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Innovative Development of Intelligent Transport Systems Based on Biocybernetical Vehicle Control Systems

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Abstract

In recent years rapid development of unmanned vehicles enables to set a task of creating prospective intelligent transportation systems (ITS) based on unconventional, hybrid approaches enabling to combine macro traffic control (T) at road and transport conditions with fine adjustment at the micro-level of physiological and intellectual actions and decisions taken by the driver. The work presents grounds for creating a biocybernetical management system as an innovative development of unmanned cars to ensure traffic safety. It examines a uniquely designed architecture of the biocybernetical management system together with hardware and software architecture and the structure of the unmanned car system based on it.

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Keywords: intelligent transportation system; traffic safety; intelligent transport security system; biocybernetical management paradigm; unmanned vehicle

1. Introduction

The fundamental document defining development priorities of the transport complex, main objectives, tasks of its development and ways of their achievement is “Transport Strategy of the Russian Federation for the Period until 2030”. In the Transport Strategy revision special attention is paid to introduction of modern systems, technologies and management methods. The main task for the Russian Federation transport complex is application of modern

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intelligent transportation systems uniting a complex of modern and innovative technologies of modeling, real time management as well as communication technologies. Modern ITS enable to exercise traffic management effectively by means of control and optimization of road and transport conditions preventing in such a way a great number of critical (conflict situations) and road traffic accidents (RTA) related to them. On the other hand, as the extensive investigations of recent years showed, the vast majority of road traffic accidents (50–70%) happen not as a result of critical situations but because of wrong actions of the driver, which means such factors as reaction time, correctness of the decisions taken by the driver and driving skills are the basis for the majority of the reasons for RTA.

One of the most important manifestations of psychophysiological qualities of drivers in terms of traffic safety is reaction time and correctness of the taken decisions. The information comes to the driver at a speed of 10^9–10^{11} bits per second. At the same time the driver can apprehend and process only 16 bits per second. The work [Klachek and Korjagin (2015)] presents statistics of mistakes made by the driver in various situations of driving a vehicle. Classification of RTA by functions: the driver doesn't apprehend the situation on the road — 49%; wrong assessment of the situation by the driver and taking the wrong decision — 41%; other mistakes — 10%. Classification by factors: 1. Direct mistakes: attention distraction — 36%; danger underestimation — 30%; timidity in behavioral patterns and dangerous habits — 25%; faulty forecast of behavior of other road users — 18%; wrong assessment of the conditions— 12%; underestimation of the own faulty behavior — 11%; conscious illegal own behavior — 8%. 2. Indirect mistakes: mistakes while forecasting the traffic conditions — 36%; hurry — 35%; mood — 17%; insufficient knowledge of skills of vehicle driving — 16%; temporary deterioration in the functional state because of psychological conditions — 16%; inaction — 5; unsatisfactory technical condition of the vehicle — 4%. So, a large amount of information or its quick changes often prevent apprehending and processing it promptly and exactly, and consequently, to elaborate a correct solution. The driver must carry out a large number of actions for driving, the part of which turns out to be faulty due lack of time for information processing and insufficient experience in driving.

In recent years rapid development of unmanned vehicles, Cooperative-Intelligent Transportation Systems technologies enables to set a task of creating prospective ITS based on unconventional, hybrid approaches enabling to combine macro traffic control at road and transport conditions with fine adjustment at the micro-level of physiological and intellectual actions and decisions taken by the driver.

2. Main text

2.1. Intelligent Transport Security System

The intelligent transportation system is intended for effective management of traffic streams, increase in traffic capacity of the street and road network, traffic jams prevention, reduction of delays in traffic flow, improvement of traffic safety, informing the road users about the emerging road and transport situation and options of the optimal traffic route, ensuring uninterrupted flow of the land urban passenger transport [Klachek and Korjagin (2015)]. Ensuring traffic safety remains the most important direction of ITS functional development. The studies of the Russian and European experience [Klachek and Korjagin (2015)].] show that application of ITS enables to reduce RTA level by 30 percent. Undoubtedly, despite so good results further development of ITS in this direction is required, also on the basis of interdisciplinary approaches. The work [Klachek et al. (2015), Klachek and Korjagin (2015)].] presents a biocybernetical traffic management paradigm based on ITS. This paradigm is intended to combine macro traffic control at road and transport conditions with fine adjustment at the micro-level of physiological and intellectual actions and decisions taken by the driver (Fig. 1). An innovative component of ITS development based on biocybernetical management paradigm [Klachek et al. (2015), Klachek and Korjagin (2015)].] is application of the intelligent transport security system (ITSS) in its structure (Fig. 2).