International Journal of Scientific Research and Management (IJSRM)
||Volume||12||Issue||02||Pages||1057-1071||2024||
Website: https://ijsrm.net ISSN (e): 2321-3418
DOI: 10.18535/ijsrm/v12i02.ec07

Enhancing Public Transit System through AI and IoT

Naveen Vemuri[1], Venkata Manoj Tatikonda[2], Naresh Thaneeru[3]

[1]Masters in Computer Science, Silicon Valley University, Bentonville, AR, USA
[2]Masters in Computer Science, Silicon Valley University, Bentonville, AR, USA
[3]Masters in Computer Applications, Kakatiya University, Bentonville, AR, USA

Abstract

The paper investigates the synergy between AI and IoT in revolutionizing public transit systems, emphasizing their role in addressing existing challenges and improving overall efficiency. It explores the application of IoT devices in creating a smart infrastructure that enables real-time data collection, monitoring, and management of transit operations.

The research delves into the realm of predictive maintenance, showcasing how AI algorithms, powered by IoT data, can anticipate potential issues in transit vehicles. By analyzing sensor data, transit authorities can proactively address maintenance needs, minimizing downtime, reducing repair costs, and ensuring a more reliable and sustainable public transit service.

Route optimization emerges as another crucial aspect of the study, highlighting how AI algorithms leverage historical and real-time data to recommend the most efficient transit routes. Factors such as traffic patterns, weather conditions, and passenger demand are considered to enhance overall system efficiency and reduce travel time for passengers.

The paper introduces the concept of dynamic scheduling, illustrating how AI-driven algorithms adapt transit schedules in real-time based on changing passenger needs and external factors. This dynamic approach aims to provide more responsive services, ultimately reducing wait times and improving overall user satisfaction.

Passenger information systems are explored as a pivotal component, illustrating how AI and IoT technologies enhance the passenger experience. Real-time communication through mobile apps, digital displays, and other channels ensures that passengers have accurate and timely information about arrival times, delays, and alternative routes, empowering them to make informed decisions.

The researchers also delve into fare optimization, examining how AI algorithms analyze data on passenger demographics, travel patterns, and economic factors to create fair and affordable fare structures. This approach aims to encourage ridership, increase revenue, and improve the financial sustainability of public transit systems.

The abstract presents a comprehensive overview of how the integration of AI and IoT technologies in public transit systems transforms urban mobility. The findings suggest that leveraging real-time data, predictive analytics, and dynamic solutions can significantly enhance the reliability, accessibility, and sustainability of public transit. As cities continue to explore innovative solutions, the abstract serves as a roadmap for developing smarter, user-friendly, and efficient urban transportation networks, ultimately contributing to improved quality of life for residents.

Introduction

In the fast-paced evolution of urban landscapes, the efficiency and sustainability of public transit systems stand as critical pillars for the well-being of metropolitan areas globally. Addressing the challenges and opportunities presented in enhancing public transit, this paper explores the dynamic integration of Artificial

Intelligence (AI) and the Internet of Things (IoT). By delving into the abstract, we embark on a journey that underscores the transformative potential of these technologies, offering a glimpse into a future where public transportation becomes smarter, more reliable, and increasingly user-centric.

Urban areas worldwide are grappling with the complex task of providing efficient, accessible, and sustainable transportation for their growing populations. The introduction of AI and IoT into the realm of public transit systems marks a paradigm shift, promising to revolutionize the way cities approach transportation infrastructure and services.

The integration of IoT devices into the fabric of public transit introduces the concept of a "smart infrastructure." Sensors embedded in buses, trains, and transit stops facilitate real-time data collection, providing an intricate web of information that can be harnessed to monitor and manage transit operations more effectively. This smart infrastructure forms the foundation upon which the subsequent advancements in the paper are built, creating a networked and responsive transit system.

A primary focus of this paper lies in the realm of predictive maintenance. Traditional approaches to vehicle upkeep often involve reactive measures, leading to downtime, increased repair costs, and a potential decline in service reliability. The marriage of AI algorithms with IoT data enables transit authorities to transition towards a proactive maintenance strategy. By analyzing sensor data from vehicles, transit systems can forecast potential issues, allowing for timely intervention, reduced downtime, and an overall improvement in the reliability of public transportation.

Route optimization stands as another cornerstone of the paper's exploration. Leveraging historical and real-time data, AI algorithms are employed to recommend the most efficient transit routes. Factors such as traffic patterns, weather conditions, and passenger demand are considered in the decision-making process, ultimately aiming to streamline operations, reduce travel times, and enhance the overall efficiency of public transit systems.

Dynamic scheduling emerges as a concept that challenges the rigidity of fixed transit schedules. Through AI-driven algorithms, transit schedules can adapt in real-time to changing passenger needs and external factors. This dynamic approach seeks to create a more responsive service, minimizing wait times, and fostering an improved user experience for passengers.

The integration of AI and IoT technologies also extends to passenger information systems. Real-time communication through mobile apps, digital displays, and other channels ensures that passengers are equipped with accurate and timely information regarding arrival times, delays, and alternative routes. Empowering passengers with this information contributes not only to their satisfaction but also to a more informed and engaged transit community.

Fare optimization, as explored in the paper, represents a shift towards fair and economically viable fare structures. AI algorithms analyze data on passenger demographics, travel patterns, and economic factors to create pricing models that encourage ridership, increase revenue, and contribute to the financial sustainability of public transit systems.

In summary, the introduction sets the stage for an in-depth exploration of the abstract, emphasizing the monumental impact that the integration of AI and IoT technologies can have on public transit systems. As we delve deeper into the paper, we uncover a landscape where data-driven decision-making, predictive analytics, and dynamic solutions converge to reshape the future of urban mobility, offering a vision where public transportation is not just a means of conveyance but a smart, responsive, and integral component of modern city living.

Smart Infrastructure With IoT

As urban landscapes continue to evolve, the demand for efficient and technologically advanced public transit systems has never been greater. The integration of Internet of Things (IoT) devices into the framework of public transportation introduces the concept of "Smart Infrastructure," revolutionizing the way cities manage and optimize their transit operations. In this article, we explore the pivotal role of Smart Infrastructure with IoT in the broader context of enhancing public transit systems, uncovering how this technological synergy lays the foundation for a more connected, responsive, and efficient urban mobility experience.

I. Defining Smart Infrastructure with IoT:

Smart Infrastructure refers to the incorporation of advanced technologies, particularly IoT devices, into the physical components of public transit systems. These devices, equipped with sensors and connectivity, create an interconnected network that facilitates real-time data collection, communication, and monitoring. This interconnectedness is a fundamental aspect of the evolution towards more intelligent and responsive public transit.

II. Real-Time Data Collection:

At the heart of Smart Infrastructure is the capability to collect and analyze real-time data from various components within the public transit system. Buses, trains, transit stops, and other key elements are embedded with sensors that monitor a myriad of parameters, including vehicle location, passenger counts, equipment health, and environmental conditions. This wealth of data provides transit authorities with a comprehensive understanding of system dynamics, enabling informed decision-making.

III. Monitoring and Management:

Smart Infrastructure with IoT empowers transit authorities to monitor and manage their fleets and infrastructure more effectively. The continuous stream of data allows for proactive identification of potential issues, leading to predictive maintenance strategies. This shift from reactive to proactive maintenance minimizes downtime, reduces repair costs, and ultimately enhances the reliability of public transit services.

IV. Enhancing Safety and Security:

The integration of IoT devices contributes to the safety and security of public transit systems. Surveillance cameras, environmental sensors, and emergency response systems are part of the Smart Infrastructure, enabling swift and informed responses to incidents. Real-time monitoring enhances passenger safety and ensures a secure environment within transit vehicles and stations.

V. Adaptive Traffic Management:

Smart Infrastructure extends beyond individual vehicles to address broader traffic management challenges. By integrating IoT devices with traffic signals, congestion monitoring systems, and city-wide transportation networks, public transit can adapt dynamically to traffic patterns. This results in more efficient routes, reduced travel times, and improved overall system performance.

VI. Environmental Impact:

The environmental sustainability of public transit is a growing concern, and Smart Infrastructure with IoT plays a crucial role in mitigating environmental impact. By analyzing data on fuel consumption, emissions, and energy usage, transit authorities can implement eco-friendly practices, optimize routes, and contribute to a greener and more sustainable urban transportation ecosystem.

VII. Integration with Emerging Technologies:

Smart Infrastructure with IoT also paves the way for integration with emerging technologies, such as autonomous vehicles and electric transportation. The interconnected nature of IoT devices provides a seamless platform for the introduction and coordination of these cutting-edge technologies, shaping the future of public transit.

Smart Infrastructure with IoT represents a transformative leap in the evolution of public transit systems. The integration of sensors, connectivity, and real-time data analysis creates a dynamic, responsive, and efficient urban mobility experience. As cities continue to invest in Smart Infrastructure, the potential for enhanced reliability, safety, sustainability, and overall user satisfaction in public transit systems becomes increasingly tangible, signaling a new era in the evolution of urban transportation.

Predictive Maintenance

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Route Optimization

In the rapidly changing landscape of urban mobility, the efficiency and effectiveness of public transit routes play a pivotal role in shaping the commuting experience for millions of people. This article explores the integral aspect of "Route Optimization" within the context of a broader paper focused on enhancing public transit systems through the amalgamation of Artificial Intelligence (AI) and the Internet of Things (IoT). As we delve into the intricate world of route optimization, we uncover how AI algorithms and real-time data analysis contribute to more streamlined, responsive, and commuter-friendly transit networks.

I. The Complexity of Urban Transit Routes:

Urban transit systems grapple with the intricate challenge of navigating diverse and dynamic environments. Traffic congestion, changing weather conditions, and fluctuating passenger demand create a complex tapestry that traditional, fixed transit routes may struggle to adapt to efficiently. Enter the realm of route optimization, where AI algorithms leverage the power of data to craft smarter and more responsive transit paths.

II. Leveraging Historical and Real-Time Data:

At the core of route optimization is the utilization of both historical and real-time data. AI algorithms analyze past transit patterns, taking into account factors such as peak hours, traffic congestion, and popular destinations. This historical analysis is coupled with real-time data streaming from IoT-enabled devices embedded in vehicles, transit stops, and city infrastructure. The amalgamation of these datasets empowers transit authorities to make informed decisions that dynamically adapt to the ever-changing urban landscape.

III. Factors Influencing Route Optimization:

a. Traffic Patterns: AI algorithms consider real-time traffic patterns to dynamically adjust transit routes. By anticipating congested areas and identifying alternate paths, transit systems can minimize delays and improve overall efficiency.

b. Weather Conditions: Weather can have a significant impact on transit operations. Route optimization algorithms factor in weather forecasts to adjust routes, ensuring the safety and comfort of passengers while maintaining schedule adherence.

c. Passenger Demand: Understanding and predicting passenger demand is crucial for crafting optimal routes. AI algorithms analyze historical ridership data and real-time information to adjust routes based on varying demand throughout the day.

IV. Improved Efficiency and Reduced Travel Times:

The primary goal of route optimization is to enhance the efficiency of public transit systems. By recommending routes that account for the dynamic nature of urban environments, AI algorithms contribute to reduced travel times for passengers. This not only improves the overall user experience but also encourages greater ridership by offering a more time-efficient alternatiVe to private transportation.

V. Integration with Multimodal Transportation:

In the era of interconnected transportation modes, route optimization extends beyond individual transit routes. AI algorithms can facilitate the integration of various modes of transportation, such as buses, trains, and even shared mobility services. This seamless coordination provides commuters with a more comprehensive and efficient journey, involving multiple modes of transit.

VI. Environmental Impact:

Efficient transit routes contribute to a reduction in fuel consumption and emissions, positively impacting the environmental sustainability of public transportation. By minimizing unnecessary detours and idling time, route optimization aligns with broader efforts to create greener and more eco-friendly transit systems.

VII. The Role of Machine Learning in Adaptive Routing:

Machine learning algorithms play a crucial role in adaptive routing. These algorithms continuously learn from real-time data, adapting and improving route recommendations based on evolving conditions. The iterative learning process ensures that transit systems become increasingly adept at navigating the complexities of urban environments over time.

Route optimization emerges as a linchpin in the evolution of smart public transit systems. By harnessing the capabilities of AI and IoT technologies, transit authorities can craft more responsive, efficient, and adaptive routes. As cities strive to create transit networks that cater to the evolving needs of their residents, the integration of route optimization represents a significant step towards a future where public transportation is not only reliable but also seamlessly aligned with the dynamic nature of urban living.

Dynamic Scheduling

Public transit systems are the lifeblood of urban mobility, connecting people to their destinations efficiently. In the pursuit of creating smarter and more responsive transit networks, the concept of "Dynamic Scheduling" takes center stage. This article explores the intricate dynamics of dynamic scheduling within the broader framework of a paper dedicated to enhancing public transit through the fusion of Artificial Intelligence (AI) and the Internet of Things (IoT). As we navigate through the realms of adaptability and real-time responsiveness, we uncover how dynamic scheduling contributes to a more agile and user-centric public transportation experience.

I. The Limitations of Fixed Schedules:

Traditional fixed schedules in public transit, though essential for providing a baseline structure, often fall short in accommodating the dynamic nature of urban environments. Factors such as changing passenger demand, unexpected events, and traffic fluctuations challenge the efficacy of fixed schedules. Dynamic scheduling addresses these limitations by introducing a more adaptive and real-time approach to transit planning.

II. Real-Time Data Integration:

Dynamic scheduling relies heavily on the integration of real-time data from IoT-enabled devices within the public transit infrastructure. Buses, trains, and transit stops equipped with sensors continuously transmit data regarding passenger counts, vehicle locations, and external conditions. This influx of real-time information forms the backbone of dynamic scheduling, empowering transit authorities to make instant decisions based on the current state of the transit system.

III. Adaptive Response to Changing Demand:

A key aspect of dynamic scheduling is its ability to respond to changing passenger demand patterns. AI algorithms analyze historical data to predict peak hours and popular routes, but the real-time component ensures that transit schedules can be adjusted on the fly. As demand surges or decreases, dynamic scheduling enables transit systems to allocate resources more efficiently, minimizing wait times and optimizing the overall passenger experience.

IV. Traffic and Incident Response:

Dynamic scheduling proves invaluable in responding to unexpected events such as traffic incidents or delays. By monitoring real-time traffic patterns and receiving alerts from IoT devices, transit authorities can reroute vehicles or adjust schedules to minimize disruptions. This proactive approach not only enhances system efficiency but also mitigates the impact of unforeseen circumstances on passengers.

V. Enhancing Accessibility:

The adaptability of dynamic scheduling extends to improving accessibility for all passengers. Real-time data on vehicle locations and passenger loads enable transit systems to provide accurate information to individuals with mobility challenges, allowing for better coordination of accessible services and facilities.

VI. Multi-Modal Integration:

In the era of interconnected transportation, dynamic scheduling facilitates the integration of various transit modes seamlessly. AI algorithms can coordinate schedules between buses, trains, and other modes, creating a more cohesive and efficient multimodal transit experience. Passengers can experience smoother transitions between different modes of transportation, enhancing the overall convenience of public transit.

VII. User-Centric Experience:

At its core, dynamic scheduling aims to create a more user-centric public transit experience. By adapting to changing demand, minimizing delays, and improving overall efficiency, dynamic scheduling contributes to a system that is not only reliable but also aligns closely with the evolving needs and expectations of passengers.

Dynamic scheduling emerges as a transformative force in the evolution of smart public transit systems. By harnessing the power of real-time data and AI algorithms, transit authorities can navigate the complexities of urban environments with agility and precision. As cities strive to create transit networks that are responsive to the dynamic nature of modern living, dynamic scheduling stands as a crucial component, ensuring that public transportation remains not only a reliable option but a seamlessly adaptable and user-centric service.

Passenger Information Systems

In the ever-evolving landscape of urban mobility, the passenger experience stands at the forefront of public transit priorities. The integration of advanced technologies, particularly in the form of Passenger Information Systems, has ushered in a new era of informed and empowered commuters. This article explores the pivotal role of Passenger Information Systems within the broader context of a paper dedicated to enhancing public transit through the amalgamation of Artificial Intelligence (AI) and the Internet of Things (IoT). As we delve into the intricacies of real-time communication and accessibility, we uncover how Passenger Information Systems contribute to a more connected and user-friendly public transportation experience.

I. The Significance of Informed Commuting:

Effective communication is fundamental to a positive commuter experience. Traditional public transit systems often left passengers in the dark regarding arrival times, delays, and alternative routes. Passenger Information Systems bridge this information gap by providing real-time updates, empowering commuters to make informed decisions and enhancing overall satisfaction.

II. Real-Time Data Communication:

At the heart of Passenger Information Systems is the integration of real-time data from IoT-enabled devices within the transit infrastructure. Buses, trains, and transit stops equipped with sensors transmit information regarding vehicle locations, arrival times, and potential delays. This real-time data forms the foundation of Passenger Information Systems, allowing transit authorities to disseminate accurate and timely information to commuters.

III. Mobile Applications and Digital Displays:

Passenger Information Systems leverage various communication channels, with mobile applications and digital displays being primary interfaces. Mobile apps provide commuters with personalized and up-to-date information on routes, schedules, and delays. Digital displays at transit stops and within vehicles offer real-time updates, enhancing accessibility for those without smartphones.

IV. Improved Commuter Experience:

The real-time information provided by Passenger Information Systems contributes significantly to an improved commuter experience. Commuters can plan their journeys more efficiently, reduce wait times, and make informed decisions in response to unexpected events or delays. This heightened level of predictability and control enhances overall satisfaction and encourages greater use of public transit.

V. Accessibility Features:

Passenger Information Systems play a crucial role in enhancing accessibility for all passengers. Real-time data on vehicle locations and arrival times empower individuals with disabilities or mobility challenges to plan their journeys more effectively. Accessible information ensures that public transit remains inclusive and accommodating to the diverse needs of the community.

VI. Emergency Communication:

Beyond routine updates, Passenger Information Systems also serve as vital tools for emergency communication. In the event of disruptions, accidents, or other emergencies, transit authorities can use these systems to broadcast critical information, ensuring the safety and well-being of passengers.

VII. Integration with Multi-Modal Transportation:

As cities embrace multi-modal transportation options, Passenger Information Systems facilitate seamless integration. Commuters can receive unified information across various transit modes, promoting a more cohesive and interconnected transit experience. This integration contributes to a more efficient and user-friendly transit network.

VIII. Enhanced Sustainability:

By providing accurate information on transit schedules and alternatives, Passenger Information Systems contribute to the overall sustainability of public transit. Commuters can make informed choices, potentially reducing the reliance on personal vehicles and promoting a more environmentally friendly mode of transportation.

Passenger Information Systems represent a cornerstone in the evolution of smart public transit. By harnessing the capabilities of real-time data and communication technologies, these systems empower commuters with information, control, and accessibility. As cities strive to create transit networks that cater to the evolving needs of their residents, Passenger Information Systems stand as a testament to the transformative power of technology in creating a more connected, user-friendly, and sustainable urban transportation experience.

Fare Optimization

Public transit systems serve as the lifeblood of urban mobility, connecting diverse communities and providing an essential service for millions of commuters. In the pursuit of creating smarter and more sustainable transit networks, the concept of "Fare Optimization" emerges as a crucial element. This article explores the nuanced dynamics of Fare Optimization within the broader framework of a paper dedicated to enhancing public transit through the fusion of Artificial Intelligence (AI) and the Internet of Things (IoT). As we delve into the intricacies of data analysis, pricing strategies, and rider incentives, we uncover how Fare Optimization contributes to fair, affordable, and financially sustainable public transportation.

I. The Challenge of Fair and Sustainable Pricing:

Public transit authorities face the complex challenge of setting fares that are not only affordable for passengers but also contribute to the financial sustainability of the transit system. Fare Optimization delves into this intricate balance, leveraging AI algorithms and data analysis to craft pricing structures that align with passenger demographics, travel patterns, and economic factors.

II. Leveraging Data for Informed Pricing:

At the core of Fare Optimization is the utilization of data to inform pricing decisions. AI algorithms analyze a myriad of factors, including rider demographics, peak travel times, and historical ridership data. By understanding the nuances of passenger behavior and preferences, transit authorities can craft fare structures that are not only financially viable but also tailored to the diverse needs of the community.

III. Dynamic Pricing Models:

Fare Optimization embraces the concept of dynamic pricing, where fares are adjusted based on real-time demand and supply factors. During peak hours or high-demand periods, fares may be slightly higher to manage congestion and encourage alternative travel times. Conversely, off-peak hours may see reduced fares to incentivize ridership during less crowded periods.

IV. Rider Incentives and Loyalty Programs:

To encourage ridership and foster a sense of loyalty, Fare Optimization may include incentives and rewards programs. AI algorithms can identify patterns of travel behavior, offering personalized discounts, loyalty points, or other perks to frequent commuters. This not only benefits passengers but also contributes to the financial sustainability of the transit system by fostering consistent ridership.

V. Integration with Multimodal Transportation:

As cities embrace integrated and multimodal transportation networks, Fare Optimization extends beyond individual transit modes. AI algorithms can coordinate pricing structures across various transportation options, providing a seamless and cost-effective experience for commuters who utilize multiple modes of transit during their journeys.

VI. Considerations for Equity and Accessibility:

Fare Optimization also addresses considerations of equity and accessibility. By analyzing demographic data and socioeconomic factors, transit authorities can implement fare structures that ensure public transportation remains an accessible and affordable option for all residents. This approach aligns with broader efforts to create inclusive and equitable urban transportation systems.

VII. Financial Sustainability:

Achieving financial sustainability is a key goal of Fare Optimization. By aligning fares with demand patterns, encouraging consistent ridership through incentives, and optimizing pricing structures, transit authorities can create a more financially resilient system. This, in turn, contributes to the long-term viability of public transit as a sustainable mode of urban transportation.

Conclusion:

Fare Optimization stands as a cornerstone in the evolution of public transit systems. By harnessing the power of AI and IoT technologies, transit authorities can craft fare structures that are not only responsive to the dynamic nature of urban environments but also fair, affordable, and financially sustainable. As cities strive to create transit networks that cater to the evolving needs of their residents, Fare Optimization exemplifies the transformative impact of data-driven decision-making in fostering a more accessible, equitable, and economically viable public transportation experience.

Conclusion

Public transit systems serve as the lifeblood of urban mobility, connecting diverse communities and providing an essential service for millions of commuters. In the pursuit of creating smarter and more sustainable transit networks, the concept of "Fare Optimization" emerges as a crucial element. This article explores the nuanced dynamics of Fare Optimization within the broader framework of a paper dedicated to enhancing public transit through the fusion of Artificial Intelligence (AI) and the Internet of Things (IoT). As we delve into the intricacies of data analysis, pricing strategies, and rider incentives, we uncover how far Optimization contributes to fair, affordable, and financially sustainable public transportation.

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Reference

1. Jevinger, Å., Zhao, C., Persson, J. A., & Davidsson, P. (2023). Artificial intelligence for improving public transport: a mapping study. Public Transport, 1-60.
2. Abduljabbar, R., Dia, H., Liyanage, S., & Bagloee, S. A. (2019). Applications of artificial intelligence in transport: An overview. Sustainability, 11(1), 189.
3. Solihati, K. D., & Indriyani, D. (2021, March). Managing Artificial Intelligence on Public Transportation (Case Study Jakarta City, Indonesia). In IOP Conference Series: Earth and Environmental Science (Vol. 717, No. 1, p. 012021). IOP Publishing.
4. Chang, H. C., Okubo, T., Kobayashi, A., & Morimoto, A. (2022). Artificial Intelligence (AI) Applications Using Big Data and Survey Data for Exploring the Existence of the Potential Users of Public Transportation System. International Journal of Information & Management Sciences, 33(4).
5. Mahor, V., Rawat, R., Kumar, A., Garg, B., & Pachlasiya, K. (2023). IoT and artificial intelligence techniques for public safety and security. In Smart urban computing applications (pp. 111-126). River Publishers.
6. Singh, P., Elmi, Z., Lau, Y. Y., Borowska-Stefańska, M., Wiśniewski, S., & Dulebenets, M. A. (2022). Blockchain and AI technology convergence: Applications in transportation systems. Vehicular Communications, 100521.
7. Henman, P. (2020). Improving public services using artificial intelligence: possibilities, pitfalls, governance. Asia Pacific Journal of Public Administration, 42(4), 209-221.
8. Gaur, L., & Sahoo, B. M. (2022). Introduction to Explainable AI and Intelligent Transportation. In Explainable Artificial Intelligence for Intelligent Transportation Systems: Ethics and Applications (pp. 1-25). Cham: Springer International Publishing.
9. Navarathna, P. J., & Malagi, V. P. (2018, December). Artificial intelligence in smart city analysis. In 2018 International conference on smart systems and inventive technology (ICSSIT) (pp. 44-47). IEEE.
10. Mnyakin, M. (2023). Applications of AI, IoT, and Cloud Computing in Smart Transportation: A Review. Artificial Intelligence in Society, 3(1), 9-27.
11. Guerrero-Ibáñez, J., Zeadally, S., & Contreras-Castillo, J. (2018). Sensor technologies for intelligent transportation systems. Sensors, 18(4), 1212.
12. Al Shebli, K., Said, R. A., Taleb, N., Ghazal, T. M., Alshurideh, M. T., & Alzoubi, H. M. (2021, May). RTA's employees' perceptions toward the efficiency of artificial intelligence and big data utilization in providing smart services to the residents of Dubai. In The International Conference on Artificial Intelligence and Computer Vision (pp. 573-585). Cham: Springer International Publishing.
13. Mhlanga, D. (2023). Artificial Intelligence and Machine Learning in Making Transport, Safer, Cleaner, More Reliable, and Efficient in Emerging Markets. FinTech and Artificial Intelligence for Sustainable Development: The Role of Smart Technologies in Achieving Development Goals, 193-211.
14. Pelleti, S., Bains, S., Bansal, A., Muda, I., Chowdhary, H., & Mahajan, Y. (2022, December). Management Information System based on Artificial Intelligence Technology. In 2022 5th International Conference on Contemporary Computing and Informatics (IC3I) (pp. 2007-2012). IEEE.
15. Samim, A. (2023). Analysis of Artificial Intelligence in Traffic Congestion and Management System. International Journal of Science and Research (IJSR), 12(1), 679-684.
16. Fazelpour, F., Vafaeipour, M., Rahbari, O., & Rosen, M. A. (2014). Intelligent optimization to integrate a plug-in hybrid electric vehicle smart parking lot with renewable energy resources and enhance grid characteristics. Energy Conversion and Management, 77, 250-261.
17. Abdulrazzaq Oraibi, W., Mohammadi-Ivatloo, B., Hosseini, S. H., & Abapour, M. (2023). Multi

Microgrid Framework for Resilience Enhancement Considering Mobile Energy Storage Systems and Parking Lots. Applied Sciences, 13(3), 1285.
18. Kour, S. P., Sharma, P., & Jalal, M. (2022, October). Artificial Intelligence in Transport-A Survey. In 2022 IEEE 3rd Global Conference for Advancement in Technology (GCAT) (pp. 1-6). IEEE.
19. Heidari, A., Navimipour, N. J., & Unal, M. (2022). Applications of ML/DL in the management of smart cities and societies based on new trends in information technologies: A systematic literature review. Sustainable Cities and Society, 104089.
20. He, R., Molisch, A. F., Tufvesson, F., Zhong, Z., Ai, B., & Zhang, T. (2014). Vehicle-to-vehicle propagation models with large vehicle obstructions. IEEE Transactions on Intelligent Transportation Systems, 15(5), 2237-2248.
21. Guerrero-Ibañez, J., Contreras-Castillo, J., & Zeadally, S. (2021). Deep learning support for intelligent transportation systems. Transactions on Emerging Telecommunications Technologies, 32(3), e4169.
22. Madhavan, B. R. (2022). Traffic Flow Rate Determination & Parking Efficiency Improvement Using Artificial Intelligence/Computer Vision (Doctoral dissertation, University of Toledo).
23. Androutsopoulou, A., Karacapilidis, N., Loukis, E., & Charalabidis, Y. (2019). Transforming the communication between citizens and government through AI-guided chatbots. Government information quarterly, 36(2), 358-367.
24. Olugbade, S., Ojo, S., Imoize, A. L., Isabona, J., & Alaba, M. O. (2022). A review of artificial intelligence and machine learning for incident detectors in road transport systems. Mathematical and Computational Applications, 27(5), 77.
25. Efthymiou, I. P., & Egleton, T. E. (2023). Artificial Intelligence for Sustainable Smart Cities. In Handbook of Research on Applications of AI, Digital Twin, and Internet of Things for Sustainable Development (pp. 1-11). IGI Global.
26. Chen, X., Liu, Z., & Currie, G. (2016). Optimizing location and capacity of rail-based Park-and-Ride sites to increase public transport usage. Transportation Planning and Technology, 39(5), 507-526.
27. Al-Turjman, F., Salama, R., & Altrjman, C. (2023). Overview of IoT Solutions for Sustainable Transportation Systems. NEU Journal for Artificial Intelligence and Internet of Things, 2(3).
28. Jha, S. B., Jha, J. K., & Tiwari, M. K. (2019). A multi-objective meta-heuristic approach for transit network design and frequency setting problem in a bus transit system. Computers & Industrial Engineering, 130, 166-186.
29. Berryhill, J., Heang, K. K., Clogher, R., & McBride, K. (2019). Hello, World: Artificial intelligence and its use in the public sector.
30. Weligamage, H. D., Wijesekara, S. M., Chathwara, M. D. S., Kavinda, H. I., Amarasena, N., & Gamage, N. (2022, October). An Approach of Enhancing the Quality of Public Transportation Service in Sri Lanka using IoT. In 2022 IEEE 13th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON) (pp. 0311-0316). IEEE.
31. Nikitas, A., Michalakopoulou, K., Njoya, E. T., & Karampatzakis, D. (2020). Artificial intelligence, transport and the smart city: Definitions and dimensions of a new mobility era. Sustainability, 12(7), 2789.
32. Shaheen, M., Arshad, M., & Iqbal, O. (2020). Role and Key Applications of Artificial Intelligence & Machine Learning in Transportation. European Journal of Technology, 4(1), 47-59.
33. Herath, H. M. K. K. M. B., & Mittal, M. (2022). Adoption of artificial intelligence in smart cities: A comprehensive review. International Journal of Information Management Data Insights, 2(1), 100076.
34. Kuziemski, M., & Misuraca, G. (2020). AI governance in the public sector: Three tales from the frontiers of automated decision-making in democratic settings. Telecommunications policy, 44(6),

101976.
35. Daganzo, C. F. (2005). Improving city mobility through gridlock control: an approach and some ideas.
36. Shladover, S. E. (2018). Connected and automated vehicle systems: Introduction and overview. Journal of Intelligent Transportation Systems, 22(3), 190-200.
37. Russo, F., & Comi, A. (2021). Sustainable urban delivery: the learning process of path costs enhanced by information and communication technologies. Sustainability, 13(23), 13103.
38. Mozur, P. (2018). Inside China's dystopian dreams: AI, shame and lots of cameras. International New York Times, NA-NA.
39. Rammohan, A. (2023). Revolutionizing Intelligent Transportation Systems with Cellular Vehicle-to-Everything (C-V2X) technology: Current trends, use cases, emerging technologies, standardization bodies, industry analytics and future directions. Vehicular Communications, 100638.
40. Zhang, J., Wang, F. Y., Wang, K., Lin, W. H., Xu, X., & Chen, C. (2011). Data-driven intelligent transportation systems: A survey. IEEE Transactions on Intelligent Transportation Systems, 12(4), 1624-1639.
41. Hager, G. D., Drobnis, A., Fang, F., Ghani, R., Greenwald, A., Lyons, T., ... & Tambe, M. (2019). Artificial intelligence for social good. arXiv preprint arXiv:1901.05406.
42. Deveci, M., Mishra, A. R., Gokasar, I., Rani, P., Pamucar, D., & Özcan, E. (2022). A decision support system for assessing and prioritizing sustainable urban transportation in metaverse. IEEE Transactions on Fuzzy Systems, 31(2), 475-484.
43. Pani, A., & Mourya, S. A REVIEW ON SMART AND INTELLIGENT E-GOVERNANCE.
44. Kharche, A., Badholia, S., & Upadhyay, R. K. (2024). Implementation of blockchain technology in integrated IoT networks for constructing scalable ITS systems in India. Blockchain: Research and Applications, 100188.
45. Yigitcanlar, T., Desouza, K. C., Butler, L., & Roozkhosh, F. (2020). Contributions and risks of artificial intelligence (AI) in building smarter cities: Insights from a systematic review of the literature. Energies, 13(6), 1473.
46. Alotaibi, O., & Potoglou, D. (2018). Introducing public transport and relevant strategies in Riyadh City, Saudi Arabia: A stakeholders' perspective. Urban, Planning and Transport Research, 6(1), 35-53.
47. Qin, X., Ke, J., Wang, X., Tang, Y., & Yang, H. (2022). Demand management for smart transportation: A review. Multimodal Transportation, 1(4), 100038.
48. Morrison, S. A., Winston, C., Bailey, E. E., & Kahn, A. E. (1989). Enhancing the performance of the deregulated air transportation system. Brookings Papers on Economic Activity. Microeconomics, 1989, 61-123.
49. Lee, H., Chatterjee, I., & Cho, G. (2023, August). Enhancing Parking Facility of Container Drayage in Seaports: A Study on Integrating Computer Vision and AI. In 2023 IEEE 6th International Conference on Knowledge Innovation and Invention (ICKII) (pp. 384-387). IEEE.
50. Chan, N. D., & Shaheen, S. A. (2012). Ridesharing in North America: Past, present, and future. Transport reviews, 32(1), 93-112.
51. Topolski, M., Topolska, K., Janicki, M., & Kolanek, C. (2016). The management of urban parking LOTS. Archives of Transport System Telematics, 9.
52. Alsamhi, S. H., Ma, O., Ansari, M. S., & Almalki, F. A. (2019). Survey on collaborative smart drones and internet of things for improving smartness of smart cities. Ieee Access, 7, 128125-128152.
53. Zantalis, F., Koulouras, G., Karabetsos, S., & Kandris, D. (2019). A review of machine learning and IoT in smart transportation. Future Internet, 11(4), 94.

54. Ma, Y., Wang, Z., Yang, H., & Yang, L. (2020). Artificial intelligence applications in the development of autonomous vehicles: A survey. IEEE/CAA Journal of Automatica Sinica, 7(2), 315-329.
55. Sriratnasari, S. R., Wang, G., Kaburuan, E. R., & Jayadi, R. (2019, August). Integrated Smart Transportation using IoT at DKI Jakarta. In 2019 International Conference on Information Management and Technology (ICIMTech) (Vol. 1, pp. 531-536). IEEE.
56. Singh, S. K., Rathore, S., & Park, J. H. (2020). Blockiotintelligence: A blockchain-enabled intelligent IoT architecture with artificial intelligence. Future Generation Computer Systems, 110, 721-743.
57. Tyagi, A. K., & Sreenath, N. (2022). Management and Impact of COVID-19 on Intelligent Transportation System. In Intelligent Transportation Systems: Theory and Practice (pp. 305-325). Singapore: Springer Nature Singapore.
58. Zhang, S., Chen, J., Lyu, F., Cheng, N., Shi, W., & Shen, X. (2018). Vehicular communication networks in the automated driving era. IEEE Communications Magazine, 56(9), 26-32.
59. Saravanan, M., Devipriya, R., Sakthivel, K., Sujith, J. G., Saminathan, A., & Vijesh, S. (2022, December). Optimized Load Balancing and Routing Using Machine Learning Approach in Intelligent Transportation Systems: A Survey. In International Conference on Hybrid Intelligent Systems (pp. 929-939). Cham: Springer Nature Switzerland.