A Driving Error Detection System within a VR Driving Simulator for Individuals with ASD

Yousaf A. Khaliq

Department of Computer Science at Middle TN State University

ABSTRACT

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder with disabilities ranging from social skill deficits to a lack of adaptive behavior skills. Less focus is given to the latter and individuals with ASD tend to have difficulty performing basic occupational tasks such as driving. Virtual reality driving simulators have been used to assess and improve driving performance; however, only one such simulator has been developed specifically geared towards individuals with ASD. This research explores the efficacy of a driving error detection system in said simulator with a focus on functionality, aesthetics, communication, and overall usability. Designed in the Unity game engine and programmed in C#, the challenge is to effectively and subtly communicate to the ASD user what driving error was made in a clear, relaxed manner. The design of this system and the testing data to validate its functionalities are presented in this paper.

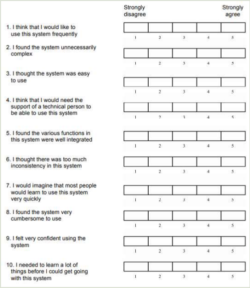
OBJECTIVES

The memory and focus required to perform basic driving tasks is challenging for individuals on the spectrum and every year, more adolescents with ASD become adults without the ability to drive. To combat this issue, the proposed solution is to improve the individual's driving performance via performance assessment in a virtual reality (VR) driving simulator. This paper discusses the Error Detection System in said VR driving simulator. The usability of the Error Detection System can be measured using the System Usability Scale (SUS) with the focus being on aesthetics, functionality, and ease of use.

AIM 1: To create an Error Detection System in a virtual driving simulator environment (VADIA) geared towards individuals with ASD.

AIM 2: To test the usability of the Error Detection System using the System Usability Scale. Continue to improve the system based on the SUS feedback and data. Provide accurate and usable data reflecting the driver's performance.

System Usability Scale



	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	1	2	3	4	5
2. I found the system unnecessarily complex	1	2	3	4	5
3. I thought the system was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8. I found the system very cumbersome to use	1	2	3	4	5
9. I felt very confident using the system	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

METHODS

Approach

I have listed every error I would like to accommodate in the Error Detection System and have classified each error into a specific category: **Navigation, Traffic Law, Special Vehicles, and Mission Errors**. Navigation Errors include illegal turns - which can be a "no turn on red" or turning down a one-way street in the wrong direction, driving in the wrong lane, and veering off course - this means any deviation from the road. Traffic Law Errors include failing to stop at a red light/stop sign or a designated area like a pedestrian crossing and railroad track, going over the speed limit (the threshold will start at 10 miles over the speed limit), and being stationary when the vehicle should be in motion such as in the middle of an intersection. Special Vehicle Errors include not pulling over for a passing ambulance or police vehicle, not pulling over when a police vehicle pulls the user over, not pulling over during a funeral procession, and not stopping for an unloading school bus. Mission Errors are only in effect when the user deviates from the simulation's mission. VADIA is broken up into "levels" and each level has a "mission" for the user which involves telling the user what turns to take. If the user deviates from the directions, a Mission Error would be generated.

Implementation

Since there are four error categories, there will be four distinct error messages. If a Navigation Error occurs, the game will pause and a box will pop up saying Navigation Error at the top with the message "Did you...Make an illegal turn? Drive in the wrong lane? Veer off course?". This will give the user a chance to figure out what they did wrong. Then there will be a prompt that says "pump the brake pedal to find out what went wrong" and then it will display exactly what the error was and what the user can do to prevent this error in the future. The same will happen for Traffic Law, Special Vehicle, and Mission Errors except 3 with the appropriate language respective to the specific error category. The user will only be able to make three errors before being prompted to either restart the mission or exit the mission. Before three errors are made, after each error the user will return to a designated checkpoint - a position that will be recorded behind the scenes in Unity just before the error was made.

Separate from the four error categories are Collision Errors. Any Collision Error (due to this being the most severe of errors) will automatically prompt the user with the option to restart the mission or exit the mission.

During the entirety of the mission, exact errors will be tracked and then upon exiting or finishing any mission, a "report card" will be generated and displayed. This will display the exact errors that were made and with what frequency. Every instance of report card will be stored. This will essentially create data points that can be analyzed. For instance, comparing the user's first report card with their final one can be an indication of the user's improvement, or lack thereof.

RESULTS

All errors were accounted for and implemented into the driving simulator. Screenshots can be seen below. The error category approach was abandoned. It was tried and found to be too complicated and with less aesthetic appeal. Instead, each error was coded separately with its own specific error message i.e. short sentence explaining the nature of the error.

After three errors, an option to restart the level or exit the game is presented. If the game is exited then a "report card" is generated and displayed. This shows the specific errors that were made and their frequency.

Upon completion of the Error Detection System, five participants tested the system and proceeded to answer the 10 questions in the System Usability Scale. The scale is out of 100 points. The scores were 82, 83, 85, 87, and 81 with an average of 83.6. A discussion of the scores can be found in the conclusions section.

CONCLUSIONS

Overall, the project went well and could be considered a success. The average SUS score was 83.6. The areas that were scored lower on average, were "I thought there was too much inconsistency in this system" and "I felt very confident using the system" and "I needed to learn a lot of things before I could get going with this system" and "I think I would like to use this system frequently" but even then, the scores were a 4 out 5. So although they were lower, it was not by much.

Going forward, we would like to implement some overlooked errors that were skipped due to time. The Special Vehicles errors and the Mission Errors. We would also like to experiment more with the font, the box size, and colors to find the most aesthetically pleasing error boxes.

This research can benefit anyone interested in improving their driving performance; however, it is geared towards autistic individuals.

REFERENCES

[1] Esubalew Bekele. "A Novel Virtual Reality Driving Environment for AutismIntervention". In:International Conference on Universal Access in Human-Computer Interaction(2013), pp. 474–483.

[2] Dayi Bian. "Design of a Virtual Reality Driving Environment to AssessPerformance of Teenagers with ASD". In:International Conference of onUniversal Access in Human-Computer Interaction(2014), pp. 466–474.

[3] Daniel J. Cox. "Can Youth with Autism Spectrum Disorder Use Virtual Re-ality Driving Simulation Training to Evaluate and Improve Driving Perfor-mance? An Exploratory Study". In:Autism Dev Disord47 (2017), pp. 2544–2555.doi:10.1007/s10803-017-3164-7.

[4] Michael J. Kofler. "Driving Simulator Performance in Novice Drivers withAutism Spectrum Disorder: The Role of Executive Functions and BasicMotor Skills". In:Autism Dev Disord46 (2016), pp. 1379–1391.doi:10.1007/s10803-015-2677-1.

[5] James R. Lewis. "The System Usability Scale: Past, Present, and Future".In:International Journal of Human-Computer Interaction34.7 (2018), pp. 577–590.

[6] Chao Lu. "Virtual-to-Real Knowledge Transfer for Driving Behavior Recog-nition: Framework and a Case Study". In:IEEE Transactions on VehicularTechnology68.7 (2019), pp. 6391–6402

[7] Maria T. Schultheis. "Examining the Usability of a Virtual Reality DrivingSimulator". In:Assistive Technology(2007).

[8] Joshua Wade. "A Pilot Study Assessing Performance and Visual Attentionof Teenagers with ASD in a Novel Adaptive Driving Simulator". In:AutismDev Disord47.10 (2017), pp. 3405–3417.doi:10.1007/s10803-017-3261-7.

[9] Lian Zhang. "Cognitive Load Measurement in a Virtual Reality-BasedDriving System for Autism Intervention". In:IEEE Transactions on Af-fective Computing8.2 (2017), pp. 176–189.

CONTACT

Yousaf A. Khaliq

yak2a@mtmail.mtsu.edu

Cell #: 615-318-7021