Smart Controlling for Traffic Light Time

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***Abstract*— traffic jam and traffic accidents become serious problems especially in crowded cities, which wasting time and money. Traffic light is basic element in control traffic flow through specify waiting and going time, fixed traffic light time systems is bad control way, since number of cars is not consistency with each traffic light, thus lead to imbalance system. Intelligent transportation system including smart way to control traffic light time based on number of cars in each traffic light, this paper develops an automatic algorithm to control traffic light time based on artificial intelligent techniques and image for cars on traffic lights, this algorithm is validated by compare its results with manual results. Applying following proposed algorithm in transportation system will regulate traffic flow and reduce traveling and waiting time wasted in roads.**

***Keywords*— Intelligent transportation system;Intelligent traffic; light control; Traffic jam; Fuzzy logic; Artificial neural network .**

I. Introduction

Intelligent transportation system become a wide range area of research, due to increase number of vehicle especially in big cities, and increase number of accidents. Thus, improving intelligent transportation system will increase safety, reliability, and traffic flow speed, and reduce average travelling and waiting time for passengers

Intelligent transportation system includes many field such as automatic license plate recognition [1] which used in management door opening system, road traffic sign recognition [2,3,4] which used to help driver react to changing road condition and navigate diver to his/her trip, pedestrian protection system [5] which detect pedestrian and interact with car to do different action like auto braking, emergency vehicle notification systems [6] which produce alarms transmitted to specific stations in emergency cases including location of car and some important information, collision avoidance systems [7], and traffic light control systems [8,9] which control the most important elements in the road, they are systems that regulate traffic flow through determine specific time for wait , ready, and go. Traffic lights control drivers and pedestrians, and before control is implemented, the designer should understand the traffic pattern of the road for the drivers and pedestrians and other people using the street for commerce, social gathering, play. [10]

There are many ways to control traffic light time, they are mainly divided into two parts manually controlling which need a skilled person to monitor cars and control their flow, and hence man energy is required and producing non-accurate controlling process. The other part is automatic controlling, generally automatic controlling separated into sensor based [11, 12] and image processing based [13, 14]. Sensor based method depend on sensor network to detect cars such as infrared radar sensor [15], magnetic loop detectors buried under road [16], this costly process and need special infrastructure, also these sensors need periodic maintenance to keep its results correct. Image processing based method depend on images extracted from videos which recording use camera fitted on traffic lights, in which number of cars on each traffic light is computed, then traffic light is controlled depending on this number, this method is the most efficient and reliable one compared with previously mentioned methods.

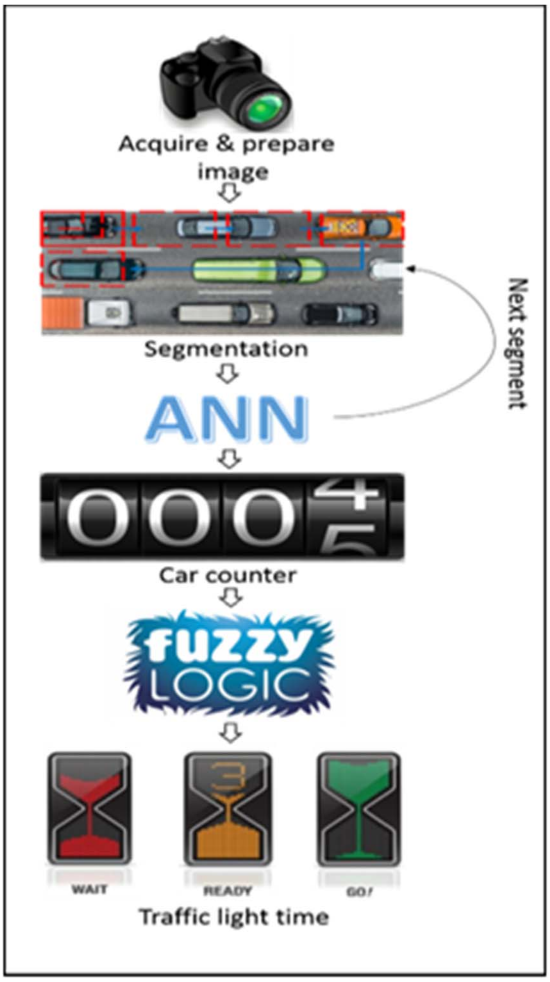

Figure 1 Algorithm overview, which starting by acquire and prepare image for cars on traffic light, then segment image into different parts using sliding window, and predict if each part is car or not using artificial neural network, total number of cars accumulated in car counter to control traffic light time using fuzzy logic controller.

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This study develops an automatic algorithm to control traffic light time based on image processing by acquire image for cars on traffic lights and ending with traffic light time as show in Figure 1, in following proposed algorithm two artificial intelligent techniques used which are artificial neural network and fuzzy logic controller with basic image processing operations, to count number of cars on traffic light and control its time.

II. THOERIES

As shown in Figure 1, the procedure of controlling the traffic light has mainly four parts. Firstly, the image that comes from the sensor (camera) is prepared, then segmentation is applied on the prepared image and then for each segment the artificial neural networks will predict if it is a positive segment (a car) or not. A counter will count the positive segments. Finally, the fuzzy logic controller is used to find the suitable periods for each light color in the traffic light. The following sections will illustrate each part.

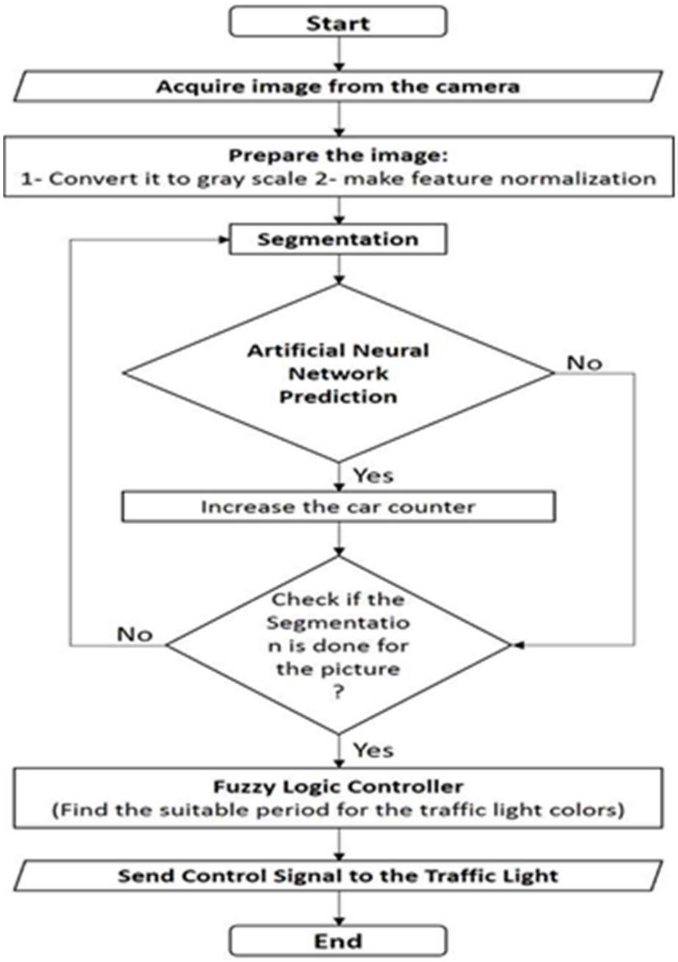

Figure 2 The flow chart that illustrates every part of the process starting with acquiring the image from the camera, then the segmentation and the artificial neural network. And the final part which is the fuzzy logic controller. It also shows the tuning process for the artificial neural network.

A. Acquire and Prepare Image

Firstly, image for road is acquired from an installed camera on tall structures at the traffic light site such that it can capture the overlook of the traffic scene on the road. This camera records video then images are extracted from the video at a specific time.

After that the image is edited to be suitable for the analysis. For better artificial neural network results, each image is converted from the red-green-blue space to the gray scale so the image will be read in a simpler form. The following equation presents the converting formula: [17]

$$I=0.333R+0.5G+0.1666B \quad (1)$$

Where R, G and B are red, green and blue intensities respectively, and I is equivalent gray scale intensity.

After converting the image to gray scale, the image features (elements) are normalized in order to improve the artificial neural network (the training data of the artificial neural network and the camera of the image has element with same range [-1,1]). The following equation presents the normalization formula: [18]

$$NI=(I-\mu)/\sigma \quad (2)$$

Where NI is normalized intensity, I is intensity value, μ is mean of all pixels, σ is standard deviation for pixels.

B. Segmentation

For segmentation part, Sliding Window technique is used. Which is an algorithm used for image analysis, it classifies each area of the image by cropping a certain box from the image and after the analysis applied, the box is moved to the next position to apply the analysis on it.

To count every car in the image regardless its size, the size of the moving box for the Sliding Window technique is changed and the same procedure it repeated. Figure 3presents the segmentation process and the changing in the box size.

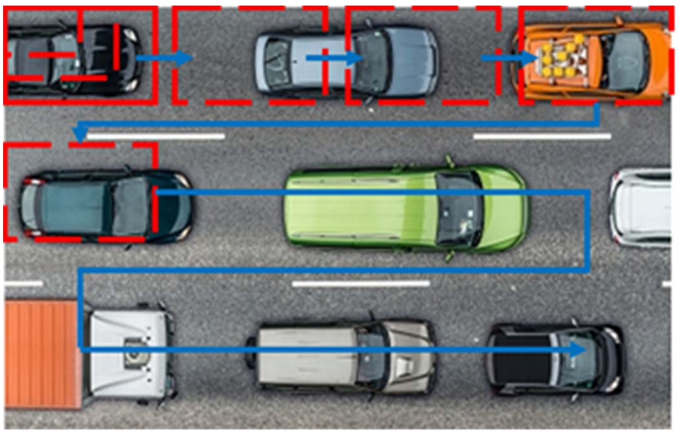

Figure 3 The Sliding Window technique and the change of window size.

C. Artifcial Neural Network

In this part, the output from the segmentation part (the cropped image) is classified to consider if it is a car or not. Firstly, the artificial neural network is tuned using training data, see Figure 4. The artificial neural network output depends directly on the training data used for tuning; the training data should be large and covers the most cases that may appear in the image.

To improve the tuning, the training data is resized to 20-by-20 and converted to gray scale. Such that every training data contains 400 elements.

The artificial neural network contains six layers; the input layer which contains 400 elements -hence each training data contains 400 elements- four hidden layers, each layer contains 100, 80, 60 and 30 elements, and the output layer which contains one element that shows how do the result close to a car. Back-propagation method is used training the neural network (tuning) in order to minimize the error between the actual output and the expected output for each training data.

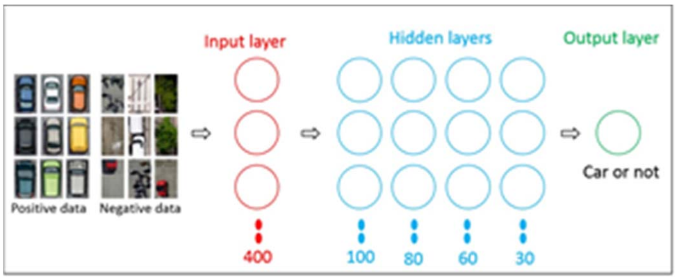

Figure 4 The artificial neural network flowchart: It will be tuned for positive and negative training data, and then it can predict if the image contains a car or not.

D. Fuzzy Logic Controller

The last part is controlling the traffic light depending on the previous parts result (the number of cars in the road). Fuzzy logic is used in this part because it is more reliable and has a biological inspire; the ON/OFF controller has crisp values (0 or 1), but the fuzzy logic controller has various states of truth and it uses reasoning rules for control. [20]

The fuzzy logic controller will decide the suitable period for the red and green lights in the traffic light depending on the number of cars in the road; as the number of cars increase, the period of the green light will increase at the expense of the period of the red light.

Firstly, the number of cars is converted from numerical variable $[0 \rightarrow 100]$ to linguistic variable (low, little low, medium, little high and high). Then the rules are applied to determine the green light period as linguistic variable. After that, the green light period is converted from linguistic variable (low, medium and high) to numerical variable $[0 \rightarrow 50]$. Figure 5 presents the membership functions for the cars and the period of the green light.

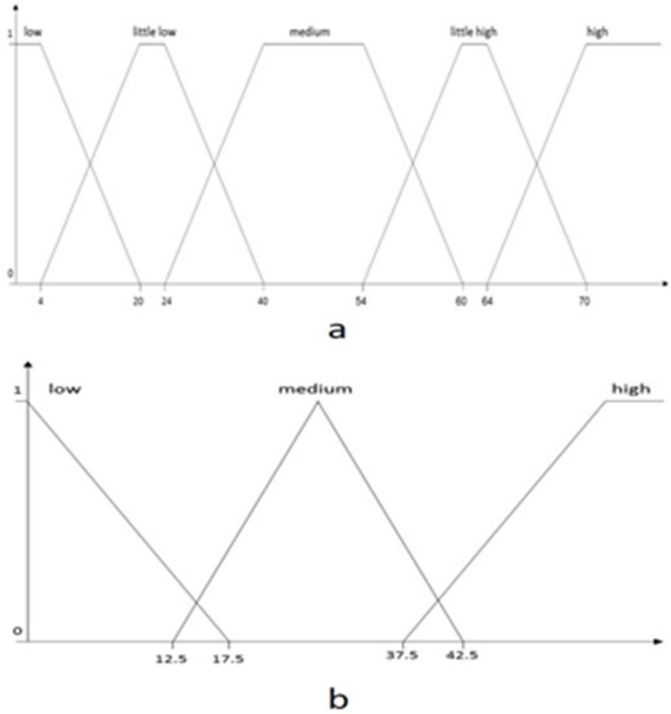

Figure 5 The membership function for the fuzzy logic controller. Where (a) is the input for the fuzzy logic controller (number of cars), (b) is the output of the fuzzy logic controller (period of green light).

The red-light period can be determined from the green light period using the following equation.

$$\text{Green Light Period} + \text{Red Light Period} = 60\ \text{s} \tag{3}$$

Where the total period will be changed depending on the location standard for the traffic lights. For the orange light, it does not depend on the traffic because it has a fixed period of 3 seconds.

III. RESULTS

The above algorithm is applied on pictures for cars in parking; since there is no pictures for cars on traffic light available, the execution time is about 1.5 seconds for one image. Results shows an error of about 2% (average error). Note that the system is not critical hence the error will affect the traffic light period by 1.5 seconds approximately. The following table illustrates the results:

Table 1 Test Results for 6 pictures

Picture No.	No. of Cars (Automatic)	No. of Cars (Manual)	Error (%)	Green Light Period
A	50	51	2%	25
B	58	56	3.6%	28
C	58	58	0%	28
D	108	108	0%	50
E	167	174	4%	50
F	283	272	4%	50

Figure 6 The six images used to test the program.

The table shows that the maximum error presented in the six pictures tested is 4% and occurs in the picutres B,E and F. Note that the error does not depend on the number of cars at each image, but depends on the overall elements in the image.

For example, in image B there is a bigger error due to the crowded people in the image hence if there are many peaple in a certain area, they may be considered as a car. And for the image E, the error occurs because the camera is not alighned correctly with the street. And for the image F, the error occurs because of the small distance between the cars. The size of the Sliding Window box has to be change many times, this will take a lot of time to reduce a small error which is not efficient.

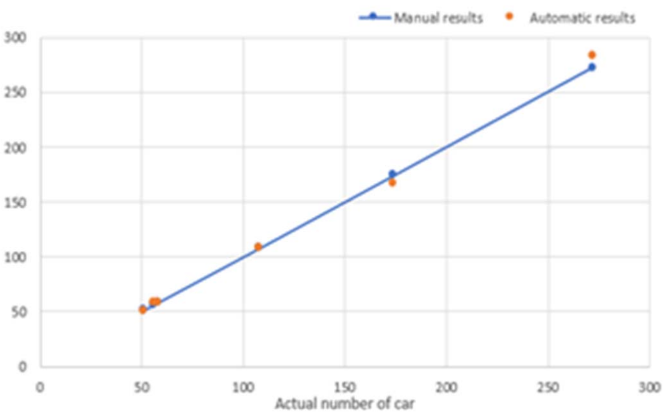

Figure 7 The actual number of cars versus the number of cars counted automatically

Figure 7 shows that the artificial neural network results are very close to the expected results so it is acceptable for the six tested images that presented in Figure 6.

And for the traffic light period, the result is acceptable if the result from the neural networks is acceptable hence it has the biological inspire, see Figure 8.

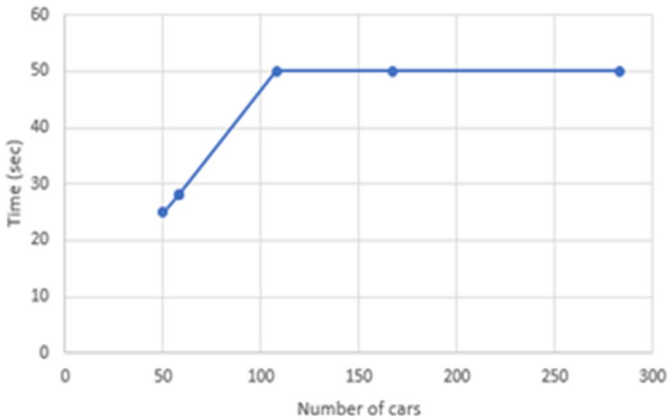

Figure 8 The relation between the number of cars in the road and the period of the green light in the traffic sign.

Figure 8 shows that green light period will increase with the number of cars in the image (the counted cars using the Sliding Window with the artificial neural network). It will increase until it reaches the maximum value (50 seconds), then it will saturate as shown in the figure.

IV. CONCLUTION

It has been found that the process used in this study is very useful and can improve the traffic light job with less cost than the other methods discussed before.

For the image analysis, it has been found that the image should be modified before analysis are applied on it; like converting it to the grayscale and normalizing its elements.

It has been also found that the Sliding Window technique is very useful for segmentation and any other analysis on the images. It has been improved such that its size is changed during the implementation so it can indicate any car regardless its size.

The artificial neural network has an accepted output with a maximum error of 4% and it can be reduced by aligning the camera correctly with the road. The error can also be reduced if the training data is increased with a new data that covers more cases. It has been found that the error does not depend on the number of cars in the road.

For the fuzzy logic controller, it has been found that it is reliable and has a biological inspire. So, it is preferred to be used with systems that have analog inputs and outputs because it has reasoning rules.

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