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Dynamic Traffic Control System for Congested Transportation using Deep Learning Algorithm

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Abstract: The paper describes the design of a keenly intellective traffic light control system, which habituates to the transmuting traffic conditions. Traffic congestion has been a major issue in every city in the world. To overcome this, the traffic has to be monitored regularly. The vehicles in the lane are detected by the camera mounted alongside the traffic signal. The vehicle detection involves CNN algorithm in Deep Learning. The vehicles are located with the bounding box and each of them is counted. Based on the vehicle count, Raspberry Pi controls the signal. In case of emergency vehicle ingression, the signal gets automatically changed to green.

Keywords: CNN Algorithm, Emergency Vehicle, Smart Traffic Control, Vehicle Counting, Vehicle Detection

I. INTRODUCTION

Transportation (Road) is the only way of carrying goods and people to and from rural areas. Traffic Regulations are formed to protect the life of people whether they are drivers and pedestrians. As the population increases, the number of private vehicles increases causing traffic congestion. According to a survey-based on traffic congestion taken in the year 2019, Bengaluru has a congestion rate of 71%. The main reason behind today's traffic problem is the technique that is adapted for traffic management.

The current traffic light control system is time-based and the vehicles have to wait even there is no congestion. In some cases, vehicles are detected using sensors which do not give an accurate result. To overcome this, there is a need for an autonomous traffic light system. This system use camera to count the number of vehicles on the lane and based on the vehicle count the signal is controlled. Hence, there is no need for a vehicle to unnecessarily wait and reduces traffic congestion.

Sometimes, traffic congestion causes the ambulance to get stuck in traffic. The autonomous traffic control system detects the ingression of an ambulance and makes the signal green. This allows the ambulance to pass through the traffic easily.

II. RELATED WORKS

A. The following are the existing systems on traffic management system:

PIR based traffic control system updates the signal based on the density of the vehicles. Depending on the output of the PIR motion detector sensor, the signal is controlled. The disadvantages of these types of systems include less coverage and low sensitivity [1]. In a smart traffic light control system, the PIC Microcontroller is used which evaluates the traffic density using IR sensors and changes the traffic light accordingly. Besides, a handheld portable device communicates wirelessly with a traffic master controlled through ZigBee transceivers to allow the smooth displacement of emergency vehicles of higher priorities such as ambulances [6].

IoT based traffic control system which enables the system to identify the density of the traffic at the crossroads using an IR sensor. It also captures the Registration number of the defaulter's vehicle [2]. A density-based traffic control system with emergency vehicle detection controls dynamic traffic systems with the change of signal based on the vehicle density in the lane. Any emergency vehicle is cleared through image processing techniques [7].

The optimization of traffic light controllers is done using an IR sensor and traffic is controlled using ATMEGA 16 microcontroller. The system contains IR sensors mounted on either side of the roads for traffic density measurement. Thus, based on the determined vehicle density, a microcontroller

controls traffic light delay [5]. The automatic intelligent traffic control system uses the RFID concept which detects the ambulance and makes the corresponding lane green and allows the free passage of the vehicle without any traffic congestion. To control the traffic density the system uses a microcontroller which in turn controls the IR system. The IR system counts the number of vehicles passing through the lane and the vehicle count is stored in the microcontroller. If the vehicle count reaches a particular value the traffic light is changed accordingly [3].

Smart control of the traffic light system is based on image processing, using MATLAB code. The images of the vehicles are captured by using a webcam and it is processed on MATLAB by applying appropriate MATLAB functions and the vehicle count is determined. According to the traffic density, the traffic lights are changed in the lane [8].

B. Limitations of the existing systems:

- In all the previous arrangements sensors such asPIR sensors are used. The sensors have their limitations and a limited range of operation. The PIR sensor has low sensitivity and less coverage.
- In a smart traffic light control system, when emergency vehicles are detected the signal gets automatically changed to green.

III. PROPOSED METHODOLOGY

Traffic monitoring and controlling has always been a challenge. The exponentially increasing vehicular traffic has led to many issues ranging from traffic congestion to increased road accidents. Improved traffic density estimation would help to curb the traffic before it becomes a critical problem. Therefore, a framework has been introduced that would help in increasing the computational speed of the existing system and would also help in improving traffic management for intelligent visual surveillance. The live video stream is given as input to the Raspberry Pi from the two cameras. Image Processing is done in Raspberry Pi with personal computer support. The PC and the Raspberry Pi are connected by a common hotspot.As a result of image processing, the vehicles in the lane are detected and counted. Based on the count of the vehicle in the lane, the traffic signal changes automatically. The delay in the traffic signal is determined by the count of the vehicles. If the emergency vehicle is detected in the live video stream, then the traffic signal automatically changes to green. So that the ambulance passes through the traffic congestion easily. Figure. 1 shows the block diagram of the smart traffic light control system.

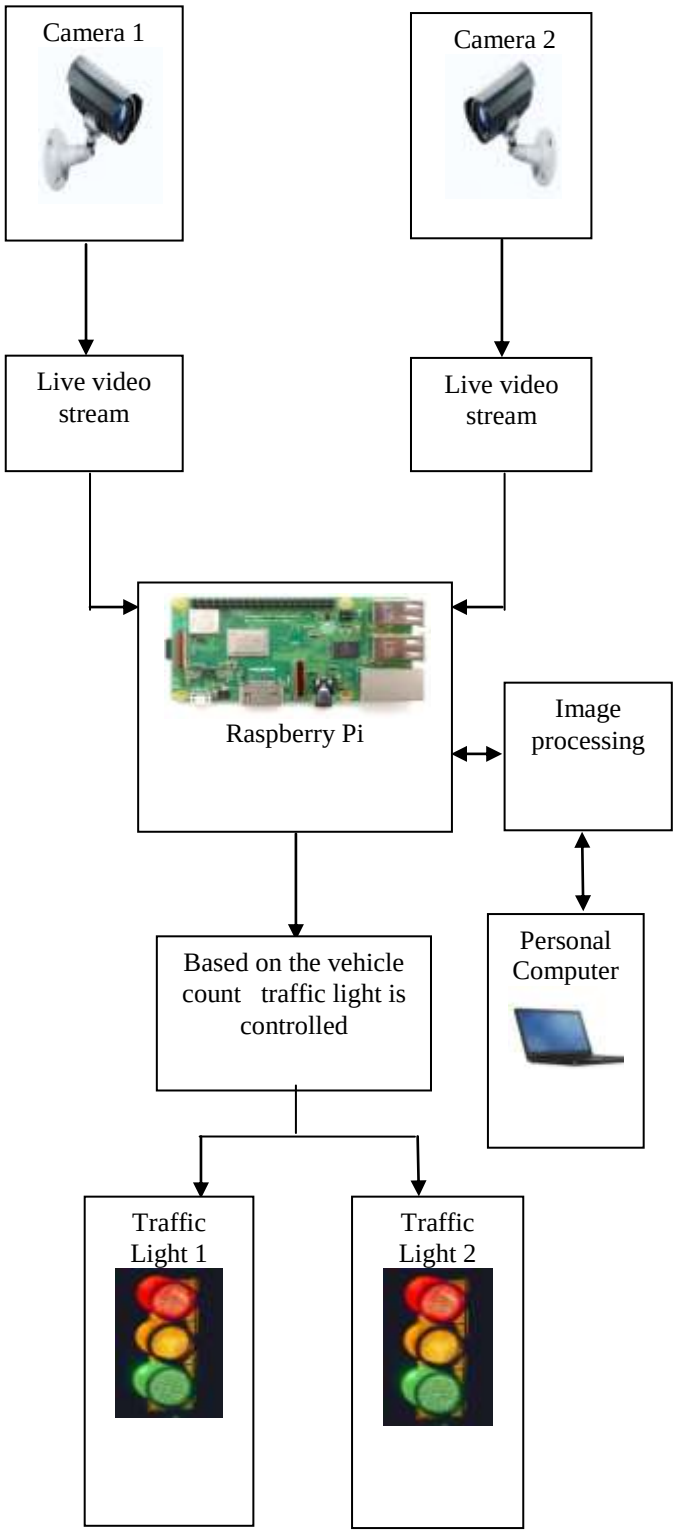

Figure.1 Block diagram of Smart Traffic Light Control System

A. Raspberry Pi

Raspberry Pi acts as both microcontroller and microprocessor. It is a credit card-sized computer. The Raspberry Pi works on a Linux based operating system. Later Raspbian operating system was developed for this system. Also, third party operating systems like windows 10 IoT Core, RISC OS can be used. The main programming language used in Raspberry Pi is Python. Raspberry Pi is mainly used to

implement IoT, Robotics, Automation, etc. The Raspberry Pi is shown in Figure.2.

Figure.2 Raspberry Pi

Raspberry Pi contains Wi-fi, Ethernet (RJ 45), Bluetooth, USB Hub, HDMI Connector, Audio Jackey, Camera, Display, MicroSD slot. Raspberry Pi works on 5V the power source given in micro USB. The Raspberry Pi has a General-purpose input-output (GPIO) connector. GPIO has a 40-pin pinout.

IV. CAMERA MODULE

Camera Module is imaging cameras that use USB 2.0 or USB 3.0 technology to transfer image data. Camera Module is designed to simply interface with dedicated computer systems by using an equivalent USB technology that's found on most computers. The USB technology in systems and high transfer rate makes this camera ideal for several imaging applications. The image resolution is interpolated to 25 megapixels. In real-time traffic management systems, the surveillance cameras are used for a live video stream. This provides a wide range vision of lane. The vehicle detection will be more accurate. Figure.3 shows the camera module.

Figure. 3 Camera Module

V. IMAGE PROCESSING ALGORITHM

In Edge Detection, the boundaries or edges of the objects are determined where the brightness of the image changes dramatically. Edge Detection can be used to detect the structure of objects in an image. Once the edge of the objects in an image is found, then use that information to find the image contours. With the contours, we can count the number of objects in the image. Figure.4 shows a flowchart of the image processing algorithm.

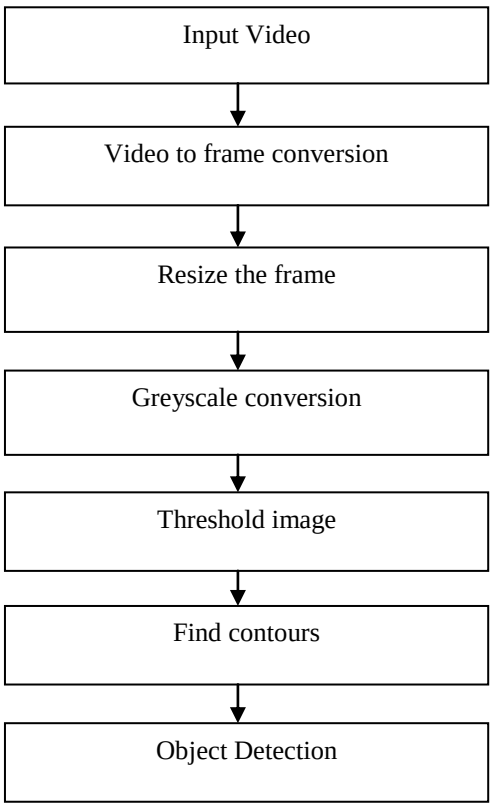

Figure.4 Flowchart of Image Processing

The live video stream is obtained from the Camera. The frame rate is set such that it captures a frames per second based on the frame rate. Resize of the frame is changing the dimension of the image, it may be height or width or both. The aspect ratio of the original image is preserved in the resized image. Next greyscale conversion is done. Grey scale is a range of monochromatic shades from black and white. Greyscale image contains only shades of grey and no color. This process removes the all color information and leaving only the luminance of each pixel. The next step involves the removal of the noise. This is done by Gaussian Blur which reduces the image noise. This is followed by thresholding of an image, which partitions an image into foreground and background. The difference between the current frame F and the background frame B is calculated by [15]:

$$d_{x,y} = \begin{cases} F_{x,y} - B_{x,y} \; if \; F_{x,y} \geq B_{x,y} \, , \\ B_{x,y} - F_{x,y} \, , \; otherwise \end{cases}$$

Contour is just a curve that joins all the continual points that has the same color or intensity. The contour is the major tool

for shape analysis, object detection, and recognition. Finding contours is finding a white object from a black background. By this image processing methods, the vehicles are detected.

VI. DEEP LEARNING ALGORITHM

Deep learning may be a subset of machine learning algorithms inspired by the human brain, learn from an outsized of knowledge. CNN is an efficient detection method developed in recent years. CNN reduces the computational complexity of the network. Object detection is defined as identifying and locating all known objects in a scene.

An Object detection algorithm typically uses extracted features and learning algorithms to recognize instances of an object. It is commonly used in applications such as security surveillance and advanced driver-assistance systems.

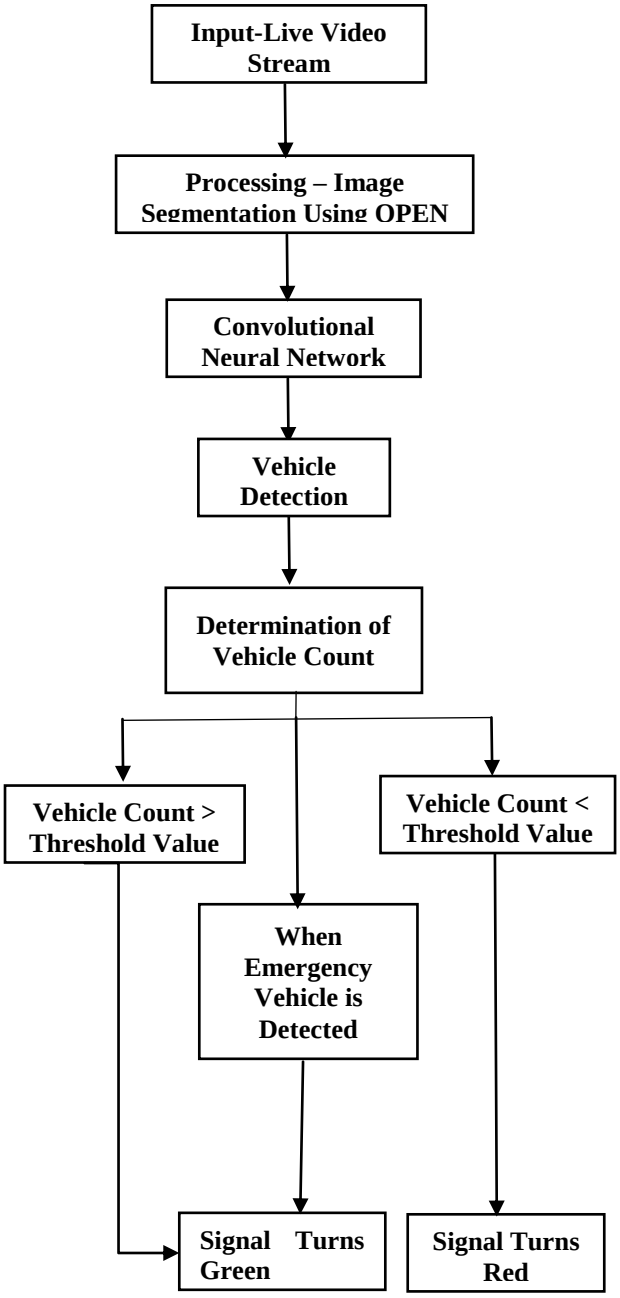

Figure.5 Flowchart

The object is then detected and counted. Based on the count of the vehicle in the lane, Raspberry Pi controls the signal. The entry of the emergency vehicle is identified by the features of the vehicle which is already trained by the images in the database. The lane in which the ambulance pass through changes to green and the remaining signal turns red. The flow chart for the process of the traffic light control system is shown in Figure.5.

VII. RESULT AND DISCUSSION

The result includes the successful implementation of the smart traffic light control system with vehicle detection. The system comprises of two crossroads and the cameras connected alongside traffic light. The cameras are used to detect the presence of the vehicle and takes the count of it. Based on the vehicle count, the traffic light is controlled. Figure.6 shows the design of a smart traffic light control system.

Figure.6 Design of Smart Traffic Light Control System

TABLE 1

Test Image	Actual Vehicle Count	Detected Vehicle Count
1	2	2
2	4	3
3	5	4
4	6	6
5	8	8
6	11	9
7	13	12
8	15	13
9	20	20
10	25	23

The above table 1 shows how many vehicles are detected and counted. Fig.7 shows the graphical representation of the tabulation. The actual vehicle count on the image and the detected vehicle count are plotted. The graph shows a linear relationship between actual and detected vehicle count. Accuracy of the system is approximately 90.7%.

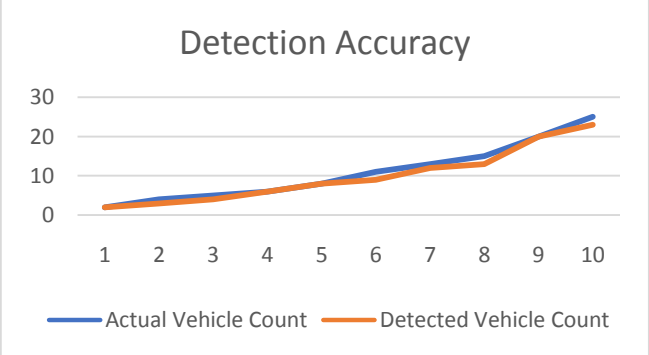

Figure.7 Graphical Representation of the Result

For example, the threshold value of vehicles is set to be 20 nos. If the camera detects more than 20 vehicles in the lane, the traffic density is considered as high and the traffic light is changed to green. When the camera detects less than 20 vehicles in a lane, the traffic density is considered as low and the traffic light is changed to red. The hard situation is when the ambulance gets stuck in the traffic congestion. So, it is important to manage the traffic signal in the time of arrival of the ambulance. When the camera detects an emergency vehicle (Ambulance), high priority is given to that vehicle and the traffic light is changed to green allowing the ambulance to pass the road easily.

VIII. CONCLUSION AND FUTURE SCOPE

The goal of this work is to reduce traffic congestion and improve an adaptive traffic management system by developing an algorithm to control the traffic based on deep learning. Typically, the traffic light control system works on a fixed periodic schedule or timer. Since the system is unaware of the congestion, the vehicle has to wait until the timer gets over even there is no congestion. In the proposed system, the waiting time of the vehicle in each junction is reduced, hence the efficiency of the vehicle is improved. The system also detects the emergency vehicle and high priority is given to it. Hence it allows the ambulance to pass through without getting stuck in the traffic.

As a future work, the specific design proposed for managing the traffic can be improvised by using a high-end processor to establish the efficiency of the system. The system can be implemented in crossroads by using additional cameras.

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