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Literature Review #3: Depth Cues in Augmented Reality

Since our final project is on 3D projections, and the human eye relies on depth cues to deliver a vivid 3D perception of the world, I have chosen to do my third, and final, literature review on papers that involve augmented reality and *depth cues*. Hyungil Kim, Joseph L. Gabbard, Alexandre Miranda Anon & Teruhisa Misu wrote my *primary paper* “Driver Behavior and Performance with Augmented Reality Pedestrian Collision Warning: An Outdoor User Study”; it’s found in the April 2018 issue (Volume 24, Number 4) of the “IEEE Transactions on Visualization and Computer Graphics” Journal. J. Edward Swan II, Adam Jones, Eric Kolstad, Mark A. Livingston & Harvey S. Smallman wrote my *secondary paper* “Egocentric Depth Judgments in Optical, See-Through Augmented Reality”; it’s found in the May/June 2007 issue (Volume 13, Number 3) of the “IEEE Transactions on Visualization and Computer Graphics” Journal. First the secondary paper…

Swan and his team focus on AR display techniques on how to display, correctly and accurately, depth for virtual objects. Swan and his team conducted two experiments. One using a perceptual matching protocol and the other using both blind walking protocols and verbal report protocols.

The first experiment used a perceptual matching protocol to study depth judgments of near to far distances. Observers sat on a stool at one end of a hallway, and saw eight real world referents positioned evenly down the hallway at two different heights (floor and ceiling). These real world referents were placed virtually using augmented reality. The observers then moved a trackball to place a target at a desired depth down the hall where they thought the referents were. This depth was recorded.

The results showed an underestimation for nearby floor-mounted referents, whereas the ceiling-mounted referents did not show underestimation.

Experiment two utilized the depth judgment protocols blind walking and verbal report to measure egocentric distance perception of ground based objects. Observers judged the distance both a physical referent object, and a virtual one using two different protocols to judge the depth of the objects: blind walking and verbal report.

In the blind walking protocol, the observer viewed the object for as long as they wanted. When they were ready, they closed their eyes and walked to where they remembered the object was. In the verbal report protocol, the observer viewed the object for as long as they needed to, and when they were ready, reported the distance they thought the object was from them.

The results showed an underestimation in egocentric distance for the virtual objects.

Overall, Swan found that the underestimation of virtual objects depth is a problem for applications using AR due to the lack of understanding of where to place graphical objects in depth relative to real world objects.

Both papers use depth cues and augmented reality using human performance as a variable in collecting data. Swan and his team used them to determine if there was an error in visualizing virtual objects. Kim and his team use them to display warnings in a heads up display of a car to see if it is effective in giving warnings while driving in a parking lot.

Kim and his team equipped a test vehicle that is able to display warnings on a heads up display. The test vehicle is a 2009 Honda Odyssey and it is equipped with a GPS, eye tracking glasses (for the driver), cameras (for the foot well, and the front of the car), and an, in vehicle, AR heads up display. Drivers drove around a parking lot to test the effect it has on the driver, testing two different heads up displays: volumetric and monoscopic.

The question asked here is "Do visual warnings presented on volumetric HUDs have benefits over monoscopic HUDs?"

Sixteen drivers with normal vision participated in this experiment. For the validity of the experiment, the drivers were given a realistic parking lot scenario.

The results showed drivers stopped in shorter distances when visual warnings appeared on the display rather than no warnings at all.

Overall, the work done here provides evidence for the effectiveness of using a AR heads up display to display warnings on screen to alert the driver to brake or slowdown. However, it does not show a great enough benefit when using volumetric heads up displays versus monoscopic heads up displays.

In conclusion, both papers show approaches using depth cues in augmented reality. Swan's approach used better real world situation when using augmented reality. Whereas, Kim's approach had better depth analysis proving there is a lack of understanding when to display virtual objects in the real world. Swan and his team did not show any problems with depth when using their AR display. This is because drivers are not blocked out of the real world when viewing the AR display; therefore, do not see the lack of precise virtual imaging as well as Swan and his team did.