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Smart Control of Traffic Signal System using Image Processing

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Abstract

Background/Objectives: This paper focus on the necessity of intelligent traffic system and the peculiar way of implementation with embedded system tools. Here it is implemented using an object counting methods and detection of emergency vehicles simultaneously thereby control the traffic signals based on the priority outcome. **Methods/Statistical analysis:** Presently various system do provide a cost effective solution, but the rate of successful operation is bad. Inductive loop detectors installed under surface, this fails in case of poor road condition and so. In the other system, the density is found by installing IR detectors along the side of the lane. These systems operate less efficiently where they are not applicable in the real time process. This method uses image acquisition method using a real time live video stream and the algorithm is processed using MATLAB. **Results/Findings:** The results obtained with the prototype are much encouraging and the system does help the present traffic control system to be more efficient. **Conclusion/Application:** Computer Vision being one of the most researched are for the future technologies, this system will add gain to this sector with efficient operation replacing the current primitive timer traffic control system. This helps the emergency casualties to be attended quickly without panic of traffic congestion.

Keywords:

1. Introduction

Road transport is one of the primitive modes of transport in many parts of the world today. The number of vehicles using the road is increasing exponentially every day. Due to this reason, traffic congestion in urban areas is becoming unavoidable these days. Inefficient management of traffic causes wastage of invaluable time, pollution, wastage of fuel, cost of transportation and stress to drivers, etc.[1] but more importantly emergency vehicles like ambulance get stuck in traffic. Our research is on density based traffic control with priority to emergency vehicles like ambulance and fire brigade. So, it is very much necessary to design a system to avoid the above casualties thus preventing accidents, collisions, and traffic jams[2]. The common reason for traffic congestion is due to poor traffic prioritization, where there are situations some lane have less traffic than the other and the equal green signal duration for both affect the wastage of resources and drivers are stressed.

2. Proposed System

The aim of this project is to control traffic signals with the help of surveillance camera present at the junction points. The frames of the traffics obtained from the camera through continuous video processing. To calculate the density, an image from the camera is used to calcu-

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late the number of vehicles in each lane. According to the number of vehicles in each lane, the time for respective green signal is given which varies time to time. If there are same numbers of vehicles in the lane, the signal will follow the basic timer circuit. But when an emergency vehicle such as an ambulance is detected, priority is given for latter lane. The time for which each lane will be green is shown in the display of the individual down counter. In case, if an ambulance is detected, the current green lane will become red and the counter display will show an ambulance symbol, after a few seconds the lane having the ambulance will be allowed. Incase if there are two ambulance detected in the junction, the ambulance which is nearer to the signal get the priority first. Successful implementation of our research will result in faster clearance of traffic and improvement in the transportation of emergency vehicles.

2.1 Flow of Algorithm

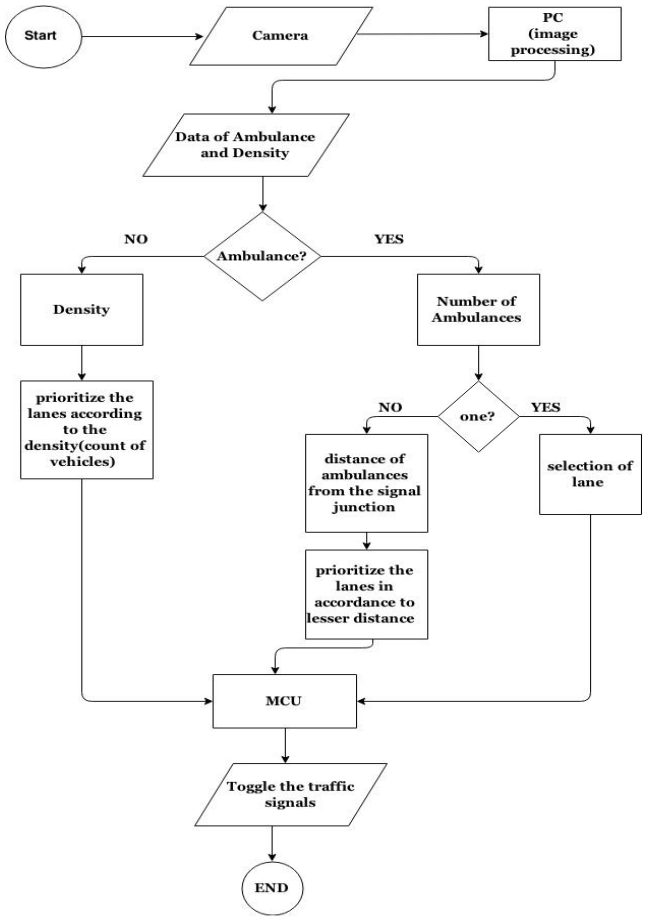


Figure 1. Flow chart of the proposed model.

2.2 Flow Chart Description

Figure 1 is the flow chart which depicts the intelligent traffic management system using image processing[3]. The camera which is mounted on a height gives the real time traffic monitoring of the road junction[2]. Frames are obtained periodically and are sent to the PC for image processing. The traffic density estimation & ambulance detection is done through image processing. If no ambulance is found then the traffic density is estimated & signal is prioritized accordingly by the MCU & the signal is toggled. But, if an ambulance is detected then signal priority is given to that lane & if multiple ambulances in different lanes are detected then priority is given to the ambulance which is closer to the signal & the signal is toggled accordingly.

The components used in this project are as follows:

2.2.1 Hardware Model

In this project the hardware used are:

- USB web camera: To capture images,
- PC: For all the image processing work,
- MCU: Arduino board for signal prioritizing,
- Toy cars for the prototype of a road junction and traffic model.

2.2.2 Software Model

In this prototype modeling circuit, the density and ambulance detection is done using MATLAB and the traffic signal is controlled by using MSP430 microcontroller.

3. Image Processing Steps Involved for Vehicle Count and Ambulance Detection

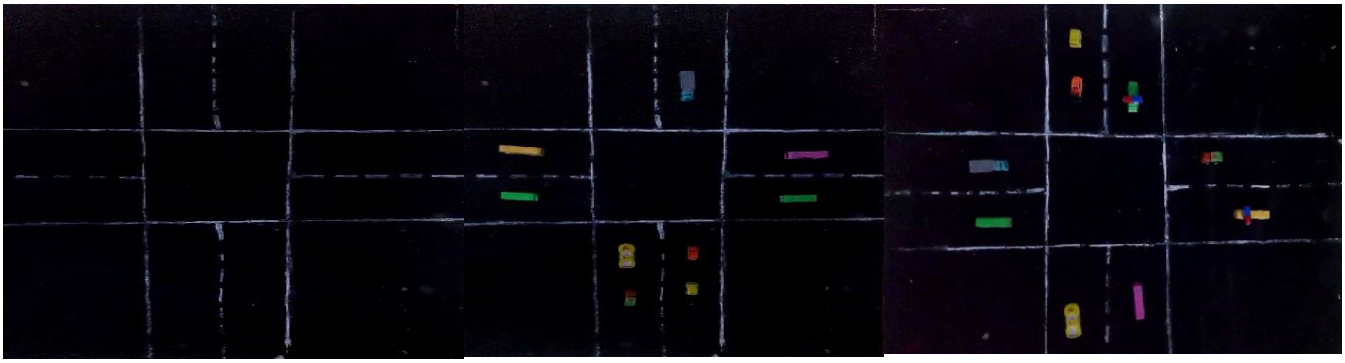
3.1 Ambulance Detection

3.1.1 Input of Frames from Camera

The initial step is to obtain the frames of the road from the live streaming of the camera. An image of the road without vehicles is taken as the reference frame (Figure 2 (a)). Then images of the road with vehicles are taken periodically as the current frames. (Figure 2 (b), 2 (c))

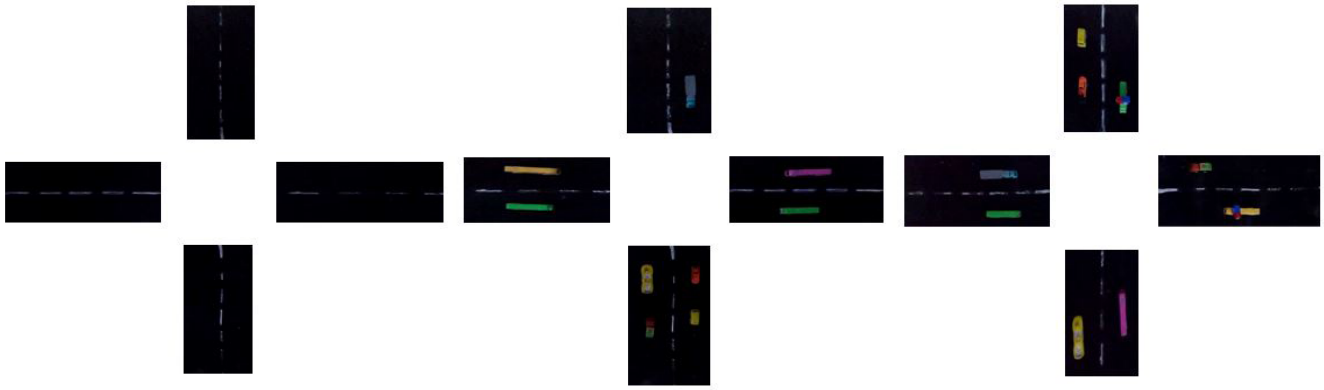
3.1.2 Cropping of the Image to Obtain Required Details

The next step is to focus only on the region of interest.



(a) (b) (c)

Figure 2. (a) Reference Frame, (b) Current Frame, (c) Current frame with ambulance.



(a) (b) (c)

Figure 3. (a) Cropping of background frame, (b) Cropping of current frame 1, (c) Cropping of current frame 2.

This is done by cropping and all the unwanted regions are eliminated. The lanes of the road are our region of interest hence it is cropped. The reference frame of the lanes (Figure 3(a)) and current frame (Figure 3(b)) and current frame with ambulance (Figure 3(c)) are cropped.

3.1.3 Detection of Ambulance

To detect the ambulance on a lane as shown in Figure 5 (a), its siren is being detected. The red color (Figure 5 (b), 5 (c)) & blue color (Figure 5 (d), 5 (e)) in the image is obtained using image segmentation based on color4. Its respective centroids are found out and distance between each red & blue pair is calculated. If the distance between them is lesser than a given predefined threshold distance, and if both the centroids lie on the same vehicle then the corresponding red & blue color is coming from the siren and the vehicle is found to be an ambulance. The ambulance with a standardized siren in our prototype is shown in (Figure 4).

Figure 4. Ambulance with red & blue colored siren in prototype.

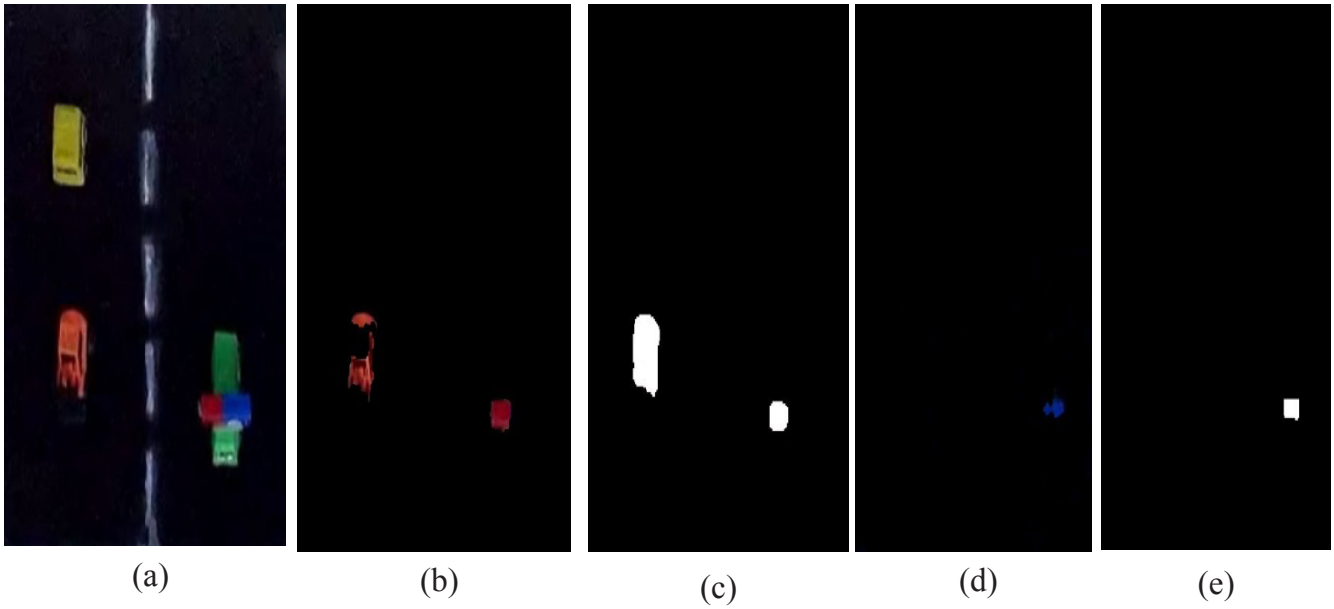


Figure 5. (a) Cropped Image of Lane 1, (b) Red Color, (c) Binary image of Red objects, (d) Blue Color, (e) Binary image of blue object.

3.2 Traffic Density Estimation

3.2.1 Detection of Vehicles

The next step is to detect the number of vehicles on the road. To obtain this the current frame and the Background frame are converted to gray scale (Figure 6 (a)) and the images are compared and subtracted to obtain presence of objects on the road[3]. Morphological operations such as dilate & erode are carried out to remove the additional noise in the image and this image is further enhanced and it is converted to binary image (Figure 6 (b)). This image is then filtered using Gaussian filter and to obtain only the vehicles on the road.

3.2.2 Count of Vehicles

The next step is to count the number of vehicles present on the roads[3]. To achieve these sets of connecting pixels

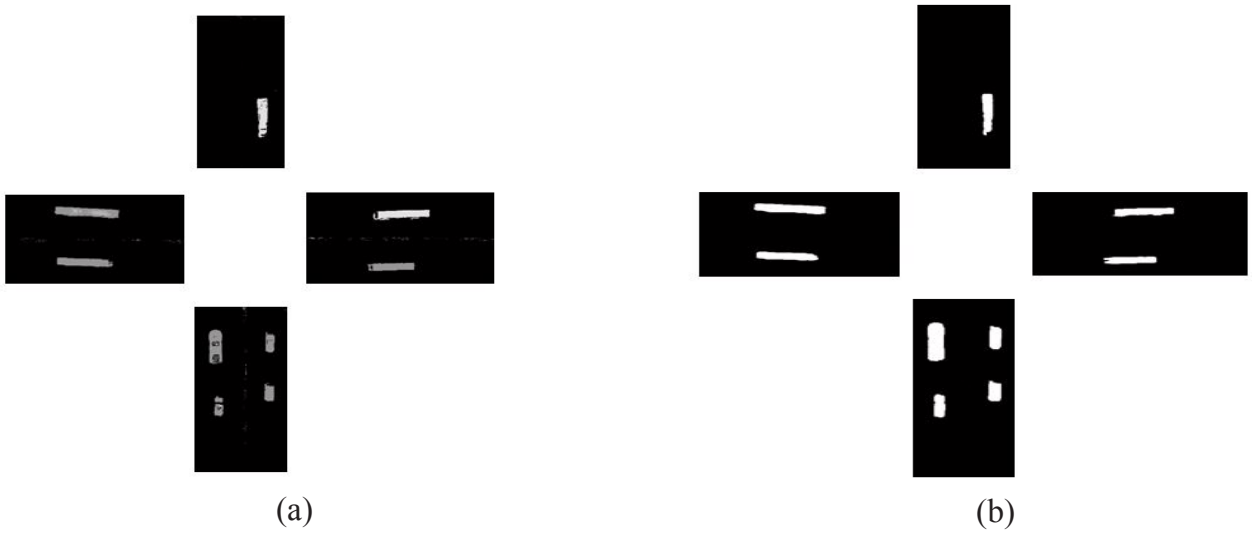


Figure 6. (a) Image after background subtraction (Grayscale), (b) Image after Enhancement (Binary Image).

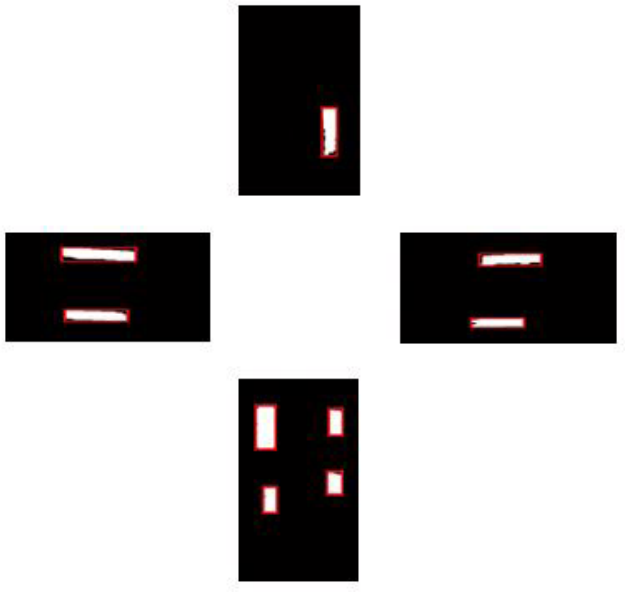


Figure 7. The bounding of connecting pixels & obtaining the vehicle count.

are labeled which are the vehicles & they are marked with a bounding box (Figure 7).

4. Results and Conclusion

In this project we have successfully made the prototype for real time image processing for smart automation of traffic signal system for density estimation and emergency vehicle detection such as ambulance[4]. Our model detects the ambulance by detecting its siren. This is achieved through image segmentation based on red & blue color of the siren. The traffic density on each lane is also estimated and the traffic signal is prioritized accordingly. The usage of our algorithm is cost effective. Extra hardware such as sound sensors or RFID tags can be eliminated.

5. Future Work

The accuracy of this work can be improvised further by doing thermal image processing[5,6]. Thermal image processing is effective even during extreme weather conditions such as, mist or fog. Secondly, Cloud computing can be done for the road data analysis.

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