GazeTrain: A case study of an action oriented gaze-controlled game.

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Keywords
Gaze-Interaction, Game, Human Computer Interaction, Accessibility, Usability, Usability Heuristics

Introduction

Creating an engaging and worthwhile gaze-controlled game poses a significant number of challenges. The challenges are compounded by the fact that a number of popular game mechanics rely on quick reactions, and complex input. The straightforward solution to this issue is to avoid these game mechanics, and use the ones that do not require quick reactions. However, avoiding specific mechanics can lead to excluding certain types of game genres, thus reducing the variety of an already meager games selection. With the intention of providing further variety to physically challenged gamers, we present *GazeTrain*, inspired by a classic action oriented puzzle game *Pipe Dream* (Wikipedia, 04.03.2009) developed in 1989. We describe the process, necessary compromises and possible pitfalls of redesigning and implementing a game concept for use with gaze control. Preliminary tests and their results are also briefly discussed at the end of the article. The game and associated source is available for free download from The COGAIN Association's homepage: *http://www.cogain.org*, in the hopes of motivating further development within the field of leisure applications using gaze-control. In addition to the downloadable game, it will be possible for gamers to contribute feedback and donations towards further development.

In *Pipe Dream*, a source of inspiration for *GazeTrain*, the player is responsible for assembling a set of short pipes through which an unidentified liquid can flow. The short pipes are placed in a grid structure and cannot be removed once placed. Individual pipe pieces can however be replaced, at a point penalty, if the liquid has yet to flow through it. Constructing a sufficiently long line of short pipes for the liquid to flow through, allows the player to advance to the next level. The player is provided with only one pipe-piece to place and a short overview of upcoming pieces. The game ends when the liquid catches up to the end of the current pipe, and it is not sufficiently long. A freeware implementation of *Pipe Dream* can be downloaded from the following location: http://members.chello.at/theodor.lauppert/games/pipe1.htm.

Developed over a two month period, *GazeTrain* (see Figure 1) charges the player with placing traintracks in front of a moving train to guide it and solve simple tasks. Although the challenges in the game vary, depending on which mode the game is played in, the ultimate goal remains the same. Earn as much money as possible by traversing new tracks and delivering cargo at various cities. The game modes consist of: Practice Mode, Resource Mode, and Timed Mode. Practice Mode allows novice players a chance to familiarize themselves with the interface without being distracted or pressured by other game elements. Resource Mode charges the player with delivering a set number of resources as fast as possible. Timed Mode challenges the player to deliver as much cargo as possible, given a set time limit. This time limit is extended as the player delivers cargo.

Game Design Choices

Pipe Dream, which *GazeTrain* is loosely based upon, is comprised of multiple game mechanics. A number of these lend themselves towards being gaze-controlled, where as others do not. During development a few core concepts from *Pipe Dream* were adopted directly into the design of *GazeTrain*, a number of them were modified before being adopted, and some were dropped altogether. Instead of detailing every core concept and the necessary modifications to make them gaze-control compatible, we describe what we consider to be the most critical design choices, which are applicable to several core concepts, below:

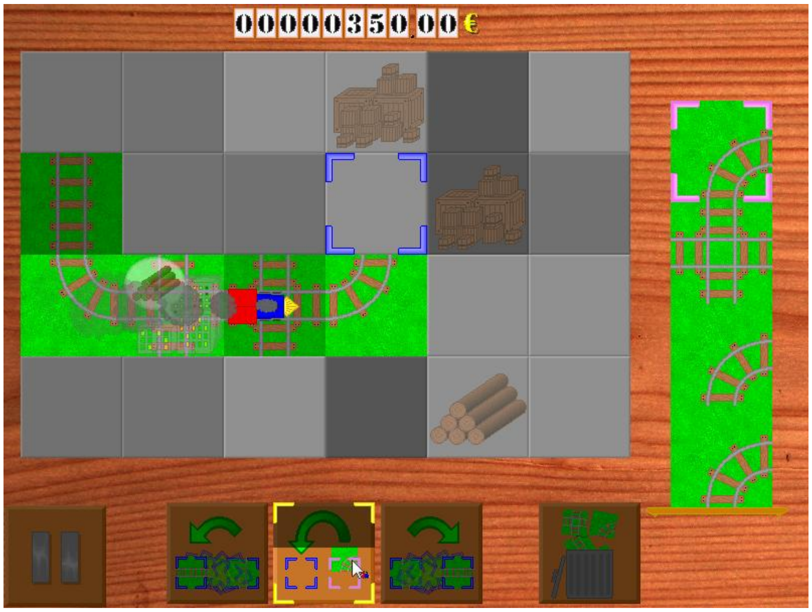

Figure 1. In-Game Screenshot of GazeTrain.

- **Customizability** – Physically challenged gamers will, to a varying degree, be unable to control their interaction with a given application. Interaction can be hampered by involuntary muscle spasm or inferior eye tracking. If a game allows for the customization of various game and/or interface elements, the user may be able to make the game compensate for the involuntary actions. The more customizable a game is, the higher the likelihood that a motivated, but physically challenged, gamer can tailor it uniquely to her needs. However, it is important to note that the developer must not shift the burden of properly tweaking various game elements, over to the user. For example, the developer should strive to properly balance the games difficulty, and then make it possible to modify, for the benefit of the user. Note that this customizability should preferably extend beyond game elements and into meta-game territory, such as the Graphical User Interface.
- **Soft penalties** – It goes without saying that any game should strive to deliver a positive experience to its users. According to flow theory (Csikszentmihaliy, 1990), people are happiest when they are in flow. Specifically, when they are just able to overcome the challenges presented to them. If the challenges are too overwhelming, they will become frustrated, but if the challenges are too easy, they will become bored. According to Csikszentmihaliy, entering flow requires that both the challenge presented and skills required to overcome it, are at their peak. Some people describe this state of flow as completely focused on the task at hand and being unaware of the world around them. But flow theory can be difficult to apply in an action oriented gaze-controlled game. Game mechanics requiring quick reactions, and involuntary player actions, are at odds, especially in this regard. If the

game cannot detect involuntary actions, then providing the player with a challenge they are just able to overcome, is very difficult. As previously stated, one solution is avoid these troublesome mechanics. But this might deprive the player of an enjoyable game mechanic. An alternate solution is to still use these mechanics, but alter the game to soften penalties for any mistakes. For example, if the player fails to react properly within a certain amount of time in *Pipe Dream*, the game ends. The corresponding penalty in *GazeTrain* is that the player either gains fewer points, or receives less time to play. A much softer penalty than an abrupt ending to the game. Using this softer penalty means that the challenge to the player remains largely intact, but the frustration of failure, either due to voluntary or involuntary action, is reduced.

- **Unorthodox interface control** – A core game mechanic in *Pipe Dream* is the ability to quickly react and place game pieces in the correct position. As previously stated, the penalty for being unable to react correctly in time has been reduced in *GazeTrain*, to better accommodate players using gaze-control. However, the standard dwell click technique used in a number of gaze-controlled games remains at odds with this fast-paced requirement. Standard protocol would involve an extended dwell time when an action of some importance is undertaken. This extended dwell time was replaced with an additional, but shorter, dwell click. Figure 2 shows the complete number of steps required to place a single tile in *GazeTrain*. First, a source tile is selected, then a destination is chosen, and finally the action is confirmed by selecting the "transfer tile" button. The selection of the source and destination would be required regardless of interaction technique. The relevant difference is that instead of letting the user dwell an extended period of time on the destination square, a movement of the mouse pointer (via the eyes) and shorter dwell time is required.

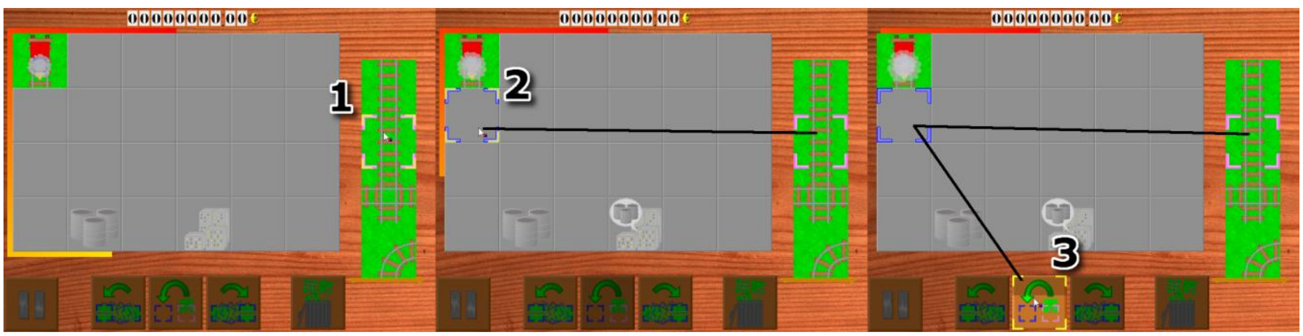

Figure 2. 3 step track tile placement process.

- **Active Elements** – Moving or animated elements in a gaze-controlled game can cause unintended effects as they have a tendency to attract the attention of the player. Once the players' attention has been attracted, the mouse pointer will follow. In an attempt to avoid unintended actions due to misdirected attention, all of the consequential actions require the user to look within an area containing no excessively active elements. Every action, which can be performed without looking in that specific area, is of no consequence or can easily be undone.

User Testing

Two volunteers (both male) participated in the preliminary evaluation. Neither with any previous eye tracker experience. The test platform was an ERICA Eye Tracker comprised of a Sahara Slate PC (Tablet PC) with an Intel Pentium M 1.3 Ghz processor and a 12.1 inch screen with a resolution of 1024 x 768.

Each participant played the practice mode of the game for approximately ten minutes. As mentioned earlier, the practice mode allows the player to familiarize themselves without any additional pressure. During the tests, each participant was asked to verbalize their thoughts. It should be noted that during each participants test the eye tracker had to be recalibrated to allow for proper interaction. After each test, a short interview was conducted with the participant to gain further insight into their experience. We have listed what we believe to be the most relevant observations below:

- **Dwell Time** – Initially, the dwell time was set to be 500 ms, based on the settings used in EyeDraw (Hornof et al., 2004). The first participant experienced a number of problems with this setting and the dwell time was increased to 1500 ms (closer to the setting described in EyeChess (Spakov and Miniotas, 2005). The second participant revealed during the interview that he felt the dwell time was somewhat too long. The difference in preferred dwell time is probably related to the players' ability and experience, as implied by Spakov and Miniotas. However, we also believe that a tolerable dwell time is related to the accuracy of the eye tracker. The more precise an eye tracker is the less trouble a user will have, which could lead to a preferred shorter dwell time. If the eye tracker is less precise the user may prefer a longer dwell as to ensure no mistaken actions are performed. All of these observations further underline the need for customizability to allow for the best user experience. Additionally, it may be beneficial to use different dwell times for different interface elements. One volunteer commented that the dwell time for the control panel elements should be reduced since these elements were much easier to differentiate than others. It is important to note that the accuracy of the eye tracker also affects the perception of how easily certain interface elements are selectable.
- **Interface Design** – When possible, the interface should consider the need for additional applications to be visible during its execution. For example, the ERICA eye tracker provides a video feed window which provides feedback on whether or not the users' eye is in view and being tracked properly. Ideally the interface should also be customizable to some degree, allowing the user to place interface elements in preferred locations or even change their sizes to allow for easier access.

Conclusion and perspectives

Although there exists a number of resources (Donegan, 2006) intended to aid the development of gaze-controlled software, there is still a need for further research and more comparative studies. The observations presented in this article are intended to provide further insight, and help similar projects during the decision making process to avoid potential pitfalls.

For future tests of *GazeTrain*, and probably most other gaze controlled applications, it would be an advantage to measure the accuracy of the used eye tracker during the tests. The accuracy has a significant effect on both the users experience and perceived interface usability. However, regardless of what concrete measurements yield, each physically challenged gamer will have their own personal set of preferences and perhaps disabilities which results in very specific requirements of the application in question. Without knowing exactly which limitations the user has, customizability is one of the best approaches to the problem.

Acknowledgements

The project has received funding from the Technical University of Denmark and the EU Network of Excellence COGAIN, for which we are thankful. We are also thankful for the loan of an Eye Tracker from the COGAIN pool during development. In addition we wish to thank Mick Donegan, ACE Centre for his insightful feedback and Henrik Jensen, IT-University for his valuable input.

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