Delay Optimization Using Genetic Algorithm at the Road Intersection

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ABSTRACT

Metropolitan road traffic mechanisms in developing countries are a critical problem due to fast motorization. The optimization of traffic control is one method to decrease this problem. In this study, a genetic algorithm was implemented to minimize delay at an intersection by finding red and green cycle intervals at an intersection. The objective function minimizes the delay at an intersection and increases progressive flows of traffic on roads. The study was done on real data collected from three t-intersections in the city of Hardwar, India. Traffic data for traffic flows, queue sizes, and traffic speed are collected using video detection systems in the study area. The digital images from the camera were analyzed in real time. The results show that the traffic control performance is improved up to 85% over existing algorithms proposed by the same author.

KEYWORDS
Genetic Algorithm, Optimization of Traffic Flows, Progressive Flow, Queue Length, Traffic Delay

INTRODUCTION

An intelligent transport system (ITS) (Kumar and Toshniwal, 2015, 2016) has a critical role in designing different type of traffic control algorithms. ITS helps one to develop the self-regulating algorithms for controlling and managing the road traffic to improve the traffic safety, making the flow of traffic smooth and reduction in fuel consumption on roads. In general, ITS is divided into four parts: a surveillance system, a communication system, energy efficiency system and a traffic light control system. Modification in existing traffic control systems infrastructure requires involvement of significant human effort and time. Due to increasing number of vehicles day by day, traffic congestion is a critical problem in many urban cities in India. There are many issues related to our daily life due to traffic congestion like high waiting and traveling time and much fuel consumption. These factors (Kumar et al., 2017) lead to a bad impact on the economy of a country as well. Unregulated and heavy traffic volumes are most important factors of the road accidents (Kumar and Toshniwal, 2017), which are increasing very rapidly (Alba and Garcia, 2011; Cheng and Yun, 2010).

Different methods have been suggested for the implementation of intelligent traffic light control systems, such as, Genetic Algorithm (Hasbullah et al., 2011), Fuzzy Logic Control (Liang et al., 2004; Kulkarni and Wainganka, 2007), Neural Network (Abdul et al., 2008; Binbin et al., 2010) and Queuing Network (Wu and Miao, 2010; Woensel and Vandaele, 2007), etc. Different assumptions

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have been used to model traffic congestion and flow at the road intersection. The traffic flow control methods are divided into interrupted and uninterrupted flow control methods (Webster, 1958). The interrupted flow is regulated by an external means such as traffic lights or traffic police, while the uninterrupted flow is defined as all flows regulated by vehicle-vehicle interaction and interaction between vehicles traveling on a roadway.

Several suppositions were prepared about the entrance and exit process of the vehicles at controlled intersections. The traffic at intersection considering a Poisson arrival process investigated the performance parameters, such as the average length of the queue and waiting time of the entire vehicle and presented an equation of the average deceleration of a vehicle in closed form, which is based on simulation (Jiannong et al., 2010). These conventions were accepted and modified by many researchers (Miller, 1968; Tarko et al., 2000). In addition to the Poisson arrival cases, there are other assumptions, such as [D / D / 1], [D / G / 1], [M / G / 1] (Yusuf and Black, 2000; Karim et al., 2005).

Various models of intersection delay at isolated intersections combining queuing theory with empirical observations of various arrival rates and discharge times are presented (Webster and Cobbe, 1966; Hurdle, 1985; Hagen and Courage, 1992). In the current study the genetic algorithm has been applied to D/D/1 queue model to find the optimized signal cycle to minimize the delay at the road intersection considering traffic volume, arrival and departure rate as critical parameters for the Indian traffic conditions. The current paper is structured as follows. Section 2 provides a brief summary of literature review. Section 3 explains sites and data description. Section 4 explains the model development and section 5 defines about results obtained. At the end, the conclusion of the work is presented.

LITERATURE REVIEW

Traffic signal control mainly falls into two categories: fixed-time and traffic responsive control. In fixed time control technique the green light timing is fixed for all the junctions. The interval for the traffic signal lights are fixed in the way that the traffic travels easily everywhere without bounding the people in the one direction for long period for their turn. Responsive traffic control is time varying traffic, the green time for each phase in a cycle is changed depending upon the traffic volume. The traffic cycle intervals are added according to the average levels of traffic at that intersection according to past experience. Traffic lights, in addition confirming the protection of road trips, may also aid in the reduction of the total time expended by all the vehicles in the intersection, if an optimum regulator approach is applied. The signal synchronization problem is to decide the optimal values for signal parameters with respect to a given objective function, meeting the given constraints.

There are several algorithms that developed for controlling the traffic lights problem during previous years. The equations for expected queue length and delay per vehicle at fixed cycle traffic light are proposed (Newell et al., 1964). The traffic flow at intersections is studied and the other theory of traffic flow model including the fluid and the steady state queuing method is discussed. The authors took the average delay per vehicle, the number of stopped vehicle, the number of waiting vehicles; anticipated delays and the average length of the queue are among the critical measures of performance in modeling the flow of traffic at the intersection (Tarko et al., 2000). The fixed-cycle traffic light (FCCTL) queue and the queue length and delay distributions by considering a poison and geometric distribution is investigated (Leeuwaarden, 2006). The mean delay is an important parameter for the stochastic properties of the arrival distribution. A summary of delay models at signalized intersections including the deterministic queuing, a shock wave, steady-state stochastic, and time-dependent stochastic delay models under-saturated and over-saturated conditions is presented (Hesham et al., 2004). The ITREGRATIONTM simulation package was as a benchmark for other models with the result that all compared delay models produce similar results for traffic lights used when the traffic density is low. But under heavy traffic, significant differences occur. A simple mathematical
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