Analysis of Medical Systems to Control the Driver's Condition to Improve Traffic Safety

Mariya Nazarkevych[1[0000-0002-6528-9867]] , Vasyl Brytkovskyi [2[0000-0003-1224-9500]] , Michal Gregus[3[0000-0001-6207-1347]]

[1]Publishing Information Technology Department,
Institute of Computer Science and Information Technologies
Lviv Polytechnic National University
12 Bandery str., Lviv, 79013, Ukraine
mariia.a.nazarkevych@lpnu.ua

[2]Department of Operation and Repair of Automotive Vehicles
Lviv Polytechnic National University,
Lviv, Ukraine
vasyl.m.brytkovskyi@lpnu.ua

[3]Comenius University in Bratislava,
Bratislava, Slovakia
michal.gregus.ml@fm.uniba.sk

Abstract. Computer information technology is penetrating our way of life. They provide more and more protection against emergencies. Particularly dangerous is the health and satisfactory driving behavior of drivers. After all, drivers are alone for a long time and face every minute with dangerous situations on the roads. Particularly difficult is the situation when drivers suffer from chronic diseases, because every minute they are in dangerous situations. A system for monitoring the health of drivers while driving is proposed. Particularly noteworthy are the differences in altitude, as drivers move along the highway. From elevations, drivers may experience headaches, anorexia or nausea, dizziness, vomiting, insomnia, tachypnea, pulmonary rales, and more. This paper provides recommendations for considering these factors to ensure the safe movement of the driver In the presence of a system to monitor the condition of the driver can avoid a large number of accidents. Today, the software market offers several variants of software packages containing various driver tracking modules already built into the vehicle.

Keywords: driver status monitoring system, tracking modules, painful condition of the driver

1 Introduction

The number of accidents caused by the state of fatigue or weakened attention [1] of the driver at the wheel of a vehicle is increasing every year and leads to injuries

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among the population worldwide. Many drivers at the wheel of a car feel tired or weakened, and they do not even suspect that they are in this condition. According to a report by the National Highway Traffic Safety Administration [2], up to nine percent of accidents are caused by fatigue of drivers behind the wheel of a vehicle. According to a study [3] by the AAA Foundation for Traffic Safety, dedicated to analyzing driver behavior when driving in a half-sleep state, short-term sleep doubles the risk of an accident compared to those who slept the recommended seven or more hours. The likelihood of a driver crashing in a dream that lasts less than four hours increases by 11.5 times; from four to five hours - increases 4.3 times; from five to six hours - 1.9 times; six to seven hours - 1.3 times. Research has shown that lack of sleep and, as a consequence, slowing down the reaction rate and drowsiness can be just as dangerous as the state of alcoholic intoxication - a slow reaction and a decrease in concentration of attention.

2 Analysis of recent publications

Traffic statistics show that a significant number of accidents are caused by the driver's physical condition [4]. A number of large automakers are actively working to create various driver monitoring systems designed to, at a minimum, alert a person to an unsafe condition and, as a minimum, to interfere with vehicle control and prevent an event. The work is conducted in several directions, including fatigue control, assessment of physical stress, determination of the driver's painful condition.

The driver fatigue control system is designed to detect the onset of driver fatigue and to prevent sleep at the wheel. The system proposes to take a break to rest the alarm sound or the signal on the dashboard ("coffee cup") [5]. Determining the onset of driver fatigue is carried out in various ways - assessment of the driver's actions in driving, control the nature of the car-mobile movement, monitoring the driver's face using a video camera [6].

Volkswagen is installing an ambulance system on the vehicle, which is an extension of the lane assistance system. If the driver is unable to drive the car (unconscious), the Emergency Assist system takes control of itself and stops the vehicle, as well as warns other road users of a dangerous situation [7].

If the driver does not use the steering for a certain period of time, the Emergency Assist system [7] warns him of visual and audible signals, slows the car. In the absence of a reaction from the driver, the system determines that it is unable to drive the car. The lane-assist system ensures that the car is within the busy lane, and adaptive cruise control prevents the car from hitting ahead. To warn other drivers, the alarm is activated, the car starts to move the snake within the lane and stops at the end. Another direction of development of control systems is to equip vehicles with biometric sensors, by means of which it is possible to monitor important health indicators (pulse, respiratory rate, skin conductivity, etc.). These developments are promising, and should appear on production cars in the near future.

The closest solution to the problem for the control system is the assessment of the driver's load, designed to reduce inattention and excessive stress. The physical stress of the driver is estimated by processing a variety of parameters: the movement of the vehicle (speed, longitudinal and transverse acceleration, speed of spinning); driver actions (steering angle, accelerator and brake position); road conditions (traffic density, pavement character); biometric parameters (heart rate, respiratory rate, skin temperature).

If the load on the driver is high enough, the system takes measures to reduce the voltage, including the function of automatically blocking the mobile phone from incoming calls (the function "do not disturb").

The following biometric sensors are used in the driver load assessment system:

- a piezoelectric sensor in the seat belt to monitor respiratory rate;
- conductive overlays on the steering wheel rim for pulse measurement;
- infrared sensors on the steering wheel rim to measure palm temperature;
- infrared steering wheel sensor that controls the face temperature.

Jaguar Land Rover [8] proposes to monitor the driver's condition with the help of biometric sensors built into the driver's seat. Driver Wellness Monitoring uses respiratory and pulse sensors. If the system identifies serious health problems or unnecessary driver arousal, then safety measures are taken. Stress regulates internal refreshment, audio system and air conditioning. An emergency call is made in the event of a sudden and severe illness, and the car stops automatically.

In 2016, Audi introduced the FitDriver project [9] under the motto "My Audi cares about me". Vital driver settings such as heart rate and temperature are controlled by handheld devices (training bracelet or SmartWatch). This data is complemented by information on driving styles, breathing rates, weather and road conditions provided by various automotive sensors. Taken together, the data allow you to determine the current status of the driver, including increased fatigue or stress.

As a result of a comprehensive assessment of the physical condition, various systems of the car are used for rest, restoration and protection of the driver: massage of seats, silent mode of the phone, climate control, adaptive infotainment system, adaptive interior lighting. In the future, Audi plans to use active safety systems.

Ferrari has patented a technology that evaluates the voltage level of a brain wave driver. Brain bioelectric activity is measured by pre-assisted wireless sensors built into the driver's seat headrest. Depending on the driver's condition, the fuel supply to the engine is reduced and the car's automatic stabilization is achieved.

Jaguar Land Rover is also working in this direction. The Mind Sense system determines when a driver is distracted or falls asleep while moving through brain activity. It is established that the human brain generates several brain impulses of different frequency. By constantly measuring the impulses, you can estimate how focused the driver is (slowing down, dozing off or distracting).

Brain waves are monitored using sensors built into the steering wheel. If the activity of the brain indicates drowsiness or poor concentration of the driver, the steering wheel or accelerator pedal begins to vibrate, paying attention to driving. If there was no reaction from the driver, a visual and an audible signal are given.

Another area of use for biometric sensors is related to controlling the physical condition of older drivers as well as drivers with chronic conditions. As far as the car companies work in this direction.

All the same, Ford proposes to control drivers who are over 40 with the use of heart rate sensors built into the seat. The basis of this technology is the electrocardiogram technology, which monitors cardiac electrical pulses and timely identifies abnormalities (eg, heart attack), as well as symptoms of other diseases (eg, high blood pressure) [10].

Toyota uses sensors on the steering wheel rim to monitor vital indicators: electrodes for heart rate monitoring and optical sensors for palm conduction evaluation. The driver's condition monitoring system is linked to an emergency braking system that allows you to stop the car in the event of a heart attack, as well as a navigation system that automatically routes the route to your nearest hospital. The system allows you to determine the onset of a heart attack from an early stage and thus prevent an accident.

BMW is working on a technology to alert drivers who have diabetes to raise their blood sugar. The device for measuring blood sugar is connected to a smartphone, which in turn is connected via Blue-tooth to the car's multimedia system. The system displays information that alerts the driver to the risk of loss of consciousness due to high blood sugar. In the long term, the measured parameters will be automatically transmitted to the driver's doctor.

The proposed system consists of the following basic elements: micro-computer, camera, backlight, sound source, car sound system, light source, battery, and can also be equipped with a device for measuring blood sugar that connects via Bluetooth, see Fig. 1 which shows the functional diagram of the device.

The camera is equipped with a block of high resolution forming, which was developed in [11].

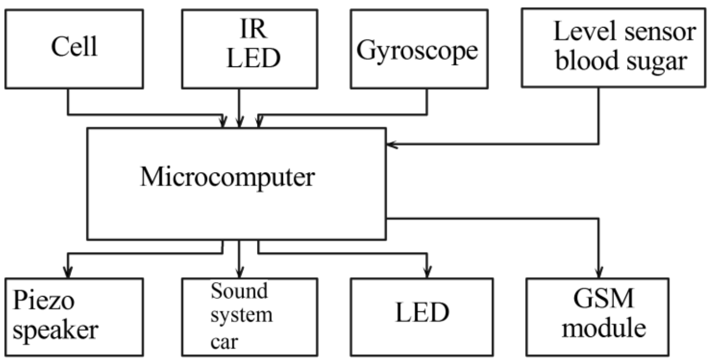


Fig. 1. Functional diagram of the device

Miniature infrared camcorder scans the driver's face in the infrared range and registers the frequency of blinking of the driver and the direction of his gaze. The information goes to the microprocessor, where after processing the algorithm, a conclusion is drawn about the degree of fatigue of the person behind the wheel.

3 Investigation of the physiological state of drivers

The physiological condition of the driver depends on many factors, including major factors such as fatigue, physical exertion and the painful condition of the driver. All these factors are manifested in the driver's driving behavior and are manifested as follows: falling asleep and distracting.

A healthy person cannot fall asleep immediately. And everything is the same for everyone: yawning begins, the picture that arises in the mind of the driver narrows, the eyelids weigh. With the accumulation of fatigue, blinking becomes more frequent, and the pupils close their eyelids for a longer time.

The first factor that 100% indicates the onset of falling asleep is the driver's perception of blinking. In normal activities, the person does not notice the movement of the eyelids down and up, but the tired person tends to fall asleep, so every blink is longer than the previous one. And, when it reaches a second or two, the driver is confronted, with the so-called, micro - in this minimum time the body has time to fall asleep, and the brain, as a rule, has already shut off.

Under normal visual conditions, the eye blinks every few seconds, approximately 15 times per minute. At the moment of blinking (the duration of blinking is from 100 to 400 ms) all visual information in the eye is practically stopped, but nevertheless the interruptions in the receipt of the light signal of perception remain relatively unchanged. As a rule, blinking is almost never noticed. This is all the more surprising that it is known: if the light in the room goes out even for a shorter time than the blinking, the person ceases to perceive the visual environment.

Although one hardly notice the impact of our own blinking, sometimes one pays attention to how other people blink, especially in certain situations. People tend to blink more often when they are frightened, anxious, and stressed or tired. In contrast to these situations, when performing work that requires visual strain, the frequency of blinking decreases. For example, when reading, the number of blinks per minute, usually equal to 15, is less than 5. However, reducing the blinking frequency is almost a random process. Blinking occurs when the need for visual information is minimal. Yes, a reading person is likely to blink when going from one line of text to another, or flipping through a page, or at the end of a sentence or paragraph. Then, when blinking, most likely, will not turn his attention and will not disturb the perception of information. Usually, when reading, a person blinks when the probability of receiving new information is minimal; when there are incentives that need attention and information processing, one can speak of some inhibition or restraint of blinking (Fogarty & Stern, 1989; Orchard & Stern, 1991).

Sometimes blinking of the eyes can indicate serious illness: Disorders of the nervous system, in particular, blepharospasm - a condition characterized by rapid, uncontrolled blinking. These spasms can also be accompanied by other changes in the face (uncontrolled movements of eyes and face, grimaces). Brain lesions such as stroke.

The frequency and duration of blinks depend on the degree of fatigue. When the person is tired, the head is less mobile, the direction of view changes less often, the person blinks more often and leaves his eyes closed for long periods of time - the difference can be measured in fractions of seconds or several degrees of rotation, but it is.

Therefore, tracking and analyzing the blinking of a driver is likely to reflect his physiological condition. If the physiological condition is poor, the driver does not perceive the road situation badly and cannot adequately respond to it. Therefore, the proposed system should evaluate the physiological condition of the driver using a sound and light notification system to inform the driver of his condition and a communication system for reports of a dangerous physiological condition.

4 Analysis of safety regarding exposure to altitude

The analysis of the safety of traffic in relation to being at altitude of drivers. In the experiment [12] Driver's health was attended by 400 people. Of these, 350 were non-smokers and 19 smoked more than 20 cigarettes daily; 326 periodically consumed alcohol, 98 regularly consumed alcohol, 42 abstained completely. 23 suffered from chronic conditions such as diabetes or hypertension; 19 took regular medication; and 107 had signs and symptoms of acute mountain sickness during previous ascents. Such painful symptoms as experience headaches, vomiting, dizziness, insomnia, tachypnoca, oedema, pulmonaru rales, ataxia were analyzed. On the basis of these experiments, the graphs of drivers' painful states with respect to their altitude, which are shown in Fig. 2. As we can see from Fig. 2 to 1000 meters above sea level 50-40 cases of painful conditions in drivers is observed, which must be taken into account when building a traffic safety system.

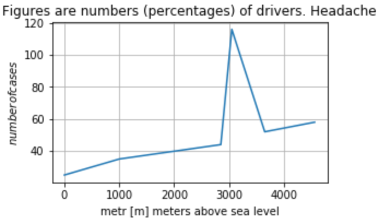
5 Construction of system safety

A large number of accidents can be avoided by having a driver monitoring system. We offer several variants of software packages containing different driver tracking modules already built into the car. These modules are only for specific car brands and cannot be used to upgrade an existing car fleet.

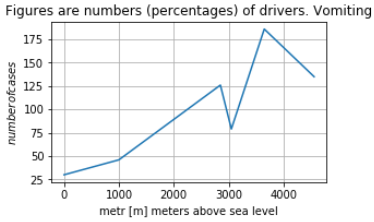
When developing a local driver monitoring system that could be installed in any vehicle. The main requirements for the system are autonomy, mobility and a minimum number of false positives.

The frames come into the microcomputer where the filtration devices are installed, in particular, the Ateb-Gabor filtration device, which was published in [13], showed considerable efficiency during installation. In [14], filtering is applied to biometric images. However, the filtering hardware was developed in [15].

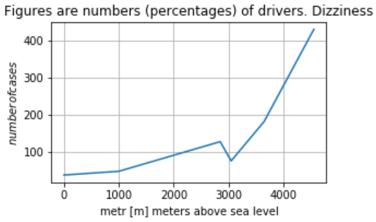
The system software can be divided into three parts. The first software module is responsible for processing information received from the camera and other sensors, recognizing the position of the eyes, tilting the head, as well as calculating the frequency of blinking of the eyes. The algorithms for this module and image compression were developed in [16].



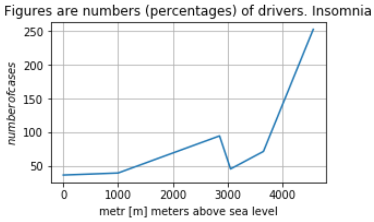
a) headaches



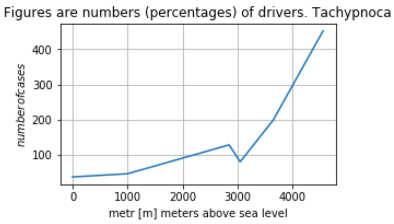
b) vomiting



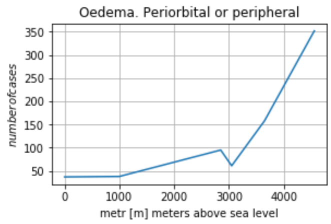
c) dizziness



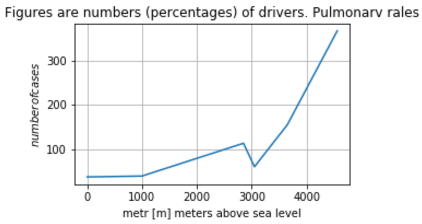
d) insomnia



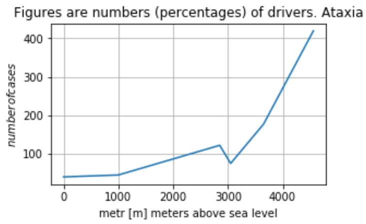
e) tachypnea



f) oedema



g) pulmonary rales



h) ataxia

Fig. 2. Analysis of the presence of painful symptoms in the presence of drivers at altitude: a) headaches, b) vomiting, c)dizziness, d) insomnia, e) tachypnea, f) oedema, g) pulmonary rales, h) ataxia

The second module - the decision module, is a server part of the system in which to make a decision about the physical condition of a person. Next, a response is formed based on the data of the decision module. The mathematical apparatus of the developed statistical estimates was established in [17]. The driver is alerted to the possible deterioration of the condition by light and sound or voice commands based on studies in [18] (Fig. 3).

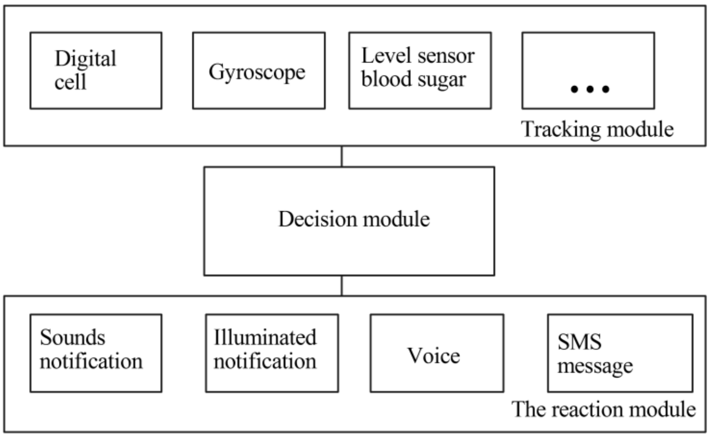


Fig. 3. Scheme of software modulesdules

The software component of the system contains the following basic development languages Python (basic logic), C ++ (maximum performance) and ZMQ (distributed message library) responsible for the interaction of individual modules, DLib (library of machine learning algorithms). The operating system the device will run on is Linux. The system is easily expandable, allowing you to modify or add new modules for the surveillance and alert system. The filtration hardware was based on [19]. To implement machine learning algorithms, it was necessary to convert image fragments into vector objects, which was implemented in [20]. The mathematical structure of the driving safety system is based on the algebra of algorithms – sequences from [21], which allowed the system to be optimized and tested quickly.

Conclusions

The number of road accidents caused by a poor physiological condition of the driver behind the wheel of a vehicle is increasing every year, leading to injuries worldwide. Most drivers are feeling tired or weakened, and they are not even aware that they are in a condition that can lead to an accident.

Leading carmakers are actively working to create different driver status systems that are designed to, at a minimum, alert you to an unsafe condition and, at the very least, interfere with vehicle control and prevent an event. The work is carried out in several areas, including fatigue control, assessment of physical tension, determination of the driver's painful condition.

The physiological condition of the driver depends on many factors, including such basic factors as fatigue, physical exertion and the painful condition of the driver. All these factors are pro-driver behavior and manifest as follows: falling asleep and distracting.

Many different methods can be used to identify a driver's poor physiological condition, but the driver's blink analysis is the most accessible because frequency and duration depend on the physiological state.

The analysis of traffic safety in relation to the altitude at sea level of drivers showed that up to 1000 meters above sea level, 50 - 40 cases of painful conditions in drivers are observed, and these must be taken into account when building a traffic safety system.

A large number of accidents can be avoided by having a driver monitoring system. We offer several software packages containing different driver tracking modules already built into the car. These modules are only for specific car brands and cannot be used to upgrade an existing car fleet.

When developing a local driver monitoring system that could be installed in any vehicle. The main requirements for the system are autonomy, mobility and a minimum number of false positives. Therefore, the proposed traffic safety system should evaluate the physiological condition of the driver and, using an audible and light alert system, inform the driver of his condition and a communication system for reports of an unsafe physiological condition.

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