Video Games for Visual Interface (Eye Tracking)

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Abstract

People with disabilities can find them as a mis-match between their abilities and the environment, where the difficulties can be clearly seen in how they interact with objects around them. No matter which type of disabilities these people suffer, cognitive or mental, they all put a very heavy pressure in socializing as well as causing stress to their mind. Since eye movements are a very effective method for disabled to acknowledge and interact with the environment, a solution for this problem is targeted in this study where we focus on eye tracking as an ideal visual interface for people with disabilities. Using the advanced technologies, a platform including multiple and different type of games is created where we bring disabled people, especially children, an opportunity to improve their complex interactions as well as receiving new entertaining experience like a normal person by directly using their gaze throughout playing time.

1 Introduction

Eye tracking has gained a huge amount of attention of researchers in a variety of fields, from human-computer interaction, computer vision to medical and psychological studies [1]. Gaming is not an exception to this technique, where numerous companies in video game industry invest to create a more natural control mechanism for users to experience instead of only focusing in traditional controllers like mouse, keyboard, joystick, etc. As a matter of fact, eye tracking is one of the available interaction interfaces. That's why researchers find it very potential when it comes to a combination of gaming and eye tracking field.

Back in the past, eye tracking devices were still huge obstacles and remained as a challenge to researchers since they were not sufficient enough to be applied to fields requiring accurate reflection of natural eye movements. During recent years, as far as technologies advance, eye trackers have been well developed and became a comfortable way to approach more possible fields, including gaming.

This research strongly focuses in social and technological aspects, where we utilize low-cost devices for eye tracking to form an interface and develop games for special subjects who are compatible with it.

Video games with eye tracking have attracted numerous researchers as time goes by. It is not a new thing when it comes to eye tracking as a way to gain access with modern devices. Therefore, being able to control our behaviors and actions with eye movements during playing time and having them as input to video games promise to give a whole new level of experience. According to Samuel Almeida et al., video games can actually help players gaining significant improvement with their visual skills [2]. Coming to this study, eye tracking is really a game-changer since it aims for a special subject, disabled children. Suffering different types of disability, these children do not have as many chances as a normal child to experience modern video games as a very huge source of entertainment. They are children and we can all see that they are, more or less, often attracted to what occurs in video games and during their playing time. Therefore, Gazeplay, a platform of multiple mini games using low-cost eye trackers, is created to give them this kind of experience. However, since the subject of this study can have different disabilities and eye awareness, it leads to a question that how to create simple, fun and educative games without causing stress to players. That is the reason why games in Gazeplay platform are not only easy for users to approach, but also give intriguing challenges to help improve their memories, intellectual abilities as well as training them for more complex interactions.

Companies in the gaming industry have put an excessive amount of effort in developing many interesting video games [3]. However, these games are no doubt very expensive and require advanced components to be able to experience, which can be computers with high level processors and graphic cards. In fact, eye trackers have been way more affordable than they used to be in the past [4], as many commercial games utilize some very common eye trackers. Therefore, we come to this research making our own efforts in creating new video games utilizing these low-cost eye trackers. Along with the entertainment and education purpose, this study can also help researchers to collect more information from results of user playing time in order to gain more understanding of their behaviors and tendency with eye movements.

2 Eye movement

As a matter of fact, human eyes are always moving. They are never completely still and always make tiny involuntary motions, which are called microsaccades. From these little motions, researchers define some distinct movements of the eyes, including fixation and saccade. Our eyes make a visual fixation when we maintain gazing and focus on a single location. A fixation is often followed by a saccade, which is a quick movement of both eyes between two or more fixations at the same time. In this study, these two movements are very important since eye trackers work on them and help us form an interaction interface for our games.

3 Eye tracker

An eye tracker is a device which can measure eye movements as well as their positions. They are widely used in research when it comes to the field of marketing, psychology, psycholinguistics and as an input device for human-computer interaction. An eye tracker consists of sensors, which are projectors and cameras, and algorithms for measurement. The mirco projectors here provide a reflection pattern of Near-Infrared (NIR) light on our eyes. Its sensors captures images of eye movements and reflection patterns with high frame rates. These movements and reflection pattern are then processed by its algorithms and return specific details of the user's eye activities. The gaze point are also calculated to display on a device screen by these algorithms. Coming to this study, we use two models of eye trackers, The Eye Tribe and Tobii Eye Tracker 4C. The Eye Tribe is not available on the market anymore, however, Tobii Eye Tracker 4C is a compatible, efficient eye-tracking device and totally affordable, which only cost 169 euros.

Figure 1: Tobii Eye Tracker 4C.

4 Game with eye tracking

Along with the development of modern eye trackers and their APIs, the gaming industry has focused more and more in video games using eye tracking. In fact, this is a great thing for disabled people, especially children. It is true that lacking capability of using hands or legs really take a lot of chances from them to experience with today's video games. However, gaze still remains as one possible and powerful method for them to approach this source of entertainment. In fact, using eye tracking in video games can be a good controlling mechanism as eye movements are fast and require less effort com-

paring to traditional ones [5]. This interaction interface gives a more intuitive user experience since it can be more natural and engaging than conventional user interfaces. This is also a good way for helping disabled children integrate in the surrounding environment and the society through what happens in video games.

Coming to this research, the subject is to create entertaining games for disabled children. With Jill M. Olthouse [6], video games can also be refered as cognitive exercises, which can form in children various skills like problem solving skill, perceptual skill, multitasking, etc. These aspects are strongly concerned in our games in order to help children with disabilities. These games utilize the gaze of the user, mostly fixations and saccades to be more specific, as the way to control and interact with what happens in them.

5 Implementation and result

5.1 Rush Hour game

Rush Hour is a fun game which can fulfill the need of training the intellectual ability of players as well as improve their memories. As mentioned in the previous section [5], video games can form in children various skills like problem solving skill, perceptual skill, multitasking, etc. We strongly focus in these attributes to implementing Rush Hour game. It follows a very simple rule, which requires the player to move all obstacles in an appropriate way to make a clear linear path for our main object to reach the door. The difficulty increases when players make it to a new level. By facing a problem to solve in each level, players have to imagine the position of obstacles if a path to the door is made, come up with several possible solutions, try move these obstacles vertically or horizontally in the right order to clear the path. In this game, brown cars are considered as obstacles while the yellow one is the player object. For choosing which car to move, players need to look at it in a fixation length as the timeline progress circle completely fill with blue. If the moving direction of the chosen obstacle intersects with the current position our object or other obstacles, that move is not possible.
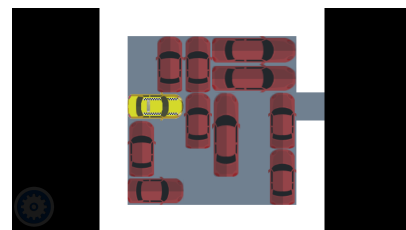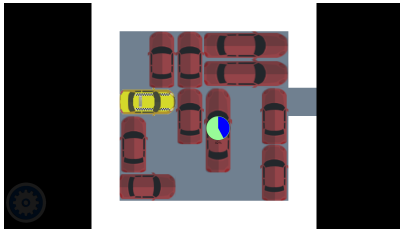

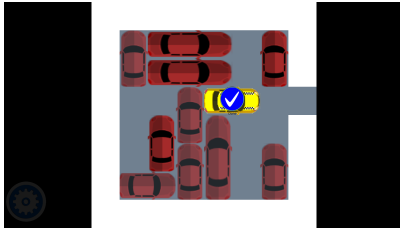
Figure 2: Level entry.

Figure 3: Choosing a car.

Figure 4: Clear path to the door.

5.2 Space game

Space game is a shooter game based on Space Invaders which is a very popular classic arcade game created in 1978 by Tomohiro Nishikado [7]. Space Invaders can be considered as one of the most influential video games of all time, which is an inspiration for the creation of later generations of shooting game, including some infamous first-person shooters like Halo, Doom and Call of Duty. Space game follows a simple scenario in which players control a spaceship flying through galaxies and use its firepower to shoot alien enemies. About controlling mechanism of Space game, players use their gaze throughout the game to horizontally move the spaceship and shooting alien enemies flying above. These enemies are also equipped with their own firepower and can shoot our spaceship with their bullets. Space game requires players to use saccades more than fixations since the range of movements widely spreads to the screen width instead of focusing in any single or specific location. Beside being a fun and intriguing shooting game, Space game can also help train and improve players more complex interactions with their gaze since it requires them to simultaneously practice reacting to events in the game and observe the whole screen across playing time.

Figure 5: Space game gameplay.

Handling movement of the spaceship between frames is a key part of creating this game. To be more specific, we use the linear motion equation

$$x' = x + v * t$$

to display the position of the spaceship in each frame where x is the position of the spaceship in the current frame, x' is its position in the next frame, v is the velocity vector (its value can be negative, positive or 0) and t as the time elapsed between these two consecutive frames. In order to perform correctly this motion, we calculate the $distance$ from the gaze point to our spaceship. The spaceship only moves horizontally so we only concern the x coordinate and consider y remains the same throughout the game. The $distance$ is an absolute value while the $direction$ can be 1, -1 or 0. The $direction$ will determine the value of the velocity vector followed by

$$v = direction * V$$

where V is the magnitude of velocity and always assigned with a suitable positive value depending on how fast the spaceship move between frames.
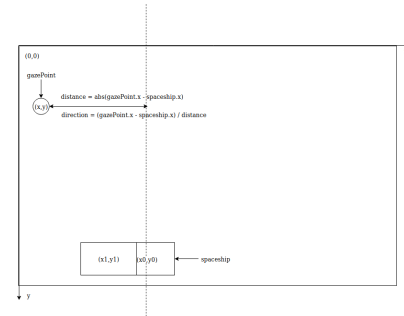

Figure 6: Linear motion of the spaceship.

Bullets of the spaceship and enemy are all translation along the y-axis. If bullets of an enemy intersect with the spaceship, the game ends. If our bullets intersect with enemies, they disappear and players gain points based on the number of destroyed enemies.

The *handle* method of Java AnimationTimer class works on a huge number of computation executed per frame. Normally the frame rate is 60 frames-per-second, however, this frame rate is hugely depended on if the processors are strong or not. Only the JavaFX thread executes this method and sometimes it can turn out to be not efficient because of the huge load of computation. We come with a solution to handle the load of computation per frame which is creating a thread pool and assigning different tasks to available threads in it.
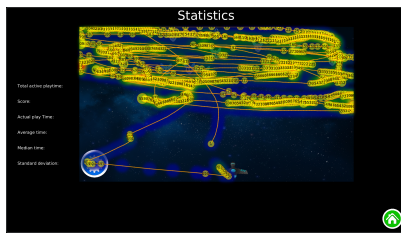
Figure 7: The fixation sequence and heatmap of the eye movements in SpaceGame.

According to Figure 7, the gaze are varies in the upper half of the screen, which shows that the player tends look on this half to get the whole view of enemies and their bullets as well as making adjustments to the spaceship position.

6 Conclusion

This study has shown that eye tracking has been a very significant and intuitive interaction interface as well as video games are no doubt a very good approach to help children with disabilities to learn and gain new experience. For the future work, creating more advanced video games should be considered along with continuing develop games which are already in the GazePlay platform. This will bring more entertaining experience to disabled children as well as helping them approach a huge source of knowledge and entertainment.

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