ADVANCED CAR DRIVING SIMULATOR – AS 1200-6

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Abstract

Article describes advanced high class research simulator of passenger car with complete inside equipment including adjustable driver seat, steering wheel, dashboard, gear selector, accelerator pedal, brake and clutch, parking brake etc. Simulator is based on six axis motion platform and original vehicle cabin adapted from Opel Astra IV body, purchased by Motor Transport Institute.

Furthermore, simulator is equipped with dedicated devices which allow conducting research on driver's behaviour which is not possible to conduct in real traffic situations due to the safety issues. Researcher can record parameters related to driver's activities, which could be next analyzed and combined with data received from other external instruments. AS1200-6 can be used also for drivers training in dangerous conditions e.g. learning how to react to the abnormal behaviour of other road users or pedestrians and learning how to drive in different weather conditions. This paper gives an overview of the hardware and software components as well as of the research possibilities that are aimed at making transportation safe and clean. The results of the research are very important especially for the road safety. The simulator enables simulation of dangerous traffic situation in the safe virtual environment.

Keywords: *road transport, driving simulator, six-axis motion platform*

1. Introduction

Car driving simulators that are built by independent producers and research institutions differ in the degree of realistic interpretation of actual driving condition. The simplest static simulators (without the traffic system) are equipped with the drivers' sits, screen, steering wheel and pedals. The most advanced world class simulators provide simulations of linear and angular acceleration by providing longitudinal and transverse movement of the cabin at the distance of several to tens meters. In addition the system performs the rotation movement of the cabin. The system of image projection in this type of simulators ensures even displaying of virtual environment around the

vehicle. Classification of the simulators due to the complexity of construction, motion and visualization was proposed in article [Kemeny A., Panerai F.: Evaluating perception in driving simulation experiments, TRENDS in Cognitive Sciences Vol. 7 No.1 January 2003]. Purchased by the Motor Transport Institute AS 1200-6 simulator belongs to the high-class driving simulators. Additional equipment can carry out the drivers testing and training, research of road infrastructure, ergonomics research of the cabin and Human Machine Interfaces studies. It is also possible to simulate and study some of the vehicle construction solutions to estimate vehicle performance in the real conditions. The results of the research are very important especially for the road safety. The simulator enables simulation of dangerous traffic situation in the safe virtual environment.

2. Construction of high-class passenger car simulator

Modern high-class driving simulator should be equipped with:

- original cabin of passenger vehicle,
- electric system of movement,
- many-projectors system of image projection covering an area of at least 180° horizontal and 40 vertically, 3 display of image of the rear-view mirrors, angular resolution of 3 minutes and minimum refresh rate of 60 Hz,
- image generation system based on the PCs, providing the typical network of roads, in different weather conditions (seasons of the year and day, rain, snow, fog) and provides special effects (lights of the cars, shadows of trees, lightning etc.)

Simulator should also provide:

- full control of other traffic participants actions that should be also easily turned into autonomous mode , at least 25 objects, including participants, cyclists, lorries, buses etc.,
- fully controlled real time changes in the behaviour of other traffic participants,
- sound simulation (environment and vehicle),
- suitable model for the dynamics of the vehicle and its weight,
- operator station that allows creating training, supervision and intervention into the simulation.

The example diagram of simulators functional architecture is showed on Fig. 1.

The high-class simulator's cabin should reflect the actual vehicles cab that means: to give a real feeling being in the car with complete accessories, including adjustable driver's seat, steering wheel, dashboard, gear selector, accelerator pedal, brake and clutch, parking brake etc. Drivers are not aware of the modifications that were made in the driving simulators. Elements located inside the cabin should work the same as in the actual vehicle. In particular they should simulate the power steering, resistance of clutch and break pedal. The simulator is also not equipped with the traditional gearbox, so its effect should be also simulated. Realistic simulation of its operation requires the use of for example gear shift in case of switching on and off the course or the lack of inclusion the gear with no clutch pedal (in case of manual gear box).

The variety in simulators used in video projections system requires tradeoffs guiding the choice of particular solution. The use of stereoscopic glasses or helmets gives opportunities to show the virtual world as the three-dimensional, but it requires very low latency response to the movements of the driver (in particular head movements). The result is that they are very rarely used in simulators for training and that they are used mostly in research simulators. This type of solutions brings many disadvantages. They usually have low resolution of image, are inconvenient (often severe) and they depend on the display can offer a small instantaneous field of view. They also require to focal visual on the screen placed in the short distance from the eye. That causes rapid eye fatigue.

In simple and low-cost simulators are used the monitors or televisions screens, usually liquid crystals, what offers high contrast and good spatial resolution but to provide the sufficient field of view requires a short distance from the user. The disadvantage is also cover of the screen, which makes gaps between different parts of the presented image. Such a screen also cause eye focusing at an abnormally small distance in compare to observations in the real vehicle.

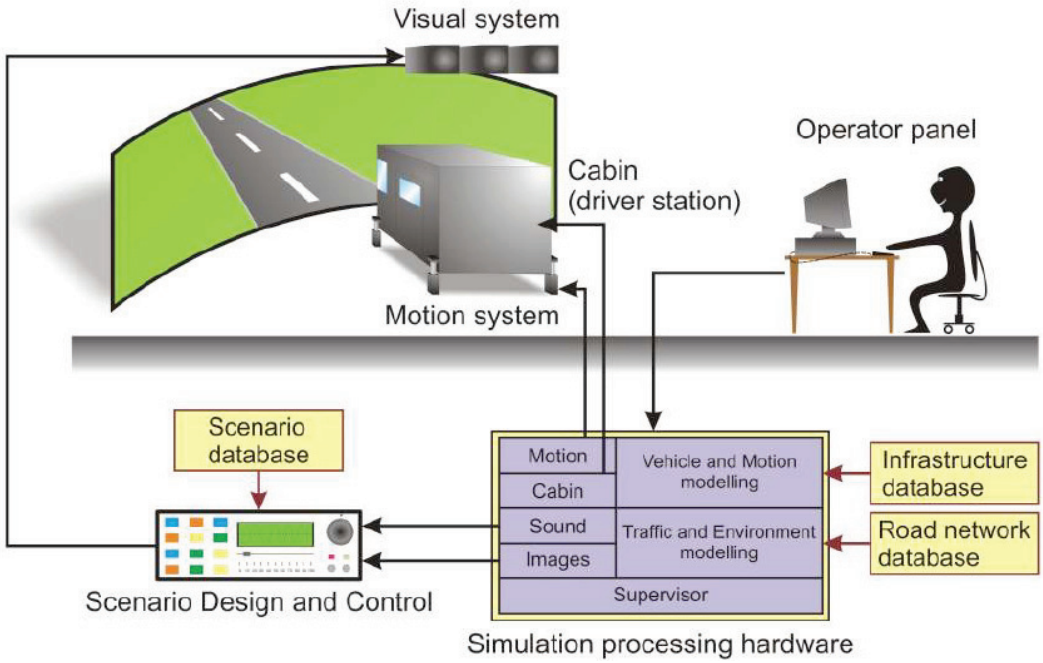

Fig. 1. Example diagram of construction of the high-class car simulator (Source: own work on the base of [1])

For these reasons the most common system of visualization used in the simulation is to use several connected screens placed in the field of vision, outside the drivers cab. In most of simulators are used projectors influencing image on the screen or screens around the driver, because the objective is to get the impression, that the whole world outside belongs to the virtual environment. The simulated field of view of the drivers position is therefore more then 180° in horizontally and 40° to 60° vertically. Depending on the visibility from the inside of the vehicle. In the truck simulator sufficient is 200 degrees that provides almost full virtual visibility around the vehicle. In the personal car simulator, depending on the design of rear-view mirrors may be required even 360 degrees. Using projectors allows also for more natural focus of the drivers vision, because the screens can be kept away from drivers ocular point more than 2 meters.

In order to map the environment close to real as possible, it is necessary to create a basic database of graphics depicting various objects seen by the driver. Typically this database consists of two related models; physical model – describing the size, simplified or pre-calculated information about the collision, the mass and other parameters needed to use in dynamic model – and the graphical model consisting of traditional polygon mesh describing the basic shape and texture mapped on it, providing details of appearance and shape of specific modification to enable them to provide in proper light condition.

The basic set of element included in the database is a road network that provides information of roads geometry, type, surface characteristic and appearance, as well as information included in simulation of autonomic vehicles. Some kind of extension of the road network is the description of surrounding area, his appearance and shape, constraints and fixed objects, unmodified. In this description can thus be considered buildings, trees, another objects blocking the visibility, terrain, but also barriers along roads, sidewalks etc.

Also additional objects encountered during the simulation can usually be added to any scenario, providing a complete beginning set increase substantially the convenience of creating new situations. Further elements necessary in the database of objects are models of other roads users and therefore, vehicles – personal cars, trucks, and vehicles of other purposes, trams, bicycles etc, as well as pedestrians, and possibly other participants of these situations, especially ignorant of traffic – children, animals and moving objects. These objects are linked by the fact, that they are changing their position in the dynamic model of simulation, and therefore must take

into account the specific, modifiable parameters, possible speed, appearance and character of animation while moving and stopping, use of algorithms and other additional information. The possibility of placing dynamic objects is very important for the freedom of creating natural scenario of simulations, reflecting real road situations. The simulator should allow modifying the behaviour of simulated objects. The car usually moves in accordance with provisions of road traffic, but the program should also allow simulation of abnormal behaviour.

The model of environment must also implement the different atmospheric conditions – the view of sky, possibility of dynamic change of time of day or night and the subsequent changes in the lightning facilities, visibility of fog and rain or snow and the related changes in visibility and lightning.

3. Construction of research simulator AS 1200-6

The Auto-Sim simulator AS 1200-6 is built with usage of the body kit of Opel Astra IV passenger car produced by General Motors Manufacturing Poland in Gliwice (Fig. 2). Movement of the cab is called by the motion platform with 6 degrees. Man has a limited ability to distinguish similar values of the accelerations acting on his body, to simulate acceleration are used quite often little inclined to do little change the vertical component (in the system associated with the driver) acceleration due to gravity, and give the impression similate to impression acceleration or delay of traffic. If it's possible, there is additionally a temporary progressive motion of the cab in one direction to simulate larger acceleration especially jerks (sudden changes of acceleration). It is important to synchronize movements of the cabin with another stimulation stimuli as well as ensuring the least possible delay for reaction of the driver. Too long reaction times and lack of synchronization of the stimuli are important reasons for the emergence of so-called "simulator sickness", the undesirable reactions of the organism – among others dizziness, nausea, malaise – contrary because of delayed stimulus.

In the AS 1200-6 stimulator the simulator motion system is built as a platform (where is installed the cab of the driver) consisting of six electric motors in the system called "hexapod"

Fig. 2 The research Simulator AS 1200-6

4. The research capabilities of simulator of personal car

As the National Safety Council informs, man's actions are the most common reason of collisions and car accidents. The danger increases:

- use of substances and drugs influencing brain activity (like alcohol, drugs, certain medications),
- transient disturbance of consciousness (cerebral ischemia, photo-sensitivity, epilepsy, withdrawal of addictive drugs, the neurological and internal diseases),
- micro-sleep - prevalent often in the group of patients with sleep apnoea, long working hours, fatigue, monotony etc).

The vehicle equipment is also important for the driver behaviour and the speed of their response. The cars are currently used GPS, built-in mobile phones, devices of the electronic collection of tolls, on-board computers, CB radios and other devices that cause drivers distraction, lengthening the time of his response on changing situation on the road. The influence of these devices on the driver may be tested using driving simulators.

The simulator can also study the way with surrounding infrastructure. In the model of car's environment can reproduce any way and apply it to any infrastructure elements, in different configurations. Studying the impact of their form, content and arrangement of the perception and drivers reaction enables better road design, which can result in lower risk and improve of traffic flow. In the Tab. 1 are selected research methods and the possible areas of research

Tab.1. Selected psychophysiology methods and possible areas of research

Method	Result of research
EKG	Emotional load, work of the autonomic nervous system
Oculography	The strategy of perception, visibility and suppress incentives, the level of attention, drowsiness
GSR (galvanic skin response)	Stimulation level and psychophysiological state
EEG	Brain activity, the level of attention, drowsiness
EMG (electromyography)	Alertness, emotional tension

Using the stimulator helps to detect diseases and disorders affecting the increased risk in road traffic, make drivers aware of the effects of driving in certain states of mental and physical states. In this way it is possible, suitable for the patient to take early treatment and further reducing the risk of road safety. The simulator also allows to assist the process of designing the vehicle, supporting research on the reconstruction of collision, an assessment of training in economical driving (so called "Eco-Driving"), optimization of road infrastructure, testing the impact of the medications on driving, assessing the impact of additional devices.

4. Summary

High-class simulators until recently were used almost inclusively in research. Due to technological devices and the consequent decline in the costs of production of components, simulators are being increasingly used in the trainings of drivers. Advanced car driving simulator AS 1200-6 is designed especially for drivers' research, studies of the road infrastructure and human-machine interfaces. Open software of the simulator allows the registration of data and activities of the driver in real time. Subsequent analysis of the data enables to define the way and time of reactions of the driver for the road accident.

Introducing the possibility of using the high-class simulators for drivers' trainings, according to the Directive 59/2003/WE, allows training drivers with the dangerous situation on the road. In this way, in the safe environment can be carried out trainings focused on dangerous situations, such as pedestrian or animal intrusion, appearance of unexpected obstacles on the road, reactions to the abnormal behaviour of another vehicle (for example enforcing the right of way).

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