***Rehabilitation Driving Simulator***: Requirements Document (v 2.1)

Project: Rehabilitation Driving Simulator

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**1. Introduction**

This document contains the requirements for the Rehabilitation Driving Simulator. These requirements were derived from discussions with Dr. Brendan Smith, Ph.D. and members of his staff.

**1.1 System Overview**

The Rehabilitation Driving Simulator helps drivers who have been physically challenged in some way re-learn how to drive. An existing driving simulator will be modified. The simulator has a seat and driving controls, but as the seat moves around, it provides haptic feedback which is (in many cases) too stressful for an injured driver. The magnitude of the haptics will be reduced, but they will still simulate the physical forces of driving by giving the driver the sensation of turns, bumps, acceleration, and braking. Linking the controls and the simulated roadway to provide a life-like experience will require precise computer control.

**1.2 How to Use This Document**

This section explains the structure of this document. Section 2 gives a full description of the project itself. Section 3 discusses the requirements that the software will meet from a user and technical standpoint.

The following language specifies requirements.

**1.2.1 “Shall”**

This expresses a mandatory requirement which must be satisfied by the product.

**1.2.2. “Should”**

This expresses a non-mandatory provision, which may or may not be satisfied during the course of this project.

**1.2.3. “Will”**

This declares a design goal, outlining a narrative by which other requirements accomplish a purpose.

**1.3 Scope of the Product**

The product will be used to assist recovering brain injury victims and in research to that end. It should help compromised users regain the ability to perform complex motor coordination tasks, including relearning how to drive, and the haptic feedback should improve driving performance of even unimpaired users relative to a system without feedback.

The product will not likely have applications for other forms of physical and psychological injury. It will also be of relatively minimal use for unimpaired persons, as there is no obvious recovery outcome.

**1.4 Overview of the Requirements Document**

The most important requirements are:

1. a software interface for researchers/therapists to manage session conditions and user settings
2. a training mode to allow subjects to practice with the quasi-haptic feedback and researchers to collect data
3. a test mode to evaluate and collect data on subjects’ progress
4. a data management module to handle the data collected during trials
5. an application to assist researchers/therapists record and collect data

**2. General Description**

This section gives the reader an overview of the project, including why it was conceived, what it will do when complete, and the types of people expected to use it. Constraints faced during development and assumptions made about how to proceed are listed.

**2.1 Product Perspective**

Dr. Brendan Smith, Ph.D. and members of his staff are developing this product because there is a significant need for a system that provides a useful driving experience for people suffering from brain trauma who might otherwise pose a danger on the road. The final product should make driving rehabilitation experience more easily accessible.

**2.2 Product Functions**

The product will simulate a variety of driving environments which will test different skill sets. Users should be able to test specific skill sets, and have their performance recorded in a "subject profile." Users should be able to perform multiple different training scenarios, as well as be tested on a certain skill set that might or might not improve throughout those training scenarios.

**2.3 User Characteristics**

The finished product is intended to be used in 2 specific contexts:

**2.3.1 Medical Facilities**

Specialized rehabilitation professionals will use this product to aid in the recovery of stroke victims. As these medical professionals' core expertise is in the medical field rather than computer technology, the goal is to build an interface that will minimize any such obstacles that may arise so that they do not need to acquire any special skills.

**2.3.2 Research**

Medical research professionals will use this product to conduct research on optimal ways in which rehabilitation regimes can be refined. These researchers should not require any additional expertise beyond any existing experience they have with Windows machines.

**2.4 General Constraints**

This project requires customized SimGear driving simulator hardware running on the Windows 10 operating system. All software must therefore remain compatible with both the Windows development and runtime environments and the SimCommander and SimTools motion control software that connects the hardware and the front-end software.

**2.5 Assumptions and Dependencies**

As discussed in **2.4**, this project depends upon a particular technical infrastructure (SimGear simulator hardware and Windows 10 operating system), and its use requires an administrator qualified to oversee human social and behavioral research and/or rehabilitation.

The simulator itself is composed of an off-the-shelf performance car seat mounted on a platform by two screw actuators, an array of 3 HD monitors, an XBox-branded steering column with game buttons (including paddle shifters) and minimal adjustment, an array of hydraulic pedals, and a Windows 10 PC.

**3. Specific Requirements**

This section of the document lists specific requirements for Rehabilitation Driving Simulator. Requirements are divided into the following sections:

1. User requirements. These are requirements written from the point of view of end users, usually expressed in narrative form.
2. Subsystem divisions.
3. Experiment scheduler. These are detailed specifications describing the functions the system interface must be capable of doing.
4. Training scenarios. These are detailed requirements relating to the software’s training mode.
5. Test scenarios. These are detailed requirements relating to the software’s evaluation system.
6. Data acquisition. These are detailed specifications describing the software’s capacity to interact with files and other applications.
7. Trial app. These are detailed specifications describing the application researchers will employ to observe users of the system.

**3.1 User Requirements**

3.1.1 Users shall be informed of operating instructions prior to operating the simulator.

3.1.2 Users shall be provided the opportunity for signed consent prior to using the simulator.

3.1.3 Users shall be made aware of safety precautions and protocols involved with operation.

Researchers will share and inform users of all precautions and protocols prior to operation.

3.1.4 Users shall be informed that some jolting will occur when the simulator is in operation.

The purpose of the simulator is to mimic all aspects of actual driving on a real road. The actions the users make and the jolting the users feel will also reflect on the way the user drives.

3.1.5 The simulator shall reflect the user’s operation by performing actions which are similar to real driving.

Such actions will include but not be limited to:

* acceleration
* braking
* turning left and right
* driving on smooth/bumpy/slick surfaces
* going uphill/downhill

**3.2 Subsystem Divisions**

3.2.1 The Rehabilitation Driving Simulator shall have five main subsystems.

3.2.2 The first subsystem shall be the Experiment Scheduler.

The Experiment Scheduler will be responsible for the organization and execution of experiments.

3.2.3 The second subsystem, Training Scenarios, shall provide long-duration practice sessions that simulate real-world driving.

3.2.4 The third subsystem, Test Scenarios, shall evaluate users’ skills in post-training scenarios.

3.2.5 The fourth subsystem shall be Data Acquisition.

3.2.5.1 Data Acquisition shall provide a means of evaluation

3.2.5.2 Data Acquisition shall provide a means of monitoring systems.

3.2.6 The fifth subsystem, the Trial App, shall provide researchers a means of recording observed data during sessions.

**3.3 Experiment Scheduler**

3.3.1 The experiment scheduler shall be implemented as a Windows desktop application.

3.3.2 The scheduler interface shall allow a researcher to set up experiment conditions.

This custom-built application will present the researchers with a user’s profile, current experiment, and upcoming experiments.

3.3.3 The scheduler interface shall allow a researcher to start/stop an experiment.

The application will allow researchers to toggle stop an experiment at any given moment, in case unforeseen issues arise.

3.3.4 The scheduler interface shall allow a researcher to send triggers to an active experiment.

The application will allow researchers to send signals to, for example, trigger road obstacles for the purpose of measuring reactions.

3.3.5 The scheduler interface shall allow a researcher to adjust haptic feedback factors.

3.3.6 The scheduler interface shall save all user data within his/her subject profile after a session.

**3.4 Training Scenarios**

3.4.1 The training sessions shall be initiated from the experiment scheduler.

Training sessions should run autonomously once started.

The training scenarios will simulate real world driving and give participants practice.

Training scenarios will take place in the simulator; no custom or extra interfaces will be built.

3.4.2 The software shall collect quantitative data from these sessions.

3.4.2.1 Data collected shall include cars hit

3.4.2.2 Data collected shall include obstacles hit.

3.4.2.3 Data collected shall include lines crossed.

3.4.3 The collected data shall be used to generate a report about the session.

**3.5 Test Scenarios**

3.5.1 Test scenarios shall include looping courses or challenges to test a user’s ability.

Test sessions will be less variable than the training sessions.

3.5.2 During test scenarios, the software shall collect more detailed data.

Data collected will include stopping distance, following distance, reaction time, lane position, and g-force.

Test scenarios will take place in the simulator, no custom or extra interfaces will be built.

3.5.3 After test scenarios, results shall be shared with the user.

**3.6 Data Acquisition**

3.6.1 Data from each session shall be saved and exported

Data will be exported as .CSV.

3.6.2 Data saved and exported from each session shall remain associated with the user.

Data will be saved within a user profile managed by the scheduler.

3.6.3 The software shall communicate with and monitor the hardware actuators via SimCommander and SimTools.

The project should incorporate an additional monitor so the researcher can see real-time hardware data.

3.6.4 The software shall record video of the simulator’s screens during sessions.

3.6.4.1 Video recording shall start at the beginning of the trial.

3.6.4.2 The video shall be recorded in .FLV format.

**3.7 Trial App**

3.7.1 The App shall be implemented as a web app.

3.7.2 The app shall keep track of time, Track Violations, Traction Losses, Crashes, and Lap Times.

3.7.3 Control of the App shall be via HTML buttons and keystrokes.

3.7.3.1 The App shall have “Start Experiment,” “Start Trial,” “Stop Experiment,” and “Clear Experiment” buttons.

These buttons will allow researchers to manage session metadata – specifically, time.

3.7.3.2 The App shall use keypress event listeners for control of Track Violations, Traction Losses, Crashes, and Laps.

3.7.3.2.1 The “1” key shall increment Track Violations.

3.7.3.2.2 The “2” key shall increment Traction Losses.

3.7.3.2.3 The “3” key shall increment Crashes.

3.7.3.2.4 The “4” key shall increment Laps.

3.7.4 The App shall be based on a timer.

3.7.4.1 The timer shall sync with the video recording (refer to 3.6.4).

3.7.4.2 The timer shall manually sync with the video by way of the “Start Trial” button.

3.7.5 The App shall export data as a .JSON file.

3.7.5.1 Data shall be saved upon clicking the “Stop Experiment” button.

3.7.5.2 The App shall have a text field in order to name the data file resulting from a session.

**4. Glossary**

**Haptics:** Relating to the sense of touch, specifically relating to the perception and manipulation of objects using the senses of touch or proprioception (the sensation of the body’s position).

**Subject Profile**: Individual profile which will be assigned to all simulator users, within which all of each participant’s pertinent data is recorded.

**Actuator**: A component of a machine that is responsible for moving and controlling a mechanism or system.

**Track Violation:** For purposes of experiments in the Rehabilitation Driving Simulator, an event that occurs when a subject leaves either the road surface or their lane.

**Traction Loss:** For purposes of experiments in the Rehabilitation Driving Simulator, an event that occurs when a subject takes a turn too sharply for their speed, causing 2 or more of the vehicle’s tires to overcome their coefficient of static friction.

**Event Listener:** A subroutine in the JavaScript programming language that runs in the background and performs actions when a specified event, such as a keypress, takes place.

**5. References and Further Reading**

SimGear - https://www.simgear.com/

SimCommander - https://www.simxperience.com/en-us/products/software/simcommander4.aspx

SimTools - https://www.xsimulator.net/simtools-motion-simulator-software/

Project Cars 2 - https://www.projectcarsgame.com/explore/?lang=en-us

American Truck Simulator - https://americantrucksimulator.com/

City Car Driving - http://citycardriving.com/