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High accuracy traffic light controller for increasing the given green time utilization ☆

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ABSTRACT

Traffic congestion has become one of the main complications in the urban cities according to the growing number of vehicles in those cities, outdated technologies used on the streets of those cities, unsuitable road design, and several other reasons. So, that has urged the need for a more precise traffic light controlling system; the one that will help in preserving high stability at all levels of demand. This paper introduces a dynamic traffic light phase plan protocol for single-isolated intersections. The developed controlling method was compared with four other methods and showed a good performance in terms of reducing the average and maximum queue lengths, optimizing the given green time amount as needed, and increased the intersection's throughput (increased the given green time utilization). In addition, it maintained a good traffic light stability at all levels of demand.

1. Introduction

Traffic congestion has become one of the major problems in the urban cities according to the increasing number of vehicles in those cities, obsolete technologies used on the roads of those cities, inappropriate road design, and many other reasons. So, that has urged the need for a more accurate traffic light controlling system; one that will help in maintaining high stability at all levels of demand.

Generally, a traffic light controlling system consists of two main entities as shown in Fig. 1: traffic light controller (TLC) and traffic light display entity (TLD). The latest solutions have suggested having a third entity, Road Status Data Collector (RSDC), in addition to the classic two entities as shown in Fig. 2. The job of the additional entity would be to collect real-time data about the approach's lanes and deliver them to the traffic light controller which would make a decision about the next phase plan based upon those collected data.

The aim of this work has been to increase the traffic light phase plan decision making accuracy and maintain high stability at all of the levels of demand. That urged researching the ability of finding solutions for the problems of what type of road data are needed to be collected, how they will be delivered to the traffic light controller, and how they will be used, within

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the TLC, to make a decision about the next phase plan. In addition, a new dynamic mechanism for the queue length detection was developed and illustrated within this paper.

The rest of the paper is organized to have a literature review section to critically analyze some of the past works then choose four of those works to compare the proposed approach with. The third section describes the developed traffic light system and its entities in detailed manner. Section 4 illustrates the system operation life time. Section 5 describes the evaluation process and how the developed approach with the other four selected methods from the literature evaluated. The sixth section lists down all the collected results from the evaluation process and discuss them. Finally, the whole paper's highlights are summed up within the conclusion section.

2. Literature review

In this section, a set of the previously proposed approaches for intelligent traffic light management systems will be briefly illustrated with highlighting their downsides. Centrally controlled city traffic lights was one of the very first proposed solutions to overcome the isolated pretimed traffic lights' downsides as in [3], which was very costly and slow because of using rented telephone lines for transmitting the roads' data to the central controller. Then a newer suggestion came up which estimates the vehicles average speed and builds the traffic light phase plan upon it. The results of such a system will not be accurate as it depends on estimation not detection [4].

Some other solutions were proposed to avoid or to reduce traffic jams on roads via propagating the traffic data for drivers hoping that they would change their path and avoid the congested roads [5,6]. According to our opinion, this solution will not necessarily solve the congestion problem on the road as it might fail in some cases, for example, when many drivers want to approach a destination which has only one way to reach to; the proposed solution will not help the driver to avoid the congestion nor ease the traffic flow.

Many researchers have argued that an image processing solution would be optimum to solve the congestion problem, such as [7–14]. Using a camera to capture the road picture or a video and then analyze the captured pictures/video will not always work as it would fail during the heavy raining, foggy, or sand storm weather, and at very dark or unlined road. While some others have argued that using Global Positioning System (GPS) would be the good solution for the traffic problem [15]. As according to our opinion, it won't be an optimum choice for urban cities with high buildings.

Finally, several studies have found Mathematical solutions for the congestion problem which have proven as better solutions than the above, such as [16–19]. Nevertheless, it has been noticed that most of those solutions face instability when a high level of demand to use the intersection occurs. Further, they face inaccuracy in decision making and that is mainly because of the incomplete list of variables that they collect and base their decisions upon or because of using the wrong control algorithm. That has motivated us to find a better solution to overcome those works' downsides. The most related and latest approaches to ours were both of [18,19]. In this paper, we will refer to them as NM1 (New-Method-1) and NM2 (New-Method-2), respectively.

3. The developed traffic light system

Just like other latest solutions, the developed traffic light system consists of three main entities: Road's Status Data Collecting entity (RSDC), Traffic Light Controlling entity (TLC), and the Traffic Light Display entity (TLD). The first entity would collect data about the vehicle types (civilian or special vehicles), its status (on-duty or free) and its position (on which lane) which will lead to determining the queue lengths of the lanes. Those data will be forwarded to the traffic light controller which will make the decisions regarding the next traffic light phase plan then forward it to the TLD to be implemented there. When the time comes to switch to a new phase, the TLC will be triggered to produce a new phase plan based on a new set of data, and so on. The intersection considered in this paper was a four leg intersection as that shown in Fig. 3.

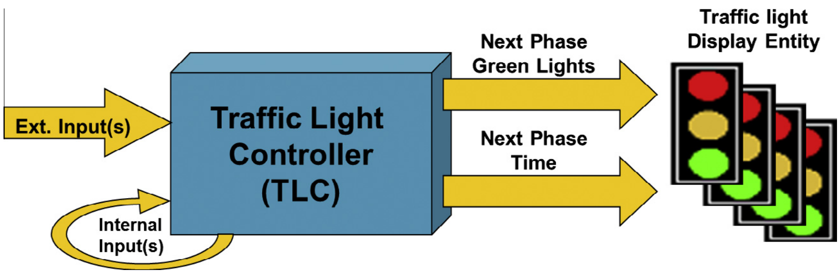

Fig. 1. Basic traffic light system entities [1,2].