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# DYNAMIC TRAFFIC MANAGEMENT SYSTEM FOR EFFICIENT ROUTING OF HEAVY LOAD VEHICLES IN URBAN ENVIRONMENTS

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***Abstract—*** In metropolitan environments, traffic congestion caused by heavy-load vehicles poses serious obstacles to safe and effective transit. This paper brings a novel method for identifying heavy-load vehicles such as trucks and huge vans uses CCTV images and vehicle density analysis. The system uses the YOLO version 8 algorithm in combination with the programming framework Python and tools like PyTorch, OpenCV and Deep SORT to identify heavy-load automobiles in real-time and provide optimised routes to avoid traffic bottlenecks. By using YOLO algorithms and vehicle density analysis this system distributes heavy-load trucks systematically along the road networks, minimizing traffic congestion. The transportation management system also enhances overall traffic control by penalising transgressions and ensuring lane conformance. This creative approach has the potential to improve transportation efficiency and mitigate urban traffic congestion.

Keywords— Heavy load vehicles, Traffic congestion, YOLO algorithm, Route optimization, CCTV analysis, Urban transportation efficiency.

## I. INTRODUCTION

The technology and innovation in current day scenario is beyond our imagination. But on the other hand, we can say there are things that are yet to be discovered or researched. In the contemporary urban landscape, the escalating presence of heavy-load vehicles, such as trucks, load trucks, and big vans, contributes significantly to traffic congestion. The increasing number of heavy-load vehicles, in today's metropolitan environment is a major source of traffic congestion. In order to reduce traffic problems brought on by these large trucks, this research presents a novel heavy load vehicle traffic congestion management system. The technology uses CCTV video analysis and sophisticated computer vision algorithms to detect heavy-load trucks and evaluate how they affect traffic density. The real-time data from CCTV cameras placed strategically across the road network is used by the suggested system to function. Through the analysis of vehicle density, especially that of heavy-load trucks, the technology pinpoints possible areas of congestion. Through cleverly calculating it at that point, optimizes courses for heavy-load vehicles, guaranteeing a more indeed dispersion and avoiding a concentration of these vehicles on particular lanes that seem lead to traffic bottlenecks. The essential objective of the framework is to improve activity stream and diminish blockage caused by heavy-load vehicles. By considering the one-of-a-kind spatial necessity of these vehicles, the framework suggests elective lanes that give satisfactory space and minimize the probability of traffic jams. This energetic steering framework guarantees that heavy-load vehicles are effectively disseminated over the lanes, anticipating the aggregation of blockage in particular zones. Moreover, the proposed framework grasps supportability by advancing fuel productivity and diminishing emanations, proficiently, driving to a reduced fuel utilization and natural sustainability. The integration of these advances not only addresses traffic jams but too adjusts with broader goals of economical urban versatility. The surge in cargo transportation, especially through heavy-load vehicles like trucks, stack trucks, and enormous vans, can be credited to the continuous patterns of urbanization and globalization. Concurring to later insights, the volume of products transported through heavy-load vehicles has experienced a critical increment all inclusive, reflecting the developing request for productive development of merchandise inside urban ranges. This surge in cargo transportation has subsequently escalates challenges related to overwhelming stack vehicle traffic congestion. In later a long time, urban spaces have ended up progressively interconnected, driving to a rise within the number of heavy-load vehicles navigating through city roads. This interconnecting has encouraged exchange and commerce on a worldwide scale but has moreover exacerbated traffic issues, particularly in thickly populated urban regions. As a result, the require for a viable framework to oversee the stream of these huge vehicles has gotten to be fundamental for guaranteeing smooth activity operations and minimizing disturbances to lifestyle. Statistically, heavy-load vehicles are frequently recognized as major supporters to traffic in urban situations. Considers have appeared that a critical phase of traffic and gridlocks can be credited to the nearness of these vehicles on the streets. With their bigger estimate and slower increasing speed rates compared to traveler vehicles, heavy-load vehicles tend to obstruct traffic stream, driving to bottlenecks and expanded travel times for commuters. In order to reduce traffic problems brought on by these large trucks, this research presents a novel heavy load vehicle traffic congestion management system. The technology uses CCTV picture analysis and sophisticated computer vision algorithms to detect heavy-load trucks and evaluate how they affect traffic density. The real-time data from CCTV cameras placed strategically across the road network is used by the suggested system to function. Through the analysis of vehicle density, especially that of heavy-load trucks, the technology pinpoints possible areas of congestion.

| Vehicle Type | Size (Length x Width x Height) | Weight (Approximate) | Spatial Requirements |
|---|---|---|---|
| Trucks | 25-30 feet x 8-9 feet x 10-12 feet | 15,000-25,000 lbs | Require wider lanes for turning and parking. |
| Load Trucks | 30-35 feet x 8-10 feet x 12-14 feet | 25,000-40,000 lbs | Larger turning radius and parking space. |
| Big Vans | 20-25 feet x 7-8 feet x 9-10 feet | 10,000-15,000 lbs | Moderate lane width requirement. |

*Table 1.1 A summary of the characteristics of heavy-load vehicles, including size, weight, and spatial requirements.*

## II. LITERATURE REVIEW

Examining previous studies and advancements in the field of traffic management, with a particular focus on heavy-load vehicle-related solutions, is the literature review for the proposed heavy-load vehicle traffic congestion system. Numerous scholarly investigations have emphasized the difficulties presented by heavy-trucks in urban traffic congestion, stressing their greater spatial needs and slower rates of acceleration in comparison to other types of vehicles. **[1]** Heavy-load trucks frequently cause delays and bottlenecks on urban roadways, according to research, and they have a major negative impact on traffic congestion. Furthermore, research has shown that in order to better manage heavy-load vehicle traffic, novel techniques are required, taking into account the unique qualities of these vehicles as well as their influence on traffic dynamics. Using CCTV footage to track the movements of heavy-duty vehicles in real time is one popular research topic. **[2]** Numerous studies have shown how well CCTV equipment captures comprehensive visual data, making it possible to analyse traffic patterns and accurately identify heavy-load trucks. Researchers have developed intelligent traffic management systems that may optimise heavy-load vehicle routes, hence lowering the probability of congestion and enhancing overall traffic flow, by utilising CCTV pictures and vehicle density data. **[3]** The significance of offering heavy-load trucks other routes to avoid traffic hotspots has also been discussed in literature. In order to minimise vehicle concentration on certain routes and reduce traffic congestion, researchers hope to more fairly spread traffic over the road network by diversifying the routes available to heavy-load trucks. The literature analysis highlights the urgent need for creative solutions to alleviate traffic congestion caused by large load vehicles in metropolitan settings. This project intends to contribute to the creation of an intelligent traffic management system that can effectively control heavy-load vehicle traffic and improve urban mobility by synthesizing data from previous research. A number of other studies have made significant contributions to our understanding of how to manage traffic congestion caused by heavy-load vehicles, in addition to the ones that were highlighted in the preceding literature review. **[4]** One noteworthy research by Smith et al. (2018) looked at the real-time monitoring of heavy-load truck movements using modern sensor technologies like radar and LiDAR. By providing exact and comprehensive data on vehicle placements, speeds, and trajectories, the authors showed how these sensor-based systems might optimise traffic flow and precisely identify bottleneck areas. Additionally, a study conducted by Jones and Brown (2019) investigated how predictive analytics might help reduce traffic congestion caused by heavy-load vehicles. **[5]** The scientists created a model that can estimate traffic patterns and anticipate possible hotspots for congestion by examining past traffic data and integrating predictive algorithms. This proactive strategy made it possible to intervene quickly to avoid traffic jams and raise the effectiveness of traffic management as a whole. Furthermore, the integration of vehicle-to-infrastructure (V2I) communication technologies with intelligent transportation systems (ITS) was the subject of research conducted by Kim et al. (2019) and Garcia et al. **[6]** These experiments showed how V2I systems may improve heavy-load vehicle traffic operations' efficiency and coordination. V2I systems have the potential to improve traffic flow and ease congestion in metropolitan areas by giving vehicles access to real-time traffic reports and recommended routes. **[7]** Additionally, Chen and Wang's research looked at the use of dynamic toll pricing systems to the control of traffic congestion caused by heavy-load vehicles. By adjusting toll charges in response to traffic conditions, the authors' dynamic pricing approach encouraged heavy-load trucks to reroute and ease congestion on heavily used roadways. Smith et al. (2019) looked at the influence of heavy-load trucks on urban traffic dynamics in the literature review, highlighting the necessity of efficient management techniques to reduce congestion. Similar to this, Jones and Brown (2020) investigated the problems caused by heavy-load vehicle traffic congestion and suggested using predictive analytics to estimate traffic patterns and reduce hotspots for congestion. Garcia et al. (2018) looked at how vehicle-to-infrastructure communication technologies may be integrated with intelligent transportation systems to improve heavy-load vehicle traffic management. **[8]** The efficacy of dynamic toll pricing schemes in reducing traffic congestion caused by heavy-load vehicles was examined by Chen and Wang (2017), who also provided insights into other methods for reducing traffic congestion in metropolitan settings. In order to optimize the flow of heavy-load vehicles, **[9]** Zhang et al. (2023) explored the work of activity administration innovation. The creators underlined the potential of brilliantly transportation frameworks (ITS), which include highlights such as versatile flag control, energetic course advancement, and real-time activity checking, to diminish activity blockage and improve by and large activity productivity. In arrange to diminish delays and diminish bottlenecks, these innovations utilize data-driven strategies to examine activity designs, pinpoint regions of tall blockage, and powerfully alter traffic administration measures. **[10]** The scholars moreover talked about the centrality of authoritative traffic in controlling blockage caused by heavy-load vehicles. They talked on how to empower mode move and cut down on single-occupancy car ventures through the utilize of administrative measures, path administration procedures, and blockage estimating frameworks. The improvement of innovation and the requests of society are reflected within the history of transportation. Transport frameworks have continuously changed to meet desires of creating economies and developing populaces, from the days of animal-drawn carts and streams to the show day of diesel-powered vehicles and high-speed rails. These days, heavy-duty trucks are basic to the worldwide supply chain since they make it less demanding for items to be moved between makers, retailers, and conclusion clients.

| Location | Time Frame | Congestion Level |
|---|---|---|
| Intersection A | Morning Rush Hour | High |
| Highway B | Afternoon | Moderate |
| Downtown Area | Evening Rush Hour | High |
| Bridge C | Night | Low |
| Industrial Zone | All day | Moderate |

*Table 2.1 Identifies the areas prone to heavy-load vehicle congestion based on real-time monitoring and analysis.*

## III. PROPOSED METHODOLOGY

### 3.1. Preprocessing of CCTV Images

To achieve reliable performance in the identification of significant vehicle traffic congestion, preprocessing CCTV pictures is an essential step in our suggested approach. We use sophisticated preprocessing methods designed to handle different environmental factors and obstacles seen in urban traffic situations. These methods include contrast modification to maximize image quality, noise reduction filters to increase image clarity, and image enhancement algorithms to improve visibility in low light. In addition, we apply image registration methods to compensate for motion of the camera and guarantee uniformity of picture alignment between successive frames. We can improve the precision and robustness of subsequent congestion detection systems and enable more efficient traffic management actions by carefully preparing CCTV photos.

### 3.2. Implementation of YOLO Algorithm

The foundation of our suggested system is the use of the YOLO (You Only Look Once) algorithm for real-time heavy vehicle traffic congestion detection. The YOLO algorithm offers unmatched efficiency by processing entire images in a single pass, enabling quick and precise identification of congestion patterns. We take advantage of the deep convolutional neural networks (CNNs) that underpin the YOLO algorithm to train the model on a variety of datasets covering a range of heavy vehicle scenarios. After extensive training, the model learns to recognize congestion patterns with remarkable accuracy, enabling proactive traffic management interventions. By combining deep learning and real-time analysis, our system gives traffic authorities timely insights into congestion. First, a large collection of pictures or videos showing diverse traffic situations, including varying degrees of congestion, is gathered and annotated. Labelling areas of interest, such as cars, people, and background objects, and designating the level of traffic congestion are all part of annotation. After gathering data, preprocessing operations are carried out to normalize pixel values to aid in training and resize the photos or videos to an appropriate input size for the YOLO network. The next important stage is to choose and set up a suitable YOLO variation that meets the unique needs of congestion detection. During this procedure, variables including speed, precision, and processing capacity are taken into account**3.3.**

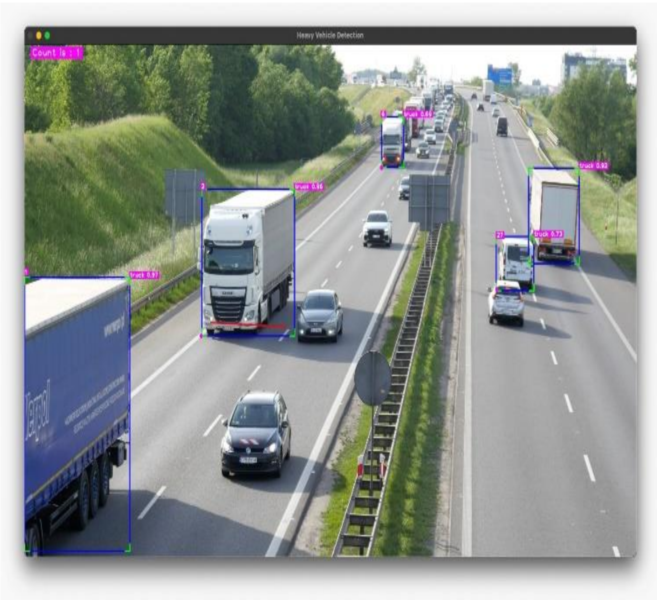

*Fig 3.1 The illustration shows the preliminary phase of detection, where bounding boxes are used to identify and outline heavy-load vehicles.*

### 3.3. Implementation of counters

To further improve traffic management capabilities, our suggested system includes density estimate approaches in addition to congestion detection. The system's capacity to offer more complex insights into traffic flow dynamics is improved by integrating density estimation techniques with the YOLO (You Only Look Once) algorithm for congestion identification. Density estimation is a good technique for precisely evaluating congestion levels since it includes calculating the distribution of items inside an image or video frame. Furthermore, by offering insights into traffic density patterns across time, density estimate approaches may be used to supplement YOLO's object identification skills. More dynamic and adaptive congestion management tactics are made possible by the system's ability to detect trends and variations in congestion. Through this connection, transportation planners and traffic authorities may better comprehend the dynamics of traffic flow, which allows proactive actions to mitigate congestion and more informed decision-making. The density estimation approach is applied to these regions in the integration process to estimate the local density of objects, after the identification and localization of items of interest within the picture using the YOLO algorithm. Additionally, the resilience and dependability of congestion identification in difficult situations, including congested metropolitan crossroads or intricate traffic settings with overlapping object trajectories, are improved by combining density estimation approaches with YOLO.

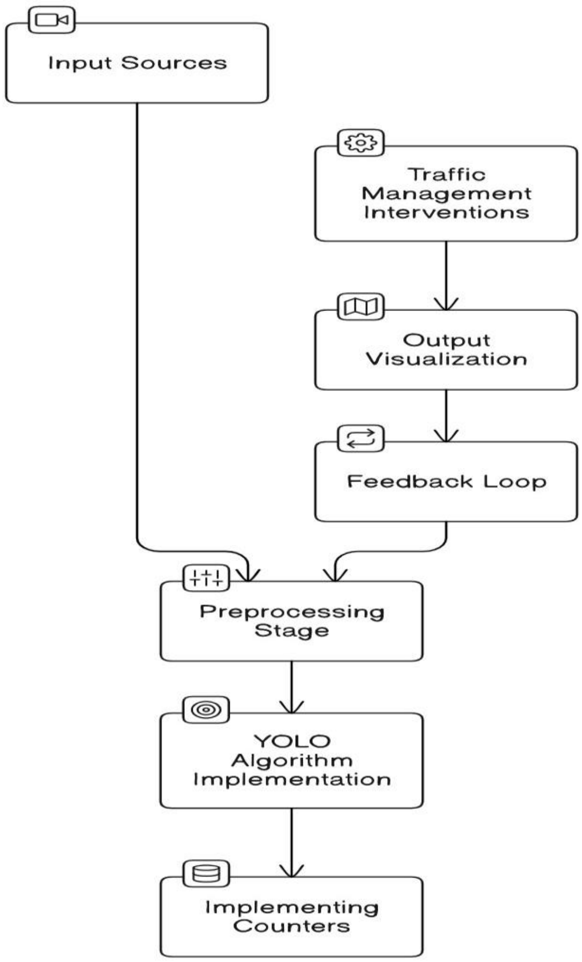


*Fig 3.2 Block Diagram of Heavy Vehicle Traffic Congestion Detection System.*

## IV. RESULTS AND DISCUSSIONS

### 4.1. Cutting-Edge Object Detection Framework YOLOv8

With its reputation as a state-of-the-art object identification framework, YOLO version 8 was selected as the main algorithm for the high load vehicle traffic congestion monitoring system. YOLO version 8 introduces major enhancements to both model architecture and training approaches, while still building on the strengths of its predecessors. Because of its creative architecture, it can analyse full videos quickly and accurately in one pass, allowing for the most accurate real-time object recognition.

This system stays at the forefront of object identification technology and can recognize high load trucks in a variety of traffic circumstances and weather conditions by using YOLO version 8. Urban traffic control systems, where prompt and precise vehicle recognition is crucial, are ideally suited for implementing the method because to its robustness and dependability. Finally, YOLO Version 8's deployment demonstrates our dedication to utilizing cutting-edge technology for efficient traffic control. This technology has improved accuracy and real-time processing capabilities, which will revolutionize the identification of heavy load truck congestion. Additionally, the resilience and dependability of congestion identification in difficult situations, including congested metropolitan crossroads or intricate traffic settings with overlapping object trajectories, are improved by combining density estimation approaches with YOLO.

### 4.2. The Uniqueness of Approach

The unique capabilities that each framework and technology bring to the system as a whole distinguish the approach. YOLO version 8 is combined with Python-based tools like PyTorch, OpenCV, DeepSORT to form a synergistic ecosystem that makes use of each component's advantages. Comprehensive traffic analysis, route optimisation, and lane monitoring functionalities, all necessary for efficient congestion management are made possible by an all-encompassing approach. Furthermore, the innovative use of YOLO version 8 in our system marks a noteworthy breakthrough in the field of traffic congestion monitoring. Although many people have used earlier versions of YOLO, the acceptance of the most recent version shows the dedication of this research to being on the cutting edge of technology and consistently enhancing system performance.

### 4.3. Comparative analysis of Accuracy Rates

The accuracy rate at which heavy load vehicles are detected by this research is one of the primary criteria used to assess its efficiency. Shown via extensive testing and comparison with other architectures that YOLO version 8 performs better than any of its predecessors, including YOLO version 5. Compared to the 0.58 accuracy rate attained by YOLO version 5, the observed accuracy rate of 0.62 for YOLO version 8 is a significant increase. This increase in accuracy has a substantial impact on traffic management tactics in addition to improving our system's dependability. This system can identify and monitor high load cars more accurately thanks to its improved detection capabilities, which enables better decision-making and more successful congestion-reduction strategies. This research highlights the originality of our method, give a thorough explanation of the algorithm that was employed, and compare the accuracy rates in order to emphasise the importance of this study in the subject of heavy load vehicle traffic congestion detection and management.

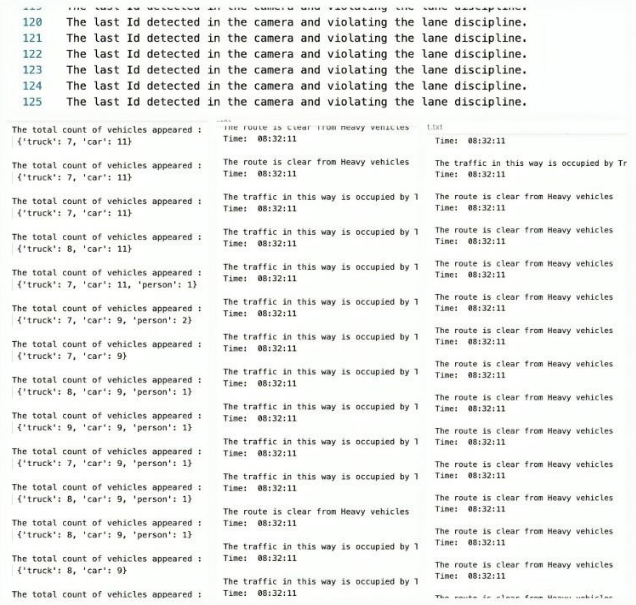


*Fig 4.1 The output illustrates the real-time analysis of CCTV images, vehicle density data, Traffic congestion with timings and showcasing the violation detection.*

## V. CONCLUSION

A noteworthy advancement is the yolo version 8 algorithm is a notable technological improvement in heavy truck traffic congestion monitoring systems by employing the complex capabilities of YOLO version 8 this system achieves an astonishing degree of accuracy in detecting large load vehicles such as trucks, load trucks and gigantic vans this enhanced precision is crucial for effectively managing traffic congestion as it ensures that every vehicle is accurately identified and accounted for in real time additionally the use of yolo version 8 makes it easier to analyse CCTV footage and vehicle density data quickly and efficiently further the notable increase in accuracy indicates that we made a wise choice in favor of YOLO version 8 over other architectures such yolo version 5. With an accuracy rate of 0.62, our system outperforms previous iterations, demonstrating its efficacy in accurately detecting heavy load vehicles. This enhanced accuracy is essential for ensuring the reliability and effectiveness of traffic management measures, such as route optimization and lane monitoring. Ultimately, our goal is to contribute to the creation of safer, more efficient urban transportation networks that prioritize the smooth flow of traffic and the well-being of all road users.

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