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THE RELEVANCE OF APPLYING ARTIFICIAL INTELLIGENCE ELEMENTS IN URBAN TRAFFIC FLOW MANAGEMENT

This article discusses the relevance of using elements of an artificial intelligence (AI) to manage urban traffic flows. It studies problems solved by artificial intelligence, such as optimizing traffic signal cycles, route planning, improving road safety, improving public transportation, and developing intelligent transportation systems (ITS). This article provides an example of the implementation of artificial intelligence in urban transportation and discusses the challenges and limitations associated with implementing this technology. The use of modern technology solutions using current information technology (AI) at all stages of road network design and operation holds significant promise for reducing the potential losses caused by traffic delays and emergencies. Increasing the share of information and smart technology components in urban traffic flow management can also have a positive impact on road safety. The report concludes that artificial intelligence has huge potential to optimize transportation systems and create more efficient, safer and more sustainable cities.

Keywords: *artificial intelligence, urban transport management, traffic flows, road traffic optimization, road safety, public transport, intelligent transport systems (ITS), autonomous vehicles, network mobility, calls and restrictions.*

Introduction

In modern society, in the context of the problems of urban development, transport systems are forced to solve another problem – traffic delays caused by excessive movement of goods and passengers on the highways of urban roads and road networks. Excessive traffic on city streets has a negative impact on the economy, the environment and the quality of life of city residents. The increase in population density, the increasing number of cars, insufficient road capacity – all these factors contribute to reducing the efficiency of urban transport systems, creating major problems not only within the boundaries of a particular city, but across the country.

Addressing congestion on urban roads and road networks requires an integrated approach that includes multiple elements:

– modernization of urban transport infrastructure;
– route optimization;
– improving traffic management efficiency;
– development of alternative modes of transport.

From this perspective, the use of smart IT solutions is an important tool, utilizing it to solve local problems of traffic flow management in the context of design and further to effectively manage the urban transportation system can make the entire city happen. major structural changes.

Purpose of the study

Modern IT smart systems are capable of improving the organization and operation of urban traffic flows based on modern trends, technological solutions and potential capabilities in the field of technology and processes, instantly improving their overall performance and efficiency, taking into account their progressive technological updates and Changes, improve the safety of the road traffic process, save the total system cost of fuel and energy, thereby reducing emissions and other negative impacts on the environment, mitigating and improving

the economic, social, and environmental efficiency of road traffic, which is an important factor affecting the overall ecosystem of large cities and important factor in its economic development. Therefore, the purpose of this paper is to identify current urban traffic flow management problems that can be solved using elements of AI systems.

The determining the significance of factors

The use of artificial intelligence elements allows us to solve a number of important problems of the urban transport system (fig. 1).

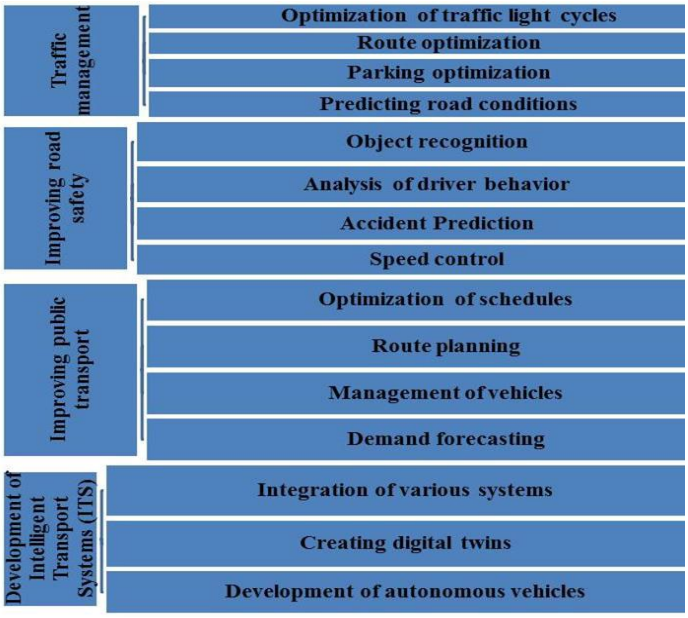

Figure 1 – Problems of the urban transport system that can be solved with the help of artificial intelligence

In general, the solutions offered by artificial intelligence can be as follows:

1. In terms of traffic management:

– the optimization process using artificial intelligence to adjust the traffic light cycle will enable real-time analysis of traffic flow data and dynamic adjustment of traffic light signals, effective adaptation to influencing factors and dynamic change of the current traffic situation to obtain the final travel time for all road users, thereby minimizing waiting, reducing delays in all elements of the road transport system and increasing road capacity on the road network;

– path optimization modeling using elements of artificial intelligence in algorithm modeling will allow analyzing data on traffic delays, current road conditions and travel time almost in real time in order to offer optimal routes for drivers, which reduces travel times and avoids delays;

– parking optimization, which involves the use of artificial intelligence to create automated parking space search systems, which increases the efficiency of parking space use and reduces the time it takes to find free spaces;

– forecasting road conditions, which involves modeling using artificial intelligence, which allows analyzing the dynamics of data on traffic flows, weather, events in the city and other factors in order to predict the traffic situation in the future, and this allows planning routes more optimally, thereby relieving the most congested sections of the road network, avoiding traffic jams and taking measures to prevent emergency situations.

2. In terms of improving road safety:

– object recognition by connecting specialized artificial intelligence to information and management systems, including those equipped with cameras, makes it possible to recognize different types of objects on the road, such as pedestrians, cars, cyclists, road signs, and warn drivers of danger;

– analysis of driver behavior by connecting specialized software equipped with elements of artificial intelligence to analytical algorithms used for system analysis of data on speed, braking, acceleration, maneuvers and other characteristics of driver behavior in order to identify potentially dangerous situations and warn about them;

– forecasting emergency situations by modeling the traffic situation and road conditions in the traffic management system using specialized software with the inclusion of elements of artificial intelligence, which will allow analyzing data on road conditions, weather conditions, traffic and other factors in order to model the traffic situation and predict the likelihood of emergency situations;

– speed control by creating intelligent control systems of adaptive speed limitation that automatically adjust the maximum permissible speed depending on road conditions.

3. Improving the operation of the public transport system:

– optimizing schedules by applying algorithms using artificial intelligence, which will allow analyzing data on passenger flows and traffic conditions, and optimizing public transport schedules, thereby ensuring regular movement of buses, trolleybuses, trams and trains, minimizing the waiting time of passengers;

– route planning using elements of artificial intelligence, allowing the control system to offer optimal routes for public transport passengers, taking into account travel time, number of transfers and other significant factors;

– vehicle control, introducing technology and process smart solutions into the urban traffic robot control system, selecting the best solution for fuel and energy consumption, reducing systemic and item-by-item wear and tear of vehicles, thereby overall improving the efficiency of the urban traffic system;

– demand forecasting, which involves the use of analytical and predictive functions of artificial intelligence, which allows predicting passenger flows on certain routes and, as a result, planning the number of vehicles and optimizing the schedule.

4. Development of intelligent transport systems:

– integration of various systems that make up the urban transport system, which allows integrating various transport systems, such as traffic management systems, public transport systems, parking systems, traffic data collection systems and others, into a single intelligent management system;

– creation of digital twins by applying the analytical characteristics of artificial intelligence in simulation modeling, which allows for virtual experiments, optimization of transport solutions and forecasting their impact on urban infrastructure and the development of the city as a whole;

– development of autonomous vehicles, the control of which is based on the use of artificial intelligence and allows for navigation on the road, remote monitoring of traffic and decision-making without human intervention;

– parking management involves optimization of parking systems using artificial intelligence, ensuring more efficient distribution of parking spaces and reducing the time it takes to find free spaces.

The creation and improvement of modern artificial intelligence systems is based on so-called machine learning – a “training” method that trains systems based on large amounts of data [1]. This enables dedicated computing systems to identify functional patterns in the studied data set and make generalizations from which practical problems can be formulated and solved. In practice, work can be done in different ways to use data to automate the autonomous operation of technical equipment:

– supervised training;

– autonomous training;

– support training.

Supervised learning is a process in which a manager (either human or intelligent software) provides the initial input and subsequent correct responses needed to form an updated AI model. Through this use of data, smart information and management models learn to recognize patterns and predict further developments in situations. For example, by modeling the time road users spend on the road, taking into account the time of day and current weather conditions. Autonomous learning is a specific process in which the intelligent information-management model itself looks for functional dependencies and, based on this, determines the pattern of data distribution and relationships between its elements, without receiving correct decisions or explicit instruction instructions. In the field of transport, an example is the analysis of input data for the comprehensive characterization of the movement of vehicles in the stream to identify existing patterns and current and future trends. Intelligent data management systems based on artificial intelligence and supervised learning in traffic management can extract ordered information from data streams of various sizes without the need for prior calibration or classification, thus improving traffic management efficiency and overall productivity and safety. Support as an element of intelligent systems simulation of vehicle processes includes the use of artificial intelligence components to simulate intelligent control systems and learn intelligent systems through autonomous interaction with the environment. Artificial intelligence makes its own decisions and is «rewarded» or «punished» based on the results obtained. An example of this approach used in the transportation industry is adaptive control of complex intelligent traffic control systems and autonomous vehicles. It can be used as a system to teach and improve autonomous driving skills when the car has to make decisions based on simulated factors such as current real-world road conditions and interactions with other road users. The learning process can start from simulation modeling and scenario development of different behavior options of the traffic system model in a virtual data environment. A car can receive a positive or negative score depending on how flexibly and correctly it reacts to certain situations: for example, whether it drives safely, effectively changes the spatial situation on the highway, or how well it performs these actions. Once the learning aid-based intelligent information management system learns to make the best decisions in a virtual information environment, it can be transferred to a testing

ground equipped with special technology and finally to real test conditions on possible public roads. improve adaptive features and make decisions based on updated experience. This approach can also be used to optimize traffic control systems, automatic load management, and other controls in the transportation industry. Thus, learning assistance enables autonomous vehicles to adapt and respond to changing road conditions, thus improving road safety, efficiency and overall performance [1].

Support training is the process of training an intelligent management information model on a dataset containing tagged and untagged packets. Unlike supervised learning or self-learning, where the data and individual data are unlabeled, supervised learning allows the use of large amounts of unlabeled data to improve the quality of modeled vehicles. This is especially useful for tagging databases or single data items. An example of the application of the above-mentioned methods in the field of organization and operation of urban traffic systems is the creation of a unique and individual driver assistance system to increase the safety and better operation of cars. In this case, the car can be equipped with an autonomous information intelligent management system that monitors the driver's habits and provides updated suggestions for improving the safety and efficiency of the vehicle. Autonomous Learning The automotive industry's intelligent autonomous driving learning systems improve driver quality, improve road safety, and provide unique, personalized and more efficient driving methods. So-called deep learning systems include a set of standard and unique machine learning methods that are based on using artificial neural networks with large envelopes to learn complex patterns in data. An example of the use of advanced AI training methods in the transportation industry is developing systems for detecting and identifying objects on the road, such as cars, pedestrians, traffic lights, and other road infrastructure elements. This intelligent data management system uses deep learning to analyze video streams from traffic cameras and road infrastructure to automatically identify various road objects and dangerous traffic conditions. With advanced learning capabilities, the system becomes more accurate and autonomous in determining current road conditions and current traffic conditions [1]. Computer vision is a branch of artificial intelligence that allows machines to interpret and analyze visual information. Examples of computer vision applications in the transportation industry are traffic monitoring and analysis systems. Computer vision systems can automatically analyze video streams from cameras and detect unusual or dangerous situations, such as road accidents, traffic jams, and vehicle delays [3–9].

At the same time, in these intelligent systems, Natural language processing algorithms use natural language processing technology in transportation systems, including syntactic analysis, sentiment analysis, name recognition and other technologies to improve intelligent system and user interaction. Information management improves logistics efficiency. An example of their use in road traffic is voice control and driver information systems. It is worth noting that natural language processing technology plays an important role in improving the interaction with vehicle information systems and the management of logistics processes, helping to improve the comfort, efficiency and safety of the transportation industry. However, in addition to the above-mentioned advantages and possibilities of using artificial intelligence, there are many limitations to its use in urban traffic management (fig. 2). The above limitations are important factors to consider when modeling intelligent information and control systems for adaptive traffic control. City traffic management system and real business.

Despite these limitations, the use of artificial intelligence in urban traffic management still has good potential. Their essence can be summarized in the following aspects:

1) the development of self-driving cars shows that artificial intelligence plays a key role in the development of self-driving cars that can navigate, monitor traffic and make decisions without human intervention. Autonomous vehicles can significantly increase the efficiency of transport systems, reduce the number of accidents and improve the quality of urban life;

2) a smart city is an urban development concept in which artificial intelligence is the key technology to create smart cities, using digital technology to solve problems in various fields, including transportation. Using artificial intelligence to manage urban traffic will create more efficient, safe and sustainable cities;

3) networked mobility uses intelligent driving systems to optimize and integrate different modes of transportation, including personal automobiles, public transportation, bicycles, and pedestrians. This makes transport more adaptable and efficient system that will meet the needs of all users;

4) by combining elements of intelligent information modeling and management and «big data» technology into one system, it is possible to analyze large-scale clusters and different initial and intermediate result data on transport flows, find hidden patterns and formulate the most efficient solutions in transport systems solution.

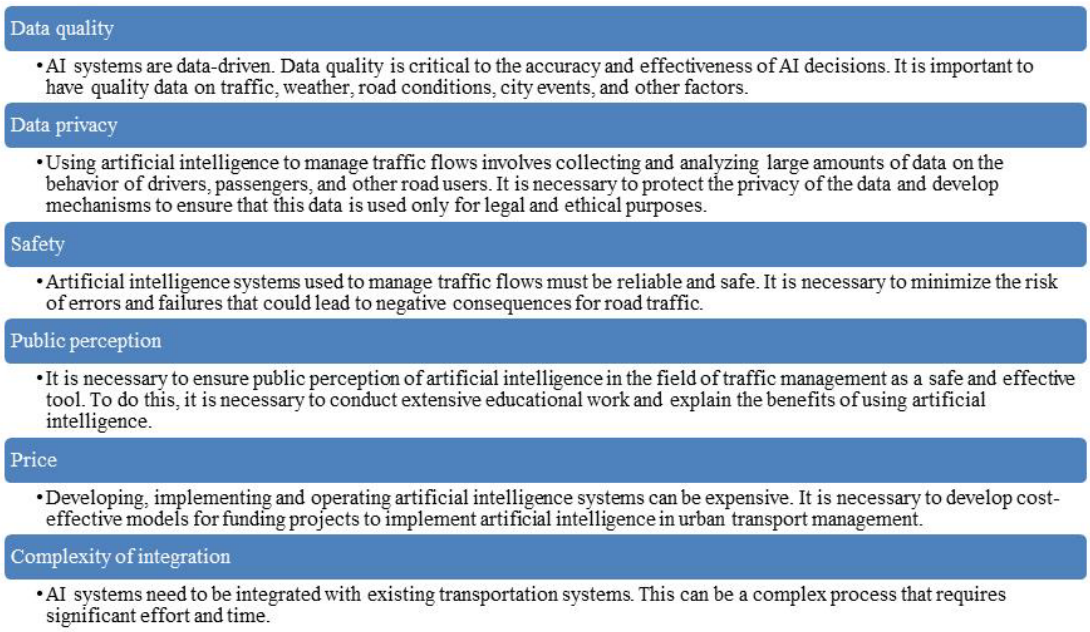

Figure 2 – Restrictions on the use of artificial intelligence in urban traffic management

Conclusion

It is worth noting that artificial intelligence is becoming a powerful tool to solve problems related to urban traffic management. If used properly, artificial intelligence can significantly improve the efficiency of the transportation system, reduce traffic congestion, improve road safety, make public transportation more efficient and convenient, and create more vibrant cities. However, data artificial intelligence has limited application in urban traffic management, data quality, privacy, security, public perception, and cost. It is important to design and implement artificial intelligence solutions in close cooperation with governments, transport companies, and city residents to ensure that they are effective and meet the interests of all participants in the transport system.

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АКТУАЛЬНОСТЬ ПРИМЕНЕНИЯ ЭЛЕМЕНТОВ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В УПРАВЛЕНИИ ГОРОДСКИМИ ТРАНСПОРТНЫМИ ПОТОКАМИ

В этой статье рассматривается актуальность использования элементов искусственного интеллекта (ИИ) для управления городскими транспортными потоками. В ней изучаются проблемы, решаемые искусственным интеллектом, такие как оптимизация циклов светофорного регулирования, планирование маршрутов, повышение безопасности дорожного движения, улучшение работы общественного транспорта и разработка интеллектуальных транспортных систем (ИТС). В этой статье приводится пример внедрения искусственного интеллекта в городской транспорт и обсуждаются проблемы и ограничения, связанные с внедрением этой технологии. Использование современных технологических решений с использованием современных информационных технологий (ИИ) на всех этапах проектирования и эксплуатации дорожной сети имеет значительные перспективы для сокращения потенциальных потерь, вызванных задержками на дорогах и чрезвычайными ситуациями. Увеличение доли информационной составляющей и интеллектуальных технологий в управлении городскими транспортными потоками также может оказать положительное влияние на безопасность дорожного движения. В результате можно сделать вывод о том, что искусственный интеллект имеет огромный потенциал для оптимизации транспортных систем и создания более эффективных, безопасных и устойчивых городов.

Ключевые слова: *искусственный интеллект, управление городским транспортом, транспортные потоки, оптимизация дорожного движения, безопасность дорожного движения, общественный транспорт, интеллектуальные транспортные системы (ITS), автономные транспортные средства, сетевая мобильность, вызовы и ограничения.*

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