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Intelligent Traffic Management System using Artificial Intelligence and Computer Vision: Review

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Abstract
Urbanization and rapid motorization have intensified traffic congestion, causing economic loss, pollution, and safety challenges. Traditional static traffic systems fail to cope with today's dynamic urban conditions, creating an urgent need for intelligent, adaptive, and real-time solutions. This review highlights Artificial Intelligence (AI) and Computer Vision (CV) as transformative technologies in Intelligent Traffic Management Systems (ITMS). Through deep learning, machine learning, and computer vision techniques, ITMS enables real-time vehicle detection, traffic density estimation, dynamic signal control, violation monitoring, and predictive analytics. Research studies across India and abroad demonstrate significant improvements in reducing travel time, fuel consumption, and accident rates while supporting environmental sustainability and smart city goals. Although implementation requires strong policy frameworks, interdisciplinary collaboration, and infrastructure investment, AI-driven ITMS holds immense potential for developing and developed nations alike. Overall, these systems represent a paradigm shift toward safer, greener, and more efficient urban mobility.
Keywords: Intelligent Traffic Management, Artificial Intelligence, Computer Vision, Smart Cities, Congestion Control

1. INTRODUCTION

Urbanization, high speed motorization, and the high growth rate in population have all had massive strain in the transportation infrastructure globally. Traffic jam has become one of the most critical problems of the modern cities that lead to economic losses, fuel waste, prolonged transportation time, and an even worse quality of life. The conventional systems of traffic control involving the use of fixed-point schedules, manual control, and the use of a static signal are becoming less and less useful in responding to the dynamic and unpredictable nature of urban traffic. These traditional systems were initially engineered to support a predictable flow and less dense traffic but in the current context of heterogeneity of vehicles, intricate road geometry and unpredictable traffic conditions, these systems fail to provide effective solutions. Consequently, there is immediate necessity of smart, dynamic, and real-time systems, which can track, examine and streamline traffic patterns besides improving road safety. This situation has led to the Intelligent Traffic Management Systems (ITMS), and especially the ones that utilize the skills of Artificial Intelligence (AI) and Computer Vision.[1]
Artificial Intelligence has changed almost all spheres of human activity, and transportation is not an exception. Machine learning, deep learning, and reinforcement learning are AI techniques that may be used in managing traffic through detection, prediction, and acting on the changing traffic pattern. Contrary to pre-programmed fixed procedures, AI systems have

the ability to be trained on huge amounts of historical and real-time traffic data, and it will become more accurate and able to make decisions further. As an example, AI can be used to predict congestion hotspots in advance, dynamically schedule signal timings, or detect deviant behavior, including traffic violations. Likewise, Computer Vision, a branch of AI, which deals with visual perception, has created new opportunities in traffic surveillance. Computer vision allows real-time vehicle detection, lane detection, pedestrian recognition, and incident detection using cameras, sensors, and sophisticated image-processing algorithms, providing a strong set of tools to the traffic authorities to cope with a complicated road situation.[2]

The development and implementation of AI and Computer Vision in traffic management systems is not a technological change as it is a paradigm shift. Through the integration of clever seeing as well as manipulative control, the systems have the prospect of changing traffic control into the proactive rather than the reactive, manual instead of automated, and inefficient into efficient. In theory, AI-based and Computer Vision-based Intelligent Traffic Management System is expected to provide a connected, real-time, and automated environment in which cars, roads, and authorities interact in a harmonious environment. The interplay of the technologies is consistent with the concept of smart cities, in which the concern of digitalization, sustainability, and efficiency are of utmost priority. Even more affordable prices of high-resolution cameras, the accelerating development of computing hardware, the presence of large datasets, only hastened the implementation of such systems on the world-wide level.[3]

Traffic congestion is not an issue which is only limited to developed countries or even megacities. Even worse realities are experienced in developing countries where the infrastructural development in most cases is years behind the vehicle expansion. In cities like Delhi, Mumbai, and Bengaluru in India, travelers are also forfeiting hundreds of hours annually in traffic congestions, and also pollution caused by vehicles is also a major cause of poor air quality. Intelligent Traffic Management Systems in such situations are not a luxury but a requirement in the sustainable urban living. Authorities will be able to develop situational awareness by installing AI-controlled cameras at intersections, highways, and other sensitive areas and reduce the number of traffic law violations. Furthermore, the systems decrease the use of manual policing, decrease the human error and enhance the transparency of enforcement procedures.[4]

Technically, an ITMS based on AI and Computer Vision works by receiving video streams at a number of cameras, processing the frames to detect cars and people and utilize algorithms to compute traffic congestion, speed, and offenses. Object detection in real-time is widely implemented using popular models, like Convolutional Neural Networks (CNNs) and sophisticated ones, such as YOLO (You Only Look Once) or Faster R-CNN. These models are trained with huge quantities of annotated data to identify various types of vehicles cars, trucks, buses, motorcycles, and can work with different lighting and weather conditions. After the processing of the data, intelligent decision modules are used to optimize the timing of the signal, predict congestion, or issues alerting of an accident. Such a smooth condition of perception, analysis and control is the hallmark of the smartness of the contemporary traffic systems.[5]

Congestion management is not the only area of AI-based ITMS. The other area in which these technologies are transformative is in road safety. As the number of accidents is alarmingly increasing because of the speeding, jumping the red lights, distracted driving, or jaywalking, the concept of the violation detection in real-time has become invaluable. Vision systems that are run by AI are able to identify and capture violations automatically, resulting in evidence that is accurate and unreliable. What is more, the systems of accident detection and response can radically decrease the number of people killed, as emergency services get informed instantly. Such systems have already been established in most of the world cities to reduce the response times and save lives. Sustainability of the environment is another crucial factor. Due to the significant fuel loss from idle engines and stop-and-go traffic, traffic congestion directly raises greenhouse gas emissions. AI-driven technologies help lower energy use and vehicle emissions by intelligently organizing traffic flow. The use of such technology is in line with more general environmental aims in the age of climate change and sustainability objectives. To establish an inclusive mobility ecosystem, smart traffic systems may be combined with networks for bicycle sharing, public transit management, and electric car infrastructure.[6]

The socioeconomic effects of ITMS should also be noted. Because it reduces lost time, fuel costs, and productivity, efficient traffic flow has a significant positive economic impact. Reduced traffic and accidents may save governments and local governments millions of dollars per year. The general quality of urban life is also improved by increased traffic safety and decreased pollution, which draws investment and promotes sustainable growth. Intelligent traffic systems may help quickly emerging countries close the gap between their expanding transportation needs and their limited infrastructure. The constantly expanding body of research and real-world implementations worldwide make a thorough evaluation of this topic crucial. Many governments are making significant investments in these systems, ranging from India's National Intelligent Transport Systems policy framework to Singapore's Smart Mobility 2030 plan. Although the subject is quite fragmented, academic academics are releasing new algorithms, case studies, and performance assessments. These contributions may be compiled, patterns can be found, limits can be pointed out, and future study topics can be suggested in a review paper. Such a synthesis is essential for computer science researchers to direct future innovation and match technological advancement with social demands.[8]

Intelligent traffic management systems that make use of computer vision and artificial intelligence provide a revolutionary way to address one of the most important urban issues of our day. These technologies offer safer roads, more efficient traffic, and greener cities by using the power of real-time perception, adaptive decision-making, and predictive analytics. But in addition to technological inventiveness, achieving this goal calls for interdisciplinary cooperation, legislative backing, and significant funding. The application of AI to traffic management is only the start of a larger process that will lead to intelligent, robust, and sustainable urban transportation. In light of this, the current review article aims to investigate the status of research, real-world applications, difficulties, and potential future paths in the area of artificial intelligence and computer vision-based intelligent traffic management systems.[9]

2. LITERATURE REVIEW

Ansh Sakhuja et. al (2023)[10] 'Intelligent Traffic Management System using Computer Vision and Machine Learning' With urban traffic management becoming more and more complex, a ground-breaking system called "Intelligent Traffic Management System using Computer Vision and Machine Learning" was created to address these issues. It makes use of the strength of two innovative technologies: computer vision and machine learning. The system can receive and analyze visual data from cameras placed across roads thanks to computer vision, and machine learning gives it the ability to learn from this data and come to wise conclusions without explicit programming.The project offers a revolutionary and ground-breaking response to the difficulties that contemporary urban traffic management must overcome. The system intends to optimize traffic flow, improve road safety, and lessen the environmental effect of urban transportation by utilizing cutting-edge technology like Computer Vision and Machine Learning. The system can dynamically alter traffic signal timings, pinpoint congested areas, and quickly handle traffic issues through real-time monitoring, analysis, and data-driven decision-making. As a result, commuters, businesses, and the economy as a whole gain from shorter travel times, fewer delays, and a more effective transportation system. The project's emphasis on road safety is crucial since the system's capacity to quickly identify and handle traffic issues can save lives and stop subsequent tragedies. The system contributes to a safer and more orderly road environment by encouraging adherence to traffic laws and encouraging responsible driving behavior, thereby lowering the frequencyof accidentsand injuries. Furthermore, the incorporation of machine learning algorithms and in-the-moment data analysis equips traffic authorities and city planners to make wise choices about traffic management tactics and infrastructure design. This data-driven strategy improves overall effectiveness and aids in developing eco-friendly urban environments, which is in line with the objectives of sustainable development and environmental preservation. Additionally, the project's commitment to educating the public through campaigns and educational programs encourages community support. The project seeks to forge a shared commitment to the system's success by involving the public in the process and highlighting their role in promoting road safety and responsible driving. The effort, which aims to change urban traffic management, is extensive and forward-thinking. The system can make cities safer, more effective, and more ecologically friendly for both residents and visitors thanks to its wide range of objectives and integrated technologies. This project has the potential to transform how we approach traffic management as it develops, ultimately improving metropolitan areas' quality of life.

Mujahid Issam Ashquer et.al (2024)[11] '*Real-Time Traffic Density Estimation Using Various Connected Vehicle Penetration Rates: A New Predictive Approach*.' Traffic density estimation using various Market Penetration Rates (MPRs) of Connected Vehicle (CV)data represents an area in need of continued research and refinement to fully leverage its potential in addressing complex real-world traffic scenarios. This study introduces an innovative approach, the Predictive Approach, employing the Temporal Convolution Network (TCN) algorithm to estimate traffic density. This method calculates the densities of input approaches at intersections with non-uniform MPRs, using these predictions to estimate the target approach density. Using the Predictive Approach, results showed that improving traffic density predictions can be achieved through factors like accounting for MPR variations between different intersection approaches and considering specific scenarios. Results also highlighted that excluding Signal Phase and Timing (SPaT) data in certain cases can enhance model performance. It offers practical applications in optimizing traffic flow and reducing congestion in smart cities and traffic control centers, particularly when rapid and real-time computations are required. Additionally, it serves as a valuable solution in areas lacking SPaT information and experiencing varying levels of vehicle connectivity, collectively providing versatile tools for efficient traffic management and urban mobility enhancement. These insights have the potential to make real-worldtrafic management more efficient, responsive, and adaptable, ultimately leading to safer and more effective transportation systems. Traffic estimation using probe vehicle data considering different market penetration rates is important because it provides real-time information about traffic conditions. This study presents the results of four distinct practical scenarios for traffic density estimation. The aim of these scenarios is to introduce the Predictive Approach as a new approach for estimating trafficdensity. For the Baseline Traffic Density Estimation (Scenario 1), which focuses on estimating traffic density at intersections by considering various factors, such as non-uniform MPRs from different approaches, thusrefecting the complexity and diversity of real-world traffic data. The analysis reveals an interesting trend:as MPR increases, the model's performance improves. Notably, the model demonstrates reasonable performance even when dealing with low MPR, provided that there is substantial traffic volume on the approach.We then, in Scenario 2, introduced the Predictive Approach to traffic density estimation, emphasizing the initial calculation of input approach densities with varying MPRs. Results demonstrated a consistent trend observed in Scenario 1: as MPR increases, RMSE decreases, highlighting the model's enhanced predictability. The analysis farmed the model's ability to explain and predict the impact of MPR on traffic density. In Scenario 3, SPaT data was excluded as inputs, which becomes pertinent when such data is unavailable. Results revealed an improvement in the model's t to the data underscores that excluding Spat data significantly enhances model predictability, emphasizing the effectiveness of this approach in Scenario 3.Finally, Scenario 4 replicates Scenario 3 but introduces non-uniform MPRs for the input approaches. Results highlighted the trend of improved model performance as MPR increases, echoing observations from other scenarios. This model adaptability remains robust even when dealing with lower MPR in certain approaches, as long as the overall traffic volume is substantial. The application of the Predictive Approach, alongside SPaT data exclusion and non-uniform MPRs, presents a promising avenue for enhancing traffic density prediction in complex real-world scenarios. In practical terms, these findings hold significant implications for traffic management systems and urban planners. They suggest that accounting for MPR variations, optimizing model parameters, and considering specific scenarios can lead to more accurate traffic density predictions. Additionally, the exclusion of SPaT data in certain scenarios can improve model performance. By embracing these insights, real-world traffic management can be more e cient, responsive, and adaptable to the dynamic nature of urban mobility, ultimately contributing to safer and more effective transportation systems.

Gupta, A., et al. (2020)[12] ‘YOLO-Based Vehicle Detection in Indian Traffic’. International Journal of Computer Applications. Urban traffic congestion remains a critical challenge, driven by increasing vehicle numbers and limitations in state of art traffic control systems. Conventional traffic management approaches often lack the flexibility to respond dynamically to real-time conditions, leading to increased congestion, greater energy consumption, and prolonged travel times. To address this, this paper proposes an Intelligent Traffic System (ITS) that leverages computer vision to enable real-time traffic control. The system uses Closed Circuit Television (CCTV) cameras strategically placed at traffic intersections to capture live streams, from which vehicle counts in each lane are determined through image processing techniques. Based on these counts, adaptive signal timings are allocated to optimize traffic flow. The results show that the proposed system saved 75.42% of the commute time as compared to a conventional traffic system. This approach not only enhances traffic fluidity but also paves the way for more responsive and efficient urban traffic management infrastructure. It is clear from this research that an intelligent traffic light control via computer vision is a good solution to the problem of traffic congestion. Current Static signals allocate fixed intervals to each lane, regardless of actual traffic flow. This approach often leads to congestion on lanes with high traffic volume while lanes with little or no traffic continue to receive the same amount of signal time. A traditional traffic signal with a fixed duration such as 60 seconds per direction, would require a total of 240 seconds for all the vehicles to pass through an intersection. Alternatively, a dynamic control strategy, like the one used above, makes adjustments in real time according to traffic circumstances, greatly cutting sown on commuting time. In this example, the dynamic approach decreased the total time to 59 seconds, saving 181 seconds (75.42%) of the initial time and reducing fuel consumption accordingly. The significant time savings demonstrates how a dynamic traffic management system can greatly alleviate congestion. By adapting to vehicle density on each lane, such a system minimizes delays for commuters, especially in urban settings where traffic congestion is a major issue

Syed Konain Abbas and Muhammad Umair Hassanet. al (2024)[13] Vision based intelligent traffic light management system using Faster R-CNN. Transportation systems primarily depend on vehicular flow on roads. Developed countries have shifted towards automated signal control, which manages and updates signal synchronization automatically. In contrast, traffic in underdeveloped countries is mainly governed by manual traffic light systems. These existing manual systems lead to numerous issues, wasting substantial resources such as time, energy, and fuel, as they cannot make real-time decisions. In this work, we propose an algorithm to determine traffic signal durations based on real-time vehicle density, obtained from live closed circuit television camera feeds adjacent to traffic signals. The algorithm automates the traffic light system, making decisions based on vehicle density and employing Faster R-CNN for vehicle detection. Additionally, we have created a local dataset from live streams of Punjab Safe City cameras in collaboration with the local police authority. The proposed algorithm achieves a class accuracy of 96.6% and a vehicle detection accuracy of 95.7%. Across both day and night modes, our proposed method maintains an average precision, recall, $F1$ score, and vehicle detection accuracy of 0.94, 0.98, 0.96 and 0.95, respectively. Our proposed work surpasses all evaluation metrics compared to state-of-the-art methodologies. In this work, we propose an intelligent traffic light system to solve traffic jams. Our proposed system counts the vehicles based on detected vehicles and dynamically assigns the traffic signal time according to each vehicle's PCU value. We fine-tune two different architectures for traffic classification of the image and object detection for traffic light automation. We label the local image dataset based on image classification, and based on object detection, we generate the predictive instances. The experiments show that our proposed method gives better accuracy than the traditional method. Our proposed method is a real-time traffic signal automation system that uses Faster R-CNN for vehicle detection. Based on the labelled dataset, our proposed method yields the vehicle's current count based on vehicle density. After getting a current count of vehicles on all sides of the road, the system takes live streaming of CCTV cameras placed on the traffic signal. There is communication between central servers, and then, based on density, it will dynamically set the time based on each vehicle's PCU value. Our proposed work is helpful for ITS by automating traffic signals. The proposed traffic light management system based on real-time data solves many problems by saving resources such as time, energy, fuel etc. It also saves economic costs, which will be helpful for any country's economy. In the future, we aim to propose efficient methods using YOLOv8 for better detection performance and enhancing the traffic management system. We will also propose methods to track the vehicles properly and measure the vehicle's current speed.

Shruti Mishraet. al (2029)[14] An Improved Smart Traffic Signal using Computer Vision and Artificial Intelligence. The growth in population all over the world and in particular in India causes an increase in the number of vehicles which, create complications regarding traffic jam and traffic safety. The primary solution to recover the jam condition is the expansion of capacities of roads by building new streets. However, this requires extra efforts and more time that is a costly and ineffective solution. Therefore, there is a need for alternative solution methodologies that are being implemented. Intelligent traffic monitoring is a branch of intelligent transportation systems that focuses on improving traffic signal conditions. The key goal of such an intelligent monitoring system is to improve the traffic system in a way that reduces delays. Many cities facing these delays because of the inefficient configuration of traffic light systems which are mostly fixed-cycle protocol based. Therefore, there is a profound need to improve and automate these traffic light systems. The establishment of a mixed technique of artificial intelligence (AI) and computer vision (CV) can be desirable to develop an authenticated and scalable traffic system which can aid to solve such problems. Proposed work supports the use of computer vision technology to build a resource-efficient, synchronous and automated traffic analysis. Video samples were collected from multiple areas to use in the system. The system applied and the vehicle was counted and classified into different classes. Manually and automatically annotated patterns were used for the classification. The multi-reference-line mechanism employed to find the speed of the vehicle and analyze traffic. The system makes its decision based on a number of vehicles, backwards-forward synchronous data and emergency conditions. Traffic congestion has become a significant issue especially in urban areas. The most generic cause for the traffic jam in India is an incapable traffic signal monitoring system which affects the traffic flow severely. Frequent traffic jams at major urban areas always create a need for an efficient traffic management system. In this dissertation, we have successfully implemented an efficient system for a real time video processing based intelligent traffic monitoring system that detect, count, identify vehicles and make decisions to control traffic jam. Through our proposed work, we tried to show the advantages of computer vision technique of Opens with machine learning for an automated traffic management system. Implementation proposed workwould exclude the need of traffic personnel at various areas for regulating the traffic. Moreover, we have used synchronous backwards-forward data sharing with each traffic signals that helps the system to makeeffective decisionsfor connected signals. This technique gives an extra advantage to our system. Thus, we can ensure that our proposed system will be valuable for the analysis and improvement of road traffic.

Kumar, S., & Singh, R.et. al (2021)[15] 'Traffic Signal Control via Reinforcement Learning: A Review on Applications and Innovations'Traffic signal control plays a pivotal role in intelligent transportation systems, directly affecting urban mobility, congestion mitigation, and environmental sustainability. As traffic networks become more dynamic and complex, traditional strategies such as axed-time and actuated control increasingly fall short in addressing real-time variability. In response, adaptive signal control—powered predominantly by reinforcement learning—has emerged as a promising data-driven solution for optimizing signal operations in evolvingtraffic environments. The current review presents a comprehensive analysis of high-impact reinforcement-learning-based traffic signal control methods, evaluating their contributions across numerous key dimensions: methodology type, multi-agent architectures, reward design, performance evaluation, baseline comparison, network scale, practical applicability, and simulation platforms. Through a systematic examination of the most influential studies, the review identifies dominant trends, unresolved challenges, and strategic directions for future research. The endings underscore the transformative potential of RL in enabling intelligent, responsive, and sustainable traffic management systems, marking a significantshift toward next-generation urban mobility solutions. Keywords: reinforcement learning; traffic management; traffic signal control; adaptive control; model-free control; intelligent transportation. Over the past decade, reinforcement learning has emerged as a transformative paradigm in Over the past decade, reinforcement learning has emerged as a transformative paradigm in traffic signal control, steering the field away from static and heuristic-based strategies toward adaptive, data-driven decision making. This review has consolidated abroad spectrum of RL-based TSC research, examining algorithmic developments, scalability trends, and performance metrics across diverse intersection types, reward structures, and simulation platforms. By distilling findings from extensive prior work, the study offers both a comprehensive overview and technical depth, framing the evolution of RL as a key enabler for tackling real-world challenges such as congestion, emissions, and urban safety. Notable trends highlight this progression—chief among them is the dominance of value-based methods, particularly DQN variants, and the widespread adoption of multi-agent architectures that enable decentralized, scalable control. Reward design has evolved from traditional congestion-focused metrics to incorporate safety, sustainability, and fair-ness, rejecting broader smart city goals. Benchmarking practices have matured, with comparisons now including established RL frameworks like Co Light and Press Light along-side conventional baselines. Furthermore, simulation tools such as SUMO and City Flow.

Dr. Megha Kadam, Aarti Uttam Sutar, Vedika Vilas Kakad, Sarika Appasaheb Dubale, Shamli Satish Vaidyaet. al (2025)[16] ‘Traffic Management Using Artificial Intelligence’. Urban traffic congestion remains a critical challenge, driven by increasing vehicle numbers and limitations in state of art traffic control systems. Conventional traffic management approaches often lack the flexibility to respond dynamically to real-time conditions, leading to increased congestion, greater energy consumption, and prolonged travel times. To address this, this paper proposes an Intelligent Traffic System (ITS) that leverages computer vision to enable real-time traffic control. The system uses Closed Circuit Television (CCTV) cameras strategically placed at traffic intersections to capture live streams, from which vehicle counts in each lane are determined through image processing techniques. Based on these counts, adaptive signal timings are allocated to optimize traffic flow. The results show that the proposed system saved 75.42% of the commute time as compared to a conventional traffic system. This approach not only enhances traffic fluidity but also paves the way for more responsive and efficient urban traffic management infrastructure. It is clear from this research that an intelligent traffic light control via computer vision is a good solution to the problem of traffic congestion. Current Static signals allocate fixed intervals to each lane, regardless of actual traffic flow. This approach often leads to congestion on lanes with high traffic volume while lanes with little or no traffic continue to receive the same amount of signal time. A traditional traffic signal with a fixed duration such as 60 seconds per direction, would require a total of 240 seconds for all the vehicles to pass through an intersection. Alternatively, a dynamic control strategy, like the one used above, makes adjustments in real time according to traffic circumstances, greatly cutting sown on commuting time. In this example, the dynamic approach decreased the total time to 59 seconds, saving 181 seconds (75.42%) of the initial time and reducing fuel consumption accordingly. The significant time savings demonstrates how a dynamic traffic management system can greatly alleviate congestion. By adapting to vehicle density on each lane, such a system minimizes delays for commuters, especially in urban settings where traffic congestion is a major issue Future research efforts should focus on enhancing the model's accuracy, and develop advanced models capable of effectively handling visibility challenges under adverse weather condition.

Vitthal B Kamble, Onkar N Mundhe, Chaitanya M Walunjkar, Gaurav A Kale et. al (2025)[17] 'AI-Driven Smart Traffic Management System': An Adaptive Approach Using YOLO and OpenCV' Intelligent traffic management systems are required due to the growing congestion in urban areas. Conventional fixed-time traffic lights frequently result in inefficiencies, such as long wait times and traffic jams at busy junctions.Using YOLO-based vehicle recognition and dynamic signal control, this work presents an AI-driven traffic light management system. In order to optimize traffic flow, the system analyzes vehicle density in several lanes using real-time image processing from IP cameras and makes informed decisions.The suggested approach prioritizes highly crowded lanes while maintaining signal distribution equity, improving traffic efficiency. Python, OpenCV, and Ultralytics YOLO are used for real-time detection in this fully software-based system. When compared to static signal systems, the results show better traffic flow management; deep learning models and reinforcement learning may be used to further improve the system. This study presents the design and implementation of a fully software-based, AI-powered smart traffic management system capable of dynamically optimizing traffic signal timings based on real-time vehicle density. Leveraging the capabilities of YOLO for accurate object detection and OpenCV for real-time image processing, the system effectively identifies congestion levels across multiple lanes and adapts signal durations accordingly. By eliminating the need for expensive hardware and focusing on a software-centric approach, the system offers a scalable and cost-effective solution suitable for smart city applications.Through comparative analysis with traditional fixed-time traffic systems, the AI-driven model demonstrated substantial improvements in traffic flow efficiency, reduction in vehicle waiting times, and equitable distribution of green signal durations. Furthermore, the introduction of a fairness constraint ensures that no single lane dominates the traffic cycle, promoting balanced traffic management across all intersections.The project not only validates the feasibility of using computer vision and lightweight deep learning models for traffic control but also lays the foundation for future advancements. Future extensions could integrate reinforcement learning algorithms to enable self-optimization, cloud-based processing for broader city-wide deployment, and V2X communication technologies to further enhance prediction accuracy and responsiveness.Overall, the proposed AI-driven traffic management system contributes toward making urban transportation smarter, faster, and more efficient, paving the way for the next generation of intelligent mobility solutions in smart cities.

Rizama Victor Samuel et. al (2024)[18] 'Computer Vision for Intelligent Traffic Monitoring and Control' Urban traffic congestion remains a critical challenge, driven by increasing vehicle numbers and limitations in state of art traffic control systems. Conventional traffic management approaches often lack the flexibility to respond dynamically to real-time

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Ravina Dnyaneshwar Chavhan, Dr. G.B. Sambare et. al (2024)[19] ‘AI-Driven Traffic Management Systems In Smart Cities: A Review’ 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.

Aryan Khareet. al (2023)[20] ‘Assessing the Impact of Artificial Intelligence on Resolving Traffic Issues in India’ This study investigates the impact of Artificial Intelligence (AI) on alleviating India's traffic congestion. With burgeoning urbanization and increasing vehicle ownership, traffic issues have reached critical levels. Leveraging AI's predictive analytics and real-time data processing, the research explores its potential to reduce congestion, enhance traffic management, and improve overall transportation efficiency. Through literature review and data analysis, the paper evaluates AI applications in an Indian context. The findings provide valuable insights for policymakers and urban planners, highlighting AI as a promising solution to create more efficient and sustainable transportation systems in India's rapidly urbanizing landscape.In the bustling urban landscapes of India, where traffic congestion, inadequate infrastructure, and safety concerns have long plagued commuters, the advent of Artificial Intelligence (AI)-powered traffic management systems offers a glimmer of hope. Through a careful examination of the correlation between the problems inherent in Indian traffic and the challenges these AI systems are designed to tackle, it becomes evident that Surtrac, SCATS, and similar technologies have the potential to bring about a transformative. They stand as beacons of progress, poised to make the daily commute a smoother and more efficient experience for millions of Indian citizens. As India continues to urbanize and its transportation needs evolve, embracing AI-driven solutions may indeed pave the way toward a brighter future for its urban mobility landscape. Surtrac, for instance, has showcased remarkable results, with reported reductions in travel time reaching as high as 40%. It's important to recognize that this percentage signifies more than just a numerical value; it represents a profound impact on the daily lives of millions. In a country known for its super long traffic commutes, a 40% reduction translates into precious hours reclaimed, less stress endured, and a substantial boost to productivity. Moreover, the significance amplifies when scaled to India's population. With the potential to reduce 40% of India's super long traffic time, the ratio becomes not just a statistic, but a beacon of hope for improved urban mobility. The potential to alleviate congestion, improve safety, and enhance the overall quality of life for India's urban population cannot be understated. As India's cities continue to grow and evolve, embracing AI-driven solutions is not merely an option; it is an imperative step towards a future where traffic woes are minimized, and daily commutes become more efficient and enjoyable. The promise is clear: AI can offer a brighter, smoother, and more productive future for millions of Indian commuters.

3. CONCLUSIONS

The paper emphasizes how conventional traffic management is being transformed into intelligent, adaptable, and sustainable systems using artificial intelligence and computer vision. These systems tackle important urban issues including traffic, accidents, and environmental degradation by combining real-time observation, predictive analytics, and automated decision-making. It is clear from international case studies and research that AI-powered Intelligent Traffic Management Systems (ITMS) maximize fuel efficiency, cut down on travel time, and enhance overall road safety. Their capacity to identify infractions, improve emergency response, and dynamically modify traffic signals represents a paradigm change in urban transportation.

Furthermore, in a variety of circumstances, the use of deep learning models like YOLO, Faster R-CNN, and reinforcement learning frameworks shows excellent accuracy in vehicle identification and density estimate. These developments also support sustainable development and smart city objectives, which place a high value on eco-friendliness and efficiency. However, multidisciplinary cooperation, robust legislative frameworks, and ongoing infrastructural investment are necessary to achieve their full potential. Scalable and affordable AI-based traffic solutions may help bridge the gap between growing motorization and inadequate infrastructure, especially in developing nations.

In conclusion, artificial intelligence (AI) and computer vision are not only new technologies; they are vital instruments for creating safer, smarter, and greener cities, guaranteeing a more effective urban future.

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