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The Human Factor in Road Traffic City

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Abstract

The driver while moving receives a lot of information about the character and modes of driving. In the process of information perception the driver must not only find necessary one, but also to revise, analyze, take appropriate action. Basis on this decision the driver must take action. The whole process from the perception to the action requires a certain amount of time, which may not be enough, according to traffic situations. In this case, the driver can make wrong decisions and actions. These reasons are the result of the mental state, driver fatigue, absence or insufficient experience of driving skills and others reasons. The driver while driving should keep for a long time the optimal emotional state. The most optimum state has been given quickly and effective process of proceeds from the perception of information to the implementation it to actions in traffic situations. The deviation from the optimal emotional state complicates the process of information perception and recycling process and increases the number of erroneous in driver's actions. The study aims is measuring of the complex traffic situations impact on the driver's emotional state. During movement process driver is faced with different traffic situations: pedestrians, "heavy traffic", traffic jam, etc. From condition of the driver's error's numbers depends from his condition. Selecting the optimum driving mode allows avoiding stress while driving. It is important to identify and examine the factors that effect on the driver's error in stressful driving situations and conditions of driver's characters changes.

Keywords

Road Traffic, Road Traffic Accidents, Critical Traffic Situations, Driver, GSR, Emotional State, Vehicle, Cities, Environment

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1. Introduction

Specificity of road traffic (RT) system functioning is in the interaction of technical and human factors. The RT is involved a lot of people: professional and non-professional drivers, and also pedestrians. Each person has their own physiological characteristics [Dmytrychenko, 2007; Rankin, Claffe and Halbert, 1981; Button and Hensher, 2001; Ponkratov, at ec., 2015). According to statistics, 70-80% of road traffic accidents (RTA) is belongs to the driver's errors (Rankin, Claffe and Halbert, 1981). The error - this is the result of action that does not achieve the goal. This is expressed in the wrong, premature or belated action of the driver. This observes, when the vehicle is controlled in a rapidly changing road conditions, especially in critical traffic situations (CTS). Errors are also any traffic infraction, which leads to an accident. In this case, the functional state of the driver is fundamental in RT system. Driver's ability to accurately drive in any road conditions and any RTA situations during working time are depends on his functional state. Fatigue and emotional stress of driver make great influence on his functional state. Examination driver's functional state and parameters of RT are hot topics today.

2. Theoretical Background of the Problem

The RT system is complex socio-technical subsystem which consists of pedestrians, different types of vehicles,

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professional and non-professional drivers, etc. Specific features and problems of RT caused primarily by "Driver-Vehicle-Environment-Road" (DVER) system. Key information for driver is: road, the environment movement, the vehicle, Figure 1 (Rankin, Claffe and Halbert, 1981; Dmytrychenko, 2007; Romanov, 2002).

The road has its own parameters: width, road configuration in plan and profile, the condition of the road surface, the road's borders (sidewalk, ditch and shoulder). Road's construction and RT level organization can simplify or complicate driving, impacting on driver's fatigue and emotional stress.

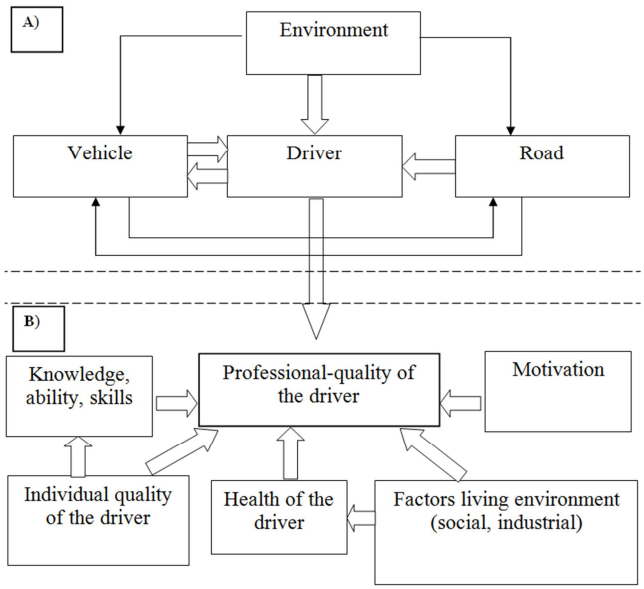

Figure 1. The interconnection of "DVER" system elements (A) and subsystem "driver" (B).

Driving environment is characterized by illumination, humidity, temperature, wind, dust and visibility. The RT system considers influence of the nature factors on road condition (humidity, snow, ice) and a distance visibility in different CTS.

Vehicle's type (in the DVER system) base on its traction and dynamic parameters, dimensions, quality brake, head lights, comfort driver's workplace, mobility, elements of passive and active security make extremely influence on RT safety.

Talking about the driver, it is important to take into account health condition, fatigue state, training level, ability to make decisions in less time situations and right speed choose according to RT conditions. A lot of the DVER's system characteristics depend on driver's condition (Dmytrychenko, 2007; Rankin, Claffe and Halbert, 1981; Button and Hensher, 2001; Romanov, 2002; Rigas, Katsis, Bougia and Fotiadis, 2008).

The reasons for reduced performance of drivers are: alcohol, illness, medications, smoking, and fatigue while driving.

Scientists assert that there is a direct relationship between the driver's health and RT safety [4]. French's researcher has shown that 6.8% of RTA with fatal result happens by reasons of driver's disability, fatigue and consciousness's loss. In 1300 cases of driver's license deprivation from traffic infraction there are: 150 drivers had visual acuity below the permissible norm, 138 drivers have high blood pressure, 42 have problems with motor function of organism, 34 - mental disorders, 31 – diabetes, 14 – cardiovascular diseases. Therefore, 31.5% of drivers in France, deprived of their driving licenses as a result of traffic infraction, have variations in health status. In the US – 4.2% of fatal RTA happen from fatigue and disability of drivers' result. The driver's functional state can turn down with medications and as result it can also cause to RTA. In this case a sensory-motor reaction of human is decreasing that effect on driver's reaction time and concentration of his attention (Rankin, Claffe and Halbert, 1981).

Fatigue – a temporary performances' reduction caused by prolonged or intense work. The amount of fatigue cannot be measured only by the scope of the work performed. Value of fatigue has to consider production factor, driving skills, experience, health, driver's individual physiological characteristics, the modes of work and rest. Each of these factors can have a critical impact on fatigue level and its origin (Dmytrychenko M. et al., 2007)

There are three types of fatigue: physical, mental and emotional. The driver combines physical labor with mental activity and a great emotional stress. This leads to the simultaneous occurrence of all three of fatigue.

The physical burdens on the driver with the continuous improvement of designs of vehicles conditions have been systematically decline. The creation of facilities and simplicity of driving still have reserve to reduce, especially for trucks or busses. The drivers' gets tired quokka physically when driving off-road, snow-covered, slippery, mountain roads, while prolonged driving and especially in difficult RTS. Physical exercises have a positive impact on physical functional state of driver.

According references analysis (Button, and Hensher, 2001; Romanov, 2002), mental fatigue will arise with prolonged high speeds or in "heavy traffic" driving. Emotional exhaustion is caused by negative feelings during a conflict or emergency situations RTS, when driving in difficult road conditions, while traffic infraction by other RT members. Emotional exhaustion depends on driver's work intensity in difficult road conditions and poor RT performances.

Previous analysis shows that the issues of fatigue, driver's emotional stress in complex RTS require today to develop new approaches to reduce the number of TRA at RT system.

3. Evaluation of the Emotional State of the Driver

3.1. Methods for Assessing the Emotional State of the Driver

Today, for the evaluation driver's functional state may use the following methods (Romanov, 2002; Rigas, Katsis, Bougia and Fotiadis, 2008; Shiwu, Linhong, Zhifa, Bingkui, Feiyan and Zhongkai, 2011 Andreassi, 2007; Lykken, 1971):

1. An electrocardiogram (ECG). ECG method allows identifying the dependence of the human's heart rhythm from his tendency to stress. Mounted on the body electrodes capture potential difference resulting from the heart rhythm.
2. The electroencephalogram (EEG). EEG method determines the brain's state and activity; it is also indispensable for central nervous system state's monitoring. The main characteristics of the brain's EEG are the frequency, amplitude, waveform, etc.
3. The electromyogram (EMG). The method is determined by dependence of EMG muscle tensions from the stress level. It's characterized by changes in the electrical potential of muscle fibers.
4. The electrooculogram (EOG). EOG stress state can be identifying by analyzing of the human's eye activities. Human's eye anterior pole electrically is positive and back side–negative, so there is a potential difference between the bottom of the eye and the cornea that can be measured. When the eye changes position, the poles will change too. The eye's potential difference occurring at this time, characterize by direction, amplitude and speed of eye movement.
5. Skin and galvanic response (GSR). The method shows the effect of the GSR stress on the sympathetic nervous system, this turn effects on the activity of the sweat-glands and then changes the electrical activity of the skin. GSR is extremely sensitive in the case of emotional response, anxiety and tension. It's often used to characterize the human's functional state.

3.2. The Emotional State of the Driver in Difficult CTS

The driver must always take a lot of information about temper and mode of all its members drive, about road's status and parameters, about state of the environment and the availability means of control, about the vehicle's components and assemblies' state. The driver, in the huge information flow perception's process, must not only find necessary one, but also to recycle, analyze and take action based on the appropriate decision.

For example, Figure 2 shows the driving mode change on the main street of one of the largest cities with an average density of intersections and crosswalks – 500 m. per km. Figure 3 shows driving modes changing in the central part of the city (old town) with an average density of intersections and crosswalks – 150 m. per km. Measurements were performed using the device «RACELOGIC». The graph presented one period of time, which clearly shows the burden on the driver and the vehicle during driving. The most influence on the emotional state of the driver have: number of stops, acceleration, braking, safe distance keeping.

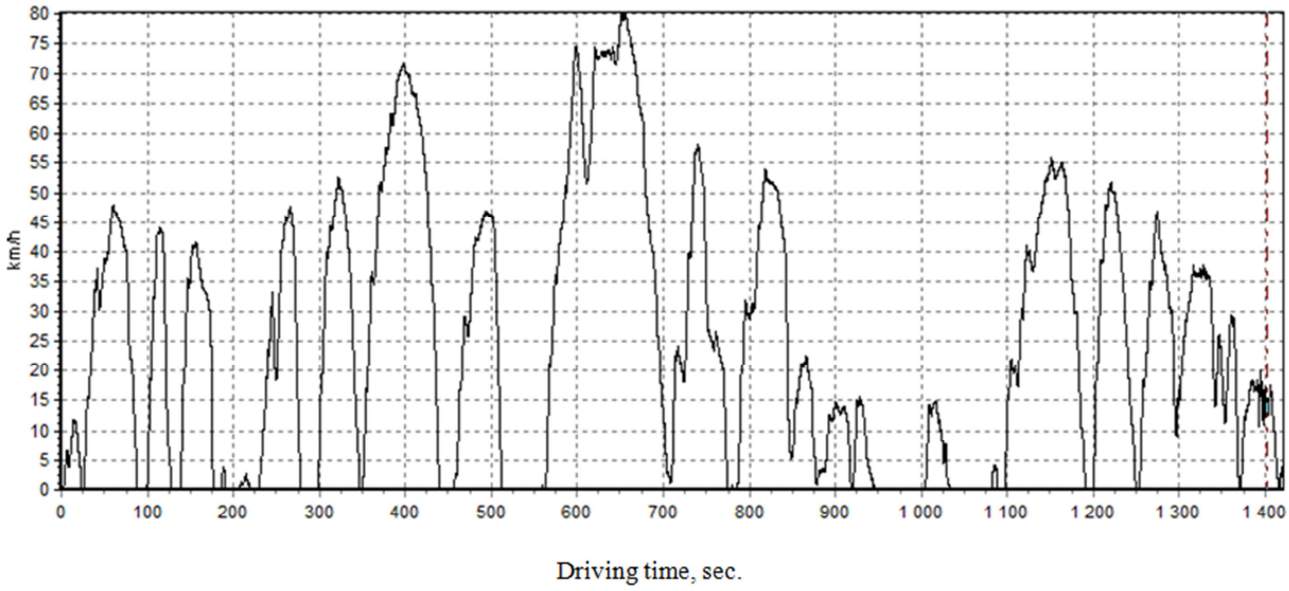

Figure 2. Driving mode changes on main streets an average density of intersections and pedestrian crossings is 500 m. / km. (The average traffic load of the road "B").

For measuring driver's emotional state in the changing driving modes on the main street with an average density of intersections and pedestrian crossings –500 m. / Km. (The average traffic load of the road "B") and traffic situations when an average density of intersections and pedestrian crossings is 150 m. / Km. (The average traffic load of the road «D») GSR method was used by Andreassi (2007). To register data «NEULOG GSR» sensor have been used. Measurement results are shown in Fig. 4-5 respectively.

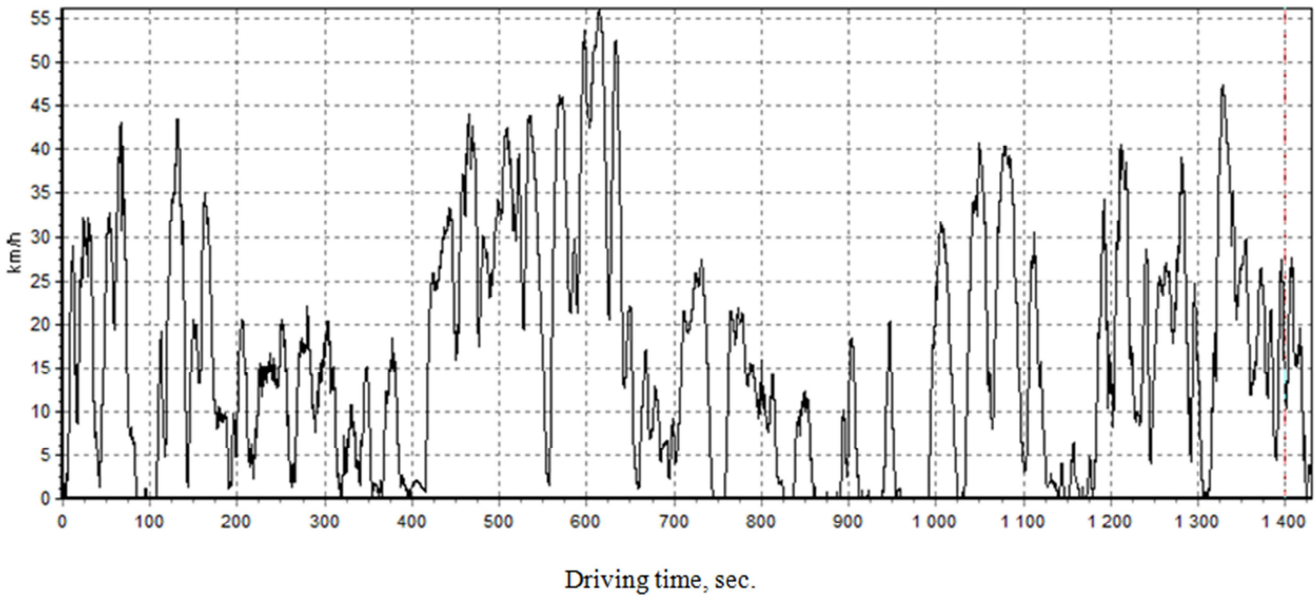

Figure 3. Driving mode changes in the central part of the city with an average density of intersections and pedestrian crossings is 150 m. / Km. (The average traffic load of the road «D»).

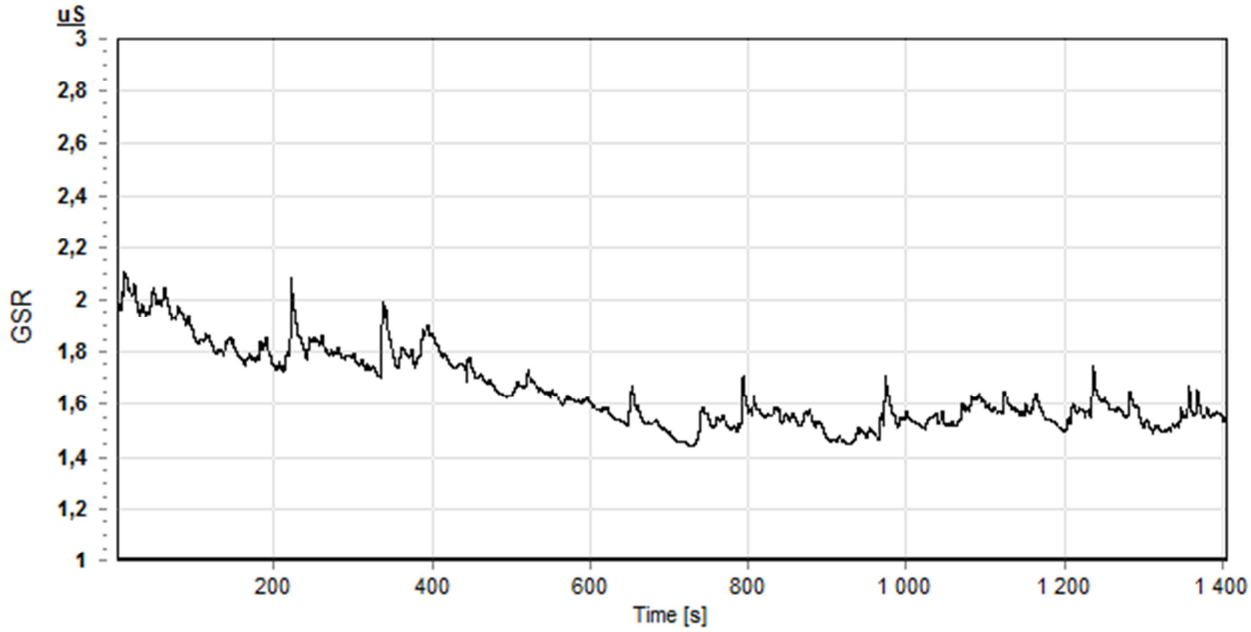

Figure 4. Driver's GSR (microSiemens) changes on the main street with an average density of intersections and pedestrian crossings – 500m. / Km. (The average traffic load of the road "B").

«NEULOG GSR» measuring results shows that the driver feels less tension depending on the load of the road traffic, number of stops, acceleration, braking, etc. It should be noted about the increase of stress condition of the driver when driving with a density of intersections and pedestrian crossings – 150 m. / Km.

In the middle of the trip the driver begins to get nervous, from all that surrounds him and sudden appearance of a

pedestrian (Fig. 5) leads to a lot of stress and errors in the RTS. One of the reasons of the incorrect actions is deviation mental condition of the driver from the norm. The strong positive or negative emotions can dramatically change the physiological quality of the driver, which ultimately can lead to RTA. Changing GSR (microSiemens) driver depending on the driving state, present in table 1.

A detailed analysis of the elements GSR measurement (Fig. 6-7) shows that the increase of the stress depends on the complexity of the RTS and the time of origin of the events of the trip. Thus, the consequences of staying in the mash at the end of the trip affected the strength to continue the movement, and the sudden appearance of a pedestrian does lead driver in a state of deep stress. This state continues to change as the cumulative increase in the amplitude characteristic of the GSR.

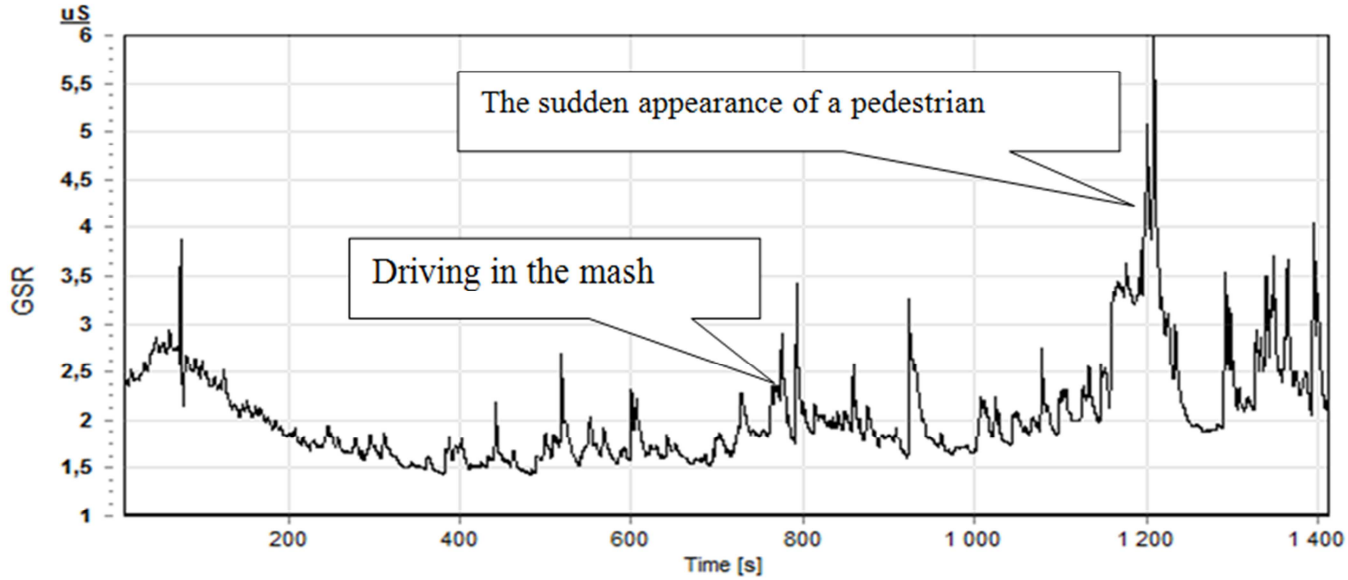

Figure 5. Driver's GSR (microsiemens) changes in the central part of the city with an average density of intersections and pedestrian crossings of 150 m. / Km. (The average traffic load of the road «D»).

Table 1. Changing GSR (microsiemens) driver depending on the driving conditions.

Parameter	Maximum	Minimum	Average	Standard deviation
The density of intersections and pedestrian crossings – 500 m. / km. (loading level B)	2,104	1,441	1,641	0,142
The density of intersections and pedestrian crossings – 150 m. / km. (loading level D)	6,01	1,437	2,283	0,744

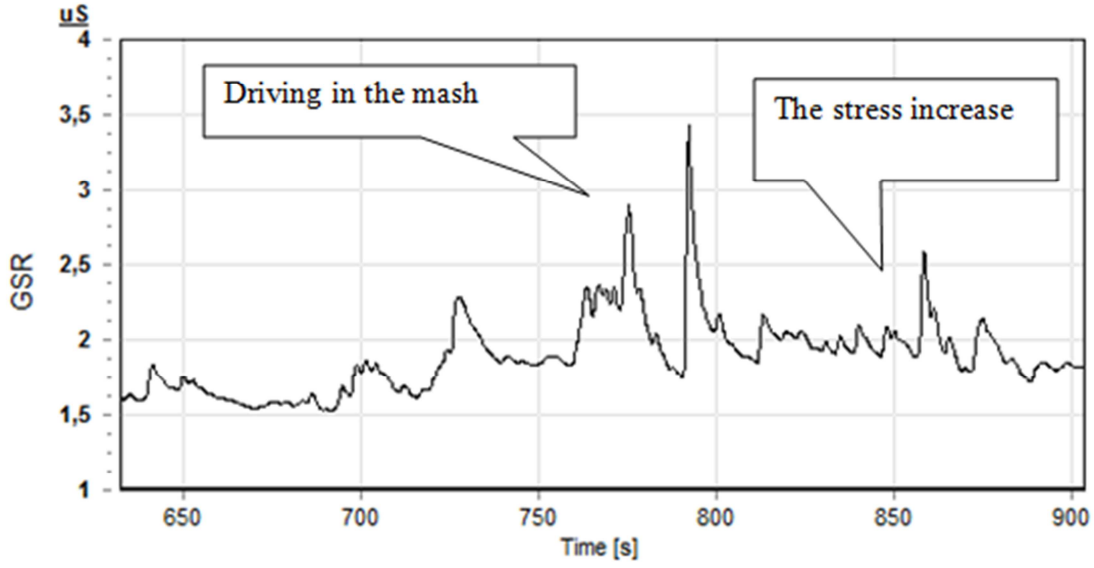

Figure 6. Analysis of GSR during the driving in the mash.

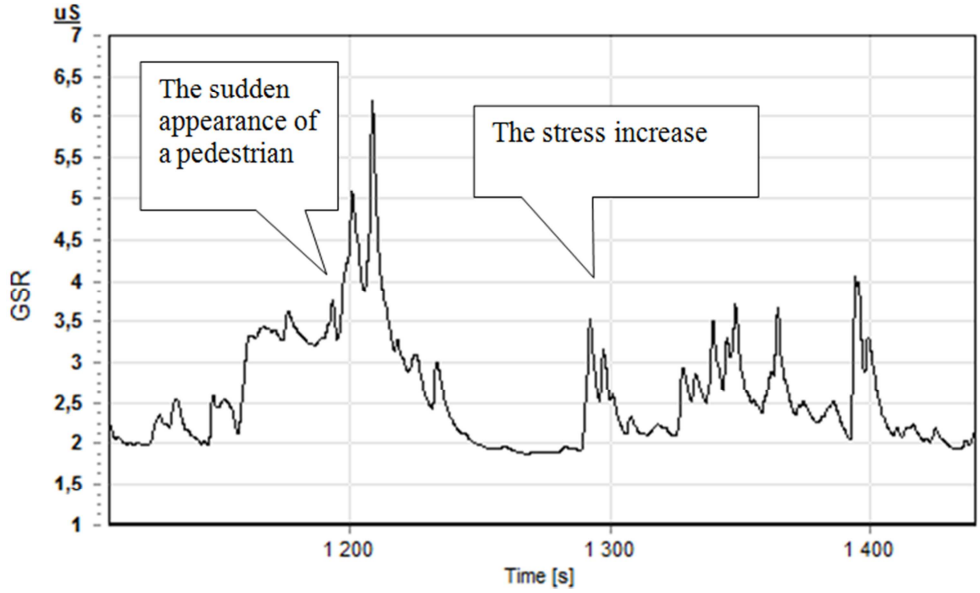

Figure 7. Analysis of GSR when sudden appearance of a pedestrian.

According to the research it was established the main factors that affect the emotional state of the driver in difficult RTS:

1. Driving in the mash;
2. Braking of the front moving vehicle;
3. Change traffic lane ahead moving vehicle;
4. Change traffic lane and choice of the driving direction by driver;
5. Parking on the roadway;
6. Dense traffic;
7. Pedestrian traffic;
8. Execution of maneuvers at the intersection.
9. Difficult road conditions.

Therefore, to reduce the number of accidents struggle with fatigue should be carried out in two ways: reduction information and emotional load the driver. The creation of such traffic conditions by organizing traffic that would maximize the efficiency of the transport stream. Reduce information overload can use the markup, separation flows in the directions of movement, isolation pedestrian traffic, creating a priority of urban passenger transport, the creation of high-quality lighting in the dark, etc. A radical solution is the reconstruction of the road, reduce load and therefore the density of the traffic flow.

3.3. Driver's Errors in Complex TRS

The whole process from the perception to the commission of the driver's actions requires certain amount of time, which can often not be enough, taking into consideration speed of TRS change. In this case, the driver may create a wrong action due to following reasons (Romanov, 2002; Rigas, Katsis, Bougia and Fotiadis, 2008; Shiwu, Linhong, Zhifa, Bingkui, Feiyan and Zhongkai, 2011 Andreassi, 2007; Lykken, 1971).

- Absence (deficiency) of the time on the process of perception of information (for example, an object is detected, but could not prevent the accident, as no other steps are implemented: information processing, analysis, etc.);
- Errors in the analysis of the initial information. For example, the car's red signal indicator taken as a braking;
- Errors in the making analysis (for example, a driver approaching to intersection decided that burning yellow traffic light signal changes to green, but turned on red signal);
- The incorrect decision (for example, instead of the maneuver, the only right decision in the TRS, the driver decides to brake immediately);
- Erroneous actions (for example, right decision to hold an emergency braking, but the driver mistakenly depresses the accelerator pedal, thus increasing the speed of the vehicle).

To identify common mistakes drivers in complex RTS was made questionnaire (Dmytrychenko et al., 2007). Drivers were asked the reasons and types of their errors. The result of it was made the drivers' error statistics, which is presented in the tables 2 and table 3. Drivers were asked the reasons of their errors condition "Well known route" and "Unknown route". In research ware involved more than 1,200 drivers of all ages and driving experience of the vehicle. The results are given in the tables below. The main important factors for

direct drivers' errors are: a distraction of attention, an underestimation of the dangers and erroneous forecast RTS. For indirect drivers' error are: the deterioration of the driver's functional state (fatigue), the deterioration of the driver's functional state while driving (stress TPA) and rush.

Table 2. Error statistics of the driver in difficult TPA according to a survey (direct errors).

reason for error	The number of errors%	
	Well known route	Unknown route
Distraction of attention	27	12
underestimation of the dangers	17	20
fearfulness of manners	13	15
erroneous forecast TPA	23	29
Not the right action in the RTS	15	17
Infringement of the rules of DD	5	7

Table 3. Error statistics of the driver in difficult RTS according to a survey (indirect error).

Reason for error	The number of errors%	
	Well known route	Unknown route
The deterioration of the driver's functional state while driving (fatigue)	27	36
The deterioration of the driver's functional state while driving (stress RTS)	25	29
The Rush	20	7
The Mood	11	5
Poor driving skills	8	12
The Inaction	3	9
The technical condition of the car (dynamic braking parameters)	6	2

To determine the importance of the criteria "Well known route" and "Unknown route" was used rank correlation method and criterion χ^2 Pearson method (Legendre, 2010; Cochran, 1952). The evaluation results matching criteria for expert opinion "Well known route" and "Unknown route" present in the table 4. Drivers were experts, because they are participants of the transport process and can put the evaluation of their actions.

Table 4. Assessment of consistency of expert opinion.

The considered totality	Coefficient of concordance	Actual value χ^2	Table value χ^2
Well known route	0,84	19,2	7,82
Unknown route	0,75	14,3	

From the concordance coefficient value is evident that there is a consistency of expert opinion for the entire set of respondents because an actual value exceeds the table one.

Driver errors in complex RTS can cause an RTA, so to enhance road safety should be improved not only a subsystem of the driver, but also the DVER system as a whole.

4. Conclusion

Human's factor questions in conditions of urban traffic associated with the "Driver-Vehicle-Environment-Road" system. Questions of driver's fatigue and emotional stress connected with conflict and emergency situations in road traffic. When driving in difficult road conditions, when traffic infractions take place drivers make mistakes in complex traffic situations. The result of the errors can be a traffic accident.

The study result was to identify factors that influence on the emotional state of the driver. Approaches have been proposed for reducing the fatigue of the driver in the city. Assessment of the effects of the driver's emotional state is shown in his mistakes. Basic errors: distraction and erroneous forecast TPA. Reasons of errors: the deterioration of the driver's functional condition at travel (fatigue, stress RTS) and haste.

In the future research of the driver's emotional state and his mistakes in driving process, it's necessary to consider his temperament and the vehicle's type and other road conditions factors.

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