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Real Time Smart Traffic Control System Using Dynamic Background

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Abstract : Introducing a method for controlling traffic congestion on roads using real time smart traffic control system with dynamic background. This work proposes a real time traffic system in which it uses dynamic background and foreground images for the determination of traffic density based on image processing techniques. It is used for calculating traffic density rather than counting the number of vehicles. The traffic density is calculated by combining gradient magnitude and direct subtraction methods.

Keywords : Image processing; traffic density; dynamic background; gradient magnitude; direct subtraction

1. INTRODUCTION

Road traffic congestion remains a major problem in many cities. Traffic congestion itself has directly cost millions of dollars of waste fuel and millions of hours of delayed man-power, and results in the rapid increase of accidents and aggravates several environmental issues. The existing timer based traffic systems are not able to control traffic congestion effectively. That is if a lane has more traffic congestion than the other one, this system fails. In order to solve this problem, a real time traffic control system is introduced which will control the traffic light according to traffic density [1]. In this paper we have proposed a dynamic background traffic cycle calculator algorithm to control traffic light according to the traffic density with dynamic background. Here the background is taken dynamically in which each and every moving object which became stationary is also considered for further processing.

In most of the related works, the main focus is on detecting the edges of the vehicles and counting the number of vehicles on the road. The main disadvantage of this approach is, it may give wrong results when space between the vehicles on the road is very small. For example if two cars are adjacent to each other it may counted as one vehicle.

2. LITERATURE SURVEY

Md.Munir Husan. *et.al* [1] proposed an intelligent traffic control system based on traffic density. The smart traffic control system offers the ability to acquire real-time traffic information using static background. The main drawback of this is it doesn't consider any stationary objects.

In order to determine traffic congestion and establish a model for controlling traffic based on image processing techniques, mainly two methods are used. The first one is gradient magnitude method [8] and the other one is direct

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subtraction method [11]. An image gradient is a directional change in the intensity or color in an image [16]. The gradient of the image is one of the fundamental building blocks in image processing. The background subtraction method [11] is most suitable for detecting foreground objects. By subtracting background image from the foreground image we can find out traffic density present in a frame. Freeman H. *et.al* [8] highlights that the edge detection process detects outlines of an object, scene text and boundaries between objects and the background in the video image. For this purpose edge detection has been carried out using Sobel edge detection operator. P. Srinivas *et.al* [9] compared the various edge detecting methods like Sobel, Prewitt, and Canny and inferred that Canny Edge Detector technique is the most efficient one.

Shriram K. Vasudevan *et.al* [12] introduced a traffic control system based on wireless technology to replicate traffic signals through wireless transmission. Comparing to image processing techniques wireless sensors require high installation cost, and maintenance work.

3. PROPOSED METHOD

This section mainly focuses on the process of extracting traffic information from images. The amount of traffic will be termed Traffic Density (TD). To find TD we used a combination of gradient magnitude and direct subtraction method [1].The background and foreground images for this process is taken dynamically and (D_{bg} and D_{fg}).

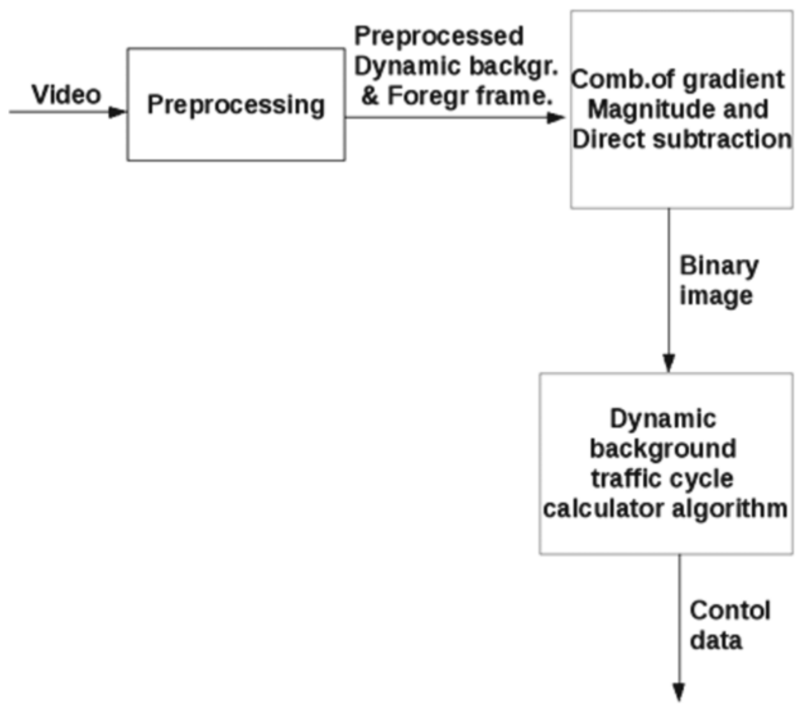


Fig. 1. System Architecture.

As shown in the figure1 the proposed method is divided into three sections.

3.1. Preprocessing

In this phase the video stream data is processed frame by frame and the foreground and background images will be identified.

3.2. Combination of gradient magnitude and direct subtraction method

3.2.1. Gradient magnitude method

The directional change in the intensity or color in an image is the image gradient. Image gradients may be used to extract information from images. The gradient of the image is one of the fundamental building blocks in image processing. Using gradient magnitude [3,5] method, the final image $Gradient_{binary}$ is obtained.

1. The F_{gray} and B_{gray} are the foreground and background images obtained after grayscale conversion.
2. Then apply canny edge detection operation [2] on the foreground and background image. $F_{preprocessed}$ and $B_{preprocessed}$ are the corresponding results obtained.
3. Foreground objects (F_{abj}) are obtained from subtracting $F_{preprocessed}$ and $B_{preprocessed}$.
4. After this median filter ($Gradient_{filt}$) is used to remove noise, mainly because of its ability to remove the additive noise.
5. Morphological operations are done on the resultant image in order to get closed contours ($Gradient_{closed}$) of the $F_{preprocessed}$ & $B_{preprocessed}$. Morphological closing essentially performs dilation of image followed by erosion [4,10].
6. Finally the resultant $Gradient_{binary}$ is obtained.

Figure 2 illustrates the binary images obtained from gradient magnitude method in four videos

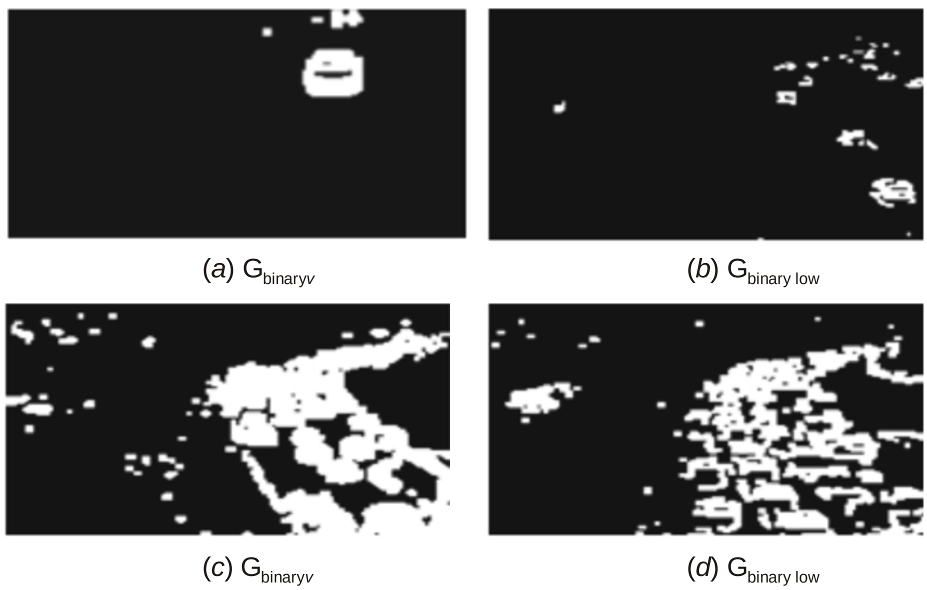


Fig. 2. (*a*) Binary image of viptraffic.avi (*b*) Binary image of lowtraffic.avi (*c*) Binary image of mediumtraffic.avi (*d*) Binary image of hightraffic.avi.

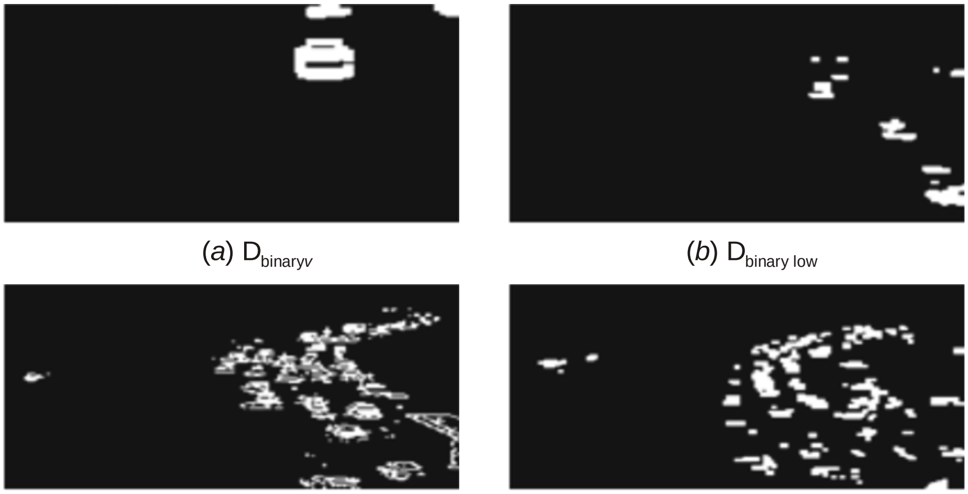
3.2.2. Direct Subtraction method

1. The grayscale background is subtracted from the grayscale foreground in order to get the foreground objects.
2. To remove some unwanted pixels, median filter is used on $Direct_{abj}$ which gives the result $Direct_{filt}$.
3. $Direct_{closed}$ is obtained by performing morphological closing operation with 6×6 square structuring element.
4. Finally the grayscale image is converted to binary image and ($Direct_{binary}$) is obtained.

The color of the vehicle plays a major role in the direct subtraction method and closed contours plays a major role in the gradient magnitude method. The drawback of direct subtraction method is while finding traffic density the black color of the vehicle can be a major problem. This can be overcome by using the gradient magnitude method.

In the case of gradient magnitude method, there will be some situations in which the detected edges doesn't form closed contour. This problem can be solved with the help of direct subtraction method, which detects this portion of the vehicle. In order to overcome their drawbacks the gradient magnitude and direct subtraction methods are combined together.

Figure3 illustrates the binary images obtained from direct subtraction method in four videos.



(a) $D_{binaryv}$ (b) $D_{binary\ low}$

(c) $D_{binaryv}$ (d) $D_{binary\ low}$

Fig. 3. (*a*) Binary image of viptraffic.avi (*b*) Binary image of lowtraffic.avi (*c*) Binary image mediumtraffic.avi (*d*) Binary image of hightraffic.avi.

The result obtained from gradient magnitude ($Gradient_{binary}$) and direct subtraction ($Gradient_{binary}$) are used together to obtain a final image using equation (1 and the result as shown below.

$$F_{binary} = Gradient_{binary} + Direct_{binary} \tag{1}$$

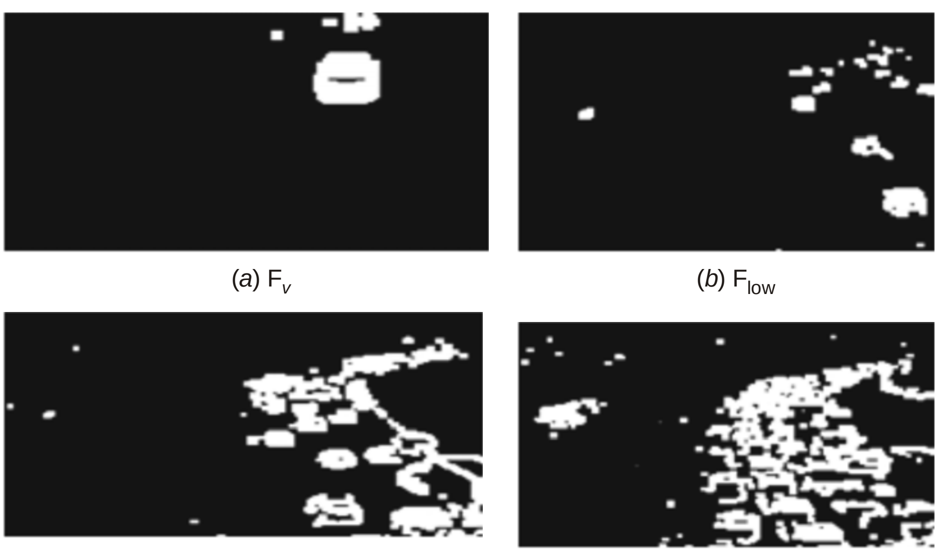
$$F_{binary} = \begin{cases} 1 \text{ if pixel value} \geq 1 \\ \quad 0 \text{ else} \end{cases} \tag{2}$$

The white pixels present in the will represent the corresponding foreground objects and the traffic density can be calculated as,

$$TD = \sum_{i=1}^{R} \sum_{j=1}^{C} F_{binary} \tag{3}$$

Here R denotes the number of rows and C denotes the number of columns of F_{binary}.

Figure 4 illustrates the final images obtained from the combination of gradient magnitude and direct subtraction in four videos.



(a) F_v (b) F_{low}

(c) F_{medium} (d) F_{high}

Fig. 4. (*a*) Final image of viptraffic.avi (*b*) Final image of lowtraffic.avi (*c*) Final image of mediumtraffic.avi (*d*) Final image of hightraffic.avi.

3.3. Proposed Dynamic background traffic cycle calculator algorithm

The proposed algorithm is used for control traffic congestion in an efficient manner. Here the background and foreground images are taken dynamically as mentioned in steps7&8 and the traffic points are considered as independent units.

Input : Video frames

Output : T_i (Total time allocated for i^{th} road)

Step 1 : Start

Step 2 : Preprocessing the selected background & foreground images [$F_{processed}$ and $B_{processed}$]

Step3 : Obtain $Gradient_{binary}$ and $Direct_{binary}$.

Where, $Gradient_{binary}$ is the binary image of gradient magnitude method and $Direct_{binary}$ is the binary image of direct subtraction method.

Step 4 : Final image,

$F_{binary} = Gradient_{binary} + Direct_{binary}$

Step 5 : Calculate,

$$TD = \sum_{i=1}^{R} \sum_{j=1}^{C} F_{binary}$$

Where, TD is the traffic density.

$$T_c = f(TD)$$

Where, T_c is the traffic cycle.

$$W_i = \frac{TD_i}{\sum_{k=1}^{n} TD_k}$$

Where, W_i is the weighted time.

$$T_i = T_c * W_i$$

Where T_i is the weighted time in the i^{th} road

Step 6 : Selected time $(S_t) = T_i - T_v$

Where, is the empirical threshold value and which is 3/4 of T_i

Step7 : Select D_{fg} at T_i and D_{bg} at S_t, where

$$D_{bg} = T_i + S_t * \text{frame rate}$$

Step 8 : if $pd\,(D_{bg}) > pd\,(D_{fg})$, where $pd\,(D_{bg})$ and $pd\,(D_{fg})$ are the total pixel density of background and foreground images

$$\text{Set}\,(D_{bg}) = (D_{fg})$$

$$\text{Set}\,(D_{fg}) = (D_{fg}) + \text{frame rate}$$

Step 9 : If D_{bg} is equal to D_{fg}, select previous D_{bg}

Step 10 : Continue with Step2

Step 11 : Exit

3.4. WEIGHT FACTOR AND TRAFFIC CYCLE

Traffic cycle (T_c) and weighted time (W_i) are used as two output variables, in which traffic cycle is the total time needed to complete one rotation of the signal lights and weighted time is assigned on the basis of traffic density.

$$T_c = f(TD) \tag{4}$$

The weight factor for each road is calculated as,

$$W_i = \frac{TD_i}{\sum_{k=1}^{n} TD_k} \tag{5}$$

Where n is the number of roads.

4. EXPERIMENTAL RESULTS

Table 1: Illustrates the two iterations of four different roads are mentioned, the data used are viptraffic.avi, lowtraffic.avi[14], mediumtraffic.avi[15], hightraffic.avi[16]

The traffic density is calculated and based on that a weight factor is determined to allocate time for each road

	Iteration			*Iteration*		
Roads	***TD***	***W***	***Time in sec***	***TD***	***W***	***Time in sec***
vip traffic	2137	0.107	27	2484	0.110	30
low traffic	1432	0.072	18	2286	0.101	28
med. Traffic	5790	0.291	120	7004	0.312	120
high traffic	10476	0.528	180	10650	0.474	180
Total	19835	1	345	22424	1	358

Table 2 : Illustrates the comparison between static and dynamic background for a given frame which contains a static vehicle. Case 1 shows the execution with static background and Case 2 shows the execution with dynamic background. From this table it is clearly understood that our method outperforms the other.

	Case 1 : Static			*Case 2 : Dynamic*		
Executions	***TD***	***W***	***Time in sec***	***TD***	***W***	***Time in sec***
Exec 1	30221	1.0	300	30221	1.0	300
Exec 2	30845	1.0	300	20712	1.0	242
Exec3	33147	1.0	360	30126	1.0	300
Exec4	32069	1.0	382	2280	1.0	63

5. CONCLUSION

This work proposes a real time traffic system in which it uses dynamic background and foreground images for the determination of traffic density based on image processing techniques. This paper demonstrates that image processing is a far more efficient method for traffic control as compared to other traditional techniques. The main advantage of this approach is that all the object which is in the state of motion, when halted or when is in the state of rest at the region of interest is also considered for further processing. We have successfully implemented an algorithm, dynamic background traffic cycle calculator for determining the traffic density. Based on the calculated traffic density, the weighted time is allotted for different roads to control traffic lights.

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