Modern Management based on Big Data III
A.J. Tallón-Ballesteros (Ed.)

doi:10.3233/FAIA220080

Implementation of a Driving Simulator for the Collection of Data on Human Behavior in Vehicular Traffic

Joshua PROAÑO [a] and Paulina MORILLO [b] and Diego VALLEJO-HUANGA [b,1]
[a] *Department of Computer Science, Universidad Politécnica Salesiana*
[b] *IDEIAGEOCA Research Group, Universidad Politécnica Salesiana*

Abstract. Traffic psychology covers not only the act of driving but also includes inherent phenomena such as accidents, violations, and the generation of emotions. This article proposes the development of a driving simulator within the video game Grand Theft Auto V, taking advantage of the artificial intelligence of characters that interact with the player, as well as other drivers and pedestrians. The implementation includes the adaptation of steering wheel type controls and the creation of a mod in C# for data collection and export. This implementation seeks to obtain useful data for the analysis of the behavior of the drivers evaluated during the driving tests carried out in three virtual circuits within a city. By performing the tests with drivers of different levels of experience, it was possible to verify the effectiveness of the tool in its use and realism. According to the individuals evaluated, the simulator achieved an average realism of 4.6 on a Likert scale from 1 to 5. Likewise, the results obtained show that the data collected by the simulator is less biased than those obtained through a post-driving survey.

Keywords. Videogame, Traffic Psychology, Artificial Intelligence, Virtual Environment

1. Introduction

The invention of motor vehicles along with the development of the automotive industry brought about a revolution in the field of human mobility. This caused an increase in the number of drivers and cars on the roads, giving rise to the analysis and study of traffic [1]. Traffic analysis studies the behavior of different vehicles and their interaction with the environment and considers several variables, and its study involves various aspects such as weather conditions, the number of cars on the streets, the design and quality of the roads, and various aspects of driver psychology [2].

Driver behavior is an important aspect that influences traffic and has been investigated by several disciplines, its analysis involves macroscopic models aimed at obtaining general vehicle variables such as size and distance from other vehicles. Microscopic models take into account more specific variables, and their analysis is much more complex than that of macroscopic models, since they include variables such as the state of

[1]Corresponding Author: Diego Vallejo-Huanga, IDEIAGEOCA Research Group, Universidad Politécnica Salesiana, Rumichaca y Morán Valverde, Quito, Ecuador; E-mail: dvallejoh@ups.edu.ec

roads, signage, city design, road infrastructure [2], which will influence the actions a driver will take. Traffic psychology is a branch of applied psychology responsible for studying road infrastructure, driver and pedestrian behavior, and road education to address road accidents with a comprehensive and preventive approach, where all elements converge in driving [3].

With the introduction of experimental psychology and psychometrics, together with industrial and social advances, psychology assumes the multidisciplinary role that allows quantitative and qualitative analysis of data collected using assessment instruments [4]. Traffic psychology encompasses not only the act of driving, but including inherent phenomena such as accidents, violations, and the generation of emotions [1]. Thus, the types of emotions vary between subjects and are related to the experiences and their learning [5]. Another important factor within the psychology of driving is that the personality of each individual is variable and is affected by external factors. The individual's personality plays an predominant role since driving is an activity that requires a decision-making process in situations with a high degree of uncertainty [6].

There are several scientific investigations that have addressed the problem of traffic and driver behavior, based on their personality, using different methodologies [7] [8] [9]. These works try to model the behavior patterns of drivers, in everyday situations, and most of these have been carried out through real scenarios, using vehicles in established circuits. However, drivers may not drive as usual if they feel they are being monitored. A solution would be to monitor driving, without the subject feeling pressured, by using driving simulators [10].

Although there are several driving simulators on the market, only the most advanced ones can simulate real situations of drivers and pedestrians during the journey. Some of these simulators are priced between 3000 USD and above, and it is usually necessary to purchase additional software and hardware for the best experience [11]. The most affordable simulators do not usually generate interaction with pedestrians or other drivers and, therefore, are not an optimal solution. This work is developed with the aim of implementing a driving simulator as realistic as possible, which presents everyday situations and sensitive controls, allowing the collection of data on the driving behavior of the person driving for later analysis.

2. Materials and Methods

This section describes the hardware and software requirements necessary to implement the simulator. In addition, the development of the methods and classes used for the data acquisition of the video game, the adaptation of the controls, and the design of routes are presented.

2.1. Materials

The development of the simulator follows the methodology shown in Figure 1. Here, the relevant data, tools, and frameworks, necessary peripherals, and their adaptation are defined for an agile development cycle with functional prototypes.

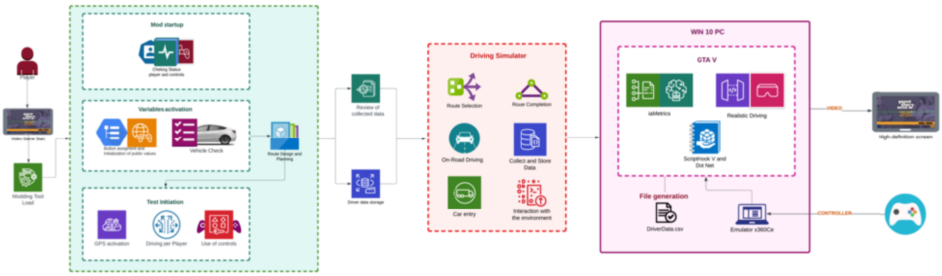

Figure 1. Block diagram of the methodology for mod development.

2.1.1. Hardware and Software Requirements

For this work, we considered the use of the video game Grand Theft Auto V developed by Rockstar North, which was released for seventh-generation consoles in 2013, for eighth-generation consoles in 2014, for Microsoft Windows in 2015, and for ninth-generation consoles in 2021. The story of this game takes place in the fictional city of Los Santos, which contains urban and rural environments, as well as an artificial intelligence designed to reproduce the behavior and attitudes of people and drivers. Thus, reproducing a realistic environment that allows drivers to behave in a natural way during the tests.

To allow the video game to run with a stable frame rate and without cuts or freezes, the developer company Rockstar proposes minimum and optimal hardware and software requirements. Taking into account the developers' recommendations, the simulator was implemented on hardware composed of an AMD Ryzen 5 3400G processor at 3.7 GHz, with integrated AMD Radeon Vega 11 graphics and 8 GB of RAM. The game runs in conjunction with OpenIV software, which is used by the modding community to implement new game modes or options not covered by Rockstar. This tool allows loading a modification (mod), developed by Killatomate called Realistic Driving V, to simulate various driving parameters such as technical details of cars, roads, and driving environments.

2.2. Methods

By default, the game does not provide tools to know the driver's performance or the values generated by the car during use. The video game has directional lighting support, although reserved only for the characters and not for the player, during their mobilization within the fictional city. So, an in-game mod was developed to extract the data and implement more realistic features in the player-controlled vehicle.

2.2.1. Game Data Acquisition

For the data acquisition, a script was created using the C# programming language and the Microsoft .NET framework [12]. The Grand Theft Auto V community has created libraries to add and enrich the game with new features. These libraries are ScriptHookV developed by Alexander Blade using the C programming language, and ScriptHookDotNet developed by Crosire using the .NET framework. Both tools focus primarily on allowing the user to develop game modifications by using scripts written in .NET that allow manipulation of game classes.

The video game modification allows for the collection of data on the drivers' actions during test drives. So it is necessary to define the vehicle's parameters to be collected as acceleration, speed, engine revolutions, steering wheel angle, clutch position, headlight status, turn signal status, collision detection, horn detection, and radio status. These variables can be obtained from the classes *GTA.Native* and *GTA.Math*, which contain, on the one hand, the data of the player's actions and, on the other hand, the actions made by other objects in the video game environment.

The next step consists of creating a new library that contains two classes: *iaMetrics* and *Metrics*. Moreover, this library inherited the public methods *Tick* and *KeyDown* of the *GTA.Script* class from the ScriptHookVDotNet library. These methods allow for the execution of instructions on each frame of the game and by pressing an assigned key, respectively. The *iaMetrics* class is created with public variables that monitor the storage of the values generated by the automobile. Meanwhile, the *Metrics* class contains the constructor method, called with the same name as the class. This method initializes the public variables and the public methods *onKeyDown* and *onTick*. In addition, it includes private methods, of which the most important are *Collector*, *getCoordinates*, *storePoints*, and *verifyAngle*.

The *Collector* method stores the car data in global variables; once verified that the player is inside a vehicle, the data are extracted using *GTA.classes*. This class contains the getter and setter methods that allow one to set and obtain the different variables. Instead, the method *onekey* oversees the activation of private methods such as *getCoordinates*, *storePoints*, *Dir Left*, and *Dir Right*. The first method stores the coordinates of the video game map inside a private variable of type list. The second method stores the coordinates in a plain text file, thus emptying the list created by the previous method. The last two methods supervise the activation of the blinkers and the parking lights by simulating the controls on the car dashboard. Furthermore, this project includes the control of the directional lights in the GTA.Native class. This option is normally enabled only for the characters in the video game. Also, the *verifyAngle* method was created to verify the use of the blinkers when the player turns in any direction.

Regarding the characters in the game, the mod doesn't make any modifications to their behavior so that the interaction with the user is as natural and realistic as possible. The video game includes characters with passive or aggressive behavior.

Finally, the sampling frequency was set to 60 Hz. This means that the mod captures the parameters of 60 frames every second, although there may be higher or lower peaks of frames depending on the graphic load of the game. The mod code and documentation are available at the following link: https://github.com/KuroGxbo/iaMetrics.

2.2.2. Route design

To define the routes, functions were designed using the *OnKeyDown* method, which activates the pre-established route within the game's GPS. For GPS activation, the *GTA.Native* class and the *Hash* function were used. The route was defined through a process of accumulating points by freely driving through the game. With the collected coordinates, three circuits were created: the first one crossing the city center, the second one through a suburb, and the third one passing through a highway. The *START_GPS_MULTI_ROUTE* method is used to draw and display the routes for the pedestrian, while the *SET_GPS_MULTI_ROUTE_RENDER* method displays the circuit on the map.

An important attribute to consider is the use of controls that provide greater immersion through controls made up of steering wheels, pedals, and even gear levers. Natively, Grand Theft Auto V does not provide support for this type of control but was incorporated into the proposed simulator. The game provides support for console controllers from Xbox and Play Station. To achieve this, the x360CE program was used, which allows the use of Xbox controllers compatible with Windows. For the tests, we used a Genius Steering Wheel model Twin Wheel F1 that includes acceleration and brake pedals. The default controls were used in the initial stages of development, but then some button assignments were changed to prevent the player from being distracted.

In addition, functions such as radio controls have been reassigned to other buttons so that the functions designed in the mod for turn signals and parking lights are assigned to the buttons on the steering wheel and used during the simulation.

2.2.3. *Evaluation of the tool*

For the evaluation of the simulator, a test scenario was set up with high-definition television, the pedals attached to the floor by means of a suction cup, and the steering wheel. The three previously defined circuits were used, referred to in a simplified way as the center, suburb, and highway.

In addition, to evaluate the simulator with reference to driving experience, a survey was designed with four sections and questions related to the information and perception of participants about the peripherals and the environment of the three circuits. The first section of the survey is related to the operation and instructions for operating the simulator and asks about the characteristics of the car, the peripherals and the types of circuit. In this section, player data, such as full names, are also collected; gender, Male (M) or Female (F); license type, Professional (PR) or Non-professional (NPR); and length of time held. Finally, it concludes by asking about their driving style, Passive (P) or Aggressive (A), and if the instructions given was clear.

Sections two, three, and four are answered after completing each circuit, and information is collected on the sensitivity of the controls and the closeness of the scenarios to reality. Interaction with other drivers and pedestrians, traffic signals, use of turn signals, parking lights, horn functions, and their usefulness during the test are included. Information about car data is also collected, such as the speed and sensitivity of the brake and accelerator pedals.

3. Results and Discussion

In the experiments, ten people with an age range between 26 and 58 years participated. Participants had different driving knowledge, that is, different types of official driving licenses, to have an objective opinion on their driving experience and interaction with the simulator. The Table 1 summarized the characteristics of the participant.

As shown in Figure 2, each person took three driving tests on three different circuits: downtown, highway, and suburbs. The main objective of each circuit is to expose the user to situations that would occur in real life while driving. For instance, in Figures 3(a) and 3(b), the interaction of the driver with traffic signals and pedestrians is shown, respectively. The average driving time in each circuit was 6, 7.7, and 5.8 minutes, correspondingly.

Table 1. Characteristics of the participants in the experiments.

Age	Type	Men		Female		Total
		A	P	A	P	
[20-30]	NPR	0	3	0	0	3
	PR	0	0	0	0	0
[31-40]	NPR	1	0	0	1	2
	PR	0	0	0	1	1
[41-60]	NPR	0	1	0	1	2
	PR	1	0	0	1	2
Total		2	4	0	4	10

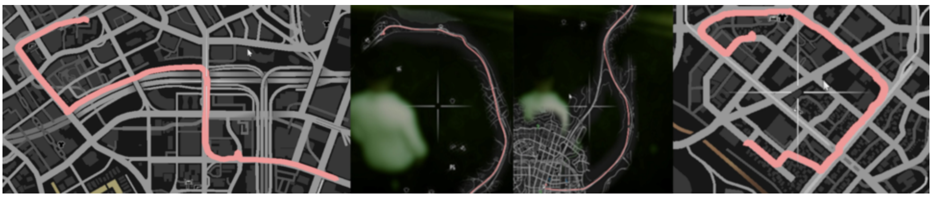

Figure 2. Downtown (left), freeway (center) and suburban (right) routes.

Once the driving test was completed, the participants conducted sections two, three, and four of the survey. These sections had 12 Likert scale questions dealing with ease of use of video game controls and perception of driving. The maximum weighting was 5 points and the minimum was 0.

Regarding the overall perception of the drivers' driving experience in the simulator, considering how real the driving test felt, i.e., the ease of use of controls, environment realism, and interaction with pedestrians and other cars, circuit 3 was rated the highest with 4.6 points, followed by circuit 2 with 4.4 points. The lowest rating, 3.9 points, was for the first circuit. Similarly, the feeling of realism was 4.2, 4.5, and 4.6 points for the first, second, and third circuits. Instead, the stress level caused by all tracks was less than 2.8 points.

On the other hand, the average ease of use of the controls of the three routes was 3.5, 4.5, and 4 points, respectively (see Figure 4). Thus, the most difficult route was the one that crossed the downtown city due to the interaction with the environment, especially traffic lights, pedestrians crossing, car acceleration and deceleration, etc.

(a) Interaction with drivers and traffic lights (b) Interaction with pedestrians and traffic signals

Figure 3. Interactions of the driving simulator with the environment.

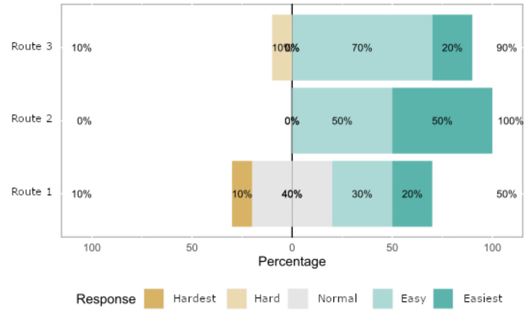

Figure 4. Results of the evaluation of ease of use in the controls of the car.

Concerning the use of the turn signals and parking lights in the three circuits, there was an appreciation with a rating greater than or equal to 4.5. In contrast, the throttle and brake controls were rated higher on routes 2 and 3, with average scores above 4.

During the tests, in a parallel and transparent way for the user, video game data on vehicle driving were obtained. A sample of the values collected is shown in Table 2. The data includes Boolean, real, integer, and time variables such as accelerator, collision, horn, revolutions per minute (rpm), turning angle (steerAng), frames per second (fps), date, etc.

Table 2. Sample data acquired with iaMetrics mod about vehicle parameters during the test drive.

Vehicle information								Lights state and game data								
accelerator	rpm	collision	clutch	steerAng	lights	highBeam	velocity	horn	rd	stateI	lockI	stateD	lockD	fps	date	hour
1	0.69	F	1	4	T	F	20.13	F	15	F	F	F	F	57	13/7/2021	14:47:14
1	0.7	F	1	4	T	F	20.52	F	15	F	F	F	F	51	13/7/2021	14:47:14
1	0.72	F	1	3	T	F	20.97	F	15	F	F	F	F	42	13/7/2021	14:47:14
1	0.74	F	1	2	T	F	21.3	F	15	F	F	F	F	56	13/7/2021	14:47:14
1	0.76	F	1	2	T	F	21.65	F	15	F	F	F	F	54	13/7/2021	14:47:14
1	0.78	F	1	2	T	F	22.06	F	15	F	F	F	F	49	13/7/2021	14:47:14
1	0.8	F	1	1	T	F	22.42	F	15	F	F	F	F	57	13/7/2021	14:47:14

It should be emphasized that the drivers, who were not feeling monitored, were able to act naturally. Therefore, the data collected reflects the behavior of drivers in an environment very similar to the real one. Each row in Table 2 shows the information stored by the collection method that runs in each frame of the game. The average sample rate was 55 fps.

4. Conclusion

In this work, we present the implementation of a driving simulator with adaptations of the Grand Theft Auto V video game. The combination of artificial intelligence and the graphics aspect of the game allows the driving experience to be perceived much more naturally. Likewise, thanks to the adaptations of the steering wheel and pedal controls, drivers were able to drive in virtual environments very close to reality, interacting with autonomous characters (drivers and pedestrians), who execute unpredictable actions, allowing the individual to face various scenarios in which we can collect data on your driving style. The modification made in C# using the .NET framework allows the data for driver behavior analysis to be collected in a way that is transparent to the user, ensuring that the drivers' attitude is not somehow masked by knowing that they are being observed. In this way, in the future, a dataset can be generated with different attributes that could be used as input to machine learning models to determine the pattern of driver behavior.

5. ACKNOWLEDGMENTS

This work was supported by the IDEIAGEOCA Research Group of the Universidad Politécnica Salesiana in Quito, Ecuador.

References

[1] Groeger, J., Rothengatter J. Traffic psychology and behaviour. Transportation research part F: traffic psychology and behaviour 1.1 (1998): 1-9.
[2] Pérez-Sánchez F., Bautista A., Salazar M., Macias A. Analysis of vehicular traffic flow using a macroscopic model. DYNA 81, 184 (2014), 36.
[3] Sullman, M. Advances in traffic psychology. CRC Press, (2019).
[4] Barjonet, P. Transport psychology in Europe: A general overview. Traffic and Transport Psychology. Theory and Application (1997).
[5] Pekrun, R. Emotions and learning. Educational practices series 24.1 (2014): 1-31.
[6] Revelle, W. Hans Eysenck: personality theorist. Personality and Individual Differences 103 (2016): 32-39.
[7] Wang W., Xi J., Zhao D. Driving Style Analysis Using Primitive Driving Patterns With Bayesian Nonparametric Approaches. IEEE Trans. Intell. Transport. Syst. 20, 8 (2019), 2986–2998.
[8] Eftekhari H., Ghatee M. Hybrid of discrete wavelet transform and adaptive neuro fuzzy inference system for overall driving behavior recognition. Transportation Research Part F: Traffic Psychology and Behaviour 58, (2018), 782–796.
[9] Li G., Wang Y., Zhu F., Sui X., Wang N., Qu X., Green, P. Drivers' visual scanning behavior at signalized and unsignalized intersections: A naturalistic driving study in China. Journal of Safety Research 71, (2019), 219–229.
[10] De Winter J., Van Leeuwen, P., Happee, R. Advantages and disadvantages of driving simulators: A discussion. Proceedings of measuring behavior. Vol. (2012).
[11] Iqbal M., Sari K., Sekarwati K., Putri D. Developing PC-Based Driving Simulator System for Driver Behavior Analysis Research. In Journal of Physics: Conference Series, Vol. 1566, No. 1, IOP Publishing, (2020), p. 012075.
[12] Thai T., Lam H. .NET framework essentials. O'Reilly Media, Inc, (2013).