

## Development of a detection road users system in vehicle A-pillar blind spots

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**Abstract.** In connection with the increase in the number of cars in the world, there is an increase in the number of road accidents. The structural elements of the car do not allow the driver to assess fully the road situation. Such zones are called blind spots. Mostly the collision of cars happens in blind spots due to the lack of visibility. This is especially true for commercial vehicles. This article presents a system that allows you to expand the visibility of the car, due to the use of displays in the windshield pillars. A review of the existing systems was carried out. However, the use of only displays is not safe, for this, a pedestrian recognition system integrated in the windshield pillars based on neural networks can be used. The system allows detection, estimation of the distance to the object and giving out a warning signal about a possible collision. It consists of an on-board computer module, a video camera and an display. This system allows you to reduce the number of accidents near a pedestrian crossing or with a sudden pedestrian exit on the roadway. Interior elements have been designed and installed, allowing a good fitment of the displays into the windshield pillars. Exterior elements have been designed and installed in such way that allowed to keep the visibility of the car. The external side-view mirrors were replaced with video cameras. Experimental studies of the system were carried out. The pedestrian recognition system has demonstrated its performance by the results of the tests, however, it is necessary to debug the coefficients taking into account the approach time to the object.

### 1. Introduction

One of the important components for the creation of an efficient competitive transport industry is the intellectualization of transport systems. The development of intelligent transport systems is a relatively new direction in science and technology and represents an effective tool for solving transport problems, being a source of creating new branches in the industry.

The systematization of existing solutions in the field of developing of intelligent transport technologies, conducting their analysis for identifying the perspective directions, and developing a unified approach for the implementation of projects in this area is very topical. For many years, research related to the development of driver assistance systems (ADAS) has been carried out to improve road safety. The main algorithm of ADAS-systems during the motion is the collection of data from sensors around the vehicle, further analysis of information, detection of a critical situation on the road and conducting measures to avoid or mitigate the consequences. To perform these tasks, the car is equipped with various sensors (video sensors, laser sensors, ultrasonic sensors), audio and visual alerts, as well as an information output device (displays).



These systems are able to distinguish between traffic situations in which a driver's inattention can lead to a traffic accident. They can simultaneously notify about each of them during the motion with unique alerts using sound or pictograms. As the basic systems of assistance to the driver it is possible to point out: the road lane keeping assistant, detection of obstacles on a road lane, detection of road signs, parking assistant, detection of pedestrians, system of night vision, adaptive cruise-control, the control system of blind spots, etc.

According to the statistics [1], one of the most common types of road accidents is the accident when entering the blind spot of the car. This is especially important for commercial vehicles, as the blind spots of the car increases with the growth of its dimensions.

Currently, there are a number of systems commercially available on Mercedes, BMW, Volvo, Tesla, Volkswagen, Toyota, Nissan, Ford, etc. The systems have unique trade names, for example Volvo - BLIS; Ford - BLISTM; Porsche - SWA (Spurwechselassistent); BMW - LCW (Lane Change Warning); Audi - Side Assist. However, the general algorithm of actions is similar. When entering the blind spot of the car, the system informs the driver of the presence of interference in this area by visualization on the side or center rearview mirror or dashboard cluster.

Such areas are located behind, from the side and ahead of the car. When a neighboring car hits the blind spot it becomes not visible due to the design features. Blind spots on the sides during motion are very dangerous. More than 70% of accidents on the roads happen due to this fault.

A common driver's mistake is changing lanes when in the blind spot there is the car, it leads to a lot of accidents.

Also the presence of areas in the front of the car should be noted. These areas are artificially created by windshield pillars, a hood or a high driver's seat. When making maneuvers or driving in a tight environment, blind spots are the cause of an accident.

Currently, most accidents with people in Russia are caused by the driver's fault, however, as statistics show, for the last quarter of 2017 [1], an accident due to the fault of a pedestrian also takes place.

The major accidents caused by pedestrians are related to the failure to comply with the rules of crossing the carriageway established by the law. Also improperly parked cars near pedestrian crossings significantly worsen the situation, which leads to a reduction in the viewing angle and improper assessment of the traffic situation by the driver.

In order to exclude these shortcomings, work is underway to reduce or partially eliminate the blind spots of the car. For example, the Jaguar Land Rover group introduced the 360 Virtual Urban Windscreen system (Figure 1), which is designed to improve the visibility of cars. The system allows you to project on the windshield pillars an image of a part of the road that is hidden by these elements of the car's construction [2].



**Figure 1.** «Transparent» pillars of the Jaguar [2]

Pillars becomes transparent automatically, for example, during lane changing or near a crossroads. Together with the screens in the pillars and cameras, there is a projection display, which highlights the participants of the traffic surrounding the car. In addition, models of the British automaker in the future

will be able to show, for example, fuel prices, streets with the accompanying information and congestion.

Another development is made by Audi, presented at the Frankfurt Motor Show. It is a concept car Nanuk quattro with the complete lack of rear-view mirrors [3]. To output information from video cameras, displays integrated into the windshield pillars are used (Figure 2a).

Designers and engineers of Renault when creating concept car, the Initiale Paris, proceeded simpler: from all three cameras the image is displayed on a single screen, replacing the inside rear-view mirror (Figure 2b) [4].

It is also necessary to highlight the development of the Volkswagen XL1. The developers propose to use the rear view camera instead of the side mirrors [5] (Figure 2c).



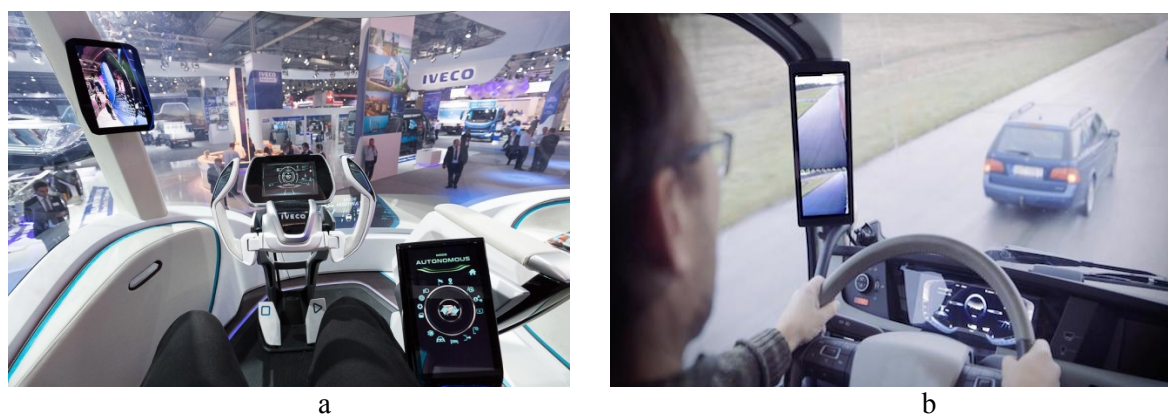
**Figure 2.** (a) Concept car Nanuk Quattro [3], (b) Concept car Initiale Paris [4], (c) Volkswagen [5]

The value of blind spots in cars depends entirely on the overall dimensions of the vehicle and the driver's location. This area is heavily endangered by cargo vehicles, (van, truck, bus and etc.).

So the company Iveco at the motor show of commercial vehicles in Hanover introduced the concept of the hybrid van Vision [6] (figure 3a), with the displays installed in the windshield pillars.

Orlaco [7] proposes the introduction of MirrorEye's video surveillance system on trucks instead of rear-view mirrors (Figure 3b).

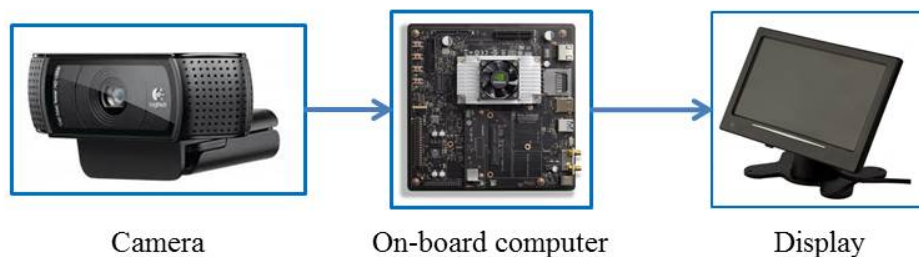
The innovative Orlaco system meets all the requirements and standards of EMC and is produced according to the guidelines for the automotive industry - ISO / TS 16949. At the request of car owners, MirrorEye's cameras and monitors will be available for all types of trucks.



**Figure 3.** (a) Iveco Vision, (b) Orlaco truck

Based on the presented review of information and works [8-12], it was revealed that the use of video cameras instead of side-view mirrors is a promising direction. However, these cameras do not allow you to look ahead of the car, which in turn could reduce the risk of a dangerous situation associated with a pedestrian collision in the «blind» areas in front of the vehicle.

Based on these findings, the authors proposed a concept system that combined the functions of detecting objects in the blind spots in front of a light commercial vehicle and exterior side mirrors (Figure 4).



**Figure 4.** System interaction diagram

Initial studies were carried out in the framework of the work described in [13]. Based on the results of these works, it was proposed to integrate the displays into the windshield pillars of the Gazelle NEXT. This solution will ergonomically fit the displays into the interior of the car, as well as maintain visibility to the driver.

## 2. Development of the system

As can be seen from Figure 4, the system consists of a video camera that collects a video stream data for further processing; a computing module based on the platform for the development of Nvidia Jetson TX2. With the capabilities of the Nvidia Jetson TX2 [14], information from the system can be sent over the CAN bus to interact with the other (executive) devices of the vehicle. Also, the performance of this platform allows processing data for other ADAS-functions, which will be installed additionally.

The Jetson TX2 module is equipped with an NVIDIA graphics processor with Pascal architecture, a CPU Complex ARMv8 module with six cores. Module Jetson TX2 has a relatively small overall dimensions (50x87 mm), its weight is 85 g.

Logitech camera is used to solve problems of object recognition in a blind zone. It should be noted that the developed system can be used with various video cameras.

On-board computer NVIDIA Jetson TX2 is placed in a specially manufactured case, which is shown in Figure 5. This case allows to reduce the risk of damage from external influences (falls, impacts, etc.). Also in the case there is installed the air cooling system of the computational module to prevent overheating of the system.



**Figure 5.** Assembling the on-board computer module

The computational module collects information from cameras installed instead of external side-view mirrors. Its location is under the seat of the car. The module connects to the Can-bus of the car to collect data on the speed of the vehicle.



For the installation of displays, computer models of plastic car interior elements were developed (Figure 6).



**Figure 6.** Computer models of car interior elements of GAZelle NEXT

At the next stage, the elements were made according to computer models. After manufacturing, the elements were installed in the car's interior (Figure 7).



**Figure 7.** Interior elements of the GAZelle NEXT

The installation of these elements allowed to fit the displays in the interior of the GAZelle NEXT. Also, the use of the elements allowed to maintain the visibility of the car. Displays were installed in terms of the convenience of the driver's perception of information, thereby increasing the ergonomics of the car's interior.

Also based on the review, it was suggested to use the system of video cameras instead of external side mirrors. The brackets for fixing the cameras outside the car has been made (Figure 8).



**Figure 8.** Brackets for attaching video cameras

Using cameras instead of external side mirrors gives a larger viewing angle, and the right angle allows the driver to correctly assess the traffic situation.

A number of experimental studies were carried out to evaluate the system's operability.

### 3. System Tests

The tests were carried out on the GAZelle Next vehicle with an installed pedestrian collision warning system. The system's algorithm consists in the following steps: The system determines the speed of motion and recognizes the object on the route with the help of a video camera, then calculates the distance to it.

To assess the performance of the system, a series of races was conducted, simulating the sudden exit of a pedestrian to the carriageway. The tests were carried out on both the right and left sides of the car, while the pedestrian was in a blind spot of the windshield pillars.

It should be noted that the braking was carried out after the start of the warning signal. A fragment of successful braking in front of a dummy simulating a pedestrian is shown in Figure 9.



**Figure 9.** Successful braking in front of a dummy simulating a pedestrian

The criterion for the correct operation of the system was the timely delivery of a warning signal to the driver about a possible collision with a pedestrian. The calculated accuracy of the determination of the critical situation, which characterizes how many of the positive triggering turned out to be really correct, was 0.91. The completeness, showing the number of correct responses from the total number of tests conducted, was 0.9. The indicator of the quality of the system was 89%.

Also test races were conducted without a warning system about a possible collision with pedestrians. The test conditions were preserved. Due to the impossibility of detecting a pedestrian by a driver in a blind spot, a collision occurred. This type of accident is mainly encountered when driving near a

pedestrian crossing [1]. Fragments of tests carried out without a collision warning system with pedestrians are shown in Figure 10.



**Figure 10.** Work without a warning system about a possible collision with pedestrians

It should be noted that the main restriction of the use of cameras instead of external side-view mirrors is only the viewing angles of the cameras.

#### 4. CONCLUSIONS

The system of visual information of the driver integrated into the windscreen pillars is presented, with the possibility of warning about a collision with pedestrians on the route. The use of video cameras instead of external side mirrors is considered.

Interior elements of the GAZelle NEXT vehicle were developed and installed. These elements have allowed to maintain visibility and increase the ergonomics of the car interior.

Experimental studies of the developed system have been carried out. The pedestrian recognition system has demonstrated its performance by the results of the tests, however, it is necessary to debug the coefficients taking into account the approach time to the object. In addition, the tests were carried out on a road covered with snow. This led to the fact that the braking distance, in comparison, with dry asphalt exceeds more than twice. This phenomenon requires detailed study and taking measures to minimize the influence of this factor on the correct operation of the system.

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