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Traffic Load Computation on Cluttered Road Scenes

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Abstract:- **Automatic traffic load computation is an important aspect of today's Intelligent Transportation Systems (ITSs). Computation of traffic load helps in better management of flow of traffic and thus can help in planning transportation infrastructure and related policy. Large urban areas are subjected to face a major problem of traffic congestion because of the increase in number of vehicles. Different techniques have been proposed to estimate the traffic load to combat traffic congestion. Most of the works detect the edge of vehicles and count the number of vehicles in the frame. The method of counting number of vehicles may give faulty results and inefficient in case of extremely overlapping vehicles in congested road. This paper proposes the method of calculating the traffic load levels based on the application of image processing techniques on the background segmented road patch. Traffic load levels are then estimated based on the careful investigation and mapping of the feature values. Proposed load computation algorithm based on segmentation of cluttered road scenes shows superior results when compared to the existing load computation algorithms. We measure the vehicle detection rate. This technique, based on video processing of traffic frames, result in about 71.65%, 81.13% and 84.19% of overall vehicle detection on cluttered roads. The technique proposed in this paper works well on cluttered roads at various weather conditions. The proposed load computation technique can be applied to better understand traffic patterns in unlaned, chaotic roads of developing countries.**

Key Words: Image processing, Intelligent Transportation System (ITS), traffic congestion, traffic density. .

I. INTRODUCTION

Long and unpredictable commutation times, environmental pollution and fuel wastes are some of the annoying negative effects of traffic congestion. These disadvantageous effects are more acute in developing countries like India, where road way infrastructure growth is slow but vehicle population is increasing drastically. Intelligent traffic management policy and better means of access to traffic information made available for commuters can help combat congestion issues to a certain extent.

In today's world Intelligent Transportation Systems (ITSs) have become increasingly popular that many of the important road traffic parameters such as traffic density and vehicle types on the roads can be obtained automatically by using these systems. Advances in computer vision technologies and use of surveillance videos makes available the required road traffic parameters and hence has attracted many researchers towards this analysis.

There is a significant difference in traffic in developing countries compared to that in developed countries. In developing countries, all vehicles from buses to two-wheelers ply together to utilize the available road infrastructure in best possible way. The main novelty of this proposed paper is the detection of the road traffic load using the average weighted volume of the vehicles occupied on the road obtained using image processing techniques on the traffic video frames. Thus making it a novel method to compute traffic load in cluttered, no lane cumbersome roads of developing countries.

The structure of the paper is organized as follows. Section II gives a brief analysis of the traffic load computation technologies that are available in the literature. Section III and IV gives the proposed algorithm and its system architecture followed by discussion on experimental results. The final section concludes the challenges faced with the recommendations on the future scope of extension of the present work.

The paper uses the standard UCSD traffic dataset that contains 254 video sequences with varying congestion levels, viz., light, medium and heavy.

II. LITERATURE REVIEW

The paper proposes a simple methodology that does not require high computational processing power to estimate the road traffic load, unlike other studies in the literature. The video based traffic flow detection system has become increasingly robust, real time and intelligent due to the developments in computer vision and digital image processing technology [1].

A. Static sensors

Static sensors like loop detectors or supersonic wave detectors were used in the past to estimate the traffic flow or traffic density on a road [2].

B. Video cameras

Video monitoring through surveillance cameras and automatic traffic flow detection provides high quality image information efficiently and stably, without causing block in the traffic or damage to the road. These advantages make video based traffic management and surveillance systems become more and more significant to ITS. Due to this reason, many approaches that are applied to low or high resolution images obtained from traffic surveillance cameras have attracted much attention in recent years and have been proposed in [3][4][5].

C. Mobile sensors

Mobile sensors like GPS in vehicles are used for the purpose of monitoring traffic in developed countries [6][7]. Most of these techniques, however, are only suited for developed countries where there is lane based orderly traffic and the penetration of GPS devices and smart phones in road transportation is also sufficiently high.

D. Vehicle Count

Pornpanomchai et al. studied on video vision for counting vehicles [8]. Mohana et al. studied on counting vehicles in real-time [9]. Wang studied on counting vehicles in hybrid traffic zones [10]. The drawback of counting the number of vehicles on the road may give faulty results and inefficient incase of extremely overlapping vehicles in congested road, i.e., if the distance between the vehicles is small then it will consider as one vehicle, then number of vehicle present in a frame is large, thus making the counting task difficult and takes more time to count.

E. Feature based

A combination of Haralick texture features along with the sum and difference histograms for extraction of urban regions from aerial images, used for assessing the range of traffic areas in transport management systems, is proposed in [11]. A method for determination of road traffic congestion based on image texture features defined by Haralick is proposed in [12][13].

III. PROPOSED ALGORITHM

Proposed load estimation algorithm includes simple image processing tools to preprocess the frames, application of filters and then the calculation of features that helps in the estimation of the traffic load.

Recent innovative advancement and development in computer vision and digital image processing technologies considerably help video based traffic flow detection system to become increasingly robust, real time and intelligent. These advantages make the use of video based traffic management and surveillance systems become more and more significant to Intelligent Transportation Systems (ITS) [14].

Algorithm:

1. Read the input video.
2. Each frame in the video is converted into images.
3. Compute a background image in which no foreground object is present.
4. Create binary image from gray – scale image using thresholding process, where individual pixels in an image are marked as object pixels if the value satisfy certain threshold condition else the threshold is marked as background pixels.
5. Apply gradient mask.
6. Apply Sobel edge detection technique on the filtered images.
7. Extract the coherence matrix features from the edge detected images.
8. Estimate an adaptive threshold from the features obtained.
9. Objects that satisfy the above threshold are recognized as segmented vehicle objects.
10. Count the segmented vehicle objects.
11. Traffic load computation.

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PROPOSED SYSTEM ARCHITECTURE

The system architecture of the proposed algorithm is shown below in Fig 1.

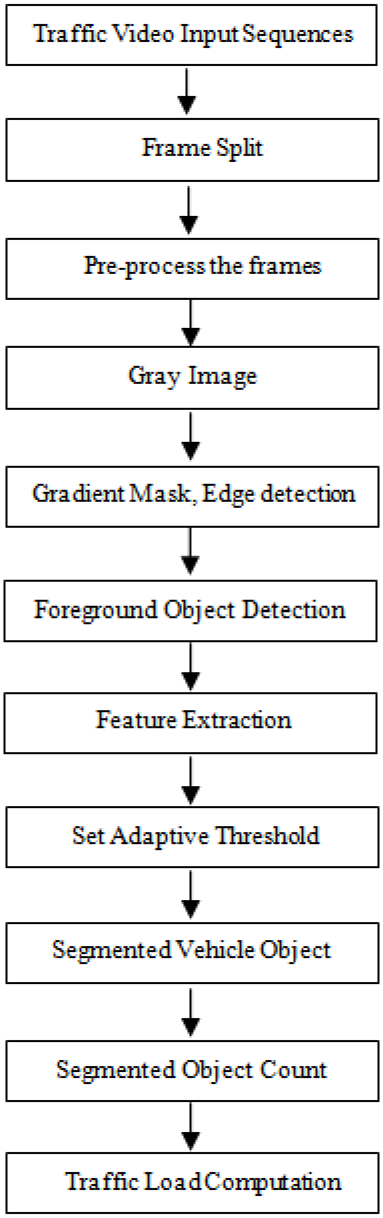

Fig 1 System Architecture of Proposed Work

The proposed system for road vehicle object segmentation and counting is depicted in above architecture.

The modules included are preprocess of frames, foreground object detection, gradient filter, feature extraction, threshold module for object segmentation and load computation based on the segmented road traffic object count.

The existing methods work well on non cluttered roads as shown in Fig 2. The proposed algorithm shows high vehicle detection rates on cluttered roads. A view of cluttered road scene is shown in Fig 3.

Fig 2 Non cluttered Road Scene *Fig 3 Cluttered Road Scene*

V. ARCHITECTURE OVERVIEW

A. Input Frame Sequence and Preprocess

The paper uses the standard UCSD traffic dataset that contains 254 video sequences with varying traffic load levels, viz., light, medium and heavy.

Type : AVI file (.avi)
Dimensions : 320 x 240
Frame rate : 10 frames/sec

The input video is split into frame sequences. The preprocessing of the frames is done to improve the frame quality. At first the RGB color image is converted to gray image taking only the 'R' component as it is easier to distinguish features of an image when only a single layer is dealt and then the gray image is converted into binary image.

B. Gradient Mask and Edge Detection

An edge in an image is a boundary at which a significant change occurs in physical aspect. Edge detection is the process of locating the edges of an image. Important features can be extracted from detecting the edges of an image. It used by high-level of computer vision algorithm.

Sobel operator is one of most popular edge detection technique. The sobel edge filter is somewhat insensitive to noise present in an image and provides good edge detection. This is due to the averaging that is performed by this edge detection during the computation of the gradient. It computes an approximation of gradient of image and provides edges map effectively. It is a Better edge detection technique for noise suppression.

In the proposed work the sobel operation is performed separately in both background and foreground image. The background gradient stored in BG_{grad} and the foreground gradient stored in the FG_{grad}.

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$$S_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} * I \qquad S_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} * I$$

$$G = \sqrt{Sx^2 + Sy^2}$$

MATLAB 2014a is used for the implementation of the proposed work. Fig 2 shows the initial implementation processes.

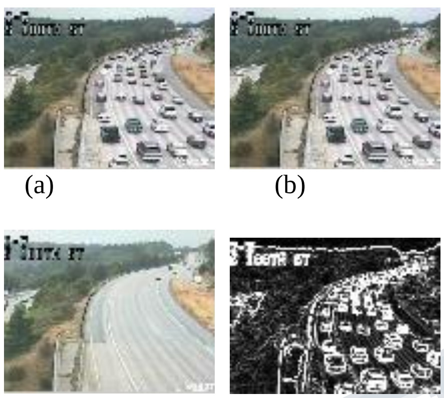

Fig 3 (a) Input video (b) Frame split (c) Background (d) Gradient Mask

C. Feature Extraction

Feature extraction helps in higher level of understanding the scene. It is a visual characteristic of images. It is a sort of description of the statistical properties of image patches. In this work the features are calculated using GLCM (Gray Level Co-occurrence Matrix). It is a square matrix.

GLCM = [Pi,j], i,j ϵ N (1)

Where,

N is the number of pixel values, containing frequencies of occurrence Pi,j of pixel values which lie at set distance from each other. GLCM texture features such as energy, entropy, contrast, homogeneity, dissimilarity and correlation are calculated. Congestion levels are then estimated based on the careful investigation and mapping of the feature values.

D. Vehicle Object Segmentation and Recognition

The technique of segmentation is the process of partitioning an image into its constituent parts or objects. Recognition is the process of assigning a label to an object based on its descriptors.

The obtained binary frame is then subjected to morphological filtering. First, the segmented binary frame is closed so as to eliminate any spurious disjoints between connected components. Then the holes in the connected components are filled to ensure that true sizes of objects are used in subsequent stages.

This approach enables the system to exploit the fact that shadows are semi-transparent and therefore by appropriately enhancing and segmenting the frames, their effects can be greatly reduced. In this way, the complex and often ineffective shadow removal algorithms are avoided

E. Traffic Load Computation

Threshold values are set and the value is used for the discrimination of the congestion level thus enabling effective load computation.

VI. EXPERIMENTAL RESULTS

Fig 4 shows the discrimination of traffic load levels based on the number of vehicles occupying the road.

Fig 4 Different Traffic load levels

Level 1 is road with only very few vehicles, where the congestion is less. Level 2 is medium congestion where the vehicles cover 50 – 70% of road patch. Level 3 is congestion state or high vehicle load on roads where the vehicles cover more than 70% of image.

The overall vehicle detection rate for the proposed method is computed and the results are given in Table 2.

TRAFFIC LOAD LEVELS	OVERALL VEHICLES DETECTED (%)	VEHICLES DETECTED DURING RAIN TIME (%)
1	71.65	73.12
2	81.13	80.56
3	84.19	84.35

Table 2 Overall Vehicle Detection Rate

$$\text{Overall Vehicle Detection} = \frac{\text{Total No. of Vehicles Detected}}{\text{Ground Truth}}$$

The overall vehicle detection rate of the proposed method is compared with that of the gradient based and GLCM based techniques and the results are given in Table 3. It is evident from the Table 3 that the proposed method gives superior results compared with the other two methods.

TRAFFIC LOAD LEVELS	GRADIENT BASED METHOD (%)	GLCM BASED METHOD (%)	PROPOSED METHOD (%)
1	55.23	34.17	71.65
2	56.68	39.01	81.13
3	66.72	52.06	84.19

Table 3 Comparison Table

CONCLUSION

In this paper a model for road traffic load computation has been developed. The algorithm proposed in this paper detects vehicles on cluttered roads effectively while the existing algorithms works well on laned, non chaotic organized roads where the number of occluded images are less [13][14]. The segmented weight based vehicle gives the number of vehicles in a cluttered scene. The accuracy of proposed algorithm is superior to other algorithms that yield poor results in cluttered scenes and is shown in Table 3. Almost all the works on vehicle detection in literature works on self captures images from traffic road scenes where the occlusion of images are less and picture quality is at par good when compared to the UCSD traffic dataset used in this proposed method. Experimental results show that the proposed algorithm gives high performance and works well in real challenging environmental conditions with various weather and blurred images and at various lighting. The texture based method can be extended for vehicle classification in future.

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