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Original Article

A Framework for Intelligent Traffic Control System

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Abstract *- Recently, traffic congestion has been among the significant problems encountered by many large cities worldwide. The reasons for the traffic congestion are the hasty increase of motor vehicles and inadequate roadways to accommodate a large number of vehicles. Many researchers find the traffic density by applying edge detection (ED), moving object detection (MOD), and frame differencing techniques separately. However, the edge detection method detects the edges for static images and the MOD method finds the traffic density when vehicles are moving. Actually, in real-time, when the red signal is on a traffic junction, the vehicles are in an idle state; this situation is better to apply the ED method. When the green signal is on, vehicles immediately start moving; this situation is best suitable for applying the MOD method to find the real-time traffic density. This paper illustrates a novel technique named Edge Detection and Moving Object Detection (EDMOD) algorithm, which uses ED and MOD approaches to find the real-time area-wide density of the traffic at the traffic light junction by dividing the Region of Interest (ROI) into two regions. It uses ED in region1 and MOD in region2.*

Keywords *- Edge Detection, Image processing, Moving Object Detection, Traffic density.*

1. Introduction

One of the considerable and vital problems in so many large cities is traffic management. Accidents due to improper traffic management at times may be causes significant injuries and sometimes deaths. Vehicles accidents demises in most of the cities, majorly out-turn on account of congestion of traffic accidents. As many vehicles are moving into the jammed traffic roads, there is a great need to introduce new techniques to overcome the drawbacks of existing traffic management situations. Since building or constructing new flyovers, new elevated expressways, new roads, etc., become very expensive, it also may take a lot of time to construct. So, the main objective is to evolve a new traffic controlling method using existing or available infrastructures and the latest technologies.

Nowadays, the world has a great deal of digital and visual data, and a lot of information is produced by processing the data using various technologies. All large and metropolitan cities of the world installed closed-circuit television(CCTV) cameras in many places, including traffic light junctions. These CCTV cameras record and store a lot of data. This data is very helpful in analyzing and developing a solution for traffic problems faced by many big cities in most countries. So many image data analysis methods are tested to understand and analyze this immense collection of data, especially the image data, i.e., recorded and stored by CCTV cameras installed at traffic junctions. ED and MOD techniques are vital among the several image data analysis methods, which have many real-world applications.

2. Related Works

Traffic jams also generate many other overcritical issues and severe problems which influence many human lives, regular activities, and sometimes reasoning for the deaths [1-2]. For instance, assume there is some emergency vehicle, i.e., an ambulance, on the way to the hospital along with an emergency treatment needed. Suppose the emergency vehicle is struck in the congestion caused by substantial traffic. The probability of reaching the patient at the hospital in the expected or needed time will be greatly reduced. And this is going to be a serious issue. Therefore, there is a need to outline and evolve an intelligent and smart traffic light controlling process, which controls and manages the signal at the junction to avoid many accidents, traffic jams, and collisions [1-2].
Earlier, there were many technologies proposed, for instance, RFID and IoT [3-4], image processing [5-7], fuzzy logic [8-9], neural networks and big data [10-13], traffic prediction techniques [14], accident detection and ambulance control [15], real video analysis technique [16], traffic congestion estimation methods [17] and Machine vision technology [18]. The study of those and present technologies [19] allow realizing a few drawbacks in existing techniques. The best solution to overcome many existing drawbacks is to use a density-based traffic control system [20].

In the recommended method, an estimate location technique is used to identify the density of the website traffic, which uses picture processing functions. The computed traffic thickness values are used for the clever

traffic signal administration system. This proposed approach can strongly assess the density of web traffic with the help of the area engrossed by the vehicle edges. Traffic density estimation using an area-based method will be added functional to manage smart traffic controlling lights than earlier conventional approaches. Prewitt and Canny edge detection methods are more popular for finding the edges in image processing, out of which canny edge detection techniques have high accuracy [21-22]. The Canny edge detection technique is used to find vehicle density in [23], and the calculated density controls the smart traffic management system.

Several techniques are used to detect the objects which are in motion. Some techniques used to find the objects in motion are recursive, and a few are non-recursive approaches. Recursive MOD approaches are Approximation media filter, Mixture of Gaussians (MoG), and Kalman filter. Non-recursive approaches are Median filter, frame differencing, and Linear predictive filter. Chandrasekhar et al. explained all these techniques' merits and demerits in detail in [24]. The importance algorithm, MoG, used to detect foreground, was explained by T. Bouwmans et al. in [25] and A. Yilmaz et al. in [26].

Optical flow estimation, frame differencing, and subtracting background are some of the moving object recognition techniques. Among these three techniques, the subtracting background paradigm is the most suitable approach for smart traffic applications. The optical flow method needs more complicated computation, and the frame differencing technique is more sensitive with its illumination switches, creating many traffic difficulties. Hence these two techniques are not suitable to use in smart traffic systems. MOD uses subtracting background paradigm. ED approaches are best suitable for static images, and Canny is the best ED technique. This paper proposed a novel technique named EDMOD algorithm, which uses Canny and MOD methods internally to produce the best solution for traffic problems.

3. Methodology

EDAMOD method for smart traffic management involves the following steps.

- Divide the ROI into two regions.
- Apply the Edge detection technique to find the presence of vehicles in the region1.
- Apply the Moving Object Detection technique to find the vehicle density in region2.
- Decision Making.

3.1. Divide the ROI into two regions

The main reason for dividing the ROI into two regions is that the edge detection method detects the edges for static images. The MOD method finds the traffic density when vehicles are moving. Generally, vehicles will wait until the green light is on at a traffic light junction, so divide the ROI into two regions in this project. In the first region, apply the edge detection technique to find the vehicle's presence. And once the green light is on, vehicles will start moving, so in the second region, applying the MOD method to find the traffic density of moving vehicles.

Fig.1 shows the sample division of ROI into two regions. Region1 is selected near the traffic light because all vehicles wait for the green light, and Region 2 is the remaining portion of ROI because once the green light is on, then focusing on the traffic coming in that direction.

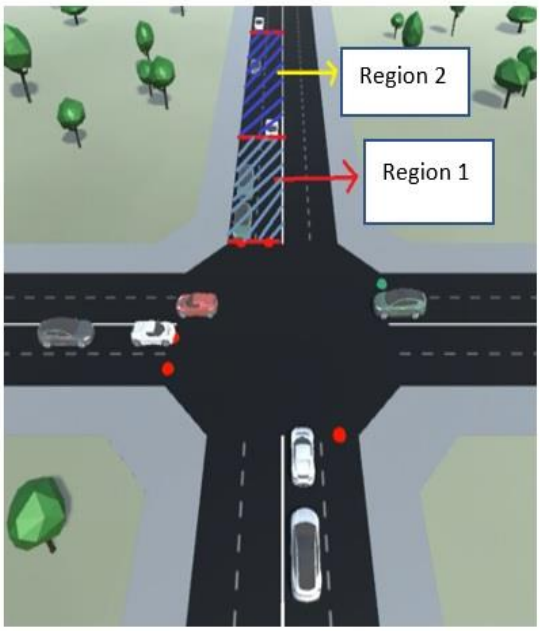

Fig. 1 Division of ROI into region1 and region2

3.2. Apply the Edge detection technique to find the presence of vehicles in region1

Canny is the best edge detection technique out of the available edge detection techniques; hence, this project uses the canny edge detection technique to find whether vehicles are present near traffic junctions. The idea is that if vehicles are waiting for the signal at the junction, then allot green signal in that direction and immediately find the traffic density in region 2. Based on the traffic density values in the region2, further decisions will be taken, i.e., explained in the decision-making section.

Step1: Noise Reduction
Step2: Gradient Calculation
Step3: Non-maximum suppression
Step4: Double threshold
Step5: Edge Tracking by Hysteresis

Fig. 2 Canny Algorithm

The key steps of the Canny algorithm are shown in fig.2, and the sample results of Canny with and without vehicles are shown in fig.3, fig.4. Here, Canny not only

detects the vehicle's edges but also detects the edges of other objects or lines present in the frame. Hence first need to apply Canny for the empty road to decide the threshold value used to identify the presence of vehicles.

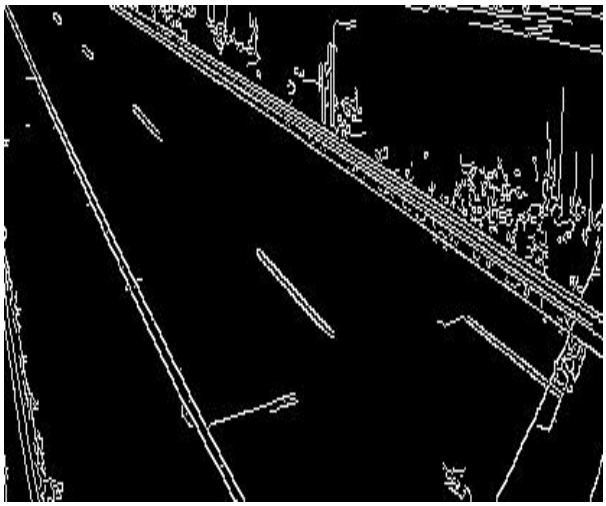

Fig. 3 Canny ED result for an empty road

Fig. 4 Canny ED result for the road with Vehicles

3.3. Apply the Moving Object Detection technique to find the vehicle density in region2

Once the green light is on at a traffic light junction, vehicles will start moving. At that time, or after 3 seconds, I started applying the MOD method to find the density of the moving vehicle in the region2. The idea is that if a greater number of vehicles are moving in the region2, then the traffic in that direction is more, so we need to continue the green signal until it reaches its maximum time (60 seconds or 90 seconds). Suppose a moving vehicle's density in region 2 is less than some threshold value. In that case, the traffic in that direction is low, so immediately need to change the green light to red light by giving 5 seconds grace time to avoid accidents at the traffic light junction.

Step1: Identifying Region of Interest (RoI)
Step2: Generating frames from the input video
Step3: Apply createbackgroundsubtractormog2() function for detecting moving vehicles
Step4: Performing masking to highlight the detected moving vehicles
Step5: Drawing contour lines i.e., rectangles over detected vehicles
Step6: Finding the area occupied by these rectangles i.e., vehicle density in the frame

Fig. 5 MOD Algorithm

The step-by-step procedure of the MOD algorithm is presented in fig.5. The Intermediary results of applying the MOD algorithm are shown in fig.6 and fig.7. Fig.6 shows the vehicle detected image after applying it to mask, i.e., step 4 result.Fig.7 shows the contour lines drawn over the detected vehicles, i.e., step 5 result.

Fig. 6 Sample frame and Vehicle Detection after Masking

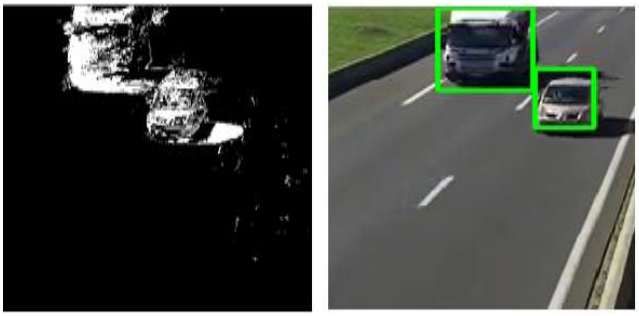

Fig. 7 Frame consisting of Contour lines over Detected Vehicles

3.4. Decision Making

A novel technique is developed and presented in this paper. The very crucial step in this novel technique in decision making. The proposed novel approach uses edge detection and moving object detection. The proposed method divides the ROI at traffic light junctions into two regions, as shown in the figure.

Initially, in the first region, the Canny edge detection technique was applied to find the area of the vehicle edges. If this value is greater than some threshold value, then the

green light signal will be given in that direction; otherwise, fewer vehicles are present so that the red light will be continued for some more time, and to the next side region1 again canny edge detection applied.

If the canny result is more than some threshold value, then the green light signal will be given in that direction, and after 3 seconds, start calculating the density of the moving vehicles in the region2. Again, a decision is taken based on the density of the moving vehicle; that is, if it is greater than some threshold value, then the green light will be continued till it is exhausted. If moving vehicles' density is less than the threshold value, traffic is much less in that direction, so traffic lights need to change from green to red by giving 5 seconds grace time. This process continued in a loop at a traffic light junction. The junction may consist of 3-direction roads, 4-direction roads, or 5-direction roads. For all types of junctions, our proposed technique will work efficiently. The detailed controlled flow is presented in the flowchart shown in fig.8.

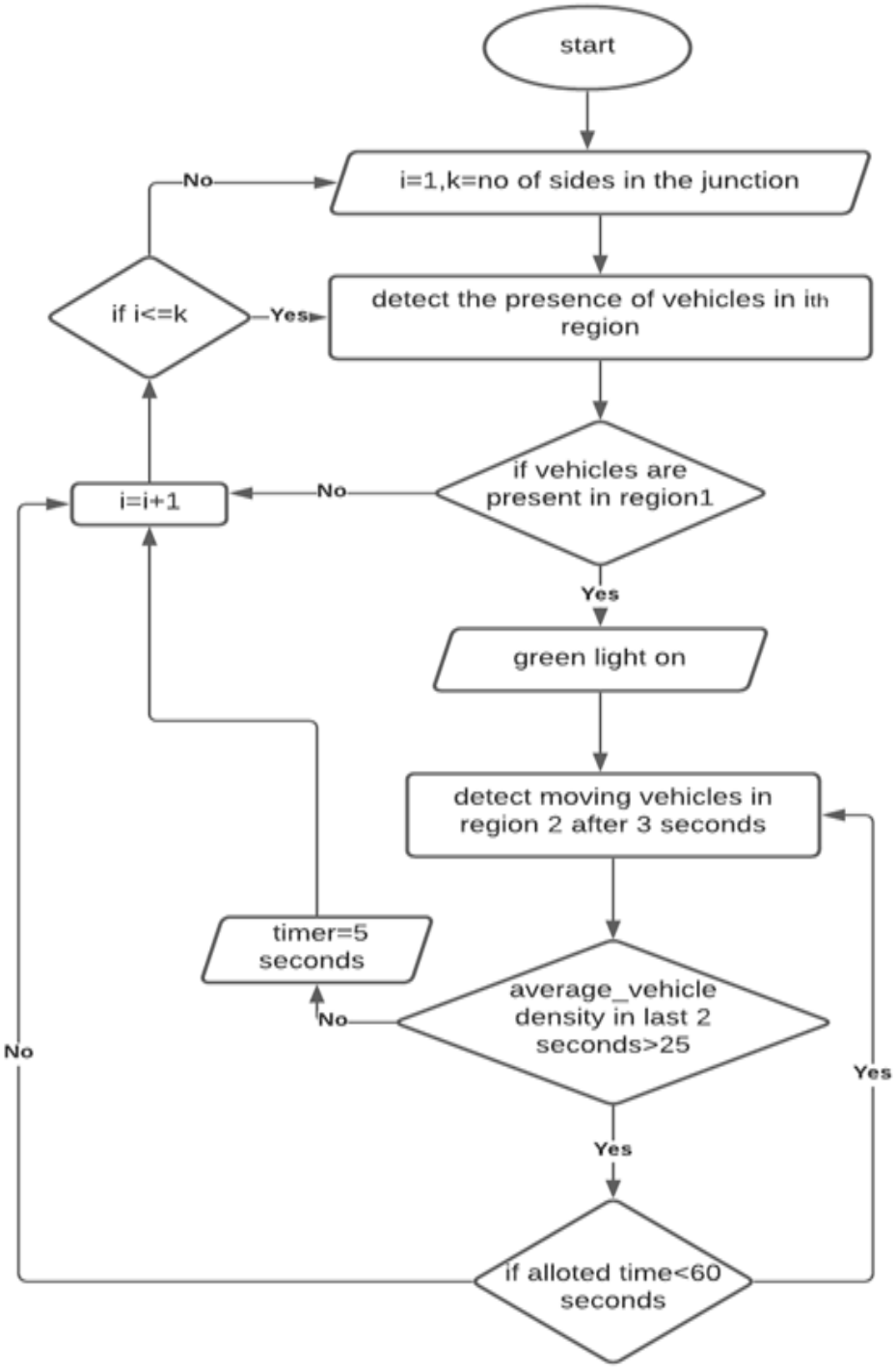

Fig. 8 Flowchart of EDMOD Algorithm

4. Experimental Results

The proposed EDMOD method was evaluated by processing three real traffic video datasets through the proposed EDMOD model. The frames are color images, and the frame rate is 30FPS.Fig.9, fig.10, and fig.11 show the sample frames, which display the traffic density values.Fig.9 consists of 31 traffic density, which means 31% of the road is occupied by the vehicles in the frame. Similarly, Fig.10 consists of 29 traffic density, which means 29% of the road is occupied by the vehicles present in the respective frame, and Fig.11 consists of 0 traffic density, which means the frame does not consist of vehicles.Fig.11 can be considered one of the proofs for extreme test cases because when the frame doesn't consist of any vehicles, it shows the result traffic density value as 0.

Fig. 9 Sample Result Frame with 31 traffic density value

Fig. 10 Sample Result Frame with 29 traffic density value

Fig. 11 Sample Result Frame with 0 traffic density value

Table 1. Traffic density value range vs. green light allocated time

Traffic Density Value using EDMOD	Greenlight estimated allocation time
Less than or equal 20	0 Sec
20 – 30	30 Sec
30 – 40	45 Sec
Greater than 40	60 Sec

The estimated green signal allocation time based on the EDMOD method, especially ED traffic density values, is shown in table 2. If the traffic density value is less than or equal to a fixed threshold value, i.e., 20, then the traffic at that instant is assumed to be very low; hence, the green signal is not allocated. Otherwise, green signal time needs to be allocated using table 1 values. The allotted green signal time may be completely used or not depending on the EDMOD algorithm that is already discussed in the methodology section, i.e., if MOD traffic density values are less than the threshold value, then the green signal is changed to a red signal by giving a grace time of 3 to 5 seconds otherwise green signal continued till the allotted time.

5. Conclusion and Future Scope

The proposed EDMOD model in this paper works efficiently and gives good results compared to existing techniques, i.e., the EDMOD approach is a novel method that works efficiently with static and dynamic frames. Using this proposed novel method, the traffic density values of live traffic frames are calculated by passing the live traffic videos as input to the proposed model. The traffic video datasets used in this paper can generate 30 FPS and the time required to process and calculate the traffic density for each frame is around 1 sec. So, there is a need to find the average value of a few latest frame's traffic densities so that it is used to monitor the traffic light, i.e., if the average density value is lesser than some threshold value, then needs to change the traffic light from green to red because this value suggests the traffic is less otherwise the green light must be continued till reaches maximum allocated time 60 seconds. In this way, the proposed system will solve the issues related to traffic congestion problems.

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