An Interactive In-Game Approach to User Adjustment of Stereoscopic 3D Settings

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ABSTRACT

Given the popularity of 3D film, content developers have been creating customizable stereoscopic 3D experiences for the user to enjoy at home. Stereoscopic 3D game developers often offer a 'white box' approach whereby far too many controls and settings are exposed to the average consumer who may have little knowledge or interest to correctly adjust these settings. Improper settings can lead to users being uncomfortable or unimpressed with their own user-defined stereoscopic 3D experience. We have begun investigating interactive approaches to in-game adjustment of the various stereoscopic 3D parameters to reduce the reliance on user doing so and thefore create a more pleasurable stereoscopic 3D experience. In this paper, we describe a preliminary technique for interactively calibrating the various stereoscopic 3D parameters and we compare this interface with the typical slider-based control interface game developers utilize in commercial S3D games. Inspired by standard testing methodologies experienced at an optometrist, we've created a split-screen game with the same stereoscopic 3D game running in both screens, but with different interaxial distances. We expect that the interactive nature of the calibration will impact the final game experience providing us with an indication of whether in-game, interactive, S3D parameter calibration is a mechanism that game developers should adopt.

Keywords: Stereoscopic 3D, video games, floating window, design, perception.

1. INTRODUCTION

Since stereoscopic 3D (S3D) effects in games can vary depending on the viewer Schild et. al., (2012)[1], customizability is seen as a core advantage to at-home stereoscopic entertainment. Stereoscopic 3D film techniques have been studies effectively[2,3] however benefit from a medium that does not allow user customization since theatre's contain many viewers in different positions. In an attempt to allow the user full customization, software designers often offer a 'white box' approach in which too many controls and settings are exposed to the average consumer typically adjusted during a parameter calibration stage prior to playing the game. However, the average user may feel uncomfortable in making such adjustments to the settings, leaving them unimpressed with their own user-defined S3D settings. Ideally, a true 'black box' approach would allow users to have all the necessary S3D parameters seamlessly defined for them, potentially leading to a reduction in the dissatisfaction currently experienced by many with existing home S3D systems. Our goals are twofold: i) investigate interactive approaches to setting these parameters (i.e., an interactive S3D calibration system), and ii) to compare the final stereoscopic settings with the methods provided by the content developers. In this paper, we present two stereoscopic 3D calibration methods for setting the interaxial distance between the stereoscopic 3D camera used to render the scene. The first method (the *slider* method) is similar to the methods used in typical games, while the second method (*S3D* lens method) was developed to reduce the effort required by the user during the calibration stage. In addition, we also describe a user-based study that was conducted to compare these two methods.

1.1 Method 1: Slider

The first method used to adjust the interaxial distance was a simple slider as shown in Figures 1 and 2. This slider is typical of methods currently used in commercial video game menus (and stereoscopic 3D drivers) to allow the user to

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adjust the amount of “depth” they can experience in the scene. Our slider simply controls one stereoscopic parameter (interaxial distance) within the range of (0.1778 m to 6.35 m).

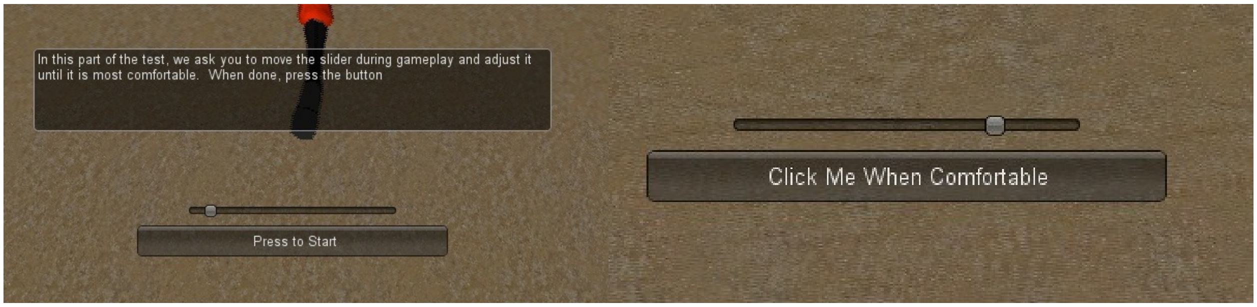
In this part of the test, we ask you to move the slider during gameplay and adjust it until it is most comfortable. When done, press the button

Figure 1: Close up screen-shot of the slider controls and instructions for the comparison trials. The slider allows the user to modify the interaxial distance between the stereosocpic 3D cameras while viewing the game environment.

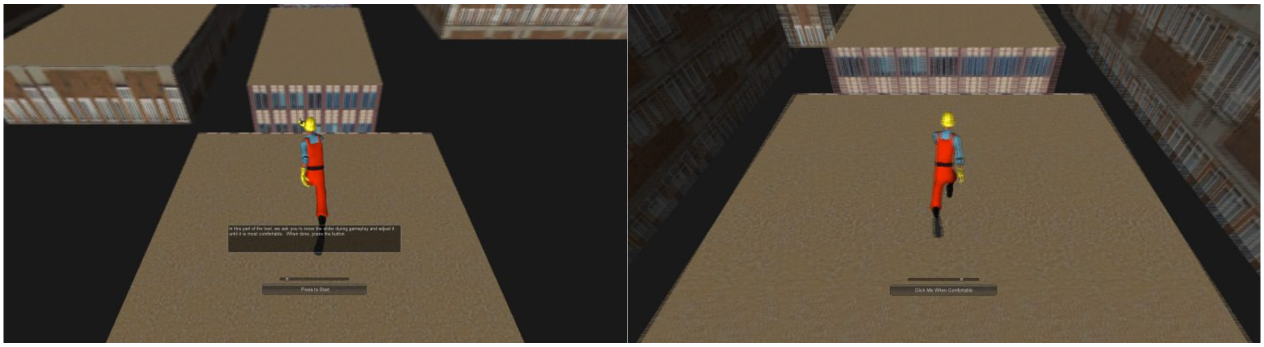

Figure 2: View of the slider comparison trials.

1.2 Method 2: S3D Lens

Our second method for modifying the stereoscopic settings is an in-game comparison of two different stereoscopic 3D “lenses” as shown in Figure 2. Inspired by standard testing methodologies experienced at the optometrist, the game is presented in a split-screen with the same gameplay running consecutively in two screens, each screen with a different interaxial distance setting. The zero-parallax plane is fixed to be just in front of the player’s avatar, as is common in many stereoscopic 3D video games. As the player jumps over buildings, the user is asked to choose the most satisfactory screen every five seconds. By using a process similar to optometrist tests, the user’s optimal interaxial distance is selected. The algorithm used to converge on the preferred interaxial distance is provided below:

```
Screen 1 (left) always starts on the lowest setting
Screen 2 (right) always starts on highest setting

Player selects their preference (left or right arrow keys)
if (selected setting) > (unselected setting)
      Update (unselected setting) to 1 step higher
else if (selected setting) < (unselected setting)
      Update (unselected setting) to 1 step lower

continue until both settings are equivalant
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The interval for the parameter is divided into 10 equal steps for setting the interaxial distances and upon each selection (selections were made using the left-right arrow keys), the left-right screens may have been swapped (50% chance of them being swapped).

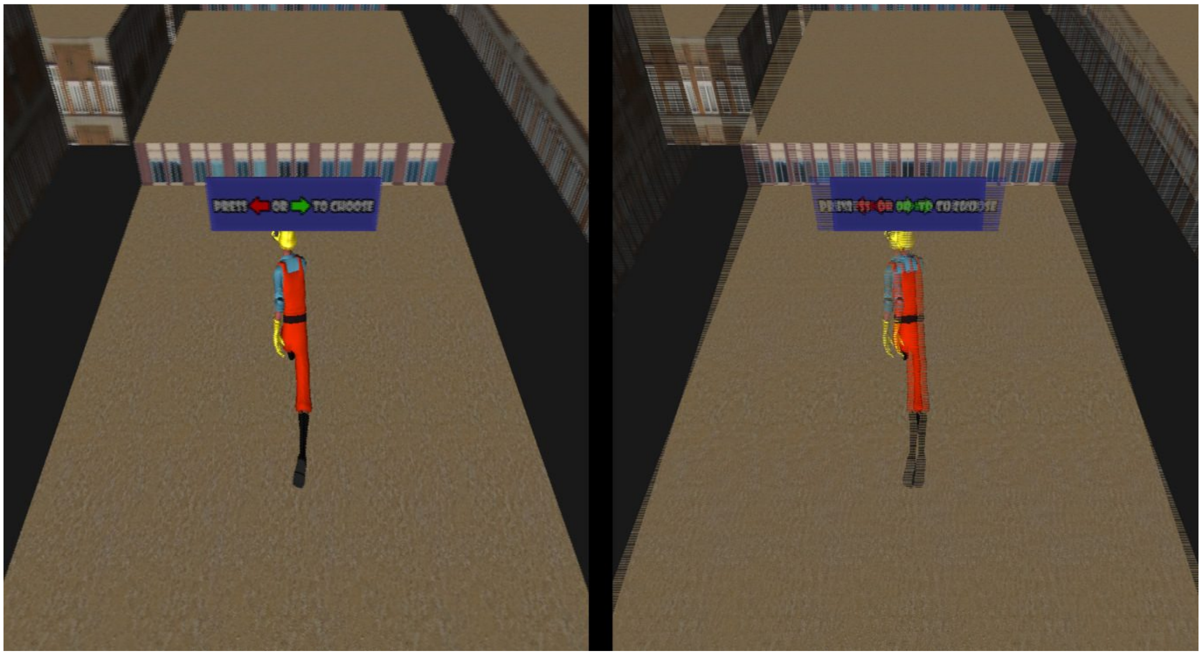


Figure 3: S3D lens method for determining the preferred interaxial camera distance. The left and right halves of the display present the same scene but have different interaxial camera distances. Using the left or right arrow keys on the keyboard, users are able to select which parameters they prefer.

2. OUR STUDY

2.1 Study design

The user study consisted of two conditions:

- Condition 1: Slider Controls
- Condition 2: S3D Lens

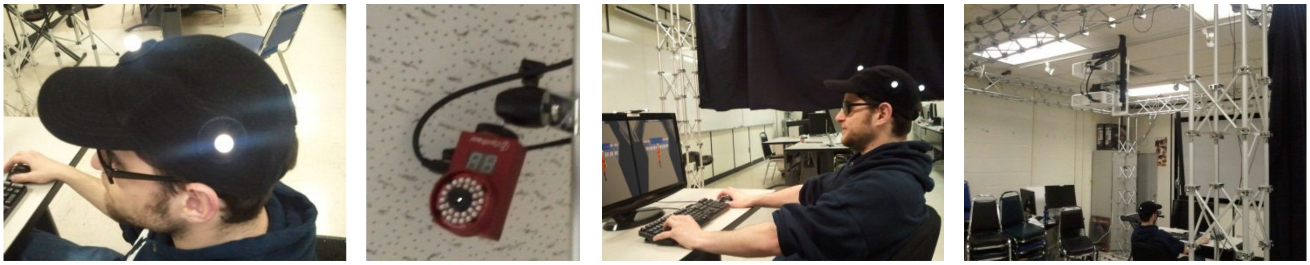
Each participant performed both of the conditions (within-groups) and the conditions were counterbalanced. To ensure that the users did not move beyond the "sweet-spot" of the monitors, their head position and orientation relative to the monitor was tracked using an Opitrack motion capture system.

2.2 Stereo Settings

The stereoscopic camera rendering parameters were initially set as follows: interaxial: 0.25 m, the zero parallax plane was fixed at 10 m, the field-of-view of the stereoscopic 3D camera was 60 degrees, no convergence (parallel cameras were employed). We used a large (0.25 m) interaxial setting due to the large size of the scene.

2.3 Scene

The game, a simple third-person view "run and jump game",was developed completely in-house using the Unity 3D Game Engine (see "Setup" section, below). At the start, the player's character was placed on a building and the player's task was to successfully jump from building to building in order to complete the game. If the user jumped at the incorrect time, they fell and were re-spawned at the building from which they fell from. The character was continually running, and the player had to press the space-bar in order to jump. In the *slider control* condition, a slider was present that allowed the user to adjust the stereoscopic settings, while in the *S3D lens* condition, a split screen was employed with the left and right halves of the screen rendered using different stereoscopic 3D settings. The user selected which stereoscopic 3D setting they preferred (left or right screen) while they played the game by pressing the left or right arrow key respectively.



(a) (b) (c) (d)

Figure 4: Testing environment. (a) User wearing hat with head tracking markers, (b) Optitrack cameras used for head tracking, (b) user performing a trial, and (d) the testing environment.

2.4 Participants

The test was administered to a group of twenty-two (22) participants, all of whom were enrolled in the University of Ontario Institute of Technology. Of the participants, 77.3% of them were students enrolled in the undergraduate Game Development and Entrepreneurship program. The majority of participants were also male, with only two females. Fourteen of the participants had prior experience with S3D games (63.6% had played S3D games prior to participating in the study). The age of the participants were dominantly between eighteen to twenty years old: 59.1% were between the ages of 18-20, 27.3% were between the ages of 21-23, 13.6 % were between the ages of 24-26. .The experiments abided by the University of Ontario Institute of Technology Research Ethics Review process. All participants were initially screened using the standard Randot Stereo Test to determine normal stereoscopic depth perception.

2.5 Setup

The study used Zalman ZM-M240 24” stereoscopic 3D monitors with a 5 ms response time for visual display and emplyed a 1920 × 1080 pixel resolution. Stereoscopic images werepresented using horizontal interlaced rows in the rendered images and the user was required to be positioned 0.30-0.60 m away from the monitor. To achieve proper stereoscopic 3D viewing with these particular monitors, the line from the user to the monitor was maintained at 90 degrees on the horizontal, and 12 degrees on the vertical. Viewers wore a pair of passive (polarized) stereoscopic glasses provided with the Zalman monitor. Participants were seated comfortably with the monitor adjusted to maintain the above viewing requirements. They sat in a lighted room and interacted with the testing environment using an Xbox 360 game controller.The PCs used were standard Dell XPS 720 computers with ATI Radeon 6870 video cards. The *Stereoskopix 3D* plugin (now called FOV2GO) was employed to provide stereoscopic rendering support.

2.6 Experimental Procedure

Participants began the experiment by completing a demographic questionnaire to determine their gaming ability and preferences. Participants were seated in front of screen / testing area and asked to put their hat/glasses on. The software was started and participants were asked to adjust their chair/monitor until they were in the stereoscopic “sweet-spot” of the display. The game was synchronized with the motion capture system to initiate head tracking and the participant begain the trials. At the end of the trials, the participant was asked to complete the free-form comments section of the survey. Each condition was completed two times by each participant for repeatability purposes.

2.7 Testing Environment

The study took place in two separate environments: Participants 1-12 completed the experiment in research laboratory at the University of Ontario Institue of Technology, while participants 12-completed the experiment in the undergraduate Game Development Laboaratory also at the University of Ontario Institue of Technology. The only differences between the two environments was the motion capture camera placement, but each environment had the identical motion tracking camera setup, the same illumination (the only light in the rooms was the Zalman monitor) the same monitor/chair combination and aside from the participant and the experimenter, there was no one else present in either of the experiment rooms. Great effort was placed to maintain consistency across the two experimental environments and we believe that any differences within the environment itself (e.g., size of the room), did not have any impact on the results.

An adjustable chair was used so that the player could adjust their height. The game was played with the lights off to reduce screen glare**.**

3. RESULTS

Based on informal testing and observations, we hypothesized that the interaxial distances chosen by the *S3D lens* test would be consistent with the values chosen by the user in the slider test. Head tracking did not aid in the data analysis as users stayed within the sweet spot range without any large/significant deviations worth noting and will therefore not be discussed further. A summary of the results is provided in Table 1 where the mean and standard deviation for each the conditions is provided.

	S3D Lens 1	S3D Lens 2	Slider 1	Slider 2
Mean	0.195	0.152	0.186	0.181
STDEV	0.128	0.114	0.156	0.133

Table 1: Results. This table shows the average interaxial (and standard deviation) setting for each condition and trial.

The data was analyzed in SPSS using a paired samples t-test which did not show a significant difference between the S3D Lens mean and the Slider Control means ($p > 0.05$), $t\ (21) = -0.417$, $p = 0.681$. Also, running the data with and without females present did not produce any different results, however future studies should include a balanced sample with equal male to female ratios.

4. DISCUSSION

In this paper, we proposed a new and unique method for adjusting stereoscopic parameters and more specifically, the interaxial distance,within a stereoscopic 3D gaming environment, interactively and in-game. We also presented the results of a study that was conducted to compare this method of interaxial distance calibration to the traditional slider-based and observed that there is no significant difference in the resulting interaxial distances that the users converged upon. These results indicates that it is a viable method that can be employed by game developers. One might ask why a game developer would wish to use this method over the traditional slider-based method commonly employed if they result in the same parameters? There are two reasons for doing so: i) a slider provides the user with the feeling of control and in some situations this may be what is desired by the game designer, thus the slider control may be a good choice, and ii) in some situations it may be desirable to have the game adapt to the user without removing them from their immersed state. If the designer wished to keep the player immersed, then in-game choices can be used to converge on the same stereoscopic settings as would be seen with immersion-breaking slider controls. This method could be used as part of a mini-game prior to the main game. Regardless, it provides another choice for designers who wish to develop user-adjustable stereoscopic parameters within their stereoscopic 3D content.

5. CONCLUSIONS AND FUTURE WORK

Our results indicate that this method is another tool in game designers' toolbox that can be effective for in-game stereoscopic parameter adjustment. Of course there are limitations in using such a method, the player has to play the game multiple times in order for the adjustment to occur. This however can be alleviated by making the game more like the iOS temple-run game where there is a progression of difficulty and other actions that must happen to complete the game. We believe that this could be exploited in other ways as well in the context of a puzzle where the player must select objects sticking out of the screen to minimize discomfort. In conclusion, we hope game designers see the effectiveness of this approach and create more interesting stereoscopic parameter adjustment mechanisms.

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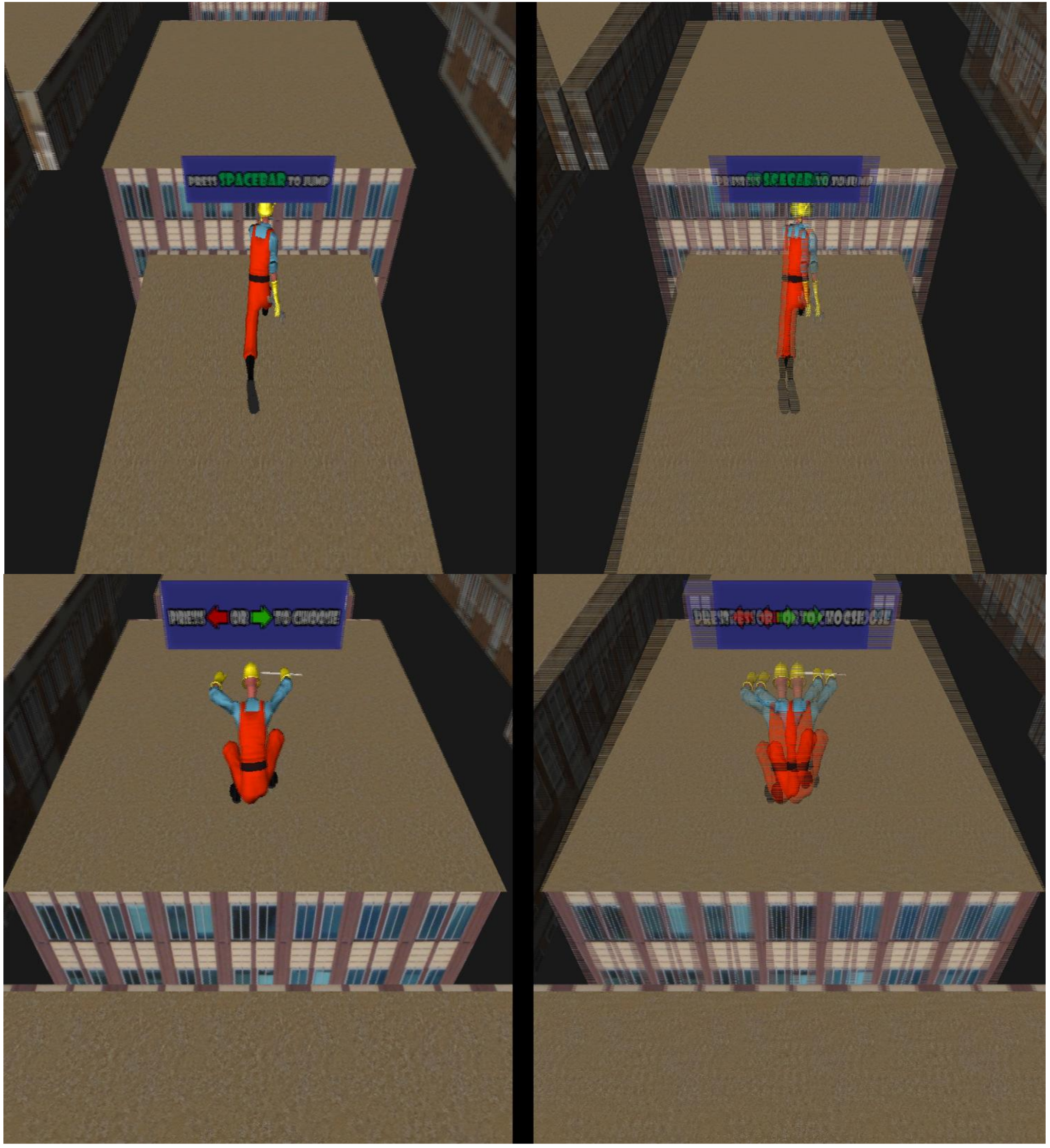

Figure 5. Two more examples of the S3D Lens technique with different stereoscopic settings.