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Smart traffic manager: Computer vision and deep learning-based approach

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ABSTRACT

In the last couple of decades, the number of vehicles has been on the road increased drastically. Hence it has become very difficult to keep track of every vehicle for traffic management and law enforcement. With the increasing number of vehicles on roads, it is getting difficult to manually enforce laws and traffic rules for smooth traffic flow. Traffic Management systems are installed on traffic signals to check for vehicles breaking the traffic rules. To automate all these processes a system is required to easily identify a vehicle. The main aim to design this system is to reduce the mishaps which occur due to reckless driving and violations of the traffic rules. The important question here is how to identify a particular vehicle, The obvious answer to this question is by using the vehicle's registered license plate as every vehicle has a unique number through which it is easily differentiated from all the other vehicles. Vehicles in each country have a unique license number, which is written on their registered number plate. This number distinguishes one vehicle from the other, which is useful especially when both are of the same make and model. So, the basic idea will be identifying whether the two-wheeler rider is wearing a helmet or not, over speeding vehicles, zebra crossing violators, etc. Most of the tasks in this will require machine learning/deep learning models for image processing tasks. In the end, this system would be very effective to automate the hectic task of the traffic police and can be very efficient in terms to reduce the workload and manage the different tasks autonomously.

Keywords: *YOLOV4, OCR, Computer Vision*

1. INTRODUCTION

It has become very difficult to keep track of every vehicle for traffic management and law enforcement. With the increasing number of vehicles on roads, it is getting difficult to manually enforce laws and traffic rules for smooth traffic flow. Traffic Management systems are installed on traffic signals to check for vehicles breaking the traffic rules. To automate these processes and make them more effective, a system is required to easily identify a vehicle.

Our purpose to design and develop a system that can take autonomous decisions with the help of Computer vision, Machine Learning, and Deep Learning techniques. The system will help to achieve advanced real-time monitoring which will focus mainly upon the traffic rules and track and recognize the violators of the safety rules. The system will overcome the limitations in existing methods with the use of various image processing techniques. Building a reliable system that is most efficient in cost and accuracy. This system consists of organized non-recurring and goal-oriented work. Advancements can be done in this system by adding some hardware-based sensors to perform more complex tasks.

2. LITERATURE SURVEY

Anselm Haselhoffand et al [1] worked on a comparison between two methods of vehicle detection. In this comparative study, the author found out the false positive rate of detection of vehicles using both HAARCascade and triangle features is high. In both models, the HAARCascade was better than triangle features.

Qingchao Liu et al [2] worked on a comparative study of a state-of-art deep learning algorithm for vehicle detection. In this study, the KITTI dataset was used. The algorithms which were compared were Faster R-CNN, R-FCN, SSD, YOLOv3, and RetinaNet. The study suggested that the highly accurate algorithm was R-FCN, with a major drawback of latency. The average algorithm with low complexity was proven to be YOLOv3. The algorithm with the lowest complexity as well as accuracy to be observed was SSD.

Chao-Ho Chen et al [3] proposed a system that worked on the recognition of the license plates of the moving vehicles. The weighted-binarization approach was used for recognition of license plate in this paper. They had results for two scenarios mentioned in the paper, which were weather condition dependent.

The average detection rate & average recognition in overall conditions was about 91.7% & 88% respectively.

Madhuchhanda Dasgupta & Sanjay Chatterji [4] worked on a comparative study of vision-based helmet detection. COCO dataset with 4000 images approx. was used in this study for comparison. Algorithms like HOG, HAAR, and YOLOv3 were compared. The study has proven that the F1 score of YOLOv3 was about 86% which was much higher than the other two algorithms.

Joel C. de Goma et al [5] implemented a system that detects the zebra crossing obstruction. This system is divided into five phases which are, Component labeling, Kalman filter, detection of ROI, Hungarian algorithm, and then finally Casting ray algorithm. The dataset used for the result analysis was unknown, which consisted of 15 videos of approximately 30 minutes' length in a 25 fps frame rate. The results were observed promising of on point 95% accuracy with 75% of precision. Based on these results, the proposed system had a good overall performance for zebra crossing obstruction detection.

Praveen M Dhulavvagol et al [6] proposed a system that works in 5 modules, which are preprocessing, vehicle detection, Feature extraction, vehicle tracking, and speed estimation. The dataset used in this system was unknown, which consisted of sample a video feed with the actual speed of vehicles. The error rate is as much as about ± 0.4 km/hr.

3. YOLOv4

There are many CNN based object detectors available right now. The most accurate detectors do no work in real time. The ones which tend to work in real-time are not accurate. For example, collision detection fails to operate in real time or gives an inaccurate warning, which may not prevent the cause for which is supposed to work.

The YOLOv3 algorithm has a running complexity that is twice more than the successor of the same algorithm, i.e. YOLOv4. Not only the speed but detection accuracy of this algorithm is proven to be increased from 10% to 12% [7].
The YOLOv4 uses Bag of Freebies, Bag of Specials for both backbone and detector. It also uses CSPDarknet53 as the backbone, SPP, and PAN as Neck and YOLOv3 as the head.

4. PROPOSED METHODOLOGY

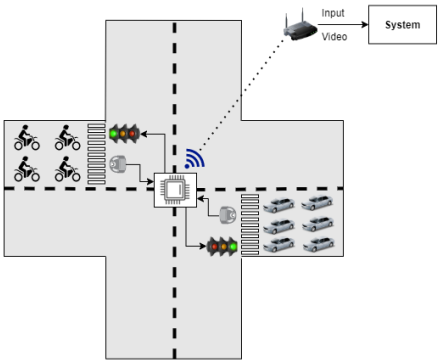


Fig. 1: Proposed Methodology

The proposed system is an architecture that is relieving hardware or software-based solution, designed particularly to help and automate the task of traffic police. Computer vision, Machine Learning, and Deep Learning-based solutions can carry out the difficult task of monitoring the traffic and the violators of the traffic safety rules. This system would be a combination of various modules that are rigorously performed by the traffic police, which will not only just ease the work of them, but also make sure that there would be a minimal amount of error in every possible task.

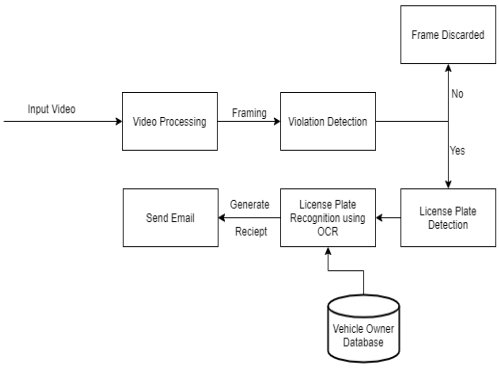
As depicted in the figure the system will continuously monitor the road using a CCTV camera. The camera will give input to the processing equipment i.e. server which will use a machine learning / deep learning algorithm. Once the input video feed will be available we can process it. The server will parallelly process the algorithms over those video feeds.

The proposed algorithm will check the frames of the video feeds if there is any violation of the traffic rule by the vehicle. The system will be used to check the violations of the traffic rules such as over speeding, helmet violation, zebra crossover obstruction.

Using this Architecture, we can detect the amount of traffic flows in the lane of intersections and it will use time smartly. Also depending upon the module the input feeds will be preprocessed, i.e. for object detection we have to use a technique called binary thresholding. After that feature points will be extracted from the video frames to match with the available trained model. In the end Classification will give output as Vehicle is present in the frame or not. Whenever there are no vehicles in the crossing roads, the testing device will work uninterruptedly. Using this Methodology, we can reduce energy consumption and protect the environment.

Once the vehicle is found to be violating a particular traffic rule, the owner will be fined. The vehicle owner is identified by using vehicle's registered number plate. The recognized number plate will lead to the owner's identity and the owner of that vehicle will receive an auto generated receipt of fine on the his/her email id which will be registered with the government vehicle registry authority.

5. SYSTEM ARCHITECTURE



The CCTV cameras on the signal junctions and road sides will continuous give our system input feeds. This input feed will be processed by the proposed system. The further processing would be like:

1. **Video Processing:** In this phase, the video will be converted into frames. These image frames will undergo binary thresholding The frames will be further process as per the respective model's required. These frames will be passed to the violation detection models.
2. **Violation detection:** This phase will consist of multiple deep learning / machine learning models. This phase will check

each incoming phase from previous phase and will classify the frame. If the frame consists of any clue of violation of traffic rules, it will pass the frame onto next phase. Else the frame will be discarded. The models in this phase will be – Vehicle detection, Helmet detection, Zebra crossing obstruction detection.

3. **License plate detection:** This phase will receive a frame only if the previous algorithm detects any violation of the mentioned traffic rules. The main task of this phase will be to locate the license / number plate of the vehicle. Once located, the cropped and processed frame with only license plate will be forwarded to the next phase.
4. **License plate recognition:** After receiving the cropped and preprocessed license plate of the vehicle, this phase will be solely responsible to find out the owner details of the vehicle from which the traffic rules are violated. Once the vehicle's registered number is identified, using that number we can easily find out the details of the owner. These details will be passed onto the next phase for the final phase of our proposed system.
5. **Send Email:** Once the vehicle owner's details are received, we can generate the receipt of fine for the violated rule. This auto-generated receipt will be sent via E-mail and SMS to the vehicles owner.

6. CONCLUSION

In this paper, Smart Traffic Manager System will perform Traffic rule violation detection and Signal Management using Machine learning and Computer Vision. This System have models like Vehicle Detection, Licence Plate Recognition, Helmet Violation Detection, Zebra Crossing Obstruction, Vehicle Speed Limit Violation which are implemented with low complexity and good performance and are designed for vehicles moving on the roads in various weather situations by using a camera. With adaptive cost-weighted and projection approach, Rules violating vehicles are located and recognized. Thus this system will be useful for automating the task of the traffic police. This system will create more accurate results than the existing system and will reduce the burden over traffic control department.

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