DRIVER BEHAVIOUR ANALYSIS METHOD USING VEHICLE DRIVING SIMULATOR

David Michalík
Doctoral Degree Programme (1st year), FEEC BUT
E-mail: xmicha61@stud.feec.vutbr.cz

Supervised by: Petr Fiedler
E-mail: fiedlerp@feec.vutbr.cz

Abstract: This paper is mainly focused on the development of a vehicle driving simulator in order to analyse human behaviour while driving a car. Using a vehicle driving simulator is a safe and financialy available method for measuring data about the driver, so a custom made car driving simulator is used. Multiple scenarios were created in order to analyse specific parameters of the driver, e.g. reaction time, driving style, and fatigue detection. A sample of the data is presented, showing that the data obtained from the simulator is relevant and could be used to improve our understanding of human behaviour while driving a car and greatly improve safety on the roads.

Keywords: data analysis, driver behaviour, car driving simulator, human reaction time, unreal engine, virtual reality

1 INTRODUCTION

In all of modern technologies, safety is the most important parameter that needs to be focused on. Scientists and engineers are trying to find a way to combine adequate safety precautions in all fields while trying to maintain a reasonable price for the product. The same goes for car industry and development of new technologies that are implemented in modern cars. A lot of tests are being held in order to test the vehicles or drivers (for example the moose test). However, they tend to be costly and - most importantly - potentially dangerous for the test subjects (drivers). In order to create a safe environment for these tests to be held, a vehicle driving simulator is a good alternative to these tests. Engineers and researchers can create multiple scenarios that may be difficult to simulate in real life. Such a simulator is being developed in order to analyse human behaviour while driving a vehicle and to measure important data about the virtual vehicle and driver himself.

2 DRIVER BEHAVIOUR

Man-machine systems are a specific kind of systems, in which a human is using a complex tool (a machine). In this case, a driver driving a car is considered to be such a system. In these systems, a person is considered to be a controller for the whole system. Reacting accordingly to information given - regulating speed, turning the steering wheel, changing gears, etc. All of these reactions (regulatory inputs) are heavily influenced by experience. [1] The human controller is always learning, adapting and such a controller can be represented and evaluated. However, the important part of human behaviour cannot be measured - and that is human consciousness. With this in mind, we are trying to find a model that represents human driver behaviour the most. [2]

A person's actions in man-machine systems depend on a system that is being controlled. These actions can be divided into three categories[2]:

- Skill-based behaviour - the lowest level of control, based on automated and fast reactions (e.g. keeping the vehicle in lane).
- Rule-based behaviour - more difficult tasks are begin performed. These tasks have a specific execution based on rules or learned procedures (e.g. overtaking, turning).
- Knowledge-based behaviour - the highest level of control. A person analyses multiple inputs and creates an optimal plan based on the person's knowledge and experience (e.g. planning a route based on the actual traffic)

3 CAR DRIVING SIMULATOR

Car driving simulator is an application that is being developed in order to analyse a driver's behaviour. The main advantage of having our own developed simulator is that we can create any kind of scenario in order to measure different types of data about a driver. Compared to the commercial simulators or even computer games, where any kind of interference in the application is considered a violation of licence agreement.

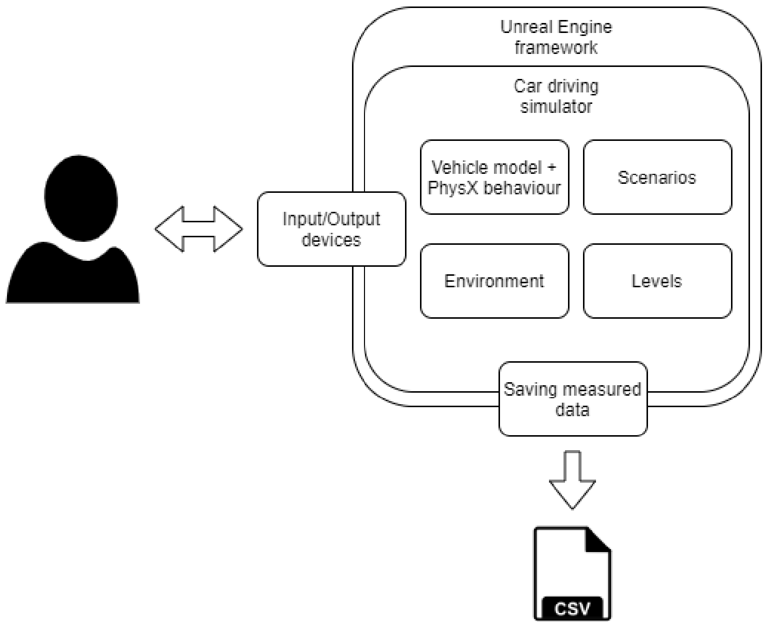


Figure 1: Car driving simulator diagram

Car driving simulator is developed in Unreal Engine 4 (UE4), which is a game engine used mainly for developing computer or console games, but can serve as a suitable framework (based on C++) for research applications. It has multiple advantages and offers us advanced graphics to create real-life looking environment, implemented PhysX vehicle model, custom C++ functions, multiple assets, VR (virtual reality) development compatibility and much more.

There are important parts of the application, which are shown in the diagram in Fig. 1. Unreal Engine offers a framework on which Car driving simulator (CDS) application is developed. CDS has implemented vehicle model with behaviour handled by PhysX, multiple scenarios, levels (maps) and the environment itself with highways, roads, nature, etc. For the input device, a Logitech G920 Steering wheel with pedals is used. The application then gathers data from the input device and environmental objects (line, car,...) and stores it in a .csv (comma-separated values) file with a custom made blueprint C++ function.

For a driver that is being tested on the simulator, the main part is his immersion in the simulation. To make the simulator as realistic as possible, the CDS offers two ways for the driver to ride through the scenarios. A standard with an ultra-wide monitor, or with a more immersive VR headset. In this case, Oculus Rift S is being used. The input devices work the same way in both possibilities. A test subject driving through a calibration level could be seen in Fig. 2.

Figure 2: First person car view with head-up display (HUD)

In both of the above mentioned ways to operate the CDS, the test subject has a user interface on his display. This user interface (as seen in Fig. 2) offers the driver multiple information about the car and the current scenario (e.g. current vehicle speed, current gear, line distance, visual warning of changing lanes, etc.).

3.1 Measured driver parameters

There are several key parameters that need to be measured in order to analyse human behaviour while driving a vehicle:

- Following a specific route – the driver needs to follow a specific route (in CDS the driver needs to follow a line that is shown or keep the vehicle in a specific lane). Data obtained from such scenarios could be used to detect a driver's fatigue.
- Reaction time – sudden changes occur and create the most dangerous situations on the road. A driver's reaction time could be measured while detecting a sudden appearance of an object on the road.
- Driving style analysis – with more focus on the input data from the driver (amount of steering wheel turning or pedal force applied).

According to these parameters, several scenarios were created in CDS in order to gather important data about the driver.

3.2 MEASUREMENT SCENARIOS

Highway – Step response
In this scenario, the driver needs to follow a line which is shown to him in his user interface. The level consists of a straight road (highway) which is over 8 kilometers long. After the driver reaches configured vehicle speed, the line changes its position in random time intervals. This change represents a step function, so from the measured data we can analyse a driver's reaction time and data from input devices.

Highway – Long distance ride
The Long distance ride scenario is represented by a long highway loop, which takes around 15 to 25 minutes to ride through (depending on the maximum velocity set on the vehicle). The only objective of this scenario is to ride through the highway multiple times while trying to stay in the same lane. When the driver goes too far from the lane, a visual warning is shown (as seen in Fig. 2) and the driver is supposed to act accordingly. This simulates a long ride on a highway in which the driver could be suffering from fatigue and sleepiness.

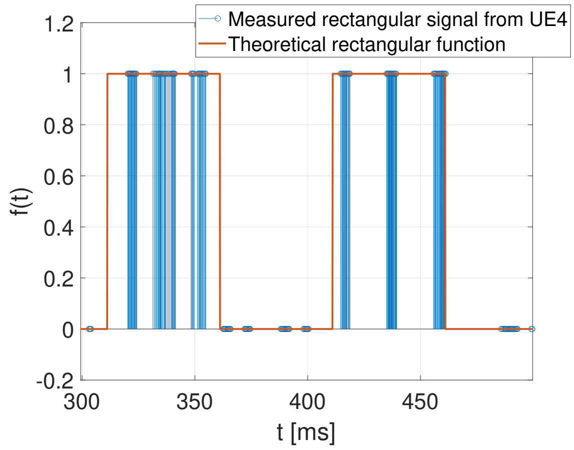
Calibration scenario
A simple scenario in which the driver rides around a level that contains a road with small curves and a few traffic cones. The purpose of this scenario is for the driver to be accustomed to the behaviour of the vehicle. No data is measured.

Highway – Sudden obstacle scenario
Similar to the Step response scenario, it consists of a long highway with no turns. In this case, the driver's objective is to ride straight in the lane the vehicle is spawned in. However, in a random time interval, an object is spawned in front of the driver. This again simulates a step function. The main difference is that the driver does not expect a sudden change. Data from the steering wheel and pedals as well are stored and analysed.

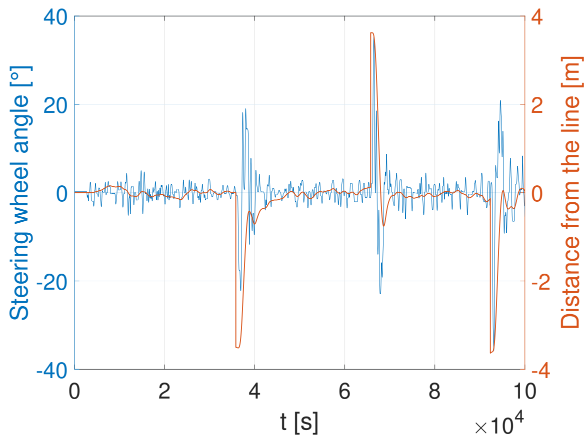
Moose test scenario
The Moose test scenario is based on a real life test in which the capabilities and dynamics of the vehicle are being measured. It is defined by ISO 388-2:2011, which defines the dimensions of the testing track, required vehicle behaviour and the maneuver that the driver needs to perform. It is mainly used to test the behaviour of the vehicle model implemented in the CDS. [3]

4 DATA MEASUREMENT

Data from the scenarios is being measured and stored in a .csv file. An example of measured data from the Highway - Step response scenario is shown in Fig. 3b. A link between distance from line and steering wheel angle could be observed. While the line changes its position (simulating a step function), the driver starts to react accordingly with a delay (which is equal to the driver's reaction time) to lower the distance as fast as possible. In Fig. 3a, an uneven sampling could be observed. This is caused by the Unreal Engine 4 framework itself because the fastest time interval is defined by the Tick function. This function is called every rendered frame. Therefore it can be said that the sampling period is highly determined by the hardware the application is running on. On the other hand, as H.J. Landau states, the average sampling frequency needs to be two times bigger than the maximum frequency of the spectrum. [4] The theorem guarantees that as long as the frames per second are on a certain level, the data from the simulator can be considered valid. We deal with sampling non-uniformities via mathematical method presented in [5].



(a) Graph 1 - Uneven sampling by UE4



(b) Graph 2 - Measured data from Step response scenario

Figure 3: Graphs displaying acquired data from the CDS

5 CONCLUSION

Creating a driver behaviour model could be considered as a difficult task. Current models suffer from a lack of measured data. In order to overcome this obstacle, vehicle driving simulators are used to gather large amounts of data with a focus on safety and low financial burden. Currently a vehicle driving simulator is being developed, with focus on measuring relevant data and creating scenarios that enable us to simulate real-life situations in which a driver's style of driving and behaviour could be observed. We strongly believe that in the future, this simulator with its measured data could have a huge impact on increasing the safety of vehicles and therefore on the roads.

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