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Automatic Vehicle Detection from Traffic Videos Using Morphology and Rule Based Technique

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Abstarct: Detection of vehicles is first and the most challenging task before designing a video based intelligent transportation system. Traditional methods proposed in the literature are either computationally complex or involve misdetections due to occlusions or less difference between pixel intensities of background and vehicles. In this paper, a novel method of vehicle detection is proposed. The proposed method use mathematical morphology techniques and rule based approach to identify the vehicles. Experimental results indicate that the proposed method performed well as compared to other state of art methods.
Keywords: Vehicle detection: Morphology: Video Identification operator: Rule based method: True detection rate.

I. INTRODUCTION

Fatalities and accidents caused by traffic is a very serious and growing problem worldwide due to increasing usage of automobiles (National Highway Traffic Safety Administration, 2011). Since the appearance of CCTV cameras in 1950s use of video analytics for surveillance have been undergoing continuous research and inventions. Now these cameras are everywhere and millions of them are recording every move on roads. The videos obtained from these cameras can be used to design Intelligent Transportation Systems which can be used for both Real time monitoring and post event analysis for finding reasons of occurrence of an event.

First and most important step in designing any Intelligent Transportation System is detecting and tracking the vehicles. After detection the information can be further used to design numerous transports surveillance related applications including detection of speed, congestion of vehicles, detection of suspicions activities *etc* [1].

In this paper we propose a method for detection of vehicles using some morphology operations. The paper is outlined as follows. Details of proposed method are described in section 2. The data set used in the experiments is described in section 3. In section 4 experimental results and evaluations are presented. Quantitative analysis of results as presented in section 5. Conclusions are summarized in section 6.

II. PROPOSED METHOD

The proposed method uses feature extraction capabilities of morphology for detecting on-road vehicles. The detailed flow chart is shown in Fig 1.

A. Frames Extraction

CCTV cameras capture the videos of fixed location while ego vehicles are moving vehicles having camera installed for capturing videos .The videos are recorded in the form of succession of frames [2]. Generally frame rate for recording the videos is 25-30 frames per second. Therefore each video sequence can be described as

$$S_T \epsilon \{s_1, s_2, s_3, \dots \dots \dots \dots s_n\} \quad (1)$$

Where $S_T = T^{th}$ Second video sequence.

$s_n = n^{th}$ frame of sequence

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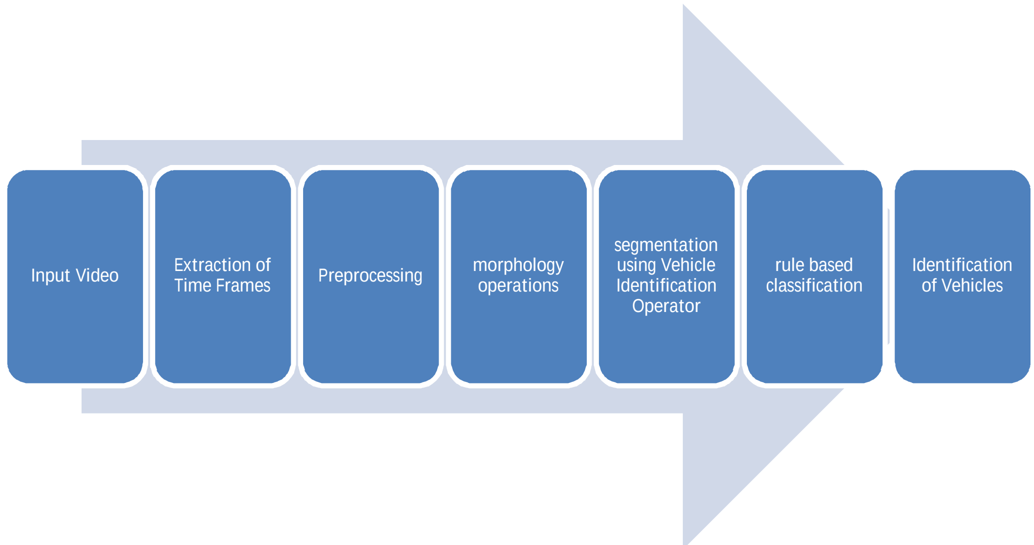

Fig.1 –Detailed Flowchart

B. Preprocessing

The videos are recorded from cameras under different environmental and illumination conditions and often contain some disturbances like noise, shadows, occlusion. Therefore before further processing the disturbances need to be removed. To remove these firstly the frame is converted to HSI frame. After getting HSI image H_n from s_n we do necessary shadow and noise removal.

1) Noise Removal: The videos recorded from different sources get easily contaminated by noise due to quality of image sensors and camera calibration. Dynamic nature of surveillance sequences is also a reason for noise generation. Due to presence of noise, a large area of frames obtained from these noisy video sequences may be misclassified as moving objects. Averaging the frames obtained is one of the possible solutions but it has limited denoising effect and also results in blur. In this paper Guassian noise removal filter is applied to each HSI frame of the video to remove noise as [3]

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-x^2+y^2} /2\sigma^2 \quad (2)$$

Where x and y pixels of frame.

2) Shadow Removal: Shadow is basically a region of relative darkness which can be casted by elevated objects like buildings, towers, trees and occlusions *etc*.These darkened regions have proven to be large source of error in all vehicle detection and classification applications as shadows can cause merging of two objects, shape distortions and false detections [4]. Shadow regions in HSI space have certain properties of intensity and saturation which can be used for their classification. Intensity of the shadow pixels is low compared to other foreground and background pixels of the image and hue value is large as shadow pixels are always dark in nature.

In this paper Saturation(S) and Intensity (I) components of HSI are used to extract shadows using [5].

$$SC_n = S_n - I_n / S_n + I_n \quad (3)$$

Where SC_n are the shadow candidates in n^{th} frame

S_n is saturation layer of HSI frame.

I_n is intensity layer of HSI frame.

After detecting shadow candidates we find a positive threshold value th to separate shadow and non-shadow regions using OTSU thresholding method. Finally a binary shadow image is obtained in which the pixel candidates having value greater than th are shadow pixels and rest are non-shadow pixels.

$$Shadow_n(i,j) = \begin{cases} 1 & SC_n(i,j) \geq th \\ 0 & SC_n(i,j) < th \end{cases} \quad (4)$$

Finally selected candidate areas are removed to get preprocessed frame P_n.

C. Video Identification Operator

In this paper features required for detection of on-road vehicles are calculated using mathematical morphology. For applyingany morphology operation first of all a structuring element (SE) needs to be identified. Disc structuring element is used in this work for detecting the cars in videos. Vehicle identification operator (VIO) used is top-hat transform of the resultant frame obtained after preprocessing. Top-hat transform is basically a morphology operator which is used to extract details and small elements from images and is calculated as

$$VIO = Top - hat(P_n) = P_n - P_n o\, SE$$

Where SE is the structuring element.

o denotes the opening morphology operation which is defined as

$$P_n o\, SE = (P_n \theta\, SE) \varphi\, SE$$

Where θ and φ are erosion and dilation operations respectively.

Finally from the binary Top-hat transform VIO_n is calculated using dynamic thresholding to find all the connected components of the frame.

D. Filtering of Miss Detections using Rule Based Method

After finding VIO_n all the connected components of the frame are identified and labeled. In this paper we used binary input frame with 8-connectivity to label all the connected components also called Object blobs (OB) or regions of interest. But all the blobs obtained are not part of the vehicles as there may be some misdetections like edges of roads, tress etc. To remove these misdetections area and perimeter of all the obtained blobs is calculated where

$$area\ (OB_j): Numbers\ of\ pixels\ contained\ by\ object$$

$$perimeter\ (OB_j): Distance\ around\ boundry\ of\ object$$

Finally all the vehicles present in the frame are identified using the rule

$$if\ area(OB_j)/\ perimeter\ (OB_j)\ >\ TH$$

$$Then\ OB_j\ is\ a\ vehicle$$

$$otherwise\ OB_j\ is\ a\ misdetection$$

Where TH is a threshold value which is calculated based on the resolution of the video frames.

E. Final Vehicle Identification

In the last step of the proposed method all the misdetections are removed from the frame and finally $OB_j s$ or the object blobs which satisfy the above defined rule are labeled as cars and rest are discarded.

III. DATASET DESCRIPTION

Experiments are carried out using various publicly available video databases of on-road traffic. One of the databases is LISA-Q Front FOV data set [6]. The videos of this database contain three different sequences consisting of 1600, 300 and 300 consecutive frames. Ego vehicle was used to capture the videos. Other than this some online available traffic videos are used for carrying out experiments [7].

IV. EXPERIMENTAL RESULTS

The result of various steps of the proposed method for a single frame of the video on both the data sets is shown in Fig 2.

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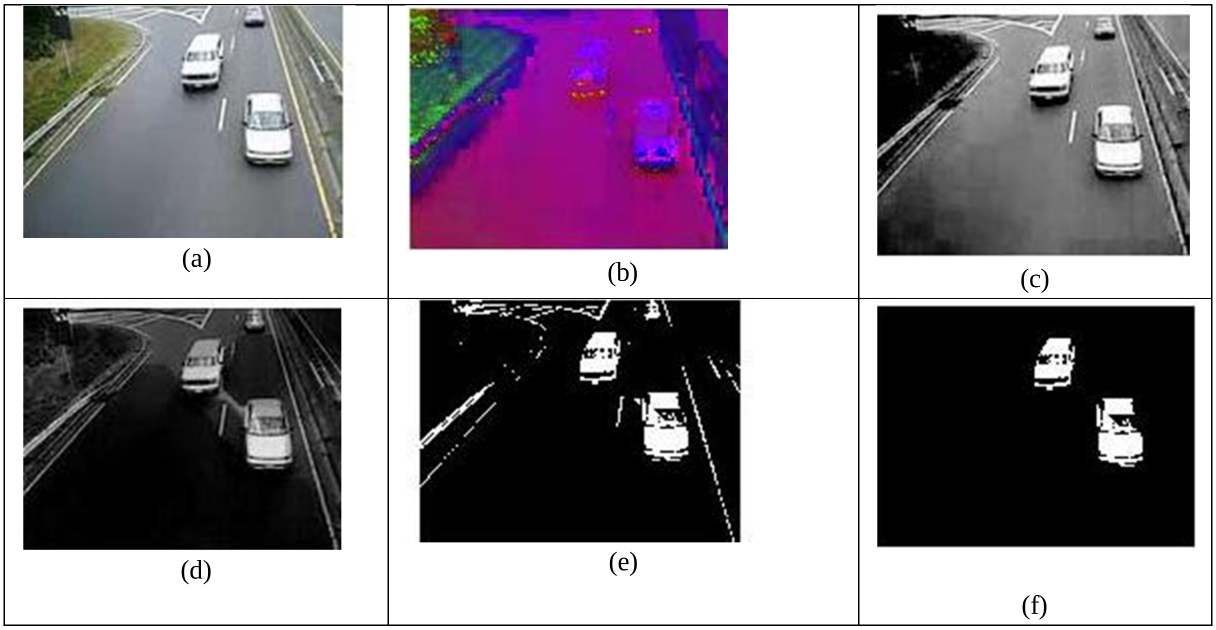

Fig.2 - Results of various steps of proposed method using first data set [22]for incoming vehicles(Top row) :(a) RGB Frame (b) HSI Frame (c) Preprocessed Frame. (Bottom row): (d) top-hat transform(e) Binary Top-Hat transform of (f) finally identified vehicles**.**

V. QUANTITATIVE ANALYSIS

For detecting the performance of proposed method a metric names as True Detection rate is calculated as

$$TR = \frac{Correct\ identified\ vehicles}{Total\ number\ of\ vehicles}$$

The proposed method was also compared with other state of the art methods. It was observed that Background Detection Method (BDM) was giving low TR. Active Learning based methods (ALR) show better TR as they keep on learning the changes in background. The comparative analysis is shown in Table 1. It can be seen that the proposed methods give better results as compared to other state of the art methods.

Results are also summarized in the form of charts in Fig 3.

Table 1-qualitative analysis with other methods.

METHOD	TDR
BDM	75.5%
ALR	80.2%
HFD (HAAR feature extraction)	85 %
Proposed method (PM)	88.2%

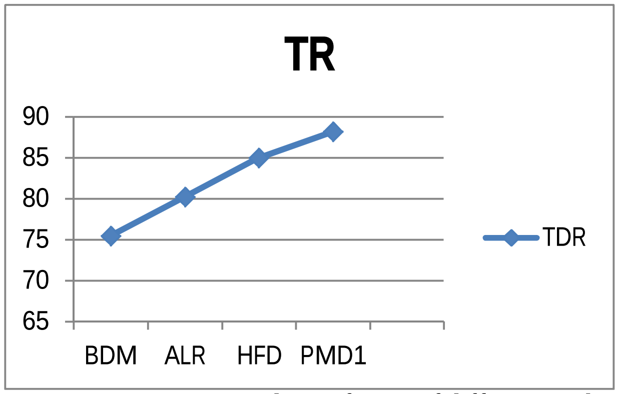

Fig.5 - Comparative analysis of TDR of different methods

VI. CONCLUSION

In this paper we proposed an automatic vehicle detection method using morphology and rule based techniques. It was observed that the method was giving better results as compared to other state of the art methods.

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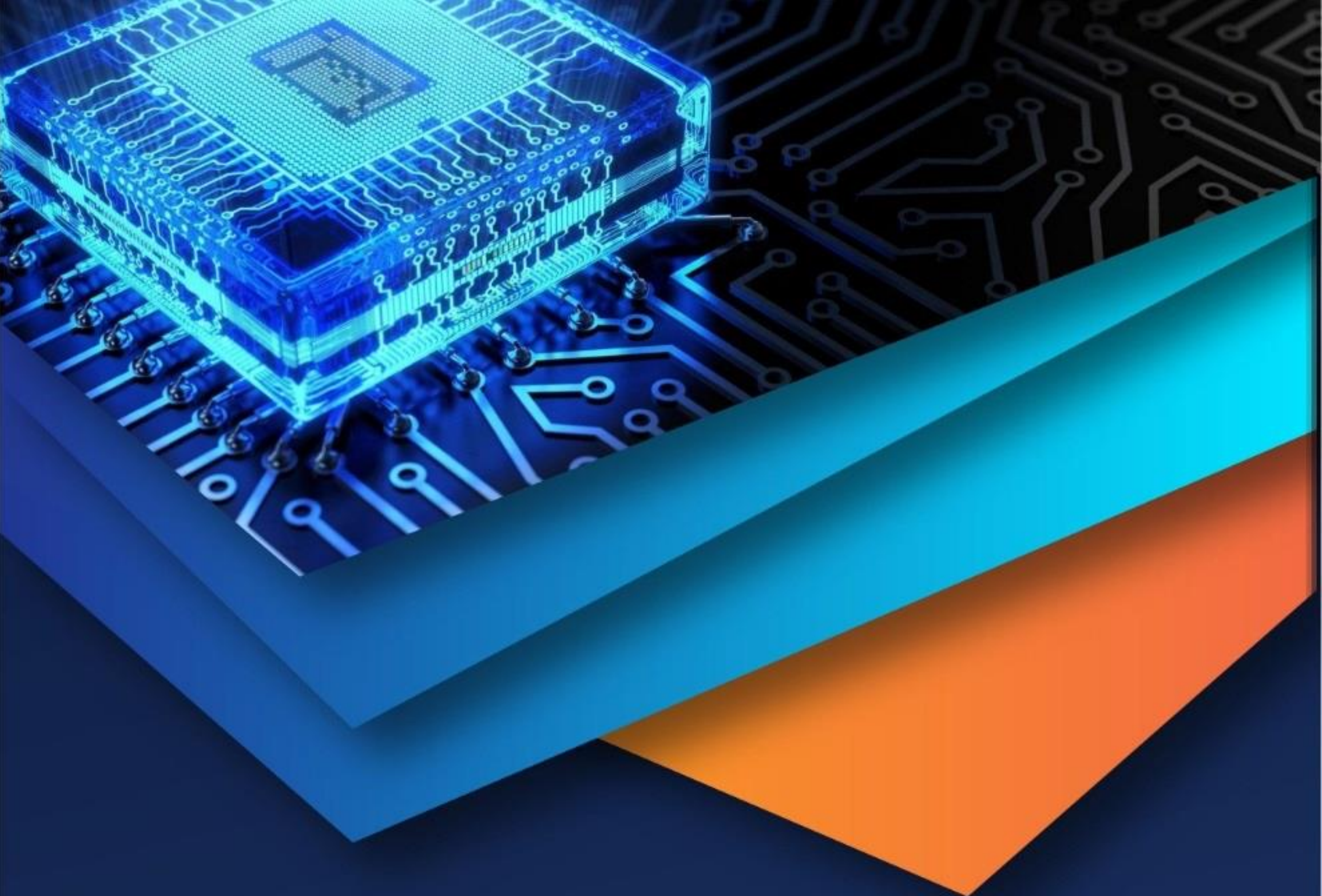

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