Video Game Controllers

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ABSTRACT

Research has shown that controllers have an influence on the enjoyment, motivation, and personality of a game, by Birk et al [4]. The type of input for the video game also has an effect on the ability level of the player in the game.

This paper will consider the history of video game controllers, areas researched in controller design, and current research problems. Currently game controllers are designed for a specific system and are then applied to a large number of games, rather than being designed specifically for one game or one type of game.

Author Keywords

Controller, games, player experience, design.

INTRODUCTION

Video games require an input from the user to control the actions of the game. A controller is an electronic device that is used as platform for the user input. These controllers have historically been in the form of a keyboard, mouse, console controllers (such as Xbox's or Playtation's), or several other types of input devices. Usually, a game's controls are determined by the type of platform the game is designed on.

An important aspect of controllers is *body-thing dialogue*, a concept designed by Larssen et al [5]. The physical properties of the controller give it shape and mass, dictating how the user controls the controller. Different masses and styles can lead to different uses for the controllers. For example, the Wii remote's design leads to a different type of play style, and actually has a higher throughput than a traditional controller, as explained by Natapov et al [3].

Video game controller design has many difficulties that this paper will discuss. One major challenge controller designer's face is size. People have different hand sizes and need to be able to function with any controller adequately. Another major challenge is the competition from the mouse

and how to design a controller such that its input can simulate enough states to play different games.

RELATED WORK

There have been several papers on the different aspects of video game controller design. Brown et al [2] studied the usability of a controller and hand size. This is an important test, because it studies this issue of size, which is a fundamental problem of generic controllers. Andrew et al evaluated potential of tangible designs in terms of child learning development. They made substantial discoveries when analyzing how the physical design of an object affects the problem solving capabilities of the user. Natapov et al [3] evaluated the controller design of the Xbox, PlayStation, and Wii, with the mouse as a base. Birk et al [4] evaluated the relationship between player experience and controller design. This evaluation shows that controller design is an important aspect of player experience.

HISTORY

The history of video game controllers is as old as the video game industry itself. Generally, original video game controllers were specialized pieces of hardware that were designed for an individual game. Except for modern specialized hardware, like Guitar Hero, most modern controllers now follow a more general approach. Instead of being specialized for a particular game, they offer enough options and capabilities to play a variety of games in a number of genres.

The following figures will show the evolution of controllers by giving examples of different game controllers and by describing how the design concepts changed over time.

Magnavox Odyssey 100

One of the first video game controllers was the Magnavox Odyssey 100. The Magnavox was introduced in 1972 and controlled the sliders for a pong game. The game only needed vertical and horizontal movement to control the pong paddles, therefore the controller only had two dials to control this movement. This early controller was very limited in capabilities and design.

Figure 1: The Magnavox Odyssey 100 controller. Note the two sliders for vertical and horizontal control.

Atari

The Atari controller was a single button and a joystick. Unlike the Magnavox Odyssey 100, it was able to play more than just one game. The joystick allowed for more precise movements compared to the original sliders or a D-pad. The Atari controller was also simplistic in design, extremely easy to learn, and had a shallow learning curve.

Figure 2: An Atari controller. Note the single joystick and single button that the player used to control the game.

Nintendo 64

The Nintendo 64 controller came out in 1996, 24 years after the Magnavox Odyssey 100. It had 14 buttons and one joystick, leading to many possible different types of inputs ranging from controlling Mario in a 3D world to controlling Starfox's ship through an asteroid field. The joystick gave the user the ability to move in a precise fashion, allowing the ability to turn in the exact direction specified by the user, rather than the directional pad which was bound to the left, right, down, and up directions. A noticeable feature of the Nintendo 64 controller is the three pronged design. This one of the few controllers to have the three pronged design and no modern controllers have it.

Figure 3: The Nintendo 64 controller. Three buttons are located on the back in addition to the eleven on the face. Note the single joystick located in the middle of the device, a feature improved upon in modern controllers.

Xbox One

The modern Xbox One controller was released in 2013, 17 years after the Nintendo 64. It has fifteen buttons and two joysticks, located mid left and mid right of center. Dual joysticks allows for even greater input from the user. Now a player can turn a character in the game while allowing for his attention/focus to be elsewhere. For example, turning a corner in Halo while also aiming your rifle, the dual joysticks allows for this to happen at the same time. This leaves the right hand side close enough to the other buttons to make it possible for the user to quickly switch between the right analog stick and the buttons.

Figure 3: The Xbox One controller. Note the dual joysticks and their new placement on the controller. The dual joysticks offer more realistic movement in a game.

Other
Modern video game controllers are not always physical devices. The Xbox Kinect allows for the human body to be the controller. Microsoft's [8] research into this domain has found that there is no tradeoff or disadvantage to using this technique compared to controllers. This means that the joy of a game is determined by the user and the game itself, not the controller. This has interesting ramifications for the video game controller industry. It means that there are no inherent human flaws in design when moving forward with this type of technology. But it does allow for the issue of misinterpretation of information gathered by the controller. This paper will focus on physical controllers rather than image based ones.

PREVIOUS DESIGN PROBLEMS
Various problems have been researched and improved upon. The biggest challenge was designing a controller that can be easy to use, comfortable, and plays a variety of games.

Easy to use
As noted earlier, earlier video game controllers were specialty controllers made for a specific purpose. While there are no papers comparing early controllers' vs modern ones in these terms, it is easy to notice through the figures and design aspects shown that the controllers have increased in complexity and usability over time. This is a natural evolution of controllers since the games that the controllers are being used for are becoming increasingly complex and need a controller with more utility. Designers

have to maintain the easy-to-use concept controllers need to be successful as games increasingly get more complex and require more player feedback. Otherwise, the controller will be too complex and will ultimately be unusable.

Comfort
The three pronged design of the Nintendo 64 was singular as a controller and was also short lived. It did pave the way for the most popular future controller designs by introducing the analog stick. Many modern controllers that don't use motion for input use the dual pronged design. This allows the player to be able to reach all parts of the controller from resting position, a feat that would be hard to accomplish on the Nintendo 64 due to its unwieldy three pronged design.

Variety
The raw increase of buttons and addition of joysticks added the capability to simulate more actions in games and added a greater degree of accuracy in movement. The hand size problem has not been solved in terms of controller design but it has been studied and improved upon, as Brown et al [2] researched.

DESIGN PROBLEMS
Every video game controller designer has to decide on a tradeoff of complexity and usability. As controllers get more complex, so does the process of learning to use the controller, as researched by Microsoft [8]. There is also the physical limitation of the hands. A controller can only be as complex as the general public's hands can allow it to be. Therefore, this paper has pulled together different aspects of a controller that have been studied and analyzed. These design problems are hand size, speed, and input.

Hand Size
While the research on specific video game controllers is scarce, the research on hand-held tools is not. Research shows that hand size and hand strength both contribute to the usability of a particular hand tool, as shown by Sperling et al [1]. Therefore, designers must account for this by setting up the controller such that a person with hands of any size can adequately navigate its features.

Brown et al [2] found that having small hands did not statically matter to any of the major controllers other than the Xbox controller. This shows that controller designers have worked hard to maintain the size of their controllers so they do not become unusable by any group of people.

Since a controller is made generically, its design must take into account that hand sizes range greatly. As pointed out earlier, the Xbox controller large design makes it so that smaller handed individual are unable to reach all the buttons from the resting position. The Wii and PlayStation controllers saw no issues with hand sizes. Microsoft must have recognized this as a problem because when the Xbox

360's controller was released, it was considerably smaller than the Xbox's controller.

Speed

Another aspect of video game controller is speed and precision. Natapov et al [3] found that a mouse is able to output more data to the game than traditional controllers. This means that players using a mouse will be able to output more data than a player using a classic controller, an aspect that controller designers must compensate for. The paper also notes that a mouse isn't always ideal because it needs a surface to be on and the player has to in a confined position, usually sitting at a desk. A controller, especially a wireless controller, allows the player to recline in a sofa, stand, or simply play in bed.
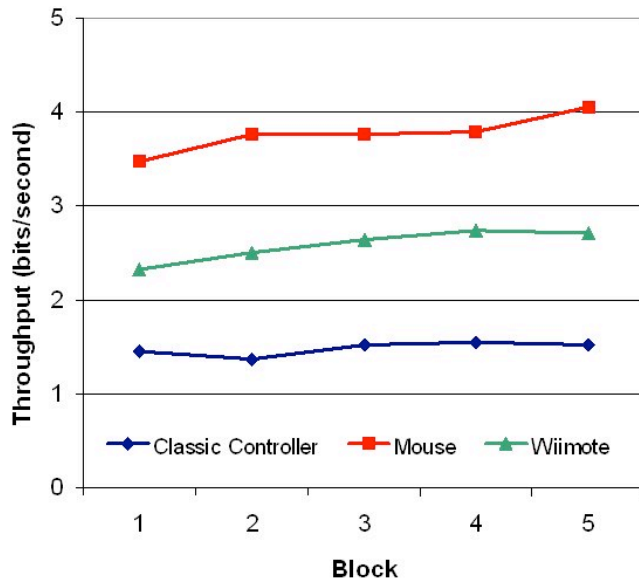

Figure 4: Natapov et al [3] result's from the study. Throughput is defined as bits/second. Note that the Wiimote outperformed the classic controller.

Input

Andrew et al has shown that physical representations have properties that can afford or limit various states and actions in problem solving. Since video games are based around problem solving in various forms, a controller's design, which is a physical representation of one's movement in a game's world, would also afford or limit various states depending on how well the controller is designed. For example, the Magnavox Odyssey 100 controller would be unusable in any modern game. It would be unusable because it only has dual sliders which only allows for two different type of movement. It does not even allow for as much functionality as the Nintendo 64's fourteen buttons and one joystick controller, which is outdated as well.

As games get more complex, the idea of how to input to a game will change too. Virtual reality helmets and stands are becoming more commercially available. These helmets will most likely be addition to a controller of some sort,

increasing the amount of input a player can provide to a game, and simultaneously decreasing the throughput gap between the mouse and classic controller. Virtual reality equipment poses its own design challenges in addition to standard controller design.

Figure 6: The Oculus Rift, a virtual reality controller.

RESEARCH ON CONTROLLERS

Barr et al [6] performed research on both the PS4 and Xbox controller. Barr noticed that participants struggled with complex controls and showed frustration when they could not figure the controls out. He calls this *systematic tension*. An example of this if a controller's poor design leads to systematic leads to problems for the player. He also notes about a *breakdown*, which is when the flow of activity is disrupted, like accidently hitting jump instead of duck in an intense fight. Both *systematic tension* and *breakdown* can be reduced by high quality controller design and simple to use interfaces.

Desurvire et al [7] used heuristics to evaluate the playability of games. Naturally, controllers and their design came into play. Several different items under mechanics and usability have controller design in their nature. For example, item 4 under section mechanics says that a controller's actions should have consistently mapped and learnable responses. A controller's design and user interface greatly affects the overall score that a game design can receive.

Barr et al [6] and Desurvire et al [7] papers both research games but do focus on controllers. This is because controllers/input can make or break a game. Barr et al [6] talked more about controller design and the ramification while Desurvire et al [7] talked more about the heuristics over a game design overall.

CONCLUSION

The video game controller design industry has come a long way since the first controllers were introduced. Early controllers were designed for a single game or purpose and have evolved into the complex modern designs we see today that allow for a wide array of inputs and uses.

As virtual reality technology evolves, there will be a need to study the design not only the newest hand-held

controllers, but also of helmets and related gear. Just like the hand size problem seen in controllers, people's heads and other appendages will vary in sizes and functionality.

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