DESIGN OF REAL TIME SMART TRAFFIC LIGHT CONTROL SYSTEM

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Abstract: Traffic jam is a big problem that faces the specialists who work on the traffic management. It is a common problem in many countries and it differs in the degree and varies from place to place according to population and the good infrastructure of that country. Consequently, some countries have developed systems to control traffic congestion. There are many methods of controlling and managing streets, highways and roads. A common and old technique is to use a timer which controls traffic lights in each line. The other technique is utilizing electronic sensors which used to detect cars and vehicles. Image processing is one of the smart and intelligent techniques to detect cars and vehicles. In this paper, MATLAB software was utilized to detect and count the number of cars. First, a mounted web camera captures a photo of the lane or the road that need to control. Then the captured image of the road is sent to the MATLAB software installed on the PC for further process and then to detect the number of cars on the road by using image processing method. After that, the detection number of cars is used to calculate the suitable time for each lane to control the traffic light according to the congestion on each lane.

Keywords: Real Time, Traffic Control, Camera, Image Processing, Arduino.

I. INTRODUCTION

Traffic light is a one aspect of controlling which used to control and arrange the streets and intersections and provide a convenient system for vehicles flow through roads. The main objective of the traffic light is to prevent accidents by alternately assigning the right way. Over time, the objectives of traffic lights tend to minimize the traffic delay, fuel consumption and to maximize the capacity of passing cars and traffic flows. There are many shapes of traffic lights over the world which depends on some standards. In this regard, the color standards of traffic lights are following the universal color (red, yellow/amber and green) and there are some special colors for those who are color blind [1].Traffic congestion is a main problem in cities of all sizes. Day by day, the numbers of vehicles on streets and road are increasing with the increasing of population. This increasing bring about crowds streets especially at traffic light at peak time which cause many economic problems like wasting time, fuel and even worsen the environment is harmed by pollutants emitted from engines of waiting cars at traffic light[2]. Thus, this paper is planning to solve the above-mentioned problems using suitable and right technique to manage traffic lights.

So far, various techniques have been developed to make traffic light more intelligence. Inductive loops, sensors and image processing are the common types of intelligent tolls that used in intelligent traffic light[3]–[6].One of these techniques as presented in [7]. In [7], the emergency vehicles preemption system (EVPS) technique gives the emergency vehicles priority at traffic lights. So, junctions are connected with special GPS/radio antenna devices to receive signals from ambulances and civil defense trucks. Emergency vehicles can send the signals from up to 1 km away, and a smart traffic gives them a green light to pass while other sides stopping till the emergency vehicles pass.

Intelligent Cross Road Traffic Management System (ICRTMS) gives a type of an integrated intelligent system for management and controlling traffic lights with the help of Photoelectric Sensors (PES) [8]. The distribution of the sensors is very significant in this system because the traffic management department has to count vehicles moving at a specific area and then to transfer this data to traffic control cabinet. The cabinet controls the traffic lights depend on the sensor's readings by employing an algorithm based on the relative load of each road. With the calculation of the relative load of each road, the system will then open the traffic for the crowded road and give it a longer time as compared to the other less congested roads. The real time decision making ability of the system stands out very saliently. Moreover, the system can also be programmed for emergency scenarios such as passing of presidents, ministries, ambulance vehicles and fire-trucks that require virtually zero congestion through an active RFID based technology.

Intelligent traffic system cooperation ofMobile Ad-hoc Network (MANET) and image processing provided a new design for intelligent traffic systems that cover the features of surveillance via the cameras presented at the cross junction and with the help of data delivery systems let the users access that data [9]. Image analysis and foreground/background modeling schemes would be the important elements of surveillance and data transmission over a mobile Ad-hoc network because it comprises the data delivery part of the entire system. Various

experiments have been conducted in [9] and they exhibit great potential in parts of efficiency and real time execution.
Adaptive Traffic Control System (ATCS) reported in [6] is depends on image processing method to control traffic light with help of MATLAB software and also integrated with GSM, thus the signals can also be controlled with the help of mobile in case of an emergency. It consists of four important components: a camera mounted on a stepper motor and installed at each intersection, a PC with MATLAB for image processing tasks, a GSM engine and AT89C52 microcontroller for controlling stepper motor and traffic light signals. After the images have been captured and processed by PC, on time is assigned to each signal according to its traffic density. Transmitter GSM engine is installed in an ambulance to send emergency message while receiver GSM engine is installed at each intersection and assigned the highest priority in order to handle an emergency situation.

In [10], smart traffic lights switching and traffic density calculation using video processing was proposed to mitigate the problem of crowded. It uses a live video feedback from the cameras at traffic cross junctions for real time traffic density estimation using video and image processing. It also focuses on the algorithm for exchange the traffic lights according to vehicle density on road, thereby proposing at reducing the traffic congestion on streets which will assist lower the number of accidents. This system contains of four video cameras on the traffic cross junctions for each lane. Cameras will capture video and transfer it to the servers that using video and image processing techniques. The density on every lane of the street is estimated and an algorithm is used to switch the traffic lights accordingly.

In this paper, a smart traffic light controlling system using image processing technique to switch the traffic lights automatically. MATLAB software was utilized to detect and count the number of cars. After that, the detection number of cars is used to calculate the suitable time for each lane to control the traffic light according to the congestion on each lane. The proposed system gives the lanes that have highest number of vehicles longer time of green light signal. The proposed system showed its effectiveness by adjusting its algorithm techniques with time changes; daytime and night-time.

II. METHODOLOGY

The main purpose of this work is to provide a convenient technique to control a traffic light signal using image processing method.The block diagram of the proposed system is shown in Fig. 1. It consists of the main parts of the system; web camera, PC, Arduino and LEDs.

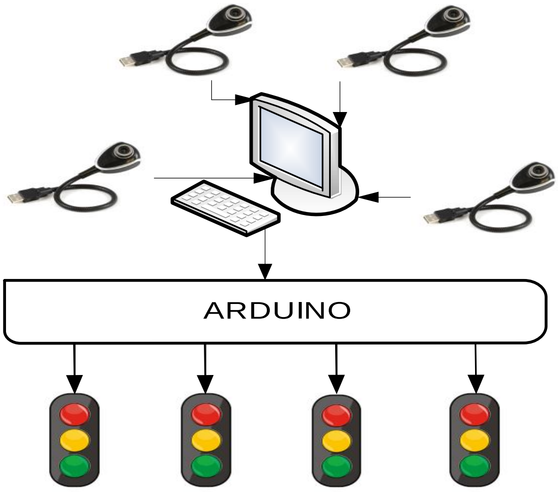

Fig. 1: Block diagram of the proposed system

The flow chart of the proposed system isillustrated shown in Fig. 2. It represents how the system operates starting when the camera captured a photo until the process is completed.

1.1. Working Principle of Proposed System

As illustrated in Fig. 2, the detection method of vehicles is divided into two different ways according to the time mode. So, during the daytime mode the subtraction count technique is used. While, during the night-time mode; it will be difficult to determine the number of vehicles. Therefore, the number of vehicles can be by counted based on the front headlights of vehicles.

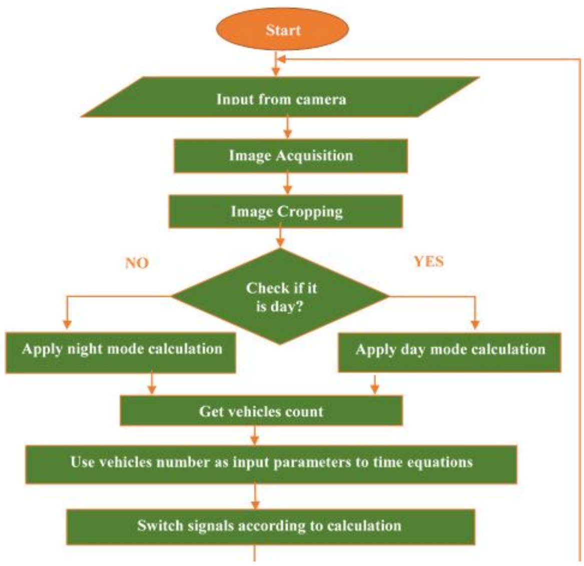

Fig. 2: The workflow of proposed system

1.1.1. Daytime Mode

The following steps show the working principle of the proposed system during daytime mode:

1. An image is captured for an empty road with no vehicles to be used as a reference image (RI)

2. Capture continuous sequence image frames from live video per one cycle, which is used as a current image (CI).
3. Crop the interest area of the road for both the RI and CI.
4. Apply the background subtraction between RI and CI to separate vehicles from the background and obtain the result image (I).
5. Convert the subtract image (I) from Red, Green, Blue (RGB) to Gray scale.
6. Useimage filtering techniques to remove any noise and produced a filtered image.
7. Use the function *bwboundaries* to make boundaries on objects and then count them.

1.1.2. Night-Time Mode

At night time, there are some problems to detect vehicles since the image will not be clear. To avoid this problem, night vision camera offers good solution; however, it adds more cost. The next steps can be used for the night-time mode:

1. The technique that applied to obtain black and white image in density count in daytime mode is used also here (steps 1-5).
2. After black and white image is produced, only the lights will remain white since they are more visible at night.
3. By using the function (NumObjets) in MATLAB, number of closed white color will be calculated.
4. Since each car has usually two headlights. So, the number of cars can be obtained by dividing the total number of headlights by two.

1.2. Traffic Light Signal Switching

The proposed system is able to calculate the number of all the vehicles inside the lanes at the any traffic light intersection that need to be controlled. After the total number of vehicles inside the lanes (*Nt*) is known, the total time that needs to complete one cycle can be determined. The time of any cycle can be calculated by product *Nt* with the time needed by the vehicle to cross the intersection (*Tv*) as expressed equations 1 and 2.

$$Nt = \sum_{i=1}^{4} Ni \qquad (1)$$
$$Tc = Tv * Nt \qquad (2)$$

where

Nt is the total number of vehicles inside the lanes.

Ni is the number of vehicles in each lane.

Tc is the total amount of time for one complete cycle of the traffic lights.

Tv is the time needed for any vehicle to cross the traffic light, for these experiments the value of Tv=2 sec.

To make the traffic light more dynamic, the weight factor (FW) of each lane was used by dividing the number of vehicles at particular lane over the total number of vehicles at all lanes as illustrated in equation 3.

$$FWi = \frac{Ni}{\sum_{j=1}^{4} Nj} \qquad (3)$$

After this parameters obtained, the time of green light at any particular lane can be determined by using equation 4.

$$TLi = FWi * Tc (4)$$

Where *TLi* is the time needed to switch the green light at a particular lane.

Finally, this value will be used to send instructions to Arduino to switch the signals accordingly based on the decision phase module.

After both modes were examined and satisfied the expected results, both programs of daytime and night-time modes were merged in one m-file. In MATLAB, one “for” loop was used and then the outputs are considered as input parameters for the equations *1* to *4*that used to calculate required time for every lane. An “if” condition function was used to determine whether time is day or night by calculation the mean(average) of the brightness at images and then make decision according to the value of brightness. Accordingly, the proposed system is working as in the following steps:

1. Capture an image and calculate the brightness.
2. Based on the results obtained during the experiments, it is found that if the brightness is more than 20 lux, daytime mode will run as mentioned above and will be repeated for all the lanes.
3. Based on the results obtained during the experiments, it is found that if the brightness is less than 20 lux, night-time mode will run as mentioned above and will be repeated for all the lanes.
4. From steps 2 and 3, the number of vehicles can be obtained and considered as input parameters to the equation of time of the traffic light.
5. Finally, instructions will be sending to the Arduino board to turn on/off lights at each lane according to number of vehicles.

RESULTS AND DISCUSSIONS

This work depends on programming and connection between Arduino and MATLAB software. First, the Arduino board is connected to the PC in order to upload the code that makes the interface between MATLAB and Arduino board. Without this code Arduino will not be able to recognize and apply the instructions that come from MATLAB.At the same time, MATLAB needs some support packages that are necessary to connect any external devices such as Arduino board and cameras. With MATLAB support package for Arduino hardware, MATLAB can be usedto interactively communicate with an Arduino board. The package enables us to perform tasks such as:

- Acquire analog and digital sensor data from your Arduino board.
- Control other devices with digital and PWM outputs.
- Drive DC, servo, and stepper motors.
- Communicate with an Arduino board over a USB cable or wirelessly over Wi-Fi.
- Build custom add-ons to interface with additional hardware and software libraries.

After the support packages and interfacing codes are finished uploading, first step for writing the code that used to detect and count number of vehicles. The proposed system is to detect and count number of vehicles according to the time of the detection daytime or night-time. As a result, two program codes on MATLAB were used.The first program is able to detect vehicles on the daytime mode as shown in Fig. 3 by using subtraction technique on images. At the beginning,the technique was applied on one lane by using one camera.The second program code was used to detect the vehicles at night-time mode as shown in Fig. 4 by counting the headlights of vehicles since the image will not be clear at night.

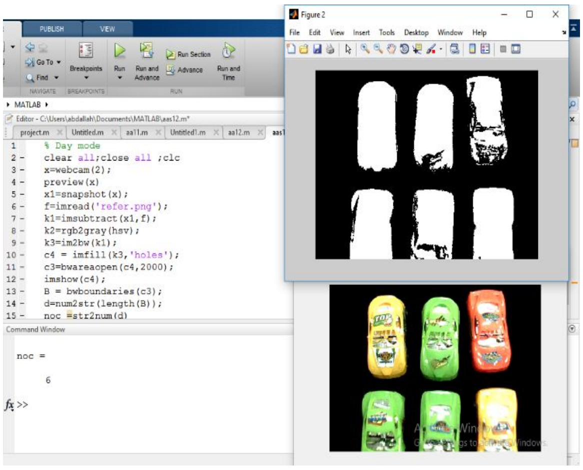

Fig. 3: Daytime mode

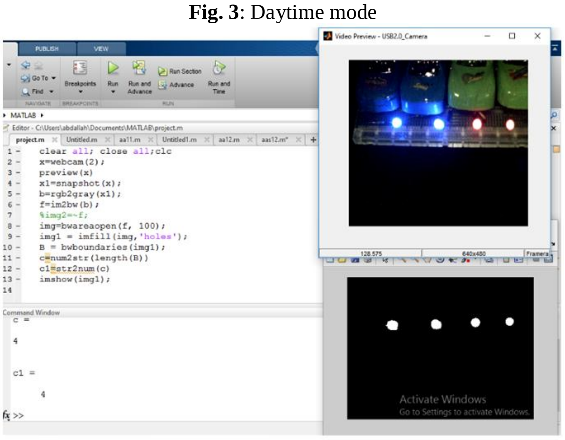

Fig. 4: Night-timemode

The proposed design in this paper went through for some experiments to validate its effectiveness in terms of the principle of work, expected results. Table 1 shows the implementation of random real time image frames of vehicles in the day and night-time modes as input. The total vehicles represent the number of actual vehicles in real time, and counted vehicles represent the number of vehicles counted by the system. In some image frames there may be some non-vehicle objects counted as vehicles so that the counted vehicles become more than the actual total number of vehicles. Also, some vehicles may not be detected so that the counted vehicles become less than the actual total number of vehicles. The system generates a good experimental result for 3 random rounds. Most of the vehicles are detected with high accuracy more than 86% which proven the effectiveness of the proposed design method.

Table 1: Measured Results

		Daytime Mode				Night-time Mode			
Rounds	lanes	Actual vehicles	Counted vehicles	Accuracy (%)	Time Given	Actual vehicles	Counted vehicles	Accuracy (%)	Time Given
Round 1	1	2	2	100	4	5	5	100	10
	2	3	3	100	6	7	6	86	12
	3	5	5	100	10	8	7	88	14
	4	4	5	80	10	1	1	100	2
Round 1	1	6	6	100	12	6	6	100	12
	2	2	2	100	4	2	2	100	4
	3	4	4	100	8	3	3	100	6
	4	0	0	100	0	2	2	100	4
Round 1	1	8	7	88	14	8	7	88	14
	2	0	0	100	0	1	1	100	2
	3	6	6	100	12	6	6	100	12
	4	0	0	100	0	2	2	100	4

A photo of the proposed system is shown in Fig. 5. All the components were placed on a wooden board which covered by A0 designed paper that simulates real traffic light intersection.

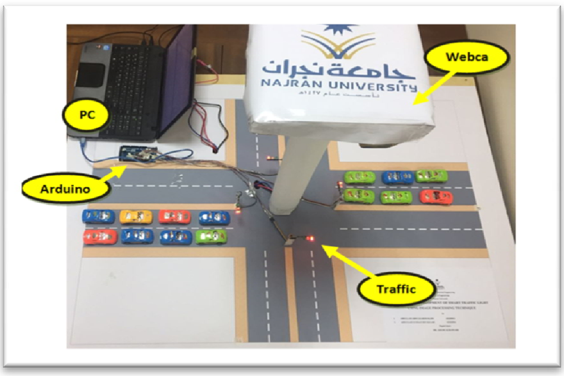

Fig. 5: Prototype of the proposed system

CONCLUSIONS

In this paper, a smart traffic light controlling system using image processing technique to switch the traffic lights automatically was designed and developed. The proposed system was working 24 hours, and the system was adjusting with time changes. In the daytime mode was able to calculate the number of vehicles by using image subtraction technique, while, in the night-time mode, the system was able to calculate the number of vehicles by measuring number of headlights. According to the crowdedness on lanes, the traffic signals will be switched. So, lanes with highest number of vehicles will have a longer time of green light signal.This proposed system offers the following benefits: providing easy method to control traffic light, adding intelligent to the traffic light to be more efficient, reducing the average waiting time at red lights, reducing the wastage of time for empty roads and saving energy wastage during wait at red light. As a result, this leads to greener environment and reducing the rates of accidents.

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