An Infrared-based design to eliminate occurrence of motion sickness in a virtual-reality simulator

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Summary: An infrared-based design was developed to eliminate the occurrence of motion sickness caused by imprecise horizontal head-position estimates in a virtual-reality simulator. The design consisted of an infrared LED attached to the virtual-reality headset and an infrared receiver that was fixed to the top-centre of a laptop screen facing the user. This design eliminated motion sickness by resetting the horizontal head-position estimation to 0° when the user's head faced the top-centre of the screen. When testing this design, we discovered that our solution never allowed the horizontal head-position estimates to become noticeably inaccurate, as well, none of the three users this design was tested on experienced motion sickness.

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1.0 Introduction

Virtual-reality headsets have seen a sharp rise in technological advancement in recent years. This advancement has given researchers the opportunity to develop virtual-worlds that can serve to diagnose, assess, and treat various kinds of illnesses. However, an issue that still plagues virtual-reality simulators is the occurrence of motion sickness, which to this date is not entirely understood. It is widely held that motion sickness is the product of sensory conflict: a disagreement between the visual system (what you see) and the vestibular system (the motion you perceive) [1]. In virtual reality simulators, motion sickness can be caused by inconsistencies between a physical motion in the real-world and its imitation in the virtual-one. For example, you may slightly move your head 5° to the right, but your surroundings in the virtual-world are rotated by 10°; this inaccurate movement in the virtual-world is believed to cause motion sickness. This report describes a solution to eliminate the occurrence of motion sickness caused by inaccurate horizontal head-position estimates in a virtual reality simulator. Figure 1 illustrates the meaning of horizontal head-position, known as yaw, and figure 2 shows the virtual reality simulator addressed in this report, which chiefly consists of a virtual-reality headset, laptop, and wheel chair coupled with motion sensors.

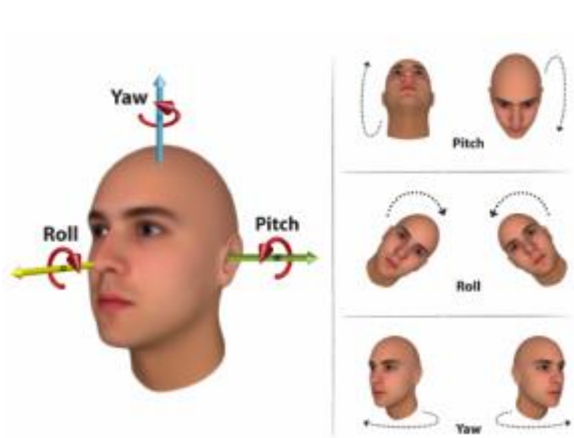

Figure 1: Head Positions [3]

Figure 2: Virtual Reality Simulator [2]

2.0 Existing Set-Up and Limitations

As mentioned earlier, the virtual reality simulator consists of three main components: a virtual reality headset to perceive the virtual-world, laptop to run the software that generates it, and wheelchair to navigate it. This set-up inhibits the use of a tracking camera, which is often used to improve the accuracy of movements in the virtual-world. For instance, mounting the tracking camera onto the desk of the wheel chair causes unintended in-game movements. To illustrate, Figure 3 (left hand side) shows how if the user were to look in some direction, then rotate the wheel-chair without changing their point of view, the tracking camera would perceive the user as turning their head. This unintended movement could easily cause motion sickness. It is possible to mount a number of tracking cameras in strategic positions within a room the user is to navigate the virtual environment. However, it is very costly and cumbersome to develop a system that would take into account the positional data from various cameras. The current design then relies solely on Inertial Measurement Units, which are sensors used to approximate position and movement. These sensors unfortunately introduce an error in the yaw head-position approximations that accumulates over time [3]. In turn, this accumulating error eventually results in movements in the virtual-world that do not match those made in the physical world, thereby increasing the chances that the user will develop motion sickness.

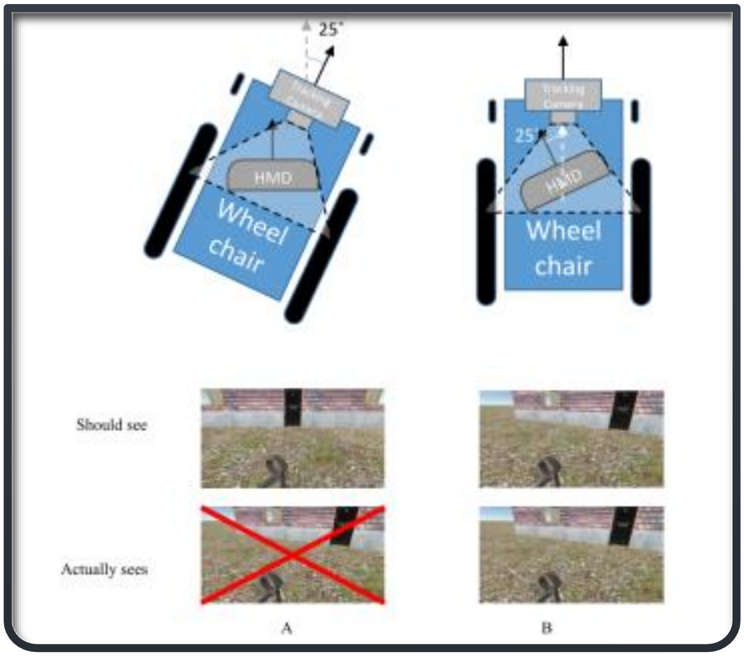

Figure 3: Limitations of mounting tracking-camera on wheel-chair [3].

3.0 Current Solution

To eliminate the accumulating error in the yaw direction, a reset function was developed. Once the experimenter or user notices that movements in the yaw direction have become inaccurate, the observer has the user align their head to the top-centre of a laptop screen facing the user, as seen in figure 3, and then resets the yaw value to 0°. The reset is performed by pressing the '2' key on the keyboard, which sends a signal to the Unity game engine to reset the yaw value. This method is cumbersome, as it is difficult to get the user to accurately direct their gaze to the top-centre of the laptop screen while wearing a virtual-reality headset. Not only this, the method fails to prevent the occurrence of motion sickness since it waits until movements in the yaw-direction have become noticeably inaccurate, which by then, could cause motion sickness.

4.0 Proposed Solution

As mentioned earlier, tracking cameras are very useful in helping improve movement and position estimations, however, in this particular virtual reality simulator it is both cumbersome and not economical to utilize. So instead, the current solution was evaluated to identify improvements. It was hypothesized that if we could automate resetting the yaw value to 0° every time the user's gaze passed the top-centre of the laptop screen during a trial, this would eliminate the possibility of the yaw estimations becoming noticeably inaccurate, such that they would cause motion sickness.

An infrared based design was developed in response to this hypothesis. It involved placing an infrared LED operating at 940nm at the top-centre of the Oculus Rift (the virtual reality head-set used in the trials) and an infrared receiver that was calibrated to receive 38 kHz pulses, which was placed at the top-centre of the facing laptop screen. An Arduino Uno was used to send 38kHz pulse signals every 500 milliseconds through the infrared LED, and to determine, based on feedback from the infrared receiver, whether a signal was received. If a signal was detected, the Arduino Uno would send a character '1' to indicate a reset signal, otherwise, a character '0' to indicate it is not, through the serial port. The Unity game engine checks for input from the Arduino every second, and if input was received, it would determine if the input is a reset signal. Provided the input is a reset signal, the Unity game engine will simply reset the Oculus Rift's yaw value to 0°.

The Arduino Uno and the Unity game engine are not synchronized. This asynchronization is intentional, as we do not want the user's yaw-value to reset at every instant they face the top-centre of the laptop screen. This is because, frequent resetting can cause a delay in frame-rate, which was observed experimentally when adjusting time interval values for both the Arduino and Unity engine.

5.0 Results

The design summarized above was tested on the two developers and a professor familiar with the experiment. No motion sickness occurred in any of the trials and yaw estimations never became noticeably inaccurate. It was found that the more often the Unity game engine checks for input from the Arduino, the slower the frame-rate would become. Through trial and error, 1 second intervals were chosen for the Unity game engine to check for input from the Arduino Uno.

6.0 Conclusion

An infrared based design was developed to eliminate the occurrence of motion sickness in a virtual reality simulator. The design consisted of an infrared LED, receiver, and an Arduino Uno, which was coded to communicate with the Unity game engine. Of the three participants that tested the design, neither developed motion sickness and none had developed noticeable inaccuracies in the yaw direction during their trials. Through more testing, the frequency at which pulses are sent from the LED and the frequency at which Unity checks for input from the Arduino can be improved to create an even more seamless virtual experience. Overall, the design achieved its goal of eliminating the occurrence of motion sickness in a small test group.

Reference:

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