Video Game Programming for Visual Interface (Eye Trackers)

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Bardawil Peter, 08 June 2019

Abstract

Most people with disabilities have limited ability to interact with their environment, whether through cognitive disabilities (language, understanding, etc.) or mental motor disabilities (hands, arms, legs, etc.). The traditional interfaces for interaction with the digital world (keyboard, mouse, voice control) thus become unsuitable for this audience, which creates stress and social difficulties, making these people even more dependent on others. To solve this problem, one approach is to adapt these conventional interfaces to each individual based on his disability. This study will consist more precisely in implementing and mastering the capacities of a visual interface called eye tracking to help disabled people get access to the same level of information a normal person can get, and that through the creation of different video games for the Gazeplay platform.

1 Introduction

Today's society is heavily investing in large video games that's main concern is to entertain kids. As discussed by Kurt Squire in *Video games in education,* all kinds of video games are a good tool to teach kids as well. Even though some may not claim that with proofs, studies shows that it is a good way to make the user immerse himself and find new interesting perspectives to learn from. However, a problem our society is facing is to implement such video games for disabled kids, specially kids that could not use their hands to interact with their environments. It is obvious that a good way to teach those kids that would be the use of video games since it combines the pleasant and the useful. This is, in fact, the main principle we based our work on. Also, the gaze is recognized as being one of the most easy and natural way to communicate and interact; Eye-based input is highly natural, eye movements are extremely fast and require little effort. U*se of eye movements for video game control.* [*David Smith, J & Graham, T.C.. (2006)].*

Always based on that, the platform Gazeplay was created to provide educational games to help kids develop the use and precision of their gaze. The actual version contains more than 30 games and has two explicit goals: First, permit the user to train his gaze to offer him more complex interaction skills, second, entertain him.
The main problem here is to understand how to create games that will be functionally coherent and helpful to be able to achieve the stated goal. It is, in fact, not as obvious as it could look like at first sight since every individual react differently due to their different disabilities. This is why it is our responsibility to create such game that will affect and teach each single user to use the gaze at their own pace using different techniques and categories of games that focuses each on different learning outcomes. This will be shown by explaining the choice of the games we implemented.

Furthermore, we need to get in parallel a feedback to understand how those individuals react to those games and why. To do so we will use different metrics provided by the Eye tracker interface that could give us this information. The understanding of those metrics will give us an idea of how Gazeplay users reacts to our games and how important is the impact of those game on their learning path.

We will also compare the statistics we get when using the mouse interface and the eye tracker interface, just to give us a clear idea of how is the mouse more suitable and easy to use for general users, thus, this will help us give a possible improvement plan to the games we create such that the interaction with the user using the Eye tracker will be as smooth as possible as the interaction with the user using the mouse.

2 Eye tracking for communication

Gaze was proven by recent studies as being an effective tool to help us communicate with the environment surrounding us, but can the eye tracker really track all the movements of the gaze in real life? Is it optimally implemented to allow the user to interact in the most natural and spontaneous way? This is a problem that would be nice to discuss and analyze since we consider that we could improve the usability to permit all users to learn in the most optimal way. For this purpose, It is imperative to standardize and find the right way to use the different metrics used to characterize the gaze, for example: the Area of Interest, the fixation points, the scanpath and many more…*Eye Tracking in Human-Computer Interaction and Usability Research: Current Status and Future Prospects[Alex Poole and Linden J. Ball (2003)].*The interpretation of those metrics could play an important role in the understanding of the needs of the users and is a vital information to progress in the HCI area specialized in disabilities.

An example of a metric useful in the process of understanding what is attracting the gaze of the user is the heat map (Figure 1), it can communicate important aspects of the visual behavior with clarity and effectiveness. The closer the color of the points displayed by the heat map is to the red color, the more time was spent by the player gazing at this particular area.

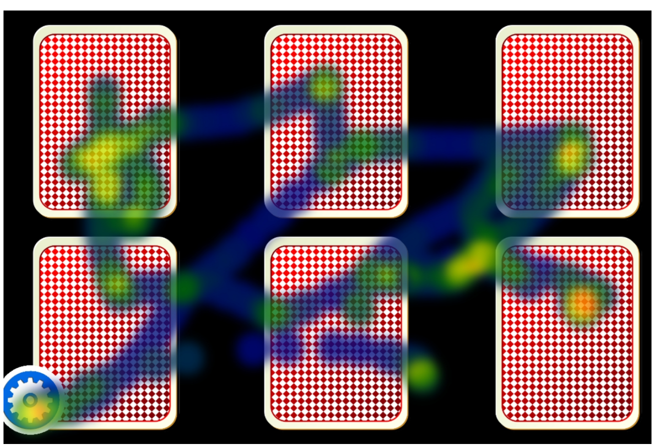

Figure 1: Heat map

We also studied other metrics that could help us understand how game users behave when interacting with the game environment; for example, fixation sequences (figure 2) give us both temporal and spatial information of the gaze of the player, this information will give us an idea of the order of fixation points, to understand better how the user react to the different items displayed on the screen. This is representative of what is most motivating to look at for the user. Eye-tracking metrics in perception and visual attention research [*Magdalena Borys, Małgorzata Plechawska-Wójcik, 2017*]. Every game that we created displays those informations to help us define how the user uses his gaze, how the different images are perceived and why.

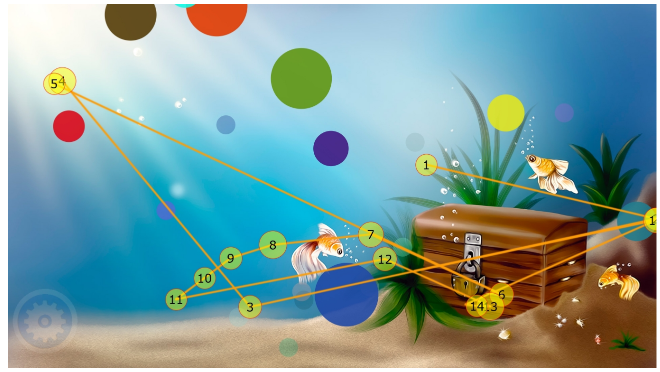

Figure 2: Fixation Sequence

Moreover, Eye trackers can be suitable to make us choose specific areas of the screen to study, such areas are areas that has an importance for us, for example areas where we need the user to focus at a specific time of the game. We can then, extract the info we need from this area that is called Area of Interest (figure 3): TTFF (time to first fixation),Time spent, Ratio and many more. Tests are then conducted in regards to those segments. This will not only help us understand how different disabled kids react to our games, but it will also teach us and explain us how to improve our games to attract each gaze in the area that we need to emphasize.

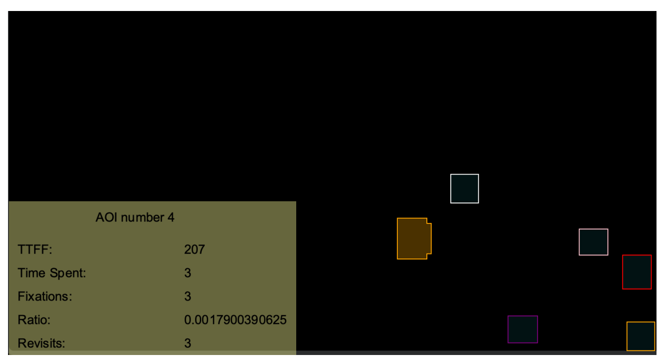

Figure 3: Area Of Interest

Since we now have all this data, we will be able to have a clear idea of the behavior of each user, and thus improving our games to permit better learning to users with different disabilities.

3 Video games for learning

This knowledge that we gathered from the study of the eye tracking system will allow us to create intuitive, logical and coherent games to achieve our primary goal, which is help disable kids in their process of growing up by teaching them basic and vital skills. Considered initially as a tool to provoke uniquely a sensation of fun, video games are these days more and more used for educational purposes. According to Jill M. Olthouse, when goals of the game and the learning goals match such that the player is engaging in metacognitive practices, playing video games could be both educative and fun. Our gaming platform Gazeplay stores a multitude of games that offers different learning skills such as:

- Memory games
- Aiming games
- Math games

Other than teaching basic skills to kids, this platform has the goal to show them how to use their gaze and let them be aware of how powerful and useful can be the use of our eye to communicate spontaneously and coherently. It is then a priority to always create new games that would give users the constant need and desire to improve their skills. This isn't an easy task since kids become more and more attracted to games that are not necessarily created for pedagogical purposes. We need a find a way to make them feel the necessity to use our platform by using different tricks such as instant gratification, challenging games with increasing difficulty.

Figure 4: Game example: Find the odd one out

Each game of the platform has specific learning outcomes that could help the user develop a particular skill; figure 2 describes the in-game process of Find the odd one out, a game proposed to gain progress in concentration and attention and at the same time, to improve the ability to classify each item into its category. The root of this game is the algorithm that chooses randomly pictures from a set of folders containing pictures of the same theme. After finding the right picture, an animation is displayed to gratify the player and give him this feeling of success.

Furthermore, We have agreed on creating a game that could bring even more to kids with disabilities such as Autism spectrum disorder (ASD), a game that could help them develop skills that are hardly attainable in their situation. To do so, we first studied the symptoms that are relevant to them: as discussed by Chris Plauche Johnson "Identification and Evaluation of Children With Autism Spectrum Disorders"(PEDIATRICS Volume 120, Number 5, November 2007), It is a characteristic of children with ASD to lack of play skills, some with severe ASDs may never progress past the sensory-motor play stage. Their play often is repetitive and lacks creativity and imitation. Puzzles, especially computerized "puzzle games," are quite popular because of being constructive games.

Accordingly, we decided to implement a puzzle-type game which could be easily playable using the eye tracker. The game is called sliding puzzle (figure 5), it consists of 6 blocks of images randomly displayed that needs to be placed at the right position. Multiple variants of this game were created with different difficulty levels: A first simple level would be a puzzle of card numbers that needs to be ordered (figure 5, left image). Another harder level would be a puzzle of a famous painting that needs to be assembled (figure 5, right image).

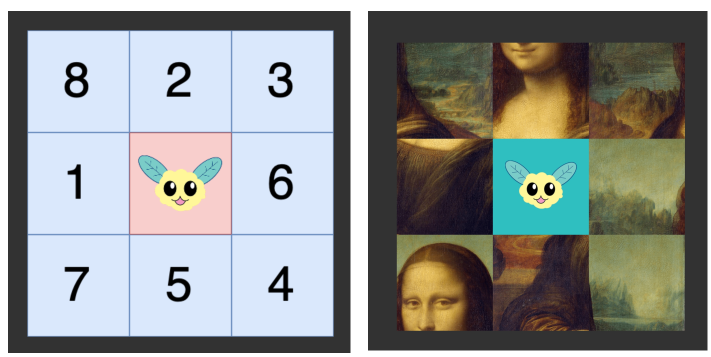

Figure 5: Sliding puzzle game variants

People with autism will face puzzles differently, because there is only one solution. Problem solving with only one possible solution is a very worthwhile and meaningful experience. Moreover, our sliding puzzle build the attention span as you have to focus on colors, shapes...Another useful benefit of the sliding puzzle is helping to develop fine motor skills as you must work carefully to fit the pieces of the image together correctly. Finally, This is an important benefit because when a person finishes this puzzle on their own it gives a great boost to their self-confidence and self-esteem.

4 Gaming stats: Eye tracker Vs Mouse

Now that we finished studying the eye tracker and the metrics relevant to us, we also successfully implemented the games targeting disabled users, we decided to take a look at the statistics that emerges after playing those games to understand how can the mouse be more efficient and usable than the eye tracker. We also want to define in which aspects is the eye tracker easier to use and lead to better result than the mouse. In this purpose, we tested multiple games with the two different interfaces(Mouse and Eye tracker), and got different statistical results (appearing in figure 6).

Eye Tracker	Mouse
Game: Biboule **Playing time:** 1m59s **Shots:** 313 **Success rate:** 98% **Average reaction time:** 375ms **Median reaction time:** 382ms **Standard deviation:** 301ms	**Game:** Biboule **Playing time:** 2m26s **Shots:** 533 **Success rate:** 98% **Average reaction time:** 271ms **Median reaction time:** 263ms **Standard deviation:** 207ms
Game: Memory **Playing time:** 1m1s **Average time:** 9s **Median time:** 6s **Standard deviation:** 6s	**Game:** Memory **Playing time:** 42s **Average time:** 5s **Median time:** 3s **Standard deviation:** 3s
Game: Ninja **Playing time:** 54s **Shots:** 15 **Success rate:** 100% **Average reaction time:** 1s438ms **Median reaction time:** 797ms **Standard deviation:** 1s982ms	**Game:** Ninja **Playing time:** 51s **Shots:** 18 **Success rate:** 100% **Average reaction time:** 669ms **Median reaction time:** 578ms **Standard deviation:** 229ms
Game: Math **Playing time:** 42s **Score:** 4 **Average time:** 2s271ms **Median time:** 2s67ms **Standard deviation:** 608ms	**Game:** Math **Playing time:** 1m30s **Score:** 9 **Average time:** 1s665ms **Median time:** 1s898ms **Standard deviation:** 869ms

Figure 6: Statistical comparison of game outputs with 2 different input interfaces.

The result of this statistical study show as expected that the use of the mouse as the input interface lead to much smaller numbers than the use of the eye tracker. This means that the user reacts faster and then get better result when playing the games we implemented. For example, when playing the Ninja game which consists of aiming at different items displayed randomly in the screen with those two different input devices, we can see that the Average reaction time, Median time and standard deviation tend to be much more significant when using the eye tracker.
Moreover, this shows that the normal user would have a much better gaming experience when using the mouse instead of the eye tracker since it brings a more spontaneous, more efficient and easier interaction with the environment as shown by the numbers, the player will get better scores.

Besides, after testing multiple games multiple times using the eye tracker, we noticed that the statistical numbers we get are exponentially getting closer to the stats obtained when playing the same games with the mouse.
A possible reason for that could be that we are training our gaze to interact better in our environment, which would shed the light on the importance of the games we implemented in the learning path of the gaze.

Furthermore, something else popped to our mind when analyzing the statistical output between the two input devices; the fixation sequence graph for the eye tracker reveals that the line between two fixations (which is defined in *Eye-Tracking Metrics in Software Engineering* as the stabilization of the eye on part of a stimulus for a period of time (200-300 ms)) is a straight line, it also shows much more informations (figure 7a).On the other side, the fixation sequence graph for the mouse(figure 7b) displays lines that are more curved and much less quantitatively important than the previous one.

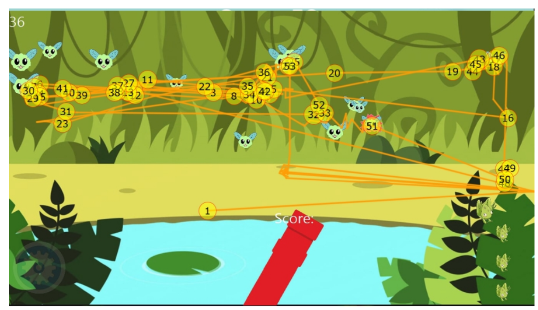

Figure 7a : Fixation Sequence with the eye tracker

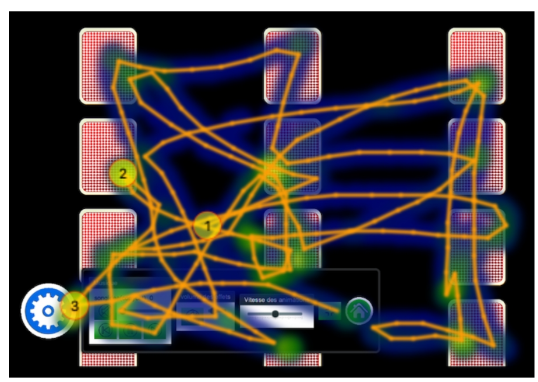

Figure 7b : Fixation Sequence with the mouse

This results from the fact that eye tracking does capture significantly more involuntary eye movement than mouse tracking, providing a window into the user's subconscious, it also give us a possible reason to the larger reaction time captured earlier during the comparative study.

5 Discussion

This study has not only a technological significance but also a social one. In fact, this topic is part of a broader communication project for people with disabilities. It brings together an international community of professionals (speech therapists, occupational therapists, etc.), families and associations. It involves the study of a big amount of different domains to be able to fully understand the needs and requirements of users with disabilities. The work we achieved here was more precisely about understanding the needs of disabled people to be able to give them a completely user-friendly, spontaneous, effective and learning curved experience during there playtime. As a result, the platform Gazeplay was incremented with different playful and pedagogical games created for specific social and educational purposes. This was successfully performed thanks to our deep study and analysis of the eye tracker metrics to understand the complex behavior of the gaze when interacting in a new environment. Also, the statistical comparison of the eye tracker and the mouse as the input process for the games helped us understand why the mouse tracking is more user friendly and spontaneous than the eye tracking. This additional information gave us some sight about future possible improvements in the use of the eye tracker as a principal input interface for our gaming platform and more generally for games targeting disabled users.

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