AENSI Journals

**Australian Journal of Basic and Applied Sciences**

ISSN:1991-8178

Journal home page: www.ajbasweb.com

# Adaptive Traffic Light Control System: A Review

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**ARTICLE INFO**

***Article history:***
*Received 19 September 2014*
*Received in revised form*
*19 November 2014*
*Accepted 22 December 2014*
*Available online 2 January 2015*

***Keywords:***
*Intelligent Transportation, system, Adaptive traffic light, Image processing, Image segmentation techniques.*

**ABSTRACT**

Intelligent transportation system (ITS) is automatic road traffic management. It is including traffic light control system as one of its sub-system. Many technologies and algorithms have been developed to optimize traffic management adaptively. Sensors have been used to collect real-time information such as wireless sensor network and smart camera. There are many different algorithms have been proposed for the design and implementation of adaptive light control system such as fuzzy logic control, neural network, genetic algorithms and queuing network, but still there are needs to develop a unique method for it. In this paper different adaptive light technologies and algorithms with its prospects are reviewed.



**To Cite This Article:** Mustafa Hassan, Dr. Amin Babikir, Dr. Khalid Abrahim and Attika Malik., Adaptive Traffic Light Control System: A Review. ***Aust. J. Basic & Appl. Sci.,*** *9(1): 246-249, 2015*

## INTRODUCTION

Intelligent transportation systems (ITS) add a significant improvement in transportation performance by applying advanced technologies of electronics, communications, computers, control and sensing and detecting in all of transportation system in order to improve safety and efficiency and traffic situation via transmitting real-time information. This reported by (Lelitha Vanajakshi and *et al*., 2010). So the goals of ITS concepts are to improve traffic safety, reduce traffic congestion, improve transportation efficiency, improve environmental quality, save energy, conserve time and to promote the development of related industries. ITS history goes back to the 1970s; the first huge meeting was in Paris, in 1994, to stimulate the development of ITS to improve the existing traffic control system in many countries round the world. ITS includes four sub-systems, a surveillance system, a communication system, an energy efficiency system and traffic light control system.

In the current traffic light control system use one of the control approaches: fixed time and actuated or adaptive which is the one of the main points of the paper study concerns, but in each case of the approaches the essential goal is the same, to increase safety, speed and energy efficiency or reduce waiting time. To achieve that adaptively (dynamically changing traffic environment), there are wide range of variables must be taken in each traffic light system, such as intersection type (single or multiple- lane), traffic volume, time of day, the effects of other roads and the involvement of pedestrian traffic. Adaptive traffic light system mainly depends on the real information getting by sensing the situation of each road at intersection. There are many approaches studied and developed to achieve that, such as sensors and cameras for counting or recognizing the amount of traffic. The implementation of the adaptive system done by utilizing different algorithms for keeping system working itself as an intelligent system. The algorithms such as fuzzy logic, genetic algorithms, neural network and queuing network. The mechanism for detecting situation of the traffic either by sensors such as object detector and wireless sensor network or cameras as vision sensors. Vision sensing is used by either for counting the amount of traffic loads or by processing the image of traffic load. It provides more many-sides for traffic parameters estimation. There are many techniques for image processing, but this paper focusing on image segmentation techniques.

### *Literature overview:*

The literature is including overview of the scope which is drawn from difference sources across a few years ago up to recent one. First part is explaining adaptive traffic light control by applying different sensors

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technologies. Second part is highlighting adaptive traffic light control by applying image processing getting from camera, but before getting through two parts, there are many terms should be defined.

***Image processing:***

Image processing is defined by (Jay Acharya and *et al*., 2013) as it refers to digital image processing. The producing the input image in the place is referred to as imaging

***Image segmentation:***

Image segmentation is a process of partitioning a digital image into multiple segments, that means a set of pixels, pixels in a region are similar depending on some homogeneity criteria like color, intensity or texture, in order to place and match objects and boundaries in an image.

Image segmentation is generally defined as the basic image processing that subdivides a digital image f (x, y) into its continuous, disconnect and nonempty subset functions from first function to n function, which provides appropriateness to extraction of feature. Practically application of image segmentation including filtering of noisy images, medical applications (Locate tumors and other pathologies, Measure tissue volumes, Computer guided surgery, Diagnosis, Treatment planning, study of anatomical structure), Locate objects in satellite images (roads, forests, and so on.), Face Recognition, Finger print Recognition, and so on. There are many segmentation methods have been proposed in the literature, which is provides options for deciding segmentation technique selected over another depending on characteristics of the problem being considered.

Image segmentation approaches divided into two parts based on the properties of the image:

***Detecting Discontinuities:***

Is to partition an image based on sudden changes in intensity, which is includes image segmentation algorithms such as edge detection.

***Detecting Similarities:***

Is to partition an image into regions that are similar depending on a set of predefined criterion; which is includes image segmentation algorithms such as thresholding, region growing, region splitting and merging.

***Classifications of image segmentation methods:***

The main categories of image segmentation are:

***Edge base segmentation:***

Edge segmentation is algorithm aim to identify points in digital image at which there is a sudden change in image brightness or where is a jump in density from one pixel to the next one. It includes sub classes such as grey histogram techniques and gradient based which is involves differential coefficient technique, laplacian of a Gaussian and canny techniques global.

***Region based segmentation:***

Region based on segments partitions of an image into regions that are similar depending on a set of predefined criteria. The main example of this techniques are thersholding (thresolding and local thresolding), region operation (region growing, region splitting and merging).

***Theory based segmentation:***

Different image segmentation algorithms were derivative from different scopes, which are very significant for segmentation approaches like neural network-based, clustering based and fuzzy-based technique.

***Model-based segmentation:***

It can be applicable if the shape of the object is exactly known.

***Related studies:***

The first part is summarized related studies of adaptive traffic light control using different sensor technologies for feeding controller about the traffic load:

(W. Wen, 2010) designed an intelligent traffic management expert system with RFID technology to provide both practically important traffic data collection and control information and can trace criminal or illegal vehicles such as stolen cars or vehicles that evade tickets, tolls or vehicle taxes. The system architecture consist of an RFID reader, a passive tag, a personal computer, a pair of infrared sensor and a high speed server with a database system. Based on RFID technology, the system collects and calculates average speed and average flow information on each road of a district area in a city. It then transmits the message from all the congested roads in a district area to the server in the district center via communication program. Through a flooding algorithm, each

server in a district center exchanges and updates information with all neighbor servers in other district centers, so all that the servers in various district centers can g*et al*l the latest congestion messages in a city. Therefore, a dynamic navigation system can find the shortest path that avoids congested roads. Meanwhile, he compares three types of tags for choosing a better solution for e-plates in the future. He also adopts infrared sensors for detecting cars that do not have a tag.

An intelligent traffic control system is proposed by (K. M. Yousef and *et al*., 2010) utilizing and managing wireless sensor networks (WSNs). An adaptive traffic signal time manipulation algorithm based on a new traffic infrastructure using WSNs is proposed on a single and multiple road intersections. The proposed system with its embedded algorithms is proved to play a major role in alleviating the congestion problem when compared to inefficient classical traffic control systems.

Structured Systems Analysis and Design Methodology (SSADM) and Fuzzy-Logic based Design Methodology is deployed by (Osigwe Uchenna Chinyere and *et al*., 2011) to develop and implement the system. Problems identified with the current traffic control system at the "+" junctions and this necessitated the design and implementation of a new system to solve the problems. The resulting fuzzy logic-based system for traffic simulated and tested using a popular intersection in a Nigerian city; notorious for serve traffic log jam. The new system eliminated some of the problems identified in the current traffic monitoring and control systems.

A new adaptive traffic light system and new traffic light green-wave control algorithms considering the driver's behavior is proposed by (Ovidiu TOMESCU and *et al*., 2012). The innovation introduced new parameters (weather, vehicle type and minor events) designed to improve the method for calculating the green wave. The improving of traffic flow is by reducing stop number and each cars delay as the according to the proposed approach. The author used a fuzzy logic simulator because of simplicity.

***The second part is covering adaptive traffic control system using image processing techniques:***

A new algorithm has been proposed for a real-time image processing based traffic controller by (Vikramaditya Dangi and *et al*., 2012). Upon comparison of various edge detection algorithms, it was inferred that Canny Edge Detector technique is the most efficient one. Proposed analyzed various contour tracing and object counting methods revealed the Moore neighborhood technique to be more robust when compared to the others. The paper demonstrates that image processing is a far more efficient method of traffic control as compared to traditional techniques. Author also has implemented a system for emergency vehicle detection based on image processing techniques.

A paper of (Ms.Pallavi Choudekar and *et al*., 2011) showed that an image processing is better technique to control the state change of the traffic light. It showed that it can reduce the traffic congestion and avoids the time being wasted by a green light on an empty road. It is also more consistent in detecting vehicle presence because it uses actual traffic images. It visualized the reality so it functions much better than those systems that rely on the detection of the vehicles' metal contents.

A method of vehicle detection and counting from an image has been implemented using MATLAB and ARM development board and LPC 2148 microcontroller by (R.Nithin Goutham and *et al*., 2014). The accuracy of vehicle detection depends on the weather conditions. Further modification in the algorithm, can improve the system accuracy.

A flexible System proposed by (Mojtaba Salehi and *et al*., 2014). The feedback of the queue length and traffic densities can be taken from images taken from cameras. Because of the flexibility of the fuzzy logic in dealing with uncertainty, it can be used advantageously for traffic light controlling systems. The proposed fuzzy logic system and fixed time controller produces little difference in results, in terms of constant traffic flow while in the case of time varying traffics, the proposed FLSC is superior to the fixed time controller. This controller gives a suitable green time to improve the traffic capacity effectively and reduces the intersection's delay, which can insure vehicles not to wait too long on the road.

A system of adaptive traffic control depending on the accuracy of ROI used to estimate occupancy by (Arif A. Bookseller and Rupali R Jagtap, 2014). Major advantage is the variation in signal time which control appropriate traffic density using artificial vision. The accuracy in calculation of time due to single moving camera depends on the registration position while facing road every time. The handling of emergency with the help of assigning priority has an advantage since safety human is maintained. Limitation of GSM network may sometime create problem of delay in delivery of message, but is not frequent phenomenon and could be taken care with the help of service provider. Automatic caution mode is new feature of this system that will ensure the withdrawal of signal control at night after predefined time when the traffic is lowest and brings it normal when needed. Thus the system will be close to traditional system with improved efficiency and safety.

***Conclusion:***

In this paper we classify and discuss the main topics of the studies including models, attributes and approaches which are very important to introduce evaluation for how adaptive traffic light it can improved by applying image processing techniques. Also the overview gives a clear illustration of image segmentations and

its algorithm. The knowledge of recent studies gives also a good plant of knowledge for how to start improving and developing. Image processing in general promising brightness future and it has becomes the focus of modern research,

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