Article 13

Designing an Augmented Reality in-car Driving Simulator

Haryati Fauzi, Aznoora Osman, Muhamad Arif Hashim
Faculty of Computer and Mathematical Sciences
Universiti Teknologi MARA Cawangan Perlis

Ahmad Hanif Ahmad Baharin
Institute of Visual Informatics
Universiti Kebangsaan Malaysia,

(This project is funded by the Ministry of Higher Education Malaysia through research grant RAGS/1/2014/ICT02/UITM//3)

Abstract *- This paper demonstrates the design of augmented reality (AR) in-car driving simulator system architecture and its experimental design. AR in-car driving simulator is developed in order to explore its effect towards subjects' simulator sickness when operating the driving simulator. Sensory conflict theory postulates that simulator sickness is a condition where an information between vestibular input system and visual that provides orientation and movement information is misaligned. Simulator sickness is a well-known issue entangled with simulator and various past research revealed that some of the methods to avoid simulator sickness are by taking prescribed medicine, shortening the length of drives and adjusting light of driving simulation environment. Augmented reality allows a combination between real world views with computer-generated object and runs in a real-time performance. By using AR, it is possible to create an outdoor driving simulator that allows a real world view with a mixture of case study that been replicate by computer. Affording similar driving experience to driving a normal car, AR is believed to be an alternative solution to simulator sickness. Therefore, the AR driving simulator would be employed in experimental study to measure its effect on simulator sickness towards subjects.*

Keywords: *driving simulator, augmented reality, simulator sickness, experimental design, system architecture*

Introduction

Driving simulator can be defined as a machine that supplies a realistic impersonation of an operation of a vehicle that is used to study driving behaviour, discover solutions for driving issues and assisting a completion of interior and exterior designs (Hale & Stanney, 2014). According to (Medenica, Kun, Paek, & Palinko, 2011), driver's attention escalates if more realistic driving simulator environment is provided. Even with the existence of new sensor technologies, high-end display and computer graphics software that allows a creation of virtual environment closed to real environment, the simulator sickness issues still exist. Sensory conflicts theory defines simulator sickness as a mismatch of communication between vestibular input systems and visual that provides an information of orientation and movement information (Domeyer, Cassavaugh, & Backs, 2013).

In essence, driving simulator shows a movement of virtual environment on display but the subject's body does not register any movement, which in turn creates a conflict that leads to simulator sickness. However, it is believed that simulator sickness can be avoided if the driving simulator is moving along with subject, similar to driving a normal car, this condition is possible if a driving simulator simulation is developed using AR concept. Therefore, AR in-car driving simulator system architecture is designed to illustrate the operational view of driving simulator. Also, the research design has been thoroughly outlined to ensure smooth and ethically sound experiment.

Designing and Development of the AR in-car driving simulator

i. Hardware and software specification

Hardware specification for driving simulator consists of three (3) basic components, which are AR glasses, camera and a car. A car is required because it is an outdoor type of driving simulator, and a car with an automatic gear is chosen because it is much easier for subject to concentrate to the experiment matters and not everyone has the ability to drive a manual gear car. A camera is installed in the car to record subject behaviour during the experiment. Subject behaviour is collected as an additional data to the experiment. As for AR glasses, ODG R-7 Glasses (AR glasses) is chosen. This glasses powered by Qualcomm Snapdragon 805, 2.7 GHz quad-core processor, 3GB pop LP-DDR3 RAM and 64GB storage. It is also equipped with dual 720p stereoscopic see-through displays at up to 80 frames-per-seconds (fps), 60 percent see-through transmission and magnetic removable photochromic lens. This AR glasses also consists sensors including altitude sensor, humidity sensor, ambient light sensor and multiple integrated inertial measuring unit (accelerometer, gyroscope and magnetometer) sensor. As for input and output system, two (2) digital microphones (user and environment), magnetic charging port with USB on-the-go and magnetic stereo audio ports with ear buds are supplied. One of the reason this glasses is chosen because no cords needed-sensors, processors, displays and power are all self-contained.

For the development process, a computer will be used, which powered by Intel ® Core ™ i5-4690 CPU @ 3.50 GHZ, 4GB of RAM, 64-bit operating system with x64 based processor, and using Windows 10 Pro. On the other hand, 3D Max 2016 software is used to develop 3d models and Unity 5.4.xx with Vuforia plugin is used to develop the AR environment that will used in the driving simulator.

ii. System Architecture

Figure 1 illustrates the system architecture of AR in-car driving simulator that include all hardware needed for the driving simulator to operate efficiently. Subject will take a position on a driver seat in the AR in-car driving simulator. Subject will be wearing an AR glasses, which is used to collect data and to display graphics. This interaction will be initiated once subject starts driving. When there is a movement of the driving simulator, the trackers (position tracker and orientation tracker) on the AR glasses worn by subject will send a tracker data pattern to process the transformation of view pattern.

Based on location and direction data provided, three-dimension (3D) geometry is transformed using transformation matrices to produce a 3D object that aligns with the real world view. OpenGL then will render the information and projecting the result to the glasses display. Subject will response based on the information being projected to the AR glasses display. A camera, which is installed in the car will be used as monitoring and recording tool of the subjects' behaviour and response during the experiment. This data will be treated as a secondary data.

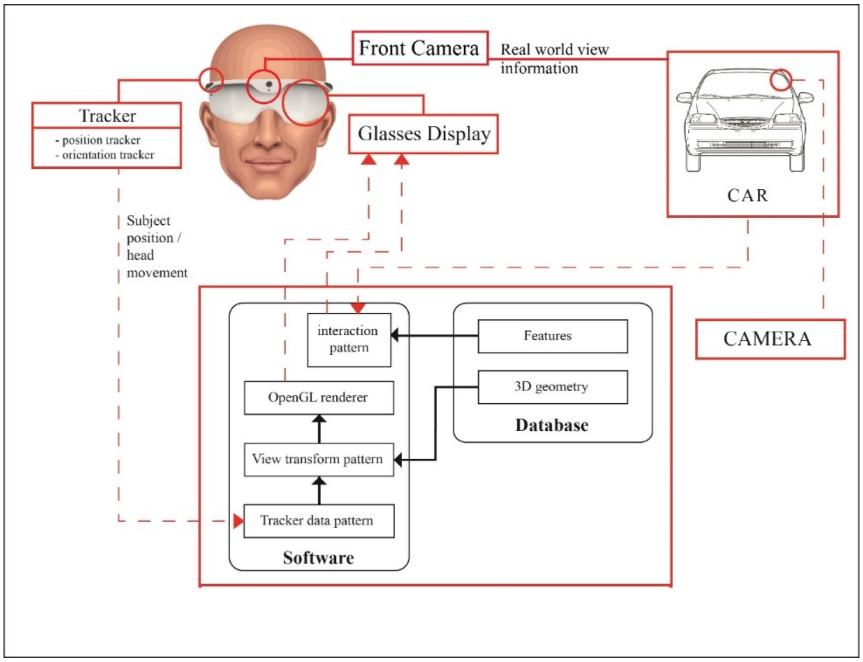

Figure 1: System Architecture of AR in-car Driving Simulator

Experimental Design

i. Screening the potential subject

To select subject for this research, subject will undergo a screening process. Screening process is important to determine if an individual is qualified to participate in this research. Potential subject may fill a form via printed copy or online, and their general information such as name, age, race, address, phone number(s) and information of their health will be collected. Persons having illness related to heart, brain, visual (other than corrected vision), inner ear ailments and pregnant women are not eligible to participate. There is an exception on subject whom had a farsightedness vision and nearsightedness vision if glasses or contact lens is worn during experiment session. Those who have inner ear ailments are not qualified because deaf individual cannot have the sense of motion sickness (Hain, 2016). Age range of preferred subject is between 21 and 55 years old, and with at least two (2) years of driving experiences. Confirming given information by potential subject by phone are exclusionary for the research, and thus a visit to the site would be a waste of time.

ii. Instruments used in experimental design

A consent form, demographic questionnaire and Motion Sickness History Questionnaire (MSHQ) will be distributed to subject prior to any experimental sessions. The Simulator Sickness Questionnaire (SSQ) (Kennedy, Lane, Berbaum, & Lilienthal, 1993) were administered to obtain measure of dependent variables, which is simulator sickness. A consent form is a basic document that needs to be signed by subject to confirm that a mutual agreement has been achieved and subject is aware of the risk that might be involved during the experiment. MSHQ was developed as subjective motion sickness measurement (Reason & Brand, 1975 as cited in Moss, 2008). The MSHQ purpose is to acquire a measurement of subject exposure's frequency to particular type of transportation that leads to the occurrence of motion sickness. The result of MSHQ is a solitary merit indicating susceptibility to motion sickness. SSQ on the other hand, will be measuring the severity level of simulator sickness exposure to subject. SSQ consists 16 items and four scale that represents the severity scale as none, slight, moderate or severe and obtaining a score of '0', '1', '2' and '3'.

iii. Experimental design

It is important to have an experimental design before commencement of any experiment. Driving simulator often have many input factors and determining a significant impact on performance measures or response of interest, which can be a truly intimidating task. Figure 2 shows the flow of experimental design for this study.

Once subject arrives at experiment site, subject will be briefed on the research introduction, objectives and experimental task within the experiment site. If the subject agree to proceed with the experiment, subject needs to sign consign form, confirming the general information that has been collected during screening period, and complete the MSHQ. Subject will be trained to operate the AR in-car driving simulator and explained how to complete the experiment. Subject needs to do practice for two minutes with the AR in-car driving simulator to be familiar with the test environment before actual experiment begins. Subject will start the experiment once they are ready. At any point in the experiment, subject has the right to rest, stop and discontinue should they experience sickness. Once the experiment is completed, subject needs to complete SSQ and be advised not to drive for the next half an hour to avoid any incident. They will be provided with refreshments and receive a payment as a complimentary for their participation.

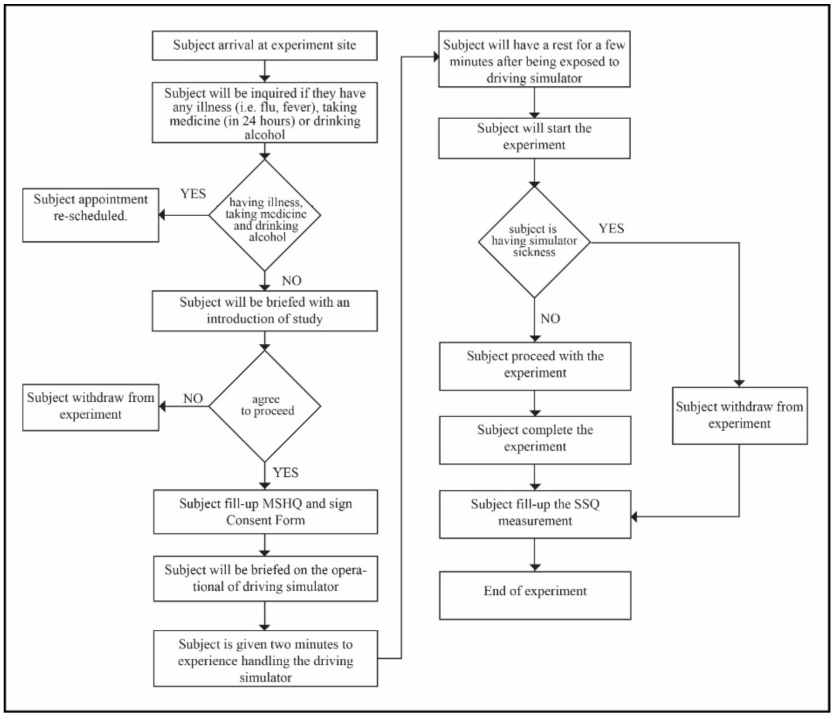

Figure 2: Experimental design

Conclusion

This paper shows the system architecture and experimental design for the AR in-car driving simulator. This design can be employed easily and helpful to support the AR in-car driving simulator experiments. In the future, the driving simulator will be used as a platform to experiment with more complex scenario for investigating various case study including a test for new technology, driver behaviour, engineering counter measure or a driving crash risks and hazard.

References

Domeyer, J. E., Cassavaugh, N. D., & Backs, R. W. (2013). The use of adaptation to reduce simulator sickness in driving assessment and research. Accident Analysis and Prevention , 53, 127-132.

Hain, T. C. (2016, May 27). Motion Sickness. Retrieved from dizzness-and-balance.com: http://www.dizziness-and balance.com/disorders/central/motion.htm

Hale, K. S., & Stanney, K. M. (2014). Handbook of virtual environments: Design,.

Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal , M. G. (1993). Simulator sickness questionnaire: An enhanced method for quantifying simulator sickness. The international journal of aviation psychology, 203-220.

Medenica, Z., Kun, A., Paek, T., & Palinko, O. (2011). Augmented reality vs. street views: A driving simulator study comparing two emerging navigation aids.

Moss, J. D. (2008). Characteristics of Head Mounted Displays and their Effects on Simulator Sickness.

Osterhout Design Group. (2016, 10 25). R-7 Smartglasses. Retrieved from Osterhout Group: http://www.osterhoutgroup.com/products-r7-glasses

Reason , J. T., & Brand, J. J. (1975). Motion Sickness. London: Academic.