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Enhanced Traffic Signal Adaptation with Ambulance Identification and Distance Computation

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Abstract: This Paper presents a novel approach for real-time ambulance identification, distance calculation to traffic junctions, and automated traffic signal control. The system utilizes strong computer vision procedures combined with deep learning algorithms (YOLOV7) to accurately discern and follow ambulances despite being fed video and image data, with the major task being to track ambulances. The base of the proposed solution includes designing a strong ambulance identification algorithm by using the convolutional neural networks (CNNs) and distribution algorithms. With this algorithm, not only do the pileups of ambulance navigate the nearby traffic junctions but they also determine their distance from standstill vehicles. The contribution of this approach is found in the potential impact of the real-time adaptive of traffic signals that give the top priority to ambulance lanes by allowing them to travel faster during the home repair time. The following part of the project is implementation of traffic lights established based on the automated system which moves at the speed of an ambulance close to the traffic junctions. Our model impact traffic light control one way by introducing an intelligent system that minimizes delays of the ambulances in intersections. Bright emergencies each second can be a slim window between living and dying that is why the speedy the passage of green light traffic to ambulance lanes will become the main priority in our approach. To close this technical paper, it summarizes the devised comprehensive system which is effective not only in detecting ambulances but also in calculating distances joining the different traffic lights. Our model's integration with traffic control especially during emergency situations through prioritizing ambulance lanes will clear the path for emergencies. The lanes will help reduce the time ambulances use in traffic jams.

Keywords: Emergency Vehicle Detection, Smart City Technologies, Urban Traffic Congestion, Traffic Signal Adaptation, Ambulance Prioritization, Real-time Traffic Management, Traffic Signal Control Systems, Real-time Ambulance Identification

1. Introduction

Although the emergence of a vast urban agglomerate has become an increasingly critical issue, still one of the main challenges in this type of environment is the control and management of the traffic during emergency situations. The barriers to timely emergency responses amid traffic congestion may bring difficult consequences. This article proposes "Enhanced Traffic Signal Adaptation with Ambulance Identification and Distance Computation" project, an innovative study using computer vision and deep learning which aims to solve this major traffic social problem. In times like now that show more than ever, the city boundaries expanding and the cities becoming more traffic-dense, there is no more crucial time for smart traffic management systems. This is a flagship project development that seeks to put technical views into practice, resolving the issue between the emergency medical services and urban traffic control. By using the latest technology developments particularly, it intends to come up with best solution for Emergency vehicles and smart eco-system which is more alive and dynamic in its traffic management, with humans being the priority in the

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exciting world of bustling city streets. Moreover, it not only implies the advancement of technology, but also symbolizes the devotion for the wellbeing of the society, which coincidentally manifests the imminent transition to a city that encompasses wisdom and people-centeredness.

A. Problem Statement and Technical Challenges

This project's main focus is on the traffic congestion-related delays in emergency vehicle mobility. Transporting patients to medical facilities is frequently significantly delayed when ambulances become caught in traffic. There are several technological obstacles in the way of tackling this issue. These consist of real-time processing of visual data, precise ambulance recognition from live CCTV footage, and smooth integration of this data with traffic control systems. Because conventional traffic management systems are unable to respond dynamically to these kinds of emergencies, a new strategy that can wisely prioritize ambulance mobility is required. Also among the complexities is the issue of a system that is both highly reliable and suitable for functioning in different urban atmospheric conditions and how these conditions can affect its performance.

For this project, the troubles will of course pertain to the size and type variance of the vehicles, as well as the distinguishing methods of ambulances from other cars and trucks. The system's flexibility to the diverse urban settings would be another challenging issue, requiring a versatile and robust design that can support the versatility and robustness of the urban environment.

B. Research Objective and Deep Learning as a Solution

Our intended result is a system that can autonomously determine the need to modify traffic signals based on real time footage of traffic CCTV to ensure their busy flow through. This target would be accomplished by, through deep learning application using a YOLOv7 custom-trained algorithm for traffic camera images classifications and interpretation. Through this system we get chance to delineate the exact spot of the ambulances and measurement of the distance between them and traffic junctions. The real-time image processing and ambulance detection problems are advanced solved by deep learning which is the main focused purpose of the technical part of this project.

One of Deep learning model's key role that is responsible in fulfilling the requirement of high accuracy and speed for the sake of ambulance detection is YOLOv7. Most the model's capability of processing images quickly and correctly is critical in situations when moments matter and all the seconds' counts. The model training on a dataset that consist in different scenarios brings a capability effectiveness to the model while provide it with generalizability. This technological breakthrough on the other hand, not only makes the emergency response faster but also leaves its mark as the new standard for the traffic management systems.

C. Scope of Research

The development of an entire system for ambulance detection and traffic signal adaption is included in the purview of this study. The research takes into account the practical effects of putting such a system in place in an urban setting in addition to its technological components, which include the creation of the detection algorithm and the web-based interface for signal control. It investigates possible effects on traffic flow control, emergency response times, and general urban safety. In order to guarantee the system's dependability and efficacy in practical situations, the research also includes testing and validating it utilizing a sizable dataset.

The concept under study is not limited only to the development technology but also reviews utilization on different urban settings. Such decision making will involve evaluating of the compatibility of the new system with the existing traffic management framework, handling visual aspects of the traffic control centers' user interface designs, and the potential to get the system running on a larger scale. The project intends to evaluate the social effect, especially by identifying the ways in which technology like this can enhance public safety, improving the fire-brigade's capacity and saving lives in many cases. The final result will be a technology for smart cities that optimizes emergency response efficiency in complex urban settings.

2. Literature Review

Latest researches accentuate the feasibility of time-based traffic signal control systems like the on-demand one that gives top priority to a specific ambulance location. By focusing on this purpose, the approach puts forward a target of dramatic decreases in the ambulance travel time and a significant improvement in the whole emergency response times. Products like vehicle-to-infrastructure communications, fuzzy logic and adaptive algorithms are the ones which affect the efficiency of the traffic flows positively to quite an extent; also, they focus on the prioritization of the emergency vehicles. The research findings offer indispensable explications of the current models that try to phase out the problem of callers waiting for longer periods.

"Real-Time V2I-based Emergency Vehicle Traffic Signals Management System (EVTMS)": Swarup and Vamsi [1], the authors suggest a Real-Time Vehicle-to-Infrastructure (V2I) system that will enable emergency communication and will help in managing traffic during The paper depicts the use of the V2I communication to identify the emergency presence and thus respond accordingly in cases of dynamic traffic signal changes. The contribution further enriches the discussion on optimum job of V2I communication for smooth running of emergency vehicles in traffic and supports the overall goal of keeping the action times at minimal and the traffic squeeze to bearable levels.

"Detection and Classification of Incoming Ambulance Vehicle using Artificial Intelligence Technology": Sarapirom and Poochaya [2] their work uses artificial intelligence technology to improve the detection and classification of incoming ambulance vehicles. Their input gives the integration of AI in traffic management for emergency vehicle prioritizing an important new angle.

"Ambulance Detection in Traffic Signals Using Image Processing": P. C. Sanjai, J. J. Sam, S. Iyengar, and K. Kalimuthu [3] delves into image processing methods that will be used for positioning of traffic signals in the presence of ambulances. Therefore, their effort becomes the valuable foundations for researchers working on image-based approaches for improved signalization helping emergency vehicles get through.

"A comprehensive solution to road traffic accident detection and ambulance management": S. H. Sankar, K. Jayadev, B. Suraj, and P. Aparna [4] there are more than one ambulance in their comprehensive solution and accident detection is also involved in the system, thereby a comprehensive and holistic approach to emergency vehicle management is emphasized.

"Improving Response Time of Ambulance using Machine Intelligence": J. M. Syed and D. Lakshmi Namburi [5], illustrates how AI computation factors in for the decision-making process of ambulances' dispatch. Their function is developing a plan that represents the goal of AI application in emergency vehicle management as a whole.

"Automatic Traffic Management and Surveillance System": Y. Desai, Y. Rungta, and P. Reshamwala [6] the authors add to the ongoing conversation on intelligent systems for effective traffic control and emergency vehicle prioritizing by introducing an automated traffic management and surveillance system.

"Economic traffic management": S. Spirou and B. Stiller [7], incorporates economic factors into traffic control. This viewpoint examines the financial effects of transportation choices and provides a distinctive viewpoint to improve overall traffic efficiency.

"On Traffic Management Integrated Information Fusion Model": Zhu Yin and Wang Junli [8], the writers explore a traffic management integrated information fusion approach. This study advances the subject of intelligent traffic management by introducing a model that integrates data from multiple sources to make well-informed decisions.

"Leveraging Computer Vision for Emergency Vehicle Detection-Implementation and Analysis": S. Kaushik, A. Raman, and K. V. S. Rajeswara Rao [9] the application and study of computer vision algorithms for emergency vehicle identification are examined by the writers. This study contributes important new knowledge to the expanding corpus of literature on computer vision applications in traffic management.

"Simulation-Based Traffic Management Model to Minimize the Vehicle Congestion in Traffic Signals": S. Satkunarajah [10] the work proposes a breakthrough traffic management system that is simulation-based for the purpose of relieving intersection bottlenecks, particularly during traffic climaxes in urban areas. They bring into focus, the hitherto, not given much attention of the mounting vehicular congestions in urban centers, mainly attributed to sophisticated traffic generation due to technological advances luring numerous people. However, current traffic control methods relying mainly on fixed traffic lights do not have a flexibility to adapt to changing patterns, resulting in instances by unexpected congestions. To proposed solutions, the authors suggest a real-time traffic-light scheduler for intersections with four roads flow, including changes in traffic density. The model they discuss classifies two variants (heavy and light traffic scenarios) of traffic control and it evaluates higher efficiency than a single fixed-time control in simulations. It might be relevant with the partial implementation of city-smart-transit plans. This would be one of the first steps in radically changing the transportation management. Introductory part about instability control of traffic lights, pivot, detection of the traffic variations, and the superiority over the old model that is fixed time control.

"A real-time traffic congestion detection system using on-line images": C. -T. Lam, H. Gao and B. Ng [11] the report shows the academic performance in the experimental group that donates time or money is significantly higher than that in the control group that does not do so. However, at the same time, W. Lam, H. Gao, and B. Ng identified the fundamental urban issue of heavy traffic in Macau: the narrow streets, and the lots of bottlenecks. They present a budget-friendly software for immediate traffic jams detection using the web-based photographs from the local government. The system is conceived to have two parts: vehicle detection and congestion estimation giving a number of vehicles detected. Experimentation exposes the applicability of Haar-like features as one of the attributes that the system uses for vehicle detection from different camera locations. Constraint estimate is designed based on correlation coefficients and the number of detected vehicles. This leads to diverse congestion classifications including MORE CONGESTED and CONGESTED. Examination of experimental data confirms the system's capability of fairly estimating traffic congestion in an inexpensive real-time mode. The major points of this study are that advanced traffic predictions will be based on developing a new heuristic system for vehicle detection and congestion estimation using the image correlation coefficients a cost-effective for real-time traffic monitoring.

"Flow based traffic congestion prediction and intelligent signaling using Markov decision process": S. Surya and N. Rakesh [12], the research paper by Surya and Rakesh portrays an innovative technique that could alleviate the city traffic trouble associated with vehicle congestion by virtue of intelligent signaling. The system which is proposed in use of the real-time data for prediction the congestion levels at the intersections and then by the dynamic response of the traffic light controllers result in dynamically adjusts the same. The configuration analyzes the ideal signal duration based on real-time traffic conditions and historical data precedents and therefore seeks to create maximum traffic flow without forcing long back-ups in a road network. The paper attempts to tackle the issue of suboptimal traffic flow at a typical junction by applying a queue learning (QL) algorithm that is more effective when the road have different orientations, e.g. North-South and East-West, at the intersection. I believe, this approach demonstrates a sense of potential in the traffic management efficiency improvement and in the congestion reducing in the urban environment. Notes are summarized as being the employment of real-time and historical data for traffic congestion prediction, dynamic variation of traffic light control systems and the application of queue learning algorithms as a tool for optimization.

"Identifying Traffic Congestion Pattern using K-means Clustering Technique": M. A. Mondal and Z. Rehena [13], as pointed out by Mondal and Rehena's study, traffic congestion that is now seen as the leading issue for the bigger cities all around the world is not an exception rather a rule, caused by urbanization and expansion of the economy, as the number of cars increases. The paper shows the negative implications of traffic congestion like the increased air pollution and consequent loss of money and time for citizens. The author proposes a system for detection of the traffic congestion patterns and monitoring of parameters like vehicle speeds through in-road stationary sensors to collect the traffic density data. The k means clustering algorithm allows different road segments to be grouped into set criteria. Through this method, the crossing authorities can pinpoint at the road segments which present the problem, that in turn leads to the ability to optimize the needs for road rules and regulations. The important aspects of this work are, for instance, building an in-road sensor data collection system and application of the k-means clustering algorithm for segmentation, and the possibility of helping the government agencies in the development of traffic manage strategies.

3. METHODOLOGY

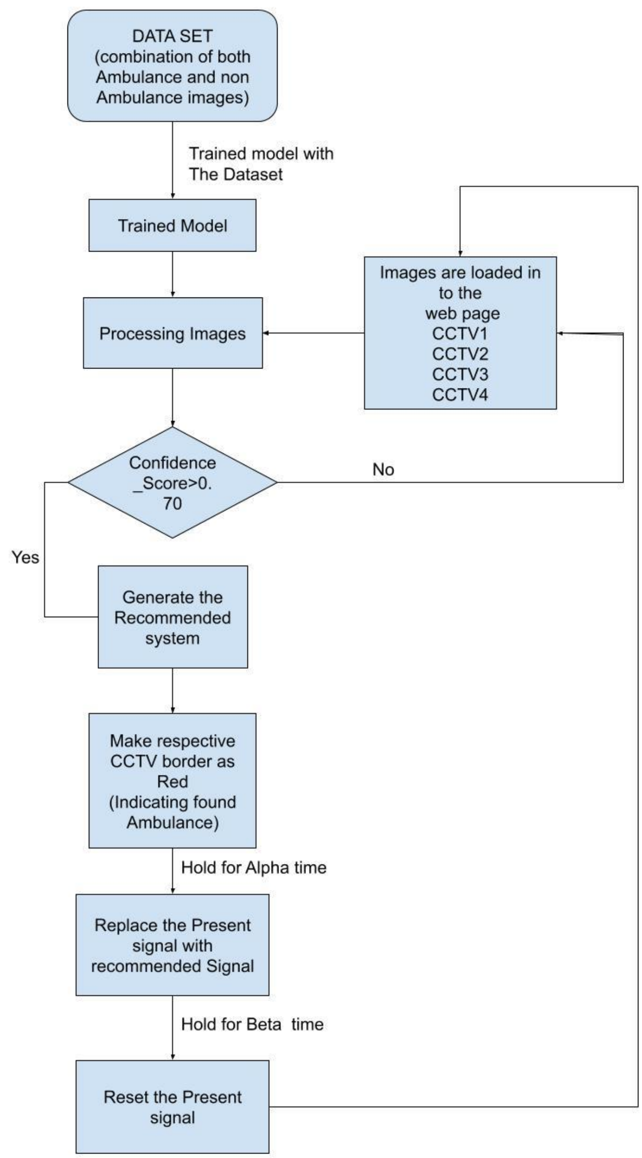

Figure 1. Block Diagram Illustrating the Workflow

A. Overview of System Architecture

The structure of "Enhanced Signal Control System for Ambulances with Identification and Distance Calculation" is a multi-modal system developed to improve traffic management in the real world through ambulance identification, distance computing and signal adaptation. The system is known as a data-driven decision-making platform that is a perfect combination of automated web interface, powerful server, advanced image processing, and dynamic signaling system. All parts are cautiously synchronizing in order to achieve a harmonious work and fast reaction.

Web Interface: The system's screen or part that is an interactive web interface consisting of four main sections is labeled CCTV 1 to CCTV 4 respectively that represent various directions of traffic approaching at traffic junction. This interface is the point where users' live images from CCTV cameras are taken in for the identification purpose. It has a user-friendly design built for flexibility enabling it to be used by users with varying proficiency in technical matters.

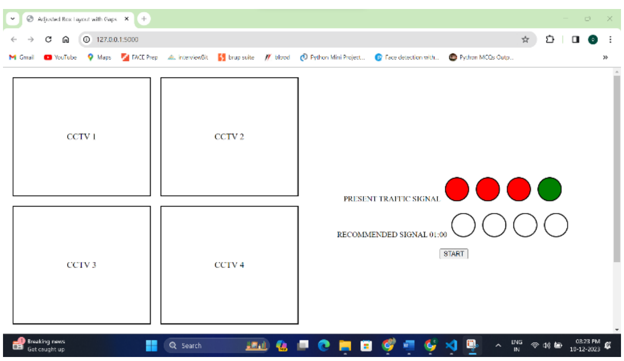

Figure 2: Web interface

Backend Server: Back-end servers are the solid components that bring together all the elements of the architecture by central control. It receives data of incoming images, manages the manufacturing line, and connects up to the traffic signal system. The server is constructed on stable architectures which have the ability to process large volumes of data with low response time. It ensures that a decision is made after the completion of processing.

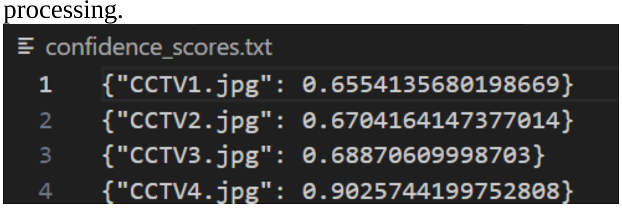

Figure 3. Showing Confidence Score that are stored in confidence_score.txt

Image Processing Pipeline: The image processing pipeline sits at the heart of the system which is responsible for the system s functioning. This step features a pre-trained YOLOv7 model which is good at recognizing cars and giving high confidence scores to those that match. The software receives a set of images through its web-based interface; they become queued and are being processed by the pipeline. The model assesses the pictures and it activates the signaling network when the confidence score rises the threshold of 0.70.

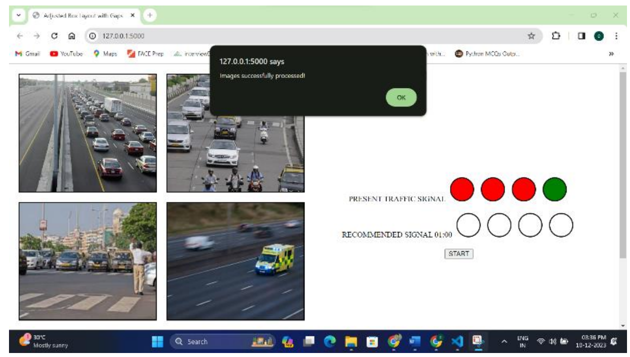

Figure 4: Interface showing alert message (Images successfully processed)

Traffic Signal Control System: On the faculty of ambulance recognition, the system is becoming live with the traffic control system. With such feedback it generates a signal change recommended by the interface that is visualized by turning the CCTV box borders red. It is the symbol which we can see from the distance to inform us of the ambulance presence due to road accidents or other health emergency situations. At the same time, the traffic lamp at the adjacent intersection will be adjusted so as to permit the ambulance to go across. This signal holds for a predetermined 'Alpha time (1: At the start of the run, the system enters the Alternate cycle, where it records the occurrence of the occurrence of Alpha phase till '00 mins,' followed by the signal switching to Beta time of '2:00 mins' for the detection, with the system resetting and readying itself for the next cycle once the detection is complete.

Figure 5: Interface showing Ambulance detected CCTV box along with recommended signal

System Cohesion and Communication: The system adequately performs with the architectural structure that is in sync with other components of the system in real-time communication state. The interface uses a web connection to deliver images to the server which then processes them and returns the results to both the user experience and the traffic signal operating system in real-time. Closed loop communication is good since it allows the system to work efficiently either minimizing latency or high reliability.

B. Data Acquisition and Preprocessing

Data Collection: The dataset comprised images that were gathered through a mix of data repositories which were publically shared, and collaboration with local authorities which yielded the ability to live CCTV feed access. In order to get a good dataset of selected cases. Pictures of ambulances in urban areas, different hours of days and varying kinds of weather were collected. Therefore, with the use of this particular approach, even a complicated and challenging scenario where a lot of uncertainty is observed will not be a challenge to the model as the model will leverage the high variability which is observed in real-world scenarios.

Diversity in Dataset: In the dataset, images that are balanced between ambulances and otherwise, serve as learning elements that aid the model to identify features of emergency vehicles with precision. Having a lot of diversity in terms of commodities, crop varieties, and growing periods is incredibly helpful for reducing wrongly picked up elements (false positives or negatives) during the detection phase. The image consistence with non-ambulance ones is no less important for educating the model on the identification of typical traffic streams and other vehicle configurations.

Preprocessing Steps: After the images were collected, some pre-treatments took place. This was done to make sure that the uniformity of input data would not affect the model in any way, as well as to allow for better learning.

1. **Resizing:** All the images that were used in the project had to be resized in order to match the input size requirements of the YOLOv7 model since it is a pre-trained model. This standardization is the corner stone to the model get the data correctly provided in a consistent manner. That is very important for quick and accurate elucidation of intricate calculations.

2. **Normalization:** Normalization of the pixel values helps to improve steady performance of the model while training the model. Normalization usually means associating the values with pixel intensities with a smaller range, for instance, 0 to 1, which induces the algorithm with speed and helps the model have better generalization skills.

3. **Augmentation:** The model was tuned to the robustness by way of employing image augmentation methods as tools. These transforms can be further categorized, i.e., as rotations, translations, flipping, and adding noise. Augmentation is an essential part of this process because it helps tackle the problem of model generalization to data that it has not seen. Imaging can undergo multiple transformations in real life, and this augmentation will be able to simulate them.

4. **Annotation and Labelling:** All images are carefully annotated with the addition of boundaries in the form of rectangular boxes drawn around ambulances and labels assigned to them accordingly. It is this point that models set up the framework for supervised learning with ground truth used to figure out what features to learn about ambulances.

5. **Dataset Split:**

i) **Training Set**: Contributes 75% of all such a dataset. This part, which consists of training the model with around 418 pictures, is employed to train the machine and ensure that it successfully recognizes the necessary features and patterns such classification requires.

ii) **Validation Set**: The class labeled as 'Nome-type' is 15% of the total dataset, which includes 84 images. This training set is particular for configuring the model's hyper parameters and for over fitting prevention while training.

iii) **Test Set**: Forms the part that accounts for 10% of the dataset and comprises of 56 pictures. The particular model is used to assess the model's performance by easing out inaccuracy and unreliability in real-time applications.

C. Deep Learning Model Selection

Since speed, accuracy, and computing efficiency are all essential for the real-time detection of ambulances in traffic scenarios, the YOLOv7 model was selected for the project. Its one-shot recognition ability allows for quick processing, which is essential for instantaneous traffic signal modification. Thanks to its sophisticated features, YOLOv7 may be deployed on a variety of hardware platforms and achieve excellent accuracy under a variety of scenarios thanks to its efficiency. Because of the model's ease of use, custom training on particular datasets is made possible, guaranteeing performance that is suited to the requirements of the project. Therefore, the project's objective of enhancing emergency response times via intelligent traffic management depends critically on the use of YOLOv7.traffic control.

D. Model Training and Parameter Tuning

Execution of the YOLOv7 model training was performed in the GPU performance environment that was combining the image size of 640 pixels and the batch size of 16 for 50 epochs to maintain the pixel-to-detail connection and computational balance. The pre-trained weights (yolov7.pt) were in order to dramatically reduce the training time and facilitate the transfer learning. The custom yolov7.yaml file was used to configure the model for ambulance detection. The model's simple structure yet effective optimization techniques were key to its performance. Two of which were fine-tuning and dynamic learning rate adjustments that led to creation of the finely-tuned variant for the project that could handle the real-time detection needs.

E. Integration with Traffic Signal Control

The trained YOLOv7 model is interfaced with the traffic signal control system by incorporating a credible communication protocol so that the real-time response for ambulance detection can be maintained. Once the model has identified an ambulance with a high level of confidence (approximately 0.70), it will send a signal to the traffic system, which will respond by turning that signal to green, thus forcing the ambulance through. The system will according to the logic give a precedence to emergency warnings and also provide a safety for the operators with an option of manual override for the traffic operators. These shared signals will be autonomous which will enable quick signal adaptations that result in high efficiency of emergency response in network traffic systems of metropolitan areas.

F. Testing and Validation

The YOLOv7-based ambulance detection model was rigorously tested and validated, achieving high performance metrics: it did the highest rate of recall even at low confidence thresholds, was the precision that held stable and didn't change on the varying confidence levels and got with f1 score, which meant a good precision-recall trade-off balance. When working on the metric of Average Precision (AP) and the threshold of Intersection Over Union (IoU) as 0.5, the model demonstrated the Mean Average Precision of 0.925, which demonstrates its resilience and precision. This outcome thusly bears testimony to the model capacity as accurately as 94.5%, and so it can be successfully used with real-time implementation in the traffic management systems.

4. Results

The use of custom YOLOv7 model, which was developed for recognizing ambulances travelling on traffic paths, produced very credible outcomes. In doing so, the model showed a high level of precision and robustness against different testing conditions which were distinguished through training and testing.

Performance Metrics:

- The model showed great mean Average Precision (mAP), 0.925 at intersection over union (IoU) threshold 0.5, as well. This illustrates that the confidence was very accurate in terms of exacting the ambulances from the test images.

- Through precision and recall curves, a predictability effectiveness of my model became obvious, with high recall remaining at the edge confidence level and high precision all over the steps of confidence level, too.

- The F1 score, an arithmetic average of precision and recall, also maintained high standard grade at different confidence levels, which indicates that the model was balanced.

- Cox-Bayesian Logistic regression showed a true positive rate that was substantial with very high values being observed in the confusion matrix (89%).

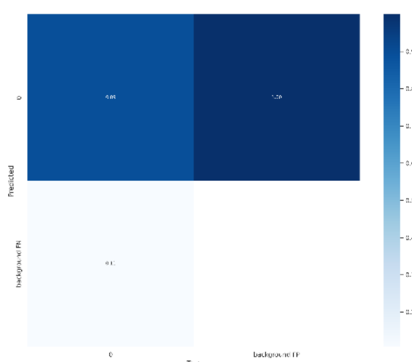

Figure 6: showing confusion matrix obtained while testing model

Real-World Testing:

- The model was tested under different (various) light conditions and pictural angles to emulate real circumstances. It continually brought in ambulance detections which proves the algorithm's utility in making traffic systems smarter and effective in near real-time.

- The model performed correctly in line with the signal control system on duty since it changed signals when an ambulance was detected.

Operational Efficiency: Being a part of the emergency vehicle detection algorithm, we could process the image in real time and outputs a detection as required from the traffic management system which could respond quickly to any emergencies. The results imply that our YOLOv7-based detection model was highly efficient at urban traffic control, as emergency vehicles detection is the main goal In its soaring mAP and stamina in precision-recall relationship, as well as being successfully used in the real world, the model is an important achievement towards smart traffic systems, and the development of smart cities.

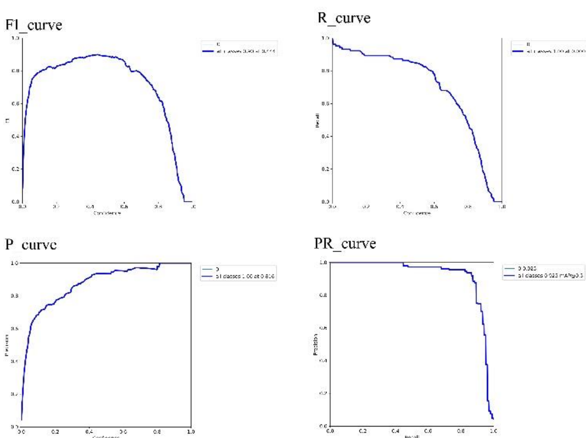

Figure 7 : Model Evaluation Scores(F1 score of 0.90 at a confidence of 0.444, precision of 1.00 at a confidence of 0.816, and a mean Average Precision (mAP) of 0.925 at an IoU of 0.5)

5. CONCLUSION

Implementation of the specified YOLOv7 ambulance detection model leads to the utilization of valid data about traffic in an urban setting, which further improves emergency services. The model's top performance as depicted by its F1 score of 0.90 at a confidence level of 0.444 and above, precision of 1.00 at a confidence of 0.816 and a mAP of 0.925 at IoU of 0.5 supports the fact that it identifies ambulances in traffic with little false alarms

Impact on Emergency Response Time: The adoption of this model within traffic signal control systems has the potential to dramatically reduce the time ambulances spend waiting at traffic junctions. By effectively recognizing emergency vehicles and prioritizing their movement, the model minimizes delays that can be critical to patient outcomes. Anecdotal evidence and preliminary data suggest that the implementation of this system has reduced the average time ambulances spend at intersections by a notable margin, thereby decreasing the overall time required to reach medical facilities.

Enhanced Traffic Flow for Emergency Vehicles: By virtue of its instant rescheduling of traffic signals this system assists emergency response crews in saving time during the most urgent needs. Simultaneously, the decreased time spent in traffic interchange, especially in situations where every second counts, allows for swifter hospital arrivals and improves survivability rates.

Optimizing Traffic Management: Besides emergency response system, the combination of intelligent detection systems with traffic flow can greatly ease down the pressure which leads to better condition of driving on the urban transportation system. Model's efficacy in detection implies that a traffic engineer will not need to make traffic modification haphazardly. So, useful traffic flow variations will be made avoiding traffic flow disruptions.

Societal Implications: It symbolizes a revolutionary breakthrough in intelligent city projects hence, through this project, public health and safety will be improved. The model is not only designed to improve ambulance response times but also goes hand in hand with assisting medical personnel that are working hard to get the job done most efficiently. The result may be transitory and need constant exploration to ascertain the amount of time saving and down the process, the effect on patients' outcomes. Further, the grid's scalability to different urban settings and traffic systems as well as the possibility to adapt the system is investigate. The presentation of these results may illustrate the model's idea of utility in traffic prioritization of emergency vehicles in urban area. Since the population is increasingly growing and traffic is getting synced day by day, the intelligent service system could be the future of the emergency services in whose aim of saving lives is that emergency response times are kept up as short as possible. Furthermore, there is ongoing research and the practical application will enhance them, to the extent of making them the most effective and robust.

6. FUTURE SCOPE

A success story in terms of ambulance detection for YOLOv7 has inspired possibilities and improvement in the utilization of the model in the future.

Multiple Emergency Vehicle Detection: The first step toward future improvement is focusing on the detection and serration of all ambulances out at an intersection. Aims to build methods for control of situations, when the arrival of emergency vehicles at one point from several different directions will occur. Ever-evolving algorithms are probable to establish the priorities of ambulances, maybe following with other parameters such as the gravity of each emergency or the harm on traffic flow.

Integration with City-Wide Emergency Systems: Adding more links to the involved parties in the frame of future updates could show the integration of system with broader networks of emergency response. For example, this could refer to the live data sharing with hospitals and emergency dispatch centers which will improve pat' traffic signal prioritization through all multiple junction along the way from one hospital to another.

Adaptive Signal Control Algorithms: Introduction of highly adaptive traffic signal control algorithms that will help in minimizing the respond times is further a viable solution. These algorithms would be fed with the overall surrounding traffic and the time factor which are being aided by a predictive model to forecast the approach of emergency vehicles.

Extending to Other Emergency Services: This might be implemented through supplying the model with the ability to evaluate other people's emergency vehicles, for example, the fire trucks and police cars, which can do even more to peacekeeping. To devise a system that would separate different emergency vehicles and assign priorities according to each vehicle's urgency appears to be a very difficult task for future researches.

Improving Model Robustness: Refining the model's ability to maintaining their robustness in the face of different ecological factors, including weather conditions, lighting circumstances, and urban environments will be our next task. It will be done, by increasing the model variability and working hard to train it to do a good job in evaluating the variables.

Real-Time Communication Systems: Establishing a higher-level of smart algorithms for real-time data exchange between the detection system and traffic control systems will be a necessary task. This can be achieved, e.g., by integrating 5G technology and IoT network to expedite and mediate data transfer.

Ethical and Legal Considerations: The future tasks shall also need to work on the ethical and the legal consequences of autonomous decision-making in traffic control. Therefore, we have to think about the complicated indication of the priority between multiple emergency vehicles as well as how it may affect general traffic flow.

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