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ANALYSIS OF METHODS FOR DETERMINING DRIVER FATIGUE AND A WAYS OF THEIR IMPROVEMENT

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Abstract

The safety of road transport is the main component of the security system for each state. The low level of road safety has a significant impact on the safety of the community.

Studies have been carried out on the etiology of road traffic accidents. They showed that as a result of the increase in traffic intensity and the increase in the number of drivers, there is an increase in the number of traffic jams which in turn leads to additional driver fatigue and, in some cases, to sleep.

There is a need to take some measures to prevent traffic accidents due to fatigue and sleep. When studying such modern systems, it becomes clear that they work by analyzing the actions of the driver and the course of the car.

The aim of the work is to conduct a comparative analysis of methods for determining driver fatigue and developing a new additional method.

The paper shows that the main disadvantages of the systems under study are: complex design; adaptation to the driver; fatigue settling time and high system cost. It is proposed to introduce a pulse fatigue detection system (PFDS), which, by analyzing the number of pulse beats, will predict human fatigue and possible sleep, which will lead to a simpler design in systems with control of physiological parameters, that is-to reduce the price.

Key words: traffic accident, fatigue, sleep, driver fatigue monitoring systems.

Introduction

38568 road accidents were registered in Armenia, as a result of which 3543 people died and 55230 were injured from 2011 to 2021. The statistics for these 10 years are presented graphically below [1].

An increase in the number of drivers and a sharp increase in traffic volume have currently contributed to an increase in traffic jams which in turn leads to driver fatigue while driving, which causes an increase in the number of traffic accidents. Based on this, it is necessary to develop measures that will help reduce the number of road accidents. Therefore, the study and comparative analysis of methods and algorithms for building driver fatigue control systems is an urgent task.

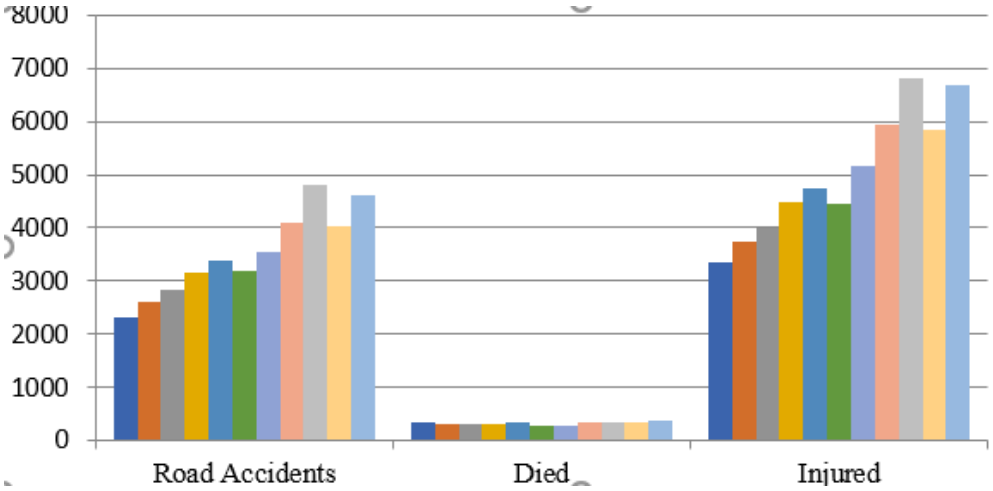

Fig. 1 Statistics of road accidents registered in the RA and injured as a result of them from 2011 to 2021

Conflict setting

The main reason for the fatigue of most drivers is incomplete sleep. 5-25% of all traffic accidents are caused by driver fatigue [2]. At the same time, road traffic accidents caused by driver fatigue usually have more severe consequences than road traffic accidents for other reasons. According to Ford experts, drivers who slept less than 4 hours were 11.5 times more likely to be involved in a traffic accident [3]. Many experts compare sleep driving to drunk driving. Such a comparison is presented below.

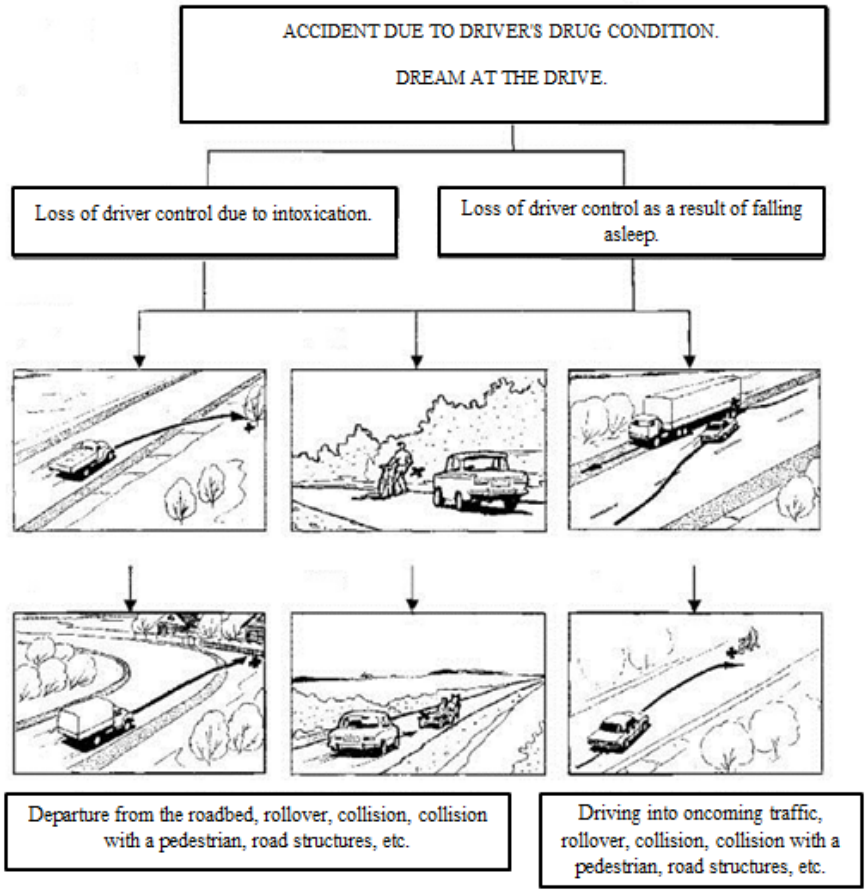

Fig. 2 Drunk or sleep driving accidents [4]

In order to reduce the likelihood of all this, a system should be developed that will make the driver feel tired and take the necessary steps to prevent possible traffic accidents.

The article aims to analyze methods for determining driver fatigue and develop a new auxiliary method.

Materials and methods

Driver reliability is understood as the ability to timely and accurately receive and process information about the state of vehicles, road conditions, as well as make and implement adequate decisions on driving a car for a given period of time with acceptable levels of labor intensity and the risks of an emergency [5].

One of the reasons for the incorrect actions of the driver is his current functional state during the execution of activity algorithms. To improve traffic safety, it is desirable to limit or completely block access to driving a vehicle in the presence of such factors. To carry out this task, special systems and tools are called upon to control the state of the driver which a number of automakers equip their cars with.

In this work, we will consider the operation of existing systems, their disadvantages and advantages by a comparative method. Then, analyzing it, an attempt will be made to propose a new auxiliary method.

Research results

Fatigue measurement systems which use the method of assessing involuntary deviations from the ideal trajectory while driving, take various parameters as a basis for assessing drowsiness. As a rule, this is an analysis of the change in the angle of rotation of the steering wheel and an analysis of the position of the car on the roadway.

The main disadvantages of systems that take the position of the vehicle on the road as the main parameter is that their operation is based on recognizing the signs of fatigue of a particular driver, as well as the complexity of their training and adaptation for each driver. In addition, these systems are not suitable for use in vehicles used by more than one driver. They cannot be used in cars of other brands to receive information about the driver's condition from auxiliary sensors (steering wheel position, gas pedal, etc.) which may not be compatible with other car brands. Another disadvantage of the systems is their high complexity, cost limiting application and high structural and functional redundancy.

Methods for automatically determining the degree of driver fatigue, which are based on automatic analysis of the characteristics of the visual analyzer, use cameras and an on-board computer. The main parameters are blinking (calculate in a predetermined time interval), direction of gaze tilt of the head (when falling asleep standing or sitting, the head leans forward a little, if the device detects that the angle of inclination forward has changed by a certain degree, then it beeps); scalogram (the orientation of the optical axis of the eyeball in space is determined) [6].

The disadvantage of these methods is significant computational complexity, which makes it difficult to implement them in the built-in on-board computing facilities of a car that do not have sufficient computing power. Increased time to receive a sleep signal due to the relatively long process of eye detection (calculations must be done in real time, given that the driver can turn his head, wear glasses, drive through tunnels or brightly lit areas, etc.).

Another direction provides for the additional equipment of a car with special biometric sensors that allow assessing the general physical condition of a person according to such parameters as respiratory rate, heart rate, skin conductivity, etc. Evaluation of the combination

of these parameters helps to determine the degree of driver stress. These systems are more complex, but also more promising, since they evaluate the real state of a person according to biological indicators and not according to algorithms of actions (as in the first direction).

The disadvantage of systems based on the control of physiological parameters is the need to use complex sensors built into the seat and steering wheel and biometric sensors which require physical contact with the human body [7].

Let's take a look at these methods in comparison.

Table 1

Comparison of some methods for determining driver fatigue

Options	Method for assessing involuntary deviations	Method for analyzing the characteristics of the visual analyzer	Control method of physiological parameters
Adaptation to the driver	-	-	+
Determination time	-	-	+
Simplicity of design	-	-	-
Physical contact	+	+	-
Price	-	-	-

Analyzing the comparison of methods, it becomes clear that the most promising and error-free will be control systems that combine the features and advantages of all directions at once. But at the same time, the complexity of the design and the price of the system remain disadvantages.

Certain changes occur in the body during fatigue and after and during sleep. One of the main changes is the reduction in the number of heartbeats. The number of pulse beats depends on age, gender, body weight, etc. On average, the number of normal human pulse beats ranges from 60-90. But depending on gender and age, it varies. All this is presented in the table below.

Table 2

Pulse beats according to sex and age [8]

Age	In a calm state		During physical exertion	
	men	women	men	women
20-40	60-75	65-80	190-200	230-240
40-60	70-85	75-90	160-180	200-220

The number of heartbeats changes when a person begins to sleep. When a person begins to sleep, his pulse can decrease by 1.5 times and reach up to 30 beats per minute.[9] That is, by analyzing a person’s pulse, one can understand the degree of fatigue and the likelihood of the driver falling asleep at the wheel. To analyze the pulse, you need to understand how it can be measured. Proceeding from this, a method based on the providence of measurements of the driver's pulse is proposed. The proposed method is as follows:

- Pulse sensors are installed on the steering wheel,
- at the beginning of driving, the pulse is counted,
- in the process of driving, the pulse is periodically counted and compared with the initial number,

- if as a result of the comparison it turns out that the pulse is underestimated, then a danger signal is issued.

Let's call it the Pulse Fatigue Detection System (PFDS).

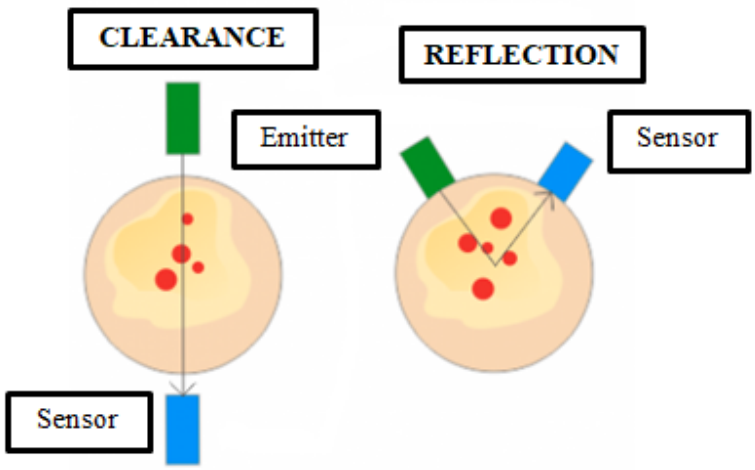

Fig. 3 Scheme of operation of the pulse sensor in the PFDS system

Since these sensors are small in size, it is proposed to install them in the steering wheel to measure the pulse from the driver's fingers.

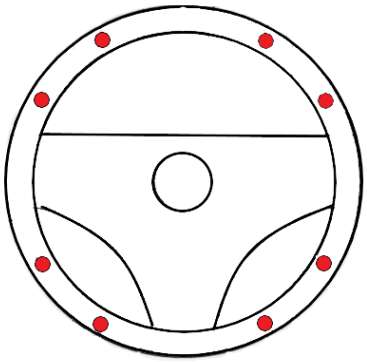

Fig. 4 The main places of the sensors

To do this, the sensors need to be placed in the optimal parts of the steering wheel where drivers hold the most. With the introduction of this PFDS system, based on the physiological characteristics of a person, it will be possible to determine the degree of his fatigue and favorable health for driving, and in case of failure to take appropriate measures to stop the car. This method can be used in the method of monitoring the physiological parameters of the driver's tension.

The driver's physical tension is evaluated by processing a variety of parameters:

- vehicle movements (speed, longitudinal and lateral acceleration, yaw rate),
- driver actions (steering wheel angle, position of the accelerator pedals and brakes),
- road conditions (traffic density, nature of the road surface),
- biometric indicators (heart rate, respiratory rate, skin temperature).

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

Conclusions

1. A comparative analysis of existing methods for determining driver fatigue was carried out in the work during which it turned out that their main disadvantages are a complex design, adaptation to the driver, fatigue settling time and high cost of systems.
2. A method of PFDS is proposed, which, by analyzing the number of pulse beats, will predict human fatigue and possible sleep.
3. A simple design of a system for monitoring physiological parameters leading to a price reduction is proposed.

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ՎԱՐՈՐԴԻ ՀՈԳՆԱԾՈՒԹՅԱՆ ՈՐՈՇՄԱՆ ՄԵԹՈԴՆԵՐԻ ՎԵՐԼՈՒԾՈՒԹՅՈՒՆ ԵՎ ԴՐԱՆՑ ԿԱՏԱՐԵԼԱԳՈՐԾՄԱՆ ՏԱՐԲԵՐԱԿԸ

Պողոսյան Վ.Գ.
Հայաստանի ազգային պոլիտեխնիկական համալսարան

Ավտոմոբիլային տրանսպորտի անվտանգությունը յուրաքանչյուր պետության համար անվտանգության համակարգի հիմնական բաղադրիչն է: Ճանապարհային անվտանգության ցածր մակարդակը էական ազդեցություն ունի համայնքի անվտանգության վրա:

Ուսումնասիրություններ են կատարվել ճանապարհատրանսպորտային պատահարների պատճառաբանության վերաբերյալ: Նրանք ցույց են տվել, որ երթևեկության ինտենսիվության բարձրացման և վարորդների թվի ավելացման արդյունքում նկատվում է խցանումների աճ, ինչն իր հերթին հանգեցնում է վարորդների լրացուցիչ հոգնածության, իսկ որոշ դեպքերում՝ քնի:

Հոգնածության և քնելու հետևանքով ճանապարհատրանսպորտային պատահարները կանխելու համար անհրաժեշտ է որոշակի միջոցներ ձեռնարկել: Նման ժամանակակից համակարգերն ուսումնասիրելիս պարզ է դառնում, որ դրանք աշխատում են վարորդի գործողությունները և մեքենայի ընթացքը վերլուծելով:

Աշխատանքի նպատակն է իրականացնել վարորդների հոգնածության որոշման մեթոդների համեմատական վերլուծություն և մշակել նոր օժանդակ մեթոդ:

Աշխատանքում ցույց է տրված, որ ուսումնասիրվող համակարգերի հիմնական թերություններն են՝ բարդ կառուցվածքը, վարորդին հարմարվելը, հոգնածության որոշման ժամանակը և համակարգի բարձր արժեքը: Առաջարկվում է ներդնել հոգնածության որոշման պուլսային համակարգ (ՀՈՊՀ), որը վերլուծելով զարկերակային զարկերի քանակը՝ կկանխատեսի մարդու հոգնածությունը և հնարավոր քունը, ինչը կհանգեցնի ֆիզիոլոգիական պարամետրերի վերահսկմամբ համակարգերի ավելի պարզ դիզայնի, այսինքն՝ գինը նվազեցնելու համար:

Բանալի բառեր. ճանապարհա-տրանսպոչտային պատահար, հոգնածություն, քուն, վարորդի հոգնածության մոնիթորինգի համակարգեր:

АНАЛИЗ МЕТОДОВ ОПРЕДЕЛЕНИЯ УСТАЛОСТИ ВОДИТЕЛЯ И ВАРИАНТ ИХ ДОРАБОТКИ

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Безопасность автомобильного транспорта для каждого государства является главным компонентом системы безопасности. Низкий уровень безопасности дорожного движения оказывает значительное влияние на обеспечение безопасности общества.

Были проведены исследования причин дорожно-транспортных происшествий. Они показали, что в результате повышения интенсивности движения и увеличения числа водителей наблюдается увеличение количества пробок, что, в свою очередь, приводит к дополнительной усталости водителей, а в некоторых случаях, ко сну. Необходимо принять определенные меры для предотвращения дорожно-транспортных происшествий, вызванных усталостью и сном. Изучая такие современные системы, становится ясно, что они работают, анализируя действия водителя и движение автомобиля.

Цель работы - провести сравнительный анализ методов определения утомляемости водителей и разработать новый вспомогательный метод.

В работе показано, что основными недостатками исследуемых систем являются сложная структура, адаптация к водителю, время определения усталости и высокая стоимость системы. Предлагается внедрить пульсовую систему определения усталости (ПСОУ), которая, анализируя количество ударов пульса, будет прогнозировать утомляемость человека и возможный сон, что приведет к упрощению конструкции в системах контроля физиологических параметров, то есть к снижению цены.

Ключевые слова: дорожно-транспортное происшествие, усталость, сон, системы контроля усталости водителя.

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