# Neural Network Based Traffic Monitoring using UAVs

**Arjun Pillai, Kajal Chourasia, Bhavya Agarwal, Robin Singh Balyan**

***Abstract*: *In large and growing metropolitan areas, the rise in traffic congestion is becoming an inescapable problem. It is estimated that the traffic congestion in metro cities costs the nation approximately 1.5 lakh crore rupees every year. With the increase in congestion, accident rate increases proportionally. The reckless driving and increased speed are the root cause of road accidents. We propose a speed detection algorithm to detect and monitor the speed of vehicles crossing a certain threshold speed limit. On national highways, the long queues at toll booths lead to loss of time and money. We propose image processing and convolutional neural network based algorithm to address the problem of traffic congestion, ease the flow of traffic, anomalies detection and ultimately reduce pollution and fuel consumption.***

***Index Terms*: *Convolutional neural network, Image processing, License plate number recognition, Speed detection, Traffic monitoring***

## I. INTRODUCTION

In India as on 31st March 2015, the total number of registered motor vehicles was 210.02 million [1]. In the last few years, there has been rapid increase in number of road accidents which was reported by a Tamil Nadu police, there were a total of 15563 injuries in 14504 accidents. This state also topped the list of the greatest number of accidents among all states for previous ten years from 2002 to 2012 [2]. In India, a major concern is the road safety which has been neglected over the years. Two wheelers account for 25% of total road crash deaths. Thus, to reduce the risk, it is highly desirable for motorcyclist to use helmet. But, the major problem in this modern era is that monitoring such cases require human assistance which are not automated. The camera deployed over an UAV monitors a certain accident-prone region. It also detects the speed of the vehicles, which are exceeding the speed limit and violating the rules. Taking these factors into consideration the real time processing is executed to detect accidents and violations, hence informing the authorities for an immediate action. This paper aims to implement automation in traffic management at various instances.

## II. METHODOLOGY

This section discusses system design and image processing algorithms which are further divided into four major sections.

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### A. Accident Detection

Every year over a lakh die as a result of road crashes. In order to provide immediate help, accident detection mechanism plays a vital role. The camera deployed over an UAV monitors a certain accident prone region and real time processing is executed to detect an accident and inform the authorities for emergency help. The system will detect an accident and then move closer to the accident zone, maintaining a safe distance, to take photographs and recordings. This model takes decision on traffic accidents by extracting features like velocity rate, position, area from the live video feed. The captured media along with the location of the drone is then sent to the authorities, which can take further decisions and actions over the situation. This live video feed can also serve as evidence for further investigation of the accident.

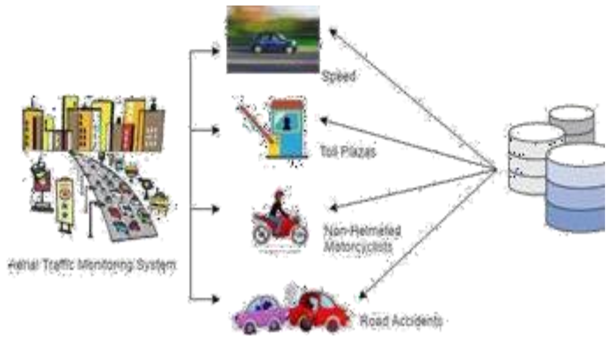


**Fig. 1: Aerial Traffic Monitoring System**

#### *A.1. Vehicle extraction*

For vehicle extraction and tracking, moving parts in each frame are detected based on a difference equation. Two continuous frames are extracted and their difference is taken based on horizontal and vertical projection. Apply the background subtraction and detect features in each frame, match them to the features of vehicles in our database. For extraction of frames, grey-level images are acquired at successive time instants respectively. Further, computation of difference images extracts the regions which are in motion.

#### *A.2. Feature extraction*

The system extracts various features such as the size, position, acceleration and direction of the motion for accident detection [3] [4].

#### *A.3. Velocity Variation*

Accident causes rapid variation in vehicle velocity. Hence, we can use velocity variation of a vehicle for accident detection. The process extracts the velocity of all the vehicles in a frame and checks it for any abrupt changes. [4]

***A.4.*** *Variation of rate of change of position*

Moving vehicles generally have a uniform rate of change of position but during an accident there will be an abrupt change or sudden change in rate of change of position. In this process, we extract the position of the vehicle in every frame and check the rate of change in position of the vehicle for any abrupt changes [4].

***A.5.*** *Variation in change of area*

We can calculate the area by simply counting the number of points in the required region. When a vehicle moves towards the camera, it's area increases and when it moves away from the camera, it's area decreases, however the rate of change is uniform and small. Whereas, accidents cause rapid changes in the size of the vehicle, where in which this output could be used for accident detection. In the process of accident detection, we extract the size of the vehicle in each frame and check the rate of change of size of the vehicle for any abrupt change.

**A.5.1 Detection using Feature Matching**

Live accidents were detected in following proposed approach mentioned above, but we also need a way which can detect an accident that has already occurred. Background subtraction and feature detection methods are applied in each frame. the features obtained from the image frames are matched with the training dataset. The regions where matching exceeds the threshold value, are extracted.

**B. Helmet Detection**

In a country like India, the majority of the population uses motorcycles for daily commuting and thus accounting for the highest fatalities in accidents. Reason being motorcyclist not wearing a helmet.

The flowchart of the proposed approach is portrayed in Fig. 2. In the proposed approach we use two YOLO v3 [5] models sequentially in order to detect whether the motorcyclist is abiding the rules by wearing a helmet. So, first with COCO [6] dataset the YOLO v3 was trained where in which in an image it detects different types of classes. The image cropped from the first YOLO v3 step is used as an input in the second model which is trained on Helmet dataset. A cluster of images are taken of the helmet which isprepared by us and it is used as a dataset in the second model. Finally, the detection of License plate of the motorcyclist who is violating the rules is carried out by using OpenALPR. [7].

*B.1. Detection of person*

YOLO v3 [5] is one of the best, real time object detection system and has the ability to detect almost all of the classes of COCO dataset since the first model is trained on COCO [6] dataset.

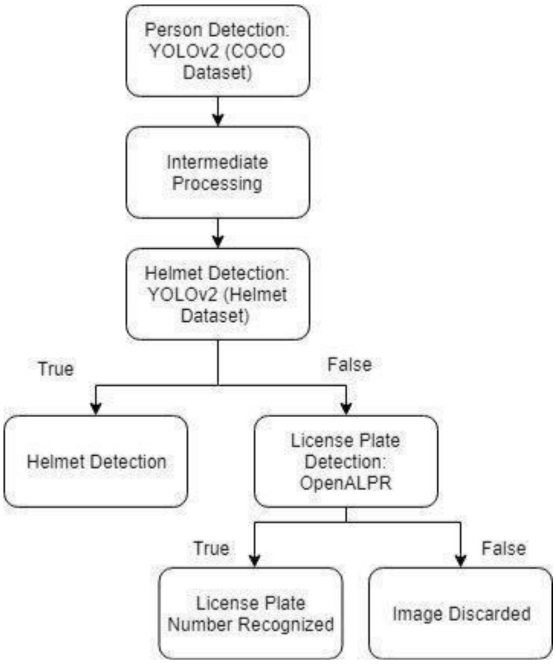


**Fig. 2: Helmet Detection Algorithm**

Various classes such as trees, persons, cars and other vehicles in the dataset can also be detected. Out of all these classes present in the dataset person detection class is used to detect the non – helmeted motorcyclists and rest of the classes are discarded. The reason for peculiarly choosing person detection is because there are many instances where the camera would be either facing the front or the back facing the traffic, so the motorcycle is barely visible whereas the person is clear based on our factual tests. So, in such instances if the detection of motorcycles class is used then it leads to many helmets undetected. However, in criteria of detection of person, the person sitting on motorcycle the head region of the person would be covering the helmet and the foot region would be close to the license plate area. This clearly increases the detection rate of the helmet.

*B.2. Intermediate processing*

As previously mentioned, the initial stage as all the classes of COCO dataset is detected in YOLO v3 [5] and in the proposed approach we consider using the person detection to detect whether the motorcyclist is helmeted or person without the helmet. Rest of the classes that come under the COCO [6] dataset other than person is discarded. The detected person is bounded in a box, that is further extracted and used for processing.

*B.3. Detection of helmet*

In this approach proposed the main goal is the detection of helmet on the motorcyclist. As discussed earlier, here we have the same approach as stage one, where we use YOLO v3[5] model again in which it is trained on the dataset of helmet image. In YOLOv3 model, the input is the processed images of person. Since this dataset is trained on helmet images, the detected person is further bounded in a box are the rest are cropped.

*B.4. License Plate Detection*

License Plate detection is carried out further when there is a detection of a non – helmeted motorcyclist from the cropped image, then the image through the License plate detector, OpenALPR [3] which further recognizes the license plate with the co- ordinates. The detected co-ordinates could extract personal information of the law breaker. If the helmet is detected in the cropped image of the person then the process stops there and is further discarded.

*B.5. Implementation for Vehicle Theft*

License plate recognition has a wide range of application, from security purposes, violation detection to automatic speed detection of vehicles. A real central database is maintained by the police department. Every car to which the number plate is recognized, is then compared with the database of stolen vehicles. If the match is successful, then the database ID is updated with the GPS coordinates of the area where the vehicle is detected and further shared with the police department.

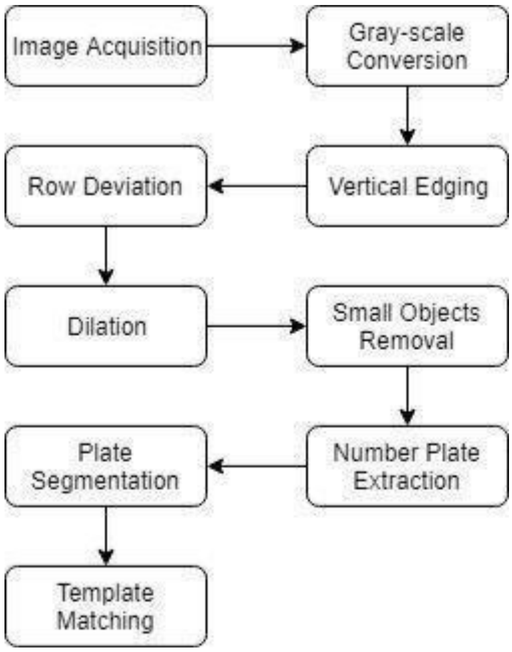


**Fig. 3: Number Plate Recognition Algorithm**

### C. Speed detection

With the increase in rate of automobiles and their use, speed detection has become a major concern in controlling surged traffic and high rate of accidents. The video stream from surveillance camera is processed in real time. The violation of speed limit can be detected and notified to the officer in law. In our system, image processing has been used to gather noiseless image frames and deduce speed of vehicles from bounding boxes. Major steps of processing includes:

*C.1 Noise reduction*

The presence of noise components in image frames occurs chiefly due to misfocus of camera lens, atmospheric conditions and motion of UAV. As a result, the edges of objects get blurred and image frames get degraded. Hence, in order to preserve the edge information, median filtering is applied. It is carried out during pre-processing step in which the output intensity of image section is extracted from median intensity values of the pixels.

*C.2 Background subtraction [8]*

A foreground mask is generated by subtracting the reference image from current image frame in order to separate the foreground elements from background. This generates a prominent region of interest.

*C.3 Edge detection*

At first smoothing is applied to remove noise from the image frames. Then edges are detected using canny edge detection algorithm [9]. Further, morphological operations [10] i.e. erosion and dilation are applied to shrink and enlarge the areas of foreground pixels respectively.

*C.4 Speed calculation*

The pronounced edges of the vehicles are used to calculate the speed by employing speed detection algorithm.
A rectangular box is chosen on the image screen.

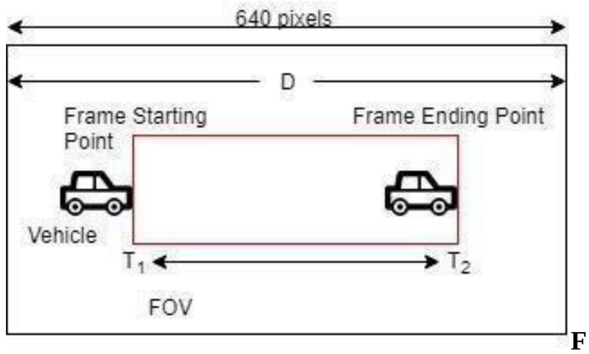


**Fig. 4: Speed Detection of vehicles**

The front edge of the vehicle is detected when the front side of the vehicle enters the first boundary of the test box. Similarly, when the vehicle leaves the test boundary, the front edge is again detected at the right side of the test box. The number of pixels are determined between the two edges and multiplied with the calibration factor. The resultant value determines the distance travelled by the vehicle. Further, the time stamps are determined at both the instances of a vehicle entering and leaving the boundary box. Finally, the distance travelled by the vehicle is divided by time difference to calculate speed of the vehicle.

### D. Toll Gate Efficiency

Automatic Toll Tax Collection System has the potential to drastically reduce the unnecessary consumption of fuel and waiting time of vehicles on roads. Hence a new automatic system using license number plate recognition can be implemented. The license plates on the automobiles serve as a unique identification to every vehicle on road today. This intelligent system is based on three components stated below,

***D.1.*** *Automatic Vehicle Number Plate Identification*

The vehicle number plate identification controls the effective flow of traffic. Upon successful identification, the License Plate Recognition algorithm is executed, an image processing technique to extract the number plate from the front view of a car. The characters are detected by applying various image processing and optical character recognition techniques.

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Real-time License Plate Recognition plays an important role in automatic monitoring of traffic rules and maintaining law enforcement on public roads. Since every vehicle carries a unique license plate there is no requirement of external cards, tags or transmitters.[11]

*D.2. Traffic Control System*

A traffic control system is used to control the traffic using signals and sensors. The automatic gates are controlled by this smart control system to facilitate an efficient traffic flow.

*D.3. A Central Server:*

Every vehicle is already registered with a Regional Transport Office and has a unique identification number. The details of the vehicle recognized can be fetched in a central system integrated with the central databases of regional transport offices from multiple states. Vehicle classification details, vehicle's load and bank accountdetails (linked to Aadhar number provided at the time of vehicle registration) can be fetched from this central database.

The proposed system has four major components:

i. Vehicle detection sensors.
ii. High-Resolution cameras for capturing images.
iii. A compute system to execute image processing algorithms and control transaction.
iv. Controlled gate system.

The proposed algorithm involves four major steps:

- Image Acquisition
- Number Plate Extraction
- Character Segmentation
- Template Matching

*D.4. Implementation in Toll Plaza*

The frame (input for the system) is captured from few meters away. Then, the license plate extractor processes the frame and sends the output for further segmentation. After recognizing the characters, the algorithm gives resultant number of the vehicle's number plate. This extracted number is then searched in a central database for vehicles obtained from the regional transport offices of different states. Once found, toll would be deducted according to the class and load of the vehicle from the associated bank account linked with the owner's Aadhar number. A confirmation message is sent to the owner upon a successful transaction. [12]

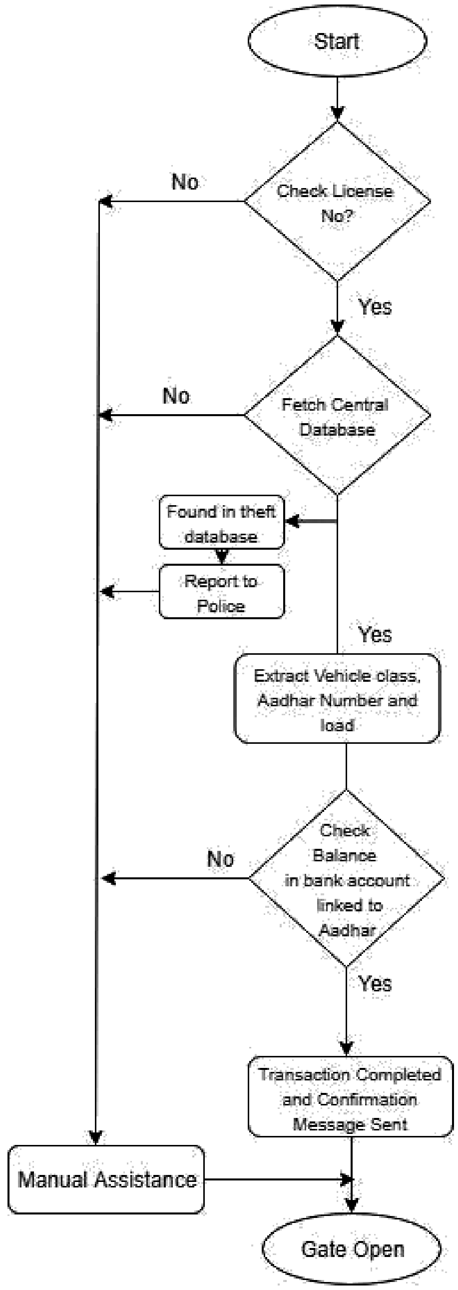


**Fig. 5: Flow Chart for implementation of automatic number plate identification at toll gates.**

## III. OUTPUT AND RESULTS

### A. Experimental results

The real time image processing on surveillance videos obtained from cameras is deployed on an UAV has been implemented to monitor traffic and accidents. The image frames extracted from video feed were processed over several stages. In the first technique, traffic accident monitoring yields an accuracy rate of 80% when iterated through 200 epochs. The dataset used for helmet detection contained around 4000 images only, so using the weights pre-trained on ImageNet we had chosen to train the model. Batch size is set to 64, for both training and testing. 400 helmeted and 400 non-helmeted images were chosen for training the model. Accuracy rates of helmet detection reached to a maximum of 85% with 200 epochs.

**Fig. 6: A sample scene with multiple vehicles**

**Fig.7: Grayscale image**

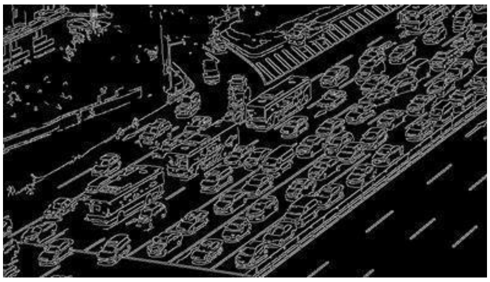

**Fig. 8: Canny edge detection**

**Fig. 9: Feature extraction**

The speeds of vehicles are detected using time stamps when they enter and exit the bounding boxes. The accuracy of speed detection algorithm decreases with the increase in noise as the speed of the vehicle reaches beyond 50km/hr. Once the vehicle crosses a certain threshold speed, the plate detection algorithm is executed and license number of the vehicle is saved for further observation.

### B. Data analysis

Neural network based traffic monitoring generates appropriate data for traffic flow analysis and prediction of road traffic congestion. The data analysis aims to generate report on various types of vehicles passing by a particular traffic signal and recognising their respective license plates. The analyses illustrated in this paper are based on automatic traffic recorder implemented in Route TH 169, Onamia. Fig.10 shows the average daily volumes for month, weekday and weekend. We can interpret that average of daily volume of traffic is highest in the month of July and August and lowest in December. This data might help in improving road's network and meet the requirements of growingtraffic.

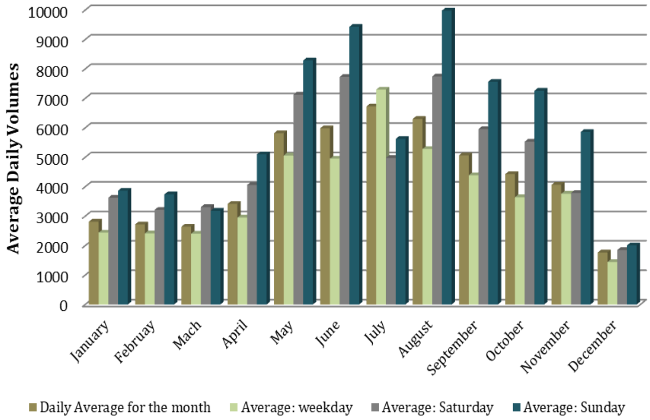


**Fig. 10: Average daily volumes of traffic for months, weekdays, Saturday and Sunday**

Fig. 11 and 12 illustrates hourly traffic volumes, ranging from 11AM to 9PM, with 11AM as the peak hour. The congestion decreases exponentially after 4PM and reaches a minimum of 10.4% at 9PM. The data can be used to predict the future traffic and thus alert the drivers to take less congested paths. Authorities can also use this information to plan, design and improve road conditions.

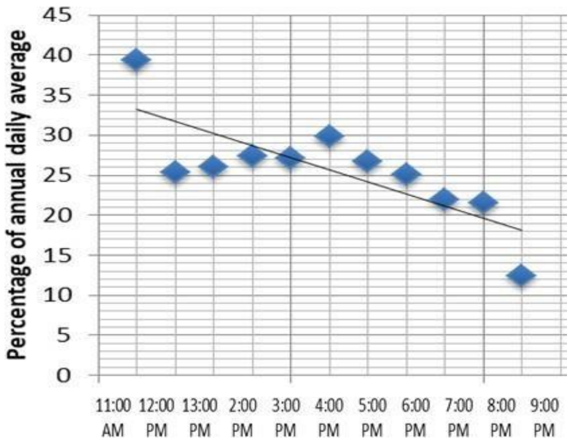


**Fig. 11: Percentage of annual daily averages at different hours**

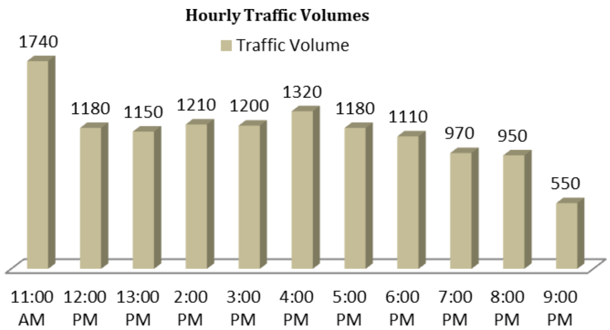


**Fig. 12: Hourly Traffic volume**

The traffic flow data acquired on daily basis can help to improve planning, design and construction of roads. The efficiency of roads can be calculated by comparing the road's capacity with hourly traffic volume. Present data can be compared with historic data to predict accident rates.

With the help of this predicted data, accident prone regions can be detected and authorities can take further measures to improve the growing rate of road accidents.

## IV. CONCLUSION

We propose an approach for aerial traffic monitoring using machine vision. In order to execute traffic management with accuracy it is executed by cameras that become mobile when deployed over an UAV. The real time processing of videos and image frames results into an intelligent system. This system will not only assist in managing traffic, but also reduces the rate of accidents via a speed detection algorithm. The image processing algorithm to detect number plates of vehicles can help reduce the emerging rate of traffic on highways. The violation of traffic rules are detected and monitored for further investigations. Incorporating artificial intelligence with the existing model, daily, weekly or monthly analysis reports can also be generated. The system overcomes the immobility of cameras and provides a reliable monitoring of accidents and traffic. With minimal operating costs, it serves as an efficient and faster solution in its domain. The results obtained on various scenarios make this approach more reliable with the accurate traffic management.

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