

THEORETICAL FOUNDATIONS OF ARTIFICIAL INTELLIGENCE APPLICATION IN THE “SAFE CITY” SYSTEM

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Abstract

This article explores the theoretical foundations of integrating artificial intelligence (AI) into the Safe City system. Key approaches to using AI to improve urban safety are examined, including monitoring, threat prediction, emergency management, and optimization of response resources. International experience in integrating AI into urban security systems is analyzed, identifying the advantages and limitations of such solutions. The role of theoretical models, machine learning algorithms, and big data analytics as the foundation for the functioning of smart city systems is emphasized.

Keywords: Artificial intelligence, smart city, Safe City system, machine learning, big data analytics, predictive security, video analytics.

1. Introduction.

Modern cities face a growing number of threats: crime, emergencies, and natural and man-made disasters. Traditional security methods often struggle to cope with the volume of information and response time. In these circumstances, artificial intelligence (AI) technologies are becoming a key tool for automating threat monitoring, analysis, and prediction, forming the foundation of the “Safe City” system.

The Safe City system involves integrating digital technologies, video surveillance, data analytics, and AI to improve the efficiency of security services and citizen protection. It is important to theoretically justify the use of AI to develop optimal algorithms for analyzing and responding to events.

2. Theoretical aspects of the research.

Artificial intelligence (AI) is an interdisciplinary field of scientific knowledge that combines computer science, mathematics, cognitive science, economics and management, aimed at developing intelligent systems capable of performing functions that traditionally require human thinking¹.

The authors of Wolniak & Stecula note that artificial intelligence in smart cities is used not only for traffic analysis and infrastructure management, but also for predicting threats and optimizing security service resources². Authors Ahmed et al. note that machine

learning and AI algorithms can detect anomalies and potential threats in urban environments, which improves the effectiveness of security services³.

Researchers Ullah et al. note that large language models (LLMs) and deep learning make it possible to analyze huge volumes of unstructured data, improving event forecasting and decision-making in smart cities⁴.

The authors, Xu et al., note in their work that the use of generative AI and digital twins of cities makes it possible to create simulations of urban infrastructure and predict emergency situations or system overloads⁵.

Szpilko et al. also note that AI in smart cities is integrated into all key areas: mobility, energy, ecology, and social services, while its implementation requires consideration of ethical and legal standards⁶. Mohammadi & Al-Fuqaha note that cognitive smart cities are built on the basis of adaptive machine learning and big data analysis, which allows AI systems to learn and improve as they interact with urban infrastructure⁷.

It should be noted that the functions of artificial intelligence include information analysis, learning, decision making, forecasting and adaptation to changing conditions⁸. From a theoretical perspective, AI is viewed as a set of algorithms and models that imitate human cognitive processes based on formalized rules and statistical methods.

¹Russell S., Norvig P. Artificial Intelligence: A Modern Approach. Pearson, 2021.

²Wolniak, R. & Stecula, K. Artificial Intelligence in Smart Cities—Applications, Barriers, and Future Directions: A Review. *Smart Cities*, 2024, 7(3), 1346–1389. DOI:10.3390/smartsities7030057.

³Ahmed, S., Hossain, M.F., Kaiser, MS, Noor, M.B.T., Mahmud, M.R. & Chakraborty, C. Artificial Intelligence and Machine Learning for Ensuring Security in Smart Cities. *Advanced Sciences and Technologies for Security Applications*, 2021, pp.23–47. DOI:10.1007/978-3-030-72139-8_2.

⁴Ullah, A., Qi, G., Hussain, S., Ullah, I., & Ali, Z. The Role of LLMs in Sustainable Smart Cities: Applications, Challenges, and Future Directions. *arXiv*, 2024.

⁵Xu, H., Omitaomu, F., Sabri, S., Zlatanova, S., Li, X., & Song, Y. Leveraging Generative AI for Urban Digital Twins. *arXiv*, 2024.

⁶Szpilko, D., Jimenez Naharro, F., Lăzăroiu, G., Nica, E., & de la Torre Gallegos, A. Artificial Intelligence in the Smart City - A Literature Review. *Engineering Management in Production and Services*, 2023, 15(4).

⁷Mohammadi, M., & Al-Fuqaha, A. Enabling Cognitive Smart Cities Using Big Data and Machine Learning: Approaches and Challenges. *arXiv*, 2018.

⁸Wooldridge M. An Introduction to MultiAgent Systems. Wiley, 2020.

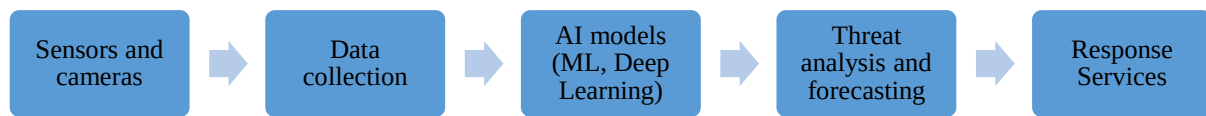


Figure 1. Theoretical model of AI application in the Safe City system⁹

Furthermore, the use of AI in the Safe City system is based on the following theoretical principles:

1. Machine learning (ML) is the use of algorithms to classify and predict events based on historical data.

2. Deep Learning - neural networks for processing complex data such as video and audio streams, face and object recognition.

3. Computer Vision - recognition of objects, faces, and abnormal situations in urban video data streams.

4. Big Data Analytics is the collection and processing of large volumes of information to identify patterns and predict threats.

5. Predictive analytics is the use of AI algorithms to assess the likelihood of incidents and prevent threats.

Key applications of artificial intelligence in urban security include automated monitoring of video and sensor data for the timely detection of anomalies and potential threats. AI is used to predict criminal activity, accidents, and emergencies to optimize emergency response.

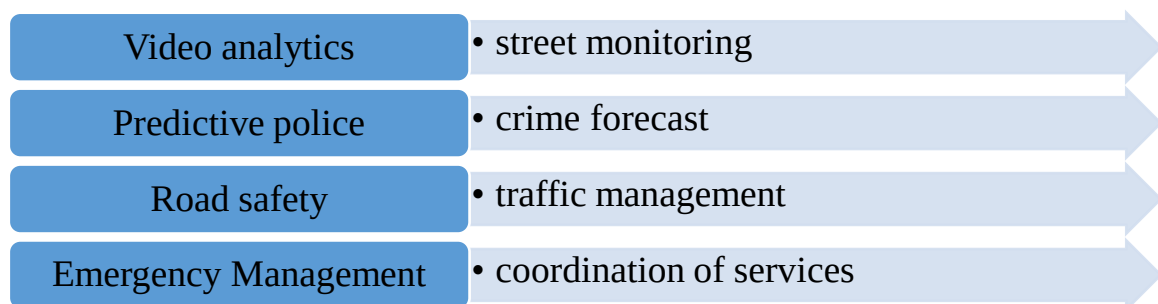


Figure 2. Main areas of AI application in urban security¹⁰

In addition, intelligent algorithms help allocate police, ambulance, and response services resources, improving the efficiency of urban infrastructure and security management.

Theoretical models include a multi-layered smart city architecture, where data from sensors, cameras, and sensors is transmitted to central analytical systems, processed by AI, and generates recommendations for emergency services.

3. Methodological aspects of the research.

The study's methodological framework includes a systemic analysis of existing theoretical models for applying AI in cities, a comparative analysis of international Safe City implementation practices, a content analysis of publications on machine learning and big data analytics for security, and AI-based threat scenario modeling to assess system effectiveness. These analytical methods allow us to identify optimal AI integration algorithms and evaluate the effectiveness of forecasting and automated response processes.

4. International experience of the research.

The United States is a global leader in the development and implementation of artificial intelligence. Government policy is focused on stimulating private investment, developing venture capital, and supporting scientific research. AI is widely used in the financial sector, defense, healthcare, and digital platforms. Universities and research centers play

a significant role in ensuring technology transfer to the real economy.

China is implementing a state-centric model of AI development, viewing it as a strategic resource for national competitiveness. The primary focus is on large-scale digitalization of industry, the use of big data, and the integration of AI into public administration. Significant public investment is enabling China to accelerate the development of intelligent technologies and integrate them into key economic sectors.

Germany is applying AI primarily in the industrial sector as part of the "Industry 4.0" concept. The focus is on intelligent manufacturing, process automation, and energy efficiency. Government support is aimed at developing applied research, standardization, and training qualified personnel, ensuring the sustainable implementation of AI in the economy.

South Korea has demonstrated successful experience in integrating AI into high-tech industries, including electronics, telecommunications, and smart cities. The government's strategy focuses on developing digital infrastructure, supporting startups, and actively using AI in education and public administration. Significant attention is paid to developing human resources in the field of digital technologies.

France, as one of the EU's leaders in AI, is implementing a model based on a combination of

⁹Prepared by the author.

¹⁰Prepared by the author.

innovative development and strict ethical regulation. AI is actively used in the public sector, transportation, healthcare, and energy. The European approach is characterized by a high degree of regulatory oversight aimed at ensuring the transparency, safety, and social responsibility of AI use.

National experience demonstrates that the successful implementation of artificial intelligence requires a systemic approach, including a government strategy, investment in science and education, digital infrastructure development, and effective institutional regulation. International practice can serve as a methodological basis for developing a national AI development model, taking into account the country's socioeconomic characteristics.

5. Analysis and results.

The use of artificial intelligence technologies in the Safe City system significantly improves the efficiency of urban security management. AI enables automated processing of data from CCTV cameras and sensors, predicts potential crimes, accidents, and

emergencies, accelerates emergency response, optimizes resource allocation, and improves the safety of road traffic, urban infrastructure, and public spaces. Intelligent algorithms can identify anomalies in human behavior and traffic flows, facilitating proactive incident prevention and improving service planning.

However, the implementation of AI is associated with a number of limitations and risks. One key issue is ensuring the privacy and protection of citizens' personal data, as the systems process large amounts of information, including video and sensor data. The high cost of implementing and maintaining technical infrastructure, the need for qualified AI and big data analytics specialists, and the difficulty of integrating with existing systems create additional challenges for city administrations. Furthermore, there is a risk of classification errors and false positives, which can lead to incorrect decisions by security services and a decrease in public trust in the technology.

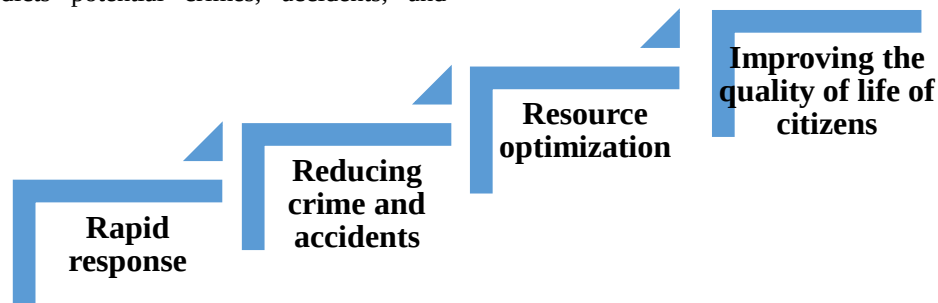


Figure 3. Benefits of integrating AI into the Safe City system¹¹

To effectively and securely integrate AI into the Safe City system, it is necessary to combine technological solutions with the development of a regulatory framework, specialist training, the implementation of transparent algorithm oversight procedures, and continuous monitoring of system performance. Equally important is the creation of mechanisms for interaction between various services, ensuring the rapid exchange of data and a more coordinated response to threats. Only with a comprehensive approach is it possible to create an intelligent, reliable, and ethically sound urban security management system capable of mitigating risks, preventing incidents, and improving the quality of life for residents.

6. Conclusion.

The use of artificial intelligence in the Safe City system relies on modern theoretical models of machine learning, deep learning, and big data analytics, enabling automated monitoring, threat prediction, and optimization of emergency services. Effective implementation of AI requires the development of computing infrastructure, the training of qualified specialists, adherence to data protection principles and the ethicality of algorithms, and the integration of intelligent solutions into existing urban management systems. The comprehensive implementation of AI

creates a safe, intelligent, and resilient urban space capable of promptly identifying and effectively responding to a variety of threats, improving quality of life and the sustainability of the urban environment.

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