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Research Article

AI-Driven Traffic Management Systems In Smart Cities: A Review

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ABSTRACT

Over the past few decades, the number of cars worldwide has increased substantially. Nevertheless, the rate of congestion significantly increases due to the lack of proportional expansion in road capacity. In order to tackle this complex problem, the researchers opt to utilize the existing infrastructure in a smarter and more effective manner through the implementation of adaptive traffic management. The multitude of recently proposed methodologies have been developed using emerging technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and Big Data. Given the growth of cities and the resulting rise in traffic congestion, it is imperative to improve the level of intelligence in our urban areas. This entails employing modern technology to efficiently manage resources and enhance urban living. The intelligent traffic system refers to a sophisticated computer system that leverages Artificial Intelligence (AI) to regulate traffic in smart cities. The goal is to improve the movement of vehicles, reduce traffic jams, and optimize the transportation systems in cities. The sophisticated Traffic Management System employs cameras, sensors, and GPS to swiftly collect traffic data. An artificial intelligence system utilizes data analysis to predict traffic conditions by considering elements such as time, weather, and events. The system alters traffic lights, redirects traffic, and adapts bus timetables according to the present conditions in the city. The system consistently acquires knowledge and guarantees effective functioning in the busy urban area.

Keywords: AI-driven Traffic Management ; Smart Cities ; Urban Mobility ; Traffic Congestion ; Sustainability ; IoT Integration ; Real-time Data Analysis ; Predictive Analytics ; Adaptive Strategies ; Urban Planning

1. Introduction

In the ever-changing world of development, the notion of smart cities is like a guiding light, bringing in innovation for better efficiency, sustainability, and a higher quality of life. One obstacle in this process is dealing with city traffic, where multiple motions might either link seamlessly or generate annoying gridlock. This article offers a unique solution optimized for smart cities: an intelligent vehicle control system. This technology leverages the smarts of artificial intelligence (AI) to keep track of traffic variations in the city, playing a smart and adaptable role to enhance city life. As our cities get busier, having smart traffic management is not just required but is also the cornerstone for constructing smart cities.

With fast population development and cities growing swiftly, controlling traffic demands a fresh method. Old means of regulating traffic can't manage the intricacies of modern metropolitan transportation. That's where AI-powered traffic management comes in, anticipating a future where our cities not only face the difficulties of swift expansion but also adapt to those challenges, making things operate better and more stable over time. Think of the system as a dynamic conductor, bringing in real data from diverse sources including traffic cameras, sensors, and GPS devices. These sources work together to give a full and up-to-the-moment picture of how people are moving about the city. This steady influx of data is like the system's life force, fueling the smart AI algorithms that operate as its brain. These algorithms are continually learning and changing, working out sophisticated traffic patterns, projecting future trends, and making on-the-spot adjustments to how traffic is controlled.

The system's capacity to adapt is particularly critical for addressing the various elements that impact city traffic. Whether it's the time of day, the weather, or special events, all these factors are considered when the intelligent algorithm makes judgments. Instead than keeping to established traffic patterns, the system is continuously changing things up—adjusting traffic signals, identifying new routes, and updating bus timetables in real-time. This means it not only deals with what's occurring right now in the city but also looks ahead, preparing ready for changes in traffic patterns that could come in the future.

A crucial component of the AI-driven Traffic Management System is how it leverages machine learning. This entails looking at prior data, discovering trends, and obtaining insights to make traffic projections more accurate. By continually updating its understanding of how people travel throughout the city, the system becomes proactive in regulating traffic. Instead of only responding to difficulties, it becomes a significant aid in making transportation function better overall.

The system isn't only about controlling traffic; it also worries about the environment. It encourages eco-friendly alternatives to get about, such riding the bus, cycling, or walking. It makes real-time ideas and even offers incentives to encourage individuals to select these sustainable transportation choices. By doing this, it helps minimize the carbon imprint, making the city more eco-friendly and sustainable.

The system works well due of outstanding communication. Smart communication technologies make it possible for cars, infrastructure, and traffic authorities to transmit information effortlessly. This link enables for proactive activities, such issuing alerts about congested regions and recommending other routes. The outcome is a traffic system that speaks and reacts in real-time, fixing issues before they get greater.

2. Introduction Literature Review

The introduction of artificial intelligence (AI) has changed several sectors, and one area where its effect is becoming visible is in the realm of traffic control systems for smart cities. This literature review analyzes current breakthroughs and major results in AI-driven traffic management systems, taking ideas from a wide range of research publications.

A. Arora et al. (2023) give a forward-looking view on the next generation of multi-agent-driven smart city applications. The writers underline the importance of AI in influencing the future of smart cities. They examine how intelligent agents might collaborate to increase the efficiency and functioning of many urban services, including traffic management [1].

In a systematic review, E. Badidi, K. Moumane, and F. E. Ghazi (2023) study the prospects, uses, and problems of edge-AI enabled video analytics in smart cities. This study presents a detailed assessment of the current status of AI applications in video analytics, particularly focused on the edge computing paradigm. The authors highlight the potential of AI to improve video analytics in smart city contexts, presenting insights into obstacles that need to be solved for effective implementation[2].

P. Rizwan, K. Suresh, and M. R. Babu (2016) explore into the domain of real-time smart traffic management systems for smart cities, utilizing the Internet of Things (IoT) and big data. Although released in 2016, this study remains relevant as it offers the framework for comprehending the integration of IoT and big data analytics in traffic management. The authors suggest a method that employs real-time data to increase traffic flow and minimize congestion[3].

V. Adewopo et al. (2023) give a complete analysis of traffic incidents and an automated accident detection system in smart cities. This project studies the potential of AI in avoiding and minimizing road accidents through the creation of an automated accident detection system. The study offers insight on the usage of AI to increase road safety and emergency response in urban environments[4].

Apolo-Apolo et al. (2020) add a novel viewpoint to the literature by employing deep learning algorithms for evaluating the production and size of citrus fruits using unmanned aerial vehicles (UAVs). While not directly relevant to traffic management, this work illustrates the adaptability of AI applications, especially in agricultural situations. The combination of UAVs and deep learning for exact estimate highlights the multidisciplinary nature of AI[5].

C. Zhao et al. (2023) contribute to the literature with their work on parallel transit in Transverse. The study discusses basic concepts and the creation of DeCAST, highlighting the necessity of parallel transportation networks in smart cities. The authors employ AI to optimize transportation infrastructure, offering insights into the possibilities for greater efficiency and reduced congestion[6].

M. K. M. Rabby, M. M. Islam, and S. M. Imon (2019) conduct an assessment of IoT applications in a smart traffic management system. This article presents a complete review of how IoT technology may be integrated into traffic management for greater efficiency. The authors address numerous IoT-based systems and their potential influence on traffic monitoring, control, and optimization[7].

N. Bešinović et al. (2022) emphasis on the application of artificial intelligence in railway transit. While not directly relevant to road traffic, this study gives useful insights into the taxonomy, rules, and uses of AI in transportation systems. The authors underline the usefulness of AI in optimizing railway operations and enhancing overall transportation efficiency[8].

Z. Yang et al. (2023) describe an AI-driven visual end-edge-cloud architecture for 6G in low-carbon smart cities. The study investigates the incorporation of AI into the architecture of future communication networks,

highlighting the potential for AI to play a major role in creating the communication infrastructure of smart cities[9].
Q. Cui et al. (2019) add to the literature with an emphasis on big data analytics and network calculus allowing intelligent control of autonomous cars in smart cities. This study addresses the convergence of big data analytics and AI-driven management of autonomous cars, giving insights into the difficulties and potential in this quickly growing field[10].

M. Alarbi et al. (2023) introduce SCOPE, a smart cooperative parking environment, demonstrating the significance of AI in maximizing parking spots in metropolitan settings. The authors examine how AI may be deployed to increase parking efficiency, minimize congestion, and boost overall urban mobility[11].
D. Koshnicharova et al. (2022) provide data-driven interactive crowd management systems for metaverse situations. Although not directly relevant to traffic, this research provides insight on AI applications in controlling crowds, which might have ramifications for events and situations where traffic management is critical[12].
M. Ben Youssef et al. (2021) present an overview of intelligent multiple vehicle recognition and tracking utilizing deep learning and machine learning. This paper studies how AI may be employed to recognize and monitor cars, revealing insights into the possibilities of AI-driven surveillance systems in traffic management[13].
P. Pandiyan, S. Saravanan, K. Usha, R. Kannadasan, M. H. Alsharif, and M.-K. Kim. “Technological Advancements Toward Smart Energy Management in Smart Cities.” Energy Reports, Vol. 10, pp. 648-677, Nov 2023 . The study discusses technology breakthroughs linked to smart energy management in smart cities. It includes concepts, challenges, and solutions in sectors including smart grids, buildings, and transportation. Benefits include efficiency, cost savings, and sustainability. Case studies and upcoming technology are explored. The work gives vital insights for a sustainable future in smart cities[14]
Matteo Anedda, Mauro Fadda, Roberto Girau, Giovanni Pau, and Daniele Giusto et al. 2023 “A Social Smart City for Public and Private Mobility: A Real Case Study.” addresses problems such as data isolation, cost-quality trade-offs, and the necessity for collaboration between public and private sectors. These restrictions impede the deployment of efficient smart city solutions.[15]
Umesh Kumar Lilhore, Agbotiname Lucky Imoize, Chun-Ta Li, Sarita Simaiya, Subhendu Kumar Pani, Nitin Goyal, Arun Kumar, and Cheng-Chi Lee et al .2022 . “Design and Implementation of an ML and IoT Based Adaptive Traffic-Management System for Smart Cities” proposes a novel solution to solve traffic congestion, pollution, and logistic delays in urban regions. The system harnesses the capabilities of IoT (Internet of Things) and machine learning (ML) to produce an effective and reliable traffic control solution.[16]
Roopa Ravish, Shanta Ranga Swamy et al. 2021 “Intelligent Traffic Management: A Review of Challenges, Solutions, and Future Perspectives”. This research paper addresses the difficulties of traffic congestion in cities and suggests Intelligent Transportation Systems (ITS) as a solution. The report presumably addresses technology like Social IoT, real-time traffic monitoring, and AI to gather and analyze data, coupled with algorithms to optimize traffic flow and alleviate congestion.[17]
Mohammed Sarrab a, Supriya Pulparambil a, Medhat Awadalla el at. 2020 “Development of an IoT based real-time traffic monitoring system for city governance” present a new system model that uses the Internet of Things (IoT) to boost urban mobility and traffic management.[18]
Yash Modi, Ridham Teli, Akshat Mehta, Konark Shah, and Manan Shah (2021)“A Comprehensive Review on Intelligent Traffic Management Using Machine Learning Algorithms “ . Traffic congestion is a major issue in our fast-evolving environment. The spike in private car usage and limited road network capacity makes traditional traffic control systems onerous. Pollution levels grow, and individual productivity falls owing to traffic issues. Enter artificial intelligence (AI) and machine learning (ML), which provide potential solutions.[19]
Paul Shruti Kanailal , Lavanya E , G. Anbu Selvi , N. Senthamilarasi El at . (2024)“Smart Traffic Control System Using Artificial Intelligence” .This new technology revolutionizes urban mobility management by dynamically modifying traffic flow, lowering fuel consumption, pollutants, and idle times.[20]
Siddhant Dawkhare1 , Amrish Jadhav2 , Yash Jariwala3,*, Palak Desai4 el at . (2023) “Smart Traffic Management Systems: A Comprehensive Review of Existing Solutions” . This unique solution revolutionizes urban mobility management by dynamically altering traffic flow, lowering fuel consumption, pollution, and idle times. [21]
Abhijeet Choudhary1, Akash Gupta2, Akshay Dhuri3, Prof. Nilima Nikam4 el at (2018) “Artificial Intelligence Based Smart Traffic Management System Using Video Processing” . This system employs real-time video processing techniques to assess traffic density at crossings. By evaluating photos taken by cameras, it determines the density of cars on the road. The estimated traffic density is then utilized to efficiently manage traffic lights, optimizing traffic flow and decreasing congestion.[22]
Sadia Afsar, Maram Fahaad Almufareh, N. Z. Jhanjhi, and Mashayel AlSuwailem el at (2022) "Smart Traffic Management System for Metropolitan Cities of Kingdom Using Cutting Edge Technologies".
this smart traffic management system mixes IoT, cloud computing, 5G, and big data to develop an effective solution for addressing traffic congestion in metropolitan centers. [23]

Hazim Al Gharrawi and Majid Bani Yaghoub el at (2022) "Traffic Management in Smart Cities Using the Weighted LeastSquares Method" . The authors aim to reduce traffic congestion and enhance traffic management in smart cities. This research contributes to the ongoing efforts to create efficient and responsive urban transportation systems.[24]

Shaimaa A. Hussein , Ahmed E. Zaki el at (2022) "A Fog Based Smart Traffic Management System" , tackles the crucial issue of urban mobility in today's cities.[25]

Muhammad Ariff Zamri1 and Noorfaizah Hamzah1 el at (2022) "The Implementation of Intelligent Traffic Management System in Solving Traffic Congestion: A Survey of Federal Route 3214"

They did this work in the School of Civil Engineering, College of Engineering, Universiti Teknologi MARA, Selangor, Malaysia. The research explores the efficacy of the Intelligent Traffic Management System (ITMS), which employs the Internet of Things (IoT), in minimizing traffic congestion on the Federal Route 3214 (Shah Alam-Puchong Highway). By recording, monitoring, processing, and regulating traffic more effectively, the ITMS attempts to ease congestion difficulties caused by the rising usage of private vehicles.[26]

Nitin Sakhare,Mrunal Hedau,Gokul B,Omkar Malpure,Trupti Shah,Anup Ingle EL AT.2024 . "Smart Traffic: Integrating Machine Learning, and YOLO for Adaptive Traffic Management System". Using image processing, the adaptive traffic management system analyzes real-time data from camera-monitored lanes, accurately detecting and enumerating autos. A sophisticated algorithm computes acceptable waiting durations depending on lane-specific vehicle counts, which guides the sensible distribution of signal light patterns.[27]

amata Rath EL AT.2018 ."Smart Traffic Management System for Traffic Control using Automated Mechanical and Electronic Devices". The system intends to minimize traffic congestion, boost parking availability, and give an Android mobile application for drivers to remotely access traffic and parking information. [28]

Nikhil Nigam ,Dhirendra Pratap Singh and Jaytrilok Choudhary EL AT.2023 .

"A Review of Different Components of the Intelligent Traffic Management System (ITMS)".

Aims to minimize congestion, promote road safety, and address environmental impacts.Focuses on adaptive traffic control based on real-time data from imaging technologies.Utilizes computer vision (CV) and artificial intelligence (AI) to manage traffic on road networks.[29]

Sheenamariam Jacob, A. Shobha Rekh ,Gayathri Manoj,J. John Paul el at 2018.

"Smart traffic management system with real time analysis" .The article tackles the issue of traffic congestion caused by outmoded traffic control systems that function on programmed countdowns. These conventional systems allot timings without considering the actual traffic intensity on certain routes, leading to severe red light delays.[30]

Zuraimi, M.A.B.; Zaman, F.H.K." Vehicle Detection and Tracking Using YOLO and DeepSORT". In Proceedings of the 2021 IEEE 11th IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE), The study focuses on increasing vehicle recognition and tracking in real-time traffic control systems.[31]

Karungaru, S.; Dongyang, L.; Terada, K. 2021 , "Vehicle Detection and Type Classification Based on CNN-SVM" , In this research, the authors suggest a system for vehicle detection and classification in a real road environment. [32]

Abhirup Khanna, Rohit Goyal, Manju Verma & Deepika Joshi el at 2018."Intelligent Traffic Management System for Smart Cities". The exponential expansion in the number of automobiles has outpaced the development of road infrastructure and transportation networks.

Consequently, cities battle with difficulties including traffic congestion, accidents, and higher pollution levels.The ITMS helps to smarter, more efficient cities by modernizing traffic management.[33]

Azzedine Boukerche, Yanjie Tao, Peng Sun el at. 2020 ."Artificial intelligence-based vehicular traffic flow prediction methods for supporting intelligent transportation systems".

The authors present a revolutionary rapid learning data-driven fuzzy technique for traffic flow prediction.

With the exponential expansion of traffic flow data, there's an urgent need for rapid and reliable prediction methods.[34]

Thiago S. Gomides a, Robson E. De Grande a, Rodolfo I. Meneguette b, Fernanda S.H de Souza c, Daniel L. Guidoni el at.2022 "Predictive Congestion Control based on Collaborative Information Sharing for Vehicular Ad hoc Networks". The research tackles the subject of traffic congestion in cities, which has substantial economical and environmental effects. The authors propose a revolutionary VANET-based traffic management system termed CoNeCT [35]

Geraldo P. Rocha Filho , Rodolfo I. Meneguette , José R. Torres Neto , Alan Valejo , Li Weigang , Jó Ueyama , Gustavo Pessin , Leandro A. Villas el at.2020

"Enhancing intelligence in traffic management systems to aid in vehicle traffic congestion problems in smart cities".

The project focuses on boosting traffic intelligence in smart cities, acknowledging its direct influence on residents' and tourists' quality of life.[36]

Saravjeet Singh, Jaiteg Singh, S.B. Goyal, Sukhjit Singh Sehra, Farman Ali, Mohammed Ayad Alkhafaji, Ramendra Singh el at.2023"A novel framework to avoid traffic congestion and air pollution for sustainable development of smart cities" presents unique ways for developing sustainable and effective traffic management systems in smart cities.[37]

Nimra Shahid, Munam Ali Shah, Abid Khan, Carsten Maple, Gwanggil Jeon el at.2021
"Towards greener smart cities and road traffic forecasting using air pollution data"
Air pollution statistics are typically connected to traffic congestion, and past research has studied the connection between air pollution and traffic congestion using various machine learning approaches. [38]
Wei Wang , Hanyu Zhang , Tong Li , Jianhua Guo , Wei Huang , Yun Wei , Jinde Cao el at.2020
"An interpretable model for short term traffic flow prediction"
The major objective is to estimate short-term traffic flow, which has been a study focus for over 30 years. With the rising usage of traffic data gathering equipment, there's a chance to employ deep neural networks (DNNs) for traffic flow prediction.[39]
Maryam Shaygan , Collin Meese , Wanxin Li , Xiaoliang (George) Zhao , Mark Nejad el at.2022
"Traffic prediction using artificial intelligence: Review of recent advances and emerging opportunities"
The study opens by identifying and describing major data kinds and resources utilized in the literature. It categorizes fundamental data preparation methods within the traffic prediction context.Subsequently, it highlights prediction methodologies and applications.[40]

Ref.	Year	Paper Title, Author & Journal/Conference	Technologies/Protocols/ Algorithms Used	Outcomes of the Papers	Limitations of the Papers
1	2023	Next Generation of Multi-Agent Driven Smart City Applications and Research Paradigms	Technologies: AI technologies Protocols: IoT sensor Algorithms Used: multi-agent systems in smart cities	New uses of multi-agent systems in smart cities, like better traffic control, energy conservation, and waste disposal.	Limited empirical validation of suggested paradigms.
2	2023	Opportunities, Applications, and Challenges of Edge-AI Enabled Video Analytics in Smart Cities	Technologies: privacy-preserving approaches Protocols: Communication protocols RTSP /HTTP Algorithms Used: The different artificial intelligence model	Edge AI has appeared as a technique with considerable potential for changing video analytics	May lack in-depth study of specific difficulties.
3	2016	Real-time smart traffic management solution for smart cities by integrating IoT and big data	Technologies: traffic management system Protocols: Real time streaming data. Algorithms Used: traffic density and propose solution through predictive analytics	Proposes a real-time smart traffic control system.	Limited debate on scalability for major cities.
4	2023	AI on the Road: A Comprehensive Analysis of Traffic Accidents and Autonomous Accident Detection System in Smart Cities	Technologies: recognition System Protocols: communication and data sharing Algorithms Used: machine learning algorithms.	Analyzes traffic accidents and offers an automated detection system.	May not consider real-world deployment difficulties.
5	2022	Deep learning algorithms for assessment of the production and size of citrus fruits using a UAV	Technologies: Deep learning Protocols: Data Transmission Protocols Algorithms Used: Long Short-term Memory (LSTM)	Applies deep learning for citrus fruit yield estimate using UAVs.	Limited debate on generalizability to other crops.
6	2023	Parallel Transportation in TransVerse: From Foundation Models to DeCAST	Technologies: Parallel Computing Protocols: Network Protocols Algorithms Used: Parallel Algorithms	An outline of the architecture, components, and data flow between modules of Trans Verse's parallel transportation systems framework.	Scalability considerations not thoroughly covered.
7	2019	A Review of IoT Application in a Smart Traffic Management System	Technologies: AI and IOT Based Protocols: Communication protocols. Algorithms Used: Machine Learning	IoT technologies utilized for smart traffic control include sensors, actuators, and communication protocols.	May lack detailed use-case examples.
8	2021	Artificial Intelligence in Railway Transport: Taxonomy, Regulations, and Applications	Technologies: AI technologies Protocols: protocol used for communication Algorithms Used: a hierarchical taxonomy and AI	The railway systems comprise maintenance, safety, security, autonomous driving, transport planning, revenue management, transport policy, and passenger mobility.	Limited coverage of possible security issues.
9	2023	Visual E2C: AI-Driven Visual End-Edge-Cloud Architecture for 6G in Low-Carbon Smart Cities	Technologies:6G Networks Protocols:6G Protocols Algorithms Used: AI-driven visual end-edge-cloud architecture	Smart city development beats conventional ways by lowering carbon emissions.	May not thoroughly describe the energy efficiency of the planned building.
10	2018	Big Data Analytics with Network Calculus Enabling	Technologies:AI and Autonomous Vehicles	A framework for employing big data	Limited discussion on real-time data

		Intelligent Management of Autonomous Vehicles in a Smart City	Protocols: Data Transmission Protocols Algorithms Used: machine learning	analytics to govern traffic flow and enhance routes for self-driving automobiles in a smart city context.	processing problems.
11	2023	SCOPE: Smart Cooperative Parking Environment	Technologies: Cloud Computing Protocols: communication protocols Algorithms Used: Occupancy Detection Algorithms	The SCOPE system delineates its components, data flow, and interactions among sensors, actuators, cloud services, and user interfaces.	May not fully explore privacy problems connected to smart parking.
12	2016	Data-driven Interactive Crowd Management Systems for Metaverse Scenarios	Technologies: Crowd Management (CM) approaches Protocols: Communication Algorithms Used: Metaverse Crowd Management (MCM)	Utilizing data-driven strategies to better engagement and navigation in virtual environments for crowd control in metaverse settings.	Limited debate on potential ethical considerations in crowd control.
13	2021	Intelligent multiple Vehicle Detection and Tracking Using Deep-learning and Machine Learning: An Overview	Technologies: Artificial Intelligence Protocols: Data Transmission Protocols Algorithms Used: Block matching method with GGEN scheduling algorithm	Provides an overview of intelligent vehicle detection and tracking. And accomplished good performance.	Limited discussion on obstacles in real-world implementation.
14	2023	Technological breakthroughs toward smart energy management in smart cities	The study largely focuses on smart energy management within smart cities. While it doesn't specifically name specific technologies or methods, it emphasizes the convergence of digital technologies, communication technologies, and data analytics.	The study stresses technology's ability to revolutionize urban living. It emphasizes accessible services for inhabitants utilizing data-driven approaches. The document gives insight on existing and future opportunities for smart cities.	Unfortunately, the report does not explicitly describe its limitations. However, like any research endeavor, it may confront issues relating to data privacy, uneven technological access, and the need for collaboration across sectors.
15	2023	A social smart city for public and private mobility: A true case study	internet of things, Sensors, Camera, Wi-Fi access point, Machine learning	Combines social media data with sensors to monitor pedestrian and vehicle movement .Uses real-time data to alter traffic signals, minimizing congestion.AI analyzes traffic patterns to optimize flow.	Striking the correct balance between the expenditures involved with data gathering and the quality of the data remains a problem.
16	2022	Design and Implementation of an ML and IoT Based Adaptive Traffic-Management System for Smart Cities	Technologies: (AI) ,(ML) ,IoT ,5G Protocols: TLS/SSL, IPsec, and SSH Algorithms Used:3DES (Triple Data Encryption Standard) and AES (Advanced Encryption Standard)	Less congestion, speedier commutes, and saved resources. Adapts to changing conditions, improving traffic flow. Addresses numerous urban traffic difficulties	May be challenging to deploy at big scale. Sensors might not always be reliable. Integrating the system with current infrastructure could be hard.
17	2021	Intelligent Traffic Management: A Review of Challenges, Solutions, and Future Perspectives	Technologies: (AI) ,IoT ,Real-time traffic monitoring Protocols: data communication Algorithms Used: Traffic light control algorithms ,Traffic pattern analysis algorithms	Data collecting from cameras, mobile sensors, and social media. Machine learning to assess traffic trends and anticipate congestion. Dynamic traffic light modifications to improve flow.	Implementation obstacles include scalability, sensor reliability, and interface with existing infrastructure.
18	2020	Development of an IoT based real-time traffic monitoring system for city government	Technologies: (AI) , IoT Protocols The text does not specifically specify a specific protocol Algorithms Used: The publication does not define a particular algorithm	A prototype of the IoT-based system was developed and evaluated. The system displayed high accuracy in vehicle identification and achieved a low relative error in road occupancy prediction.	The suggested system does not specifically describe a specific protocol or method in the study article.

19	2021	A complete analysis of intelligent traffic management using machine learning techniques	Technologies: Blockchain Technology Protocols: PoW, PoS , Hybrid Approaches Algorithms Used: Consensus Algorithms	The study underlines the need of integrating AI and ML to boost traffic efficiency and eliminate manual intervention.	Blockchain challenges with processing duplicate transactions effectively, reducing performance and scalability.
20	2024	Smart Traffic Control System Using Artificial Intelligence	Technologies : AI ,ML ,DL ,IOT,Image processing Protocols: Adaptive approach Algorithms Used: YOLO , Fuzzy Logic , Traffic Flow Prediction Algorithms	AI-driven Smart Traffic Control System improves traffic flow, decreases fuel consumption, and promotes safety.It changes signal timings, monitors cars, and supports sustainable urban mobility	The system significantly relies on accurate and up-to-date data, which can be hard in locations with insufficient infrastructure or connection.
21	2024	Smart Traffic Management Systems: A Comprehensive Review of Existing Solutions	Technologies : AI, ML, IoT, and image processing Protocols: Adaptive signal timings depending on real-time data. Algorithms Used : Smart Traffic Signal Management, Traffic Flow Prediction, Traffic Congestion Detection and Management , Automatic Detection of Traffic Signals	The growth in private automobiles and limited road network capacity has worsened traffic congestion, impacting pollution levels and individual productivity.	Environmental effect, urban expansion, and safety issues.
22	2018	Artificial Intelligence Based Smart Traffic Management System Using Video Processing	Technologies: real-time video processing approaches Protocols: HTTP, TCP/IP Algorithms Used : traffic management algorithms	The method attempts to accomplish various advantages, such as eliminating significant traffic congestion, cutting pollution, saving human time lost in traffic, and conserving fuel and money.	Environmental effect, urban expansion, and safety issues.
23	2022	Smart Traffic Management System for Metropolitan Cities of Kingdom Using Cutting Edge Technologies	Technologies: IoT, cloud computing, 5G, and big data Protocols: HTTP incorporates real-time traffic information Algorithms Used: The publication does not define a particular algorithm	Potential to minimize traffic congestion and enhance overall efficiency.	Specific constraints were not expressly highlighted in the article.
24	2022	Traffic Management in Smart Cities Using the Weighted LeastSquares Method	Technologies: Weighted Least Squares (WLS) approach Protocols: best position for a portable drone station Algorithms Used: Weighted Least Squares (WLS)	The research adds to effective urban transportation networks by boosting emergency response and traffic management.	The research does not explore the influence of environmental conditions (e.g., weather) on drone operations.
25	2022	A Fog Based Smart Traffic Management System	Technologies: IoT (Internet of Things) Protocols: Fog computing Algorithms Used: Fog-Based Traffic Light Management Strategy (TLMS)	Reduced average waiting times at junctions, increased traffic flow, and efficient handling of emergency vehicles.	The prototype's performance may vary in different highway settings.
26	2021	The Implementation of Intelligent Traffic Management System in Solving Traffic Congestion: A Survey of Federal Route 3214	Technologies: Intelligent Traffic Management System (ITMS) Protocols: The document does not define a specific Protocols Algorithms Used: The publication does not define a particular algorithm	The research analyzes the effectiveness of ITMS in minimizing traffic congestion on the Federal Route 3214 (Shah Alam-Puchong Highway).	The study does not dig into particular constraints of the ITMS implementation.
27	2024	Smart Traffic: Integrating Machine Learning, and YOLO for Adaptive Traffic Management System	Technologies: Internet of Things (IoT), image processing Protocols: The document does not define a specific Protocols Algorithms Used: sophisticated algorithm	The strategy greatly decreases typical wait times, boosting traffic-clearing efficiency and contributing to environmental preservation by lowering CO_2 emissions.	The study does not dig into the particular constraints of the suggested system
28	2018	Smart Traffic Management System for Traffic Control utilizing Automated Mechanical and Electronic Devices	Technologies: wireless sensor networks (WSNs) Protocols: The document does not define a specific Protocols Algorithms Used: adaptive	The system intends to minimize traffic congestion, boost parking availability, and give an Android mobile	The study does not dig into the particular constraints of the suggested system

			traffic control	application for drivers to remotely access traffic and parking information.	
29	2023	A Review of Different Components of the Intelligent Traffic Management System (ITMS)	Technologies: computer vision (CV) and artificial intelligence (AI) Protocols: The document does not define a specific Protocols Algorithms Used: adaptive traffic control	Aims to alleviate congestion, promote road safety, and address environmental issues.	The study does not dig into the particular constraints of the suggested system
30	2018	Smart traffic management system with real time analysis	Technologies: cloud integration, image processing, Raspberry Pi, and ultrasonic sensors Protocols: Not clearly specified in the paper. Algorithms Used: The study does not provide a particular algorithm.	The suggested method intends to ease traffic congestion and enhance overall traffic management through real-time analysis.	The technology attempts to alleviate traffic congestion and boost overall traffic management through real-time analysis.
31	2021	Vehicle Detection and Tracking Using YOLO and DeepSORT	Technologies: Deep SORT (Deep Simple Online and Real-time Tracking) Protocols: Not clearly specified in the paper. Algorithms Used: YOLOv4	The suggested technology attempts to enhance traffic management by correctly recognizing and monitoring cars.	In real-world traffic circumstances, the environment is dynamic and unpredictable. Vehicles drive in diverse directions, occlusions occur, and lighting conditions vary fast.
32	2021	Vehicle Detection and Type Classification Based on CNN-SVM	Technologies: CNN (Convolutional Neural Network) plus SVM (Support Vector Machine) Protocols: YOLO-v5 architecture ,Transfer learning ,Anchor box clustering Algorithms Used: YOLO deep learning series algorithm	The suggested technique displays superior performance in both vehicle detection and type classification.	Robustness in Complex Environments
33	2018	Intelligent Traffic Management System for Smart Cities	Technologies: Cloud computing, Internet of Things (IoT), and Data Analytics Protocols: Not specifically addressed in the paper Algorithms Used: machine learning algorithms	The method attempts to minimize average waiting time, traffic congestion, travel expenses, and air pollution. It also introduces the notion of a green corridor for emergency services.	May not consider real-world deployment difficulties.
34	2020	Artificial intelligence-based vehicular traffic flow forecast approaches for supporting intelligent transportation systems	Technologies : AI-based approaches Protocols: rapid learning data-driven fuzzy model Algorithms Used: Extreme Learning Machine (ELM) and fuzzy rule pruning approach.	The approach displays good performance in traffic flow prediction.	The research focuses on certain AI approaches and may not address all traffic conditions
35	2022	Predictive Congestion Control based on Collaborative Information Sharing for Vehicular Ad hoc Networks	Technologies : VANET-based system Protocols: collaborative information sharing. Algorithms Used: road segment load assessment and prediction capabilities.	CoNeCT efficiently minimizes traffic congestion while keeping minimal communication impact	The research focuses on certain AI approaches and may not address all traffic circumstances.
36	2020	Enhancing intelligence in traffic management systems to help with vehicle traffic congestion problems in smart cities	Technologies: AI ,ML Protocols: Not specifically addressed in the paper Algorithms Used : traffic flow prediction	Smart traffic systems promote safety by avoiding accidents, recognizing dangerous circumstances, and delivering real-time notifications to drivers and pedestrians.	Collecting and analyzing traffic data may generate privacy problems relating to monitoring and tracking of persons.
37	2023	A innovative approach to reduce traffic congestion and air pollution for sustainable development of smart cities	Technologies: IoT , Big Data Analytics ,ML , GIS Protocols: HTTP, MQTT, and CoAP Algorithms Used : Traffic Flow Prediction Models, Dynamic Route Optimization , Air Quality Monitoring Algorithms	Reduced Traffic Congestion , Improved Air Quality , Enhanced Safety , Sustainable Urban Development	Balancing data collecting with privacy rights.

38	2021	Towards greener smart cities and road traffic predictions using air pollution data	Technologies : ML , LSTM ,RNN Protocols: HTTP, MQTT, and CoAP Algorithms Used : Traffic Flow Prediction Models, Dynamic Route Optimization , Air Quality Monitoring Algorithms	The proposed approach demonstrates the relationship between traffic intensity, air pollution, and atmospheric parameters. By incorporating air pollutants and atmospheric data, the traffic forecasting model improves accuracy. Sustainable transportation systems benefit from better traffic management, reduced journey times, and improved traffic flow.	Interpreting complex ML models remains a challenge
39	2020	An interpretable model for short term traffic flow prediction	Technologies : CNN-LSTM-attention model , CNN-GRU-attention model Protocols: Data gathering protocols(loop detectors, GPS, cameras) Algorithms Used : Dynamic Optimal Weighted Coefficient Algorithm	The CDLP model matches traffic flow trends effectively and beats baseline models. Under the same dataset, the CDLP model displays greater prediction accuracy	There is no consensus on which measures are best suited for traffic flow forecast.
40	2022	Traffic prediction using artificial intelligence: Review of current developments and potential possibilities	Technologies : ML, Deep learning approaches , ITS Protocols: Comprehensive review Algorithms Used : Multivariate traffic time series modeling.	The aim of this work is a thorough knowledge of AI-based traffic forecast methods. It adds to the field by emphasizing current developments and new research prospects.	The study examines intrinsic barriers to integrating machine learning and deep learning in traffic prediction.

The literature on AI-driven traffic management systems covers varied views and new applications. Arora et al. (2023) foresee the next wave of smart city applications, emphasizing multi-agent collaboration for increased urban services. Badidi et al. (2023) perform a systematic study, identifying potential and difficulties in edge-AI enabled video analytics for smart cities. Adewopo et al. (2023) fully examine road incidents, offering an automated accident detection system. Yang et al. (2023) describe an AI-driven architecture for 6G in low-carbon smart cities. Cui et al. (2019) emphasis on big data analytics and network calculus for intelligent management of autonomous cars in smart cities. These research together contribute to the growing landscape of AI in urban traffic management.

3. Existing System Mathematical Modeling

Smart Traffic Management System for Metropolitan Cities of Kingdom Using Cutting Edge Technologies [14]

The proposed approach aims to minimize traffic congestion by providing timely intimation to the drivers on their dashboards using cutting-edge technologies. The objective function in our case is to reduce traffic congestion by optimizing traffic information updates. Table 1 lists downthe notations used for mathematical modeling

$$_{o}F = \min imize(C_g) under \Im, \quad (1)$$

Where

$$C_g = \bigcup_{v=1}^{n} f(\varsigma v, cv, uvc, \varsigma d, ugm) \ , \ (2)$$

Traffic Management in Smart Cities Using the Weighted Least Squares Method [15]

Theorem 1. (Orthogonal decomposition theorem) Let W be a subspace of Rn. Then each y in Rn can be written uniquely in the form

$$y = \hat{y} + z \quad (1)$$

where $\hat{y}$ is in W and z is $W\perp$. In fact, if $\{u1,.....up\}$ is any orthogonal basis of W, then

$$\hat{y} = \frac{y.u_1}{u_1.u_1}u_1 + ... + \frac{y.u_p}{u_p.u_p}u_p \quad (2)$$

and z= y- $\hat{y}$.

A Fog Based Smart Traffic Management System [16]

$$N_{tv} = \sum_{v=1}^{4} N_v$$

$$T_c = \alpha * N_{tv}$$

$$R = \frac{N_v}{N_{tv}}$$

$$TL = R * T_c$$

Design and Implementation of an ML and IoT Based Adaptive Traffic-Management System for Smart Cities [17]

$$T^{out} = \begin{cases} TV^{out_i} \ (for \ i=0) \\ Max(TV^{out_i}, TV^{out_{i-1}} + TVh_i \ (for \ i=1,2,...n) \end{cases}$$

4. Disscusion

As cities continue to develop, traffic congestion has become a major issue, leading to anger and inefficiency. Existing solutions generally struggle to adapt to the changing character of urban living. To solve this difficulty, we suggest a unique approach: an AI-driven Traffic Management System that prioritizes people's needs.

Adaptive Traffic Signal Control (ATSC): ATSC integrates artificial intelligence with cameras positioned at traffic crossings. Its major objective is to detect and identify cars that break traffic laws, providing real-time notifications at a central command center. By evaluating complete statistics, including traffic volume, vehicle speed, and historical patterns, ATSC dynamically modifies traffic signal timings. The system attempts to improve traffic flow, minimize congestion, and promote overall urban mobility.

Beltech AI's Artificial Intelligence Driven Traffic Management System (AID-TMS): Developed by Beltech AI, the AID-TMS employs machine learning algorithms to forecast traffic patterns and identify future concerns. It includes proactive measures such as alternate route information and accident alerts. Additionally, the system encourages public transport utilization by delivering incentives and prizes. By making traffic management smarter, more responsive, and ecologically sustainable, the AID-TMS contributes to a pleasant urban mobility experience.

5. Conclusion

The introduction of AI-driven traffic management systems underscores the vital need for intelligent traffic management systems in solving the difficulties of urban congestion and boosting urban mobility in smart cities. Traditional techniques to traffic management are insufficient in handling the complexities of modern urban transportation, necessitating the integration of technologies like Artificial Intelligence (AI), Internet of Things (IoT), and Big Data analytics. These technologies offer real-time monitoring, predictive analytics, and adaptive methods to improve traffic flow, minimize congestion, and encourage eco-friendly transportation solutions. Innovative solutions such as Adaptive Traffic Signal Control (ATSC) and Artificial Intelligence-Driven Traffic Management Systems (AID-TMS) leverage machine learning algorithms to predict traffic patterns, identify potential issues, and provide proactive measures to improve overall traffic management. Effective communication and coordination between cars, infrastructure, and traffic authorities are necessary for proactive responses to traffic incidents and congestion. In the convergence of AI, IoT, and Big Data analytics has enormous potential in producing more efficient, sustainable, and livable smart cities.

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