Chapter 80
A New Design of Intelligent Traffic Signal Control

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ABSTRACT

Dynamic traffic signal control in Intelligent Transportation System (ITS) recently has received increasing attention. This paper proposed an adaptive and cooperative multi-agentfuzzy system for a decentralized traffic signal control. The proposed model has three levels of control, the current intersection traffic situation, its neighboring intersections recommendations and a knowledge base, which provides the current intersection traffic pattern. The proposed architecture comprises a knowledge base, prediction module and a traffic observer that provide data to real traffic data preparation module, then a decision-making layer takes decision to how long should the intersection green light be extended. Also every intersection flow is predicted in two different ways: 1- through a recursive algorithm. 2- based on a two stage fuzzy clustering algorithm. The proposed solution is tested with traffic control of a large connected junction and the result obtained is promising in comparison to the conventional fixed sequence traffic signal and to the vehicle actuated traffic signal control strategies which are the most applicable strategies in this area. Also to simulate the proposed traffic control solutions, a Netlogo-based traffic simulator has been developed as the agents' world which simulates the roads, traffic flow and intersections.

1. INTRODUCTION

The problem of intelligent traffic control (ITC) has been studied in the area of intelligent transportation system (ITS) for many years and many centralized and distributed control model has been taken into consideration to the traffic light control problem (Dimitrakopoulos, 2010; Akcelik, 1994; Allsop, 1972; Anuran, et al., 2009; Wang, 2010; Yousef, et al., 2010; Gokulan & Srinivasan, 2010; Zhao, 2000; Martinez, et al.,, 2010; Papadimitratos, et al.,, 2009; Tacconib, et al.,, 2010; Wang, 2010; Tubaishat, et al.,, 2009; Katwijk, 2008; Ossowski, 1998). ITS is also an intelligent control system for providing key solutions to the current road congestion problems and also it has the potential

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to reduce traffic jams, traffic accidents and environmental emissions by improving traffic flows and transportation efficiency (Dimitrakopoulos, 2010).

ITS has been considered as a new and efficient solution to the traffic control problem for many years and there are many traffic control strategies which have been developed based on it. Most of the current methods are based on gathering traffic information during different times of the day and year to help agents to make decisions (Ossowski, 1998; Kaedi, 2008). Another solutions are based on fuzzy control (Kosonen, 2003; Hsu, & Liu, 2007), timed petri nets (Bosch et al., 2003), SPSA (simultaneous perturbation stochastic approximation) (Choy et al., 2004), ant algorithm (Bertelle, et al., 2003), knowledge based multi-agent system (Dresner, & Stone, 2005; Hirankitti, & Krohkaew, 2007) and mobile agent (Kheyruri, et al., 2007).

Most of the traffic signal control techniques have a centralized or distributed control models which gather data from the roads to a central management control to decide what to do at the next time.

Recently researchers have realized that multi-agent systems are attractive and well suited to the domain of traffic signal control due to its distributed nature because they consider the social aspects of human interactions over distributed systems (Daneshfar, et al., 2009a; Daneshfar, et al.,, 2009b; Roozemond, & Rogier, 2000; Srinivasan, & Choy, 2006; Cai, & Yang, 2007; Ferreira, et al.,, 2001). There are more research and studies have been done using distributed artificial intelligence for controlling urban traffic networks. Also there are more efforts in applying fuzzy logic and fuzzy systems to control the urban traffic lights (Kim, 1997; Zhang, et al. 2007; Cheng, & Yang, 2008). Kim (1997) has been presented a new fuzzy logic controller with variables of arrival, queue, and traffic volume for an adaptive traffic management system which alleviate traffic congestion. Zhang et al. (2007) proposed a two-layer fuzzy control algorithm for traffic control of a class of traffic networks and Cheng and Yang (2008) established a self-learning traffic signal control model based on fuzzy clustering and genetic algorithm. However it appears that the most proposed approaches is based on a unified model and agents may not be able to gain a higher perspective of the overall problem to determine the green light extension.

In this paper, a unified model, based on a high level of abstraction which considers most correlated intersections to predict the traffic volume in which each agent has the ability to communicate and exchange relevant traffic information and cooperate with other agents have been introduced. To controland predict the traffic volume in each intersection, three parameters have been taken to the accounts simultaneously:

1. The current intersection traffic volume (number of stopped cars behind the red light and flow of cars from the green light.
2. Neighboring intersections' traffic volume.
3. The current intersection traffic pattern.

In this paper two different solutions for traffic prediction in each intersection have been introduced based on a cooperative multi-agent and an adaptive fuzzy inference system, which efficiently manages the traffic flow according to its current conditions. The first approach is based on a recursive algorithm and the second one is based on a two-stage fuzzy clustering algorithm which finds the most correlated intersections to the current intersection. The proposed methods aim to reduce each car's delayed time at each junction. In addition, an agent-based traffic simulator in NetLogo (Wilensky, 2008) has been developed, that can easily test and evaluate the performance of the approaches against various traffic conditions.

The organization of the rest of the paper is as follows. In Section 2, we present the first proposed model which is based on a recursive algorithm with its components, relations and simulation results.

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