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Smart Traffic Light Controller

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Abstract—*There is an upsurge in the number of vehicles, around the world in the recent past, which cannot be managed efficiently, with the conventional traffic control systems which are currently in use. The traditional traffic signals function in a round robin fashion, allotting fixed time duration to each side, irrespective of the traffic density. The present traffic scenario requires modernisation of the system to make it more dynamic, in order to deal with the diverse traffic conditions. The objective of the project is to develop a density based dynamic traffic signal system, which works in real time by analysing the traffic using cameras, the input is then processed using python and openCV. The proposed system aims at dealing with the problem of traffic congestion, caused by the conventional traffic system, in an efficient manner.*

Keywords*: Image Processing, Traffic Density, Embedded Systems, Object Detection, Dynamic Traffic Management System.*

1. INTRODUCTION

There has been a massive rise in the number of vehicles in the last six decades, as shown in table 1, and following a similar trend a further swell is anticipated [2]. This rise in the vehicular population requires a sophisticated traffic monitoring system to replace the currently existing timed controller.

Traffic signals are the most convenient method of controlling traffic in a busy junction. But, we can see that these signals fail to control the traffic effectively when a particular lane has got more traffic than the other lanes. This situation makes that particular lane more crowded than the other lanes [1]. This condition of traffic congestion can be dealt with, by dynamising the conventional traffic light system, to adapt to the diverse traffic conditions and vary the duration of each signal in accordance with the situation.

The proposed system examines the possibility of deploying a real-time traffic signal controller, which receives information regarding the density at each side of the junction and utilizes the information to optimize the traffic signal scheduling at the intersection. The observed density value is used to vary the delay in the traffic signal. In general each traffic light is assigned a fixed signal time. It is possible to propose a time-based scheme, where the signal time is varied in accordance with the current traffic conditions [3].

To implement the density based smart traffic controller, four cameras are mounted, each facing a specific side of the intersection. These cameras are used to monitor the traffic intensity using image processing (object detection), which is being done by using openCV and python as the software. To ensure that there is a smooth and efficient transit at each intersection, the dynamic system issues a required duration of delay.

Table 1: Historical trend of number of vehicles[2]

S. No.	Historical trend of worldwide vehicle registrations 1960-2012 (thousands)		
	Type of vehicle	**1960**	**2012**
1	Car registrations	98,305	773,323
2	Truck and Bus Registrations	28,583	341,235
3	World total	126,888	1,114,558

Avoiding traffic jams is considered to be beneficial to both environment and the economy [4], and adaptive traffic management at intersections is one of the major contributors towards the same.

The rest of the paper is structured as follows: Section 2 outlines the related work. Section 3 discusses the proposed smart traffic control system, and the methodology used. Section 4 describes the system implementation and a discussion of results. Finally, conclusions and areas for future work are presented in Section 5 to conclude the paper. The final section of this paper mentions the references used for this work.

2. RELATED WORK

In retrospect there have been several works dedicated to the study and creation of a smart traffic control system. In terms of intrusive control, a system with weight sensors is proposed which divides the traffic based on the difference in weight and controls the signal using PLC and SCADA [2]. Another system proposed to solve the congestion related problems, uses simple electronic component like LED as traffic light

indicator, IR sensors to detect the number of vehicles and a microcontroller for defining the time period of the traffic light signal based on the density, but the range of the short range of the sensor is a major drawback for real time application [5]. Use of magnetic sensors along with optical sensors is another proposed system, magnetic sensors based on magnetoresistors are very sensitive and can detect the magnetic anomaly in the Earth's magnetic field that results from the presence of a car, but their continuous operation would drain more than 1.5 mA at 3 V, hence limiting the autonomy of a battery-supplied sensor node. Passive, low-power optical sensors can detect the shadow cast by car that covers them, but are prone to false detections. The use of optical triggering to wake-up a magnetic sensor, combined with power-efficient event-based software, yields a simple, compact, reliable, low-power sensor node for vehicle detection whose quiescent current drain is 5.5 μA. This approach of using a low-power sensor to trigger a second more specific sensor can be applied to other autonomous sensor nodes [6]. However, intrusive sensors may cause disruption of traffic upon installation and repair, and may result in a high installation and maintenance cost [7]. Non-Intrusive type of sensor is fitted on the road. The establishment of this type of sensor is easy as no cutting of road is needed to be done. Non-intrusive sensor includes audio sensors or video image processors to detect the presence of vehicles waiting at the traffic intersection. Petri nets (PNs) are utilized as a visual and mathematical formalism to model discrete-event systems. The system uses deterministic and stochastic PNs to design an emergency traffic-light control system for intersections providing emergency response to deal with accidents. It can be used to improve the state of the art in real-time traffic accident management and traffic safety at intersections [8]. Other schemes of traffic control propose the use of image processing and edge detection with MATLAB or openCV to establish the density and exercise control over the signal [9][10].

3. PROPOSED SYSTEM

The rise in the number of vehicles has resulted in a consecutive rise in the load upon the traffic management system. The system discussed in this paper uses LEDs as traffic signals, whose signal duration is varied by the microcontroller, in accordance with the density value received from the installed cameras.

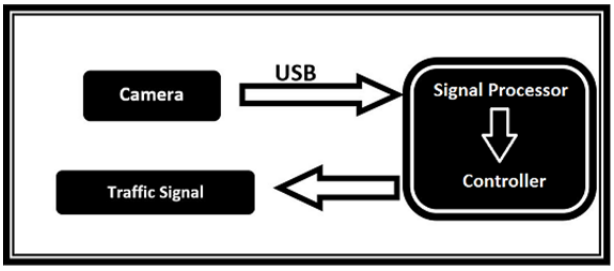

Fig. 1: Block diagram of the proposed system

3.1. Density Monitoring System

The functioning of the intended system is based on the number of vehicles at each side of the intersection, and in order to monitor the same cameras are installed in such a way that the vehicular count can be easily obtained. The real-time information obtained from the cameras is processed using python and openCV to get the required density value of each side.

3.2. Object Detection

The video input received from the cameras, connected to each side of the road is subjected to the process of object detection, which is done using a cascade classifier.

The cascade classifier consists of a list of stages, where each stage consists of a list of weak learners. The system detects objects in question by moving a window over the image. Each stage of the classifier labels the specific region defined by the current location of the window as either positive or negative – positive meaning that an object was found or negative means that the specified object was not found in the image. If the labelling yields a negative result, then the classification of this specific region is hereby complete and the location of the window is moved to the next location. If the labelling gives a positive result, then the region moves of to the next stage of classification. The classifier yields a final verdict of positive, when all the stages, including the last one, yield a result, saying that the object is found in the image [11].

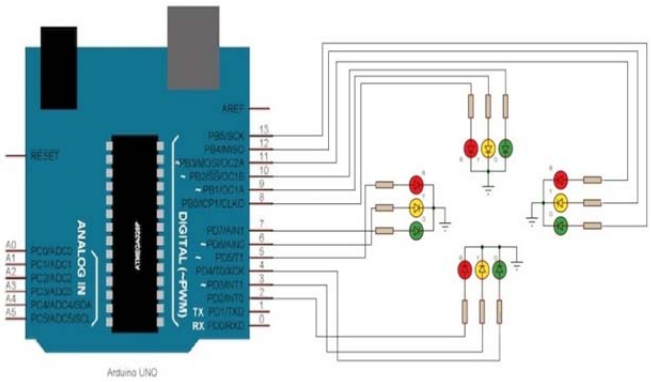

Fig. 2: Traffic signal controller set-up

3.3. Traffic Signal Controller

Arduino UNO board connected to the LEDs is used as the traffic signal controller, operating on the serial data received from the density monitoring system, mentioned earlier. The traffic density information is used to vary the signal length of the green light, in order to increase the system efficiency and optimize the traffic movement. The controller is as illustrated in Fig. 2.

4. IMPLEMENTATION AND RESULTS

The proposed system has been implemented in a model based prototype, to regularize the traffic at a four-way intersection.

4.1. Prototype Setup

The cameras placed at each side of the junction, pick up real-time signals and communicate the data to the processor. The video input to the signal processor is then subjected to object detection, which is done using cascade classifier, in python with openCV library. Density estimated by the signal processor system is compared to the preset threshold value, and this comparison is used to establish the time delay to be given to each green signal.

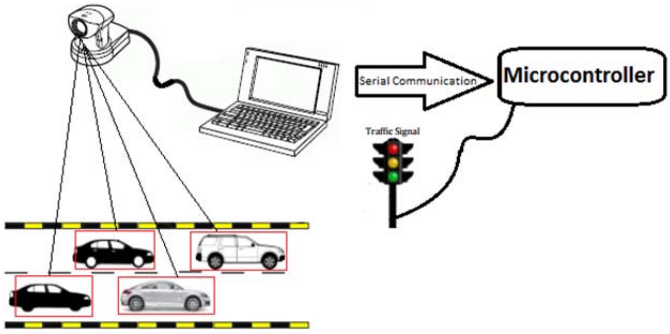

Fig. 3: Communication between signal processor and traffic controller [7][3]

4.2. Observed Results

An increased vehicular density detected at any particular side, secures a longer delay in the green signal for that lane. The number of vehicles is measured at the beginning of each cycle, and this estimated density information is used to alter the time delay of the traffic signals.

5. CONCLUSION AND FUTURE SCOPE

The massive surge in the number of vehicles has driven the need to modernize the conventional traffic signal controller, to equip them with a system which can deal with the diverse traffic scenarios in an efficient manner. The dynamic system which varies the delay of the traffic signals, helps regularize the intersections by providing the required duration of signal to a side with higher density, which not just enables a smooth flow of traffic, but also increases the system efficiency.

The density value communicated by the signal processor is compared to the threshold number, and this information is used to vary the duration of traffic signal, giving the lane with higher density a longer green signal, to ensure a smooth flow in the traffic. The density measurement is done using object detection, which is implemented using python and openCV, with the help of cascade classifier, which performs a frame by frame comparison in order to determine the presence of a vehicle. The cascade classifier needs to be trained by giving a feed of positive and negative image samples to increase the accuracy of the system.

The present system can be upgraded and integrated with ultrasonic sensors to detect traffic rule violations, such as crossing the stop line or breaking the signal [12]. The cascade classifier used in the project can be further upgraded, by adding a second cascade to detect emergency vehicles, and on detecting the presence of these special cases, the traffic flow at that side would be enabled till the emergency vehicle moves out [8]. This particular system can be improved further by integrating it with wireless communication system, to alert the next traffic junction about the emergency situation [14][15]. Video-based automatic incident detection (AID) systems are increasingly being used in intelligent transportation systems (ITS). Video-based AID is a promising method of incident detection, and can prove to be an addition to the proposed system [13].

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