# A Virtual Road Traffic Monitoring System Using Internet of Things and Machine Learning Techniques

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A system and method to monitor traffic in virtual mode based on surveillance cameras and the road traffic lane signal has integrated to Internet of Things (IoT).The lane traffic lights would be automated based the on frequency of moving vehicles or fixed time slots. The video analytics incorporates the machine learning for object recognition, tracking and prediction of road traffic in various scenarios. Even the moving vehicle breaks the traffic rules the automated message send to the owners mobile numbers. The system comprises of video monitoring equipment and equipment for automatic lane discipline control. The Video monitoring equipment is IoT enabled and it can facilitate traffic monitoring using remote web-based applications. The video equipment at any point in time tracks the state change of traffic signals. The real time video capturing helps to extract the vehicle identity from the vehicle number plate fixed in vehicle. The IoT enabled video camera and lane control traffic lights may be deployed at any vehicle traffic junction. The video recordings can be stored in the cloud server and applying the video analytic techniques to extract vehicle information such as type of vehicle, color and number plate information with additional attributes. Finally this system support high quality video enhancement to provide better statistical information and remote vehicle traffic control management. The GUI allows the traffic cops to operate the system automatically or manually from a remote area, thereby increasing the productivity and reducing the traffic congestion. This method is categorized into different phases such as pre-processing the video input file, applying the background subtraction algorithm to it, and then proceeding to the next operations. In this paper, we intend to design a system to classify and detect vehicles using a mainstream algorithm such as the background subtraction algorithm. For vehicle tracking we have used YOLOv3 and Simple Online and Realtime Tracking (SORT) algorithm. We have used YOLOv3 and SORT methodology for vehicle classification and extraction of information.
**Keywords**: Vehicle traffic Monitoring, Video analytics, Remote Traffic Management, IoT, Computer Vision, YOLO and Simple Online and Realtime Tracking (SORT).

## 1. Introduction

The internet of things (IoT) extends the internet's capabilities beyond computers and smart phones to a wide range of objects such as processes and surroundings. It refers to the collection of all gadgets that can connect to the internet, gather data, and share it. Connecting items to the internet has a lot of advantages. We have all experienced these advantages with our smart phones, computers, and tablets, but the same can be said for anything else. IoT works in a simple way with help of sensors or devices that collect data, this data is shared to cloud through Bluetooth, wifi or other connecting, which

means, once the data is send to cloud [1].The data is processed through for software and information is made available to user through email, text, notification [2].

One of the maximum tough and complex demanding situations in recent times is traffic congestion. The boom in populace and excessive person earnings in any united states has bad results on current transportation systems, and it has emerge as a worldwide problem The main cause could be traffic lights and their operation over a predetermined time period, which does not prioritize emergency vehicles just works on set time due to this many problems caused for pedestrians, passengers and increase vehicular queuing , hence there is urgent and great need of integrating smart technologies to the existing system for better performance. This demand become more rigid in development of smart cities [3]. Our proposed system is not only a better management of traffic through the traffic lights operation but also helps the traffic policeman to remotely control many junctions without the need of visiting to the place of traffic junction or signal.

The image data can be processed using a variety of complex techniques such as representation, compression, and a number of operations that can be performed on the image. As an example of image processing, sharpening, blurring, brightening, and edge enhancement can all be considered image enhancement operations[4]. The digital image processing methods involves the input of an images are processed by the signal processing techniques that, such as captured image or video frames converted to the output images either in a set of features or parameters associated to the image. Generally, processing images mentions the images transformed to digital or converting the analog and optical image processing. The two dimensional and standard signal-processing techniques are applied for digital image processing. Since last four to five decades have seen many new techniques in Image Processing.

Taking advantage of the virtues of images as a means of controlling traffic, we propose a technique for counting the number of objects detected and thresholding the intensity of the traffic. The different threshold value can be chosen to suitable requirements, for example if we define N as the threshold value to detect the number vehicles which is greater than N, then traffic density is high or if the number of detected vehicles is less, traffic density would be considered low. Developers have to determine the threshold value because it is a static value.

As there are many emerging technologies in the field of machine learning, a reliable system for identifying and classifying vehicles with extraction of number plate can be designed and deployed easily. With this regard, we have employed the background subtraction algorithm, YOLOv3, Simple Online and Real-time Tracking (SORT) algorithm and K-nearest neighbors (KNN) methods to develop our system [5]. The main idea behind using background subtraction algorithm is that it is one of the mainstream algorithm for motion detection in video surveillance. The segmentation of moving objects is carried by taking the difference between the input images and background [6].

For real-time object detection we have employed YOLOv3 and SORT algorithms. The YOLOv3 is a best suitable algorithms to detect an object with constraint features through a convolutional neural network (CNN) in the process of deep learning. The CNNs can detect and classify the objects based on incoming image frames are stored in arrays to find the respective patterns[7]. The YOLO algorithm has the great feature of detecting objects faster than other networks even though maintaining a good accuracy.

The SORT (Simple Online and Real-time Tracking) is used for tracking 2D multiple object in video sequences where only the previous and current frames are provided and the technique generates object identities on the fly [8].

## 2. Literature Survey

The credit assignment cerebellar model articulation controller (CACMAC) technique is a combination of composite control method and proportional-integral-derivative (PID) used for finding density of vehicle in the highway roads. Initially, highway traffic evolution process uses a macroscopic traffic model for finding density of vehicle with greater accuracy. The models were analyzed based the principle of CACMAC-PID and techniques were observed in detail. Later CACMAC-PID technique is designed with the combination of nonlinear feedback technology and road density controllers for highway traffic density analyzing model[9].

Multi-object tracking (MOT) helps to detect the multiple objects form video frame and assigns a unique ID for every object based on prediction techniques as well as location of all objects. It uses the deep learning for detecting moving objects towards computer vision applications. MOT includes a very important theoretic analysis and application scenarios are associate to object detection and tracking. MOT algorithms are defined with greater performance and plays vital role in a visual security monitoring systems and human computer interaction for navigation vehicle in this systems [10].

The Raspberry Pi system is integrated with a camera that consistently captured screens and sent to the cloud storage or cloud environment, which also introduced monitoring vehicles; this observation can be documented used for identifying a vehicle. In order for any typical violation of standards to occur, it can be effectively seen and the person who breaks the guidelines can be appropriately pushed back or fined. In this way, by capturing vehicle movement and transmitting it directly to the control room, we meet our activity identification needs [11].

Now a days the road traffic congestion is a serious problem in our daily life. Large numbers of vehicles, incorrect signage and inadequate infrastructure are the primary causes of road traffic jamming. Due huge traffic the pollution levels are increasing because the engines of the vehicles will operate normally and natural resources like gasoline and diesel are also wasted if not used properly[12].

The YOLO algorithm analyzes video frames sequentially and predicts the outputs motion objects to perform video tracking. There are different algorithms, has its own advantages and drawbacks. While selecting algorithm the major considerations are intended use. The purpose of visually tracking objects in consecutive video frames is to detect or predicts target objects. In this pattern is used to track objects in the video frame the SORT algorithm has followed [13].

## 3. Methodology

Figure 1 and Figure **2** is a Virtual Traffic Control System and method for Smart Road traffic System includes a traffic lights which is controlled by raspberry pi. The IP Cameras captures a real time video which is accessed by raspberry pi with the sequence of video frames. The machine learning algorithm in raspberry pi extract the road traffic condition and control the traffic lights based situations on road traffic. The IOT Gateway connected to raspberry pi to synchronous with the cloud server and to store all information in the cloud through a MQTT broker. The web application is also deployed in the cloud server which performs video analytics on real time road traffic and stores those features in cloud server. The web application extract features from real time video and can be visualized in virtual traffic room as well as to control traffic lights manually. The personal computer or mobile can support to access the web application anywhere and anytime to see the statistics of a real time traffic features such as vehicle count, type, number, color and pedestrians in a traffic signal.

Even IP Cameras cameras can be used for the application to provide a dedicated services for high quality of video steaming.

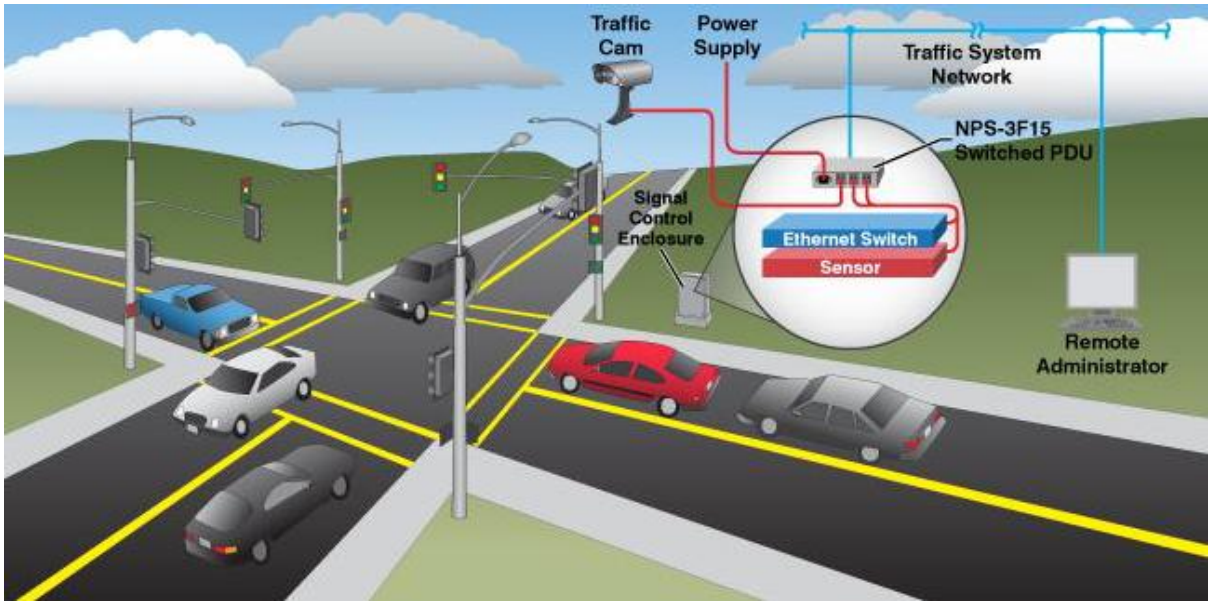


**Fig. 1: Smart Traffic Control**

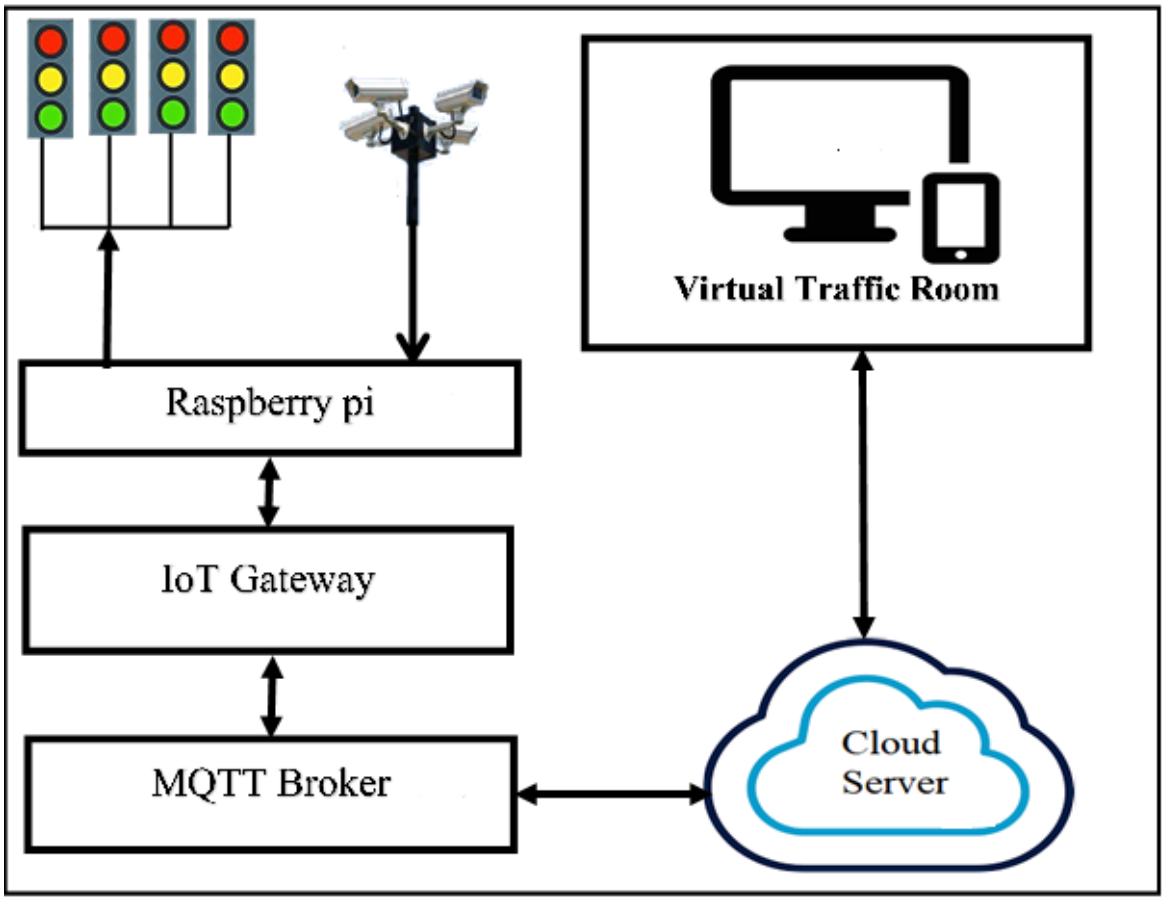


**Fig. 2: Virtual Traffic Control System**

### 3.1 MQTT

Raspberry pi transmit the data to using Message Queuing Telemetry Transport (MQTT). MQTT is a publish or subscribe concept simple and lightweight messaging protocol for sending a messages. It designed for IOT platform implemented in specific devices by utilizing low bandwidth and high latency even in the unreliable networks. MQTT ensures that minimise network bandwidth based on the resources integrated in the device and also ensure delivery messages reliability. The IoT devices are connected all over world using principles such as machine-to-machine communication and mobile applications with low power and less bandwidth utilization[14].

The MQTT Broker communicated through Server holding the concepts of Subscribers and Publishers trough a Clients. Mosquitto is a server software for MQTT protocol supports Raspberry Pi communication.

The MQTT protocol send or receive the messages asynchronously either publish or subscribe Model. The broker sends or receives the messages or commands similar to web services and manages the incoming or outgoing messages. Even through the RESTful services for HTTP over the web makes very significant distinctions. Moreover all IoT devices such as smart security cameras, traffic lights, sensors and appliances producing large amount data and interacting to different machines on a daily basis through the internet services.

All of the IoT enabled devices offering a functionality using Embedded System through the internet connected API calls. IoT technologies are more vulnerable to attack which are connected through a internet a low powered embedded devices and presents them with unique security threats.

Every IoT enabled devices must have additional securities built by engineers that they have not implemented with security anti-patterns to the address newer problems, this blog message will investigate different anti-patterns that have been used in IoT devices[15].

The proposed methodology has USB Camera which are connected Raspberry Pi for capturing the videos in a real time road traffic conditions. The captured videos are transmitted to cloud by using MQTT communication which is initiated form the Raspberry Pi device [16]. The Raspberry Pi is also conned to traffic lights for controlling the traffic lights either automatically The captured videos from the traffic signal junction will send to object detection and classification algorithms such YOLOv3 and SORT algorithm which deployed in cloud environment to access and control the traffic lights. Live streaming of video is accessed from any of the remote devices using MQTT Subscribers and Publishers. The model support for connecting multiple cameras and streamed through MQTT using IoT applications[18][19].

### 3.2 YOLOv3 and SORT algorithm

YOLO is an object detection algorithm. It is a good choice for detecting real-time objects. It predicts various vehicles by marking bounded rectangle boxes and predicting probabilities for these boxes using a single CNN. It includes identifying the vehicles and assigning them a unique ID. Then the images are labelled.

The video is given as an input to the system and extraction of the frames occurs which is then forwarded to object detector YOLO [17].The YOLO algorithm bind a rectangle boxes and assign a class ID for each group. The SORT algorithm keep track of the detected objects forwarded to next tracker group.

The SORT technique is one the strongest method for online tracker which helps to detect and track objects by Kalman filter. By assigning individual ID to every bounded box, there is a chance of predicting a wrong detection, SORT tracks each detection. New ID will be assigned to the newly found object by the tracker.

### 3.3 Identification and Classification of Vehicles

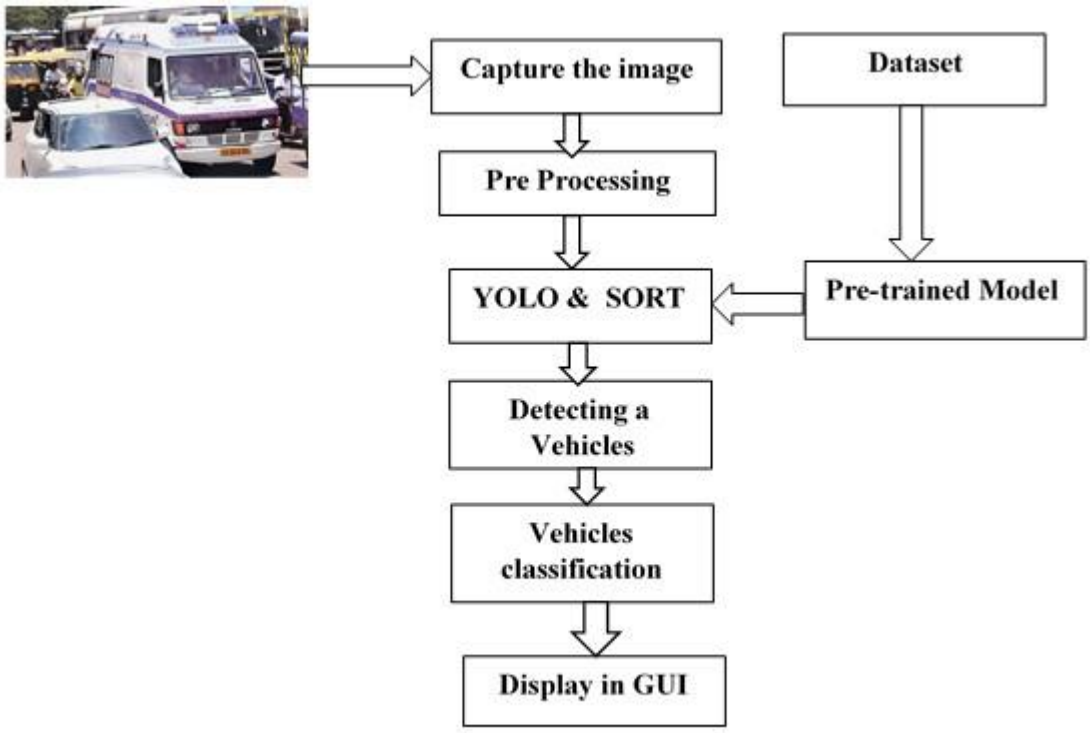


**Fig 3. Detecting and Classification process**

In this paper we have employed YOLO & SORT model detecting and classifying vehicles. The following steps are involved in the extraction process:

***Pre-processing***:
To reduce camera noise in most computer vision systems, simple temporal and/or spatial smoothing is utilized in the early stages of processing. In order to reduce the noise caught in camera smoothing process is employed. Various Frame per Second with different frame size are often employed to lower the data processing rate in real-time systems.

**Frames Creation from Input Video:**
In this step we give a video as an input and capture frames from it and these frames are in- turn used for further processes like detection of vehicles and extraction of number plate.

**Results for identification and classification of vehicles**:
which depicts the count of the vehicles. After the video and the area are selected the counting of the vehicles begins along with its classification and a total sum of vehicles and individual count of all types of vehicles passed through the area selected will be displayed. Frames are created from the input video and the same is passed to extract the number plate. This frame is then convert from color image to grey scale image Then this image is converted to the threshold image from which characters are segmented and detected. Finally the number plate extraction is done and displayed.

## 4. Experimental Results

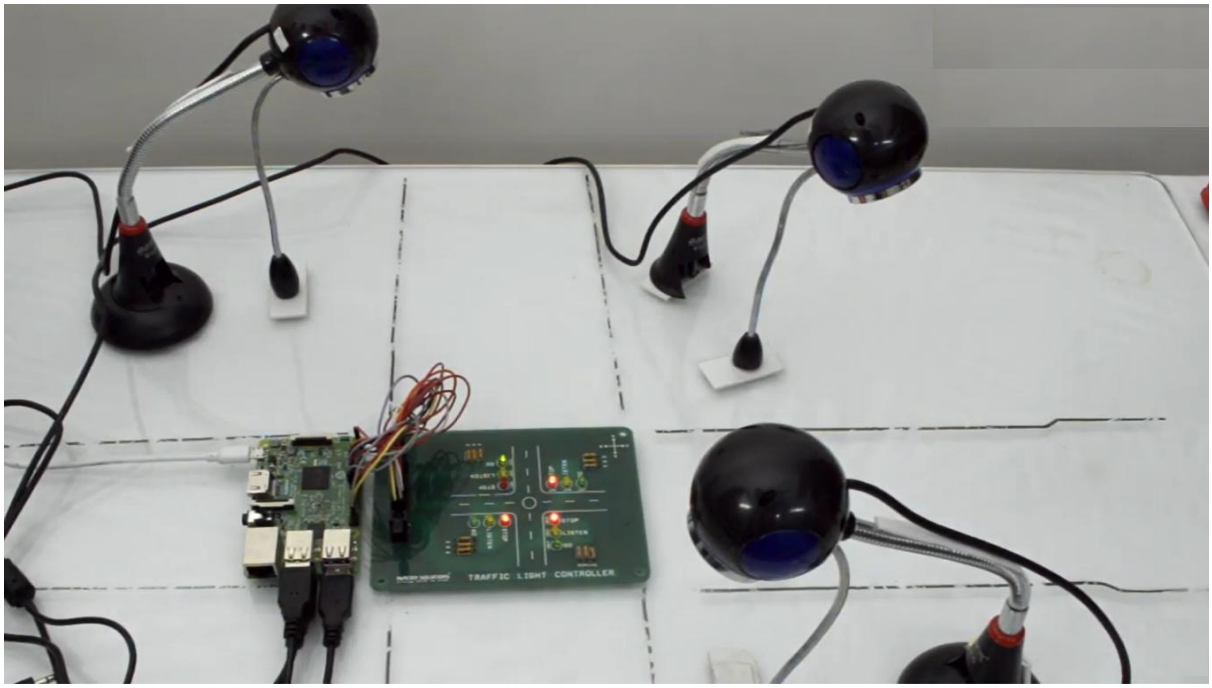


**Fig. 4 Traffic Light Prototype**

The proposed Virtual Road Traffic Monitoring system experimented in different scenarios for controlling the traffic lights as well as for detecting the density of traffic through a prototype model. It plays a major role for detecting, classifying and tracking of objects using the combination of YOLO and SORT algorithms. The project is implemented and tested using python programming. It has evaluated different Frames Per Second (FPS) such as 10,20 and 30 FPS. Initially the model is trained using verities of Common Objects in Context (COCO) dataset referred for generating weights files or labelled files in the part of pre-trained data model. The second part the identification and tracking of vehicles the real-time input video is broken down into 10,20 and 30 FPS passed to YOLO and SORT model for detecting and tracking of vehicles. The detected objects are marked as bound box and the object information is passed to SORT algorithm for tracking the objects.

When testing the application the visual object identification and tracking vehicles, the input video broken down into 10, 20 and 30 FPS and every frame generates a output video is saved as displayed in the GUI Screen. This algorithm for finding density of vehicle in the respective lane for detection vehicle and tracking the vehicles with assigned with unique ID.

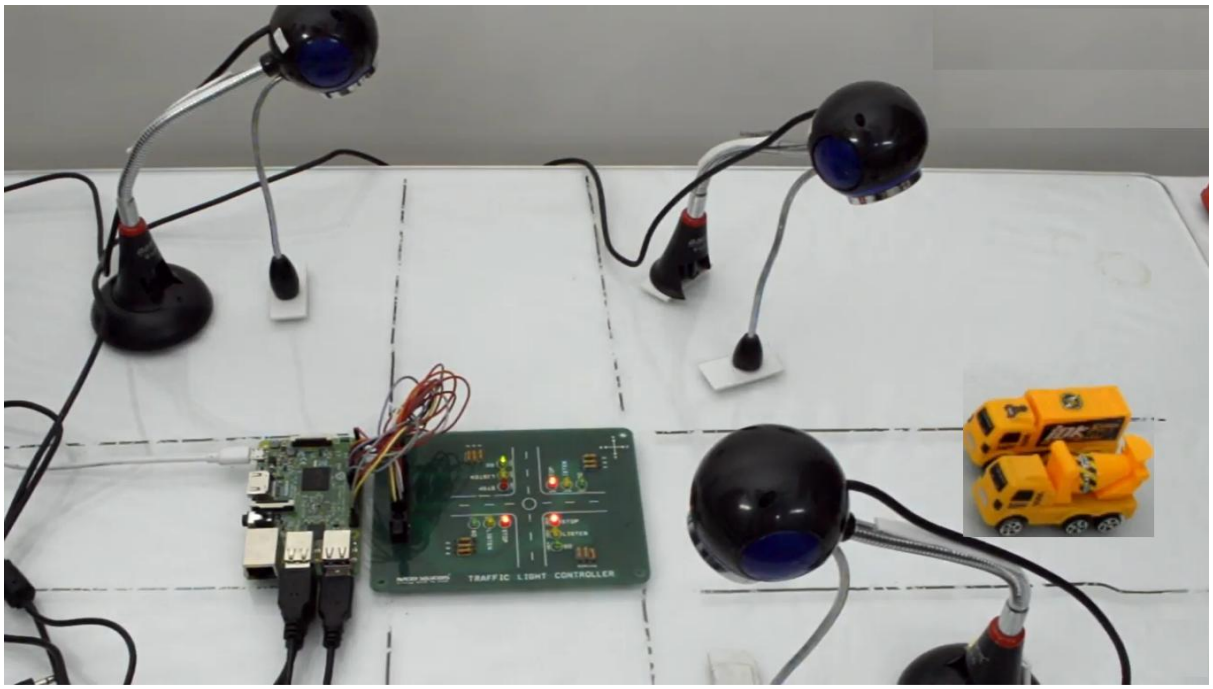


**Fig. 5 Traffic Light Prototype with vehicles**

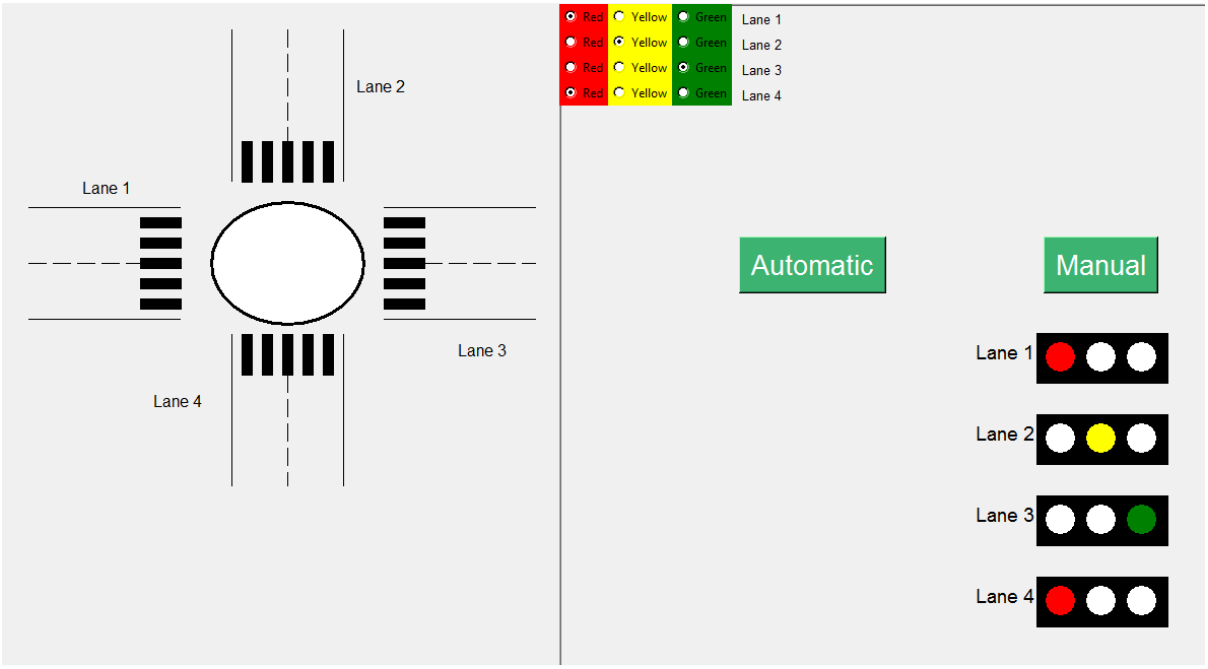


**Fig 6. GUI of Virtual traffic Monitoring**

## 5. Conclusion

In today's situation tracking the vehicles that violates the traffic rules is difficult. Different smart traffic control system are exist since few decades. Even though automatic and smart traffic control system has a key challenges for vehicle identification and classification vehicles as well as monitoring road traffic junction during the real time. So this paper

deals with the objective of detecting and classifying the vehicles and automating a traffic

signal using IoT and YOLO and SORT algorithm.

In this paper YOLO and SORT is used for identification, classification as well as density of vehicles. It has been observed that as the noise in the characters in the image increases, the error rate increases and the overall performance decreases. Therefore we designed our system that provides a fair accuracy level for automating and monitoring a traffic junction. Also it supports for monitoring the many traffic junctions simultaneous. The scope of further enhancement would be to increase the accuracy of detecting vehicle identification number correctly and sending an instant SMS of the vehicles violating traffic rules to the higher authority as well as respective vehicle owners.

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