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BASIC DIRECTIONS FOR THE USE OF ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN THE TRANSPORTATION AND LOGISTICS SECTOR

PUGACHEVA OLGA
PhD, Associate Professor,
Department of Economic Informatics, Accounting and Commerce
Francisk Skorina Gomel State University
Gomel, Belarus
OPugacheva@gsu.by
ORCID ID: 0000-0003-4554-0038

Abstract: The article investigates the issues of using artificial intelligence technologies in the field of transportation and logistics in order to find effective solutions for their implementation. Based on the available data in this area, the main directions of development of transportation and logistics based on artificial intelligence, their characteristics and examples of implementation of technological solutions are considered, the main effects from the application of AI solutions are given.

It is shown that AI technologies are used in key processes of passenger and cargo transportation, traffic flow and road infrastructure management, and customer interaction. The development of AI in the industry corresponds to the global dynamics of the world technological development of the industry - these are the technologies of autonomous movement that can completely change the whole face of both personal mobility and passenger and cargo transportation in all modes of transportation.

Research reveals that in the field of AI applications for transportation and logistics, solutions based on computer vision technology are developing to the greatest extent. This is explained by the industry specifics, characterized by a high demand for solutions aimed at road safety, support of road service activities, photo and video recording of violations, control of resource consumption, and monitoring of harmful emissions reduction. The demand for computer vision technologies is also expected to continue to grow due to the implementation of large-scale projects in the field of unmanned transportation.

In addition, the vector of transport and logistics industry development is aimed at the formation of "smart" transport infrastructure (seaports, air harbors, railway system, etc.), which are fully automated facilities based on AI, Internet of Things, big data, blockchain, and other technologies.

Based on the results of the study, it is concluded that the considered directions of using AI technologies in the transport and logistics sphere contribute to improving the efficiency, safety and sustainability of transportation systems.

Keywords: artificial intelligence, machine learning, technology, transportation, logistics
JEL Classification: O32, C45, L86, R41

1 Introduction

The relevance of the research is determined by the need to find effective solutions in the field of transportation and logistics based on artificial intelligence technologies in order to stimulate their use.

The development of the domestic economy is largely determined by the effective operation of the transportation and logistics sphere, which provides connectivity of economic entities within

the country and interaction with international partners. High-quality management of transportation and logistics processes can increase operational performance, reduce costs and improve the competitiveness of companies in the transportation industry. Modern challenges and reorientation of trade operations and passenger flows faced by transportation and logistics companies determine the need to develop effective solutions in the implementation of logistics operations. New trends in the industry related to the development of electric vehicles, the development of unmanned vehicles, multimodal, intermodal, transmodal transportation, robotization and the application of innovative technologies require a high level of data integration, the use of advanced information systems and technologies for processing large volumes of information. Digital transformation and accompanying artificial intelligence (hereinafter - AI) technologies are able to move the transportation industry and individual processes in companies to a qualitatively new technological level and a new stage of operational efficiency, to reduce transportation and logistics costs.

Artificial intelligence is a set of technological solutions that allows imitating human cognitive functions (including self-learning and search for solutions without a predetermined algorithm) and obtaining, when performing specific tasks, results comparable, at least, with the results of human intellectual activity (Pugacheva, 2023, p. 209).

The indicators of the global AI market volume for transportation and logistics and the growth of the global AI solutions market by 2030 are given in Figure 1 (Application of artificial intelligence in priority sectors of the economy, 2023).

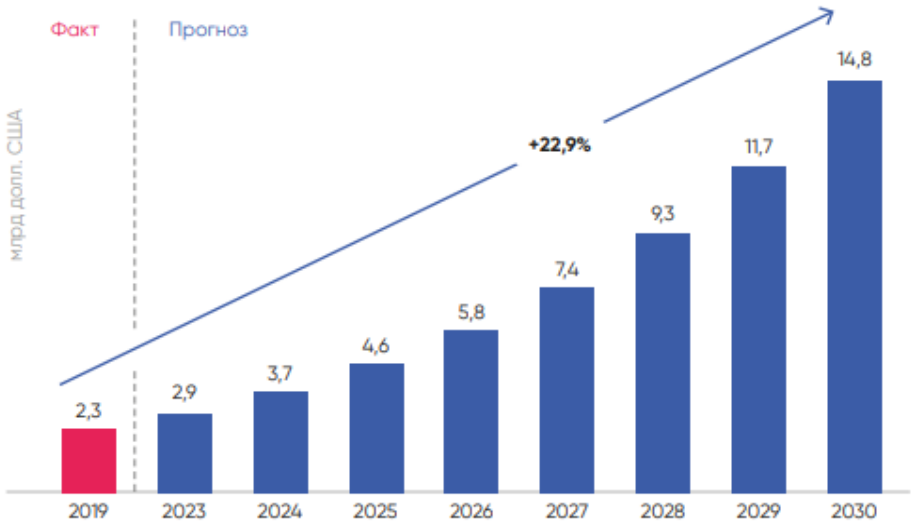

Figure 1 Global AI for transportation and logistics market size and growth figures for the global AI solutions market by 2030

Source: based on Interindustry Technology Transfer Center (2023)

2 The main directions of development of transportation and logistics based on AI technologies see the size of headings

Let us consider the main directions of development of the sphere of transportation and logistics, in which the application of AI technologies is of great importance.

The key directions of development of the sphere of transport and logistics on the basis of AI, their characteristics and examples of implementation of technological solutions are given in Table 1: what paragraph indentation (Artificial Intelligence in Transportation, 2024).

Table 1 Directions, characteristics and examples of implementation of AI-based technological solutions in the sphere of transportation and logistics

Characteristics	Examples
1 Development of autonomous transportation	
1.1 Autonomous transportation by passenger transport	
Advances in sensor, wireless communication, and machine learning technologies are enabling vehicles to more accurately recognize their environment and make complex decisions in real time. In autonomous vehicles, AI technologies are applied in perception, localization, decision making, feedback, and control of vehicle control. Autonomous mobility is predicted to improve safety and reduce accidents, fuel efficiency, productivity, and change the urban landscape. The large-scale deployment of autonomous vehicles raises a set of challenges, in the areas of cybersecurity, legal regulation (especially of cross-border transportation) and liability in case of accidents and incidents, as well as changing insurance models.	The Russian company Yandex has moved to the final stage of testing driverless unmanned cars with the potential for use in various areas: freight transportation, "last mile" (delivery of orders to the final customer), and cabs. Waymo (Alphabet) is developing and testing unmanned driving technologies in the US. In addition to Waymo, Tesla and a number of Chinese brands have their own autonomous cars.
1.2 Autonomous Freight Transportation	
In the transport and logistics industry, there is a trend towards the development of autonomous systems for freight transportation, capable of increasing the efficiency of logistics operations, reducing the cost of transportation by reducing labor costs and optimizing fuel costs. This is especially relevant in the context of the growing shortage of necessary personnel in the labor market and rising transportation costs. Autonomous transportation requires the realization of certain conditions: high-quality digital maps and geographic data, coverage of roads with high-speed communications, sensor systems and road safety infrastructure. The implementation of unmanned freight transportation differs from passenger autonomous mobility in terms of infrastructure requirements, the need for	In Russia, unmanned KAMAZ trucks were launched in 2023 to transport commercial cargo on the M-11 highway. The vehicles are equipped with communication, navigation, vision, and incoming information processing systems. TuSimple (USA) offers a solution of autonomous freight transportation network (AFN - Autonomous Freight Network). It has developed autonomous trucks based on an AI and sensor-based platform. Several trips without human presence or intervention have been realized in China and Japan. The trucks are capable of navigating urban and

dimensioning and payloads, control systems, safety and logistics management processes.	intercity roads in different weather conditions, taking into account the operation of traffic lights and lanes.
1.3 Autonomous delivery by robots and drones	
Robots equipped with AI systems and mobile platforms can deliver goods directly to the consumer's door, providing a more convenient service. The use of unmanned aerial vehicles (drones) to deliver goods is evolving, which is especially relevant in remote areas or in environments where traditional means of transportation have very low efficiency. The advantages of drones are: the ability to fly completely autonomously, avoiding obstacles; the availability of live video streaming; and real-time recording of drone location, status, altitude, and speed. Routing algorithms in AI-powered autonomous robots can improve routes based on various factors such as traffic, time of day, and customer preferences. Machine learning technologies provide more accurate prediction of delivery demand, which helps optimize inventory and lead times. Sensors and IoT devices can track and monitor transportation conditions such as temperature, humidity, and cargo condition. Retailers, postal services, and marketplaces are the most interested in these technologies.	In 2021, postal operator Russian Post launched a parcel delivery project using Yandex's unmanned robots in Moscow. In 2024, California-based Vayu Robotics unveiled its first robot courier. Robot One can follow store employees as they load customers' orders and then navigate city streets on its own to deliver goods. The robot is designed to drive on roads as well as bike paths, sidewalks and inside stores. An artificial intelligence model for autonomous robotics called Vayu Drive processes various types of data, such as images, text instructions and route data, and makes decisions about the robot's actions based on this information.
1.4 Unmanned specialized transport	
Autonomous Specialized Transport (AST) uses AI and automatic control technologies to perform tasks without human intervention. One of the main benefits of such transportation is increased efficiency and productivity. Autonomous vehicles can operate around the clock, allowing companies to reduce personnel costs and increase production. AST can be safer than traditional modes of transportation. It is equipped with advanced safety systems that avoid human error. The large number of sources of analyzed information allows for better operations than manual operator control, such as more efficient harvesting or warehousing of finished products.	Russian company Cognitive Robotics develops autonomous control systems for special vehicles for agriculture - Cognitive Agro Pilot. The technology is capable of autonomously performing a wide range of agricultural operations: tillage, cultivation, sowing, spraying, fertilizing, harvesting grass, tilled crops, while ensuring high accuracy of trajectory following and safety.

2 Using AI for customer interaction	
One way to realize this trend is through the use of chatbots. Chatbots can be useful for automating communication with customers, for example, to provide information on the status of a shipment delivery or vehicle tickets. Another way AI is being used in the transportation and logistics industry is to process data using optical character recognition and natural language processing. Optical character recognition can be used to recognize text on documents, such as invoices or bills of lading. This can help companies speed up document processing and improve data accuracy.	The Russian airline S7 uses a chatbot that allows to purchase, exchange, and surrender a flight ticket, clarify the status and schedule, and get advice on transportation rules. The implementation of the solution has reduced contact center support costs by 35%. About 70% of customer requests are processed automatically.
3 Technologies for integrating vehicles and infrastructure into a single loop of dynamic information exchange	
Development of connected car technologies (V2V, V2X, V2I)	
Connected Car technologies enable interoperability between different vehicles (V2V - Vehicle-to-Vehicle), vehicles and infrastructure (V2I - Vehicle-to-Infrastructure), and the overall technological environment around transportation systems (V2X - Vehicle-to-Everything). AI plays an important role in these technologies, enhancing their functionality and enabling more efficient and intelligent interactions in transportation systems. It is involved in big data processing and analysis, pattern recognition and sensor interpretation, decision-making systems, autonomous driving systems, and warning and safety systems.	The Connected Car technology of the Russian Telematica concern is currently being tested on the smart central ring road. V2X solutions of Russian development allow to receive actual data on the road situation in real time. The system receives information from traffic cameras and sensors about weather conditions, accidents, traffic density, congestion and obstacles on the road.
4 Smart transportation hubs	
4.1 Smart airport	
A smart airport is an airport concept in which advanced technologies are used to improve operational efficiency, ensure passenger safety and optimize resource management. This concept emphasizes technologies such as the Internet of Things (IoT), AI, data analytics, biometrics and others. IoT sensors and devices monitor the condition of equipment, air quality, and noise levels, while biometric technologies are used for identification at access, to enhance security and speed up the process of passing through	Russia's Sheremetyevo Airport has implemented an AI-based "digital twin" system that performs simulation modeling of all key processes (passenger flows, aircraft maintenance, cargo flows, etc.) a year or more ahead.

checkpoints. Machine learning algorithms analyze flight, passenger and baggage data for predictive analytics of possible failures and resource optimization, in managing various aspects of operations such as staff allocation, flight service coordination and infrastructure optimization. The technological structure of a smart airport also includes robots and automated vehicles, energy management systems, and various mobile applications for passengers and staff.	
4.2 Smart Port	
A smart port is a fully automated port where AI, big data, blockchain and Internet of Things technologies are combined in a centralized system. They address the challenges of monitoring, data collection and analysis, process optimization, decision-making assistance, improving efficiency, productivity, safety, environmental friendliness and reducing the likelihood of human error. The role of AI in a smart port is to manage the movement of ships and other transport in the port area, forecasting the need for resources and parking time, and optimizing routes. Internet of Things systems conduct constant monitoring of the state of infrastructure, port equipment, cranes, ship movements, water levels, etc. In addition, the smart port includes information systems of various classes, such as automated container terminals, unmanned vehicles, biometrics, digital platforms and energy-saving technologies.	The Port of Xiamen (China) launched the "Smart Port 2.0" platform in 2020, which includes the application of low-, medium- and high-frequency 5G networks, unmanned container ships, high-precision positioning and multi-sensor control of the Beidou navigation system. This solution is characterized by low investment, short construction time, environmental friendliness and wide applicability.
4.3 Smart railroad and railway station	
Smart railroad and railway station is a concept of developing railway infrastructure using modern technologies to improve efficiency, safety, and sustainability, as well as to provide a more comfortable environment for passengers. AI is used here to manage train movements, optimize train speeds and intervals, and enhance adaptation to changing conditions along the route to improve transportation efficiency. AI and big data enable the collection and analysis of data on track condition, equipment, weather conditions and	Using the Cognitive Rail Pilot platform on the Russian railroad allows using vision and artificial intelligence to detect objects on the railroad, including other trains, switches, tracks, people, traffic lights, etc. The complex can assess the situation, issue danger warning signals to the driver, make necessary decisions in case of his/her lack of reaction, and is also capable of ensuring safety in any weather.

other factors, which can be used to predict maintenance needs, replace equipment, minimize train downtime and reduce the likelihood of accidents. At the railway station, AI plays an important role in ensuring control and safety, monitoring passenger flow, providing personalized service, improved ticket management, and efficient management of energy consumption, lighting and climate at the station.	
5 Robotization and automation of warehouse management	
Various digital technologies are being used to digitalize the warehouse: AI, IoT, digital twin, automation and data analytics. Smart warehouses are equipped with various types of sensors such as RFID tags, temperature, humidity sensors, as well as devices to track the location of goods and equipment in the warehouse, which can monitor the condition of goods, the environment and the operation of equipment in real time. AI is used for demand forecasting, as well as for route optimization, sorting and distribution. Robots play an important role in this concept, which are used to automate processes such as sorting goods, packing, inventory and moving goods around the warehouse. Warehouse management systems (WMS) are being developed, including those with AI components, which combine various technologies to effectively manage all aspects of warehouse operations from receiving goods to shipping.	Russia's X5 Group, which operates the Pyaterochka, Perekrestok and Karusel retail grocery store chains, is using Geek+S20 sorting robots in a number of its distribution centers from 2019.
6 Using AI for driving safety	
AI technologies are actively used to ensure the safety of traffic and vehicle operation. Video-analytics systems of driver's condition (the system detects distractions, driver's drowsiness, which makes it possible to prevent road accidents due to driver's inattention) are actively spreading, and they are also used for traffic monitoring and fixing violations of traffic rules. In addition, telemetry technologies are used in freight forwarding and commercial transportation to monitor driver's driving style and risk profile, and to reconstruct the	In Russia, video analytics from MTS (Skai) analyzes the driver's behavior when the vehicle is moving, and having detected a dangerous condition or behavior, the system immediately warns the driver with an audio/graphic signal and voice notification (regardless of the availability of communication) and sends information about the event to the secure "cloud" SKAI.

circumstances of a road accident. The data obtained can be used to warn the driver, as well as for automated calculation of insurance costs.	
7 Intelligent Transport Systems (ITS)	
AI is being actively used to optimize transportation infrastructure. Modern video analytics systems, connected cars and IoT systems make it possible to analyze data on traffic flows, including information on speed, traffic density and congestion. Using this data in intelligent transport systems allows for more efficient traffic management on roads: controlling the operation mode of traffic lights is one of the most effective ways to optimize traffic flow.	In Russia, as part of the national project "Safe and Quality Highways", AI solutions in the field of traffic flow management are being widely implemented.
8 AI and predictive analytics in transportation and logistics	
8.1 Logistics planning and route optimization	
To allocate resources and manage vehicles, transportation companies use special routing algorithms that are based, among other things, on predictive analytics using machine learning. Such systems for solving routing tasks are capable of learning from data on traffic, weather conditions and other factors to make independent decisions on when and where to send vehicles, what are the ways to optimize planning and how to organize the performance of a particular transportation by the required mode of transport. Such systems provide comprehensive transportation planning and execution capabilities, including fare management, load planning and automated selection of the most appropriate carrier.	Built for Alibaba (China), UPS and project44's "Ware2Go" platform solves the problem of close tracking and logistics coordination by connecting 25,000 e-commerce companies, offering logistics companies smart routing and sorting services, and providing brands with integrated warehousing solutions.
8.2 Demand forecasting	
AI-powered demand forecasting in transportation and logistics helps in planning and optimizing the performance of complex transportation systems. Predictive analytics with AI can more accurately predict demand for transportation services depending on various factors such as time of day, weather, and holidays, as well as plan their resources more efficiently, reduce costs, and improve customer service. Demand forecasting methods include the use of neural networks that are trained on demand data, machine learning algorithms (regression analysis,	Novo Forecast Enterprise software product - allows FMCG and DIY companies, as well as distributors to produce and purchase exactly as much goods as they will be able to sell, minimizing shortages and inventory costs. High forecast accuracy is achieved through the use of Big Data technologies and ML algorithms. This allows companies to create accurate demand plans,

decision trees) and statistical methods (correlation analysis, time series).	align them with financial goals, and optimize supply chain operations.
8.3 Dynamic pricing	
The use of AI-based technologies allows for more accurate forecasting of supply and demand: machine learning algorithms and statistical model building are used, working with observational data, based on which the system/algorithm in an automated format adjusts prices for transportation services in response to changes in external factors important to the company.	The dynamic pricing system developed by Uber (USA) adjusts fares based on a number of variables such as route time and distance, traffic and current demand between drivers. This ensures that there will always be enough drivers on the road, even during peak hours when demand and prices are more likely to increase.
9 AI in vehicle shering systems and in personal mobility equipment (PME)	
AI is used in the shearing industry to improve management processes and service delivery: in demand forecasting, technical condition monitoring, automatic transportation allocation, risk and safety management. One of the promising areas of electric transportation development is AI in PME, which include: electric scooters, electric skateboards, gyroscooters, segways, monowheels and other similar devices. In the field of PME shearing, AI has gained the most traction by improving the use of electric scooters and enhancing road safety. For instance, AI can be used in CCTV cameras to detect violations committed on PME. These devices predominantly work similarly to complexes that record violations by motorists by recognizing vehicle license plates.	A system with traffic cameras capable of detecting traffic violations by PME operators has been tested in Moscow. The devices work on the most popular routes and in places where accidents involving PMEs are concentrated, recognizing three violations: riding off the cycle track and driving in the oncoming lane of the cycle track, driving on PMEs on a crosswalk and driving on one scooter with two people. Spin Insight Level 2 solution developer Drover AI specializes in using IoT artificial intelligence to optimize last-mile transportation services in electric scooters, giving people convenient and fast access from subway stations or public transportation stops to their places of work or residence. The PathPilot platform, using machine learning and computer vision technologies, detects improper sidewalk riding and parking of electric scooters.
10 Digital model of the supply chain	
Digital supply chain model using AI is an innovative approach to managing and optimizing supply chain	Cainiao (China) is working with Procter&Gamble (USA) to develop

processes. It allows tracking and optimizing logistics processes in real time, which helps improve efficiency and reduce costs. Intelligent analysis of aggregated data allows making an optimal set of decisions for each stage of the logistics process: forecasting demand, dynamically adjusting the price for services, choosing the optimal mode of transport and route for transportation. An integrated approach to supply chain management allows to obtain better results compared to separate decision support systems for each process, which is expressed in the strengthening of economic and environmental effects.	the Green Supply Chain digital supply chain system. The system covers and manages the logistics process from purchase to delivery to the consumer. Green Supply Chain is one of the components to achieve Alibaba Group's goals of achieving carbon neutrality and halving emissions by 2030.

Source: based on Intelligent Transportation Systems of Russia (2024)

3 Conclusions

Thus, the considered directions of using AI technologies in the transportation and logistics sphere contribute to improving the efficiency, safety and sustainability of transportation systems. The given examples of using AI solutions demonstrate that AI becomes an indispensable tool for optimizing transport logistics, increasing its efficiency, reliability and cost-effectiveness.

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