Evaluating Player Performance and Experience in Virtual Reality Game Interactions using the HTC Vive Controller and Leap Motion Sensor

Diego Navarro and Veronica Sundstedt
Blekinge Institute of Technology, Karlskrona, Sweden

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Abstract: An important aspect of virtual reality (VR) interfaces are novel natural user interactions (NUIs). The increased use of VR games requires the evaluation of novel interaction techniques that allow efficient manipulations of 3D elements using the hands of the player. Examples of VR devices that support these interactions include the HTC Vive controller and the Leap Motion sensor. This paper presents a quantitative and qualitative evaluation of player performance and experience in a controlled experiment with 20 volunteering participants. The experiment evaluated the HTC Vive controller and the Leap Motion sensor when manipulating 3D objects in two VR games. The first game was a Pentomino puzzle and the second game consisted of a ball-throwing task. Four interaction techniques (picking up, dropping, rotating, and throwing objects) were evaluated as part of the experiment. The number of user interactions with the Pentomino pieces, the number of ball throws, and game completion time were metrics used to analyze the player performance. A questionnaire was also used to evaluate the player experience regarding enjoyment, ease of use, sense of control and user preference. The overall results show that there was a significant decrease in player performance when using the Leap Motion sensor for the VR game tasks. Participants also reported that hand gestures with the Leap Motion sensor were not as reliable as the HTC Vive controller. However, the survey showed positive responses when using both technologies. The paper also offers ideas to keep exploring the capabilities of NUI techniques in the future.

1 INTRODUCTION

Virtual reality (VR) has become a popular consumer technology thanks to its mass production and constant development of novel interactive content tailored for it. VR offers a high level of immersion due, in part, to its coverage of the full peripheral view of users and head tracking capabilities. Despite this, the initial level of immersion experienced with VR technology can be deteriorated when users fail to interact naturally and effectively with the virtual environments (Kato et al., 2000; Lee et al., 2017; Bachmann et al., 2018). Hardware manufacturers, including HTC, have addressed this issue by implementing direct hand manipulation through a set of proprietary peripherals, adapting design concepts from traditional gamepad controllers (buttons, triggers, rumble packs and wireless connectivity) into hand-held devices suitable for 3D-space interaction. The HTC Vive controller is one example of them. More recent designs have tried to further enhance the user experience by introducing natural user interactions (NUIs), techniques that recreate real-life action within a certain level of fidelity (McMahan et al., 2010), as a novel method for interacting with VR environments. An example of them is the Leap Motion sensor, which allows hand tracking and natural hand manipulation of virtual objects. Different VR interactive applications have featured novel interaction techniques using the HTC Vive controller and the Leap Motion sensor. Nonetheless, despite previous contributions, few studies offer a detailed evaluation of how user performance and experience could be affected by their use. This situation offers an opportunity to analyze how efficient NUIs could be when performing basic interactive tasks in VR environments, in comparison to hand-held devices. To contribute to the previous gap, the following study proposes a couple of research questions: (1) What are the variations in player performance between the HTC Vive controller and the Leap Motion sensor when used as the main interaction input for picking up, dropping, rotating and throwing objects in VR games? and (2) What are the variations in the perceived player experience between the HTC Vive controller and the Leap Motion sensor when analyzed in terms of enjoyment, ease

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of use, sense of control and user preference?. An initial hypothesis proposes that the HTC Vive controller will offer a better overall performance result, compared with the Leap Motion sensor. However, there will not be a significantly large difference between the results obtained with both sensors and the Leap motion will be the preferred one by participants. The previous questions are addressed by performing a user study, that differentiates from similar contributions (e.g. (Caggianese et al., 2019)) by offering a more complex game environment in which tracking precision and accurate control over the interaction techniques play a greater factor in the performance measurements. Results from this study could help to identify some of the possibilities and challenges, offered by NUIs and hand-held controllers, in the field of efficient 3D-interaction techniques. Additionally, it can provide an initial understanding of how these technologies can affect the overall perceived user experience when used in VR environments and other visual and interactive applications.

2 BACKGROUND

The HTC Vive controller is a hand-held motion and pointing device that resembles a television remote controller with a hollow ring attached to its top. It features a track-pad in the front, a couple of buttons on either side and a trigger button in the back side of its handle. It uses a set of 24 infra-red (IR) sensors for positional tracking with the HTC Vive base stations (devices responsible for the tracking of the headset and controllers), and operates in a frequency ranging between $250Hz$ and $1KHz$[1]. On the other hand, the Leap Motion sensor is a small rectangular device that combines three sources of IR light, together with a stereoscopic array of IR cameras, fitted inside of a metallic frame[2]. It allows the tracking of hand movements, with a 5-finger level of detail, without the need of wearing any additional hardware. It operates at a frequency of 200 frames/sec, with a field of view of 150°, an interaction area of $0.74m^2$ approximately and an overall accuracy of $0.7mm$ (Weichert et al., 2013; Hornsey and Hibbard, 2015). Previous contributions analyzing VR technologies, in combination with NUI devices, have focused on exploring their interactive capabilities in a wide variety of scenarios, while also identifying some of their potential drawbacks and limitations (Peter Wozniak, 2016). Nonetheless, only a small set of recent studies offer a direct comparison between the HTC Vive controller and the Leap Motion sensor, evaluating quantitative and qualitative variables from the user performance and experience, that derives from their respective use.

An initial usability evaluation analyzed two different interaction techniques for manipulating objects in a VR environment. The techniques focused on translating and rotating virtual objects through direct (touching the object) and constrained (using a visual pivot attached to the object) manipulation. The results were qualitatively analyzed and showed that participants preferred to use direct manipulation for translating objects, while constrained manipulation was the preferred method for rotation (Caggianese et al., 2016).

A performance analysis was conducted on a collaborative virtual environment. In this study, pulling and pushing interactions were tested by 30 participants in an exergame setup. Two participants took the test at a time. The first one was immersed in the virtual environment while the second monitored the performance of the first participant and provided visual assistance to complete the task. Performance results were analyzed quantitatively and showed an overall better performance of the HTC Vive controller over the Leap Motion sensor, requiring a less amount of interactions and less time to complete the experimental task (Gusai et al., 2017).

A similar study evaluated the variations in user experience when interactively manipulating 3D graphs, comparing traditional input methods (gamepads, mouse and keyboard) against natural interaction techniques with the Leap Motion sensor. Results have shown that participants had an overall better experience when using the traditional input methods, suggesting ease of use and responsive control to be some of the determining factors for such an outcome. Even if participants found the use of natural interaction techniques interesting and fun, the limitations of the technology and the variations in user preference for performing and articulating gestures made the Leap Motion sensor a challenging platform to manipulate 3D graphs (Erra et al., 2018).

Finally, a more recent study analyzed the possibilities each device offered in terms of interaction design, and evaluated their respective performance when used for object manipulation in virtual environments. Results from this study show an overall user preference for the HTC Vive controller, while identifying a necessity for simplifying complex interaction techniques in virtual environments, to deliver an overall better user experience (Caggianese et al., 2019).

[1] https://www.vrheads.com/exposing-magic-behind-htc-vive-controller, visited October 2018.

[2] https://learn.sparkfun.com/tutorials/leap-motion-teardown, visited October 2018.

3 METHODOLOGY

A user study was selected as the main methodology for the research. Volunteering participants were exposed to two different VR games featuring either the HTC Vive controller or the Leap Motion sensor. During gameplay, different data was captured as quantitative metrics for evaluating the player performance. A survey, consisting of a modified version of the Game Experience Questionnaire (IJsselsteijn et al., 2013), was presented to the participants in order to analyze the perceived player experience upon completing each game level.

3.1 Participant Criteria

The participant criteria aimed to provide a more homogeneous group in terms of age, previous experiences with VR and the evaluated game genres. It was: (1) experience with VR content of at least 2 hours, (2) experience using the HTC Vive controller of at least 2 hours, (3) experience with puzzle games (e.g. Tetris, World of Goo, Antichamber or Lyne) of at least 10 hours, (4) an age range between 20 and 28 years old, (5) no previous cases of photo-sensitivity or epilepsy and (6) no other medical or physiological condition that limits the use of stereo vision or the use of hands and fingers. Only participants that self-reported they fulfilled these criteria were included.

3.2 Experiment Procedure

The experimentation was a within-participant user study, with one factor and two levels of repeated measures. Volunteers were initially presented with a consent form, describing the inclusion criteria, goal of the study, experimental procedure, stimuli, tasks, required time, risk of participation, data captured and data protection policies. Upon agreeing to and signing the form, the experimenter then verbally introduced the two interaction devices used for the test and guided the participant to the gameplay area (see Section 3.3). The HTC Vive headset was placed upon the participant head and, since the interaction devices are capable of tracking both hands, participants were told the study should be performed using only their dominant one. A couple of VR games were presented to the participants as the main stimuli. One game featured the HTC Vive controller as the primary interaction device, while the other used the Leap Motion sensor. The VR games, composed by a tutorial, a Pentomino puzzle level and a Ball-throwing level (shown in Figure 1 and Figure 2), were identical in content, being the interaction devices they featured, together with their respective interaction techniques, and the reference image provided for the Pentomino level the only variations between them. Both games were developed using the Unity game engine, v. 2018.2.7f1. The HTC Vive headset and controller were integrated using the Steam VR plugin for Unity, v. 2.0.1, by Valve Corp. For controlling the Leap Motion sensor, the Unity Assets for Leap Motion Orion Beta v. 4.4.0 and the Leap Motion Interaction Engine Module for Unity v. 1.2.0, both published by Leap Motion Inc, were used.

The tutorial level was presented first and introduced the participants to the virtual environment, the 3D elements and the four main interaction techniques evaluated in the study: *picking up, rotating, dropping* and *throwing* virtual objects. Participants were verbally guided through the tutorial level, receiving explanations about the rules of the game, experimental conditions, tasks and how to perform them correctly using the respective interaction device. Participants were allowed to proceed to the following levels only when they manifested a complete understanding and sense of control over the game tasks and how to use the interaction devices. In this way, the lack of experience with the game or unfamiliarity with the interaction techniques were minimized.

The Pentomino puzzle was the first game level participants were exposed to, being tasked with assembling a diamond-shaped figure by picking, dropping and rotating a set of 12 Pentomino pieces (geometric shapes composed of five cubes of the same size, connected through one or several faces [3]) as fast as possible. A reference image was offered as a visual aid, showing the correct arrangement of the pieces. The same diamond shape was used in both games, but the original reference image was flipped horizontally and vertically in the Leap Motion game (see inset in Figure 1) to control for carryover effects without the risk of increasing the difficulty of the task. The Ball-throwing level was shown last, tasking players with hitting six targets, floating in the horizon, by throwing a set of three balls at them. The task had to be completed in the least amount of time possible. Targets were placed at different distances and heights from the initial viewpoint of the participants, while the balls appeared directly in front of them. Players were surrounded by leaned walls with no friction, so balls could rapidly bounce back to the their position.

To grab a piece with the HTC Vive controller, participants needed to press and hold the trigger button while touching its surface with the top ring of the controller. Releasing the trigger button dropped the piece. For rotating, participants needed to physically

[3]https://en.wikipedia.org/wiki/Pentomino

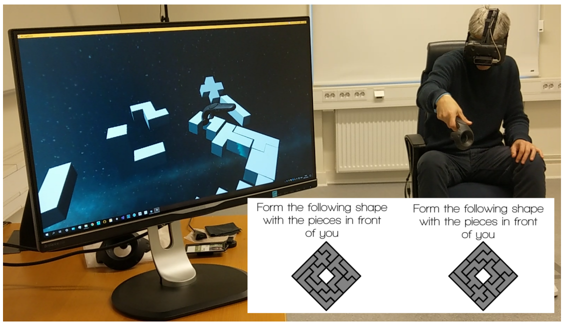

Figure 1: The Pentomino puzzle level, using the HTC Vive controller. Inset in the lower-right corner shows the reference images used for the Pentomino levels.

Figure 2: The Ball-throwing level, using the Leap Motion sensor. Inset in the lower-right corner shows the HTC Vive, its controller and the Leap Motion sensor attached to the front of the headset.

rotate the controller while holding the piece in their hands. To perform these actions with the Leap Motion sensor, participants needed to recreate similar hand movements as they would usually do in the real world. To grab a piece, the thumb and any other finger from the participants' hand needed to be in contact with its surface. Participants were instructed to grab pieces by pinching or claw-gripping them to avoid tracking issues with the sensor since a closed fist showed an erratic behavior during initial tests. To release a piece, participants simply opened their hand widely. To rotate a piece, participants needed to hold it in their hand while rotating it. For throwing a ball, participants had to release it while performing the throwing motion.

Upon completing each of the VR games, the headset was removed from the participants, and a modified version of the Game Experience Questionnaire (IJsselsteijn et al., 2013) was presented. The survey evaluated their perceived experience when interacting with the virtual world, by performing each of the evaluated tasks with the respective interaction device. The game stimuli were presented counterbalanced to the participants in an alternated order. This means that if the current participant started with the game featuring the HTC Vive controller, the next started with the game using the Leap Motion sensor. When both games were completed, the final part of the survey was given. The final part evaluated their overall opinion and preferences when having a general comparison between both devices.

3.3 Experimental Setup and Equipment

The study was conducted within a dedicated controlled environment, provided by the Department of Creative Technologies (DIKR) at the Blekinge Institute of Technology. Following the criteria for an appropriate exposure of VR content proposed by (Lopez et al., 2017), a dedicated squared gameplay area of 2.5 x 2.5 meters, free of any obstacles, was prepared for the participants. Also, participants were seated during the entire length of the experimentation.

Outside the gameplay area, a dedicated workstation computer ran the VR games while, simultaneously, managing the different apparatus needed for the experimentation. The computer had an Intel Core i7 6700k CPU @ 4.00GHz, a Nvidia GeForce GTX 980 GPU and 16 GB of Corsair DDR4 RAM @ 1333MHz. The apparatus used for this study were the HTC Vive VR headset, its base stations, controller, and the Leap Motion sensor. The HTC Vive controller was held in the participants' hands and was attached to their wrists. The Leap Motion sensor was attached to the headset using the Universal VR Dev Mount that was glued to the front of it (see inset in Figure 2).

4 RESULTS

A total of 20 participants volunteered for the study. Gathered data were classified into performance (Section 4.1) and experience results (Section 4.2). Statistical significance tests were applied to the gathered performance data, while the survey results were analyzed according to the scoring parameters exposed in the Game Experience Questionnaire (IJsselsteijn et al., 2013).

4.1 Performance Results

The total amount of pieces grabs needed to complete the game, together with the total completion time, were the evaluation metrics for the performance analysis in the Pentomino level. The Ball-throwing level evaluated the total number of throws required to finish the level, along with the completion time. Performance data was initially tested to verify the ANOVA assumptions and determine an appropriate significance test. Normality was evaluated using

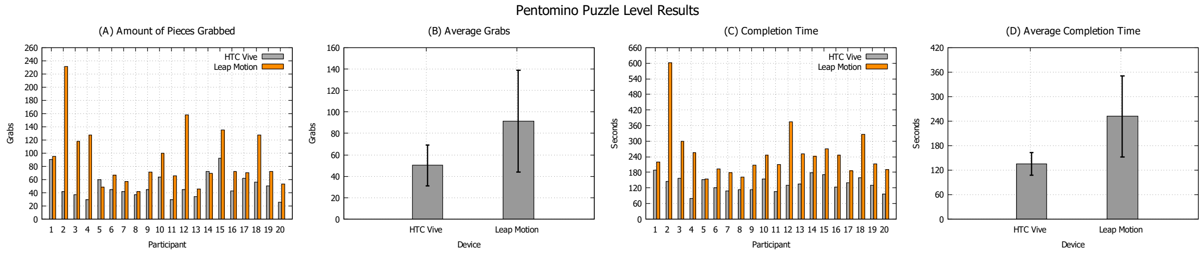

Figure 3: Performance summary for the Pentomino puzzle level results. Figure (A) shows the total amount of pieces grabs per participant and device. Figure (B) shows the average number of grabs per device. Figure (C) shows the total level completion time per participant and device. Figure (D) shows the average completion time per device.

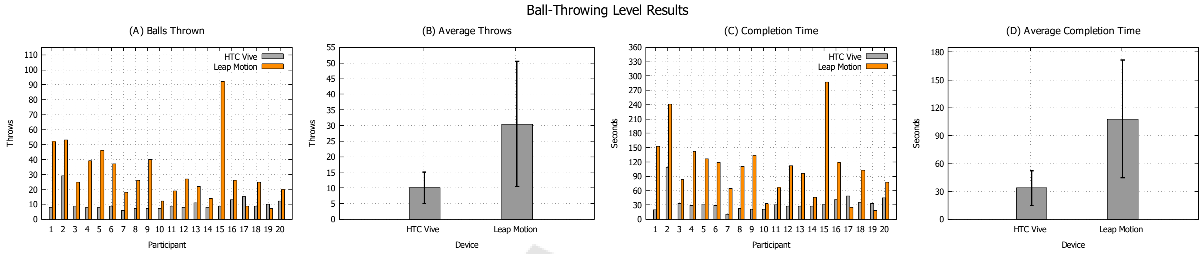

Figure 4: Performance summary for the Ball-throwing level results. Figure (A) shows the total amount of throws per participant and device. Figure (B) shows the average number of throws per device. Figure (C) shows the total level completion time per participant and device. Figure (D) shows the average completion time per device.

the Shapiro-Wilk test on data residuals, while homoscedasticity was reviewed with the Levene's test. None of the gathered data was able to satisfy the ANOVA assumptions. Therefore a non-parametric test was applied. Based on the data properties and the proposed experimental design, a Wilcoxon-Mann-Withney (WMW) test was used for the statistical significance evaluation.

4.1.1 Pentomino Puzzle Level

The summary of the results obtained in the Pentomino puzzle level can be seen in Figure 3. Overall, participants had better performance when using the HTC Vive controller, requiring fewer pieces grabs and time to complete the level. For the pieces grabs, participants averaged 50.1 when using the HTC Vive controller, compared to 91.35 with the Leap Motion sensor. After applying the WMW test, results showed a statistically significant difference between the HTC Vive controller and the Leap Motion sensor.

$$WMW_{(1,n=20)} = 3.7355, p < 0.05$$

For completion times, participants required more time to complete the game using the Leap Motion sensor, scoring an average of 251.48 seconds. The time needed with the HTC Vive controller was less, averaging 135.29 seconds. Results from the WMW test showed a statistically significant difference in the completion times for each interaction device.

$$WMW_{(1,n=20)} = 5.1395, p < 0.05$$

4.1.2 Ball-throwing Level

A summary of the results gathered from the Ball-throwing level is illustrated in Figure 4. Participants had overall better performance when using the HTC Vive controller, needing fewer throws and less time to complete the game, when compared with the scores obtained with the Leap Motion sensor. The average amount of throws needed to complete the level using the HTC Vive controller was 10.1, while 30.45 was the average needed with the Leap Motion sensor. The WMW test showed a statistically significant difference between the number of throws needed with each interaction device.

$$WMW_{(1,n=20)} = 4.3283, p < 0.05$$

The time required to finish the level was higher when using the Leap Motion sensor, with an average of 107.73 seconds among the participants, when compared with the average time of 33.61 seconds obtained with the HTC Vive controller. Time results had a statistically significant difference between them when evaluated with the WMW test.

$$WMW_{(1,n=20)} = 4.0846, p < 0.05$$

4.2 Experience Results

The survey was composed by three parts: Part 1 evaluated the game featuring the HTC Vive controller, Part 2 focused on the game using the Leap Motion sensor and Part 3 made a direct comparison between both interaction devices. Each part of the survey was, subsequently, composed of two modules. For Part 1 and 2, there was a module for the Pentomino puzzle and the ball throwing levels. In Part 3, each interaction device had its module respectively. Each module from Part 1 and Part 2 presented 11 different statements to participants. They evaluated five components from the perceived experience: Statements 1, 3 and 5 evaluated competence, Statements 2 and 7 evaluated challenge, Statements 4 and 10 evaluated tension, Statements 6 and 8 evaluated positive affects and Statements 9 and 11 evaluated negative affects. Similarly, each module from Part 3 offered four different statements. Statement 1 evaluated enjoyment, Statement 2 ease of use, Statement 3 sense of control and Statement 4 evaluated preference, respectively. A total of 52 statements were presented to participants in the survey. To answer the survey statements, participants used a Likert scale to determine the level of the agreement they had with them. Value one represented the lowest level of agreement, while five represented the highest one. Following the evaluation guidelines offered in the Game Experience Questionnaire (IJsselsteijn et al., 2013), each component was analyzed by directly comparing the average answer score between the interaction devices.

4.2.1 Pentomino Puzzle Level

The average survey results for the Pentomino puzzle level are shown in Table 1. Overall, the HTC Vive controller was perceived to offer a better experience in the Pentomino puzzle level when picking, dropping and rotating pieces, compared with the Leap Motion sensor. In the level of challenge experienced when using the interaction devices, the Leap Motion sensor was perceived to be the more challenging. The tension generated by the use of the interaction devices was perceived to be lower on the HTC Vive controller, while the perceived positive affects were higher on the same device. Despite offering a better-perceived experience on all previous components, the negative affects results were not considerable different between the HTC Vive controller and the Leap Motion sensor.

4.2.2 Ball-throwing Level

The average survey results for the Ball-throwing level survey are shown in Table 2. As an overview, participants perceived to have a better experience using the HTC Vive controller than the Leap Motion sensor. They felt to be more competent at picking up and throwing balls when using the HTC Vive controller and they gave a higher positive affect score when interacting with it. The Leap Motion sensor was perceived to generate more tension and challenge with its use. Despite this, the negative affects perceived by players were not considerably different between the devices.

Table 1: Average scores for the experience components in the Pentomino puzzle level.

Component	Vive Controller	Leap Motion
Competence	4	2.85
Challenge	1.62	2.75
Tension	1.45	2.27
Positive Affect	4.27	3.61
Negative Affect	1.12	1.27

Table 2: Average scores for the experience components in the Ball-throwing level.

Component	Vive Controller	Leap Motion
Competence	3.73	2.86
Challenge	1.72	3.05
Tension	1.37	2.2
Positive Affect	4.02	3.38
Negative Affect	1.17	1.57

Table 3: Average scores for the experience comparison components between the HTC Vive controller and the Leap Motion sensor.

Component	Vive Controller	Leap Motion
Enjoyment	4.25	4.35
Ease of Use	4.5	3.15
Sense of Control	4.35	2.95
Preference	3.95	2.55

4.2.3 Experience between Devices

The average scores for the experience comparison between the interaction devices can be seen in Table 3. Overall, the HTC Vive controller was perceived to be the better option among the interaction devices. It was considered by participants easier to use than the Leap Motion sensor, offering a better sense of control over the evaluated interaction techniques, and being the preferred interaction device for the proposed tasks. Nonetheless, despite having lower performance and a worse perceived experience than the HTC Vive controller, the Leap Motion sensor was reported as the most enjoyable interaction device to use in the study by a small margin.

5 DISCUSSION

Results showed that participants had an overall better performance and experience when using the HTC Vive controller, as predicted in the hypothesis. Nevertheless, the considerable differences in the performance and experience results were unexpected.

In the Pentomino puzzle level, participants were able to pick up, rotate and drop objects faster with the HTC Vive controller, requiring on average a lower number of pieces grabbed with this device than with the Leap Motion sensor. A possible explanation for this could be the way the devices triggered the interaction techniques, which were activated by only using the trigger button in the HTC Vive controller, offering a simple execution with an immediate response from the game engine. However, for the Leap Motion sensor, a more robust calculation was needed to determine the movements, positions and collisions from different parts of the hand, making it more susceptible to errors that affected the accuracy of the sensor. Additionally, it was observed during initial tests that subtle and slow finger movements were nor effective for triggering the interaction techniques, especially dropping objects, which showed a ”sticky hand” effect when performed in this manner. To control for this phenomenon, fast and exaggerated movements were instructed to participants during the tutorial level.

For the Ball-throwing level, the Leap Motion sensor had a worse overall performance among the devices. In addition to the issues previously exposed, the limited tracking capabilities of the Leap Motion sensor had a detrimental effect in this level. Thanks to the constant tracking from the base stations and simple execution of the throwing interaction, movements performed by the HTC Vive controller were smooth and consistent among participants. Since the interaction area for the Leap Motion is smaller and tracking is only possible when the hand is in front of the device, a natural throw movement was not possible with the proposed setup. When a ball was grabbed, participants instinctively raised and moved their hand towards the back of their head to charge a throw. Since the Leap Motion sensor was attached to the front of the headset, their hands left the interaction area causing erratic movements and abruptly readjusting the virtual elements once the hand re-entered it. Participants were informed about this limitation during the tutorial level and were instructed in how to perform the throwing interaction properly, making sure that the hand was always within the interaction area and that the hand dropping gesture was fast and exaggerated. Nevertheless and despite the training offered in the tutorial level, some participants, instinctively, performed the natural throwing movement affecting the performance data.

Results from Part 1 and 2 of the survey showed that participants had an overall better experience when using the HTC Vive controller than the Leap Motion sensor. The sense of competence and positive affects experienced by participants were higher when using the HTC Vive controller, probably due a more efficient activation of the interaction techniques and better tracking capabilities when compared to the Leap Motion sensor. These same reasons might have affected the perceived level of challenge and tension, since the Leap Motion sensor scored higher in those components, especially in the Ball-throwing level. Results from Part 3 of the survey showed that the HTC Vive controller was perceived to be easier to use than the Leap Motion sensor, offering better control over the proposed tasks in this study and was the preferred device for this evaluation. Nevertheless and despite having a lower score in the majority of the survey questions, the difference between the Leap Motion sensor and the HTC Vive controller, regarding the Negative affects and user enjoyment components, was reasonably low. This particular result suggests that even if the interaction capabilities of the Leap Motion sensor were not on par with the HTC Vive controller, the use NUIs generated a rather strong impression in the participants, as some of them mentioned. Having the ability to interact with virtual environments by using your own body, is a novel interaction concept that has rarely been experienced before, and that could have the potential of redefining the way we communicate with VR applications. This could be the reason why, despite having the lower performance and experience scores, the Leap Motion sensor reported higher scores for the enjoyment component.

6 CONCLUSION AND FUTURE WORK

The study presented in this paper has offered an analysis of the variation in performance and experience between the HTC Vive controller and the Leap Motion sensor when used for VR game interaction tasks. A user study exposed 20 participants to a couple of VR games, each composed by a Pentomino puzzle and Ball-throwing level. Performance data was captured automatically by the games while the perceived experience was evaluated through a survey based on a modified version of the Game Experience Questionnaire (IJsselsteijn et al., 2013). Results showed that the HTC Vive controller offered overall better performance when compared to the Leap Motion sensor.

More straightforward interaction activation and better tracking capabilities allowed participants to achieve higher scores when using the HTC Vive interaction device. Similarly, the HTC Vive controller was also considered to offer a better overall experience to participants regarding the ease of use, sense of control and user preference. Nevertheless, the survey results for the Leap Motion sensor showed little difference in the scores for negative affects, when compared with the HTC Vive and, despite interactive and tracking limitations, it reported the higher scores for enjoyment in this study.

Future work could evaluate the capabilities of the Leap Motion sensor in other game genres, since games this study were based on the physical interaction between virtual elements. Board, adventure or fighting games are considered interesting environments for the design and implementation of NUIs. Also, the large difference seen in the performance results motivates a more detailed examination to determine how the interaction devices and techniques could have led to such results. A further analysis relating the amount of grabs per piece, or the amount of actions (grabs) per time interval could offer a better insight of how and when the complexity and accuracy varied among the devices. Additionally, different software solutions could be explored to compensate for the limitations found with the Leap Motion sensor. Improved gesture control and recognition, snapping capabilities and physiologically aware environments are possible ideas to explore in the future.

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