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Smart Traffic Management System using IOT and Machine Learning

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ABSTRACT: With the rapid development of road infrastructure, the volume of vehicles on the road network increases, which leads to traffic congestion. The consequences of road traffic were not just wasting human working hours but also polluting the environment at a very high level. At present, most of the traffic rule violations are signal jumps which result in road accidents which may also lead to loss of lives. Thus, addressing this issue, a low-cost model was built using IOT and image processing techniques which aims to not only manage high traffic density dynamically but also reduce the traffic violations by ensuring strict regulations when a violation is detected.

KEYWORDS:YOLO; low-cost model; Traffic signal; Traffic violations; IOT

I. INTRODUCTION

Technology in today's world has transcended all possible barriers, and it has now become easy to solve most of the problems related to human beings. In most of the densely populated countries, including India, the most significant problem faced by the citizens is traffic congestion. Traffic congestion has increased drastically over the years and has had negative impacts that include road rage, accidents, air pollution, wastage of fuel and, most importantly, unnecessary delays [3]. One of the many causes for traffic congestion is improper/inefficient traffic management system.

The main purpose of this project is to introduce a low-cost system which allots time for each signal dynamically based on the amount of traffic [1], [2], [5], [7] on the roads. A network of Raspberry-PI is installed at each and every type of junction [10] of roads. The traffic densities are calculated by the Raspberry-PI using object (vehicle) detection algorithms on real time feed from IP-camera [6],[13] installed at the junctions. The green signal time is allotted dynamically based on the traffic density of the lane, thus reducing the occurrence of traffic congestion. In order to bring the traffic signal violation under control, the Raspberry-PI also takes a finite number of snaps for each violation sensed by the IR sensor [4] when the traffic indicator is signalling red. Later, these images are processed to read the registration number of the vehicles. Based on the registration number, the registered user gets intimated about the violation [11]. This way, the smart traffic management system fulfils its purpose by enabling the smooth movement of vehicles and preventing the occurrence of traffic signal violations.

II. RELATED WORK

In [9], a smart traffic management system that is partially deployed in the Cambridge city where queue detectors are buried in the roads that detect the traffic queue and inform the central control unit and take a decision accordingly is discussed. Since the system is centralized, it slows down due to networking issues. In [10], the researcher used surveillance cameras to detect traffic and OCR to identify the vehicles through number plate recognition, which is a simple detection technique, but the system will fail in other populated countries as there are different kinds of traffic including cycles, donkey carts which have no number plate packets. In [11], Osman et al. proposed a system in which they have used surveillance cameras to detect traffic density using MATLAB, a traffic controller and a wireless transmitter used to send images to the server after that server calculated traffic density by using those images of every section. This system used fixed (predefined) thresholds that depended on the number of vehicles on the road. An algorithm was used to set a time span of red light for a particular lane of the intersection, which is determined by traffic density on the road and forwarded to the microcontroller and then server. Some drawbacks were the optimization function uses the individual node's battery energy; if a node is having low energy level, then the optimization function will not use that node. In [8], Jadhav et al. used surveillance cameras, MATLAB and KEIL (Microcontroller coding) to control traffic congestion. This paper also discusses the priority-based traffic clearance and red signal broker (number plate detection). Due to using heavy hardware, it is difficult to manage and is not cost-effective. In [12], Bui et al. analyzed a real-time process synchronization-based system to manage the traffic

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flow dynamically. Sensors were used to detect the traffic and vehicle to vehicle, vehicle to infrastructure communication was utilized by using wireless communication devices. The controller placed at the center of the intersection received vehicles and pedestrians' information and requests and process using first come first serve method. In [13], Swathi et al. proposed a smart traffic routing system that chooses the shortest route having the least congestion. Sensors were used to collect data about traffic density, these sensors use solar energy and battery. Sensors kept transmitting infrared light, and when any object came near, they detected traffic density by monitoring the reflected light from the vehicle. However, this model fails as readings may change with the change in temperature and humidity.

III. PROPOSED SYSTEM

A. *System Architecture:*

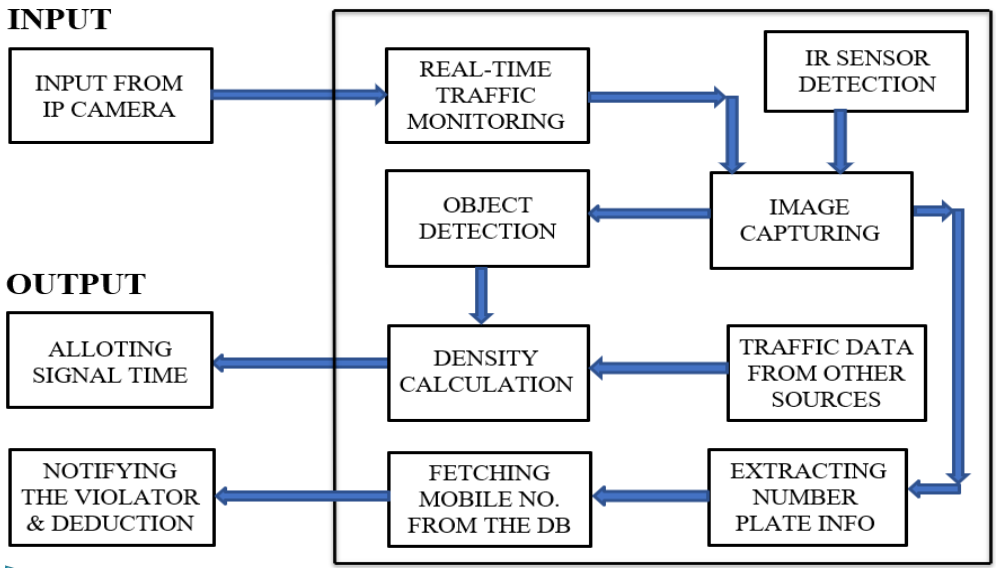

Fig 1 Architecture Diagram

The system architecture can be discussed as follows:

- **Input:**The input to the system is real-time traffic monitored video/image from the IP camera which is connected to the Raspberry-PI at the junction.
- **Object detection:** The real-time monitored video is converted to frames and the images are converted to gray scale and objects from the images are detected using deep neural networks (DNN). YOLO v3 algorithm is used to identify the objects, based on different classes of vehicles.
- **Density Calculation:**From the number of vehicles detected, the density of the lane is calculated and based on which the traffic signal light (TSL) is allotted with appropriate green signal time.
- **Violation:** When the TSL is red, the IR sensor at the end of the roads is active and for any movement detected from the sensor results in the capture of the image of the object on the lane.
- **Extracting Number Plate:** This image is later subjected to object detection through which the number plate is detected and read using the Tesseract OCR algorithm. Based on the registration number, the user information is fetched from the database, and the registered user is notified about the violation.

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B. Module Decomposition:

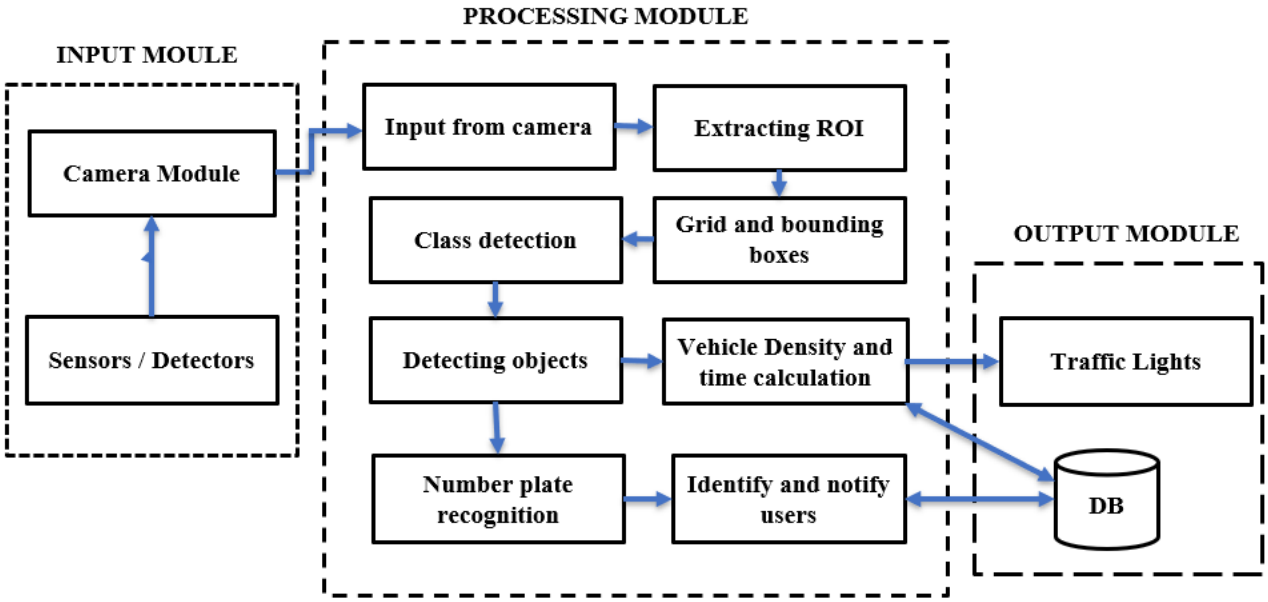

Fig 2 Block of modules in the system

The system is divided into 3 modules such as the Input, Processing and Output module.

- **Input module:** The IP cameras perform real-time traffic monitoring and input images/video are processed by the Raspberry-PI. The IR sensors are active when the traffic signal is signaling red. They also act as input by sensing vehicles.
- **Processing module:** The processes occurring within the processing module are:
  - **Input from Camera:** The input from the camera is the real-time video and snapshots of the lane which can be used to set timer and detect violation.
  - **Extracting ROI:** This module extracts the data required for processing.
  - **Grid and bounding boxes:** The images are divided into grids.
  - **Class detection:** This class of the object is detected and bounding boxes are drawn across the object.
  - **Detecting Objects:** This phase detects the objects such as cars, busses, bikes etc., on the lane based on the vehicle class.
  - **Density Calculation:** The density of the lane based on the size and count of the vehicles and green signal time is calculated.
  - **Number plate recognition:** This phase recognizes the registration number of the vehicle and the registered user is identified.
- **Output module:** This module consists of the TSL (traffic signal light) and the database. The TSL is provided with density data from the processing module using which the green signal time is calculated and is stored in the database

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C. *Interface Design:*

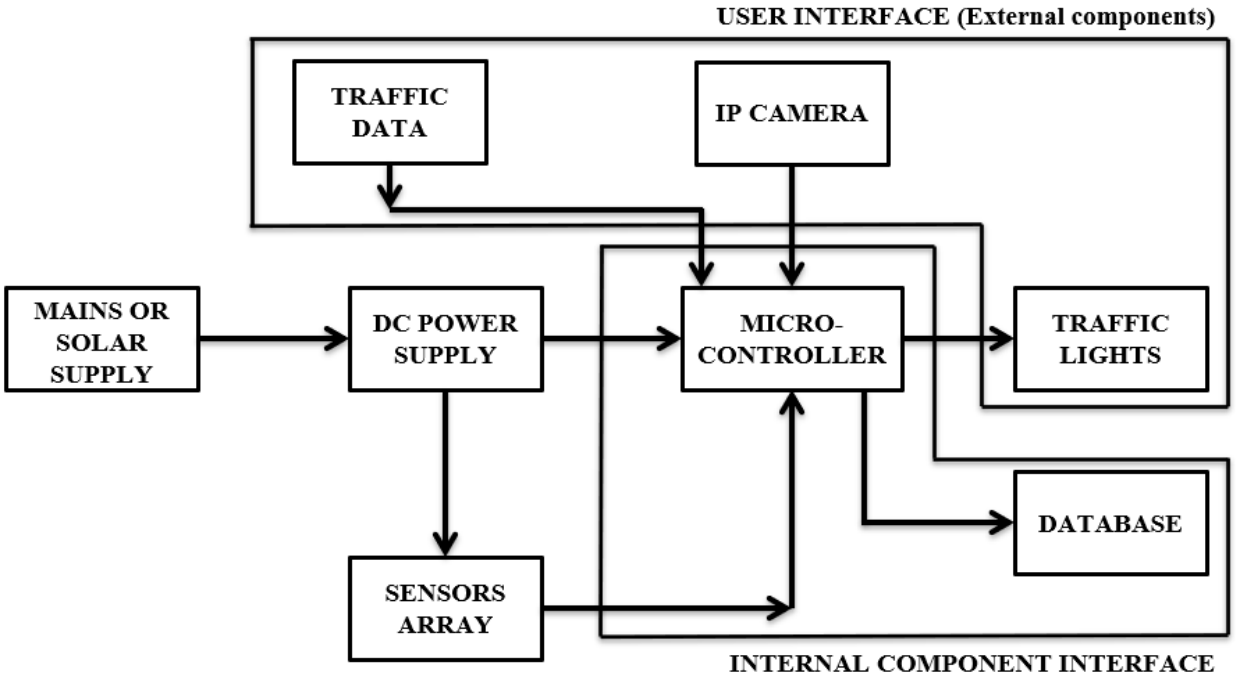

Fig 4: External and Internal Component Interface

- **User:** A user is a person who uses or operates a system. The users are System Admin, Vehicle owners and Traffic Police.
- **Task:** A task is a piece of work to be done or undertaken. The tasks performed by the system are collecting traffic images, process the images for traffic density, allot green signal time, detect violations, process image for reg. No., Notify users, etc.
- **Environment analysis:** Environment Analysis is described as the process which examines all the components, internal or external, that have an influence on the performance of the system. The internal components indicate the strengths and weaknesses of the business entity, whereas the external components represent the opportunities and threats outside the system.
  Environment: Transport, Industrial, Safety and Security.

IV. SIMULATION RESULTS

The simulation studies involvethe simulation model was run for 3 minutes with a fixed time (existing system) and the number of vehicles that crossed each lane were calculated. Also, the number of vehicles that crossed the lane for 3 minutes in the proposed traffic model with dynamically allotted green signal time was calculated.Based on the results we found out that the proposed system could easily allow more vehicles through the junction reducing the waiting time for vehicles and hence reducing traffic congestion at the junction.

V. USER IMPLEMENTATION

The model just depicts the abstract of the main system. The components used in the system which includes a Raspberry-PI 3B+ along with a bread board for connections. A webcam is used instead of an IP camera and ultrasonic sensors are used as an alternative to IR sensors. Male-female wires are used for connections between the raspberry-pi and the bread board components. Resistors of 220 ohms and 1k ohms are used for connections between the raspberry-pi and the LED's and also between raspberry-pi and the sensor. Additionally, sound buzzers are also used to buzz when a traffic signal violation occurs. The frames are then processed with OpenCV deep neural networks using yolo v3 algorithm to identify the objects based on their class. Bounding boxes with label names are drawn around each and

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every type of vehicle identified in the frame.The number of vehicles of each type, that cross the virtual line are taken into account and the traffic density of the lane is calculated. The green signal time of the traffic signal light is calculated dynamically based on the calculated traffic density of the lane.In the above image the vehicles are detected based on their types and are displayed with their labels on the main window screen. Their corresponding counts are incremented as they cross the virtual orange line.

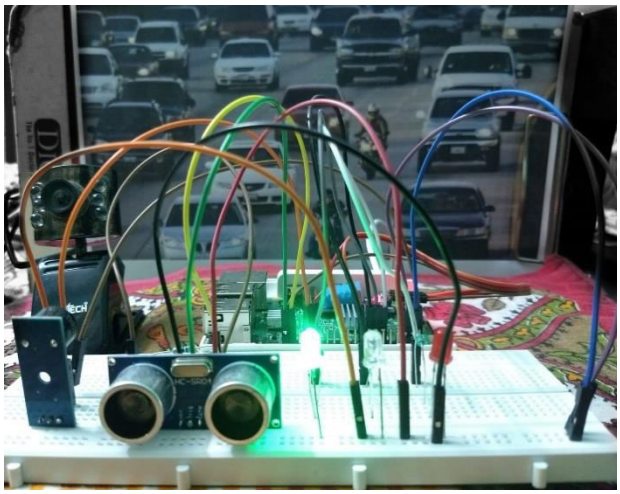

Fig.1Smart traffic Management System Model

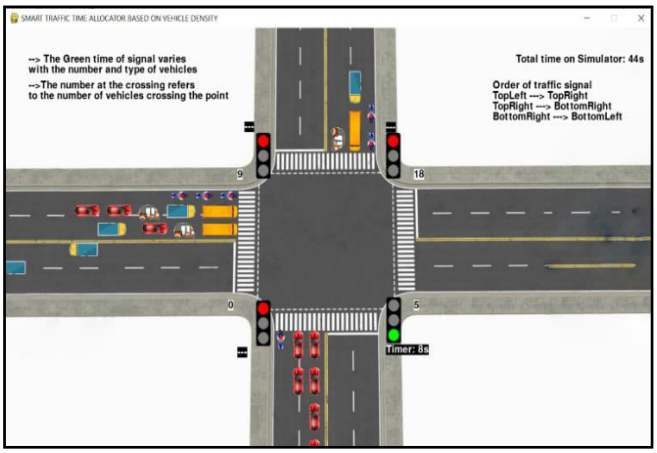

Fig 2. Simulation Testing model for the System

Fig. 3. Identification of vehicles through real time traffic video(left)
Vehicle number plate detection and message notification (right)

VI. CONCLUSION AND FUTURE WORK

This system of configuration reduces huge traffic queues caused by the conventionally implemented fixed signal time system used in many places. The system also additionally reduces the workload of officers who would have to direct the traffic in unexpected situations, or when the traffic lights are not operating correctly. It also enables traffic lights to work continuously with fewer chances of malfunctioning. The system reduces traffic violations to a great extent, as people get charged immediately for the violation. The system also helps in reducing the road accidents as damaged roads can be identified immediately and immediate help can be offered for accident victims. The system in simple

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words provides a simple yet effective solution to improper traffic management. More sensors can be used in each lane to make the system more accurate and sensitive to small changes in traffic density. Driver-oriented or driver-less cars can access the website to view the intensity of traffic at an intersection and choose the fastest route accordingly. Data mining techniques such as classification can be applied on traffic data collected over a long term to study the patterns of traffic in each lane at different times of the day.

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