SIMULATION OF DANGEROUS OPERATION INCIDENTS IN DESIGNING ADVANCED DRIVER ASSISTANCE SYSTEMS

1. Introduction

Driving electrical sport vehicle, which has been built for an international challenge “Shell Eco-marathon” [5] demand greater attention of a driver. The main aim is to minimize risk of dangerous situations on a track, where vehicles are very close to other vehicles. In the currently developed electrical vehicle, many improvements have been introduced [5], especially Advanced Driver Assistance Systems (ADAS) [11] [4] have been completed with systems which increase safety during a race. Blind Spot Information System (BLIS) [11], which is a part of advanced driver assistance systems have been modified and adopt into the car. This solution required researches and computer simulations. Prototype vehicle named MuSHELLka has excellent aerodynamic properties and is very energy efficient [2]. Unfortunately specific body shape has negative impact on visibility in the rear-view mirrors. Following to the rules and in order to increase safety on the track, special system like Blind Spot Information System has been introduced.

2. Concept of safety system

Official Shell Eco-marathon rules [5] clearly define safety requirements which are checked during safety and technical inspection. Vehicle must have rear-view mirrors and its driver is obligated to use horn when it is necessary. Horn is used during overtaking in case of giving information about maneuver to another participants. Driver uses rear-view mirror but unfortunately in some actions other cars can be mistimed. Consequence of this mistimed could cause dangerous situation or accident [2]. It shows how important is developing advanced safety systems.

Safety system contains three special, selected sensors (Fig. 1) [2]:
- Two ultrasonic sensors, range 2 meters, on the both sides of the vehicle.
- One photoelectric sensor, range 3.5 meters, in the centre of the vehicle.

Prototype category, acquaintance of the track, feedback from last year. All this information have given opportunity to prepare schedule of research and expected results of the experiment. Research has been made in order to fit BLIS urban car to sport electric vehicle. Also, what is important, in order to optimization and selection of hardware parameters for specific environment [3] [4]. Race takes part on street track in Rotterdam, Holland. Data from sensors are transmitted to the driver via special LEDs on the steering wheel (Fig. 2). They turn on and change colour, provide relevant information.

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Driver get three different information:
- Opponent or obstacle is on the left.
- Opponent or obstacle is on the right.
- The rear area is not free.

3. Research methodology
PreScan from TASS [9], which is a special software cooperating with Matlab/Simulink, has been used for designing safety systems and computer simulations of dangerous situations [2]. PreScan is a physics-based simulation platform that is used in the automotive industry for development of Advanced Driver Assistance Systems that are based on sensor technologies such as radar, laser/lidar, camera and GPS.

Using PreScan [9] means: less costly and time-consuming road test, less difficulties with experiment conditions, ability to repeat the experiment, ability to reject full data. Some systems and scenarios could be too dangerous or need costly prototype at the early stage of design process. Virtual prototyping of suggested Advanced Driver Assistance
Systems has given several advantages. Research methodology consists of four steps: (Fig. 3):
- Building scenario.
- Modeling sensors.
- Adding control system.
- Running experiment.

![Four steps of designing Advanced Driver Assistance Systems](image)

Fig. 3. Four steps of designing Advanced Driver Assistance Systems [9].

### 3.1. Building scenario

Building scenario assumes planning real time actions. Preparation of scenario includes:
- Building model of urban track (Fig. 4).
- Import CAD model of vehicle.

Computer model shows reality on a very high level. Each important detail, from the point of view of sensors are maintained. In order to have desirable accuracy, it was necessary to build model of a track by own. The organizer [5] provided special, assistance map (Fig. 4). This operation was helpful to maintain every details, like properties, shapes and dimensions. What is also important, a CAD model of MuSHELLka has been imported to the PreScan [9]. This action caused possibility to test safety system on a very early stage of designing process. Taking part in prototype category and rules have obligated to create layout, which will be working with high level of precision. Furthermore, this solution enable adjustment that system to known conditions.
3.2. Modeling sensors

Vehicle model can be equipped with different sensors type. This allows to verify them in different ways. Their parameters were earlier set up, after laboratory experiment on special testing station. Characteristic of chosen sensor [2] was mapped in PreScan Software [9] (Fig. 5). This method of testing has given satisfying results, because having a real prototype system, it was possible to test them on the track. It is obvious that system has been optimized for a specific race to provide driver a highest level of safety. Sensor used in Blind Spot Information System has minimized the possibility of overlooking another vehicle in the rear-view mirrors, very well. Computer simulator provides a possibility to modify and change parameter in a very easy way. A preliminary risk analysis, computer simulations, simple changes of systems properties have given opportunity to reach safety system with very high level of efficiency, performance, and also reliable system.

Fig. 4. Left picture – Track map [5], Right picture – Track model.

Fig. 5. Modeling sensors in PreScan Software.
3.3. Adding control system

A Matlab/Simulink [12] interface (Fig. 6) enables users to design and verify algorithms for data processing, sensor fusion, decision making and control. Simulation tests are carried out according to pre-established scenario of possible dangerous situations during the race. Risk analysis gave possibility to perform a few completely different, sometimes abstract scenarios. Through the computer simulation experiments, system is verified for correct working, including sensor precision, their suitable for vehicle and arrangement on the body (Fig. 6). Experiment was made in different road and weather conditions, which allow to improve declared solutions, at the beginning. Control system in Matlab/Simulink interface (Fig. 6) helps in clearly understanding of main aim. It gives an ability to adjust control system to selected sensors or safety requirements, or else tips from driver. This is important because, vehicle could be driven by only a small group of drivers with appropriate mental and physical abilities. Therefore, each of driver can determine sensitivity and specificity of the system operation, itself. Using computer simulations and observations of signals, operator can quickly tune the system for specific requirements and check if there has been improvement activities within a given scenario of events. The control system is created particularly for a one vehicle. It is created from the beginning.

![Control system in Matlab/Simulink](image)

**Fig. 6. Control system in Matlab/Simulink**

3.4. Simulation experiment

A 3D visualisation viewer [9] allows users to analyse the results of the experiment. It provides multiple viewpoints, intuitive navigation controls, and picture and movie
generation capabilities. It is the last action, during process (Fig. 3). With a properly build environment, road infrastructure and vehicle imported from CAD file. With a properly selected sensor and control system, with a properly planed test schedule (Fig. 7), the experiment has been made. Effects of simulation were satisfactory and predictable in a general sense. Simulations have fulfilled the expectations of the designer. The results of chosen simulation are shown in the graphs (Fig. 8) As well as a realistic preview in the PreScan Software [9].

Fig. 7. Test schedule on track model.

Fig. 8. Response of ADAS system to the situation on the track.
This experiment has given a chance to see the car from multiple views and has given a opportunity to see how system works. Test with a different set of sensors, different properties and scenarios allow to optimize the system and eliminate possible errors that could adversely affect actual security system.

4. Summary

A major advantage of this method of testing and verification, is possibility to change very quickly parameters of the safety system. This method provides full adaptation of system to expected and unexpected conditions. What is also important, almost all tests could be done irrespective of other work, which prepare vehicle to challenge. Modelling of environment and suitable selection of the sensors is very important, but more important aspect is to plan adequate and prepare the experiment, position of opponents, obstacles, bands and track properties. Making experiment in different states, gives possibility to optimize system on early stage of designing process. Please note that each change in PreScan is associated with change in Matlab/Simulink Software. Properly built system of data acquisition and data processing allows for extraction of the most important information and use them in the future for creating simply information for a driver. For driver, it is very important to get quick and short information about situation in blind spots (Fig. 9). Having that kind of information, driver has chance to consider way of driving, find adequate solution. This solution also helps in prediction of situation on the track. Driver can focus on driving according to the instructions from Pit-Stop. System will warn driver automatically without any help. All this advanced driver assistance systems, especially safety systems are important for race. When somebody can predict the danger, also he/she can plan next steps to avoid it and feel safety and comfortably. This confidence causes driving in an environmentally friendly and energy-efficient way.

Fig. 9. MuSHELLka during race on Shell Eco-marathon 2013.
Bibliography


Abstract

Electric vehicle MuSHELLka during develop for 2013 Shell Eco-marathon, has been equipped with active safety systems. Blind Spot Information System (BLIS) will ensure driver and his opponents more safety. Blind Spot Information System this is a system to monitor the rear zone of the vehicle. Adaptation of those system for our vehicle and race needs were complicated. With aid of special software PreScan from
TASS, which is a computer simulator for advanced driver assistance systems, there were possibilities to design and test safety systems in the specified environment.

**Keywords:** Advanced Driver Assistance Systems, Blind Spot Information System, Safety systems, TASS PreScan, Shell Eco-marathon, MuSHELLka.

**SYMULACJA NIEBEZPIECZNYCH ZDARZEŃ PODCZAS PROJEKTOWANIA ZAAWANSOWANYCH SYSTEMÓW WSPOMAGANIA KIEROWCY**

**Streszczenie**
Podczas wyścigów samochodowych ryzyko wypadków jest bardzo duże, dlatego tak ważne są zaawansowane systemy automatyki jazdy zwiększające bezpieczeństwo kierowcy. W niniejszej pracy został omówiony system bezpieczeństwa wspomagający kierowcę elektrycznego pojazdu MuShellka, startującego na zawodach Shell Eco-marathon. Układ ten bazuje na rzeczywistych systemach, które są wykorzystywane obecnie w samochodach. Przy pomocy specjalnego oprogramowania PreScan firmy TASS zaprojektowano i przeprowadzono symulację system BLIS (Blind Spot Information System) system informujący kierowcę o pojawieniu się obiektu w martwym polu.

**Słowa kluczowe:** Systemy bezpieczeństwa, zaawansowany system wspomagania kierowcy, PreScan, Bolid MuShellka, Shell Eco-marathon, BLIS.