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Automatic Vehicle Counting and Classification

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ABSTRACT:
Vehicle counting and classification can give accurate information about the vehicle density on a particular city road or highway which helps in advanced traffic monitoring and management. Various image processing techniques like frame differentiation, segmentation, filtering, morphological operations, blob detection, etc. are used using MATLAB software. The final count of the number of vehicles passed through the path of choice will be displayed and classified throughout the day. This is an advancement over the hardware counterparts which are made using sensors, since sensors are severely affected by weather conditions such as temperature, lightening.

Keywords: Frame extraction, background subtraction, morphological operations, blob detection, vehicle counting.

I. Introduction

Traffic management and information system mostly depend on sensors for estimating traffic parameters. As of now magnetic loop detectors are used to count vehicles passing over them. Vision based systems have a number of advantages. Along with counting vehicles, a large set of parameters can be derived. Cameras are much less disruptive to install than magnetic sensors [1].

The output from the camera based system can give information about the traffic density on a particular road and can warn about traffic congestion if it arises. This project is mostly aimed at counting and classifying vehicles at highway from dynamic data obtained from the camera. In case of heavy traffic in a lane the vehicles can be redirected and this would maintain a better traffic flow. The types of vehicles passing in each lane can be counted and classified based on the properties (length, width) obtained from images of vehicles. This method is inexpensive and requires little or almost no human intervention.

II. System Block Diagram

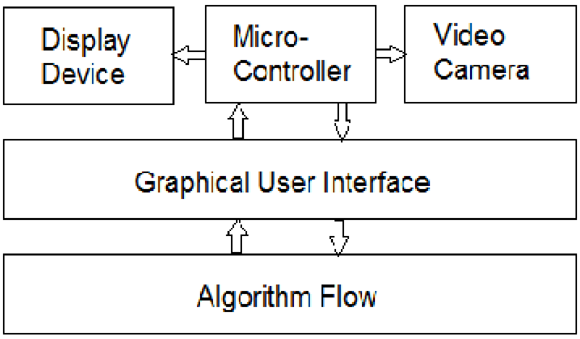


Figure 1. System Block Diagram

The system uses a camera for the live video streaming of the traffic. The captured video is then converted into frames at a rate of 25 frames per second .The frames thus obtained are subjected to adaptive background subtraction against an background image. The result of background subtraction gives us an image with only the vehicles in it which in turn can be counted with the blob detection approach, which gives us the vehicle count for a particular frame. For each blob that is obtained, the blob parameters (height, length, width, profile, area) are determined, which can be used to classify a vehicle to the respective category. The obtained vehicle count for each category is constantly updated on a graphical user interface

III. HISTORY

The system for vehicle counting and classification has been taken up as projects by multiple industries and work is still going on to obtain a perfect system for the same. Even though, a great amount of research has been done on the vehicle detection and tracking. However, not much work is done on the vehicle classification. This is due to existing difficulties associated with vehicle classification problem which are hard to remove. The much wide variety of vehicle shapes and colors within same class, make the classification task even more challenging. The main goal of vehicle classification is to categorize the detected vehicles into their respective types. Majority of the papers reported in the literature on vehicle classification are based on model-based approach [1, 2-3] and recently which is based on the vehicles color. The model-based classification relies on sets of 3D models that coarsely describe the shapes of each vehicle type. Perhaps the most serious disadvantage of the model-based approach is the need to represent various shapes of vehicles (although belonging to the same class) with a single model [4].

There are a number of sensor based approaches which have been implemented:

1. Magnetic Loops: They require costly test equipment or diagnostic software and require continuous power supply to function. Loops will only be useful in presence of laned traffic.
2. Microwave radars: These use specially allocated radio frequency for detecting vehicles. Microwave. They have problems like over estimating speed. It cannot detect stationary vehicles
3. Laser based detection: These systems offer reliability and durability. Do not require civil engineering unlike the above approaches. It assumes structured traffic which is not the case in India. Requires overhead installation.
4. Infrared detectors: This system can only detect vehicle passage or presence. It cannot provide any information regarding speed of the vehicle. Change in weather conditions such as fog, rain or snow results in performance degradation of these systems
5. Ultrasonic detectors: They transmit sound at 25 KHz to 50 KHz. This technology is expensive and is sensitive to noise and environmental conditions. These sensors are expensive with limited capacity and involve installation, maintenance, and implementation difficulties

There are several camera based approaches too.

a. In temporal difference, the image difference of two consecutive image frames are obtained, however, this approach has some limitations such as visual homogeneity requirement and its effectiveness depends on the speeds of moving objects.
b. Optical flow method was developed to obtain effective background modification, which bases on the detection of intensity changes, however, illumination change due to weather or sun-light reflections decreases its effectiveness. It is also computationally inefficient
c. The third method, background subtraction, is the mostly seen method in the literature for effective motion tracking and moving object identification. In background subtraction, background can be static, in which a fixed background is obtained beforehand and used in the entire process; or dynamic, in which background is dynamically updated with changing external effects like weather [5][6].

IV. PROPOSED DESIGN

The system uses a camera for the live video streaming of the traffic. The captured video is then converted into frames at a rate of 18-20 frames per second .The frames thus obtained are subjected to adaptive background subtraction against an background image. The result of background subtraction gives us an image with only the vehicles in it which in turn can be counted with the blob detection approach, which gives us the vehicle count for a particular frame. For each blob that is obtained, the blob parameters (height, length, width, profile, area) are determined, which can be used to classify a vehicle to the respective category. The obtained vehicle count for each category is constantly updated on a graphical user interface.

A. Background Subtraction

Background subtraction is a method of obtaining the foreground mask from an image after eliminating the stationary background. We propose to use adaptive background subtraction for the same. Most researchers have abandoned non-adaptive methods of background subtraction because of the need for manual initialization. Without re-initialization, errors in the background accumulate over time, making this method useful only in highly-supervised, short-term tracking applications without significant changes in the scene. A standard method of adaptive background subtraction is averaging the images over time, creating a background approximation which is similar to the current static scene except where motion occurs. While this is effective in situations where objects move continuously and the background is visible a significant portion of the time, it is not robust to scenes with many moving objects particularly if they move slowly. It also cannot handle bimodal backgrounds, recovers slowly when the background is uncovered, and has a single, predetermined threshold for the entire scene [3].

- First we initialize the camera by setting its adaptor name, ID and format
- Then we set the camera property i.e. set its returned colour space.
- We set the trigger repeat to infinity so that it keeps taking video.
- Then by the help of a loop we decide how many frames we need and within the loop we capture the images from the video

- We perform the subsequent operations on the obtained frame.
- We can even save or delete a particular frame if needed.

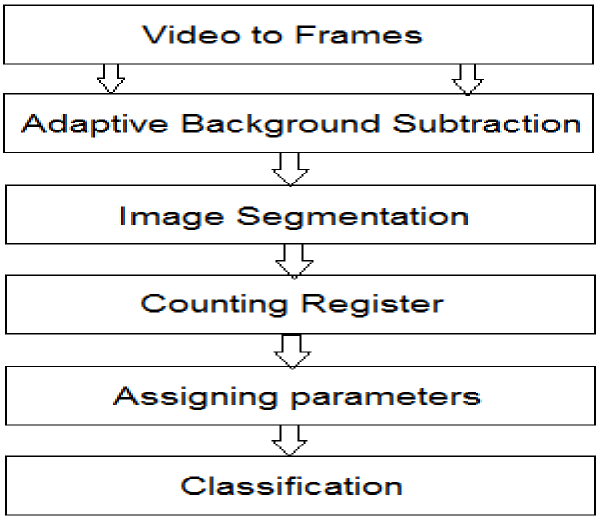


Figure 2. Algorithm flow

B. Image Segmentation

Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels). The goal of segmentation is to simplify or change the representation of an image into something that is more meaningful and easier to analyse. Image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain properties [7]. We perform thresholding of image obtained to convert the image in a binary image. A simple method to obtain binary image is by comparing the intensity of the pixel against a particular value and changing them to 0 or 1 based on the result.

C. Blob Detection and Tracking

Blob detection identifies the number of objects in the thresholded image. Connected component labeling (alternatively connected-component analysis, blob extraction, region labeling, and blob discovery or region extraction) is an algorithmic application of graph theory where the subsets of connected components are uniquely labeled. Connected-component labelling is used in computer vision to detect the connected regions in binary digital images, and although colour images and data with higher dimensionality can also be processed [8] [9]. When integrated into an image recognition system or human-computer interaction interface, connected component labelling can operate on a variety of information [10] [11]. Blob extraction is generally performed on the resulting binary image from a thresholding step. Blobs may be counted, filtered, and tracked. Connected component labelling can be performed by two algorithms, 4 point labeling or 8 point labeling. In 4 point labeling only the immediate edges are considered and in 8 point labeling, the corners along with the edges are considered.

We track the same blobs in subsequent images, a flag will be associated with each blob which will be set to 1 as a blob is visited and thus avoid recounting of the same vehicle. If a new vehicle is detected, we check the flag associated with it, if the vehicle is unregistered the flag is incremented and otherwise ignored. Sometimes due to occlusions two vehicles are merged together and treated as a single entity. Sometimes while image subtraction and thresholding, a vehicle may get converted to more than one blob, in that case, the vehicle parameter of the respective blobs in proximity are calculated and based on that morphological operations can be used to reconnect the blobs of the same vehicle for further processing.

D. Counting

For counting the vehicles a counting register is maintained. We can calculate the number of centroids of all the blobs available, the number of centroids of the moving vehicles will give information about the number of vehicles that have passed that particular path.

E. Classification

We reject the blobs of areas smaller than those of vehicles as they are random noise, thus the first part of classification occurs at the blob detection level. The classification of vehicles in various categories can be done by setting parameters to the blobs obtained in the video, like length, width, height and or area. The colour based classification can be done on RGB content of the blob images obtained. If we want information regarding traffic density then the total area of the moving objects detected can be calculated by adding and compared against a fixed value, if the obtained value is surpassed or not, it can be said that the density is more or less, thus helping in better monitoring systems.

V. Experimentation and Result

This project is a combination of image processing and embedded techniques which combine to give a standalone system which has never been used in the past. The project will run on a processor like Raspberry pi or PIC based on the requirement and will require almost no human dependence. The project will help in tracking criminal vehicles by the help of color and type of vehicle detected. Various steps of detection are shown below.

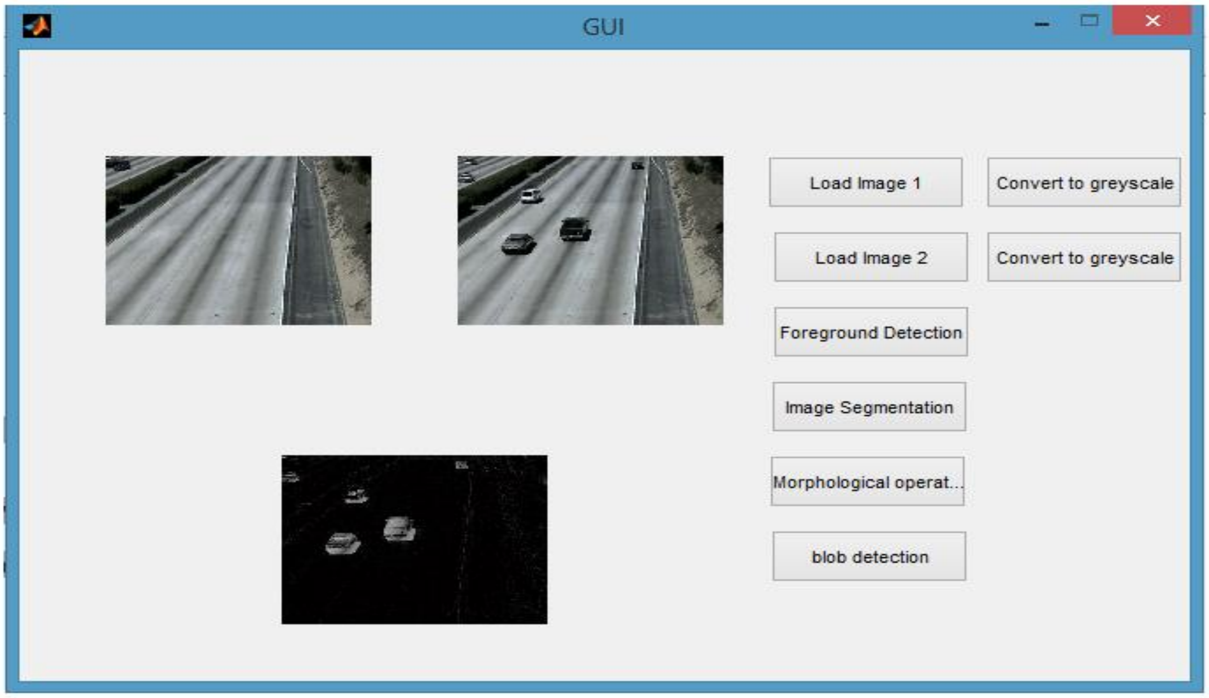
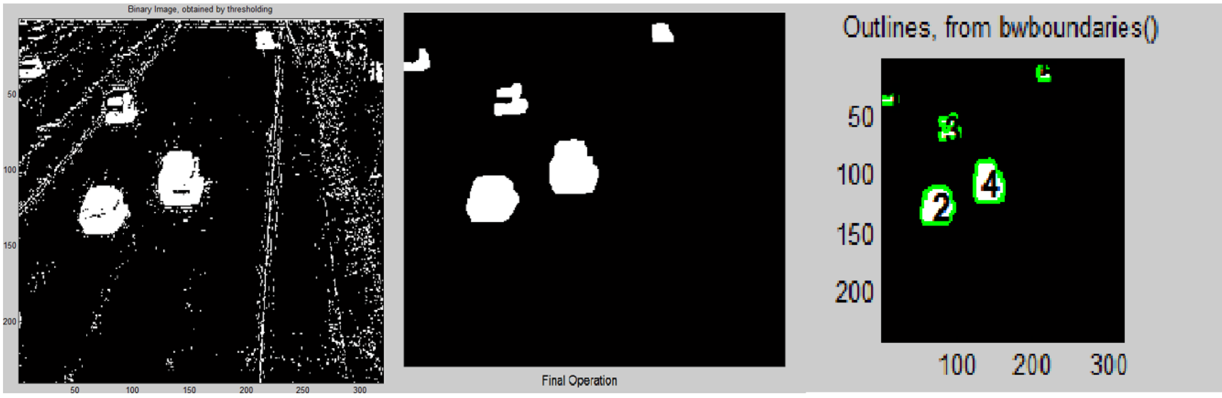


Figure 3. GUI performing Image subtraction




```
numberOfBlobs =

     5

Blob #      Mean Intensity  Area   Perimeter    Centroid       Diameter
# 1              1.0       186.0     63.6     13.1      34.3     15.4
# 2              1.0      1171.0    130.7     74.4     127.0     38.6
# 3              1.0       402.0    115.7     90.6      60.7     22.6
# 4              1.0      1245.0    137.4    142.0     106.5     39.8
# 5              1.0       199.0     53.9    216.8      14.5     15.9
```

Figure 4. Binary Image, Morphological operations and Counting and Obtained Blob properties

AREA USED FOR VEHICLE CLASSIFICATION

Vehicle	Area (pixels)
Small	100-400
Medium	401-700
Big	701-1000

Figure 5. Example of classification

VI. CONCLUSIONS

This single project produces multi domain outputs. It can count and classify vehicles on highways by the methods mentioned above and help with highway management and toll collection, it can calculate traffic density on busy traffic roads for better monitoring. Some more work is needed in reducing the occlusions present in the image

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