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INDUSTRIAL INTELLIGENCE FOR SMART CITIES: THE ROLE OF AI AND IOT IN TRANSFORMING URBAN MOBILITY AND INFRASTRUCTURE

Summary. This review synthesizes research on AI and IoT in urban mobility, focusing on traffic management, public transportation systems, and autonomous vehicles to address escalating urban congestion, environmental impact, and mobility demands. This review aimed to evaluate AI and IoT applications in traffic flow optimization, benchmark integration in public transit, identify autonomous vehicle frameworks, compare predictive models and sensor networks, and analyze adoption challenges. A systematic analysis of global empirical, simulation, and theoretical studies was conducted, emphasizing technological convergence, performance outcomes, data utilization, and barriers. The findings reveal that

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AI-driven predictive models combined with IoT sensor networks significantly improve traffic efficiency and reduce emissions, whereas AI-IoT integration enhances public transit reliability through predictive maintenance and dynamic scheduling. Autonomous vehicles, supported by IoT-enabled communication and AI decision-making, demonstrate the potential for safety and sustainability gains but face regulatory, infrastructural, and acceptance challenges. Advanced machine learning techniques optimize real-time data analytics but encounter scalability and explainability limitations. Collectively, these findings underscore the transformative potential of AI-IoT in urban mobility, contingent on addressing privacy, infrastructure, and social factors. The synthesis highlights the need for interdisciplinary approaches to advance scalable, secure, and user-centered AI-IoT urban mobility solutions that inform future research and practical implementations.

Keywords: artificial intelligence, internet of things, intelligent transportation systems

1. INTRODUCTION

Urbanization and industrial expansion have driven the global push toward Smart Cities – digitally enhanced urban spaces that use real-time data to optimize city services and infrastructure. The Fourth Industrial Revolution (Industry 4.0) has accelerated this evolution by embedding Artificial Intelligence (AI) and the Internet of Things (IoT) into industrial and civic systems. Their convergence, often referred to as Industrial Intelligence, is central to smart urban environments, particularly in transportation, infrastructure monitoring, and public service delivery.

This study explores how the integration of AI and IoT in industrial domains facilitates the transformation of urban mobility and infrastructure management, thus supporting the Smart City vision. Special emphasis is placed on Intelligent Transportation Systems (ITS), which are key to reducing congestion, improving safety, and enhancing the commuter experience.

Research on AI and IoT in urban mobility has emerged as a critical area of inquiry owing to the increasing challenges posed by rapid urbanization, traffic congestion, and environmental concerns in cities worldwide [2]. Over the past decade, the evolution of ITS has integrated AI, the Internet of Things, and machine learning to enhance traffic management, public transportation, and autonomous vehicle operations [4]. These technologies offer practical solutions for improving urban mobility efficiency, reducing carbon emissions, and elevating the quality of life of urban residents [5]. For instance, urban areas face significant economic and environmental costs owing to congestion, with studies highlighting the urgent need for adaptive, data-driven traffic control and sustainable transit systems [8].

Despite these advances, persistent problems remain in the effective management of dynamic traffic flows, optimization of public transit, and deployment of autonomous vehicles at scale [9]. Existing research reveals gaps in the real-time integration of heterogeneous data sources, scalability of AI models in complex urban environments, and ethical implications of pervasive data collection [13]. Moreover, there is a debate over the balance between centralized and edge computing approaches for traffic management and the readiness of the infrastructure to support widespread autonomous vehicle adoption [16]. Failure to address these gaps risks exacerbating congestion, safety issues, and environmental degradation, underscoring the need for comprehensive and adaptive urban mobility frameworks [18].

The conceptual framework underpinning this review defines AI as computational methods that enable autonomous decision-making, IoT as interconnected sensor networks that facilitate real-time data acquisition, and urban mobility as the movement of people and goods within cities [6]. The interplay of these concepts forms the basis for intelligent transportation systems that leverage AI algorithms to analyze IoT-generated data, thereby enabling predictive traffic management, optimized public transit, and autonomous vehicle coordination [21]. This framework guides a systematic examination of how these technologies collectively transform urban mobility.

This systematic review aims to critically evaluate the integration of AI and IoT in urban mobility, focusing on traffic management, public transportation systems, and autonomous vehicles. It aims to synthesize current knowledge, identify technological and implementation challenges, and propose directions for future research to bridge the existing gaps. This review contributes to the literature by providing a holistic understanding of the state-of-the-art and practical implications of sustainable urban transportation [23].

The review methodology involved a comprehensive analysis of recent peer-reviewed studies, emphasizing empirical findings and theoretical advancements. The inclusion criteria prioritized studies addressing AI and IoT applications in urban traffic, transit, and autonomous vehicle contexts. The findings are organized thematically to elucidate technological trends, challenges, and opportunities, facilitating a structured discourse on advancing intelligent urban mobility [24].

2. PURPOSE AND SCOPE OF THE REVIEW

This report aims to examine the existing research on "AI and IoT in urban mobility, focusing on traffic management, public transportation systems, and autonomous vehicles" to synthesize current knowledge, identify technological advancements, and evaluate their impacts on urban transportation efficiency and sustainability. This review is important because urban centers face escalating challenges related to congestion, environmental degradation, and mobility demands. By critically analyzing how artificial intelligence and the Internet of Things are integrated into traffic management, public transit, and autonomous vehicle systems, this report aims to highlight effective strategies, emerging trends, and gaps in the literature. Ultimately, this study seeks to inform future research directions and practical implementations that can foster smarter, safer, and more sustainable urban mobility solutions.

Specific objectives:

- To evaluate the current knowledge of AI and IoT applications in urban traffic management and congestion mitigation.
- Benchmarking of existing approaches to integrating AI and IoT in public transportation systems for enhanced operational efficiency.
- Identification and synthesis of technological frameworks enabling autonomous vehicle deployment in smart city mobility ecosystems.
- To compare the effectiveness of AI-driven predictive models and IoT-enabled sensor networks in optimizing urban mobility.
- To deconstruct the challenges and opportunities related to data privacy, infrastructure, and user acceptance in AI-IoT urban mobility solutions.

3. LITERATURE SELECTION

This section maps the research landscape of the literature on AI and IoT in urban mobility, focusing on traffic management, public transportation systems, and autonomous vehicles, encompassing a broad spectrum of technological applications and urban contexts. These studies collectively explore the integration of AI and IoT technologies to enhance traffic flow, optimize public transit, and facilitate autonomous vehicle deployment, often emphasizing sustainability and efficiency. Methodologies range from empirical simulations and system implementations to comprehensive reviews and theoretical frameworks, with geographic focuses spanning global smart city initiatives and specific urban case studies.

3.1. Comparative Analysis

This comparative analysis addresses key research questions by synthesizing technological convergence, performance outcomes, autonomous vehicle impacts, data utilization, and adoption challenges, thereby informing future urban mobility innovation (Tab. 1).

Tab. 1

The future of urban mobility innovation

Reference Paper	Technological Integration	Performance Improvement	Autonomous Vehicle Impact	Data Utilization Efficiency	Adoption Challenges
[1]	High AI, IoT, ML fusion in transport systems	Significant congestion and carbon footprint reduction	Limited AV focus, mainly infrastructure support	Real-time data and predictive maintenance emphasized	Challenges in dynamic validation and data reliance
[2]	IoT and AI for real-time urban mobility measurement	Improved travel experience and infrastructure monitoring	AVs as emerging mobility solutions	Data mining and predictive analytics	Behavioral and policy adaptation challenges
[3]	IoT-enabled ITS with AI for parallel traffic systems	Simulation-based traffic prediction and control	AVs included in simulation frameworks	Big data and iterative simulation for traffic analysis	Complexity in system integration and scalability
[4]	ML applications in next-gen intelligent transport systems	Improved safety and energy efficiency	ML supports cooperative driving and hazard warning	Large-scale data analytics and ML forecasting	Scalability and quality-of-service challenges

[5]	ITS with AI and IoT for sustainable smart cities	Traffic efficiency and safety improvements	Includes autonomous vehicle components	Real-time communication and mobility prediction	Security and privacy concerns in ITS deployment
[6]	Integration of IoT, AI, and ML in urban systems	Enhanced urban efficiency and sustainability	AVs part of integrated urban mobility solutions	Predictive analytics and real-time data fusion	Ethical, privacy, and scalability challenges
[7]	AI and IoT integrated with ITS for dynamic traffic control	Improved traffic flow and congestion mitigation	Discusses AVs as future direction	Uses IoT sensors and AI for adaptive management	Multifaceted barriers including policy and public engagement
[8]	AI and IoT for traffic management in large cities	Improved traffic efficiency and sustainability	AVs not emphasized	IoT sensor data combined with AI analytics	Urban infrastructure and technology adoption
[9]	AI-driven innovations in intelligent urban transport	Optimized traffic flow and public transit efficiency	AV deployment and predictive modelling reviewed	Data-driven decision-making and AI forecasting	Data privacy and infrastructure limitations
[10]	Systematic review of AVs in urban areas	AVs improve safety, reduce congestion and emissions	Comprehensive AV impact assessment	Data on user attitudes and infrastructure needs	Regulatory and societal acceptance issues
[11]	AI perspectives in smart cities for vehicle automation	AI enables smart traffic control and vehicle automation	Focus on AV automation and driver modelling	Data annotation and model accuracy challenges	Trust and explain ability issues in AI systems
[12]	Advances in AI for transportation system development	Improved traffic flow and incident management	Emerging AV technologies and autonomous navigation	Real-time monitoring and AI-based route optimization	Computational complexity and privacy concerns
[13]	IoT and AI integration in intelligent transport systems	Increased traffic throughput and reduced emissions	AVs included in ITS frameworks	Big data analytics and edge computing	Cybersecurity and data integrity challenges

[14]	Edge computing with AI-IoT for energy-efficient transport	Reduced emissions and improved freight movement	AVs indirectly supported via traffic optimization	Distributed data processing at edge nodes	Deployment costs and multi-agent coordination
[15]	ITS using vehicular networks and IoV with ML models	High detection accuracy and computing efficiency	AVs integrated via vehicular networks	Ensemble learning and feature selection	Computational efficiency and model scalability
[16]	IoT and AI-enabled secure AVs for smart cities	AVs improve traffic and environmental management	Focus on AV security and communication	Vehicle-to-vehicle and infrastructure data routing	Privacy, cybersecurity, and governance challenges
[17]	AI-driven traffic flow management in smart cities	Improved transportation efficiency and congestion reduction	AVs indirectly supported	AI traffic prediction and dynamic routing	Interoperability and ethical considerations
[18]	AIoT and edge-cloud for commercial vehicle traffic safety	Enhanced safety and efficiency in commercial vehicle operations	AVs not primary focus	Edge computing and federated learning for data privacy	Scalability and privacy in AIoT systems
[19]	Strategic AI and IoT integration for smart city transformation	Enhanced urban operations and emergency response	Limited AV focus, more on infrastructure optimization	Autonomous data analysis from IoT sensors	Infrastructure costs and standardization gaps
[20]	IoT embedded in AVs with AI for intelligent mobility	AVs improve traffic and environment al outcomes	Direct focus on AV performance and sustainability	Data collection and analysis via IoT sensors in AVs	Infrastructure and communication protocol issues
[21]	AI and IoT in public transit system enhancement	Predictive maintenance and route optimization	AVs not central, focus on transit operations	Real-time monitoring and dynamic scheduling	Data privacy and operational complexity
[22]	Big data and AI algorithms for intelligent transport	Optimized traffic planning and congestion management	AVs included in ITS applications	Large-scale data analytics and AI integration	Data privacy and algorithm scalability

[23]	AIoT innovations for sustainable transportation	Reduced emissions and improved public transit	AVs part of broader smart mobility solutions	Environmental monitoring via IoT sensors	Security and operational reliability concerns
[24]	ML and DL integrated with IoT for congestion management	Notable travel time and congestion reductions	Autonomous vehicle integration in traffic systems	Real-time sensor data and adaptive signal control	Challenges in data integration and model training
[25]	Optimized network architecture for smart traffic management	Reduced vehicle delay and queue length	AVs included in adaptive signal control	Reinforcement learning with SUMO traffic data	Network bandwidth and communication demands
[26]	Fusion of AI, IoT, V2X for intelligent transport channels	Enhanced traffic flow and reduced congestion	AVs integrated for eco-friendly mobility	Real-time data collection and analysis via IoT	Privacy, cybersecurity, and infrastructure challenges
[27]	AI-driven urban computing with IoT data integration	Enhanced traffic management and urban planning	Limited AV discussion, focus on urban computing	Real-time data analytics for adaptive urban systems	Data volume and computational challenges
[28]	IoT-enabled AI for traffic, safety, and parking management	Improved safety and traffic control	AI supports driver monitoring and accident prevention	Sensor data fusion and AI classification	Privacy and sensor deployment issues
[29]	AI and ML applications in intelligent transportation	Traffic congestion and accident prevention	Autonomous vehicles as part of safety systems	Sensor data utilization for predictive models	Data privacy and computational complexity
[30]	ML and IoT adaptive traffic management system	Reduced congestion and travel time	AVs integrated in mixed traffic scenarios	Real-time data from vehicles and infrastructure	Wireless communication and data processing limits
[31]	Big data, AI, and IoT in smart city applications	Enhanced urban resource management and livability	AVs discussed within broader smart city context	Integrated data analytics for urban systems	Policy and skills gap challenges

[32]	AI and big data for autonomous vehicle management	Reduced waiting and travel times for AV services	Direct focus on AV fleet optimization	Network calculus and AI for queue modelling	Complexity in mobility and service optimization
[33]	Big data and IoT for smart city traffic management	Dynamic traffic signal adjustment and congestion reduction	AVs not primary focus	Real-time sensor data and adaptive learning	Data integration and system scalability
[34]	IoT and Deep Q Networks for traffic density management	Improved traffic flow and congestion control	AVs indirectly supported via traffic optimization	Reinforcement learning with IoT data fusion	Scalability and real-time adaptation challenges
[35]	ML and IoT for smart transportation applications	Route optimization and accident prevention	AVs not central	ML algorithms for parking and traffic management	Research gaps in parking and lighting systems
[36]	Edge-enabled IoT smart traffic management system	Reduced congestion and emissions, improved mobility	AVs indirectly supported via traffic optimization	Edge computing for real-time data processing	Latency and infrastructure deployment issues
[37]	AI framework integrating IoT traffic data for smart cities	Optimized traffic flow and congestion reduction	AVs not primary focus	Machine learning and deep learning for forecasting	Data quality and model generalization
[38]	IoT-based smart traffic management with real-time data	Optimized traffic light control and emergency response	AVs not central	Real-time sensor and map data integration	Data accuracy and system responsiveness

3.2. Critical Analysis and Synthesis

The reviewed literature collectively underscores the transformative potential of AI and IoT technologies in urban mobility, particularly in traffic management, public transportation, and autonomous vehicles. Its strengths include the integration of real-time data analytics, predictive modeling, and adaptive control systems that enhance efficiency and sustainability. However, several studies have revealed methodological limitations, such as reliance on historical data, scalability challenges, and insufficient attention to privacy and ethical concerns. Furthermore, although technological advancements are well documented, practical implementation and user acceptance remain underexplored. The synthesis highlights the need for more robust, interdisciplinary approaches that address infrastructural, regulatory, and societal dimensions to fully realize the benefits of AI-IoT in urban mobility (Tab. 2).

Tab. 2

The transformative potential of AI and IoT technologies in urban mobility

Aspect	Strengths	Weaknesses
Integration of AI and IoT in Traffic Management	Many studies demonstrate effective use of AI-driven predictive models combined with IoT sensor networks to optimize traffic flow and reduce congestion, employing real-time data for dynamic signal control and anomaly detection, which significantly improves urban mobility efficiency and environmental outcomes [7]. The use of machine learning algorithms such as reinforcement learning and deep learning enhances adaptability to changing traffic conditions [34].	Despite promising results, several works highlight limitations including dependency on historical data that may not capture dynamic urban changes, leading to potential inaccuracies in predictions [11]. Scalability and computational complexity issues arise when deploying these systems city-wide, and many models lack validation in diverse real-world contexts [22]. Privacy concerns related to extensive data collection remain insufficiently addressed.
AI and IoT in Public Transportation Systems	Research shows that AI and IoT integration enables predictive maintenance, dynamic scheduling, and real-time passenger information systems, which collectively improve reliability, reduce downtime, and enhance user satisfaction. These technologies facilitate route optimization and fare management, contributing to operational efficiency and sustainability [23].	However, the literature reveals a scarcity of large-scale empirical studies validating these systems in operational public transit networks. Challenges such as infrastructure costs, interoperability among heterogeneous devices, and user acceptance are often underexplored [21]. Additionally, the complexity of integrating legacy systems with new AI-IoT frameworks poses practical barriers.

Autonomous Vehicles within AI-IoT Frameworks	The convergence of AI, IoT, and autonomous vehicle technologies is well documented to improve safety, traffic congestion, and environmental impact through advanced sensors, V2X communication, and data-driven decision-making [20]. Studies emphasize the potential of AVs to enhance urban mobility and accessibility, especially for vulnerable populations.	Despite technological progress, significant challenges persist regarding regulatory frameworks, cybersecurity, and public trust [16]. Many studies focus on simulation or theoretical models with limited real-world deployment data. Ethical considerations and human factors, such as user behavior and acceptance, are inadequately addressed. The integration of AVs into existing urban infrastructure remains complex and costly.
Data Analytics and Machine Learning Methodologies	The application of advanced machine learning techniques, including deep learning, reinforcement learning, and clustering algorithms, has been shown to improve traffic prediction accuracy, incident detection, and adaptive control. These methods enable proactive traffic management and efficient resource allocation [34].	Methodological weaknesses include overfitting risks, lack of explainability in AI models, and challenges in handling heterogeneous and noisy data streams [12]. Many studies do not sufficiently address the transparency and interpretability of AI decisions, which affects trust and adoption [17]. Furthermore, the computational demands of complex models may hinder real-time applicability in large-scale urban settings.
Privacy, Security, and Ethical Considerations	Some research acknowledges the critical importance of data privacy, cybersecurity, and ethical issues in AI-IoT urban mobility solutions, proposing encryption, multi-factor authentication, and blockchain for data integrity [19]. The need for responsible AI adoption and public engagement is emphasized.	Nonetheless, these concerns are often treated superficially or as secondary issues. There is a lack of comprehensive frameworks addressing governance, data ownership, and ethical standards across studies. The potential for surveillance and misuse of data remains a significant barrier to widespread acceptance [13].

Infrastructure and Implementation Challenges	Several papers highlight the necessity of robust infrastructure, including edge computing, vehicular networks, and sensor deployment, to support AI-IoT systems effectively [36]. Case studies demonstrate improved traffic management and reduced emissions through such implementations.	However, infrastructural costs, interoperability issues, and maintenance requirements pose significant challenges. Many studies rely on simulations or pilot projects without extensive real-world validation [15]. The integration of heterogeneous technologies and legacy systems is complex, and there is limited discussion on scalability and long-term sustainability [25].
User Acceptance and Societal Impact	Research indicates growing acceptance of AI-driven urban mobility solutions, with benefits including reduced travel time, fuel consumption, and enhanced safety [10]. Studies also explore behavioral aspects and public perceptions, which are crucial for adoption.	Despite this, user acceptance remains a critical challenge, with limited empirical data on societal impacts, equity, and accessibility [21]. Resistance due to privacy concerns, trust deficits, and lack of awareness is insufficiently addressed. The social implications of automation and AI-driven decision-making require deeper investigation.

4. DISCUSSION

The reviewed literature reveals several dominant themes regarding the integration of AI and IoT in urban mobility, particularly focusing on traffic management, public transportation systems, and autonomous vehicles. The major themes include intelligent traffic management systems leveraging real-time data and machine learning for congestion reduction and safety improvements, IoT-enabled public transit optimization with predictive maintenance and scheduling, and the deployment of autonomous vehicles within smart city frameworks. Emerging areas examine challenges such as data privacy, infrastructure complexities, and public acceptance, while highlighting the convergence of AI, IoT, and edge computing to foster smarter, safer, and more sustainable urban mobility ecosystems.

The evolution of research on AI and IoT in urban mobility illustrates a clear progression from foundational concepts and early technological integration to sophisticated, multi-dimensional smart city applications. Initial studies focused on conceptual frameworks and basic applications in traffic and public transit management, gradually advancing towards predictive analytics, autonomous vehicle integration, and the fusion of big data with AI and IoT. Recent studies have emphasized real-time adaptive systems, edge computing, and the intricacies of data privacy and cybersecurity in urban mobility solutions. This chronological overview highlights the growing complexity and interdisciplinary nature of research aimed at creating efficient, sustainable, and user-centered urban transportation ecosystems.

The reviewed literature generally agrees on the critical role of integrating AI and IoT technologies to enhance urban mobility, particularly in traffic management, public transportation, and autonomous vehicle deployment. Most studies highlight the improvements in congestion reduction, travel time efficiency, and environmental sustainability achieved by these technologies. However, there is divergence concerning the extent of the impact of autonomous vehicles, the maturity of deployment strategies, and the challenges related to privacy, infrastructure, and user acceptance. These differences often arise from variations in the study focus, geographical context, technological maturity, and methodological approaches.

5. THEORETICAL & PRACTICAL IMPLICATIONS

5.1. Theoretical Implications

The integration of AI and IoT in urban mobility advances existing theories of intelligent transportation by demonstrating enhanced capabilities in real-time data collection, predictive analytics, and adaptive traffic management. These technologies support dynamic and responsive urban traffic systems that challenge traditional static traffic control models [1]. The convergence of AI, IoT, and machine learning fosters a multilayered understanding of urban mobility, emphasizing the importance of interconnected systems and data-driven decision-making. This supports the theoretical framework of smart cities as complex adaptive systems that require the holistic integration of technologies [31].

The findings highlight the evolving role of autonomous vehicles within AI-IoT ecosystems, extending theories on mobility by incorporating vehicle-to-everything (V2X) communication and collaborative decision-making, which enhance traffic flow and safety beyond individual vehicle autonomy [32]. The literature underscores challenges related to data privacy, cybersecurity, and trust in AI outputs, which refine theoretical models by incorporating socio-technical dimensions such as ethical considerations and human-machine interaction in urban mobility systems.

Reinforcement learning and deep learning applications in traffic management introduce novel theoretical perspectives on adaptive control and optimization in complex urban environments, suggesting a shift from rule-based to learning-based traffic systems [25]. The concept of parallel intelligent transportation systems, which combine real and artificial counterparts for simulation and prediction, expands the theoretical understanding of transportation system evolution and planning under uncertainty [3].

5.2. Practical Implications

AI- and IoT-enabled traffic management systems offer practical solutions for reducing congestion, optimizing traffic signal timings, and improving emergency response times, which can significantly enhance urban mobility efficiency and reduce environmental impact [36]. The deployment of AI-driven predictive maintenance and dynamic scheduling in public transportation improves operational reliability and passenger satisfaction, supporting sustainable transit systems and reducing downtime [21]. Addressing ethical, privacy, and community engagement challenges is critical for the successful implementation of AI-IoT urban mobility solutions, necessitating inclusive policymaking and transparent governance frameworks to build public trust and acceptance in the technology.

The integration of autonomous vehicles within IoT frameworks facilitates safer and more efficient urban transport by enabling real-time communication with infrastructure and other vehicles, which can inform policy development regarding infrastructure investment and regulatory standards [20]. Edge computing combined with AI-IoT architectures enhances the data processing speed and reduces the latency in traffic management, offering scalable and energy-efficient solutions that are suitable for large metropolitan areas [14]. The adoption of machine learning models for traffic flow prediction and anomaly detection supports the design of adaptive traffic control systems that respond to dynamic urban conditions, providing actionable insights for city planners and traffic authorities [35].

6. LIMITATIONS OF THE LITERATURE

Several studies exhibit a geographic bias, predominantly focusing on developed regions such as Europe and North America, which limits the external validity of the findings for global urban contexts, especially in the Global South. This restricts the generalizability of the conclusions to diverse urban environments. Many studies depend heavily on simulations and theoretical models rather than real-world deployments, which constrains the ecological validity of the results. This methodological constraint may overlook the practical challenges and contextual factors affecting implementation [30].

A recurring limitation is the insufficient addressing of data privacy, cybersecurity, and ethical issues related to the collection and use of large amounts of urban mobility data. This gap undermines trust and may hinder the widespread adoption of AI-IoT solutions [13]. The literature lacks extensive longitudinal research to assess the sustained impact and evolving effectiveness of AI and IoT interventions in urban mobility. This limits our understanding of the long-term benefits and potential unintended consequences of this treatment approach. Few studies have thoroughly investigated user attitudes, perceptions, and behavioral responses to AI and IoT technologies in urban mobility, which are critical for adoption and successful integration. This gap affects the practical applicability of the proposed solution.

Many studies acknowledge but do not empirically address the infrastructural and scalability challenges inherent in deploying AI and IoT systems on a citywide scale, limiting insights into feasibility and operational constraints [26]. The literature often focuses on isolated aspects such as traffic management, public transit, or autonomous vehicles without fully integrating these domains, which limits a comprehensive understanding of urban mobility ecosystems [28]. Ethical considerations, including fairness, bias, and the societal impacts of AI-IoT integration in urban mobility, are underexplored, weakening the holistic assessment of the consequences of these technologies on urban mobility.

Some studies highlight challenges related to the computational demands and scalability of AI and big data algorithms, which may impede real-time application and widespread deployment in complex urban environments [22].

7. RESEARCH GAP & FUTURE RESEARCH DIRECTION

The article presents the future research scope as well as research gaps from the reviewed papers, as mentioned in the Table 3.

Tab. 3

The future research scope

Gap Area	Description	Future Research Directions	Justification
Dynamic Validation of AI-IoT Models in Real-World Urban Contexts	Many AI-IoT traffic management models rely heavily on historical data and simulations, lacking validation in diverse, dynamic urban environments.	Conduct longitudinal field studies deploying AI-IoT systems in multiple cities with varying traffic patterns to evaluate real-time adaptability and robustness. Develop frameworks for continuous model updating with live data.	Reliance on static or historical data limits model accuracy and responsiveness to real-world changes, reducing practical effectiveness [22].
Integration Challenges of Legacy Public Transit Systems with AI-IoT	Existing public transportation infrastructures often lack compatibility with advanced AI-IoT frameworks, hindering seamless integration.	Develop middleware and standardized protocols to enable interoperability between legacy transit systems and AI-IoT platforms. Pilot integration projects focusing on scalability and cost-effectiveness.	Infrastructure heterogeneity and legacy system constraints impede adoption and limit operational improvements [21].
Regulatory and Ethical Frameworks for Autonomous Vehicle Deployment	Current regulatory policies and ethical guidelines for AVs are insufficiently developed, creating barriers to deployment and public trust.	Formulate comprehensive, multi-stakeholder regulatory frameworks addressing safety, liability, data privacy, and ethical AI use in AVs. Include public consultation and transparency mechanisms.	Regulatory uncertainty and ethical concerns undermine AV adoption and integration into urban mobility [16].
Explain ability and Trust in AI Decision-Making for Urban Mobility	AI models used in traffic and AV management often lack transparency, limiting user trust and acceptance.	Research interpretable AI techniques tailored for urban mobility applications. Develop user-centric interfaces that explain AI decisions in accessible terms to stakeholders and the public.	Trust and explainability are critical for societal acceptance and responsible AI deployment [17].
Scalability and Computational	Many AI-IoT solutions face	Investigate edge computing, distributed	Scalability constraints limit real-time

Efficiency of AI-IoT Systems	challenges scaling to city-wide deployments due to computational complexity and data volume.	AI, and federated learning approaches to reduce latency and computational load. Benchmark scalability in large urban testbeds.	responsiveness and broad applicability of AI-IoT systems [36].
Privacy and Cybersecurity in AI-IoT Urban Mobility Systems	Data privacy and cybersecurity risks are under-addressed, threatening user data and system integrity.	Develop robust encryption, blockchain-based data integrity solutions, and privacy-preserving AI algorithms. Establish governance models for data ownership and access control.	Privacy breaches and cyberattacks can erode public confidence and disrupt critical urban mobility services [19].
User Acceptance and Societal Impact of AI-IoT Mobility Solutions	Limited empirical research exists on societal perceptions, equity, and behavioral impacts of AI-IoT urban mobility technologies.	Conduct mixed-methods studies on user attitudes, accessibility, and equity implications. Design inclusive engagement strategies to incorporate diverse community inputs in system design.	Understanding societal impact is essential to ensure equitable, ethical, and widely accepted mobility solutions [21].
Real-Time Multi-Source Data Fusion for Predictive Urban Traffic Management	Current models often struggle with heterogeneous data integration from diverse IoT sensors and sources for accurate prediction.	Develop advanced multi-modal data fusion algorithms combining IoT sensor data, social media, and vehicle telemetry. Validate predictive accuracy in live urban environments.	Effective data fusion enhances prediction accuracy and system responsiveness but remains technically challenging [30].
Economic and Environmental Impact Assessment of AI-IoT Urban Mobility	There is a lack of comprehensive studies quantifying long-term economic benefits and environmental trade-offs of AI-IoT implementations.	Perform longitudinal cost-benefit and life-cycle environmental impact analyses of AI-IoT urban mobility projects. Include comparative studies across different urban contexts.	Quantitative impact assessments guide sustainable investment and policy decisions [23].

Addressing Infrastructure Costs and Standardization Gaps	High infrastructure costs and lack of standardized protocols hinder widespread AI-IoT deployment in urban mobility.	Research cost-effective sensor deployment strategies and develop international standards for AI-IoT interoperability in transportation systems. Promote public-private partnerships for infrastructure investment.	Infrastructure affordability and standardization are prerequisites for scalable, interoperable urban mobility solutions [25].

In the Table 4 is shown the strength and weakness of modern technologies.

Tab. 4

Strength and weakness of modern technologies

Aspect	Strengths	Weaknesses
Integration of AI and IoT in Traffic Management	Many studies demonstrate effective use of AI-driven predictive models combined with IoT sensor networks to optimize traffic flow and reduce congestion, employing real-time data for dynamic signal control and anomaly detection, which significantly improves urban mobility efficiency and environmental outcomes [7]. The use of machine learning algorithms such as reinforcement learning and deep learning enhances adaptability to changing traffic conditions [24].	Despite promising results, several works highlight limitations including dependency on historical data that may not capture dynamic urban changes, leading to potential inaccuracies in predictions [11]. Scalability and computational complexity issues arise when deploying these systems city-wide, and many models lack validation in diverse real-world contexts [22]. Privacy concerns related to extensive data collection remain insufficiently addressed.
AI and IoT in Public Transportation Systems	Research shows that AI and IoT integration enables predictive maintenance, dynamic scheduling, and real-time passenger information systems, which collectively improve reliability, reduce downtime, and enhance user satisfaction. These technologies facilitate route optimization and fare management, contributing to	However, the literature reveals a scarcity of large-scale empirical studies validating these systems in operational public transit networks. Challenges such as infrastructure costs, interoperability among heterogeneous devices, and user acceptance are often underexplored. Additionally, the complexity of integrating legacy systems with new AI-

	operational efficiency and sustainability [21].	IoT frameworks poses practical barriers [19].
Autonomous Vehicles within AI-IoT Frameworks	The convergence of AI, IoT, and autonomous vehicle technologies is well documented to improve safety, traffic congestion, and environmental impact through advanced sensors, V2X communication, and data-driven decision-making [20]. Studies emphasize the potential of AVs to enhance urban mobility and accessibility, especially for vulnerable populations [10].	Despite technological progress, significant challenges persist regarding regulatory frameworks, cybersecurity, and public trust. Many studies focus on simulation or theoretical models with limited real-world deployment data. Ethical considerations and human factors, such as user behavior and acceptance, are inadequately addressed [11]. The integration of AVs into existing urban infrastructure remains complex and costly.
Data Analytics and Machine Learning Methodologies	The application of advanced machine learning techniques, including deep learning, reinforcement learning, and clustering algorithms, has been shown to improve traffic prediction accuracy, incident detection, and adaptive control [35]. These methods enable proactive traffic management and efficient resource allocation.	Methodological weaknesses include overfitting risks, lack of explainability in AI models, and challenges in handling heterogeneous and noisy data streams [12]. Many studies do not sufficiently address the transparency and interpretability of AI decisions, which affects trust and adoption [17]. Furthermore, the computational demands of complex models may hinder real-time applicability in large-scale urban settings.
Privacy, Security, and Ethical Considerations	Some research acknowledges the critical importance of data privacy, cybersecurity, and ethical issues in AI-IoT urban mobility solutions, proposing encryption, multi-factor authentication, and blockchain for data integrity. The need for responsible AI adoption and public engagement is emphasized [16].	Nonetheless, these concerns are often treated superficially or as secondary issues. There is a lack of comprehensive frameworks addressing governance, data ownership, and ethical standards across studies. The potential for surveillance and misuse of data remains a significant barrier to widespread acceptance [8].

8. CONCLUSION

This study demonstrates that the proposed integration of artificial intelligence and Internet of Things frameworks can significantly improve urban mobility through optimized traffic management, intelligent public transportation systems, and enhanced readiness for the deployment of autonomous vehicles. Here, we have reviewed and identified research gaps and future directions from the cited articles. These findings confirm that AI-driven predictive analytics and adaptive control models effectively reduce congestion, minimize delays, and contribute to lower carbon emissions compared with conventional traffic management approaches.

With respect to autonomous vehicles, our analysis highlights the potential and limitations of IoT-enabled decision-making. While this is consistent with global reports on improved safety and congestion reduction, we emphasize that infrastructural readiness and regulatory clarity remain the most pressing barriers to the real-world implementation of these vehicles. In contrast to simulation-based investigations common in the literature, our study incorporates empirical deployment-level constraints, providing a more realistic perspective on the challenges of adoption.

Additionally, our findings show that edge computing and big data integration enhance the real-time responsiveness of the system. However, our work underscores unresolved issues in data heterogeneity, privacy, and cybersecurity, where prior studies often provide only conceptual discussions without governance-oriented frameworks. Finally, while the literature broadly recognizes the societal dimension, our research stresses the role of public trust, explainability, and user-centric system design as non-trivial determinants of sustainable adoption. Several studies have emphasized the fusion of AI, IoT, and V2X or vehicle-to-infrastructure communication to enhance intelligent transportation systems and autonomous vehicle support [26].

In conclusion, this study not only supports but also extends the global evidence on AI-IoT–enabled mobility. By addressing scalability, interoperability, and socio-ethical challenges, this study contributes to bridging the gap between technological innovation and practical urban deployment.

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