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Controlling High-Traffic Intensities: Detection of Vehicular Movement in a Pre-Specified Region of Interest Using Morphological Image Processing

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Abstract- Traffic intensities in Sri Lankan roads are ever increasing making current traffic light system ineffective. Then it is imperative to make new methods to control increasing traffic. This end could be achieved only by eliminating inherent defects in traffic light system. Among approaches suggested to address the problem of managing higher traffic intensities includes extract information about the traffic concentration by processing digital images. This study attempts to estimate the traffic intensity by using image processing which also a part of intelligent traffic control system adopted in the future.

This study focused on eliminating the problem encountered in commercial image processing system which does not work well in traffic congestions. The difficulty arrives when vehicles are exposed partially and appears differently under different light and environment conditions. This study proposed to develop an algorithm to detect vehicles from a stream of images extracted from a video. This algorithm will separate vehicles from their backgrounds and detect vehicles on the basis of morphological characteristics.

Data collection was carried out from a video camera mounted at higher elevation on the road sides in different places (Peradeniya) in the city and sequence of image sets were collected from sampling frames. These sequences are used to test the algorithm formulated

Index Terms- Image processing, Vehicle detection, Image subtraction, Morphological image processing, Object tracking

I. Introduction

Detection and classification of vehicular traffic is considered not only important but also essential for modern traffic control systems. Presently in Sri Lanka, the only traffic control mechanism is the traffic light, which is triggered using timers. This system has some inherent defects obviously due to the fact that the system had been developed at a time when the traffic flows on the roads were less in intensity. The traditional approach for improved traffic handling is to install intelligent traffic lights that are controlled by inductive sensors mounted under the road surface. However, installing and maintaining such a system in most of Sri Lankan roads is nearly impossible due to the way the roads are constructed and maintained.

Therefore, in order to handle higher traffic intensities, it can be hypothesized that one of the faster approaches is to process digital images and extract information rather than installation of other sensors and connected hardware which is a more involved invasive procedure. It is necessary that digital images be processed and information about the traffic concentration be extracted from them. In addition to the wheel clearance of the vehicle, such features as the number of vehicles on the move and the type of the vehicle at any given time are required to be estimated.

Hence, during initial stages of the research it was necessary to concentrate on identifying a mechanism to estimate the number of vehicles in the traffic flow based on the data collated from the images. This paper presents a novel camera based image processing system that can indicate the number of moving vehicles on the road, based on a streaming video taken through a web camera. This could be a part of the detection mechanisms in the proposed intelligent traffic control system in the future.

The mechanism thus developed required to carry the capacity to differentiate the various features of motorbikes and automobiles to classify them as individual vehicles. The determining factors were color intensity and shape of vehicles. The differences between the color or the shine of the vehicles and that of the asphalt ground had to be used in this research to identify vehicles. The type of vehicle, non-uniformity in the traffic flow and the unconventional driving habits of motorists are also bound to present an obstacle in processing the images.

Increasing number of vehicles (moving objects) on freeway and problems associated with existing sensors has increase an interest in new object tracking technologies such as video image processing. Available commercial image processing systems properly work in free flowing traffic, but the systems are very costly and have difficulties with congestion, shadows, overlapping and lighting illuminations. These problems partially occurs one another and the fact that vehicles appear differently under various lighting conditions.

In this research, an algorithm was developed to detect vehicles from a sequence of images extracted from a video. The path of each vehicle was extracted from this sequence as an effort to isolate and count them. In image processing, background subtraction is required to detect the vehicle precisely. Apart from using background subtraction, morphological image processing operations were also used in this study to filter the image.

Data collection was carried out at different places. A digital video camera mounted at a higher elevation by the roadside was used to acquire a video stream. Thus sequences of image sets were collected from the video by sampling different frames. These image sequences were used in testing the algorithms developed.

I. LITERATURE REVIEW

Moving object detection and tracking applications are widely used as embedded electronic systems. It is widely use in robotics, automated systems, imagine system, and many more. But this applications hardware and software integration is main core of performance of itself. Hence efficiency is mostly depends on its low level programming (Algorithms), hardware and input data.
There are two types of approaches discussed in Yokoyama [1] as region based approach and boundary based approach (contours). Most popular region based algorithm involves background subtraction and optical flow. The approach described here is also based on background subtraction. This method is responsive in constant background situations. But it does not work with rapidly changing backgrounds. This method is not considering region based, it depends on edge based approach. It's rather fast than normal region based method and its get some errors form when several sharp edges appears on effects of reflection and illumination. For overcoming the above deficiencies in the background optical flow with contour based model, Hai Tao, et al., [2] developed a model based on rapid image subtraction system. That model is rather advanced and capable of handling rapid changes in the background. Detection of vehicles by tracking their wheel is also a popular approach. This method was introduced by Achler and Trivedi[3] in their research. But it has some difficulty to detect a vehicle when another vehicle overrides at the same time.

Another popular method is block matching algorithm (BMA). In this method Stefano, and Viarani [4] keep all the available model (vehicle types) and compare each. For that reason it takes more time to find the exact vehicle. Due to the illumination and reflection of light, sometimes it can't match exact vehicle on the database. Tesei,et al.,[5] propose an algorithm for object recognition and track in as alone or group.in here moving objects(blobs) are tracking by using numerical characteristics. Algorithm is also based on moving blob matching approach.
Loria and Machi[6] present an algorithm used to identify find, bound and index moving objects at a pedestrian zebra crossing. This method detects moving blobs as pedestrian at crossing and find trajectory of object movement. This also region based method and it has illumination and light reflection problems on background.The proposed system is also mainly involved in object indexing (vehicle indexing). In the developed system, available object and the entire data map is instantly extracted into the table at the same time using Bwlabel function. The algorithm functions to manage apparently moving noisy components safely and also to recognize and track well behaving pedestrians and cars correctly. Work is ongoing to improve its efficiency in tracking vehicle on the road.

II. THEORETICAL BACKGROUND

A. Image thresholding

Thresholding[7] is a non-linear operation that converts a gray-scale image into a binary image. In levels between 0 and 255 are assigned to pixels that are below or above the specified threshold value. Finding optimal threshold value is very important factor for image morphology. Some gray levels operations combine with dynamic optimal threshold value for different occasions for avoid loss of data due to background illumination.

B. Image erosion

Erosion [8] is one of the two basic operators in the area of mathematical morphology, the other being dilation.
This operator basically apply for binary images and several parameters use for different operations. Some of them are working properly on grayscale images also.
The basic effect of the operator on a binary image is to erode away the boundaries of regions of foreground pixels (i.e. white pixels, typically). Thus areas of foreground pixels shrink in size, and holes within those areas become larger.

C. Object indexing (bwlabel)

L = bwlabel(BW, n)[9] returns a matrix L, of the same size as BW, containing labels for the connected objects in BW. The variable n can have a value of either 4 or 8, where 4 specify 4-connected objects and 8 specifies 8-connected objects. If the argument is omitted, it defaults to 8.Retun L matrix has different segment and has different values. It is depend on number of regions in the matrix. The pixels labeled "0" are the background and pixels"1"represent the first object and so on.
[L, num] = bwlabel(BW, n) returns in num, the number of connected objects found in the black & white image BW.

D. Center of gravity

The regionprops(Binary image, properties)[9] ,properties can be a comma-separated list of strings.

III. RESEARCH OBJECTIVES AND METHODOLOGY

The main objective of this part of the research was to track objects moving along the road. In order to be able to minimize problems due to computing capacity limitations, it was assumed that the number of simultaneously moving objects on the road is limited to 10 (however, software was developed so that this limitation could be released through software). It was also attempted to base the development on basic image processing techniques to save on computing time. In order to achieve the main objective, software routines were developed to identify different objects in a sequence of images, and to follow them through indexing. The methodology adopted is described in the form of a block diagram below.

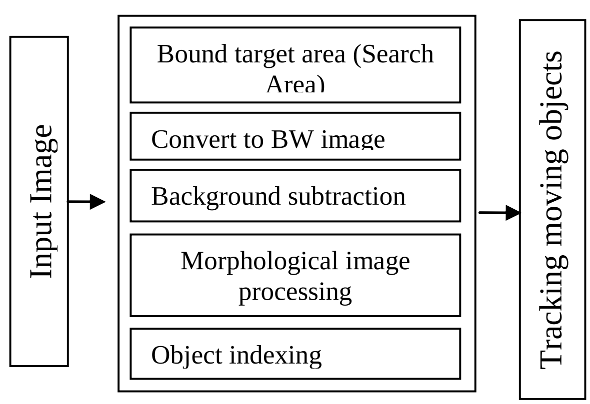

Figure 1- Block diagram of the procedure for tracking moving vehicles

A. Read image from video

Input image is read directly from a video in the developed proposed system that uses indeo5 video compression technique with 30 frames per second rate and with a frame size of 320x240.

Figure 2- Extracted color image

B. Video Image thresholding

Firstly, the color image was converted to a binary image. For that step, the method used was the MATLAB function Im2bw and the threshold value was kept as 0.4, based on many trials.

Figure 3-BW image

C. Remove unwanted area using a mask

Since these were taken from a fixed camera, only a smaller region becomes the region of interest (ROI), and the other areas need not be processed. Identification of a ROI, and limiting the processing to it can reduce the processing time. The ROI was therefore marked as shown below.

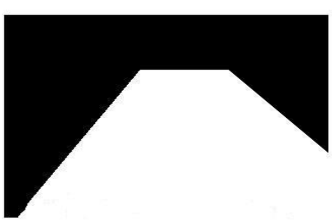

Figure 4- Background Mask

D. Morphological Image Processing

Image dilation was done using the strel [9] function. It increases the boundary region. The Image Processing Tool (IPT) function strel constructs structuring elements with a variety of shapes and sizes.

E. Tracking Objects

The initial position of the object is detected as it enters the ROI. At this position bwlabel function was used to return the Centre of gravity of a particular object. Noise points were removed by assuming a minimum size of a vehicle image in the ROI. The next location of the center of gravity of each object region was found by comuting the inter distance.

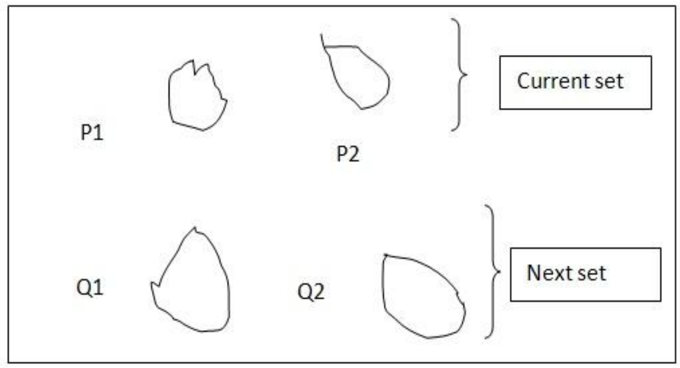

Figure 5 - Object with ROI

$$Target\ Pixel = P_n(x_n, y_n)$$
$$Predicted\ Pixel = P_{n+1}(x_{n+1}, x_{n+1})$$
$$Current\ Pixel\ Set(C) = \{P_1, P_2, \dots \dots . P_n\}$$

Where; C is a set of current object pixel coordinates.

$$Next\ Pixel\ Set(N) = \{Q_1, Q_2 \dots \dots . Q_m\}$$

Where; N is a set of next object pixel coordinates

$$Difference(D_{P1}) = \begin{Bmatrix} (P_1 - Q_1), (P_1 - Q_2), \dots \\ \dots . (P_1 - Q_m), \end{Bmatrix}$$
$$D = \{D_{P1}, D_{P2}, \dots \dots . D_{Pn}\}$$

Where; D is the cumulative inter pixel difference.

$$P = \{min[(D_{p11}, D_{p12} \dots D_{p1m})], \\ min[(D_{p21}, D_{p22} \dots D_{pmm})] \dots .. \\ min[(D_{pn1}, D_{pn2} \dots D_{pnm})]\}$$

Where; P is the closest next location of the center pixel concerned.

V. DATA COLLECTION AND ANALYSIS

In this analysis, the object indexing approach was used mainly. It kept the current positions and judged the most suitable next position by comparing the least distance out of the set of differences.

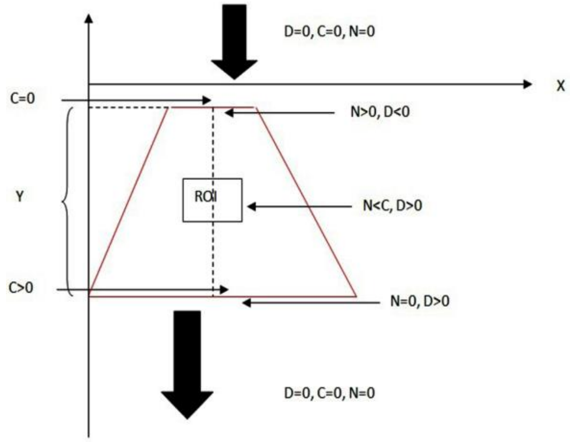

Figure 6 – Y-Coordinate assignment with inter pixels coordinates set (incoming)

Inter pixel set (D)
Difference=Current – Next
D=C-N

1. Before an object enters the ROI: D=0,C=0,N=0

2. After an object enters into the ROI: C=0, N>0

   Hence; D=C-N <0 (since N is a high value)

3. As the object moves within the ROI:

   Then immediate next pixel set C, becomes equal to N and N carries the next value set. Therefore; D=C-N >0 (Positive value)

   If D remains constant, its indicative of an object moving at a constant velocity.

4. As the object exits from the ROI: C has small positive value (nearly equal to the zero), N become zero.

   Then D=C-N >0 (positive peak).

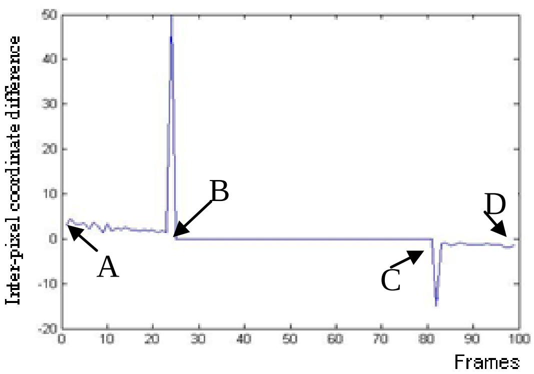

Figure 7 - The graph of object's Inter-pixel coordinate difference

Figure 7 illustrates the movement of object in ROI.
AB= movement of the object in ROI
B= indicates the point where the vehicle leaves the ROI
BC = shows no object in ROI
CD = shows the movement of object in ROI
At the region A-B and C-D shows some object movement in the ROI. In position B, it has a positive peak. It means that, one vehicle exits the ROI. In position C, it has a negative peak. It means that a vehicle along the path enters the ROI.

A situation where a vehicle enters the ROI from the bottom side of the frame is described below.

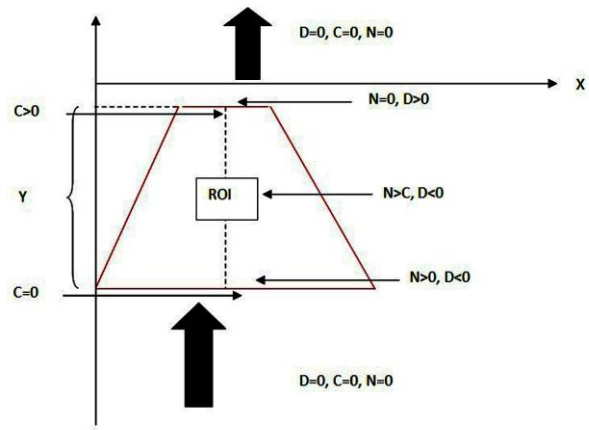

Figure 8 – Y-Coordinate assignment with inter pixels coordinates set (outgoing).

1. Before ROI(D=0,C=0,N=0)

   No object detect on this region just enter object from bottom of ROI

   C=0 and N >0 (N has small positive value)

   Hence D=C-N <0 (Negative peek)

2. Within the ROI, next immediate frames C replace with N pixels value and N find suitable next data set.

   Then, D=C-N in here N>C. therefore

   D=C-N <0

   D has small negative value

3. Just exit the ROI

   This particular position C has positive high value and N instantly become a zero. Therefore,

   D has positive peak.

D=C-N C>0 and N=0, D > 0 (high positive peak).

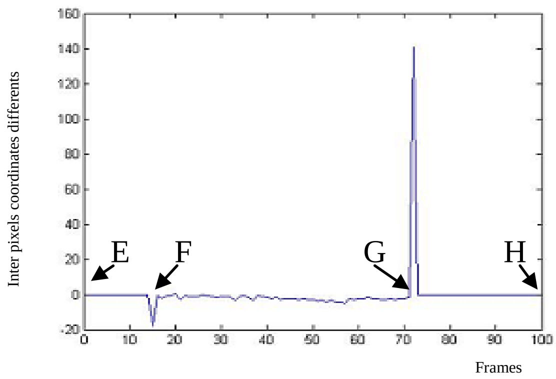

Figure 8 - The graph of object Inter-pixel coordinates difference

Figure 8 illustrates the movement of object in ROI.
EF = the straight line indicates no object in ROI
F= indicates the entrance of the object in ROI
FG = illustrates the changing nature of the speed of the object
GH = the constant pattern indicates the constant velocity of the speed.
H= exit point of the object from ROI
HI = no movement of objects in the area

Table I: Comparison of actual count and model count

No of Frames	5200
Actual Vehicle Count	55
Program Count	67
Vehicle Detection Accuracy	78.18%

VI. FUTURE WORK

In this research, we have analyzed the traits of the traffic images and put forward a method of detecting moving vehicles in the traffic video. At the same time, the processing techniques need to be further improved to obtain better vehicle identification and separation by a combination of inter-frame difference method and background subtraction method. It is also suggested to find a suitable dynamic threshold value for each and every frame.

It is necessary to consider variations in the scene due to sunshine and rain for further improvements. Experiments indicate that it can satisfy real-time requirements of vehicle detection under controlled conditions. Its disadvantage is that the detection efficiency is not very satisfactory. Incorporating color in image segmentation may make the identification more efficient, even though it would be more demanding. A study is carried out to improve the accuracy of the detection method in all kinds of environments in order to adapt the moving vehicle detection in different situations even when the road is much crowded.

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