Vehicle Detection using Gaussian Mixture Models Algorithm

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Abstract:— **Cities in the modern era often face a hectic challenge due to increased urbanization and industrialization. This problem is caused by the increasing number of vehicles from time to time and the increase of vehicles is not anticipated with the development of adequate new road sections. In our project, we have developed an algorithm to detect and count vehicles from the CCTV footage. The vehicles are tracked using blob analysis and detected as well as counted by Gaussian Mixture Models.**

Keywords— **CCTV, counting, Gaussian Mixture Models, foreground extraction, Blob Analysis**

1. Introduction

Traffic management is becoming one of the most important issues in rapidly growing cities. Due to bad traffic management, a lot of man-hours are being wasted. Increasing congestion on highways and problems associated with existing detectors has generated an interest in vehicle detection technologies such as video image processing.

The detection of vehicles and its accuracy is an integral part in an intelligent transportation tracking system since it solves the most important issue when building a traffic surveillance system. The system becomes unreliable when it misses to detect a moving vehicle and detect something which is not a vehicle. This halts the system to perform the necessary functionalities that depend on vehicle detection namely, the vehicle detection itself, the number of vehicles passing through the camera and its accuracy.

Traffic video footage from a Closed Circuit Television (CCTV) camera is one of the frequently used traffic sensors since they have the ability to capture a large amount of information. Regarding this problem, developing a self-adaptive system which can help in better traffic management using the technique of image processing is a necessity

One of the popular models in vehicle detection is Gaussian Mixture Model (GMM) due to its reliability in the foreground segmentation and background extraction process. Moreover, the characteristics of a moving object in video surveillance are easier to detect. However, this method has not worked effectively on high levels of light variance and shadow, vehicle density on the road and video resolution. Hence, to provide accurate results it needs to be improved.

The major goal of this study is to demonstrate how to detect moving automobiles using a Gaussian Mixture Model and Blob Analysis. Along with it, we apply four filters to our work and observe which is best suitable among the lot. The following is a breakdown of the paper's structure:

Video processing is a subclass of DSP (Digital Signal Processing) techniques in which one (or more) video frames from a continuous stream are handled at a time. This form of processing is essential in systems with live video or video data that is so vast that putting the complete set into the workspace is wasteful. The Computer Vision System Toolbox from MATLAB & Simulink was used to process the dataset provided in this paper.

2. OBJECTIVES OF THE WORK

Objectives of any filtering approach are:

- To detect vehicles in motion based on Gaussian Mixture Models and Blob Analysis.
- Enhance the quality of the frames by denoising the frames.
- Reduce the effect of shadow in the frames.

3. PROPOSED WORK

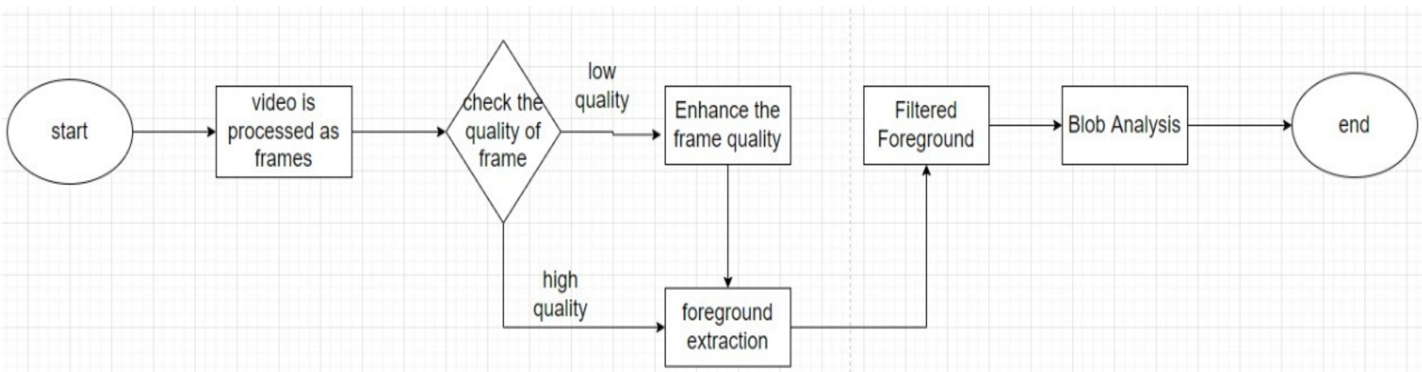

Fig.1 Flow Chart

The CCTV footage is processed as frames and quality of the frame is computed.
By experiment, we found the approximate mean value of the video during different times of the day i.e., mean of mean of the frames to determine a specific set of conditions to optimally enhance the image's contrast as well as brightest, so that impact of shadow on the frames is reduced to an extent.

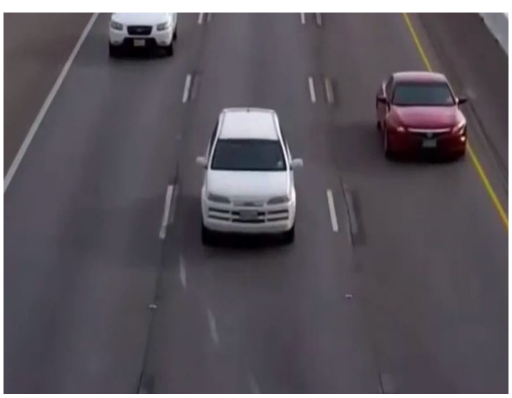

Fig.2 Original Frame

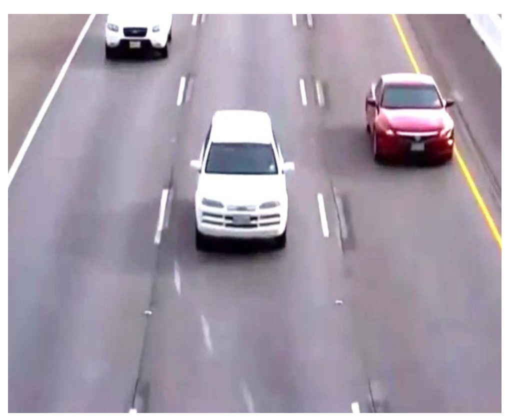

Fig.3 Enhanced Frame

Gaussian Mixture Model

GMMs (Gaussian Mixture Models) are a sort of density model that uses Gaussian function components. Because it is simple, this algorithm is used to accomplish the background extraction process and the latter is dependable when it comes to light variations and object detection conditions. This is one of the oldest semi-supervised methods. Image processing tools and techniques are widely utilised.

In this model, every pixel in an image frame is made to be a K Gaussian Distribution. Here, K stands for the number of Gaussian distribution model usage.
A different pixel colour is represented by each Gaussian model. In this scenario, a scalar value is used for the grayscale image, whereas a vector value is used for the RGB image. The value of K is chosen by taking into account image resolution, computer system performance, and the complexity of the backdrop models. Each pixel in each image frame is matched with a K Gaussian distribution model. As stated in formula (1), if a pixel is within 2.5 deviations of the standard range, it matches one of the Gaussian distribution models. On the other hand, if a pixel's value exceeds the 2.5 standard deviation, it is classified as an unsuitable to the Gaussian distribution model.

$$\mu_k - 2.5 * \sigma_k < X_t < \mu_k + 2.5 * \sigma_k \qquad (1)$$

Chance of K Gaussian distribution function modeling is described as show in (2)

$$P(X_t) = \sum_{k=1}^{K} \omega_{k,t} * n\left(X_t, \mu_{k,t}, \Sigma_{k,t}\right) \qquad (2)$$

Where the K value indicates the number of distribution, $w_{k,t}$ is the weight of Gaussian function to K at time t and n (X_t, $u_{k,t}$, $\Sigma_{k,t}$) is Gaussian Probability density function.
The next step consists of determining for each pixel if it will be included in the foreground or the background object. The initial step lies on sorting the existing model based on the fitness value (ω/σ2), where the optimal distribution as background remain placed on top priority, and the distribution that do not reflect background is laid on the lowest priority.
From several distribution models, several high values are selected until its weight values meet the predetermined threshold value. The selected distribution model will be selected as a background candidate. If a pixel is categorized to one of the background model
candidates, the pixel will be considered as background (pixel will change its value to zero or black). Otherwise, the pixel will be considered as foreground (changing its value to one or white). This selection criterion will output a black and white image.

To remove noise from the foreground image, we have decided to examine edge detection filters and select the appropriate filter.

Image Filtering using Bilateral filter

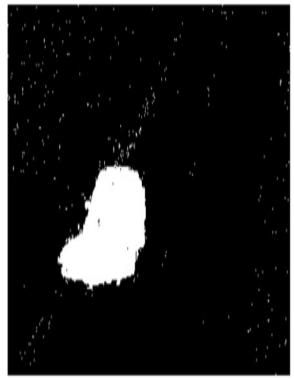

Fig.3 Original foreground

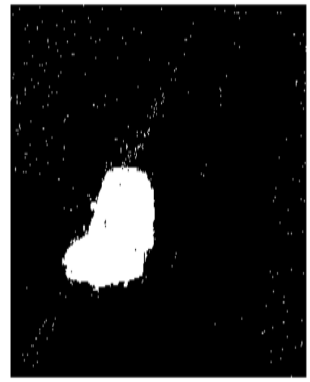

Fig .4 Filtered foreground

Image Filtering using Morphological filter

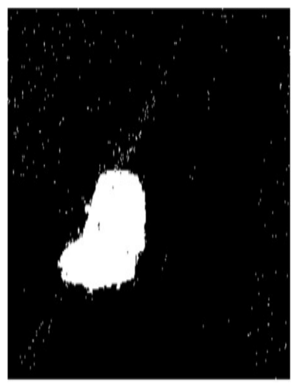

Fig.5 Original foreground

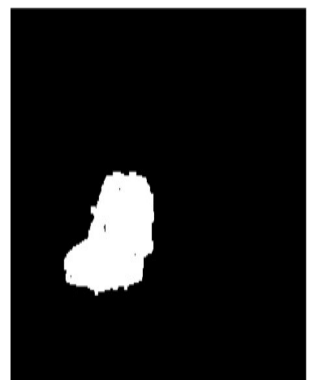

Fig.6 Filtered Foreground

From the above figures, we infer that morphological filter is a more suitable edge detection filter for this system.

Blob Analysis

Blob Analysis is a technique which is used for performing foreground segmentation in image processing by defining an area of pixels inside an image to be the item or region to be identified.
To make an ideal blob, various elements must be considered while determining the blob value. The area of the label region, centroid, bounding box, label matrix, and blob count are all factors in computer vision.
One approach for seeking the blob value is the Laplacian of Gaussian formulation. This procedure begins with the tagging of a foreground object, followed by the collection of blob data such as the beginning pixel location, x- axis and y- axis lengths, and pixel area.

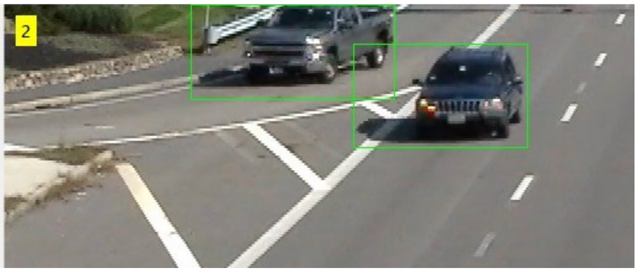

Fig.7 Blob Analysis of frame

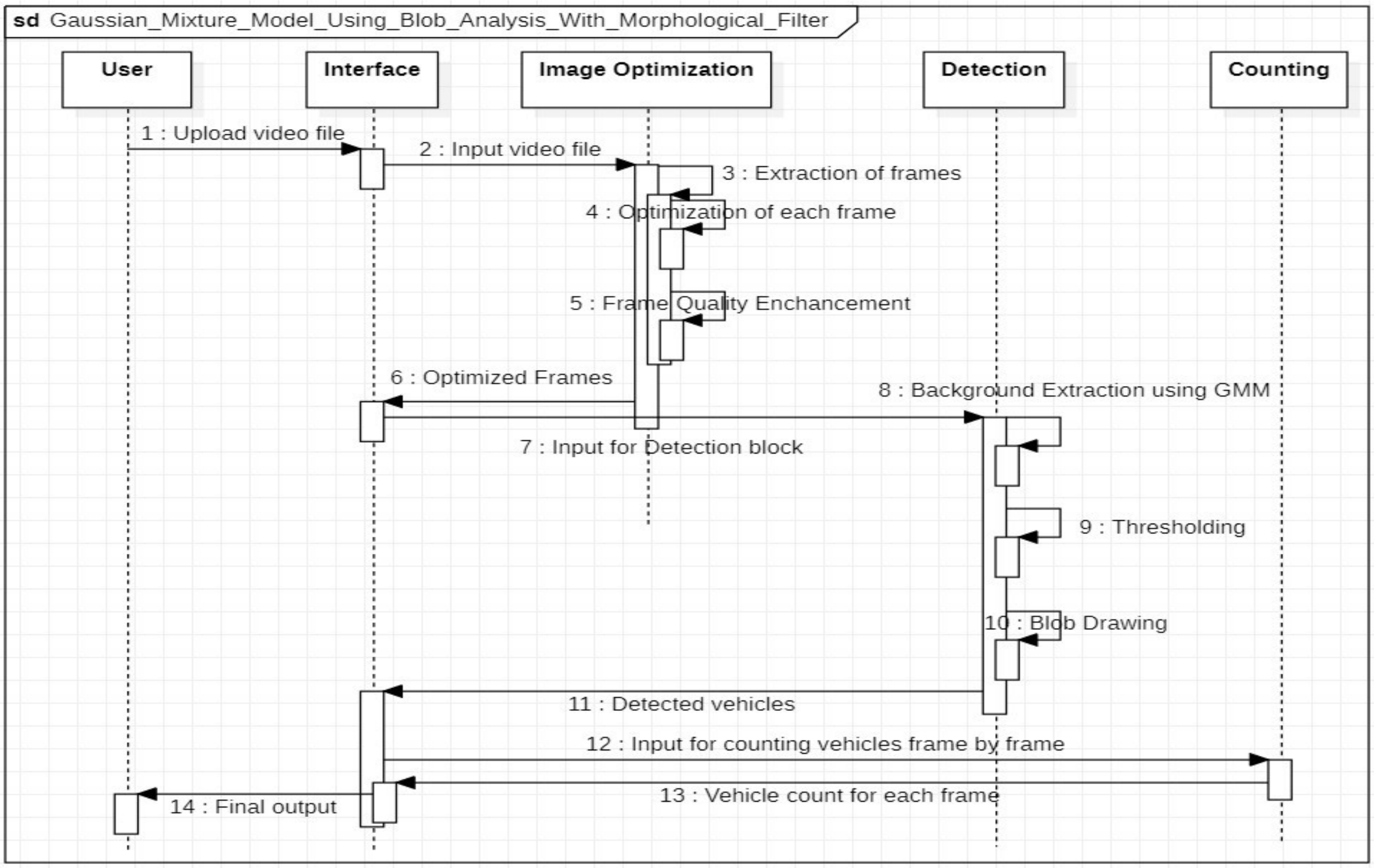

Fig.8 Diagrammatic representation of the proposed system

3.1. ALGORITHM:

Step1: Input of the video file from the CCTV recording.

Step2: The video file will be extracted into its composing frames, where each frame will be processed and optimized for the next process.

Step3: Enhance the frame quality such that the blobs do not capture the shadow of moving vehicles in the evening.

Step4: Separate Background and foreground objects using Gaussian Mixture Models (GMM) algorithm

Step5:Apply a morphological filter to the foreground image to remove the noise present in the image.

Step6:Draw blobs circling the foreground objects that represent the presence of detected objects

Step7: Count the number of cars tracked by the blobs, insert the result on top of each video frame.

4. RESULTS

The video has been processed as frames and has been successfully implemented using our proposed work. The video frames are enhanced according to their brightness and contrast. The number of cars in each frame has been tracked by the blobs and result is printed on top of each frame.

Fig.9 output in command prompt

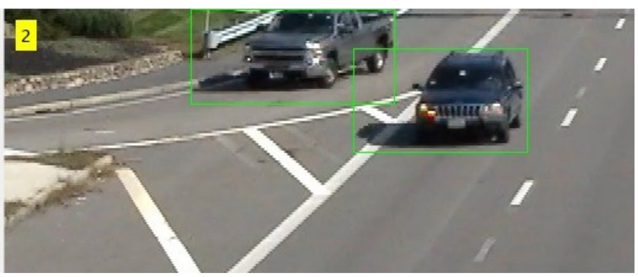

Fig.10 output frame

Video Input	True positive	False positive	False Negative	Sensitivity	Precision
1	4	0	0	1	1
2	2	0	0	1	1
3	78	9	3	0.963	0.896

Table 1: Experimental results of proposed work

From the table, take sample video 3:

Number of vehicles in video= 81
Number of vehicles detected by system = 78
Error percentage = ((81-78)/81)*100 =3.7%

In existing work, the error percentage of an unknown video = 8.76%

From this, we can say our proposed work performs better.

5. LIMITATIONS

The following are the limitations of our system:

- Difficult to detect dark colored vehicles in poor lighting conditions.
- Blob cannot track vehicles that appear to be less than the minimum blob area due to elevation of camera from the vehicle.
- If more than two cars come side by side close to each other then a big blob captures the group along with the smaller blobs tracking the vehicles separately

6. CONCLUSIONS AND FUTUREWORK

In this paper, we use the CCTV footage of traffic cameras and obtain the vehicle frequency after enhancing video frames and removing the noise in the extracted foreground using a method that is based on Blob Analysis and Gaussian Mixture Models. This system can be highly useful for tracking vehicle density. Though the existence of shadow has been minimized by the system, it is difficult to get rid of the shadow as it contributes to little error in detecting vehicles.

The angle of elevation of the camera from the vehicle also makes the vehicle sometimes go undetected as its size is less than the minimum blob size.

This system provides best accuracy where the brightness is optimal but the system accuracy is actually determined by the condition of video recording , the condition of road lanes and choosing of suitable input parameter s for the algorithm

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