This goal can be broken down into several objectives. The first objective is to accurately capture the user's distance from the screen, as this is critical in ensuring the program can react appropriately based on the distance measured. The next objective is to find a way to effectively communicate the user's viewing distance and promote healthy distance awareness.

1.6 General Project Contribution

This project holds the potential to contribute to the fields of computer vision, context awareness, and healthcare. Its primary goal is to address the persistent issue of children maintaining unhealthy viewing distances while consuming digital content. By incorporating positive and negative reinforcement techniques, the system can effectively assist children in forming habits that promote a healthy distance from screens during content consumption.

1.6.1 Contributions toward Children’s Healthy Media Consumption Habits

Targeting children, who are at a critical stage for habit formation, allows the system to create a lasting impact on their screen usage habits throughout their lives. By fostering healthy viewing habits and raising awareness of appropriate viewing distances, the project has the potential to enhance children's eye health and overall well-being. This, in turn, can reduce the risks associated with unhealthy proximity. The proposed system, with its emphasis on habit formation during childhood, serves as a valuable tool for mitigating the adverse effects of digital screen usage on children's health.

2. Literature Review

This section provides background knowledge on IoT and introduces the concept of context awareness,the methods of habit formation, as well as potential drawbacks of close-range screen viewing habits.

2.1 The Prevalence of Excessive Digital Media Consumption

There is a high prevalence of excessive screen time among young adults and adolescents, which has become increasingly common in recent years with the rise of smartphones, social media, and streaming platforms. In Brazil, for example, recent national estimates showed a prevalence of 51.8% in screen time among adolescents (Oliveira JS, Barufaldi LA, et al., 2016), and data from the Brazilian National School-Based Health Survey (PeNSE) showed that 78.0% of children are exposed to at least two hours a day of watching TV (Ministério do Planejamento, et al., 2010). Ten studies only reported data related to excessive screen time, and the meta-analysis showed a prevalence of 58.8% (95% CI: 49.4-68.0%) among Brazilian adolescents (Schaan, Camila W., et al., 2019). Similarly, in Spain, 59.2% of adolescents spend more than two hours per day in front of screens (Mielgo-Ayuso J et al., 2017). In Canada, 80.6% of adolescents spend more than two hours per day in front of screens (McMillan R et al., 2015).

In summary, unhealthy consumption habits of digital content have become increasingly common in recent years, as people spend more time than ever on their devices, often engaging in behaviors that can be detrimental to their mental and physical health due to the rise of smartphones, social media, and streaming platforms.

2.2 Problem with Extreme Proximity

2.2.1 Introduction

Extreme proximity to screens, such as mobile devices, laptops, and televisions, has become a widespread issue in today's society. People spend several hours daily using their devices, and this can negatively impact their health. This section discusses the drawbacks of getting too close to screens, including neck and shoulder pain, poor posture, and digital eye strain.

2.2.2 Neck and Shoulder Pain

A disadvantage of getting too close to a screen is that it can cause neck and shoulder pain (Shan, Zhi, et al., 2013). When people lean close to a screen, they may hold their neck and shoulders awkwardly, leading to muscle strain and discomfort (Shan, Zhi, et al., 2013). When people sit too close to a screen, they often stay in one position for an extended time without moving. This can cause muscles to become stiff and tense, leading to pain and discomfort (Shan, Zhi, et al., 2013). Studies have shown that prolonged screen time can result in musculoskeletal disorders (Kanchanomai et al., 2015).

2.2.3 Digital Eye Strain

Digital Eye Strain (DES), also known as computer vision syndrome, is caused by excessive use of digital devices (American Optometric Association, 2016). One of the most common symptoms of this condition is blurred vision.. This condition can sometimes last for a long time and is often temporary. Eye alignment is a process that allows one's eyes to work in a coordinated manner. Each eye sends different images to the brain, which then produces a single image. If one's eyes are not aligned correctly, they can potentially have double vision or have a negative impact on their depth perception. The study revealed that people who use a device with a closer viewing distance are more prone to experiencing visual problems. This suggests that getting closer to the screen can lead to more dysfunctional eyes (American Optometric Association, 2016).

In addition to eye alignment condition, viewing distance negatively correlates with eye strain (Long, Jennifer et al., 2017). One study implies that viewing distances are closer, and eye strain symptoms are more significant after reading from a smartphone for 60 minutes (Long, Jennifer et al., 2017). Symptoms of tired eyes, irritated eyes, and blurred vision increased significantly as people got closer (Long, Jennifer et al., 2017). Also, the shorter viewing distance implied poorer vision and a more significant deterioration of ocular accommodation. The primary cause of accommodation deterioration was the recession of the near point, and this is a risk factor for myopia (Marumoto, Tatsuya, et al., 1999).

2.2.4 Viewing Distance and Myopia

Myopia, commonly known as nearsightedness, is a condition in which a person can see nearby objects clearly, but objects farther away appear blurry(American Optometric Association, 2022). Myopia has become a significant public health issue worldwide, with an increasing prevalence of the condition in various countries in Southeast and East Asia, such as China, Japan, South Korea, Singapore, Taiwan, and Hong Kong (CW Pan, D

Ramamurthy, et al., 2012). In these countries, about 80% of students finishing high school are now considered to have myopia. On the other hand, around 10% to 20% of the population can have high myopia, a severe form of nearsightedness that can lead to vision loss (LL Lin, YF Shih, CK Hsiao, et al., 2004).

However, myopia is not limited to urban areas in these countries. In North America, the prevalence of myopia is also rising (S Vitale, RD Sperduto et al., 2009). It is estimated that the prevalence of myopia and high myopia will increase significantly from 2000 to 2050, with implications for planning services, including managing and preventing myopia-related ocular complications and vision loss among almost 1 billion people with high myopia (Holden, Brien A. et al., 2016).

One of the leading risk factors for myopia is the shorter viewing distance, which implies a poorer vision (Long, Jennifer et al., 2017). The study reported that close television viewing distances are significantly associated with myopia in 12-year-old Chinese children (Li, Shi-Ming, et al., 2015). The study suggests that children who spend more time indoors and engage in near-work activities, such as reading or using electronic devices, have a higher risk of developing myopia.

Furthermore, a study conducted in Singapore found that the prevalence of myopia among young adults was significantly higher among those who spent more time using electronic devices (Foreman, Joshua, et al., 2021). The study also revealed that prolonged screen time and a shorter viewing distance were associated with a higher risk of developing myopia.

Another study suggests that outdoor activities can help prevent the development of myopia in children (Wu, Pei-Chang et al., 2013). The study recommends that children spend at least two hours per day outdoors to reduce the risk of developing myopia.

In general, myopia is a growing public health concern globally, and the shorter viewing distance is one of the leading risk factors for developing myopia. Therefore, it is essential to promote outdoor activities and limit screen time, especially for children, to prevent the development of myopia.

2.2.5 A Healthy Viewing Distance

Eye care professionals recommend that individuals sit at least 2.2 to 4 meters away when watching TV (Sakamoto et al., 2009). However, the viewing distance is flexible and can be determined by the size of the TV (Sakamoto et al., 2009).

In the experiment conducted by Sakamoto et al. (2009), participants watched a 42-inch TV, and the researchers found that their visual fatigue reached a minimum at a distance of 220 cm. In experiment 2, participants watched a 65-inch TV, and the researchers found that their visual fatigue reached a minimum at a distance of 220 cm as well.

Therefore, it can be concluded that the healthy viewing distance is 220 cm relative to the screen size (Sakamoto et al., 2009).

2.2.6 Summary of Health Concerns

With the widespread adoption of technology and the reduction of technology products' cost, people's available screen time has increased significantly over the past decades. However, the excessive consumption of TV content can lead to various health problems, such as cardiovascular and cerebrovascular diseases, obesity, and poor concentration (Sharma, 2006). Additionally, excessive screen time can cause eye alignment dysfunction and myopia, particularly among adolescents and young adults, who are in critical periods of eye development (Long,Jennifer et al., 2017).

Therefore, it is crucial to promote healthy viewing habits, including maintaining a healthy viewing distance and taking regular breaks from screen time. Furthermore, technology companies should also design and market products that encourage healthy screen use, particularly among teenagers and young adults.

2.3 Habit formation in Childhood

2.3.1 Importance of Childhood Habit Formation

Childhood is a critical period for forming habits that can last a lifetime. During this developmental stage, children's brains are highly adaptable, allowing them to learn new behaviors and establish routines more easily than adults (Bronfenbrenner, Urie 1979).

In early childhood, the brain undergoes significant changes, including synaptogenesis, the process of forming new synaptic connections between neurons (Huttenlocher, Peter R., et al., 1997). This process results in an increased capacity for learning, making it easier for children to acquire new behaviors and establish routines.

The prefrontal cortex, an area of the brain responsible for decision-making, impulse control, and habit formation, also undergoes substantial development during childhood (Casey, BJ, et al., 2008). As the prefrontal cortex matures, children become better equipped to regulate their behavior, making it an opportune time for habit formation.

2.3.2 Habit Formation Methods in Behavioral Psychology

Behavioral psychology focuses on understanding how human behavior is shaped by environmental factors and the consequences of actions(Friedman, Howard S et al., 1999). Several habit formation techniques have been derived from behavioral psychology, helping individuals develop and maintain healthy habits including classic conditioning(Pavlov, Ivan P. 1927) and operant conditioning(Skinner, B.F. 1938). And operant conditioning is a learning process in which behaviors are influenced by their consequences, including rewards and punishments (Skinner, B.F. 1938). And under the category of operant conditioning, there are four major methods: positive reinforcement, negative reinforcement, positive punishment and negative punishment.

These methods have proven to be effective in designing products that target habit formation and behavior change. A recent design project that integrates both positive and negative reinforcement focuses on developing habit-forming applications and products aimed at fostering healthier lifestyles, such as engaging in physical activity and embracing nutritious eating habits (Ryan, R. M., & Deci, E. L., 2020). These applications frequently employ gamification, rewards, and personalized feedback to inspire users to participate in desired behaviors. At the same time, they utilize negative reinforcement by removing barriers or diminishing unpleasant experiences associated with these behaviors (Cugelman, B., 2013). By combining positive and negative reinforcement, these design projects effectively harness the principles of behavioral psychology to encourage users to adopt and maintain healthy habits.

2.3.3 Positive reinforcement & Negative reinforcement

Among these four methods, positive reinforcement and negative reinforcement are generally considered the most effective methods for encouraging habit formation, particularly in children (Kazdin, Alan E. 2013).

One of the reasons why positive and negative reinforcement are powerful is that they provide immediate feedback. This immediate feedback helps individuals make a direct connection between their actions and the consequences that follow. As a result, the association between the behavior and its outcome becomes stronger, making it more likely that the individual will repeat the behavior in the future.(Miltenberger, Raymond G., 2015). The other reason is that both positive and negative reinforcement create positive associations with the desired behavior. In the case of positive reinforcement, a rewarding stimulus is added after the behavior, making the experience enjoyable and reinforcing the behavior. With negative reinforcement, the removal of an aversive stimulus following the desired behavior creates a sense of relief, also creating a positive association with the behavior. These positive associations make it more likely that the individual will engage in the behavior consistently(Cooper, John O et al., 2018).

2.3.4 Summary

Understanding the importance of habit formation during childhood and the factors that influence it has significant implications for interventions designed to promote healthy behaviors. Programs and technologies that target children can leverage the unique opportunity to establish habits during this critical period. By incorporating reinforcement techniques and considering the environmental factors, interventions can be more effective in fostering lasting behavioral change.

In the context of this project, a computer vision-based system designed to promote healthy viewing distances from digital screens can be particularly beneficial for children, given their heightened capacity for habit formation. By utilizing positive and negative reinforcement techniques and involving parents in the process, the system can help children establish and maintain healthy screen habits that persist into adulthood.

2.4 Context Awareness

2.4.1 What is Context?

Context awareness is the ability of a system or application to understand and respond to the situation or environment in which it is being used(Perera, C et al., 2013). This involves taking into account information about the user, their location, their activities, and other relevant factors and using that information to adapt its behaviour or provide more relevant and valuable information (Perera, C et al., 2013).

Context awareness is essential to many modern technologies, including smartphones, smart homes, and wearable devices. It can help improve the user experience, increase efficiency, and provide more personalized and relevant services(Ganti, R.K., Ye, F., 2011). For instance, a context-aware music player might automatically adjust its playlist based on the user's location, time of day, and previous listening history. Similarly, a context-aware messaging app might suggest pre-written responses based on the content of the message, the user's past messages, and other factors.

Traditional computing methods require users to provide input to the computer to take advantage of the context(Abowd, G. D, et al., 1999). In contrast, context-aware computing enables users to collect contextual information easily using automated methods (Abowd, G. D, et al., 1999). Context-aware computing gained popularity after Mark Weiser published his seminal 1991 paper "The Computer for the 21st Century" (M. Weiser et al., 1991). In 1994, Theimerin and Schilit coined the term "context-aware" (B. Schilit and M. Theimer., 1994).

Numerous studies on context-aware computing have been conducted in the field of computer science. Over the years, engineers and researchers have also worked on various systems and prototypes that use context-aware computing techniques. Advancements in sensor technology have led to the development of more powerful and smaller sensors, leading to the large-scale deployment of these devices (H. Sundmaeker et al., 2010). The number of these sensors is predicted to continue to grow over the next decade (H. Sundmaeker et al., 2010).

In conclusion, context-aware computing is an essential component of modern technologies that can help improve the user experience, increase efficiency, and provide more personalized and relevant services. With the increasing deployment of sensors and the growth of data analytics, the potential for context-aware computing will continue to expand, enabling even more intelligent and adaptive systems and applications in the future(H. Sundmaeker et al., 2010).

2.4.2 History of Context Awareness

In the early days, context awareness was limited to simple sensors that could detect temperature, humidity, light, and other environmental parameters(Perera, C et al., 2013). These sensors were used in building automation systems and industrial processes to optimize energy usage and improve safety(Perera, C et al., 2013).

The first significant development in context awareness came with the emergence of mobile devices in the late 1990s (Papin-Ramcharan Jennifer, 2006). These devices were equipped with GPS, accelerometers, and gyroscopes, which allowed them to detect their location, movement, and orientation (Papin-Ramcharan Jennifer, 2006). This enabled mobile applications to provide location-based services, such as navigation, search, and personalized content (Wei Liu, Xue Li and Daoli Huang., 2011).

In the early 2000s, context-aware computing became an active area of research, with many universities and research institutes developing algorithms and models to infer context from sensor data (Dey, Anind K., 2018). These models were used in various applications, such as context-aware music recommendation systems, smart homes, and healthcare monitoring.

In 2007, the iPhone was released, revolutionizing the mobile industry and bringing context awareness to the mainstream. The iPhone's built-in sensors and apps provided users with location-based services, such as maps and weather, and paved the way for developing a wide range of context-aware applications.

Since then, context awareness has continued to evolve and expand to new domains, such as smart cities, intelligent transportation systems, and augmented reality (Herath, H., 2022). Machine learning and artificial intelligence have made it possible to develop more sophisticated models that can infer context from a wide range of data sources, such as social media, user behaviour, and environmental sensors (Pung, Hung Keng et al., 2006).

To sum up, the history of context awareness has been one of steady progress and continuous innovation, driven by technological advances and the growing demand for intelligent systems that can adapt to the user's needs and environment.

Today, computer vision technology is used in a wide range of applications, including autonomous vehicles, security systems, medical imaging, and augmented reality. The field continues to evolve rapidly, with breakthroughs and applications constantly emerging (Khattak, Sajid., 2023).

In computer vision, context awareness can improve the accuracy and usefulness of computer vision systems (Wang, Xuan et al., 2023). For example, a computer vision system can provide more targeted and relevant information or recommendations by incorporating contextual information about the user's location or preferences. Similarly, computer vision systems can improve their ability to recognize objects and interpret visual information accurately by understanding the broader context in which visual data is captured.

3. Related Works

3.1 Framework

In recent years, the usage of intelligent devices has become increasingly prevalent, and the need for effective usage monitoring and management has become more important than ever. To address this need, researchers have developed various frameworks for categorizing and analyzing the usage habits of intelligent devices.

One such framework divides usage habits into three dimensions: When, How, and What. The "When" dimension refers to the general screen time, which can be easily monitored using the Screen Time function available on smartphones and TVs. This function has been around for some time now and has become a popular way for users to track their usage time (Hartmann-Boyce, J., et al., 2021).

The "How" dimension encompasses how users interact with their devices, including the type of device they use, how they operate it, and the viewing distance. Studies have shown that these factors can affect not only the user's experience but also their health (Han, S., et al., 2019).

The "What" dimension refers to the type of content that users consume on their devices. This can include watching TV series, playing games, browsing social media, or engaging in other activities. Understanding what type of content users consume can provide insights into their interests and preferences and help developers create more personalized and engaging experiences (He, W., et al., 2016).

By analyzing the usage habits of intelligent devices across these three dimensions, researchers and developers can gain a better understanding of how users interact with their devices and develop more effective strategies for managing and improving the user experience.

3.2 TV Recommender System

Kim Noori and his team proposed a television recommender system that uses quadratic programming to learn a user's time-aware watching patterns. This system is a part of the larger field of recommender systems, which aim to provide personalized recommendations to users based on their past behavior and preferences(Kim Noo-ri et al., 2018).

The TV recommender system proposed by Noori and his team consists of three main modules: data collection, time pattern learning, and recommendation(Kim Noo-ri et al., 2018). The data collection module collects the user's watching history and preference information, which are used by the system to learn the user's viewing habits. The time pattern learning module uses quadratic programming to learn the user's time patterns, such as the preferred time to watch specific programs. This module takes into account factors like the day of the week, time of day, and the user's historical viewing behavior. Finally, the recommendation module generates personalized recommendations based on the user's watching history, preferences, and time patterns(Kim Noo-ri et al., 2018).

This TV recommender system is one of many examples of recommender systems being used in the entertainment industry. Other examples include music recommendation systems like Spotify, and movie recommendation systems like Netflix. These systems have become increasingly popular due to their ability to provide users with personalized recommendations, leading to a better user experience.

Recommender systems like the TV recommender system proposed by Noori and his team show the potential to revolutionize the way we consume entertainment. With the help of machine learning algorithms and data analytics, these systems can provide users with tailored recommendations that meet their unique preferences and viewing habits.

3.3 iPhone Screen Time Monitor

The iPhone Screen Time monitor is a feature introduced by Apple in iOS 12 to help users track the amount of time they spend on their iPhones and the apps they use. It is a useful tool that provides users with a detailed report on their phone usage habits, including the most frequently used apps and how often they pick up their phones(Apple., 2018).

Users can use the Screen Time monitor to limit their time on specific apps or categories of apps, such as social media or games, and when they reach their set limit, the app or category is blocked until the next day or until users turn off the limit. The monitor also allows users to set "downtime," during which certain apps or features of their phone are blocked, helping them to reduce their phone usage during certain times of the day, such as when users are supposed to be sleeping or studying(Apple., 2018).

In general, the iPhone Screen Time monitor is a helpful tool for anyone who wants to be more mindful of their phone usage and reduce their dependence on their devices. It provides valuable insights into users' usage habits and enables them to set limits and restrictions to help achieve their goals(Apple., 2021).

One study found that the introduction of the iPhone Screen Time monitor resulted in a significant reduction in phone usage, particularly among young people (Dwyer et al., 2020). Another study showed that the monitor was helpful in reducing problematic phone usage and increasing self-regulation among college students (Bozkurt et al., 2021). These findings suggest that the Screen Time monitor is a useful tool for promoting healthy phone usage habits.

3.4 Comparison

Prototypes	What	How	When
TV Recommender System	✓✓✓		
iPhone Screen Time Monitor			✓✓✓
Viewing Distance Monitor			

		✓✓✓	

3.5 Conclusion

Numerous products are available on the market to enhance users' usage habits, but most of them focus on "What" and "When." Examples of such products include YouTubeKids, Jellies, and Video Collections in the "What" category. Moreover, following the iPhone's pioneering inclusion of the Screen Time Monitor feature, major technology companies have started to follow suit. Thus, the need to improve "How" has become even more significant.

Kim Noori and his team's television recommender system is an excellent example of such an improvement. By using quadratic programming to learn a user's time-aware watching patterns, the system provides personalized recommendations based on the user's watching history, preferences, and time patterns(Kim Noo-ri et al., 2018).

Furthermore, the iPhone Screen Time monitor is a remarkable tool that helps users track their phone usage by providing detailed reports on the time spent on their phones, the apps they use the most, and how often they pick up their phones. It allows users to set limits and restrictions on certain apps or categories, such as social media or games, and even set "downtime" to block certain apps or features during specific periods(Apple., 2018).

In conclusion, it is essential to continue improving the "How" aspect of intelligent devices usage to enhance user experience and improve their overall well-being. The television recommender system and the iPhone Screen Time monitor, discussed above, are excellent examples of such improvements.

4. Methodology

4.1 Research through Design

Research through Design (RTD) is an approach to research that involves utilizing design practice and creating prototypes to investigate and explore research questions (Stappers, Pieter Jan et al., 2017). Instead of relying on traditional research methods such as surveys or experiments, RTD emphasizes the creation and testing of tangible artifacts. Designers often build and refine prototypes based on user or stakeholder feedback, using iteration to produce more accurate and effective results (Stappers, Pieter Jan et al., 2017).

RTD is commonly used to explore complex or emergent phenomena that may be difficult to capture using traditional research methods alone. By generating new ideas and insights that may have been previously impossible through more traditional forms of research, RTD allows for more innovative and creative approaches to problem-solving (Stappers, Pieter Jan et al., 2017).

During the design and development process, I utilized the RTD approach. This approach allowed me to explore the complex issue of distance awareness and develop innovative solutions.

My design and development process was aimed at providing users with awareness of distance. The first three prototypes aimed to capture distance.The prototypes could detect faces and measure distances, but they could not give real-time feedback to users. Therefore, the next task phase was to make the system capable of providing feedback to users. The Pause/Play prototype could pause the video when users' distances reached a threshold, but it needed to give feedback on why the video paused. The Audio Reminder prototype solved this problem by playing back voice hints. However, some users might not be sensitive to voice prompts. Therefore, the final prototype reflected users' distance through a progress bar.

The finger distance prototype was inspired by existing research on the accuracy of fingertip distance measurement in various applications, including healthcare and gaming (Reinecke et al., 2013). The eye distance prototype was influenced by research on the importance of accurate eye-tracking technology in various fields, including psychology and human-computer interaction (Holmqvist et al., 2011).

The Pause/Play prototype was influenced by research on the effects of interruptions on user experience and productivity (Mark et al., 2008). The Audio Reminder prototype was based on research on the effectiveness of audio prompts in various applications, including healthcare and education (Gates et al., 2016).

Finally, the use of a progress bar to reflect users' distance was influenced by research on the effectiveness of progress bars in various applications, including e-commerce and software development (Morville, 2008).

In summary, RTD is an interdisciplinary approach combining design, engineering, and social science research elements to create innovative solutions to complex problems.

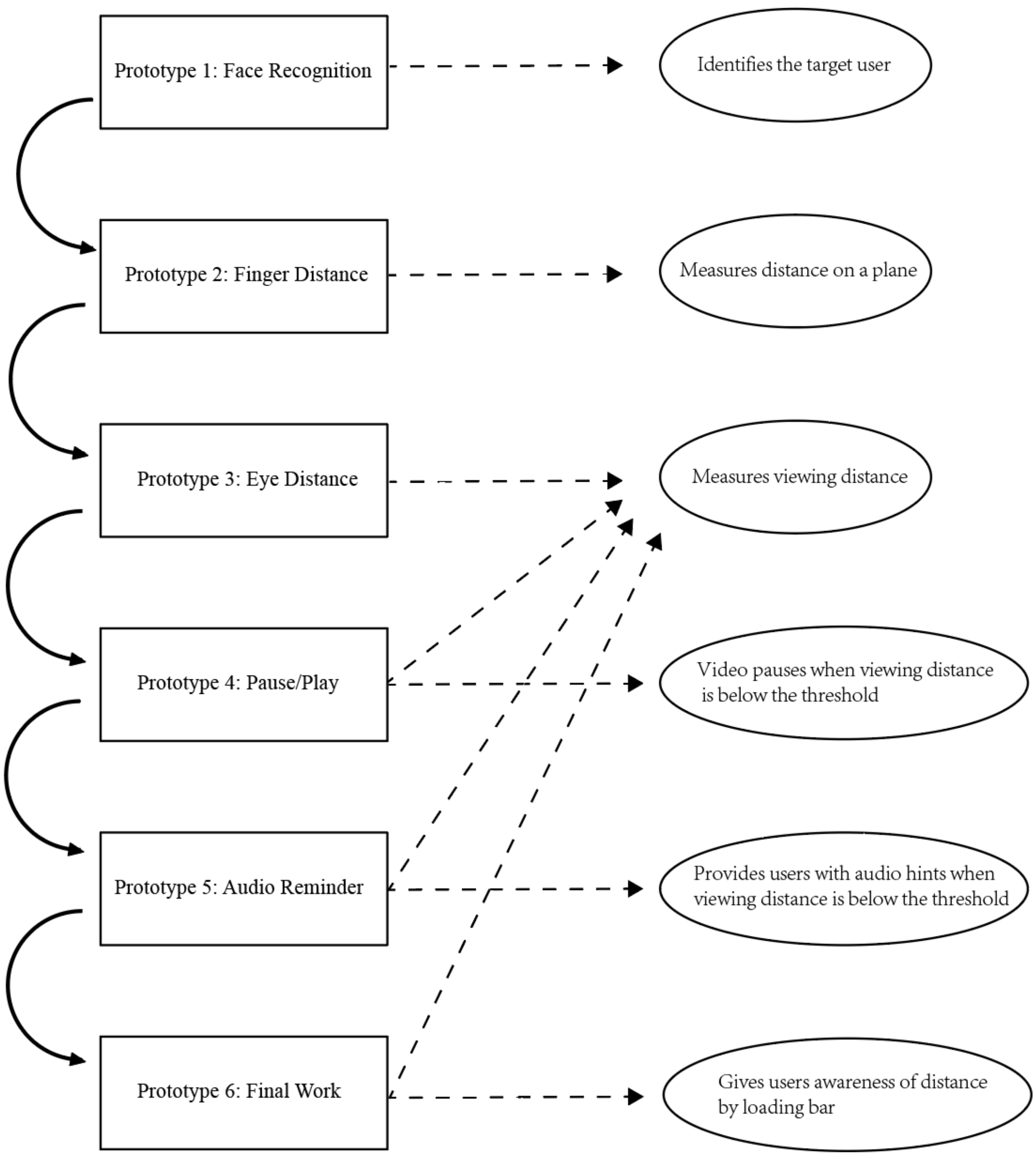

Figure 4.1 The Map of RTD of the Thesis Prototypes

4.2 General Design

Figure 4.1 depicts the theoretical design of the Viewing Distance Monitor. This computer vision project requires a camera to function. The camera captures the user's face, allowing the face detector to identify the target user and calculate their distance from the screen. The data is then transmitted to the front-end through the server. If the distance is less than the threshold set, a reminder is triggered to notify the user to adjust their viewing distance.

To ensure accuracy, the face detector must be capable of detecting faces under different lighting conditions, angles, and facial expressions. A possible solution to this is to use deep learning algorithms to train the face detector. Deep learning has been applied in numerous computer vision tasks, including face recognition and detection, with impressive results (Schroff, Kalenichenko, & Philbin, 2015).

Another aspect to consider is the selection of a suitable camera for the project. A high-resolution camera with low-light sensitivity would be ideal to capture facial details accurately, even in low-light conditions. In addition, the camera should be positioned in a way that ensures optimal facial capture and distance calculation.

Furthermore, the threshold for the minimum viewing distance should be based on scientific research. According to the American Optometric Association, the minimum viewing distance for electronic devices should be at least 25 inches (AOA, 2021). Therefore, setting the threshold at 25 inches could be a reliable starting point.

In summary, the Viewing Distance Monitor's theoretical design requires a camera, deep learning algorithms for face detection, a suitable camera for facial capture, and a scientifically-based threshold for minimum viewing distance. By implementing these elements, the Viewing Distance Monitor could help users maintain a healthy viewing distance and reduce eye strain.

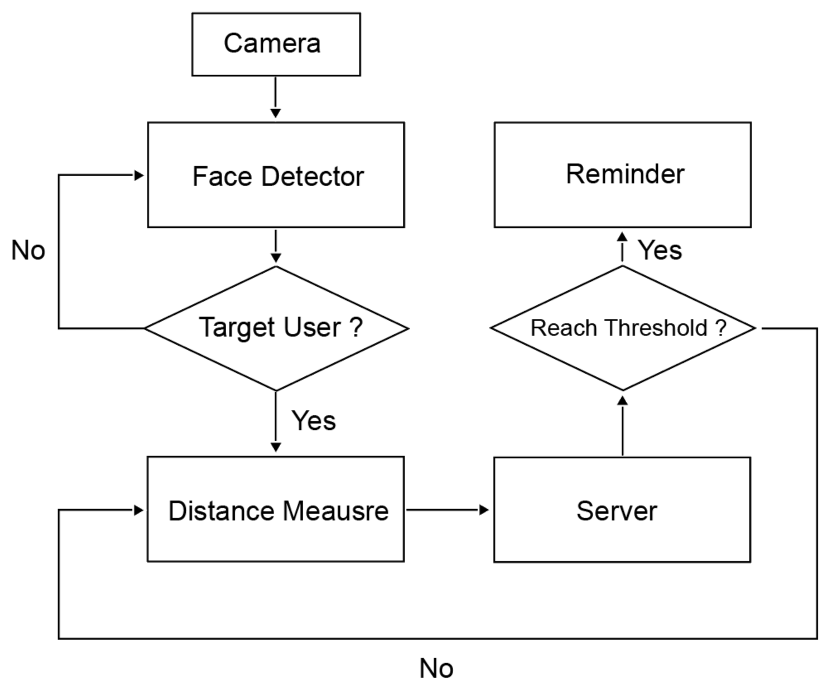

Figure 4.1 Theoretical Framework

4.3 Evaluation Parameters

The chosen evaluation framework is designed to address the research question: "How can individuals be effectively reminded to maintain a healthy viewing distance from their digital screens while consuming digital content?" To evaluate the prototype effectively, five parameters have been selected: 1) reinforcement strategy effectiveness, 2) consistency in feedback provision, 3) adaptability to individual needs, 4) engagement and motivation, and 5) integration with the daily routine. Each parameter is crucial in understanding how the system can contribute to habit formation in children.

4.3.1 Reinforcement strategy effectiveness

Reinforcement strategy effectiveness is a crucial parameter. The effectiveness of the reinforcement strategies employed by the system, such as positive and negative reinforcement, is essential to ensure that the desired habit formation takes place (Kazdin, Alan E. 2013).

The choice of this parameter is supported by research in behavioral psychology, which has shown that positive reinforcement and negative reinforcement are particularly effective in promoting habit formation, especially in children (Kazdin, Alan E. 2013). These reinforcement techniques work by providing immediate feedback and creating positive associations with the desired behavior, which in turn makes it more likely for the individual to engage in the behavior consistently (Gershoff, Elizabeth T., and Andrew Grogan-Kaylor 2016).

In the context of the system, the effectiveness of the reinforcement strategies is critical, as it directly influences the success of the habit formation process. If the reinforcement strategies are not effective, the system will be unable to help children form the habit of maintaining a healthy viewing distance, which is the primary goal of the project. Therefore, evaluating the system's reinforcement strategy effectiveness is essential for understanding whether the system is capable of achieving its intended goal (Kazdin, Alan E. 2013).

4.3.2 Consistency in feedback provision

Consistency in feedback provision is another essential parameter. Providing consistent feedback is crucial for habit formation, as it ensures that the reinforcement strategies are continuously applied, leading to stronger associations between the desired behavior and its consequences (Domjan, Michael 2018).

The importance of consistent feedback in the learning process has been well-established in the literature. Consistency promotes the development of automaticity, which is a key aspect of habit formation (Lally, Phillippa, et al. 2010). Consistent feedback allows individuals to learn and internalize the desired behavior more quickly, as it reinforces the behavior and its outcomes repeatedly (Gershoff, Elizabeth T., and Andrew Grogan-Kaylor 2016).

In the context of my project, consistency in feedback provision is essential for promoting habit formation in children. When the system provides consistent feedback about maintaining a healthy viewing distance, children are more likely to internalize the behavior and incorporate it into their daily routines. Evaluating the system's consistency in feedback provision helps determine whether the system is effective at promoting habit formation, which is crucial for achieving the project's goals (Domjan, Michael 2018).

4.3.3 Adaptability to individual needs

Adaptability to individual needs is also a crucial parameter. The system's ability to adapt to the unique needs of each child ensures that the reinforcement strategies and feedback are tailored to their specific requirements, thus increasing the effectiveness of the habit formation process (Miller, William R., and Stephen Rollnick 2012).

The importance of adaptability in learning and habit formation has been well-documented in the literature. Individual differences in learning styles, motivation, and personal preferences require a tailored approach to maximize the effectiveness of habit formation interventions (Ryan, Richard M., and Edward L. Deci 2000). Customizing the reinforcement strategies to the individual needs of each child allows for a more personalized and engaging experience, which can lead to better habit formation outcomes (Corno, Lyn 2008).

In my project, adaptability to individual needs is essential for promoting habit formation in children. By taking into account each child's unique characteristics and preferences, the system can deliver personalized feedback and reinforcement strategies that are more likely to encourage the desired behavior of maintaining a healthy viewing distance. Evaluating the system's adaptability to individual needs helps determine whether the system is effective at promoting habit formation and achieving the project's goals (Miller, William R., and Stephen Rollnick 2012).

4.3.4 Engagement and motivation

Engagement and motivation are vital parameters for evaluating the system. A system that effectively engages and motivates children is more likely to encourage the desired behavior and facilitate habit formation (Csikszentmihalyi, Mihaly 1997). Moreover, engaging and motivating interventions have been shown to lead to better learning outcomes and increased retention of new habits (Ryan, Richard M., and Edward L. Deci 2000).

The importance of engagement and motivation in habit formation has been well-established in the literature. Engaging interventions can capture children's attention, sustain their interest, and promote active participation in the habit formation process (Fredricks, Jennifer A., et al. 2004). Motivation, on the other hand, is a critical determinant of behavioral change, as it drives individuals to initiate, persist in, and complete tasks (Ryan, Richard M., and Edward L. Deci 2000). A system that can effectively engage and motivate children is more likely to succeed in helping them form new habits (Csikszentmihalyi, Mihaly 1997). In the context of my system, engagement and motivation are essential for fostering habit formation in children. By capturing children's attention and sustaining their interest, the system can facilitate the adoption of healthy viewing habits. Evaluating the system's ability to engage and motivate children helps determine whether the system is effective in achieving the project's goals and addressing the research question (Fredricks, Jennifer A., et al. 2004).

4.3.5 Integration with the daily routine

The final parameter is Integration with the daily routine. A system that can seamlessly integrate with children's daily routines is more likely to facilitate habit formation and promote long-term adherence to the desired behavior (Lally, Phillippa, et al. 2010).

The importance of integrating interventions with daily routines has been emphasized in the literature on habit formation. Habits are context-dependent and more likely to form when the desired behavior is consistently practiced within the same context (Wood, Wendy, and Dennis Rünger 2016). By integrating the system with children's daily routines, it becomes easier for children to associate the new habit with their everyday activities, leading to a more robust habit formation process (Gardner, Benjamin, et al. 2012).

For my project, integration with the daily routine is essential for fostering habit formation in children. The system should be designed in a way that it can be easily incorporated into children's everyday lives, without causing significant disruption or inconvenience. Evaluating the system's ability to integrate with children's daily routines helps determine its effectiveness in achieving the project's goals and addressing the research question (Lally, Phillippa, et al. 2010).

4.4 Speculative Approach

In this work, rather than focusing on user studies, a speculative approach has been adopted to adjust and refine the prototypes. This approach allows for the exploration of various potential use cases and the evolution of the prototypes, with the aim of better understanding how they might benefit the speculative user persona in both the short and long term.

The speculative approach employed in this work involves envisioning possible future scenarios and use cases for the prototypes. This method enables the development of creative solutions and strategies to address the problem of children getting too close to screens. By considering potential future scenarios, the design process can remain flexible and open to new ideas, enabling the prototypes to evolve and improve over time.

In addition,, In the speculative case, the criteria for success and the potential evolution of each prototype are explored. This includes examining how the prototype benefits users in the short term, such as immediate improvements in viewing distance and reduced parental intervention, as well as the long-term benefits, like the development of healthier viewing habits for children. Additionally, the speculative case considers how each prototype might evolve over time, both in the short term (e.g., enhancing accuracy or adding customization options) and the long term (e.g., integrating with other platforms, devices, or developing more advanced features).

Persona: Little Mike, a 7-year-old boy who loves watching his favorite cartoons. He has a curious and energetic personality, which often leads him to get excited and unconsciously move closer to the screen while watching. Despite his parents' efforts to set boundaries and explain the importance of maintaining a healthy viewing distance, Mike struggles to remember and follow the advice, as he gets easily absorbed in the content. His parents are concerned about the potential impact of Mike's screen habits on his eyesight and posture. They have tried different strategies such as setting timers, using a tape on the floor as a boundary, and even limiting his screen time. However, these methods haven't been successful in helping Mike consistently maintain a healthy viewing distance.

Prototypes	Short Term (1-2 years)	Long Term(3 or more years)
How does the prototype benefit the user?	In order to explore how the prototype is going to benefit little Mike after the prototype is being used in one or two years.	In order to explore how the prototype is going to benefit little Mike after the prototype is being used in 3 or more years.
How does the prototype evolve?	Short term plan for the prototype evolution	Long term plan for the prototype evolution

4.5 Summary

This chapter outlined the methodology employed in this project to address the issue of children maintaining a healthy viewing distance from screens. A Research through Design (RTD) approach was utilized, enabling the exploration of complex issues and the development of innovative solutions through design and prototyping. The chapter also discussed the theoretical design of the Viewing Distance Monitor, which relies on computer vision, deep learning algorithms, and a suitable camera to provide real-time feedback to users.

The evaluation parameters proposed in the chapter provides a comprehensive framework for assessing the potential effectiveness of the system in helping children form a habit of maintaining a healthy viewing distance from their digital screens while consuming digital content. The five parameters – reinforcement strategy effectiveness, consistency in feedback provision, adaptability to individual needs, engagement and motivation, and integration with the daily routine – are all rooted in the principles of habit formation, behavioral psychology, and user-centered design.

These evaluation parameters have been carefully selected to address the research question and ensure that the system is designed to facilitate the habit formation process in children. By examining the system's performance across these parameters, it is possible to identify areas where the system is successful in promoting the desired behavior and where improvements may be needed.

A speculative approach was adopted, focusing on potential use cases and the evolution of the prototypes, rather than user studies. This approach allows for the development of creative solutions and strategies for addressing the problem of children getting too close to screens, as well as the exploration of short-term and long-term benefits of the prototypes. The speculative use case of little Mike and his family serves to exemplify the potential impact of these prototypes on users.

Overall, this chapter provided a comprehensive overview of the methodology employed in the project, including the RTD approach, general design considerations, evaluation parameters, and the speculative approach for refining and evolving the prototypes.

5. Iterative prototyping

5.1 The First Computer Vision Project: where it begins

As mentioned, my interest in computer vision technology began with my early interaction with it. Here is a brief description of my very first computer vision project. The aim of this project was to explore the possibilities of basic computer vision implementations. The project demonstrates how the computer can be controlled with body movements, essentially using the body as a remote control. The project was developed using P5JS and PoseNet.

```
function setup() {
  createCanvas(400, 300);
  //background(0)
  video = createCapture(VIDEO);
  scale(-1,1);
  image(video,-video.width,video.height)
  video.hide();
  poseNet = ml5.poseNet(video, modelLoaded);
  poseNet.on("pose", gotPoses);
  a = 100;
  c = a * 2;
  d = 3;
}
function gotPoses(poses) {
  console.log(poses);
  if (poses.length > 0) {
    pose = poses[0].pose;
  }
}
function modelLoaded() {
  console.log("poseNet ready");
}
```

Figure 5.1 Closer/Further - code snippets

The program requests the use of the computer's webcam. Once the webcam is activated, it measures the distance between the person and the computer. There is a purple dot in the middle of the screen, and as users move closer to the camera, the square around the dot gets larger. Conversely, the square gets smaller as users move further away from the camera. In addition to motion capture, a "random" function has been implemented to vary the color of the dot.

Figure 5.2 Closer/Further - the dot

5.2 Early Prototypes

The initial design process starts with a set of computer vision experiments to examine the feasibility of implementing the final feature.

5.2.1 Face Recognition prototype[1]

The ultimate aim is to create awareness of distance among people. Therefore, the system must be capable of identifying the person whose distance needs to be measured. Hence, the first step is to locate the target user from a group of individuals. This necessitates facial recognition when people are in a crowd.

[1] https://www.youtube.com/watch?v=L1YjriXmIz8

The purpose of facial recognition is to identify the target user accurately when people are in a group. The project is generally divided into two sections: face registration and face recognition.

5.2.1.1 Face Register

As the name implies, the primary function of Face Registration is to record an individual's facial features using the dlib-hog face detector. Once it detects a face, the system captures the features of that face and saves them in a CSV file.

```
#hog face detector:
hog_face_detector = dlib.get_frontal_face_detector()
#shape detector:
shape_detector = dlib.shape_predictor('./weights/shape_predictor_68_face_landmarks.dat')
#feature descriptor.
face_descriptor_extractor = dlib.face_recognition_model_v1('./weights/dlib_face_recognition_resnet_model_v1.dat')
```

Figure 5. 3 Dlib Hog Face Detector

When the face detector is active, the system initially determines if the object is a face. If it is, the face_recognition_model extracts features from the face, specifically, labeling 68 crucial face landmarks. These 68 landmarks construct the final face feature vector. To improve the prediction accuracy, more data on the face should be collected. Hence, it is better to collect more than three pictures of each face.

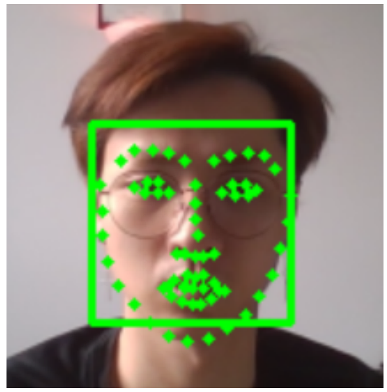

Figure 5. 4 68 Face Landmarks

```
if collect_count < count:
    # time
    now = time.time()
    # time interval
    if now -start_time > interval:

        # face_descriptor
        face_descriptor = face_descriptor_extractor.compute_face_descriptor(frame,points)

        # list-Fy
        face_descriptor =  [f for f in face_descriptor]

        # CVS file
        line = [label_id,name,face_descriptor]

        csv_writer.writerow(line)


        collect_count +=1

        start_time = now

        print("collect_count:{collect_count}".format(collect_count= collect_count))
```

Figure 5. 5 Making Comparison

Moreover, the CSV file, which stores face feature data, contains detailed information about facial features. In Figure 5.4, the red box represents the username, i.e., users recognized by their face, while the yellow box represents the face features of that user.

```
1,Target User,"[-0.11887996643781662, 0.10075860470533371,
1,Target User,"[-0.14295551180839539, 0.09002546966075897,
1,Target User,"[-0.11393478512763977, 0.09448565542697906,
1,Target User,"[-0.12127745151519775, 0.10972572863101959,
1,Target User,"[-0.11278428882360458, 0.09412015229463577,
```

Figure 5. 6 CSV File storing the face feature

The first step is now completed. The next step is to develop a face recognizer. While the face registration module can capture the facial features of the target user, it cannot identify them because the program lacks the ability to compare the newly captured face with the database and determine whether the face belongs to the target user. Therefore, a face recognizer is required in this scenario.

5.2.1.2 Face Recognizer[2]

In the process of face recognition, after the system captures the facial features of the target user, the face recognizer comes into play. The primary goal of this stage is to compare the newly captured face with the data available in the CSV file to determine if the person is the target user. The system sets a threshold value for the comparison score, which is used to decide whether the newly captured face belongs to the target user or not.

```
# feature descriptor for new face
face_descriptor_extractor = dlib.face_recognition_model_v1('./weights/dlib_face_recognition_resnet_model_v1.dat')

# read features from new face
label_list,name_list,feature_list = getFeatureList()
```

Figure 5. 7 Feature Descriptor for new face

[2] https://github.com/YoungYoungYoung10/Face-Recognizer

As shown in Figure 5.7, the feature descriptor for the new face is compared with the database to calculate the comparison score. Figure 5.8 illustrates the comparison score and threshold value, which is a critical factor in deciding whether the face belongs to the target user or not. If the comparison score is less than the threshold, the console will print "Target User," and if the comparison score is higher than the threshold, the console will print "Unknown."

```
# calculate the distance from the data base
face_descriptor = np.asarray(face_descriptor,dtype=np.float64)


distances = np.linalg.norm((face_descriptor-feature_list),axis=1)
# minimun distance
min_index = np.argmin(distances)
#
min_distance = distances[min_index]

if min_distance < threshold:


    predict_id = label_list[min_index]
    predict_name = name_list[min_index]


    if predict_name in recog_record:
        pass
    else:
        recog_record[predict_name] = time.time()
        print(predict_name)
else:
    print('Unknow')
```

Figure 5. 8 Comparison Score & Threshold

However, identifying the target user alone is not enough; we also need to determine their distance. Therefore, the program must identify the distance of the target user to provide awareness of distance. As shown in Figure 5.9, the working pattern of the face recognition prototype includes both face register and recognizer. The two components of the prototype, face register and recognizer, work in tandem to provide a comprehensive solution for the user.

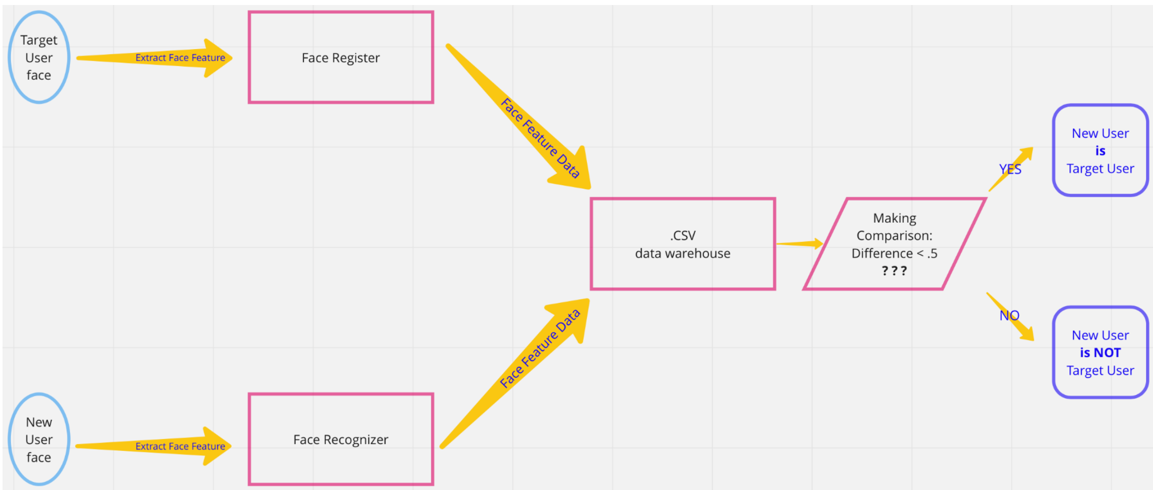

Figure 5. 9 Working Pattern of Face Recognition prototype

5.2.1.3 Functional Evaluation

The primary purpose of the Face Recognition prototype is to enable the system to recognize the target user among a group of people. For instance, if three people are watching TV, the parents would want their child to be the target user instead of themselves. Under such circumstances, the system should be able to locate the target user and measure their distance from the screen. Therefore, the most crucial standard for evaluating the prototype is to see if the program can still recognize the target user while others are in the camera.

Functional evaluation is conducted to test if the prototype functions as intended. The first step is to record the facial features of the target user. The program collects five mugshots of the target user and stores them in the database. This process is displayed in the console.

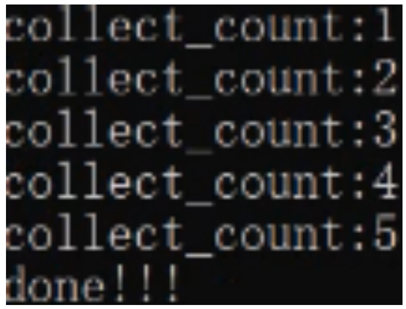

Figure 5. 10 System Feedback

When the file, named feature.csv, has been re-written and vectors and float data are showing up, it means that the face feature has been successfully recorded and processed. Then I can start to test if the logic and codes work fine. As usual, in the console, I choose the model of "recog," which stands for face recognition. When the program starts along with the built-in camera, if the person standing before the camera is the target user, the console will log "Target User." However, if the face is unrecognized, the console will log "Unknown."

In this case, the console logged "Target User," indicating that the prototype is fully functional.

5.2.1.4 Subjective Evaluation

Reinforcement strategy effectiveness: 1/5

The face recognition prototype does not directly incorporate reinforcement strategies as its primary focus is on identifying the target user. However, it lays the foundation for reinforcement strategies by accurately identifying the child as the target user. Therefore, it is a necessary component for future reinforcement implementation.

Consistency in feedback provision: 3/5

The prototype detects and recognizes the target user, allowing the system to consistently provide feedback when the child is present. However, the described precision of 65% indicates that there is room for improvement to ensure consistent feedback.

Adaptability to individual needs: 2/5

The prototype can be tailored to recognize different children by registering their facial features. This adaptability allows the system to cater to individual users effectively. However, it doesn't directly address the unique reinforcement needs of children.

Engagement and motivation: 1/5

While the prototype successfully recognizes the target user, it doesn't directly contribute to engagement and motivation related to habit formation. The face recognition component is essential but doesn't provide engaging or motivating elements by itself.

Integration with the daily routine: 2/5

The Face Recognition prototype does not seamlessly integrate into users' daily routines, as it requires manual setup and calibration to ensure accurate identification. Additionally, it may not work optimally in various environments or lighting conditions, which could limit its usefulness in daily life. To improve this aspect, the prototype could be developed further to become more user-friendly, adaptable to different settings, and less reliant on manual intervention.

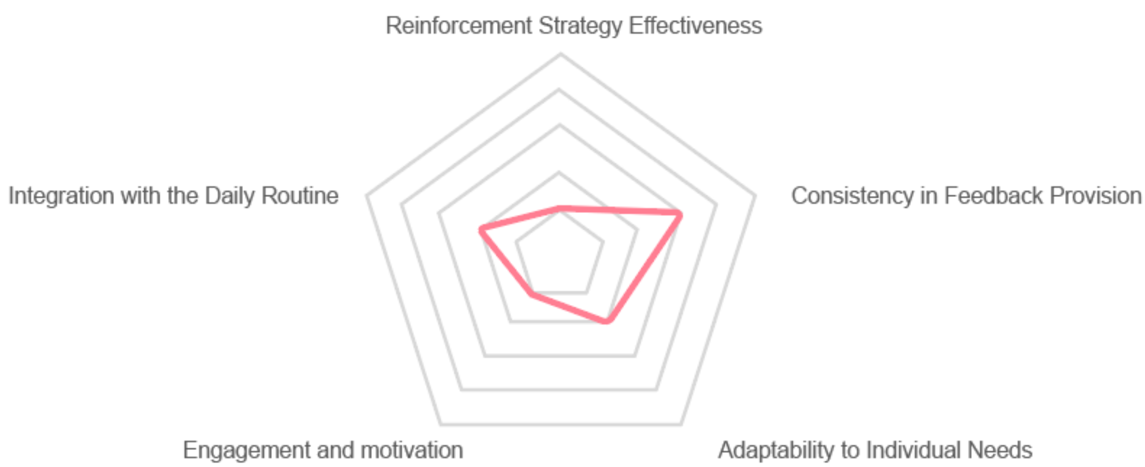

Figure 5.11 Subjective Evaluation for Prototype 1

5.2.1.5 Speculative use case and Evolution

Persona: little Mike from Chapter 4.4

Face Recognition Prototype	Short Term (1-2 years)	Long Term(3 or more years)
How does the prototype benefit the user?	As the prototype does not give feedback on the viewing distance, it can hardly bring benefits to little Mike in the short term.	As the prototype does not give feedback on the viewing distance, it can hardly benefit little Mike.

	However, it does provide value by enabling the system to identify target users in multi-user environments. For instance, when little Mike and his parents are sitting in front of the TV, the prototype can differentiate between them and potentially offer customized feedback specifically for little Mike. This feature enhances the user experience and lays the foundation for future improvements to the system.	
How does the prototype evolve?	Enhanced accuracy: By refining the computer vision algorithms, the prototype can detect and analyze users' viewing distances with increased precision, leading to more timely and accurate reminders.	As the purpose of the prototype is to lay the foundation for future iterations, it does not have long-term development plan.

5.2.1.6 Limitations

Although the Face Recognition prototype is fully functional, it does have certain limitations that need to be considered. For example, the prototype needs to be tested in different environments to ensure that it works effectively in real-life scenarios.

One of the most significant concerns regarding the prototype's functionality is precision. There are two dimensions to measuring a successful Face Recognition Algorithm:

processing speed (i.e., random access memory) and precision. However, the prototype often fails to recognize the Target User, and the precision is only around 65%, which is not up to the product level. In contrast, the precision of the face recognition algorithm used by Apple, the Voila-Jones Detection Algorithm, is up to 97%(Face ID Security Overview, 2018), indicating that the prototype still requires significant improvements.

Another limitation of the prototype is its inability to perform effectively in a multi-person environment. Although the prototype's original intention was to locate the Target User in a crowd, it struggles to do so due to its low precision. This problem can only be solved by improving the algorithms, which requires extensive engineering and testing.

5.2.1.7 Summary

The face recognition prototype successfully detects and identifies the target user, which is crucial for providing personalized reminders. This capability addresses one aspect of the research question, as it helps identify the individual who needs to be reminded. However, the prototype does not fully answer the research question due to two missing elements: distance measurement and effective reminder provision.

The current prototype lacks the ability to measure the distance between the user and the screen, which is essential for determining if the child is maintaining a healthy viewing distance. Without this feature, the prototype cannot accurately assess when a reminder is needed.

Additionally, the current prototype does not provide any effective reminder mechanism. To address the research question, the prototype should incorporate reinforcement strategies, such as visual or auditory cues, to effectively encourage them to maintain a healthy viewing distance.

In conclusion, the face recognition prototype does not fully answer the research question, as it only addresses user identification. To provide a comprehensive solution, the prototype needs to be enhanced by adding distance measurement capabilities and an effective reminder system. By addressing these missing elements, the refined prototype will be better suited to help children maintain a healthy viewing distance while consuming digital content.

5.2.2 Finger Distance prototype[3]

5.2.2.1 Why does it need distance?

One of the main goals of this project is to raise awareness about viewing distance. Measuring distance is crucial for achieving this function in the final product. The system requires distance measurement as a controller to respond to varied viewing distances. Moreover, viewing distance is negatively correlated with the possibility of developing myopia. Therefore, this project aims to answer a fundamental question: Is it possible to

[3] https://www.youtube.com/watch?v=GUgdP-sSWPk&t=133s

measure distance with a built-in camera? The exploration of this question starts with measuring the distance between two fingertips.

5.2.2.2 Process

The OpenCV library provides great features for users, including the ability to realize various functionalities. For this project, I used the Mediapipe library[4]. As discussed in the Literature Review section, Mediapipe is a framework for perceiving and processing reality.

The first step in the process is to enable the program to recognize hands. To achieve this, I imported the Mediapipe library and called for a hand model. Once the hand model was successfully implemented, I appended all the hand landmarks to the list, and the hands were detected.

[4]https://google.github.io/mediapipe/solutions/hands.html

```python
#mediapipe JUSTIFICATION
import mediapipe as mp
mp_drawing = mp.solutions.drawing_utils
mp_drawing_styles = mp.solutions.drawing_styles
mp_hands = mp.solutions.hands

hands = mp_hands.Hands(
    model_complexity=0,
    min_detection_confidence=0.5,
    min_tracking_confidence=0.5)

#camera
cap = cv2.VideoCapture(0)

#
height = int(cap.get(cv2.CAP_PROP_FRAME_HEIGHT))
width = int(cap.get(cv2.CAP_PROP_FRAME_WIDTH))
```

Figure 5. 12 Importing Mediapipe Hand Model(https://google.github.io/mediapipe/solutions/hands.html)

After successfully implementing the hand model, I appended all the hand landmarks to the list. Therefore, I could see the hands being detected.

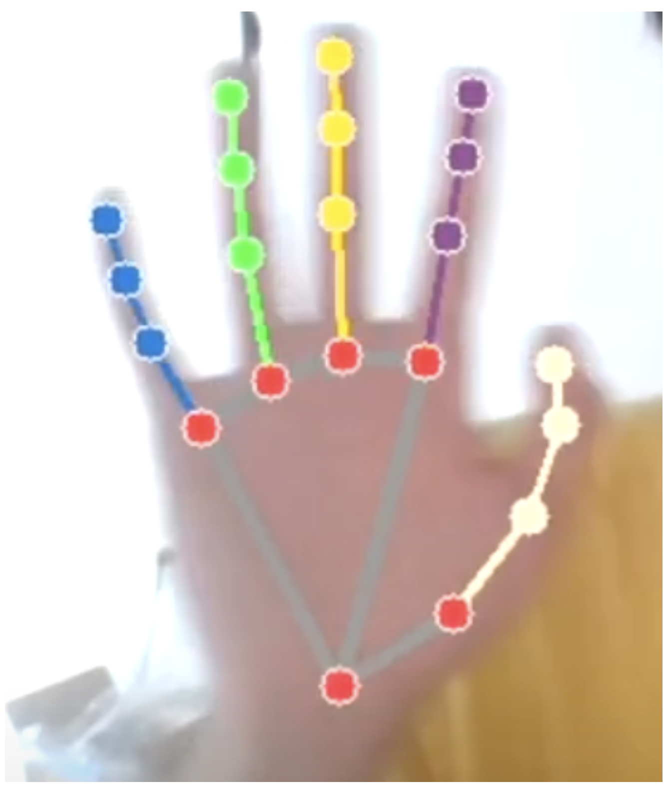

Figure 5. 13 Hands detected

Measuring the distance between fingertips involves algorithms within the scope of two-dimensional Mathematics. One of the fundamental formulas used in this process is Pythagoras's theorem, which provides the formula for the distance between two points in a plane (Tanimoto, Steven L., 1998). Distance metrics are increasingly essential because they are used in a growing number of internet and database search engines.

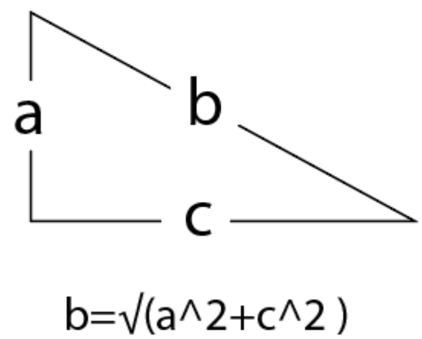

Figure 5. 14 The Pythagorean Theorem

5.2.2.3 Functional Evaluation

In this experiment, the primary objective was to determine whether measuring the distance between fingertips using a built-in camera is possible. To test this hypothesis, a removable rectangle was drawn on a canvas, and the distance between the tip of the middle finger and the index finger was measured. The experiment proceeded with the assumption that both the middle and index fingertip coordinates fall within the rectangle's border, and the distance between them is less than 30 pixels.

The fingertip distance was calculated to determine whether the rectangle could be removed. If the distance between the fingertips was less than 30 pixels, the rectangle could be removed. However, if the distance exceeded 30 pixels, the rectangle remained still and was unremovable.

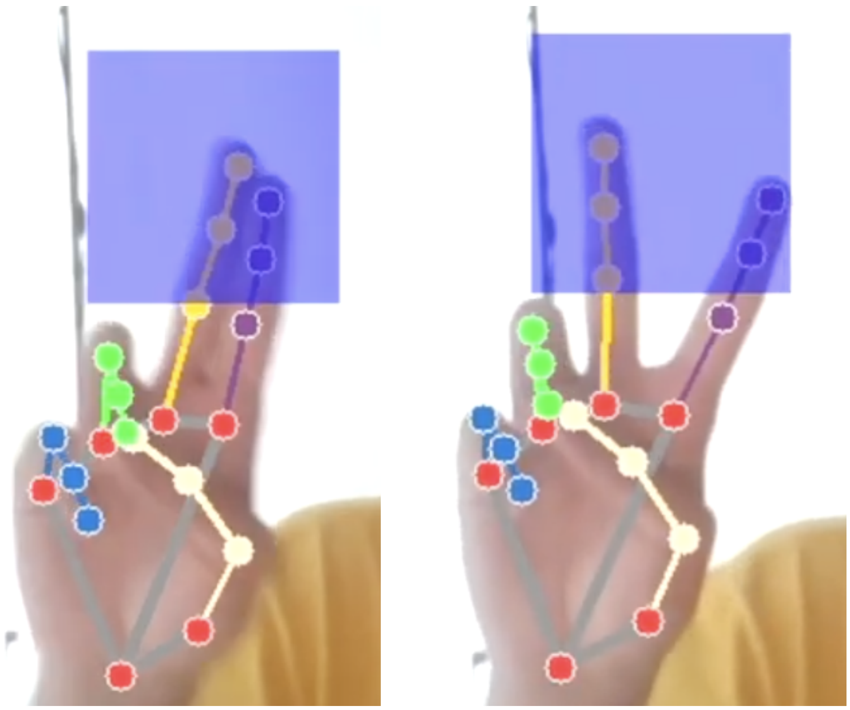

Figure 5. 15 Rectangle Status: "Picked up" & "Released"

According to the results, the rectangle is removable whenever the distance is less than 30 pixels and vice versa. This means that the prototype is fully functional.

5.2.2.4 Subjective Evaluation

Reinforcement strategy effectiveness: 1/5

The Finger Distance prototype measures the distance between two fingertips but does not provide any reinforcement or feedback regarding healthy viewing distances from digital screens. As it does not directly contribute to promoting or reinforcing healthy habits, its effectiveness as a reinforcement strategy is limited.

Consistency in feedback provision: 3/5

The prototype consistently measures the distance between fingertips, providing a reliable method for this specific measurement. While this consistency is useful, it is not directly related to feedback on maintaining a healthy viewing distance.

Adaptability to individual needs: 1/5

The Finger Distance prototype measures the distance between two fingertips using a built-in camera, which may not be relevant or adaptable to individual needs in the context of maintaining a healthy viewing distance from digital screens. As the current prototype does not provide any customization options or specific features that cater to the target audience, its adaptability to individual needs is quite limited.Engagement and motivation: 2/5The Finger Distance prototype, as it currently functions, measures the distance between two fingertips using a built-in camera. While this feature may be engaging and motivating for users interested in measuring the distance between their fingertips, it does not directly address the research question of maintaining a healthy viewing distance from digital screens.

Engagement and motivation: 1/5

The Finger Distance prototype, as it currently functions, measures the distance between two fingertips using a built-in camera. However, it does not directly address the research question of maintaining a healthy viewing distance from digital screens.

Integration with the daily routine: 2/5

The Finger Distance prototype measures the distance between two fingertips using a built-in camera, which makes it relatively easy to use without additional hardware. However, its application to the research question of maintaining a healthy viewing distance from digital screens is limited. The prototype, as it currently stands, does not offer a direct solution to the problem, so its integration into users' daily routines for the intended purpose is not highly effective.

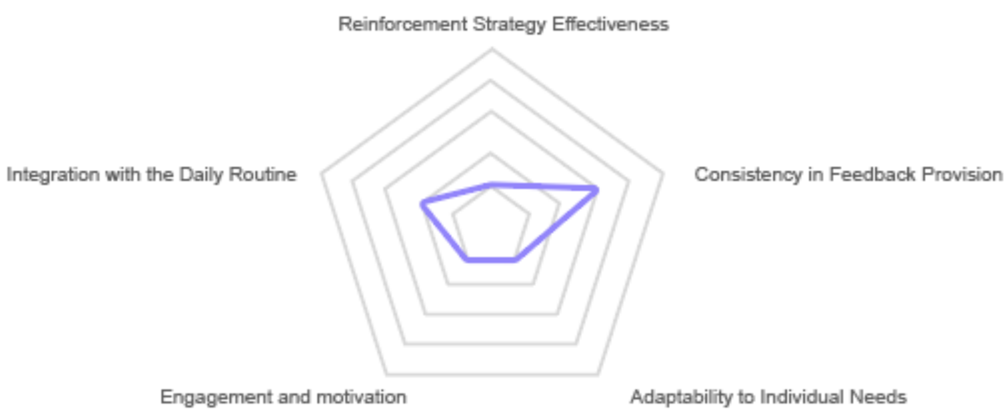

Figure 5.16 Subjective Evaluation for Prototype 2

5.2.2.5 Speculative use case and Evolution

Persona: little Mike from Chapter 4.4

Finger Distance Prototype	Short Term (1-2 years)	Long Term(3 or more years)
How does the prototype benefit the user?	As the prototype does not give feedback on the viewing distance, it can hardly bring benefits to little Mike in the short term.	As the prototype does not give feedback on the viewing distance, it can hardly benefit little Mike.
How does the prototype evolve?	As the purpose of the prototype is to lay the foundation for future iterations, it does not have further development plan.	As the purpose of the prototype is to lay the foundation for future iterations, it does not have further development plan.

5.2.2.6 Summary

Finger Distance Prototype[5] successfully demonstrates the ability to measure the distance between fingertips using a built-in camera, which highlights its potential for distance measurement applications.

However, the prototype falls short in fully addressing the research question as it does not directly tackle the issue of maintaining a healthy viewing distance from digital screens. Additionally, the prototype lacks a mechanism for providing effective reminders to users, which is a key component of the research question.

[5] https://github.com/YoungYoungYoung10/Finger-Distance

In summary, while the Finger Distance Prototype shows promise in distance measurement using a built-in camera, it does not fully answer the research question due to its inability to address healthy viewing distance from screens and provide effective reminders. To fully address the research question, further development of the prototype or exploration of additional prototypes is needed, incorporating solutions for both distance measurement from screens and effective reminder mechanisms.

5.2.3 Eye Distance prototype

5.2.3.1 Why Eye Distance?

In a previous experiment, a prototype measuring finger distance was created, which proved that measuring the distance with computer vision technology is possible. However, the Finger Distance prototype only measured distances on a two-dimensional plane. To accurately measure the distance that reflects the vertical proximity of a person to the screen, a more advanced and complex distance-measuring prototype is needed.

5.2.3.2 Solutions

Accurate distance measurement is essential for robots and smart systems to identify their positions and distances, especially in industrial applications. Stereo cameras are one of the most frequently-used tools for this purpose. Stereo cameras can help robots locate objects and faces with high precision (Dandil, Emre, et al., 2019).

A stereo camera is an imitation of human eyes, with two monitors just like humans have two eyes. This is because, evolutionally, most mammals take advantage of binocular localization, which makes it easier for them to locate their prey (Wei, Meng., 2018). Similarly, stereo cameras can accurately locate objects with relatively high precision.

Another method for distance measurement is using one-channel cameras, which have only one monitor. While one-channel cameras are less precise than stereo cameras, their precision can be improved through the use of algorithms.

However, due to the complexity of the algorithm required for stereo cameras, they are often more expensive than one-channel cameras. A versatile and functional stereo camera can cost over $400, which may be outside of the budget for some projects. Therefore, this method may not always be feasible.

In summary, both stereo cameras and one-channel cameras can be used for distance measurement in computer vision technology. Stereo cameras are more accurate but more expensive, while one-channel cameras are less precise but more cost-effective. The choice of camera will depend on the specific requirements of the project and budget constraints.

5.2.3.3 Process

The process of measuring distance using computer vision technology involves several steps. Firstly, the program needs to locate the target user accurately. Previously, face registers and face recognizers were used, but they were limited due to precision and technical complexity. Instead, a face predictor can be used, which is a more effective tool for locating faces but does not have the functionality of registering and recognizing a target user. It simply detects if a face appears in the camera.

After locating the user's face, the next step is to measure the distance between the user and the screen accurately. One method that can be used is the side-angle-side (SAS) theorem, which states that two triangular structures are similar if the ratios of the two adjacent sides are the same, and the included angle between them is congruent.

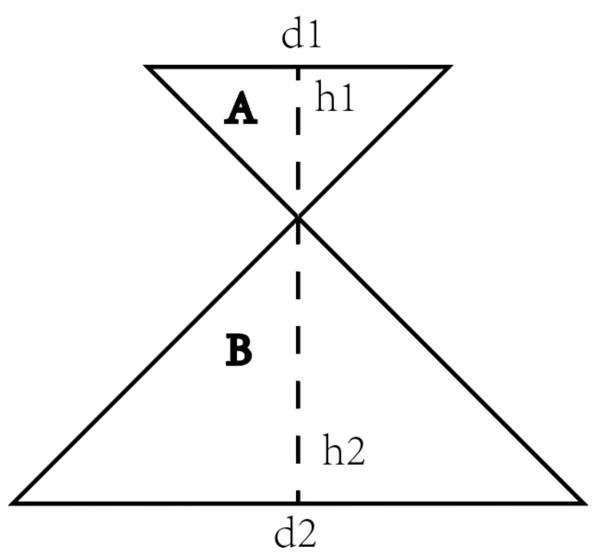

Figure 5. 16 SAS Theorem

To apply this theorem, we need to create two triangles, A and B. We know the lengths of the bottom sides of the two triangles, d1, and d2, respectively, and the height of triangle A, h1. Using the SAS theorem, we can calculate the height of triangle B, h2, by h2 = (d1/d2) * h1. This height is the vertical distance between the user's face and the screen, which accurately reflects the user's proximity to the screen.

5.2.3.4 Functional Evaluation

The prototype developed aims to accurately identify human faces and measure the distance between the camera and the face. The evaluation process for this prototype involves measuring its ability to identify faces and accurately measure distances.

Upon turning on the program, the face predictor successfully identified faces. The next step was to evaluate the prototype's accuracy in distance detection. To do this, a 1-meter-long tape was cut and pasted on the floor, creating two ends. The camera was positioned above one end, ensuring that it was aligned with the other end. The user then stood on the second end, creating a distance of 1 meter between the face and the camera. With the program turned on, the prototype was tested for accuracy in measuring the distance between the face and the camera.

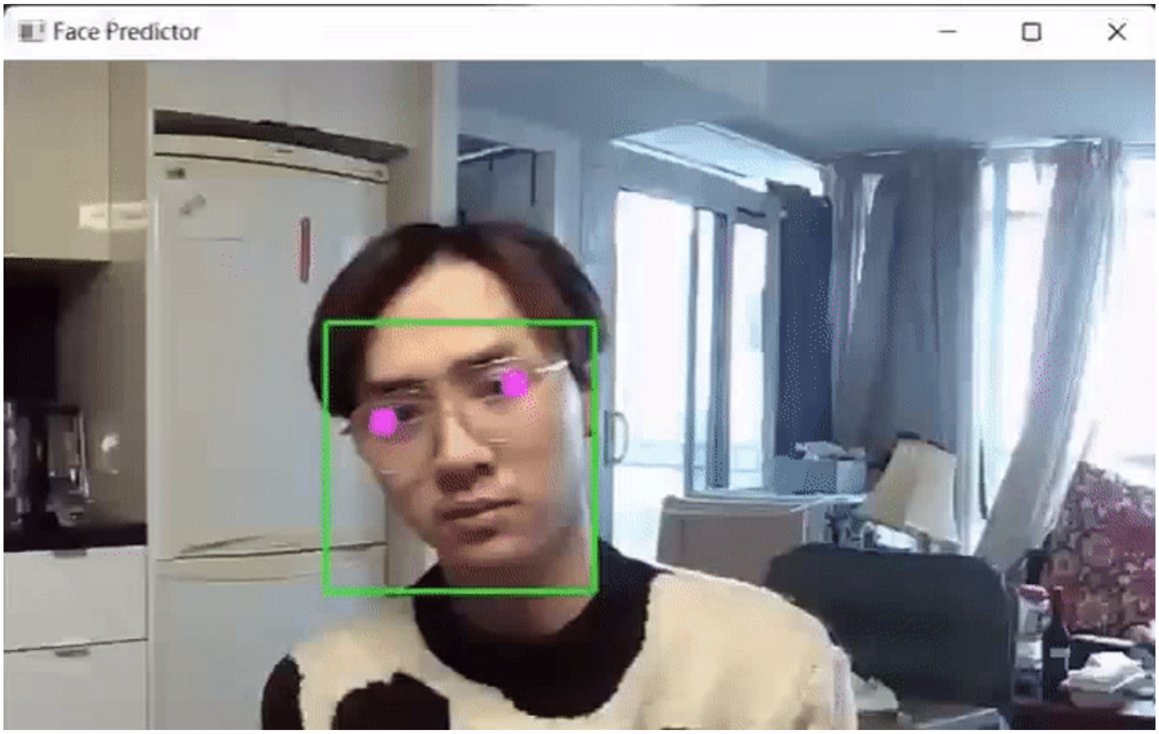

Figure 5. 17 Project Snippets

The results of the evaluation showed that the distance varied between 0.99-1.02 meters, indicating that the program had nearly perfect accuracy in measuring the distance, and the error did not exceed 2%. This means that the prototype is effective in accurately measuring the distance between the face and the camera.

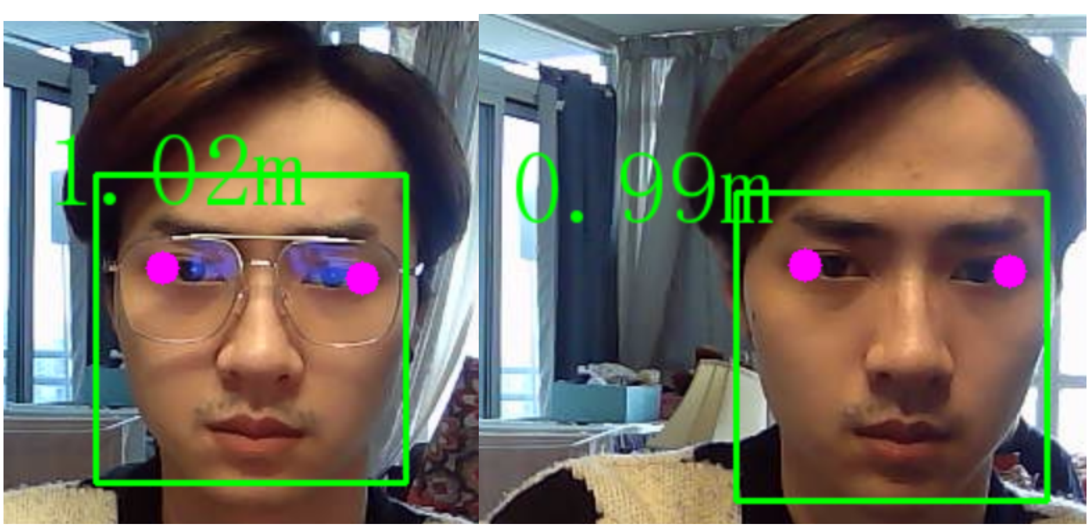

Figure 5. 18 Evaluation

It is important to note that this evaluation was conducted under controlled conditions. Therefore, further testing is needed to ensure the prototype's accuracy in various environments and lighting conditions. Nevertheless, this evaluation shows that the prototype has promising potential in accurately measuring the distance between a person's face and the camera.

5.2.3.5 Subjective Evaluation

Reinforcement strategy effectiveness: 1/5

The Eye Distance prototype measures the distance between the user's face and the screen, which is an essential factor in understanding the impact of viewing distance on myopia development. However, the prototype does not currently provide any direct reinforcement or guidance to the user on how to maintain an appropriate viewing distance. This limits its effectiveness in reinforcing good habits. Further development is needed to incorporate active reinforcement strategies and improve its effectiveness in this area.

Consistency in feedback provision: 3/5

The feature of measuring vertical distance enables users to be aware of their distance. Although the feedback may not be as frequent or as precise as desired in certain situations, the prototype still manages to offer users valuable information on their viewing distance.

Enhancements in face detection accuracy and expanding the system's capabilities to work effectively in various lighting conditions would significantly improve the consistency of the feedback provided.

Adaptability to individual needs: 2/5

While the prototype is successful in measuring the distance between the user's face and the screen, it lacks the ability to recognize and register individual users. This limitation may affect its adaptability to cater to specific individual needs, particularly in scenarios where multiple users are present.

Engagement and motivation: 1/5

The Eye Distance prototype primarily measures the distance between the user's face and the screen. It does not offer any direct engagement or motivation features to encourage users to maintain a healthy viewing distance or adjust their habits. As it stands, the prototype may not be sufficiently engaging or motivating for users, which could limit its effectiveness in addressing the research question. Incorporating interactive elements, feedback mechanisms, or user incentives would be crucial to improve this aspect of the prototype.

Integration with the daily routine: 2/5

The Eye Distance prototype measures the distance between the user's face and the screen, but it does not currently provide any seamless integration with users' daily routines. As it stands, users would need to manually activate the prototype and ensure they are in the proper environment for accurate measurements. This lack of convenience may discourage users from consistently utilizing the prototype and incorporating it into their daily routines.

To improve this aspect, the prototype should be developed further to allow for passive measurement and more effortless integration with users' day-to-day activities.

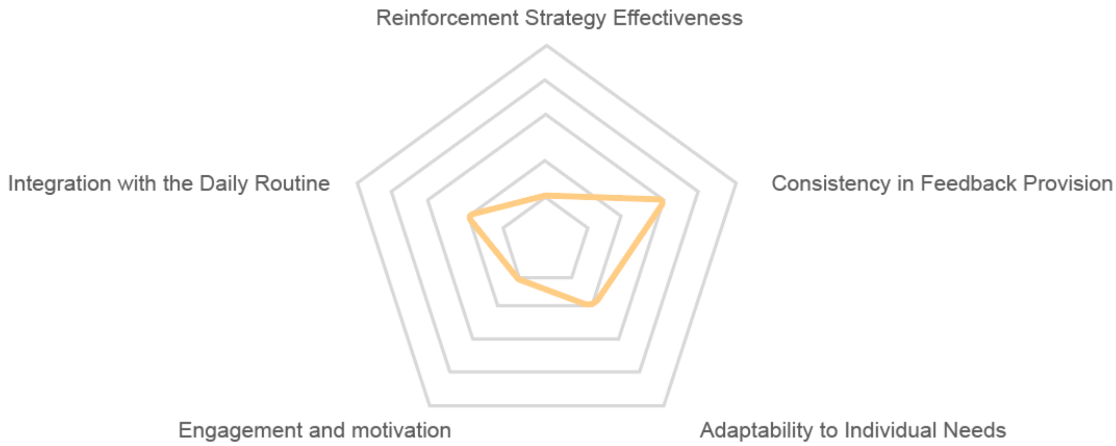

Figure 5.19 Subjective Evaluation for Prototype 3

5.2.3.6 Speculative use case and Evolution

Persona: little Mike from Chapter 4.4

Eye Distance Prototype	Short Term (1-2 years)	Long Term(3 or more years)
How does the prototype benefit the user?	As the prototype does not give feedback on the viewing distance, it can hardly bring benefits to little Mike in the short term.	As the prototype does not give feedback on the viewing distance, it can hardly benefit little Mike.
How does the prototype evolve?	Enhancing accuracy: Efforts can be made to improve the accuracy of distance measurement. By	Personalization: The prototype could incorporate individualized settings that cater to different little

	refining the underlying algorithms and incorporating more advanced sensor technology or computer vision techniques, the prototype can offer more precise distance detection.	Mike’s needs and preferences. For instance, it could allow his parents to set custom distance ranges based on little Mike’s age, vision, and other factors. Integration with other devices: The Eye distance prototype could be integrated with other smart devices, such as smart TVs or wearables, to provide a more seamless and connected experience. This would make it easier for little Mike to maintain healthy viewing habits across different devices and platforms.

5.2.3.7 Limitation

While the prototype is capable of identifying faces and measuring distance, it still has some limitations that need to be addressed. Firstly, the prototype lacks the ability to register and recognize target users. This means that it cannot distinguish between different individuals and might become confused when multiple faces are present in the camera's field of view. This limitation poses a challenge to applications where the prototype needs to recognize the target user among a group of people.

Another limitation of the prototype is its sensitivity to the lighting conditions. The prototype works best in well-lit environments, where it can easily distinguish between the pixels of faces and the pixels of the background. However, in dimly lit environments, the prototype's accuracy decreases significantly, as it struggles to differentiate between the face and the background. This limitation makes the prototype less suitable for use in environments with low lighting conditions.

Another limitation of the prototype is that it only measures distance vertically, which means that it does not take into account any horizontal distance. This limitation might affect the accuracy of the distance measurement, especially if the target user is not standing directly in front of the camera.

Finally, the prototype's performance might be affected by factors such as camera angle and distance from the target user. If the camera angle is not optimal or the distance between the camera and the target user is too large or too small, the prototype's accuracy might be compromised. These limitations need to be addressed to improve the prototype's accuracy and make it more reliable for different applications.

5.2.3.8 Summary

The Eye Distance Prototype demonstrates progress towards addressing the research question. The prototype's ability to accurately measure the distance between a person's face and the camera under bright lighting conditions is a significant step forward in terms of monitoring functionality.

However, the prototype does not fully address the research question, as it has limitations that affect its overall effectiveness. These limitations include the inability to recognize individual faces in scenarios with multiple people and reduced accuracy in dimly lit environments. Additionally, the prototype does not provide an effective reminder mechanism, which is a crucial aspect of the research question.

In summary, while the Eye Distance Prototype demonstrates potential for measuring distances between users and digital screens, it does not yet fully address the research question. Further development is needed to overcome its limitations, such as face recognition and performance in varying lighting conditions. Moreover, incorporating an effective reminder mechanism is essential to ensure that the prototype can effectively help individuals maintain a healthy viewing distance from their digital screens.

5.3 Final Prototypes

The early prototypes were designed to monitor the distance between users and the screen using computer vision technology, while also integrating context awareness. This enabled the accurate measurement of the distance between individuals, making it possible to alert them when they were too close to the screen.

However, it was important to also educate people on the risks associated with being too close to the screen and encourage them to maintain a healthy distance. This led to the development of three new prototypes, which focused on providing users with visual/audio cues to remind them to move further away from the screen.

The final prototypes represent a significant step forward in promoting healthy screen use habits among users. By combining computer vision technology with visual cues and reminders, the prototypes provide a comprehensive solution to the problem of screen overuse.

5.3.1 Pause/Play Prototype

5.3.1.1Purposes

The Pause/Play prototype serves the purpose of creating awareness among users about their watching distance. The prototype aims to remind users that watching digital content at an unhealthy distance can lead to several health problems, such as eye strain, headaches, and neck pain.

When people watch digital content, they often get immersed in it, and it becomes challenging to pull them out of that virtual world. Moreover, people tend to move closer to things they are interested in unconsciously(Jiang, Yuhong V., et al., 2010). This tendency makes it even harder to make them aware of their watching distance.

The Pause/Play prototype offers a simple solution to this problem. It pauses or freezes the video when the audience gets too close to the screen which is essentially a negative reinforcement to users. Once the audience is back to a healthy distance, the video resumes playing. This feature acts as a reminder for users to maintain a healthy watching distance, thus avoiding any potential health problems.

5.3.1.2 Early Exploration

The first step towards creating the Pause/Play prototype was to build a browser-based video player using HTML, CSS, and JavaScript. Once the video player was in place, the next challenge was to integrate the computer vision technology with the player.

```
<body>
    <video src="../screenRecordings/4.mp4" id="myVid" controls></video>
```

Figure 5. 20 Video player

To achieve this, I needed to send the distance data calculated by the computer vision program to the browser. This required some backend engineering technology. So, the question that arose was: how could the distance data be passed from the computer vision program to the web browser?

5.3.1.3 Solutions

APIs

APIs are a popular solution to help programs interact with each other seamlessly. An API, which stands for Application Programming Interface, is a type of software that acts as a contract between two programs, describing how they should interact with each other (Lutkevich, Ben, 2022). There are different types of APIs available, such as those open to all developers and those only available to partners, and some of the well-known examples of this type of programming interface are the Facebook and Twitter APIs (Jacobson, Daniel, et al., 2012).

Using an API can increase the confidence of both the consumer and the provider in the system, as it guarantees that the program will work seamlessly. However, there are also some drawbacks to using APIs. One of the most important drawbacks is that when the front-end and back-end communicate, an HTTP request must be polled from the front-end to the back-end, and then the back-end responds to the front-end by sending a few sets of data(MuleSoft, 2023). In the case of the Eye Distance Prototype, the distance.

To address this issue, a real-time monitoring system is needed, where the back-end constantly sends data, the distance, to the front-end without any request polled from the front-end.

WebSocket

WebSocket is a protocol designed for real-time communication between a client and a server, and it is becoming increasingly popular due to its advantages over traditional HTTP requests. WebSocket connections are full-duplex, bidirectional, and use a single socket, which allows for real-time data transmission without the need for multiple HTTP requests and responses (Leeuwen, Pascal van., 2021). In contrast, HTTP polling, which is often used in real-time applications, involves sending repeated requests to the server to check for updates, which can be inefficient and slow (Wang, Vanessa, et al., 2013).

Moreover, the HTTP protocol used by traditional web applications was not designed for real-time communication, making it difficult to achieve real-time data transmission (Pimentel, Victoria et al., 2012). WebSocket, on the other hand, provides a more efficient and reliable means of real-time data transmission.

In addition, WebSocket provides several other advantages over traditional HTTP requests, such as lower latency, reduced network overhead, and the ability to handle large volumes of data (Leeuwen, Pascal van., 2021). WebSocket connections are also more resilient to network interruptions, as they can automatically reconnect and resume transmission after a connection is lost (Wang, Vanessa, et al., 2013).

WebSocket is a powerful tool for real-time communication in web applications, and it offers several advantages over traditional HTTP requests. By using WebSocket, I can create a more efficient version of Viewing Distance Monitor which is a reliable real-time application that can handle large volumes of data and provide a seamless user experience.

5.3.1.4 Process

Initially, to establish the connection between the server and the browser, I imported the websocket library[6] and connected the server to localhost.

```
import websocket    # pip install websocket-client
ws = websocket.WebSocketApp("ws://localhost:12345/")
```

Figure 5. 21 Websocket connects to localhost

However, I encountered a problem while running the program as Python is a single-threaded programming language. Therefore, the program could not run simultaneously while running the computer vision program. To address this issue, I researched and discovered that Python provides a threading[7] library that can create a new thread. By using this library, I was able to start the server while running the computer vision program. After successfully sending data to the browser, I was able to manipulate the video player with the received distance data.

[6] https://developer.mozilla.org/en-US/docs/Web/API/WebSockets_API

[7] https://realpython.com/intro-to-python-threading/#starting-a-thread

```python
import websocket     # pip install websocket-client
import threading

ws = websocket.WebSocketApp("ws://localhost:12345/")
wst = threading.Thread(target=ws.run_forever)
wst.daemon = True
wst.start()
```

```python
person_distance = round(self.pose_estimator.get_distance(self.eyeBaseDistance),2)
if person_distance > 0.5:
    ws.send(str(person_distance))
```

Figure 5. 22 Start a new Thread

And now that the data is successfully sent to the browser, I can start manipulating the video player with the distance data.

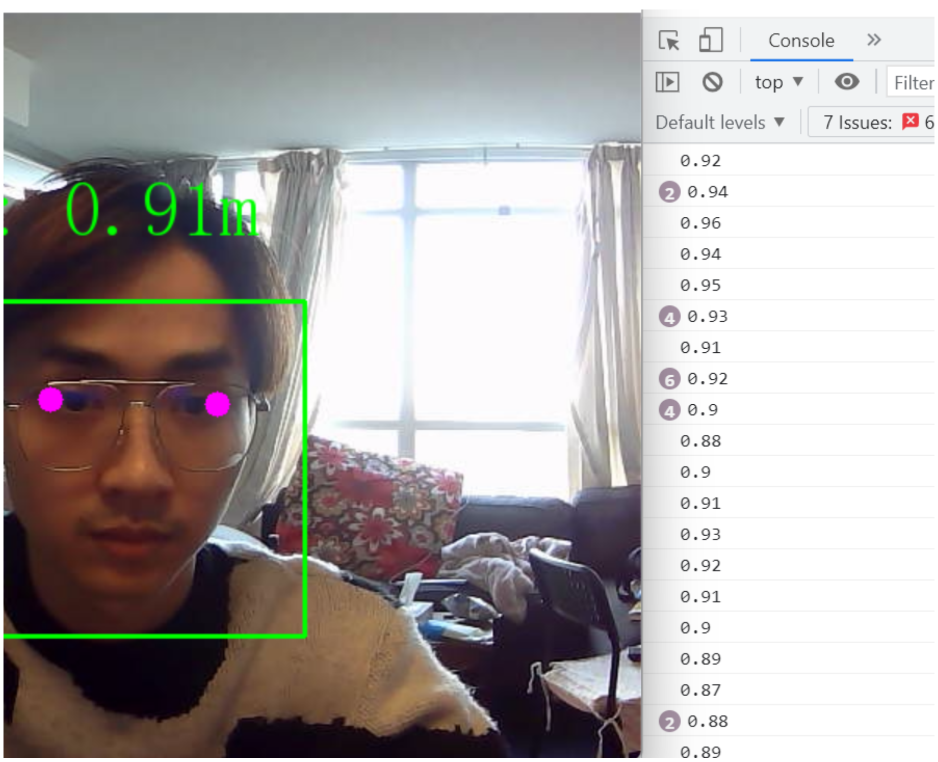

Figure 5. 23 Distance data in the console

```
var video = document.getElementById('myVid');
document.addEventListener('DOMContentLoaded', function () {
    const websocketClient = new WebSocket("ws://localhost:12345/");
    websocketClient.onopen = function () {
        console.log('Client Connected!')
        // websocketClient.send("hello!")
    }
    websocketClient.onmessage = function (msg) {
        console.log(msg.data);
        if (msg.data < 1.2) {
            video.pause()
        } else {
            video.play()
        }
    }
}, false)
```

Figure 5. 24 Video Player

5.3.1.5 Functional Evaluation

In this prototype, the problem of data communication was solved, and video manipulation was initiated using distance data. To test the functionality, the threshold was set to 1.2 meters. In other words, if the distance between the user and the screen is less than 1.2 meters, the video should pause, and when the user moves to a healthy distance, the video should resume playing.

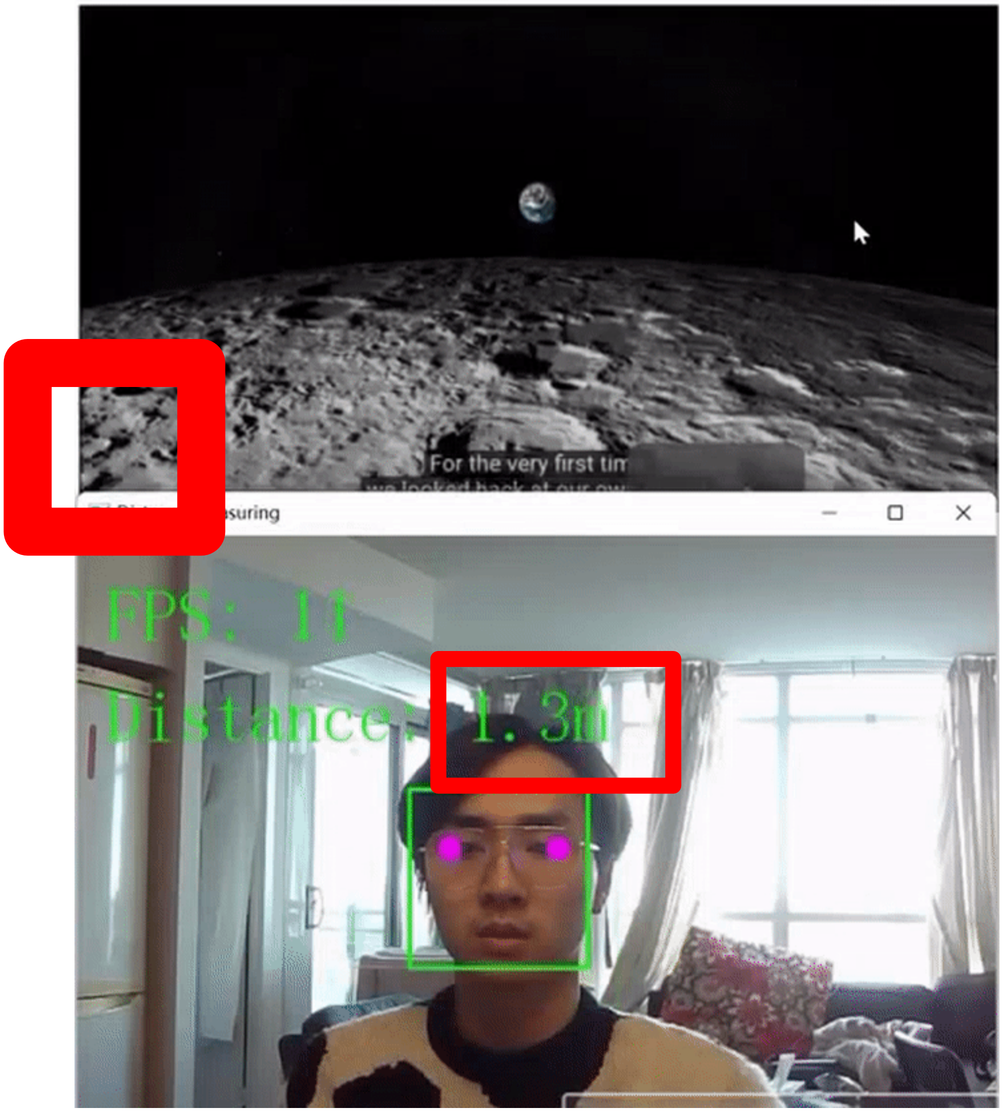

Figure 5. 25 Evaluation

5.3.1.6 Subjective Evaluation

Reinforcement strategy effectiveness: 2/5

The Pause/Play prototype employs negative reinforcement by pausing the video when users are too close to the screen. Negative reinforcement can be effective in certain situations, as it encourages users to change their behavior to avoid an undesired outcome (in this case, the video being paused). However, this prototype's reinforcement strategy might be less effective because users could become confused or frustrated when the video pauses without a clear indication of the reason. It's important to provide users with a better understanding of why the video is pausing in order to enhance the effectiveness of the negative reinforcement strategy.

Consistency in feedback provision: 3/5

The consistency of feedback depends on the accuracy of the Eye Distance prototype. It may work well in well-lit environments but can be less consistent in dimly lit conditions. As a result, feedback consistency may vary depending on the environment and lighting.

Adaptability to individual needs: 2/5

The Pause/Play prototype can be adapted to individual needs by adjusting the threshold distance that triggers the pause. However, it might not be as adaptable when it comes to recognizing multiple users in the frame or adjusting to different screen sizes.

Engagement and motivation: 2/5

Pausing the video without a clear explanation can cause confusion and frustration, which may negatively impact the user's overall experience. While the prototype does serve as a reminder for users to maintain a healthy distance from the screen, the lack of clarity about the reason for the pause may result in lower engagement and motivation. Improving the user's understanding of the pause's purpose could enhance engagement and motivation, leading to more effective behavior change.

Integration with the daily routine: 3/5

The prototype’s effectiveness in promoting a healthy screen distance may vary depending on the user's willingness to accept interruptions to their video watching experience.

Additionally, the prototype's limitations in dimly lit environments may hinder its usability in various settings, which could negatively impact its integration with the daily routine. Improving the prototype's functionality in different lighting conditions and providing clearer information about the pause's purpose would likely enhance its ability to integrate more seamlessly into the user's daily life.

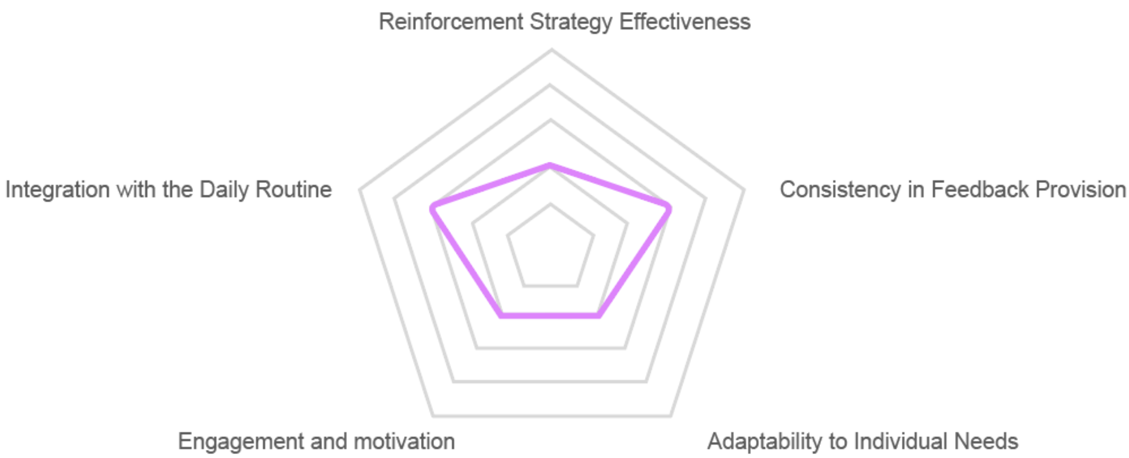

Figure 5.26 Subjective Evaluation for Prototype 4

5.3.1.7 Speculative use case and Evolution

Persona: Persona: little Mike from Chapter 4.4

Pause/Play Prototype	Short Term (1-2 years)	Long Term(3 or more years)
How does the prototype benefit the user?	When little Mike uses the system, he starts to realize that the video will pause if he stands too close to the screen. As a result, he moves back to a healthy viewing distance. This eliminates the need for his parents to constantly remind him to maintain a	Gradually, little Mike develops a habit of maintaining a safe distance from the screen whenever he consumes digital content, leading to a healthier and safer viewing experience. This not only benefits Mike's long-term health, but also provides

	safe distance from the screen	peace of mind to his parents, knowing that their child is engaging in healthier screen habits.
How does the prototype evolve?	Enhancing accuracy : By refining the underlying algorithms and incorporating more advanced sensor technology or computer vision techniques, the prototype can offer more precise distance detection and provide a better user experience for little Mike and his family.	Smoother transitions: To ensure a more comfortable experience for little Mike, the pausing and resuming of the video can be made smoother by incorporating subtle animations or visual effects. This would make the transition less abrupt and more engaging for him. Dynamic overlays: Dynamic overlays could also be introduced as an alternative to pausing the video. Instead, the video could blur or darken as Mike moves too close, and become clearer as he moves back to a safe distance. This visual feedback would encourage him to maintain proper viewing habits while making the experience more enjoyable. With these improvements, the parents can trust the system to effectively guide Mike's behavior, further reducing their concerns and enhancing their overall satisfaction with the solution.

5.3.1.8 Summary

The prototype does not fully answer the research question due to the shortcomings in its effectiveness. The primary issue is that the pause/play approach might not be an effective reminder for users, as they may not understand the reason behind the video pausing. This lack of clarity could lead to confusion or frustration, rather than encouraging users to adjust their viewing distance.

To more fully answer the research question, the prototype would need to incorporate a more explicit and informative reminder mechanism. This could involve providing visual or auditory cues that clearly communicate the need to maintain a healthy viewing distance from the screen, thus improving the user experience and the effectiveness of the reminder.

In conclusion, while the Pause/Play prototype is a step towards addressing the research question, it is not yet entirely effective in reminding users to maintain a healthy viewing distance from digital screens. By refining the reminder mechanism to be more informative and explicit, the prototype could potentially become more effective in achieving its goal.

5.3.2 Audio Reminder prototype[8]

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[8] https://www.youtube.com/watch?v=UV2Fs0Ua2xo&list=PLBWULpy9tN31jzcLtq7YW-IIyR1HoKBCN&index=2

5.3.2.1 Purposes

As I delved into the topic of user experience, I discovered that providing clear and explicit instructions is essential for creating a seamless interaction between users and technology. Audio cues have been proven to be effective in providing such instructions, as they are easily understandable and accessible to users of all ages and backgrounds. By integrating explicit voice prompts into our program, we can enhance the user experience and make the interaction more intuitive and user-friendly.

Research has shown that audio cues can help users to understand complex concepts and procedures more easily. According to a study conducted by the University of California, San Diego, audio instructions can improve task completion times by up to 25% (Saldana, 2018). Additionally, the use of audio cues has been found to increase user engagement and satisfaction, leading to higher retention rates and repeat usage (Davis et al., 1989).

5.3.2.2 Processes

During my exploration of designing a more effective reminder for users, I experimented with incorporating audio cues. I found that creating voice prompts as audio hints and embedding them into an HTML page using an audio tag was a seamless process. The voice prompt, which essentially serves as negative reinforcement, is played when triggered by a specific action or event, offering users clear instructions or warnings. Once the user returns to a healthy viewing distance, another voice prompt is played to encourage this behavior, acting as positive reinforcement.

```
<audio id="myaudio" src="../audioRecordings/moveAway.mp3" type = "audio/mpeg"></audio>
```

```
var a = document.getElementById("myaudio");
```

Figure 5. 27 Audio HTML

```
websocketClient.onmessage = function (msg) {
  console.log(msg.data);
  if (msg.data < 1.2) {
    v.pause();
    a.play()
  } else {
    v.play()
  }
```

Figure 5. 28 Function Logic

5.3.2.3 Functional Evaluation

To evaluate the efficacy of the voice prompt prototype, I established a threshold of 1.2 meters. When the user comes within this range, the voice hint is triggered, informing them that they are too close. As the user returns to a healthier distance, an additional voice prompt is played, encouraging them to maintain such behaviors consistently. The prototype proved to be functional and effectively offered users a clear and audible reminder.

5.3.2.4 Subjective Evaluation

Reinforcement strategy effectiveness: 3/5

The Audio Reminder prototype incorporates positive and negative reinforcement by using voice prompts to guide user behaviour. However, its effectiveness may be limited for younger children who may not have a strong grasp of language or may not fully comprehend the instructions. Additionally, some individuals may not be as sensitive to audio cues, which could affect the impact of the reinforcement strategy on their behaviour.

Consistency in feedback provision: 3/5

The prototype provides consistent feedback through voice prompts when the user moves into an unhealthy viewing distance and when they return to a safe distance. However, the effectiveness of this consistency might be compromised in certain situations, such as when the user is unable to hear the voice prompts due to environmental noise or when the distance prediction accuracy is affected by lighting conditions. Additionally, younger children may not fully understand the language used in the voice prompts, which could further impact the consistency of the feedback provided.

Adaptability to individual needs: 3/5

It provides clear and explicit instructions through voice prompts, which may be helpful for users who prefer or benefit from auditory guidance. However, it may not be as adaptable to the individual needs of all users. Young children, especially those in early childhood, might not fully understand the language used in the voice prompts, and some individuals may not be sensitive to audio cues. Additionally, users with hearing impairments might not benefit from this approach.

Engagement and motivation: 2.5/5

The prototype aims to keep users engaged and motivated through the use of clear and easily understandable voice prompts, which incorporate both positive and negative reinforcement strategies. These prompts help guide users to maintain a healthy viewing distance while consuming digital content, reinforcing desired behaviors and discouraging undesired ones. However, the level of engagement and motivation might vary depending on the individual's sensitivity to audio cues and their ability to comprehend the language used in the voice prompts. Some users, particularly younger children, might not be as responsive to the audio cues, while others might find them repetitive over time. Despite these potential limitations, the reinforcement strategies employed in the prototype contribute to its effectiveness in promoting engagement and motivation.

Integration with the daily routine: 3/5

The voice prompts are triggered automatically when the user is too close to the screen, which allows for real-time feedback without the need for user initiation or manual input. This makes it easier for users to adopt the system and integrate it into their daily lives.

However, it is important to consider that the effectiveness of the prototype's integration with daily routines may be influenced by individual preferences and the living environment. For example, some users might find the audio reminders disruptive or irritating, especially in shared living spaces where multiple people are watching the same screen. Additionally, the prototype's reliance on audio cues may not be ideal for users with hearing impairments or who are in noisy environments.

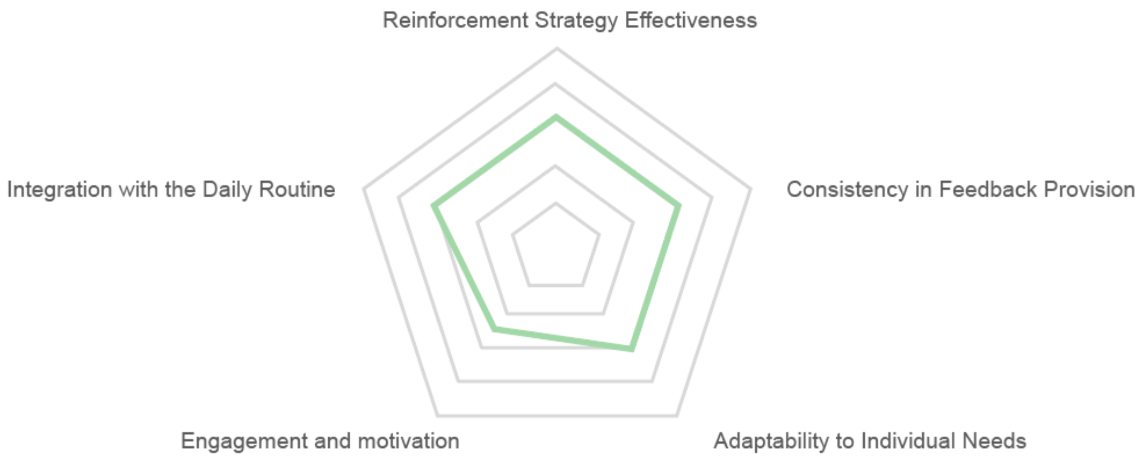

Figure 5.29 Subjective Evaluation for Prototype 5

5.3.2.5 Speculative use case and Evolution

Persona: little Mike from Chapter 4.4

Audio Reminder Prototype	Short Term (1-2 years)	Long Term(3 or more years)
How does the prototype benefit the user?	As little Mike uses the Audio Reminder prototype, he receives audio cues when he is too close to the screen. These cues prompt him to move back to a safe viewing distance, reducing the need for his parents to constantly remind him. This saves the parents time and energy while ensuring Mike maintains a healthy viewing distance.	Over time, little Mike becomes more aware of his viewing distance and forms a habit of staying at a safe distance from the screen. This promotes healthier viewing habits and reduces the risk of eye strain or other issues related to excessive screen exposure. As Mike develops better habits, his parents can worry less about his screen time and focus more on other aspects of their family life.

How does the prototype evolve?	Customizable audio cues: To make the audio reminders more engaging and effective, the prototype could allow users to customize the audio cues with their own recordings or choose from a library of sounds. This personalization would help capture little Mike's attention more effectively and make the reminders more enjoyable. Incorporating animated character audio cues: The system could incorporate audio cues from various animated characters, such as Mickey Mouse, to make the reminders more intriguing and engaging for little Mike.	Integration with smart devices: The Audio Reminder prototype could evolve by integrating with smart home devices and platforms such as Amazon Alexa, Google Home, or Apple HomeKit. This integration would enable the reminders to be delivered through various devices in the home, ensuring that little Mike receives the reminder even if he moves from one screen to another. Adaptive reinforcement strategies : The prototype could implement adaptive reinforcement strategies based on Mike's responses to various animation cues and game elements (e.g., positive or negative reinforcement). This tailored approach would maximize the impact of the system on little Mike's behavior, encouraging him to consistently maintain a healthy viewing distance.

5.3.2.6 Summary

In summary, the current prototype, which utilizes audio cues and a combination of positive and negative reinforcements to remind individuals to maintain a healthy viewing distance from their digital screens, offers a somewhat effective solution to the research question.

While the prototype effectively provides audio reminders for some users, its reliance on audio cues alone restricts its universal applicability. Individuals who may not respond well to or be attentive to audio reminders, such as those who are hearing impaired or easily distracted, might not benefit from this approach, thereby limiting its overall effectiveness in maintaining a healthy viewing distance. Additionally, the prototype's dependence on lighting conditions for distance prediction accuracy, though not the central issue, also contributes to its limitations.

To fully address the research question, a more effective and inclusive approach should be considered for future iterations of the prototype. Incorporating visual cues or other means of communication could better accommodate diverse user needs and preferences, ultimately enhancing the prototype's ability to support healthy viewing distance habits. By refining the prototype to address these limitations, a more comprehensive solution to the research question can be achieved.

6 Final prototype[9]

6.1 Purposes

As I explore more ways to provide better user experience, I have found that loading bars are a great tool to accurately reflect progress. A loading bar is a graphical user interface element that shows the progress of a task or process. There are several advantages to using this element in web or app development.

One of the essential advantages of a loading bar is that it provides visual feedback about the progress of a particular task. This can make users feel more engaged with the process and give them an idea of how long they must wait before the task is completed. Without this feedback, users may feel uncertain and frustrated about how long the task will take to complete(Nielsen, J., 1994).

Therefore, using a progress bar to reflect users' distance to the screen has the potential to be an effective way to give awareness of healthy viewing distance. A study found that participants who were presented with a progress bar were more likely to complete an online survey than those without a progress bar (Bargas-Avila et al., 2011). Similarly, Another study found that participants who were presented with a progress bar showing

[9] https://www.youtube.com/watch?v=cPUimjQ3anw&list=PLBWULpy9tN31jzcLtq7YW-IIyR1HoKBCN&index=1

their progress towards their physical activity goal were more likely to engage in physical activity than those without a progress bar(Orji, Rita., 2018).

In the context of promoting healthy viewing distance, users can see how far they are from the screen by keeping an eye on the length of the bar. This could provide users with a clear visual representation of their behaviour and encourage them to adjust their behaviour to maintain a safe distance.

Moreover, research has shown that visual cues and feedback are important in promoting healthy behaviour. A study found that the use of a virtual agent providing visual feedback and reminders improved patients' adherence to their treatment plan(Bickmore, Timothy W., et al., 2016).

Therefore, using a progress bar to reflect users' distance to the screen could be a useful tool to promote healthy viewing habits. It provides users with a clear visual representation of their behavior, which may motivate them to adjust their behavior and maintain a safe distance from the screen. Additionally, the use of visual cues and feedback has been shown to be effective in promoting healthy behavior, supporting the use of a progress bar as a tool for promoting healthy viewing habits. Furthermore, it is essential to ensure that the loading bar is well-designed and visually appealing to avoid boring or confusing the user. By using loading bars effectively, we can improve the user experience and make our apps or websites more user-friendly.

6.2 Process

The final prototype I divided the bar into three parts: Green, Yellow, and Red to represent healthy, relatively unhealthy, and unhealthy distances, respectively. The reason for selecting these colors is that people are already familiar with them due to their association with traffic lights(Hollis, Nigel, 2018). Using these colors makes it easier for users to understand and perceive the viewing distance.

```
<div id="adjust" class="bar" style="--percent: 50;"></div>
```

Figure 6.1 Loading bar HTML

To adjust the bar's length and color, I used JavaScript. When the user's distance is less than 1 meter, the video pauses, and the length of the bar is set to 34 pixels, displaying red. When the user's distance is between 1 meter and 1.25 meters, the length of the bar is set to 67 pixels, displaying yellow. Meanwhile, the video will play at a slower speed of 0.45 to remind users of the relatively unhealthy distance. Finally, when the user is at a healthy distance, the video will resume playing at a normal speed of 1, and the length of the bar will be 100 pixels, displaying green.

```javascript
websocketClient.onmessage = function (msg) {
    console.log(msg.data);
    if (msg.data < 1) {
        video.pause();
        barChange.style = "--percent: 34;";
    } else if (msg.data < 1.25) {
        video.play();
        video.playbackRate = 0.45;
        barChange.style = "--percent: 67;";

    }else{
        video.play();
        video.playbackRate = 1;
        barChange.style = "--percent: 100;";
    }


}
```

Figure 6.2 Adjust loading bar by JavaScript

6.3 Functional Evaluation

In this final generation of the prototype, my main objective was to enhance the user experience by providing them with a better understanding of their viewing distance. Therefore, there were two primary goals that I aimed to achieve. The first goal was to ensure that the final prototype had clear indications of the user's viewing distance. The second goal was to make sure that these indications were straightforward and self-explanatory, allowing users to easily understand and interpret the information being presented to them.

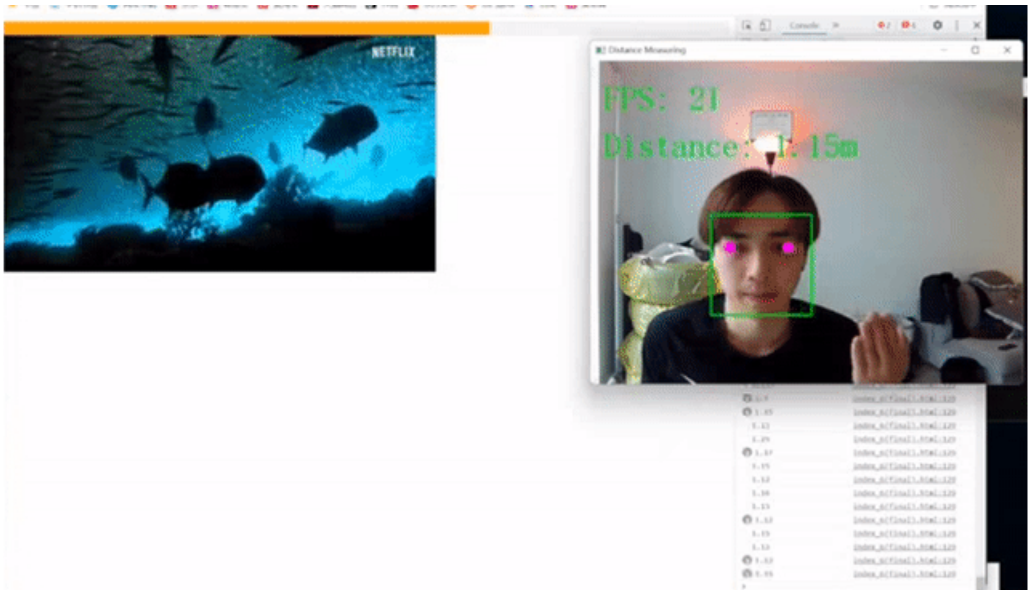

Figure 6.3 Evaluation

Additionally, it was crucial that the program was fully functional and able to perform its intended purpose effectively.

6.4 Subjective Evaluation

Reinforcement strategy effectiveness: 4/5

The final prototype effectively utilizes a progress bar as a visual reinforcement strategy, conveying the user's viewing distance by changing colors and lengths. The use of familiar colors, such as green, yellow, and red, helps users quickly understand the implications of their viewing distance. Although this strategy is quite effective, it may not be as powerful as incorporating audio and visual reinforcement cues. Nonetheless, it still offers a strong and easily comprehensible reinforcement strategy for promoting healthy viewing habits.

Consistency in feedback provision: 3/5

While the progress bar provides real-time feedback based on the user's distance from the screen, it may not be as consistent as it could be. Users might not always look at the progress bar while watching content, which could lead to missed feedback. Additionally, it may require users to divert their attention from the screen, which could potentially disrupt the viewing experience.

Adaptability to individual needs: 3/5

The final prototype uses a visual progress bar to communicate healthy and unhealthy viewing distances. While this approach is generally effective for a wide range of users, it may not be suitable for those with visual impairments or color blindness, as they might struggle to perceive the changes in the progress bar. Additionally, the prototype does not account for different screen sizes or devices, which may affect the viewing distance recommendations.

Engagement and motivation: 3/5

The final prototype uses a visual progress bar with different colors to represent various viewing distances, creating a simple yet visually engaging way to inform users about their distance from the screen. However, the prototype relies primarily on visual feedback, which may not be as motivating or engaging for some users who may respond better to auditory or tactile feedback. Additionally, while the color-coded progress bar is a familiar concept, it may not be as engaging for users in the long run, as it lacks novelty and could become less effective over time.

Integration with the daily routine: 4/5

The final prototype can be easily integrated into the daily routine of users as it provides real-time feedback while they watch TV or engage with screens. However, the visual nature of the progress bar may require users to pay constant attention to the bar while watching content, which could be intrusive or distracting for some users.

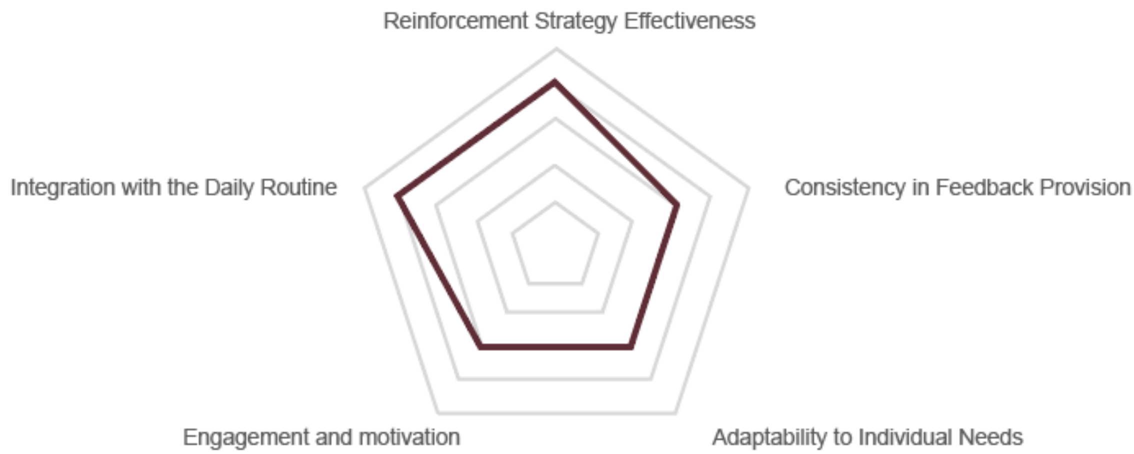

Figure 6.4 System Feedback

6.6 Speculative use case and Evolution

Persona: little Mike from Chapter 4.4

Final Prototype	Short Term (1-2 years)	Long Term(3 or more years)
How does the prototype benefit the user?	With the final prototype, little Mike is provided with an engaging animation and gamification system that represents the appropriate viewing distance from the screen. As Mike gets too close to the screen, the animations change and the game elements provide	As little Mike consistently uses the final prototype, he becomes more aware of his viewing distance and forms a habit of maintaining a safe distance from the screen. This promotes healthier viewing habits and decreases the risk of eye strain or other issues related

	feedback, prompting him to move back to a safe viewing distance. This real-time feedback helps Mike maintain a healthy viewing distance, reducing the need for his parents to constantly remind him.	to excessive screen exposure. Consequently, his parents can worry less about his screen time and focus on other aspects of their family life.
How does the prototype evolve?	Integration with various content types : The final prototype could be adapted to work with different types of content, such as games, streaming platforms, or educational apps. This broader compatibility ensures that little Mike maintains a healthy viewing distance, no matter what type of content he consumes.	Advanced tracking and analytics: The prototype could incorporate advanced tracking and analytics features to monitor little Mike's viewing distance over time. This data could be shared with his parents, allowing them to track his progress and adjust the system's settings or reinforcement strategies as needed. The collected data could also contribute to research on screen time habits and their effects on children's health. Using animation as reminders: In the long-term evolution of the prototype, animations could be used as engaging and appealing reminders for little Mike. These animations could be designed to capture his attention and deliver the message of maintaining a safe viewing distance in a more entertaining and effective manner.

6.7 Summary

The final prototype effectively addresses the research question. The prototype employs a progress bar with color-coded sections to represent healthy, relatively unhealthy, and unhealthy distances, providing a clear visual indication of the user's viewing distance.

The progress bar offers advantages such as familiarity and ease of understanding due to the association of colors with traffic lights. Furthermore, it serves as a visual reinforcement strategy that encourages healthy viewing habits. By utilizing this approach, the final prototype successfully answers the research question and provides a practical, user-friendly solution.

Although the prototype has certain limitations, it still offers a comprehensive solution to the research question. The integration of the progress bar into users' daily routines and its adaptability to individual needs demonstrate the effectiveness of this solution in promoting healthy viewing distances for a wide range of users.

The final prototype also benefits from its ability to engage and motivate users by visually displaying their distance. The use of familiar colors and real-time feedback helps to keep users informed and encourages them to adjust their behavior accordingly.

In terms of consistency in feedback provision, the progress bar provides real-time feedback based on the user's distance from the screen. However, users might not always look at the progress bar while watching content, which could lead to missed feedback opportunities. To address this, future iterations could explore incorporating auditory or tactile feedback alongside the visual progress bar.

Despite these limitations, the final prototype effectively addresses the research question and offers a promising foundation for future development. By refining the prototype and considering additional feedback methods, this solution has the potential to become an even more effective and inclusive tool for promoting healthy viewing distances among individuals consuming digital content in the future.

7. Discussion

In this section, I will discuss the iterative prototypes. To begin with, I will present a comparison table that outlines the different features and questions that I have about each prototype. This will help me to identify the strengths and weaknesses of each iteration and make informed decisions for future versions.

7.1 Discussion of the Iterative Prototypes

The following table analyzes and shows the problems solved by each prototype, the features and reinforcement methods used and the limitation

Prototype	Question	Features & Achievement	Problem	Reinforcements	Limitation
Face Recognition	How to capture the target user among a group of people?	Identifies the target user.	It does not monitor the context environment.		Current face recognition algorithms do not support working in low light areas

Finger Distance	How to measure distance with a camera?	Measures distance on a plane	It does not measure viewing distance		
Eye Distance	How to measure vertical distance instead of two-dimensional distance?	Measures viewing distance	It does not give awareness to users.		Can't process multiple faces at the same time

Pause/Play	How to use person distance giving awareness to users that keeping a healthy distance.	Video pauses when viewing distance is below the threshold	It lacks clear hints	Negative reinforcements	
Audio Reminder	How to avoid confusion of users when video pauses ?	Provides users with clear audio hints when viewing distance is below the threshold	It lacks visual cues.	Negative reinforcements and Positive reinforcements	
Final Work	How to improve awareness of distance while watching?	Gives users awareness of distance by loading bar		Negative reinforcements and Positive reinforcements	Can't process multiple faces at the same time

7.2 Summary

The development of the six prototypes was an iterative process, with each version building on the strengths and addressing the weaknesses of its predecessors. The main goal was to answer the research question, "**How can individuals be effectively reminded to maintain a healthy viewing distance from their digital screens while consuming digital content?**" Each prototype aimed to address this question in different ways, with varying levels of success, while keeping in mind the particular needs of children as a key target audience.

The early prototypes, although basic, provided clear indications of the user's distance from the screen. Among the final prototypes, however, the Pause/Play prototype lacked an efficient feedback mechanism to inform users about their viewing habits. The Audio/Reminder prototypes took a step forward by implementing both negative and positive reinforcement through the use of audio cues. Nevertheless, this approach presented limitations in terms of user-friendliness and adaptability to different user groups, such as young children or those less sensitive to audio cues.

In the final prototype, reinforcement strategies were further improved by utilizing a straightforward and easily understandable distance bar that conveyed the importance of maintaining a healthy viewing distance without being intrusive or patronizing. This visual reinforcement provided users with real-time feedback about their distance from the screen, allowing them to make necessary adjustments. The use of familiar color coding, inspired by traffic light signals, made the reinforcement more intuitive and effective.

In conclusion, the final prototype represents a significant improvement over the earlier iterations and offers a more effective solution to the research question by incorporating refined reinforcement strategies. By providing users with clear, self-explanatory indications of viewing distance, the final prototype serves as a valuable tool in promoting healthy viewing distances and habits among screen users.

8. Conclusion, Limitation and Future Work

8.1 Limitations

One limitation of this Viewing Distance Monitor is that it aims to improve usage habits in the domain of “How”. But it doesn’t improve usage habits in the domain of “What” and “When”. Therefore, the project does not track users’ screen time or record users’ preference.

Second of the limitations of the Viewing Distance Monitor is the lack of user testing. User testing is a crucial step in the design and development of any new technology or product, as it allows designers to gain valuable feedback and insights from real users that can inform further improvements and iterations(Francis, Naomi., 2022).Without user testing, it is difficult to know how well the Viewing Distance Monitor will perform in real-world scenarios or how users will respond to its design and functionality. For example, users may have difficulty understanding audio instructions. Additionally, user testing can help identify any unforeseen issues or limitations with the Viewing Distance Monitor that may not have been apparent during the design and development process. For example, users may encounter difficulties using the device with certain types of screens or in different lighting conditions.

The third limitation of the Viewing Distance Monitor is the potential for privacy concerns related to its use of computer vision technology. The device uses a camera to detect the user's distance from the screen, which may raise privacy concerns for some individuals.

Some users may be uncomfortable with the idea of a camera constantly monitoring their viewing habits, particularly if they are using the device in a private or sensitive setting.

In general, while computer vision technology can be a powerful tool for promoting healthy digital habits, it is important to be aware of potential privacy concerns and to take steps to address these concerns in the design and implementation of the Viewing Distance Monitor. By prioritizing user privacy and data security, the device can provide a valuable tool for promoting healthy viewing habits while also respecting users' privacy rights.In addition to the privacy, the lack of user testing is a major limitation of the Viewing Distance Monitor. To address this limitation, future iterations of the device should include user testing as an integral part of the design and development process to ensure that the device is effective and user-friendly in real-world scenarios.

8.2 Directions for future work

8.2.1 Privacy

In the future, one of the focuses of this work is to improve privacy and conduct user tests. In order to enhance privacy, several steps could be taken. First and foremost, hardware modifications could be made to the monitor to incorporate a privacy filter that restricts the viewing angle, allowing only the user sitting in front of the screen to view the contents of the monitor. Second, the project also needs to prioritize user privacy and data security. This could include incorporating privacy features such as built-in camera covers or providing clear information to users about how their data will be collected, stored, and used.Additionally, the device should be designed with the ability to disable the camera or to allow users to manually adjust the camera settings as needed.Another approach could be the integration of a physical screen cover that can be easily removed when the user wants to view the content. Furthermore, software-based solutions could be implemented, such as adding an option to blur the screen when viewed from a certain angle or implementing an automatic screen timeout feature to prevent accidental disclosure of sensitive information.

8.2.2 User Testing

User testing is a crucial step in the development of any product, including viewing distance monitors. To conduct user testing I need to select a group of participants who fit the target audience and provide them with the viewing distance monitor to use in their daily work or play. The participants' feedback can be collected through surveys, interviews, or observations. Based on the feedback, improvements can be made to the monitor to better meet the users' needs. Additionally, A/B testing could be performed to compare different versions of the monitor and determine which version performs better in terms of user satisfaction, productivity, and comfort. Finally, it is essential to conduct user testing with a diverse group of participants to ensure the monitor works well for people with different needs, including those with disabilities or different visual abilities.

8.2.3 Animations & Cartoon Figure Voices

Through evaluations across previous prototypes, I found that it is especially hard to improve the Engagement and Motivation aspect. To address this challenge and create a more engaging experience for children, incorporating animations and popular cartoon character voices into the prototype can make it more appealing and enjoyable.

By leveraging the power of animations and recognizable characters, the monitor can provide a more immersive and motivating experience, encouraging children to maintain a healthy viewing distance. This can be particularly helpful for users who may have struggled with engagement and motivation in previous prototypes.

To cater to the interests of children, future work should focus on developing a variety of animations that visually convey the importance of maintaining a safe viewing distance. These animations can be designed to capture the child's attention and elicit an emotional response, making it more likely that they will follow the monitor's guidance. Moreover, the animations can be tailored to different age groups, ensuring that they remain relevant and engaging as the child grows older.

Additionally, integrating popular cartoon character voices into the monitor can further enhance its appeal and effectiveness. For instance, using the voice of Mickey Mouse or other well-known characters to provide reminders about maintaining a healthy viewing distance can make the experience more enjoyable and motivating for children. This can also help reduce the burden on his parents, who may not need to remind him as often, as the familiar character voices can effectively capture his attention and encourage him to follow the recommendations.

To ensure that the monitor remains engaging and appealing to a wide range of children, it is essential to regularly update the animations and character voices. This can involve collaborating with animation studios, licensing popular characters, or even allowing users to contribute their own custom animations and voice recordings. By continually expanding the library of animations and character voices, the monitor can stay fresh and engaging for users like little Mike and his parents, promoting long-term adherence to healthy screen time habits.

8.2.4 Gamifications

Gamification can be an effective way to encourage children to maintain a healthy distance from the screen. By incorporating game elements into the monitor, such as point-based systems, levels, and rewards, users can be motivated to adhere to recommended viewing habits.

A point-based system can be implemented to reward the kid for maintaining a safe distance from the screen. For example, points can be accumulated for every minute spent at the recommended distance. These points can then be redeemed for in-app rewards or unlockables, such as new animations, character voices, or even tangible rewards, like stickers or small toys.

To further enhance the gamification experience, the monitor can introduce levels that correspond to the user's progress. As the kid accumulates points and advances through the levels, the system can unlock additional content, such as more challenging tasks or exclusive rewards. This level-based progression can keep the kid engaged and motivated to continue practicing healthy screen time habits.

Moreover, incorporating social features, such as leaderboards or the ability to share progress with friends, can create a sense of friendly competition among users. Kids can compare their progress with that of his friends, which may encourage him to maintain a healthy viewing distance and continue earning points.

To ensure that the gamification features remain engaging and relevant, it is essential to periodically update the rewards, challenges, and content. This can involve adding new levels, rewards, and game mechanics or soliciting user feedback to identify areas for improvement. By continually refining the gamification experience, the monitor can help children like little Mike to develop and maintain healthy viewing habits in an enjoyable and engaging manner.

8.2.5 Parenting support

To further enhance the impact of the viewing distance monitor and make it a more comprehensive solution for families with kids, a companion app for parents can be developed. This app can provide valuable insights and tools to help parents support their children in developing healthy screen time habits.

The companion app can include features such as real-time monitoring of children's viewing distance and screen time. This allows parents to receive alerts when the kid is too close to the screen for an extended period and intervene if necessary. In addition, the app can track kids' progress over time, including his viewing distance, screen time, and adherence to recommended guidelines. This information helps parents to monitor kids' habits and identify any trends or areas for improvement.

Parents can also customize the viewing distance monitor settings for their kids, adjusting the safe distance range, selecting specific animations, or choosing cartoon character voices that resonate with their child. This personalization can help make the monitor more effective and engaging for children. The companion app can also provide parents with educational resources on the importance of maintaining a healthy viewing distance and tips for promoting good screen time habits.

Furthermore, parents can collaborate with their kids to set goals related to screen time and viewing distance. When the kid achieves these goals, parents can provide rewards, such as a special outing or a small gift, to reinforce his positive behavior. By incorporating parenting support into the viewing distance monitor solution, parents like those of little Mike can take a more active role in their child's screen time habits. The companion app serves as a valuable tool for parents, providing insights, customization options, and resources to help them support their child's development of healthy screen time habits.

8.2.6 Integration with other platforms and devices

For families with kids, it is essential to ensure that the viewing distance monitor can be used seamlessly across a variety of platforms and devices. In the future, the monitor can be further developed to integrate with other platforms and devices, such as tablets, smartphones, and laptops. This integration would allow kids and their parents to maintain healthy viewing habits regardless of the device being used.

One approach to integration is to create an app or browser extension that can be installed on multiple devices. This app or extension can work in tandem with the existing viewing distance monitor, providing the same functionality and features across various screens. With the app installed, parents can receive real-time updates and notifications about children’s viewing distance and screen time on different devices.

Another aspect of integration involves compatibility with popular streaming platforms like Netflix, YouTube, and Amazon Prime Video. By working directly with these platforms, the viewing distance monitor can be more easily incorporated into children's and his family's daily routines. For example, the monitor can automatically pause a video or provide an on-screen reminder when children is too close to the screen, regardless of the platform he is using.

Moreover, integration with smart home systems such as Amazon Alexa, Google Home, or Apple HomeKit can help little parents control and monitor his screen time more effectively. Parents can set up routines or voice commands to manage the viewing distance monitor and even receive updates through their smart speakers.

By integrating the viewing distance monitor with other platforms and devices, children and their parents can consistently maintain healthy viewing habits across their various screens. This comprehensive approach ensures that the monitor can effectively support families like Mike's in fostering good screen time practices.

8.2.7 Accessibility

Accessibility is a crucial aspect of any technology, particularly when it comes to children with different needs. In the future, the viewing distance monitor can be further developed to cater to children with various abilities and requirements, including those with colorblindness, visual impairments, or hearing difficulties. This will ensure that the monitor is usable and effective for a diverse range of users, including, for example, little Mike's friends or classmates who may have different accessibility needs.

For example, for children with colorblindness, the system could provide alternative visual cues or indicators that do not rely solely on color. This may include the use of patterns, textures, or distinct shapes to convey the necessary information. Additionally, the system could offer customizable color schemes that allow users to choose the colors that work best for their specific type of colorblindness.

For children with visual impairments, the viewing distance monitor can be adapted to provide more prominent visual cues, such as larger text or icons. Alternatively, the system could incorporate audio cues or haptic feedback to convey the necessary information to the user. For example, the monitor could emit different tones or vibrations to indicate if the user is too close to the screen or if they are maintaining a healthy viewing distance.

For children with hearing difficulties, the system could rely more on visual or haptic feedback to communicate information about viewing distance. This may include the use of on-screen text, flashing icons, or vibrations to alert the user about their viewing habits. Additionally, the system could be designed to be compatible with hearing aids or other assistive devices that help amplify the audio cues.

By focusing on accessibility, the viewing distance monitor can better support a diverse range of users, including children with different needs and abilities. This ensures that the technology is inclusive and can have a positive impact on the lives of many children, not just little Mike and his friends.

8.3 Conclusion

In conclusion, viewing distance monitors can play an important role in promoting good eye health and preventing the negative effects of prolonged screen time.The use of computer vision technology to monitor viewing distance and provide prompts can help users maintain a healthy distance from the screen, reducing the risk of eye strain, headaches, and other related health problems. However, privacy is a major concern when it comes to viewing distance monitors, and there is a need to explore ways to enhance privacy without compromising the functionality of the monitor. Additionally, user testing is critical to ensuring that the viewing distance monitor meets the needs of its target audience and is easy to use, comfortable, and effective. By continuing to refine and improve viewing distance monitors, the project can help people stay healthy and productive in an increasingly digital world.

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