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Mathematical Modeling of Cyber-socially Physical Systems in Transport

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Introduction

The need to develop modules for mathematical modeling, design, and production of devices and diagnostic tools as part of the control system of the transport cyber-physical system, which provides physical accessibility to infrastructure and cities, is causing an urgent problem within the concept of "smart cities" as one of the most important directions of the digital economy, as demonstrated by the automation of the diagnostics of state transport infrastructure facilities. At first, road safety and capacity for traffic flow are significantly influenced by the quality of the road surface, category of the road, visibility, roadway width, and location of appropriate road signs. The idea of "road conditions" is defined by them all, and the car's trajectory and speed are dependent on them. Experts say that the conditions of the road play a role in between 60% and 80% of road traffic accidents. Additionally, accidents rank among the most common causes of death worldwide [1].

Description

As demonstrated, more than 1.35 million people die annually, which equates to a loss of approximately 3% of GDP for countries affected by this disaster. Second, according to the analysis of road accidents, it is necessary to determine who broke the rules of the road (traffic laws) and how much it will cost to fix a damaged motor vehicle (AMV).Thirdly, the untimely detection and repair of cracks and potholes in the road surface tends to increase the economic and social losses caused by a decrease in traffic flow speed and road capacity. The mobile systems based on laser scanning were a significant advance in resolving the issue of objective road condition diagnostics. However, the situation is made even more difficult by the high cost of this technology and the absence of information regarding the texture of road objects [2].

The development of digital technologies for designing road repairs, increasing mobility, and lowering the cost of work is given a new boost by the use of modern, inexpensive photogrammetric methods for determining damage and unevenness of the road surface and structural elements. In light of the foregoing, it is urgent to develop autonomous mobile devices that can "on the spot" collect and analyze road data, including photographs and videos, in a format suitable for disputed situation investigation and examination. An affordable illustration of a cyber-physical system in transportation are the aforementioned autonomous mobile road data collection and analysis devices that function as part of a single measuring and processing complex. This also adds a system of stationary city security cameras for road safety and, possibly, unmanned vehicles that can independently analyze the environment, make decisions, and learn from previous experiences thanks to a sophisticated artificial intelligence software system on board [3].

Consequently, these devices as a whole form a heterogeneous distributed artificial intelligence system that should be enhanced by a hierarchical structure that enables devices to share tasks, interact with their surroundings, and exchange information in accordance with fundamental goals and settings. In order to create a global cybersocio physical urban traffic management system as part of the concept of creating "smart cities," this implies the existence of protocols for their joint work at the lower level of interaction, as well as protocols for sharing in data processing centers (DPC) at the mid-level, further transfer to a single data center, and development of management decisions at the upper level. The presence of "socio" as applied to the street here is in no way, shape or form coincidental, since the street isn't a manufacturing plant or field with the possibility of an abandoned creation innovation, however a fundamental component of the "brilliant city", giving mishap free activity and greatest throughput of the vehicle framework, with the presence in it of dynamic street clients, making the impact of eccentricism of cognizant or oblivious way of behaving of individuals, drivers, people on foot and so on [4,5].

Conclusion

In a series of papers, the foundations of the multi-agent approach were discussed, as was the possibility of using stochastic models to design and investigate economic actor multi-agent systems. For frameworks with swarm insight Markov irregular field was proposed as a model. Random variables are used to model the agents, which are at the top of the final graph. The proposed situational approach to resource management and the possibility of utilizing multi-agent technology to solve planning issues in industry; developed methods for receiving and processing actual data from production resources in real time, as well as a multi-agent platform for the development of intelligent systems that preserve the scene in the context of the situation, to improve the quality and efficiency of planning in the process of events' changes. Special attention should be paid to the study of connected subsets (clusters) of agents. The allocation of road objects, the establishment of a production, or transport associations all correspond to the formation of clusters. An estimate of the probability of a cluster's existence that penetrates the entire system can serve the analytical results obtained for these lattices in the percolation theory under the assumption that agents are located at the vertices of a regular lattice. The availability of the agent's coefficients, which determine the probability of the existence of a global cluster and coherent subsets of agents, is lower estimated by the critical probabilities of nodes and links.

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