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A Segmentation Framework for Vehicle Counting &Classification for Non-lane Indian Roads

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***Abstract*—As we are moving towards maximum independent automation systems to avoid manual errors, corruption and ultimately increasing awareness of rules and regulations for citizens of India, it becomes mandatory to introduce automation without any intervention in traffic monitoring and regulation system. In proposed system we are trying to implement such a system which is applicable for Indian non- lane roads. In proposed system MATLAB simulation software is used for implementation. In Matlab video processing toolbox is mainly used. Outcome of this proposed system is to count & detect different types of vehicle through video processing. This paper is proposing real time vehicle counting and classification in traffic for Non-lane roads. It will be especially beneficial for Indian roads supposed to be one step towards following traffic rules.**

***Index Terms*—Vehicle detection, background subtraction, morphological operator, traffic analysis**

I. Introduction

In current years, we read through newspapers as well as get awareness through different media that police are getting burdened due to heavy work. They are not getting their personal life. Due to lack of availability of police crime rate has been increased. Getting deeper in to that we get senses that some of police and anti-social elements are doing corruption as well. These types of issues are occurring in different sectors of India. This may be due to increased population and lack of infrastructure. In proposed paper we are focusing on traffic sector and will try to deal with the problem. We are not saying that we are giving final solution but it would be definitely first step towards the better traffic monitoring and regulations. In India we often see non lane roads where there is always kiosk of traffic. Most of people don't follow traffic rules. The reason behind it lack of seriousness of traffic rules and lac of police power.Even at some extent corruption is also responsible. With increase in population and open economy there is a drastic increase in number vehicles. Though India is seeing large vehicle flow although roads are not broadened and increased in proportionate to vehicles. This leads to kiosk ad large traffic jam at roads. This type of situation is increasing road accidents. In proposed system we are offering automatic counting and detection of vehicle for non-lane roads in india. It will lower requirement of police personal at roads, will help to reduce corruption upon breach of traffic rules due to real time video analysis and records, will increase awreness of traffic rules due to strict actions against anti elements

Breaching traffic rules. These solutions may lead towards good traffic condition over Indian roads. To implement this system Matlab software is proposed. In matlab computer vision toolbox is used for video processing. The proposed system is divided in to vehicle detection, vehicle counting and vehicle classification in terms of type of vehicle. In proposed system image preprocessing , image segmentation, background subtraction algorithm are mainly used which are explained further.

II. LITERATURE REVIEW

A. Paper Survey

A paper 'Robust Image Segmentation for Overhead Real Time Motorbike' by Y. Dupuis,published in 2014 IEEE 17th International Conference on Intelligent Transportation Systems (ITSC) says that "Motorbikes are often difficult to detect in overhead road traffic images due to the variability of colour, size, shape as well as trajectories. This paper tackles the problem of robust and real time image segmentation for motorbike counting. First of all, we perform background subtraction. Foreground blobs are then refined with Laplacian densities. This fusion enables to achieve a significant robustness to cast shadows. Thus, simple features, such as area, height and width, can be used to discriminate motorbikes from other vehicles. Our real time algorithm achieves interesting performances on multiplereal traffic video sequences." [1]
A paper 'Vehicle Classification and Lane Categorization 'by Shashank Ramesh, published in 2016 International Conference on Computer, Control, Informatics and its Applications says that "this research was carried out in order

to use image processing techniques to detect, track, classify, and count vehiclesin a real-time traffic video. Additionally this research also focuseson occlusion detection and handling, which involves detectingand handling the states when one vehicle superimposes the otheror when two superimposed vehicles split, and lane categorizationi.e. dividing the vehicles in the moving traffic scene into their Corresponding lanes of the road in which they are travelling in. The challenge taken up was to achieve all this using basic imageprocessing techniques and algorithms and not compromise on thedesired output, most importantly keeping the single frameprocessing time less and the speed of processed video playback tobe comparable to that real-time video playback speeds. It is tonote that all of the above is achieved through the techniquesdemonstrated in this research. The process cycle followed fromframe extraction to the final classification of vehicles involvesalgorithms that are all highly region based and do the necessaryprocessing only on the region of interest, only as and whenrequired. Thus saving processing power and time. The finalresults obtained could easily be moulded to use in any application in surveillance, traffic monitoring etc. by just adding the Required decision-making statements in it."[2]

A paper 'A real-time computer vision system for vehicle tracking and traffic surveillance' by Benjamin Coifman ,published in pergamon 1998 states that "Increasing congestion on freeways and problems associated with existing detectors have spawned aninterest in new vehicle detection technologies such as video image processing. Existing commercial imageprocessing systems work well in free-owing traffic, but the systems have difficulties with congestion, shadows and lighting transitions. These problems stem from vehicles partially occluding one another and the fact that vehicles appear differently under various lighting conditions. We are developing a feature-basedtracking system for detecting vehicles under these challenging conditions. Instead of tracking entire vehicles, vehicle features are tracked to make the system robust to partial occlusion. The system is fully functional under changing lighting conditions because the most salient features at the given moment aretracked. After the features exit the tracking region, they are grouped into discrete vehicles using a commonmotion constraint. The groups represent individual vehicle trajectories which can be used to measure traditional traffic parameters as well as new metrics suitable for improved automated surveillance. This paperdescribes the issues associated with feature based tracking, presents the real-time implementation of aprototype system, and the performance of the system on a large data set. [3]

A paper 'Traffic Video Surveillance: Vehicle Detection and Classification' by Saran K B published in 2015 International Conference on Control, Communication & Computing India (ICCC) | 19-21 November 2015 states that "Vehicle detection and classification is the most important and challenging stage of traffic surveillance usingcomputer vision techniques. The videos captured using theclosed circuit television (CCTV) cameras placed in roadsides ordriveways are used for the surveillance. The surveillance systemincludes detection of moving vehicles, counting the number ofvehicles and the classification of the detected vehicles. The mainchallenge of the computer vision technique is the real timeapplicability of the algorithms used. In this work a vehicledetection and classification algorithm which works in real timeis proposed. The detection is carried out by the method ofbackground subtraction where the background is modelled usingthe mixture of Gaussians and the detected vehicles are classified Using the Artificial Neural Network (ANN) with a new set of Features, Histograms of Oriented Gradients (HOG) and geometric measures of the vehicles. Experimental results show that theproposed methods with the new combination of features as training parameters for ANN give better result as compared to otherpopular algorithms."[4]

Paper'Real time object identification for automated video surveillance system' by L.Menaka published in International Conference on Information Systems and Computing (ICISC-2013), INDIA. States that "Intelligent video surveillance system has emerged as a very important topic of research in the field of computer vision in the recent years. It is well suited for a broad range of applications such as to monitor activities at traffic intersections for detecting congestions, and then predict the traffic flow which assists in regulating traffic. Manually reviewing the large amount of data they generate is often impractical. Moving object classification in the field of video surveillance is a key component of smart surveillance software. In this paper, we have proposed robust methodology and algorithms adopted for people and object classification in automated surveillance systems. Object motion can be detected using background subtraction model. The background subtraction and image segmentation based on morphological transformation for tracking and object classification on highways is proposed. This algorithm uses erosion followed by dilation on various frames. Proposed algorithm segments the image by preserving important edges which improves the adaptive background mixture model and makes the system learn faster and more accurately, as well as adapt effectively to changing environments. A probabilistic algorithm for object identification and visual tracking using twin comparison method that incorporates height width based classification method and robust SVM classifier with histogram oriented gradients is utilized for identifying human and vehicles. The experimental results demonstrate the effectiveness of the proposed approach in classifying human and other objects."[5]

B. Background Subtraction

Foreground detection same way called as background subtraction is broadly used concept for real time video analysis and surveillance .Normally an image's ROI regions of interest are objects (cars, text etc.) in its foreground. Post to the initial stage of image pre-processing (post processing like morphology, image de-noising etc.) target localization is required which may utilize this technique. Background subtraction is a broadly used technique for identifying moving objects in videos from static cameras.

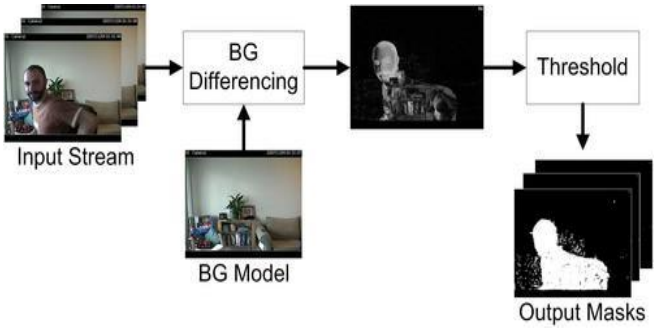

Figure.1Block diagram of Background Subtraction Scheme.

Background subtraction is a widely used approach for detecting moving objects in videos from static cameras. The rationale in the approach is that of detecting the moving objects from the difference between the current frame and a reference frame, often called “background image”, or “background model”.

The most representative background subtraction method the Gaussian mixture model (GMM) [6, 10], which adaptively models pixel color as a mixture of Gaussians. But this method is susceptible to quick illumination changes. To overcomes the problem caused by the illumination changes a local binary pattern [7] histogram method was used to model the background. A robust method for background subtraction and shadow removal for grayscale video sequences [8]. The background image is modeled using robust statistical descriptors, and a noise estimate is obtained [8, 9].

The popularity of Background Subtraction largely comes from its computational efficiency, which allows applications such as human-computer interaction, video surveillance, and traffic monitoring to meet their real-time goals.

The objective in the technique is to identify the moving objects from the subtraction between the current frame and a reference frame, normally called “background image”, or “background model”. Background subtraction is often done if the image as a target is a part of a video stream. Background subtraction gives crucial clues for number of applications in computer vision, for example video surveillance tracking or human poses estimation. However, background subtraction is basically relied on a static background hypothesis which normally not applicable in real time environments. At indoor scenes, with reflections or with animated images on screens may lead to background changes. In a similar way, as due to the wind, the rain or an illumination changes by weather, static backgrounds methods have problems with outdoor scenes. An object motion detection algorithm starts with the image segmentation concept where foreground or dynamic objects are extracted from the background. The easiest method to implement this is to get an image as reference background and take the current frames obtained at the current time t, denoted by I(t) to compare with the ideal background image denoted by B. Here using easy arithmetic calculations, it could segment out the objects by using background image subtraction technique of Matlab computer vision for each pixels in I(t), Let get the pixel value denoted by P[I(t)] and extract it with the respective pixels at the same position on the background image denoted as P[B].

In mathematical equation, it is written as:

$$P[f(t)] = P[I(t)] - P[B] \qquad \text{eq.1}$$

The background is supposed to be the frame at time *t*. This subtracted image would only show slight intensity for the pixel locations which have differentiated in the two image frames. As it has seemingly extracted the background, this approach will only work for some cases where all foreground pixels are dynamic and all background pixels are stationary. A threshold "Threshold" is taken on this subtracted image to improve the subtraction.

$$P[f(t)] - P[f(t+1)] > \text{Threshold} \qquad \text{eq. 2}$$

This indicates that the difference image's pixels' intensities are 'threshold' or filtered on the basis of value of Threshold. The accuracy of this proposed approach is relied on speed of movement in the video. Faster movements may require greater thresholds.

III. PROPOSED METHODOLOGY

3.1 Block diagram:

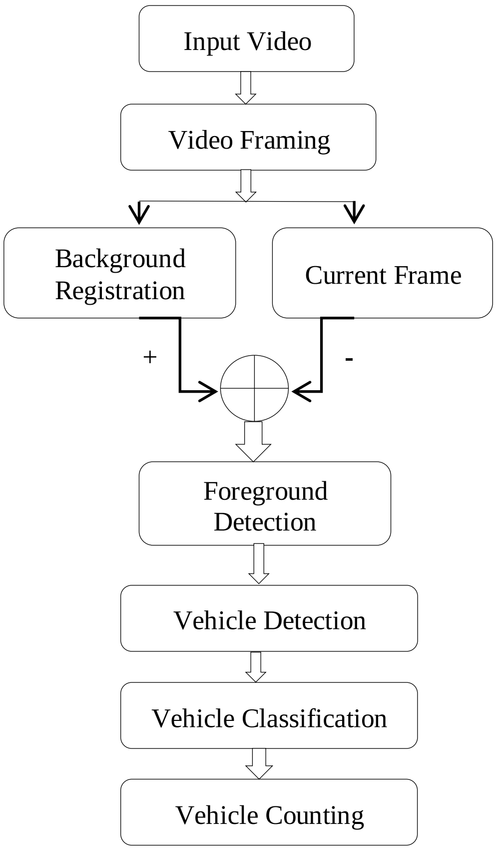

Figure.2 System Architecture

In proposed system background subtraction is used as a key approach. The proposed system starts with reading an input video which is real time captured. This video is converted in to number of frames to analyze and process out frame by frame. As it should be known that number of frames running synchronously forms video. These frames processed one by one. Background without any kind of vehicle is registered as an Ideal background. Here forth each and every real time frame is treated as a current frame. With background subtraction foreground is detected. Once the foreground is detected with the help of morphological operators and Gaussian mixture model vehicle detection and classification is done and counted separately.

3.2 Algorithm

1. Read real time video.
2. Convert video to frames.
3. Perform background registration.
4. Read Current frame.
5. Perform Background subtraction.
6. Detect Foreground.
7. De-noise Foreground.
8. Detect Vehicle and classify them.
9. Count classified vehicles.

IV. Motion Segmentation:

Segmentation is a process of partitioning an image into multiple segments based on certain attributes. The ultimate goal of the segmentation is to convert the image into a simplified form that is more useful as compared to the original image. The results of multiple segmentation techniques depend upon the requirement for segmentation. Background subtraction provides an effective means of segmenting objects moving in front of a static background. Researchers have traditionally used combinations of morphological operations to remove the noise inherent in the background-subtracted result.

V. Shadow Removal:

A known drawback of background subtraction techniques the undesired detection of shadows as foreground objects. In proposed system, a cascading process similar to [8] is proposed to detect shadows from foreground pixels. We discard the local relation estimator in [8] and change the strategy of the spatial adjustment step. The shadow detection process can be described as follows.

A. Chromatic Difference Estimator

To discriminate the shadow pixel and the object pixel, we define the chromaticity difference $CD^k(\mathbf{x})$ as in [11] as follows:

$$CD^k(x) = \frac{I_s^k(x)}{\| I_s(x) \|} - \frac{I_b^k(x)}{\| I_b(x) \|}$$

Where the subscripts sand brepresent the shadow and the background respectively. $\|I_s(x)\|$and $\|I_b(x)\|$are the norms of $I_s(x)$and $I_b(x)$respectively.

For every pixel $\mathbf{x}$ in the set of moving pixels, we calculate $CD^K(\mathbf{x})$. According to the assumptions in [11], $CD^K(\mathbf{x})$ of the shadow pixels has Gaussian distribution, and its mean is close zero. $CD^K(\mathbf{x})$ of the moving object pixel has an unknown distribution that depends on the object. Thus, we can determine that a pixel is a moving object pixel if $CD^K(\mathbf{x})$ is far from zero.

To reduce computation, we only use pixels which satisfy the condition

$$-0.2 \leq CD^k(x) \leq 0.2$$

While estimating the mean $m_{CD}^k$and σ_{CD}^kcan be estimated as follows:

$$m_{CD}^k = \frac{1}{N_M} \sum_{p(x) \in M} CD^k(x)$$

$$(\sigma_{CD}^k)^2 = \frac{1}{N_M} \sum_{p(x) \in M} \left(CD^k(x) - m_{CD}^k\right)^2$$

Where M is the set of pixels which satisfy (6) in the set of moving pixels, and $N_M$is the number of pixels in M.

Using the estimated m_{CD}^k and σ_{CD}^k, we calculate the threshold α_h^k and α_l^k

$$\alpha_h^k = m_{CD}^k + 1.96 * \sigma_{CD}^k$$

$$\alpha_l^k = m_{CD}^k - 1.96 * \sigma_{CD}^k$$

With reliability of 95%; $P(-1.96<Z<1.96)=0.95$, $Z \sim N(0,1)$.

After calculating α_h^k and α_l^k, the class of the pixel is determined by

$$\begin{cases} P(x) \in S_1, \text{if } \alpha_l^k < CD^k(x) < \alpha_h^k \\ P(x) \in O, \text{otherwise} \end{cases}$$

Where $S_1$is the 1st candidate set of shadow pixels and O is the candidate set of object pixels.

B. Brightness Difference Estimator

After the processing of the chromaticity difference estimator, there still exist many moving object pixels in the 1st candidate set of shadow pixels. The brightness difference estimator separates moving object pixels from the 1st candidate set of shadow pixels using brightness difference $BD^K(x)$ of all pixels in the 1st candidate set of shadow pixels. $BD^K(x)$ can be defined as follows [8]:

$$BD^k(x) = \frac{I_s^k(x)}{I_b^k(x)}$$

According to the assumptions in [11], the distribution of $BD^K(x)$ of the shadow pixels is Gaussian such that the mean is m_{BD}^k and the standard deviation is σ_{BD}^k. We estimate m_{BD}^k and σ_{BD}^k as follows:

$$M_{BD}^k = \frac{1}{Ns} \sum_{p(x)\in S1} BD^k(x)$$

$$(\sigma_{BD}^k)^2 = \frac{1}{N_s} \sum_{p(x)\in S_1} (BD^k(x) - m_{BD}^k)^2$$

Where N_S is the number of pixels in S_1.
Using the estimated m_{BD}^k and σ_{BD}^k. We calculate the threshold β_h^k and β_l^k as follows:

$$\beta_h^k = m_{BD}^k + 1.96 * \sigma_{BD}^k$$

$$\beta_l^k = m_{BD}^k - 1.96 * \sigma_{BD}^k$$

With reliability of 95%; $P(-1.96<Z<1.96) = 0.95$, $Z \sim N(0, 1)$.
After calculating β_h^k and β_l^k, the class of the pixel is determined by:

$$\begin{cases} P(x) \in S_2, if\ \beta_l^k < BD^k(x) < \beta_h^k \\ P(x) \in O, otherwise \end{cases}$$

Where S_2 is the 2nd candidate set of shadow pixels and O is the candidate set of object pixels.

C. Spatial Analysis For Shadow Verification

By the previous two estimators, the set of moving pixels are divided into the 2nd candidate set of shadow pixels and the candidate set of object pixels. However, two types of shadow detection errors may commonly occur, namely shadow detection failure and object detection failure.

To improve the accuracy of shadow detection, we propose adding a post processing spatial analysis for shadow confirmation. The process can be described as follows: In order to break the weak connection between shadow regions, we apply an opening morphological operator to the shadow mask. Then a flood-fill operation is used to fill the holes in shadow regions. The foreground consists of shadow regions and object regions. If the shadow candidate is a true shadow, less than a half of the boundary should be adjacent to the boundaries of object regions. Thus we can use the boundary information of a shadow candidate region to confirm whether the shadow is a true shadow or not. The outer pixels S_E of each candidate shadow mask M_S can be calculated as follows:

$$E_S = M \oplus S_E - M_S$$

VI. Noise Removal

For noise removal, morphological operation is performed.

Morphological Operation:

Morphology is a broad set of image processing operations that process images based on shapes. Morphological operations apply a structuring element to an input image, creating an output image of the same size. In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbors. By choosing the size and shape of the neighborhood, you can construct a morphological operation that is sensitive to specific shapes in the input image. The most basic morphological operations are dilation and erosion. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the structuring element used to process the image. In the morphological dilation and erosion operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbors in the input image. The rule used to process the pixels defines the operation as dilation or erosion. This table lists the rules for both dilation and erosion.

The following figure illustrates the dilation of a binary image. Note how the structuring element defines the neighbourhood of the pixel of interest, which is circled. The dilation function applies the appropriate rule to the pixels in the neighbourhood and assigns a value to the corresponding pixel in the output image. In the figure, the morphological dilation function sets the value of the output pixel to 1 because one of the elements in the neighbourhood defined by the structuring element is on. Thus dilation and erosion help in removing noise from the segmented image. Segmented image might contain gaps or overshoots because of the noise from the background which are levelled and image is clearly demarcated.

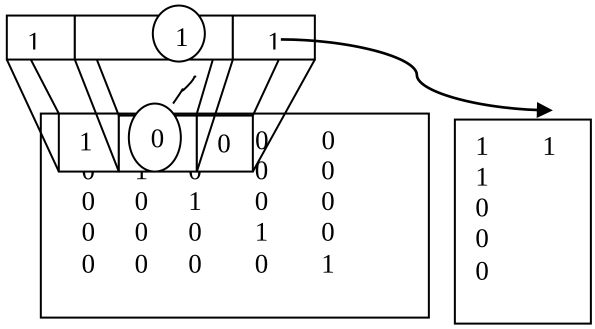

Fig.3 Dilation of binary image.

VII. Simulation Software

The Proposed system is developed on MATLAB software. Matrix laboratory is embedded with versatile toolboxes. These versatile toolboxes increase its applicability over different applications such as communication, audio video processing, aviation, animation. Strong functions library made Matlab easier as well as much effective over different application. In proposed system as well matlab pre-defined functions and tool boxes has played important role for implementation of video processing. Matlab provides flexibility in programming with much user friendly environment. Due to its effectiveness and applicability Matlab has become strong platform for image processing and video processing research and environment.

VIII. Conclusion

The proposed system will be effective in terms of accuracy and traffic regulation. The vehicle classification in terms of two wheelers and four wheelers differentiate this system as compared to previously done existing works. The simulation software MATLAB found to be so effective to implement this system due to its strong functional library.

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