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Remote Monitoring of the Driver Status as a Means of Improving Transport Safety

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Abstract

The majority of accidents and accident occurrences on motor transport are connected with human factor. To reduce the risk of a negative effect of human factor it makes sense to use automatic remote monitoring of the driver status on a trip. The article describes the task presentation, description of the development and introduction of this system based on one of MOSTRANSAVTO (Moscow-based Transportation Enterprise) divisions.

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Keywords: Transport, traffic accident, human factor, driver’s keeping awake, remote monitoring of the driver keeping awake.

1. Introduction

Statistics of the Russian Interior Ministry testifies that around 80% of tragic accidents occur through a driver’s fault. Of those, 20% of grave accidents can be put down to the low level of the driver’s keeping awake, i.e. deterioration of vigilance, state of drowsiness and falling asleep behind the steering wheel [Horne and Reyner (1999/1995)]. A driver who feels sleepy slackens self-control and may fall asleep suddenly. In this case he is threatening not only to himself, but also other traffic participants. Thus, an obvious need arises to create a device that would monitor the driver’s status behind the steering wheel.

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2. Main part

Review of existing methods and control systems for monitoring the driver's working capacity

At present, there is a wide variety of proposals, finished research works, and even industrial products which are more or less aimed at the solution of the driver vigilance control. These systems are based on analysis of one or several physiological and (or) behavioral patterns [Federal Highway Administration (1997), Whitlock (2002)]. Table 1 shows data parameters of the driver's vigilance control evaluated on the basis of dedicated literary sources and checked out in experiments dealing with fallen asleep on the vehicle driving simulator and/or in conditions of simple monotonous movements (p is a probability of a dangerous failure, 1/hour).

Table 1. Methods that determine symptoms of sleepiness and deep relaxation.

Technology of evaluating the driver's keeping awake	Intensity of dangerous failures flow, p $hour^{-1}$
Pulse	10^{-2}
Change of the "driving pattern"	10^{-3}
Rational actions	10^{-3}
Pose (muscular tonus)	10^{-3}
Look direction	10^{-3}
Head inclination (muscular tonus)	10^{-3}
Speech	10^{-3}
Eye tracking	10^{-4}
Blinking	10^{-4}
Micro-saccades (potentially)	10^{-6}
Electro-dermal activity (72 mln. man-hours without accidents)	10^{-8}

Area of research and development

For research, using each method, experimental benches were created for measuring physiological and behavioral parameters by physical techniques. The most reliable, in terms of a dangerous failure, appeared to be the driver's status control by registering the electro-dermal activity [Ogilvie et al. (1991)]. Electro-dermal activity (EDA) is a change of resistance between two electrodes applied to the skin of a human hand in the finger, palm or wrist area. EDA characterizes psycho-emotional condition of man, in particular, the level of his keeping awake. In the cause of behavioral experiments, with the help of a special method aimed at creating monotony, it was established that the specific EDA impulses often disappear before the operator makes errors like falling asleep.

One of the main problems that had to be resolved in using this phenomenon in the real control technology was to achieve reliable registration of exactly EDA impulse instead of interference. For this purpose five independent experts were given records of skin resistance (conductivity) of a large number of persons subjected to tests. Each expert had to mark EDA impulses in those records. All in all, there were 10^5 impulses marked by 5 experts. Using this database, a method was elaborated for identifying impulses according to their shape. The testing of this filter in the model experiment while white noise was sent to its input showed that the intensity of the failure flow of the second level (EDA impulse registration when there is no one) does not exceed 10^{-9} $hour^{-1}$. Artifacts of the drivers' and engine operators' motions, arising in performance of their professional duties, are filtered with the same trustworthiness. This made it possible to create a line of the driver's status control instruments with a dangerous failure probability flow up to 10^{-8} $hour^{-1}$ (ISO 26262 ASIL C).

Quantitative results were obtained in this experiment which made it possible to assert with a 0.9999 certainty that if the time between two EDA impulses does not exceed 60 seconds, a man is in an active state of keeping awake [Dorokhov et al. (1998)]. All this put down the basis for developing a system of continuous control of the psycho-physiological condition of a driver on a trip, which system was called Vigiton [Bonch-Bruevich et al. (1994)] (Fig. 1).

The system includes a portable part manufactured as a bracelet, stationary unit, and switching unit. The portable part is fitted with electrodes by which information is continuously read off about the electric resistance of the man's