FUZZY CONTROLLER FOR AN IMAGE BASED TRAFFIC SYSTEM

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Abstract:

Traffic problems nowadays are increasing because of the growing number of vehicles and the limited resources provided by current infrastructures. The simplest way for controlling a traffic light uses timer for each phase.

We propose a fuzzy based system for traffic control since the most desired factor in a traffic controller is that it should be adaptive to any changes in the traffic flow. Thus a fuzzy logic enables control engineers to systematically implement control strategies used by human operators with experience and expertise. The system detects vehicles through images instead of using electronic sensors embedded in the pavement. The image sequence is analyzed using digital image processing for vehicle detection and a set of fuzzy rules tuned to urban traffic conditions are used for traffic control. The image-processing modules extract visual data from the scene by spatio-temporal analysis during daytime and by morphological analysis of headlights at night. A MATLAB-SIMULINK environment is used for implementation.

Index Terms— Fuzzy rule base, multi-level thresholding, optical flow, image processing, segmentation

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I. INTRODUCTION:

Automatic vehicle detection in traffic scenes is an important goal in the field of transportation systems, since it allows the enforcement of traffic policies with precise information on traffic. Image Processing Techniques have been employed in the Vehicular traffic tracking system thus making the system act like a complete urban traffic monitor which is able to track vehicles and also to count vehicles.

In a conventional traffic light controller, the traffic lights change at constant cycle time. Hence it does not provide an optimal solution. A traffic light controller based on fuzzy logic can be used for optimum control of fluctuating traffic volumes thereby improving the vehicular throughput and minimizing delays.

A vision based camera is used to detect vehicles in traffic scenes and extract visual data using image processing techniques. Detection of vehicles in images represents an important step towards achieving automated roadway monitoring capabilities. Since traffic system has to operate in various luminous conditions over 24 hours two models i.e. one for day time and another for night time will be required. The models are implemented using MATLAB SIMULINK environment.

The SIMULINK provides an interactive graphical environment and a customizable set of block libraries that let you design, simulate, implement and test a variety of time varying systems, including communications, controls, signal processing, video processing and image processing.

II. DAY - TIME VEHICLE DETECTION:

Automatic vehicle detection mainly consists of three steps: detection, classification, and tracking. The detection step is to segment objects of interest from its background. The classification step is to recognize the types of the segmented objects and put them into the right categories. The tracking step is to re-identify the same object in a sequence of frames to enable movement data collection over a distance. Through the above three steps, a complete spatio-temporal trajectory for each vehicle appearing in the field of view can be collected.

Two algorithms for motion detection are optical flow algorithm and frame differencing algorithm.

Optical Flow:

Optical flow is the motion of brightness patterns in time-varying images. There are many different methods to estimate the optical flow, which can be divided into correlation, energy, phase and differential based method. The differential based method of estimating optical flow, based on partial derivatives of the image signal and the sought flow field and higher-order partial derivatives, can be solved using Horn Schunck method, Lucus Kanade method, Buxton Buxton method, Black Jepson

method and Discrete Optimization method.

In Horn Schunck algorithm, there are two types of important parameters; number of iteration and smoothing, which are used to produce the optimum motion of optical flow.

Frame Differencing:

Frame-differencing algorithms can be divided into two main categories: difference with background and inter-frame difference. SAD block of SIMULINK is one of the most effective algorithms in current automated video surveillance systems. SAD is a summation of the absolute differences between pixels in an image. In this algorithm, each pixel is compared with every pixel from the next image (one frame delay).

The Inter-frame difference algorithm takes the difference between previous and next frame. If the difference is greater than threshold value, the frame is captured otherwise it's ignored. In difference with background algorithm the first frame is captured and considered it as the static base frame. Next all other frames are subtracted from this static base frame. When the difference is greater than some threshold value, then only frame is captured and displayed.

Background Subtraction:

Background subtraction is the process of separating out foreground objects from the background in a sequence of video frames. However, such a solution is not feasible for many surveillance problems where the background is not known a priori. Moreover, if background image difference is used with no update of background image, this would lead to incorrect and unsuitable results. Therefore, the dynamic background extraction method which can estimate it while there are environmental changes in a traffic scene is required.

Object tracking requires **image segmentation** to make a distinction between the target objects and the rest of the scene in the captured image. This process partitions the captured image into several disjoint object regions based on discontinuity or similarity. Three types of intensity discontinuity detecting techniques are- Point, Line and Edge Detection.

Thresholding is the simplest method of image segmentation. The process of thresholding returns a threshold image differentiating the objects in motion (in white) and static background (in black).

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Morphology is a tool for extracting image components. Morphological operations preserve the image shape and make it simple, and increase the quality of the object. Morphological operations are used generally for the object structure improvement. We use closing, opening, erosion and dilation technique to fill the holes inside moving objects. The dilation is used for examining and expanding the shapes in the input image to extend the border of the regions of moving objects. Binary open operation based on the size of the objects is used to remove small unwanted objects.

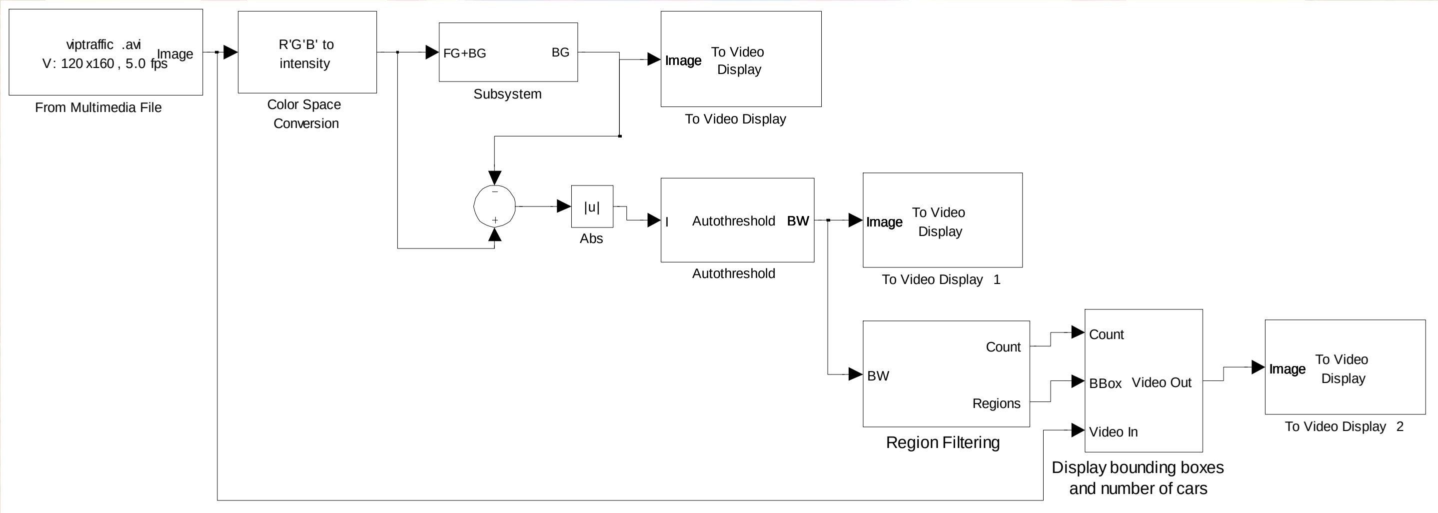

Figure 1: SIMULINK model for Day Frame

Initially a video is read from the multimedia file. Then using the colour conversion block the RGB image is converted into intensity format. The vehicle motion is detected and tracked along the frames using frame differencing with background algorithm. By thresholding and morphological closing on the motion vectors the binary feature images are produced. A Median Filter is then applied to remove salt and pepper noise from the threshold image without significantly reducing the sharpness of the image Median filtering is a simple and very effective noise removal filtering process and an excellent filter for eliminating intensity spikes. The labeled region in the binary image is then statistically analyzed using Blob Analysis and thus the cars are located in each binary feature image. Then rectangles are drawn around the cars that pass beneath a reference line and the number of blobs detected in the binary image is used to get the count.

Figure 2: Result obtained for Day Frame in MATLAB

III. NIGHT - TIME VEHICLE DETECTION

The main motivation for differentiating the vehicle extraction procedure at night is that the salient vehicle features are different from those in daytime illumination. The bright regions generated by headlights, taillights, brake lights and reflected lights around light sources are used as the vehicle feature in the night time. Traffic looks like a pattern of bright lights on a black background.

The algorithms for night vehicle extraction are as follows:

i. Image thresholding

ii. Template matching on the image with a headlight template.

iii. Cross – correlation on headlight pairs.

Template matching is a technique in digital image processing for finding small parts of an image which match a template image. Template matching can be subdivided between two approaches: feature-based and template-based matching.

In the template matching approach, researchers create a library of possible visual patterns of vehicles (objects) to seek similarity between a segment of the actual video frame and a library image, or template. Once such similarity is found, the frame part is classified as vehicles (objects) image.

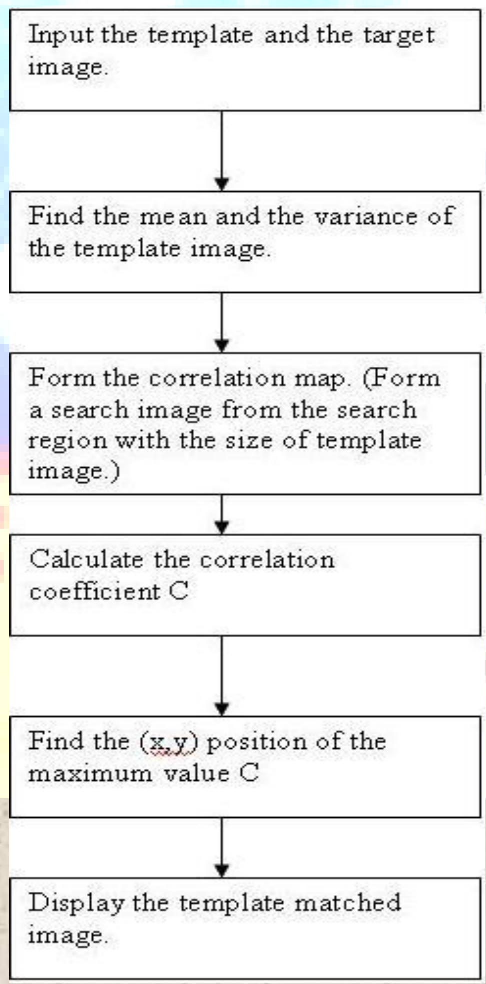

Figure 3: Block diagram for Template Matching

The matching process moves the template image to all possible positions in a larger source image and computes a numerical index that indicates how well the template matches the image in that position. Match is done on a pixel-by-pixel basis.

Template is a sub image that contains the shape we are trying to find. Accordingly, we centre the template on an image point and count up how many points in the template matched those in the image. The procedure is repeated for the entire image, and the point that led to best match, the maximum count, is defined to be the point where the shape (given by the template) lie within the image. If standard deviation of the template image compared to the source image is small enough, template matching may be used.

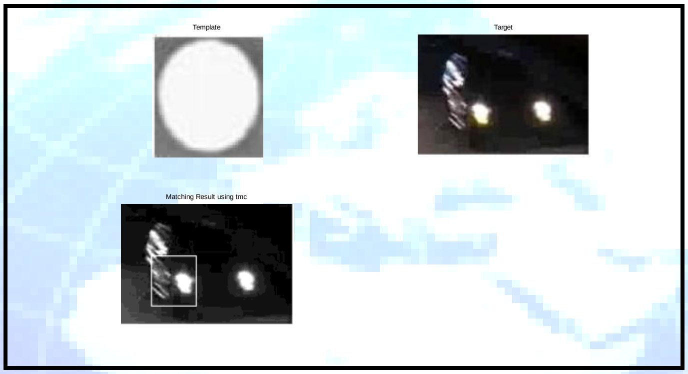

Figure 4: Result obtained for Template Matching in MATLAB

Drawbacks:

- The template matching is not very efficient because it requires the creation of a huge library of templates.
- Correlation is Computation Intensive. Matching by correlation utilizes the position of the normalized cross-correlation peak between a template and an image to locate the best match. This technique is generally immune to noise and illumination effects in the images, but suffers from high computational complexity caused by summations over the entire template.

- The method quickly fails by influence of disturbance, such as with illumination changes and rotation of the object.

Image Thresholding:

The Autothreshold Block of SIMULINK uses Ostu's method for image thresholding. The Otsu method is a basic method for threshold selection based on histogram analysis or the reduction of a gray level image to a binary image. The algorithm assumes that the image to be thresholded contains two classes of pixels (e.g. foreground and background) then calculates the optimum threshold separating those two classes so that their intra-class variance is minimal.

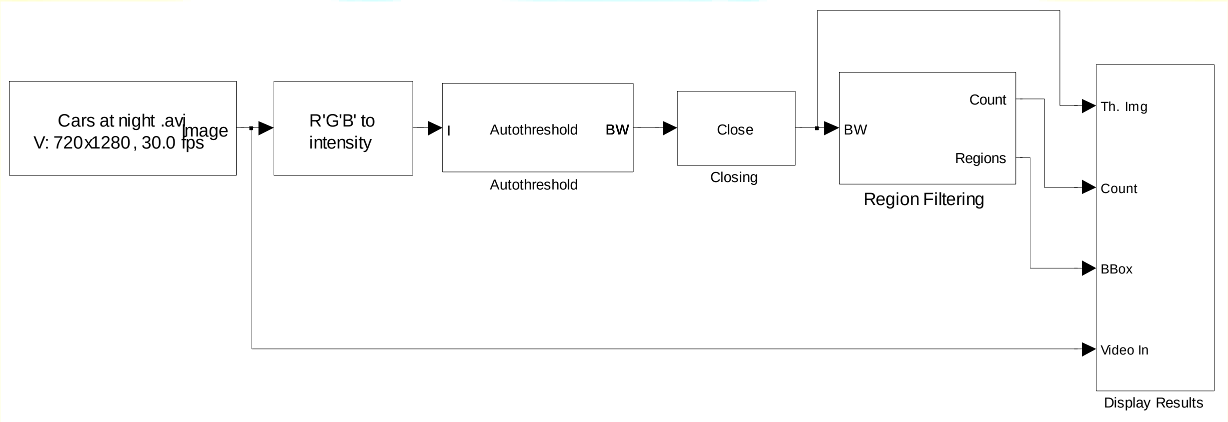

Figure 5: SIMULINK Model for Night Frame

The night time detector extracts vehicles using the morphology constraint like the headlight size and shape. Because the image histogram is strongly bimodal at night, a binarized image can easily be obtained with a simple threshold near the maximum intensity. In this binary image, the light sources are clustered using connected component labeling i.e Blob analysis.

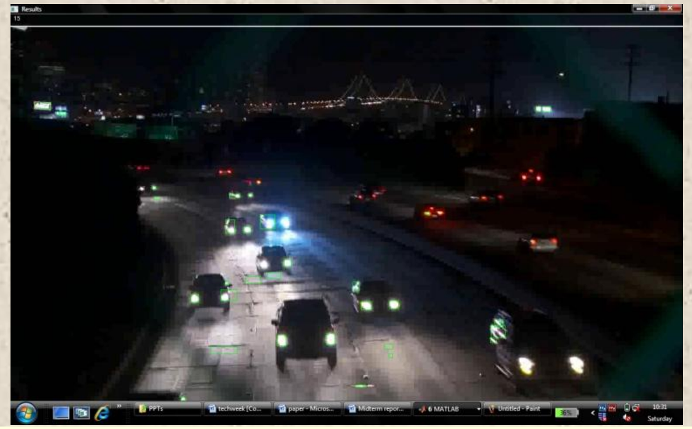

Figure 6: Result obtained for Night Frame using MATLAB

IV. FUZZY BASED CONTROL:

The main aim of designing Artificial Intelligence traffic controller is that the traffic controllers have the ability to adapt to the real time data from detectors to perform constant optimizations on the signal timing plan to reduce traffic congestion.

The components of a Fuzzy Traffic Controller are Fuzzifier, Fuzzy Rule base, Fuzzy Inference engine and Defuzzifier.

In this paper we have considered fuzzy controllers that involve a small number of fuzzy sets with simple membership functions. The fuzzy sets "Short", "Medium" and "Long" are associated with green phase module, next phase and decision module and an embedded MATLAB function is used for the switching module.

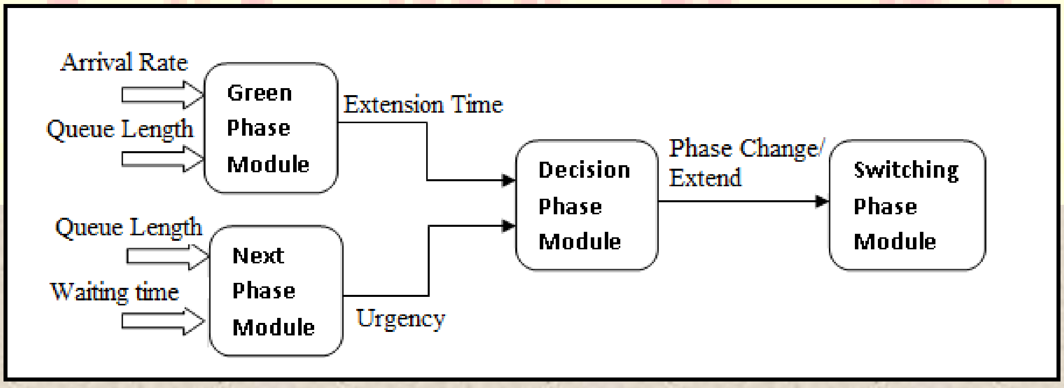

Figure 7: Proposed fuzzy based traffic light controller

Green Phase Module:

Green light extension time of the green phase is produced by this module according to the condition of the observed traffic flows. The length of the current green phase is extended or terminated depending upon the ‘arrival’ i.e. the number of vehicles approaching the green phase and the ‘queue’ that corresponds to the number of queuing vehicles in red phases.

A Mamadani Fuzzy Inference System has been used in the fuzzy controller and 13 rules have been defined in the fuzzy rule base.

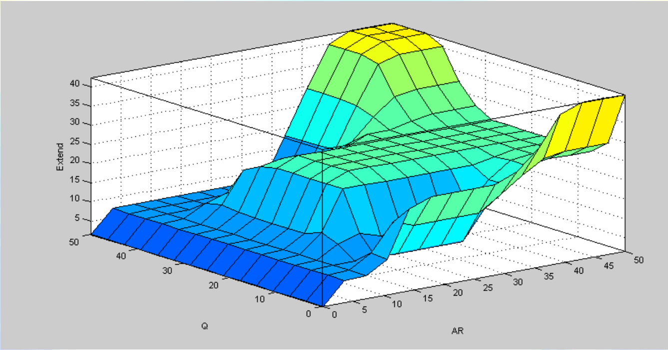

Figure 8: Result obtained using MATLAB for green light extension time.

Next Phase Module:

Next Phase module takes queue length in red phases and waiting time of red phases as inputs and produces the urgency of a phase to receive green signal as output. In an intersection road the most appropriate phase to receive green signal is decided by taking the maximum of the urgency of all red phases. 10 rules have been defined in the fuzzy rule base.

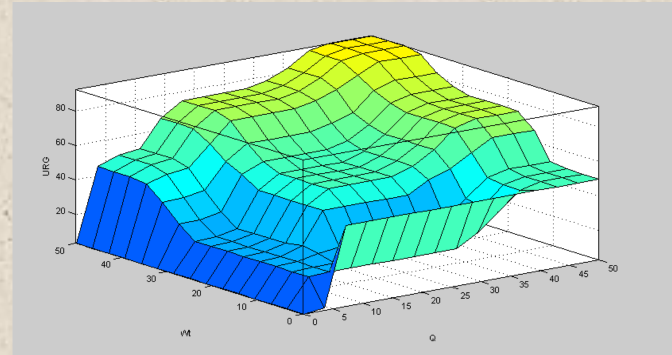

Figure 9: Result obtained using MATLAB for Urgency

Decision Module:

The Decision Module either extends the timing of the current green phase signal or shifts to appropriate phase depending upon on the urgency of next phase and extension time of the green phase.

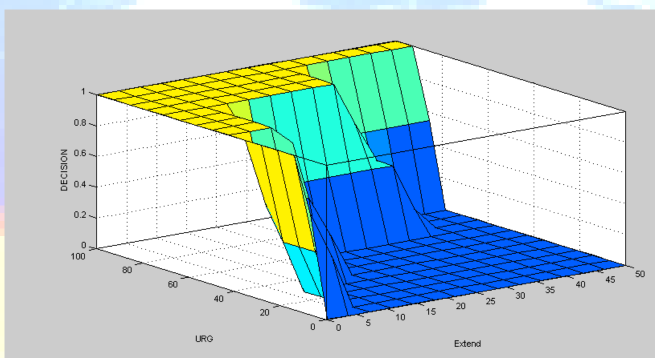

Figure 10: Result obtained using MATLAB for Decision Module

Switching Module:

This module does the actual switching to the appropriate next phase depending on the output of the decision module. A series of if-then statements are used in the Embedded Matlab Function block.

V. CONCLUSION:

Intelligent transport system is a wide research area where artificial intelligence and image processing can be applied to traffic data. In this paper, day – frame and night – frame models for vehicle detection are developed using SIMULINK. The traffic controller is developed using fuzzy inference method implemented in MATLAB.

Capabilities of this system include vehicle tracking, vehicle speed measurement (without use of traditional sensors), and recognition of license plate numbers of moving vehicles. Additional features of the system are object/data searching. In turn the vision based traffic monitoring system leads to reports of speed violations, traffic congestions, accidents, or illegal behaviour of road users. Thus they provide a helping hand in the tough job of traffic management.

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