Traffic analyzer and route mapping

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Abstract

Traffic is one of the greatest problem in most of the metropolitans. Many cities in India like Kolkata, Delhi and Mumbai have a great volume of traffic all around. The traffic conditions could worsen at a certain peak hour and could be a major fallout for the people travelling on the roads. Traffic reports are generally given over radio by radio jockeys and over news, but this facility is not a realtime solution and is very naive and results in chaos due to a high volume traffic redirection. As a solution to this problem, a smart traffic monitoring tool based on image processing could be setup in metropolitans. The number of cars on a certain road can be easily tracked and also whether they are moving or not. This simple analysis can help in great deal by redirecting excessive incoming traffic towards a given area and suggesting them an alternate route to reach a given destination. Some of the suggestive reports from the Road Traffic Organisation(RTO) bring to light the fact that majority of the traffic is generated because there is currently no mechanism to monitor and analyse traffic. Some of the major highways have cctv monitoring which is prone to human errors. The proposed system tries to eliminate all the possible problems that could arise from the human errors and improving traffic conditions.

I. Introduction

Traffic flow monitoring and traffic analysis based on computer vision techniques, and especially traffic analysis and monitoring in a real-time mode raise precious and complicated demands to computer algorithms and technological solutions. Most convincing applications are in vehicle tracking, and the crucial issue is initiating a track automatically. Traffic analysis then leads to reports of speed violations, traffic congestions, accidents, or illegal behaviour of road users. Various approaches to these tasks were suggested by many scientists and researchers. The approach in this article focuses on methods of image processing, pattern recognition and computer vision algorithms to be applied to road traffic analysis and monitoring. One of the main aspects was to modify these algorithms to fit to real-time road monitoring processes, and as a consequence the prototype of system for traffic analysis was developed. Technically this system is based on stationary video cameras as well as computers connected to wide area network. Capabilities of the system include vehicle tracking, vehicle speed measurement (without use of traditional sensors), and recognition of license plate numbers of moving vehicles, lane jam detection. Additional features of the system are object/data searching and archiving, statistical analysis. Image processing tasks utilized in the system are image filtering, correction and segmentation, object modeling, tracking and identification, morphological, geometrical and statistical methods. Technical tasks used are motion shooting, video sequence transmitting, frame extraction. Road traffic monitoring aims at the acquisition and analysis of traffic figures, such as presence and numbers of vehicles, and automatic driver warning systems are developed mainly for localization and safety purposes. Video systems for either traffic monitoring or driver warning normally involve two major tasks of perception: i) estimation of road geometry and ii) vehicle and obstacle detection. Temporal differencing and background modeling techniques are widely used for vehicle and obstacle detection in road traffic monitoring systems. Although background modeling techniques provide more reliable results, computational complexity is a trade off that one has to consider. Adaptive systems to environmental changes have been proposed, and robust tracking algorithms are implemented under various conditions such as occlusion. 2-D and 3-D algorithms have been implemented to analyse the scene, where robust feature sets are used. In order to obtain valid feature sets, most of the studies use close-up static cameras, where sufficient number of features can be obtained. It is worth noting that there are less number of studies considering road geometry for detecting and tracking of the vehicles. Thus, implementing traffic monitoring systems requiring less features for detection/tracking, and that can be used for general camera setups is beneficial.The Traffic Control Center of Istanbul Municipality collects real-time images using a video processor system consisting of 110 cameras of various characteristics. Currently, all of the images are displayed at a control room and are monitored by operators to detect any incidents such as accidents or unexpected road conditions. In the second chapter of this thesis, a feasibility study that can be used to analysis the traffic flow for mentioned purposes is implemented.Automatic driver warning system is another crucial application that used in ITS applications. Road geometry and vehicle detection algorithms have been thoroughly examined, and different warning applications have been proposed in the literature. Most of the vehicle warning systems can be classified into two groups for onboard camera applications: feature and model based. In the first group, feature based methods are used. This group is mainly derived from detection of edges as features in the image, and aggregation of these features into meaningful models. In general, feature driven approaches are highly dependent on the methods used to extract features and they suffer from noise effects and irrelevant feature structures. Lane tracking is predicated on lanes rather than lane marks, and priori information about the lane structure is needed for lane model. Often in practice the strongest edges are not the road edges, so that the detected edges do not necessarily fit a straight-line or a smoothly varying model. The second group is the model based methods. In this group, deformable templates are used to describe a scene with a set of parameters that fits to the scene model. The road boulders and lane markings are often approximated by circular arcs on a flat-ground plane. Model-driven approaches provide powerful means for the analysis of road edges and markings. Their main advantage is that the lane can be tracked with a statistical technique, thus, false detections are almost completely avoided. However, the use of a model has certain drawbacks, such as the difficulty in choosing and maintaining an appropriate model for the road structure, the inefficiency in matching complex road structures and the high computational complexity noise effects and irrelevant feature structures. Lane tracking is predicated on lanes rather than lane marks, and priori information about the lane structure is needed for lane model. Often in practice the strongest edges are not the road edges, so that the detected edges do not necessarily fit a straight-line or a smoothly varying model. The second group is the model based methods. In this group, deformable templates are used to describe a scene with a set of parameters that fits to the scene model. The road boulders and lane markings are often approximated by circular arcs on a flat-ground plane. Model-driven approaches provide powerful means for the analysis of road edges and markings. Their main advantage is that the lane can be tracked with a statistical technique, thus, false detections are almost completely avoided. However, the use of a model has certain drawbacks, such as the difficulty in choosing and maintaining an appropriate model for the road structure, the inefficiency in matching complex road structures and the high computational complexity. To increase transportation safety, to decrease the number of traffic accidents and hence to save lives and valuable resources, Drive-Safe project that is supported by the State Planning Organizations is currently in progress. The aim of this project is to create conditions for prudent driving on highways and roadways with the purposes of reducing accidents caused by driver behavior. To achieve these primary goals, critical data is being collected from multimodal sensors (such as cameras, microphones, and other sensors) to build a unique databank on driver behavior. In the third chapter of this thesis, a feasibility study for a driver warning system that is based on the windshield camera recordings is implemented parallel to the Drive-Safe project.

A. Keywords

subjective classification, histogram mapping, semantic variation.

II. Problem Statement

Metropolitans are currently facing a grave problem of traffic which is cause of congestion and frustration for people. Many roads in India get jammed due to excess number of vehicles or roads being under maintenance. The maintenance measures leave a very small part of road open for traffic to flow freely. Also people have no option to find a road where the amount of traffic will be less. Traffic alerts are given currently over news or livefeed, but they are inconsistent most of the times

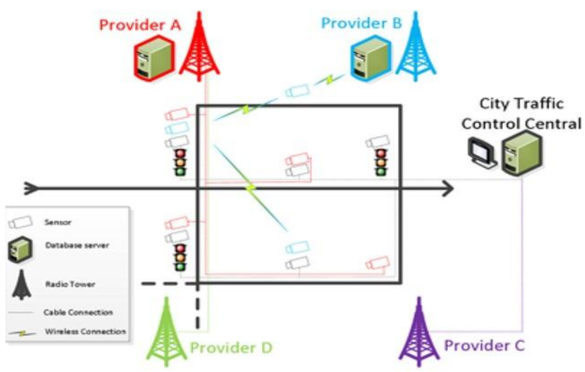
III. Motivation

The growth of vehicles in past 20 years has resulted in major growth in traffic on roads and is also a major cause of road rage and accidents. In cities like California, the traffic problem is at such a worse condition that there are on an average 40 major traffic jams across the city every month. India is now highly developing, so are its metropolitans. Therefore we should implement the proposed system for traffic control and tackle the traffic problem in dormant stages itself.

IV. Future scope

the system can be further extended to become a full fledged network server which can monitor traffic in re-altime along with gps and provide updatesautomatically through deamon service of our phone.

V. Propose System Workflow



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The main objective of this work is to detect vehicle and count them in order to analyse the traffic. Figure depicts sequence of image processing techniques applied in order to analyse the traffic. To detect and count the vehicle two images are taken, first one is kept as reference image (road without vehicle) and the second image is road without vehicle. At First, two RGB images are converted into gray scale image and then these images are subtracted using absolute difference operation. The enhanced image is filtered using, median filter to reduce the noise. Filtered image is then converted into binary image using Otsus gray scale threshold. Differential morphological operations are used to segment the shape of vehicles. Proposed algorithm, automatically detects the shape of vehicles by setting some initial parameters like a series of opening and closing operations of disc-shaped structure sizes to implement the morphological profile. Finally Centroid of the segmented shapes is calculated and then the length of centroid is used to count the number of vehicles in the image.

A. Image Acquisition Image acquisition in image processing can be broadly defined as the action of retrieving an image from some source, usually a hardware-based source, so it can be passed through whatever processes need to occur afterward. The first step in this process is image acquisition, to acquire a digital image. To do so, it requires an image sensor and the capability to digitize the signal produced by sensor. For this purpose existing closed-circuit television or special cameras specifically designed for the task may be used.

B. Image Preprocessing Preprocessing images commonly involves removing low-frequency background noise, normalizing the intensity of the individual particles images, removing reflections, and masking portions of images. Image preprocessing is the technique of enhancing data images prior to computational processing. The initial task of vehicle detection is to convert true color input image into gray level image. This is achieved using equation (1).

$I_g = 0.2989*R + 0.5870*G + 0.1140*B$ .... (1)

where R represents the red color, G represents green color and B represents blue color; I_g, represents gray scale intensity.

C. Image Enhancement The principal objective of image enhancement is to process a given image so that the result is more suitable than the original image for detecting objects. The enhancement does not increase the inherent information content of the data, but it increases the dynamic range of the chosen features so that object can be detected easily.

D. Absolute Difference Image arithmetic is the implementation of standard arithmetic operations, such as addition, subtraction, multiplication, and division, on images. Image arithmetic has many uses in image processing both as a preliminary step in more complex operations and by itself. Image subtraction can be used to detect differences between two or more images of the same scene or object. For this process two images are needed. First one is the reference image (road image without vehicles) and another one is its corresponding road image with vehicles. This process is achieved by equation (2)

g (x, y) = — h (x,y) - f (x,y) — .... (2)

where h(x,y) denotes the gray scale road image without vehicles and f(x,y) denotes gray scale road image with vehicles. It subtracts each element in array f(x, y) from the corresponding element in array h(x, y) and returns the absolute difference in the corresponding element of the output array g(x, y). h (x,y) and f (x,y) are real, nonsparse numeric arrays with the same class and size. g has the same class and size as h (x,y) and f (x,y). If h (x, y) and f(x, y) are integer arrays, elements in the output that exceed the range of the integer type are truncated.

b) Filtering After pre-processing, image enhancement is done. Image enhancement operations namely median filter, wiener filter, averaging filter, smoothing filter, adaptive noise removal filtering, cross correlation can be used to improve the quality of an image. In this work median filter is used. In median filtering, the neighboring pixels are ranked according to brightness (intensity) and the median value becomes the new value for the central pixel. Median filters can do an excellent job of rejecting certain types of noise, in particular, shot or impulse noise in which some individual pixels have extreme values. Median filter can be used to improve image contrast and brightness characteristics, reduce its noise content or sharpen its details. The algorithm for median filtering requires arranging the pixel values in the window in increasing or decreasing order and picking the middle value.

Steps for 2D-median filtering: 1. Construct a window of size [x , y] 2. Sort the values in the window 3. Find the median value 4. Keep the border values unchanged 5. Replace the remaining values in the window with median value

6. Slide the window Median filtering is a nonlinear operation often used in image processing to reduce ”salt and pepper” noise. Median filter is more effective than convolution when the goal is to simultaneously reduce noise and preserve edges. Smoothing is often used to reduce noise within an image or to produce a less pixelated image. Most smoothing methods are based on low pass filters. A low pass filter is the basis for most smoothing methods. An image is smoothed by decreasing the disparity between pixel values by averaging nearby pixels. Using a low pass filter tends to retain the low frequency information within an image while reducing the high frequency information. Some specific smoothing and filter types are: Kalman filter, KolmogorovZurbenko filter, Digital filter and so on. In particular, compared to the smoothing filters, a median filter does not shift boundaries, like conventional smoothing filters (a contrast dependent problem) and also the median is less sensitive than the mean to extreme values (outliers), those extreme values are more effectively removed.

D. Image Segmentation Image segmentation has become an indispensable task in many image and video applications. This work proposed an image segmentation method based on the modified edge-following scheme where different thresholds are automatically determined according to areas with varied contents in a picture, thus yielding suitable segmentation results in different areas. The simplest method of image segmentation is called the thresholding method. This method is based on a threshold value to convert a gray-scale image into a binary image. The technique behind this method is to select the threshold value (or values when multiple-levels are selected). Several popular methods are used in industry including the maximum entropy method, Otsus method (maximum variance), and K-means clustering.

a) Otsus Binarization In this work Otsus Binarization or gray level thresholding is applied on the enhanced image to label the vehicles. Otsus thresholding converts the gray level image into binary image. Otsus method is the most successful global thresholding method. It automatically performs histogram shape-based image thresholding for the reduction of a gray-level image to a binary image. The algorithm assumes that the image for thresholding contains two classes of pixels (e.g., foreground and background) and then calculates the optimum threshold separating those two classes so that their combined spread (intra-class variance) is minimal. It exhaustively searches for the threshold that minimizes the intra-class variance, defined as the weighted sum of variances of the two classes. Global thresholding, using an appropriate threshold T:

n(x, y) = 1, if g (x, y) ¿ T n(x, y) = 0, if g (x, y) T ....(3) where n(x,y) represents the binary image. The result of the computation displays binary image.

E. Morphological Operations The segmented image undergoes a series of morphological operations to detect the exact shape of the object. Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. Morphological operations are affecting the form, structure or shape of an object, applied on binary images (black white images Images with only 2 colors: black and white). It can be used in pre or post processing (filtering, thinning, and pruning) for getting a representation or description of the shape of objects/regions (boundaries, skeletons convex hulls). The dilation process is performed by laying the structuring element on the image. If the origin of the structuring element coincides with a ’white’ pixel in the image, there is no change; move to the next pixel. If the origin of the structuring element coincides with a ’black’ in the image, make black all pixels from the image covered by the structuring element. The erosion process is similar to dilation, but here pixels are turned to ’white’, not ’black’. If the origin of the structuring element coincides with a ’white’ pixel in the image, there is no change; move to the next pixel. If the origin of the structuring element coincides with a ’black’ pixel in the image, and at least one of the ’black’ pixels in the structuring element falls over a white pixel in the image, then change the ’black’ pixel in the image (corresponding to the position on which the center of the structuring element falls) from black to a ’white’.

a) Opening Opening consists of an erosion followed by a dilation and can be used to eliminate all pixels in regions that are too small to contain the structuring element. In other words, foreground structures that are smaller than the structure element will disappear.

b) Closing Closing consists of a dilation followed by erosion and can be used to fill in holes and small gaps.

Closing can also be used to remove pepper noise in images. It is normally applied to binary images. Closing is the dual of opening, i.e. closing the foreground pixels with a particular structuring element, is equivalent to closing the background with the same element. To extract the targeted vehicle, shape index or structuring element is computed. A structuring element is simply a binary image (or mask) that allows us to define arbitrary neighborhood structures. In this work disk- shaped structuring element is used. Binary image area open and closing Morphological operations are used to segment the vehicle. Binary image area open operation removes small objects that are smaller than the pixels and it produce another binary image. In that binary image closing operation is performed.

F. Object Analysis Region and image Properties are used to analyse the number of objects in an image. A region property can compute the 'area', 'centroid', 'bounding box' measurements and so on. To get region properties information about the objects in an image, centroid of the detected vehicle is computed. Using centroid points, number of objects is counted and displayed. The centroid of the object is determined as,

$m(x,y) = x\ i / i, \ \ y\ i / i$ .... (4)

where the centroid is denoted as m(x,y). The length of the centroid points are counted to display the number of vehicles in the image or vehicles found in an image. Then the result is used to control the traffic.

Modules: The system can be broken down into three modules which are as follows: 1) Cam-Feed Sensor: The system is connected to different cam feeds or cctv's which provide real time footage of the road. This cam feed sensor cams can be off different resolutions depending on the kind of the road to be monitored. A small patch of highway can be monitored by a basic 2MPix bullet cam, larger details can be obtained by 5-8MPix cams which are suited for monitoring 4-6 lane highways. 2) Object Detection and Movement Analyzer: This module is responsible for the analysis of the overall footage taken from the camera. This module employs various filtering and feature transform techniques to analyze the volume of the traffic currently on the road. The FPS rate here is between 8-10 fps. The system will use Hidden Markov Model for decision of traffic state. 3) Traffic Routing: This module will employ static route finder methodologies for finding the best way out depending on traffic conditions and distance/time taken to provide optimum route.

Conclusion

In the traffic monitoring systems, different methods have been proposed in the previous studies, but there have been few studies considering the road geometry as in this thesis. Temporal frame differencing and background modeling algorithms are implemented for foreground extraction in the literature. Although temporal differencing algorithms are well suited real-time applications, most of the previous implemented applications use probabilistic models to the model background. The reason for this choice is that adaptation to environmental changes such as illumination variations is necessary for outdoor applications. As a result, the second point to question is the trade off between the computational complexity and efficiency of the model used in the detection systems. Another important issue is the feature dependency of the proposed algorithms, where nearly all model based application proposed in literature based on the valid feature selection. Image oriented, discriminant and reliable feature sets such as texture, color, edge, etc.., are extensively used in the detection and tracking systems to analyse the scene. Previously proposed systems handle most of the problems such as occlusion. However, most of them are implemented for close-up recordings. After considering the outlined issues above, in this study we performed a feasibility study of a road monitoring system where adaptive bounding box size is used to detect and track vehicles according to their estimated distance from the camera.

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