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DEVELOPMENT OF ADVANCED DRIVING SIMULATOR FOR DRIVING SCHOOLS

Libor Topol, Michal Malý*

Czech Technical University in Prague, Faculty of Transportation Sciences, Department of Vehicle Technology, Konviktská 20, 110 00 Prague 1, Czech Republic

* corresponding author: malymic7@fd.cvut.cz

Abstract. This paper describes development of an innovative advanced driving simulator (ADS), that will be implemented into the driver education process as a method to improve education of students and thus their readiness to enter everyday traffic. ADS will allow the driving school students to get more practice in general vehicle control, unusual situation solving and use of modern assistant systems, as well as objectively evaluate student's skills by the instructor. As a conclusion, expected outcomes of innovative simulator design and results validation possibilities are discussed.

Keywords: Simulator, driver, education, safety, evaluation.

1. Introduction

Quality of driver education is a key factor to road safety. This research aims to improve driving school education and thus novice drivers' readiness to enter everyday traffic. This goal is to be achieved by an advanced driving simulator (ADS) development, that will be used in the education process. Reduction of beginner's mistakes that might cause accident is expected.

1.1. Accident rate of young and beginner drivers

The accident rate of novice drivers is disproportionately higher than for other groups of drivers. As for the accident statistics of young and novice drivers, it can be stated that young drivers under the age of 24 cause around 10,000 accidents each year in the Czech Republic. Despite reduced fatal accidents, young drivers remain the most at-risk group. They cause 9 % of accidents and 15 % of deaths. According to available data, 84 people were killed due to young drivers under the age of 24, and another 272 were seriously injured in 2020. The highest proportion of persecuted drivers is registered with drivers aged 24 [1]. Other statistics show that as a result of accidents caused by young drivers, 35 drivers of passenger cars (44 %), 33 passengers in passenger cars (41 %), 6 motorcyclists (7 %), 3 lorry drivers (4 %) and 3 cyclists (4 %) died [2]. Beginner drivers acquire the skills needed to drive a motor vehicle relatively quickly, but it takes significantly longer to acquire all the perceptual and cognitive skills necessary for safe interaction in the traffic environment. With increasing age and gained experience, there is a decrease in risky and immature behaviour of drivers [3].

1.2. Accident rate of young and beginner drivers

The accident rate of novice drivers is disproportionately higher in the long term than for other groups of drivers. The key factors causing increased accident rate among novice drivers are inexperience, underdeveloped personality, and the related willingness to take risks and underestimation of risks. Driver training is a factor that clearly affects novice driver's behaviour in real traffic, both positively and negatively [4]. Modern advanced vehicle simulators can help to increase quality of training by enabling training in safe conditions not only for routine tasks, but also for risky situations with a high probability of an accident in case of incorrect or slow reaction. It allows also to fully practice all types of traffic environment (highway, suburbs, city) and driving in different weather conditions (including slippery roads). Another significant advantage is the possibility of individualizing the training (a driving school student can focus more on situations in which he struggles), and the possibility of practicing/demonstrating dangerous situations that cannot be simulated during training in a real vehicle, such as reacting to a dangerously overtaking vehicle in the opposite direction [5]. During the training at the driving school, the student will therefore be able to try out various climatic conditions and driving manoeuvres that he would not encounter during the standard training interval and thus be better prepared for real environment [6, 7]. Moreover, inappropriate behaviour at railway crossings and dangerous overtaking of cyclists, which also appear in increased accident rates statistics, can be reflected in training scenarios. Also, drivers often don't come across modern driving assistance systems during their training at a driving school and only test them in real traffic, which can be very dangerous both for them and for those around them. Advanced driving simulator will provide possibility to learn how to control these systems safely [8].

2. Method

The car simulator is designed to imitate the driving of a car in a virtual environment as similar to real road conditions as possible. Construction of the “light interactive vehicle simulator” (dashboard with pedals, steering wheel, gauges/driver display and visualisation screens) consists of real car parts; the design meets requirements for both hardware robustness and plausibility of scenarios implemented in software [9]. The cabin of the simulator consists of the parts of lower middle-class passenger car Lada Granta with manual transmission (five forward gears, one reverse), which are firmly attached to steel frame. It comprises following cockpit parts: cockpit dashboard (shortened on the passenger side), central console with controllers, central tunnel including gear lever and handbrake, adjustable driver’s seat with seatbelt, the floor of the vehicle under the driver’s seat, left front door interior trim, three-pedal console, steering wheel with a controlled feedback, functional light controllers (parking, high beam, low beam, fog lights), turn indicators, etc. The functional dashboard instrument panel with speedometer, rev counter, indicator lights and warning notifications is an important part of a cockpit as well. The overall image, sound and background computing processes of the simulation is provided by computational equipment of the car simulator. Virtual reality is rendered on powerful graphic workstation hardware with state of art graphic card (GPU Nvidia Quadro M 4000) ensuring the smooth visualisation. Three 31,5” full HD LCD monitors offer panoramic frontal and partially peripheral view from the simulated car. All image information generated by the virtual reality system is shown by this projection system, the horizontal range covers 120° of driver’s view. Rear view mirrors are represented by displays with relevant graphics and are placed at the appropriate location of the projection system. The audio system is directly connected to the virtual reality computer and generates sounds that are normally audible by the driver while driving. The sound is provided by a set of six speakers situated around the driver. Software equipment of the car simulator reproduces the sensations normally perceived by the driver in a vehicle. If the car simulator is not equipped with a movement platform, movement sensations are excluded. The software of the simulation system consists of mathematical-physical model, virtual environment visualization module and a surround sound generator. The mathematical-physical model periodically reacts to the inputs from the control elements and calculates the values of the forces and moments, from which it determines the upcoming state of the vehicle such as position, speed, etc. taking into account the influence of the surrounding environment. Car simulator software behaviour corresponds to four-wheel vehicle with independent axles, front-wheel drive and manual transmission. The virtual reality simulation module is made of few essential components – an image generator that creates an image of the scene based on inputs consisting of vehicle position data, data from the terrain database (virtual environment in which realistically-looking objects surround the road track) projected by display system. To make a driving experience even more realistic, the virtual environment visualisation system is combined with the surround sound generator that gives driver additional information. The vehicle simulator exports operational data into a data file, which contains a complex information about the drive, i.e., position of the car in time, the steering wheel position/turning velocity, pressure levels on individual pedals, position of vehicle control elements and distance from the collision elements. Data from individual rides are stored in a matrix, number of columns corresponds with the number of monitored values and number of rows is determined by the distance of measured ride. The visualisation engine Unity plays the most important role in the visual quality of the scene. It is a software in which virtual environment is modelled, and it ensures image generation on the screen. Unity is a multi-platform engine for creating 2D and 3D scenarios. The subject of the research is to fully adapt this program environment for simulator training on the simulator, including full synchronization with the controllers and communicators built into the simulator, The general issue in SW development is to find a balance between realistic appearance and the complexity of the created scene. The driving simulation in the virtual environment runs in real time and because of that, it is necessary to reach the minimum frame refresh rate of at least 45 frames per second (in ideal case 120) which requires substantial computing power of the vehicle simulator hardware. The visual quality of rendered image could reach the level of current computer games, which is considered as high-end of the real time simulations. That allows for better immersion into simulated driving experience.

The growth of computing power also allowed quality enhancement of the parameters evaluated during the ride. The vehicle simulator allows real-time evaluation of:

- the offset distance from the centre of the lane,
- keeping safe distance from forthcoming vehicle (see Figure 1),
- respecting maximum allowed speed both in and outside of the city,
- stopping position in front of intersection.

3. Results

The target of this applied research was to develop advanced and innovative driving simulator for education purposes. The goal was achieved by using innovative and advanced technologies.

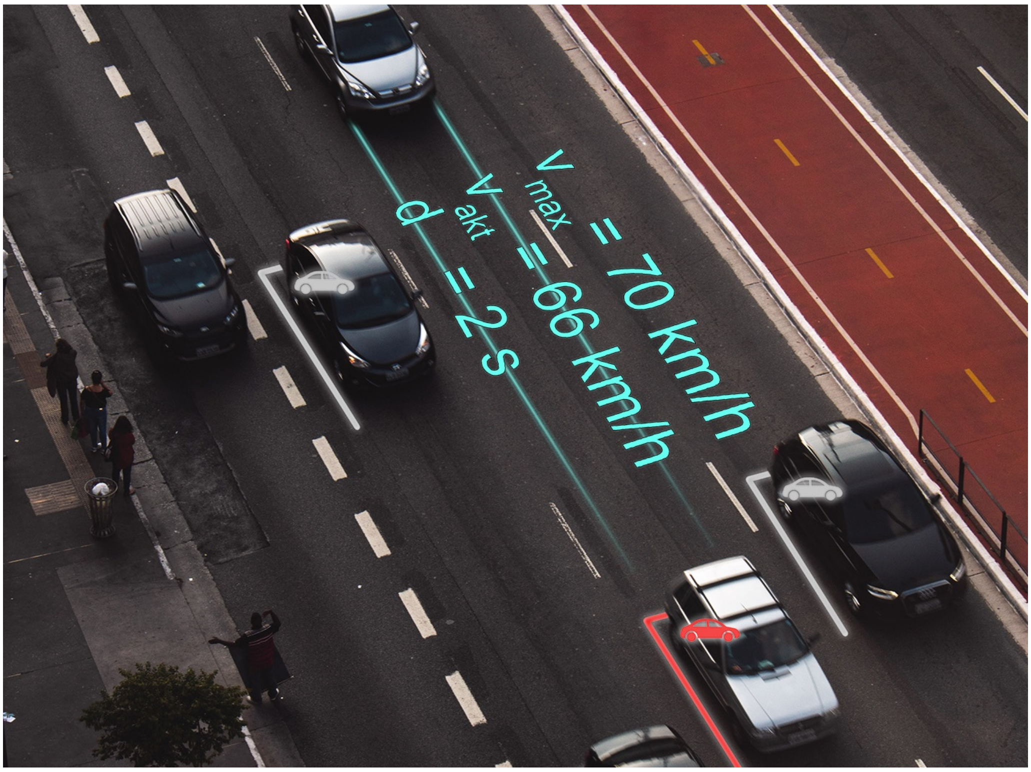

FIGURE 1. Safe distance monitoring.

3.1. Innovation 1

Implementation of acoustic assistance system to the vehicle simulator. This system monitors all driving parameters and movements in a virtual environment in real time and is able to react to the driver errors or shortcomings during driving. These systems can be used at two levels. At the teaching level, the assisted sound system alerts drivers to upcoming situations and guides them safely in a virtual environment. This category consists of a acoustic overspeeding warning, an explanation of the intersections driving rules or a need for gear change. In the phase of controlled drive training, the driver is no longer guided in a virtual environment, but is alerted about misconducts and dangerous behaviour such as speeding, failing to keep a safe distance or inability to keep the lane. This system can be supplemented with additional warnings depending on the technological equipment of the vehicle simulator [10].

3.2. Innovation 2

Eye tracking system is considered as another innovative approach. The system allows to monitor and record the driver's gaze direction using the video analysis of the eye pupils and head movement while driving (see Figure 2). There are various technical solutions available for eye movement tracking, in this particular simulator a distance unit will be used, which offer contactless and thus less distracting measurement. The system uses a series of cameras in front of the driver and specialised software, which is able to monitor the driver and evaluate the direction of view. Such systems can even be built into the dashboard and are basically do not affecting the drive. Eye tracking data allows to analyse if the driver focused his vision on traffic sign, whether he does not spend excessive time monitoring instrument displays or controls, or the frequency of watching rear-view mirrors.

3.3. Innovation 3

One of the latest advanced systems to complement current simulators is the Intelligent Driver Training Management System. It is a system that evaluates the results of the drive quality parameters in the vehicle simulator and, based on these results, individualises the training scenarios selection specifically to train the situations with weakest performance that would need to be improved.

4. Discussion

All the innovative systems mentioned in Section 3 can improve the driver training process and may help to safely prepare future drivers for the unexpected situations they may encounter in real conditions. Synergic effect of all three innovations is expected when implemented simultaneously.

5. Conclusion

Driver education is a key factor in improvement of the road safety. Innovative advanced vehicle simulator can objectively increase the quality of driver training if the teaching process is accordingly adapted. These

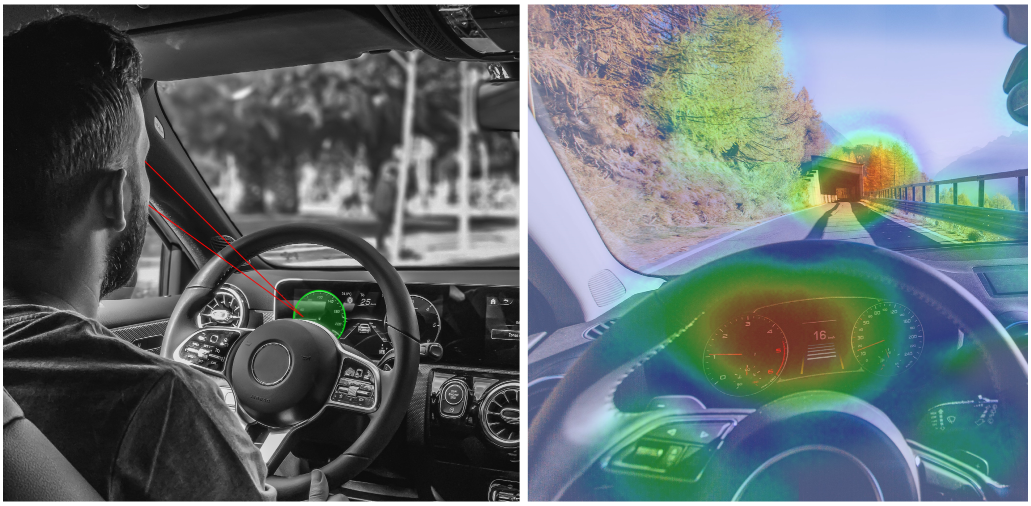

Figure 2. Eye tracking system.

devices have ambition to impact everyday life and indirectly reduce the amount and consequences of vehicle crashes. Further detailed testing of the prototype will be conducted. The functional prototype concept is designed to allow further extension and evolution.

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