Real-Time Detection of Simulator Sickness in [redacted] Virtual Reality Games Based on Players' Psychophysiological Data during Gameplay

Xi'an Jiaotong-Liverpool University 西交利物浦大学

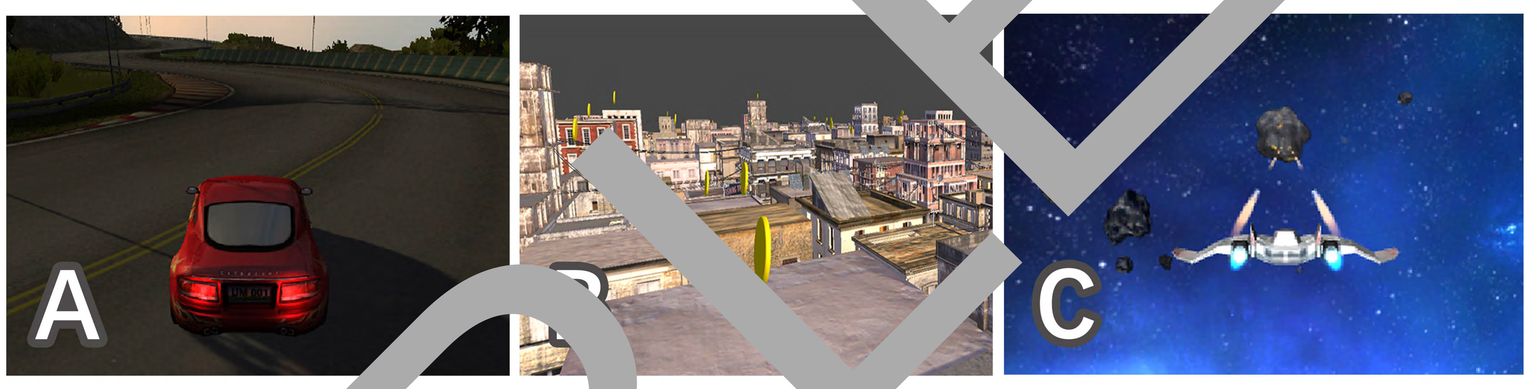
Abstract

Virtual Reality (VR) technology has been proliferating in the last decade, especially in the last few years. However, Simulator Sickness (SS) still represents a significant problem for itswider adoption. The main way to detect SS is usually through the Simulator Sickness Questionnaire (SSQ), which is a subjective measurement and is impossible to be used in real-time applications such as VR games. This research aims to investigate how to use machine learning techniques to detect SS based on character's and users' physiological data during gameplay in VR games. To achieve this, we designed an experiment to collect such data in three types of games. We trained a Long Short-Term Memory neural network with the dataset eye-tracking and character movement data to detect SS in real-time. Our results indicate that our model is an accurate and efficient way to detect SS for VR games in real-time.

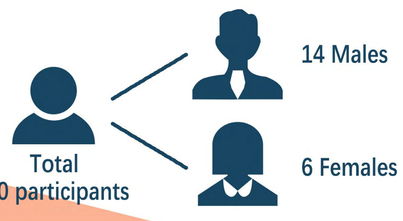
Introduction

Virtual Reality (VR) technology has been growing in the last decade, especially in the last few years, with the proliferation of mass-marketed Head-Mounted Displays (HMDs). Despite these advances, Simulator Sickness (SS) remains a constraint and challenge of VR and has a negative effect on its wider adoption. The most commonly used method to assess SS is the Simulator Sickness Questionnaire (SSQ) . It can be used to quantify SS for activities that could lead to SS symptoms. However, it is impossible to quantify real-time SS for VR environments with SSQ. In this research, we proposed a low-cost method to achieve real-time SS detection with current consumer-level VR HMDs with eye trackers.Based on our theoretical analysis and an electroencephalogram (EEG) study, we hypothesize that two in-game features are highly linked to SS: H1: Eye Movement (EM); and H2: Character Movement (CM). We used our novel labeling method to break real-time gaming events into classes, which in turn can be used to train our model and subsequently detect real-time SS in VR. We used a Long Short-Term Memory (LSTM) neural network to train our model using EM and CM. To our knowledge, we are the first to associate these data when looking for SS. Our model can be used to improve the gaming experience in real-time whenever SS is detected during gameplay.

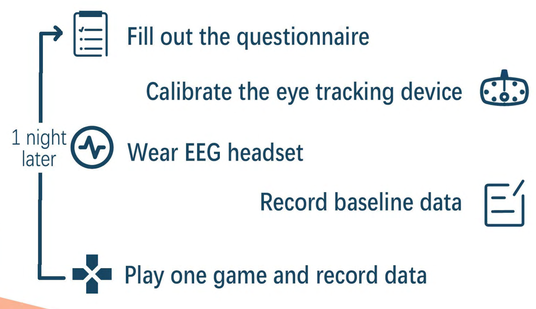
Using Unity3D, we developed three VR games ((A) Racing Car. (B) Parkour (C) Space Miner) to collect the data during gameplay. Our pilot run showed that these three VR games could produce enough SS stimulation with different levels during gameplay. To record possible SS symptoms and levels, no SS mitigation techniques have been applied to the VR games.



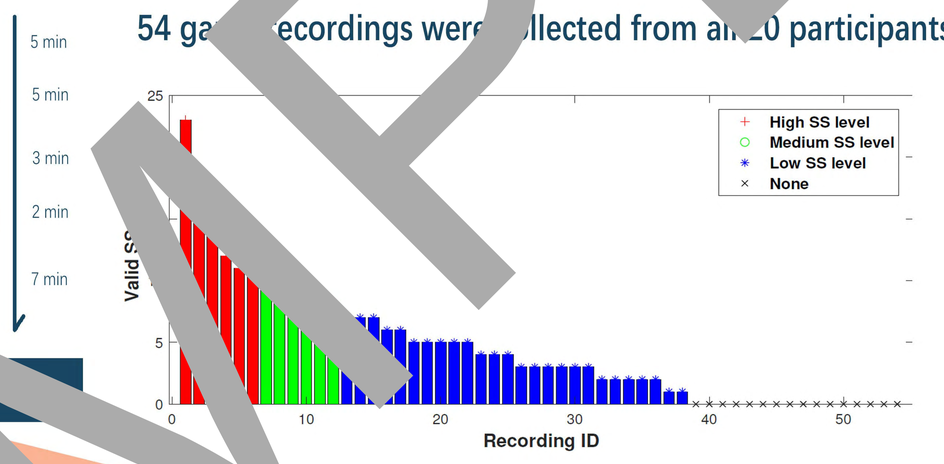
Methodology



I. Participants



II. Procedure



III. Data Collection

To collect the dataset, we chose a 14-channel Emotive Epoc+ headset for EEG recording and HTC VIVE Pro Eye for both displaying and eye tracking.

HTC VIVE Pro Eye

Emotive Epoc+

IV. Equipment

Model

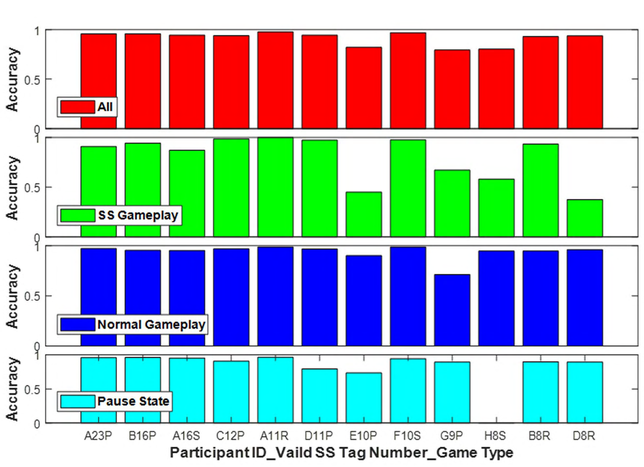
Concept and Model

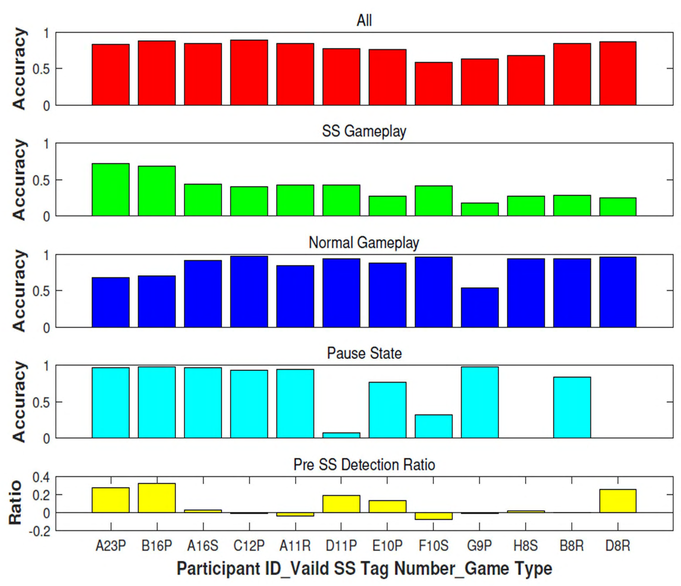
The final dataset contains four types of data: (1) magnitude of each eye acceleration, (2) magnitude of character acceleration, (3) speed, and (4) angular acceleration. The magnitude of eye acceleration speed was calculated from 13 types of raw eye movement data recorded from the HTC VIVE Pro Eye. Magnitudes of character acceleration speed and character angular acceleration were calculated using the virtual sensor script in the VR games. There are three event IDs in the raw dataset: 0 is normal gameplay without SS; 1 is 30 seconds before SS become intolerable (the player would pause the game); 2 is the pause state. Long blink (trigger pause) is classified into event 0 to prevent mixed patterns between events 1 and 2. We trained two LSTM models A and B to detect SS in VR games, pre- and after its onset.

Results

Model A has an excellent performance on classifying SS; however it can only detect post-SS. This model can be used to reduce SS stimulation during the development stage of VR games. It provides developers a low-cost and efficient solution to locate and remove possible SS stimulating aspects during game development or adding ways to mitigate them in the game when compared to existing SS detection methods in the literature. Our Model B can detect real-time SS events for players who are highly sensitive to SS, but the model is not as sensitive in other cases. Using the model, developers can design pre-defined actions or features in response to SS feedback to improve user experience and gameplay. For example, when SS is detected, the game difficulty can be automatically adjusted to a lower level. There is one crucial difference between Model A and Model B. Model A can only be used to detect post-SS events. Model B can detect part of pre-SS events for players in some games (e.g., 1PP VR games like Parkour).

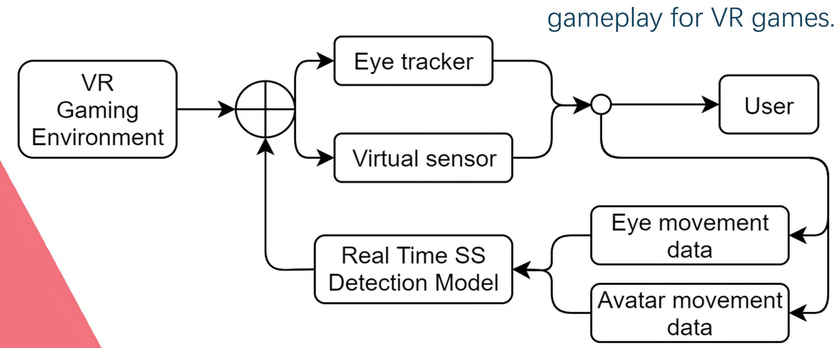
Accuracy of Model A (left) and Model B (right) to classify game events





Conclusion

Our real-time SS detection during gameplay can be used as the basis of an AI-based feedback system in the VR gaming environment. The real-time SS detection model can detect SS from user's real-time data (i.e., eye movement plus character movement data) during gameplay. Then, the VR environment can respond to the SS feedback, possibly reducing SS stimulation in the game. In this study, we used three different VR games to produce SS stimulation while collecting data. We posed two hypotheses from the etiology of motion sickness and the result of EEG analysis: H1 SS may cause EM; H2 CM may cause SS. The evaluation of our model showed its high performance of post-SS detection for players who are highly sensitive to SS. One of two models, Model A, can be used to detect post-SS for game developers to reduce SS stimulation in their VR games. The other module, Model B, can be used to detect part of pre-SS events for some VR games with strong SS stimulation and player who are highly sensitive to SS. Our preliminaryresults indicate that our detection method is a simple yet effective way to detect SS during gameplay for VR games.



SAMPLE