Traffic Circle Design Based Fuzzy Control Method

Guo-hua Chen[1], Qi-fei Liu[2], and Xiao-lian Liao[1]

[1] Department of mathematics Hunan Institute of Humanities Science and Technology, Loudi 417000, China
hnldcgh@163.com
[2] School of mathematics southwest University, Chongqing 400715, China
liu_qifei@163.com

Abstract. Theoretically, fuzzy control has been shown to be superior in complex problems with multi-objective decisions. Traffic signal control is a typical process, where traffic flows compete for the same time and space, and different objectives can be reached in different traffic situations. In this paper, through the matlab program we attain a problematic multi-phase Traffic signal control with the fuzzy control method. Based on the results of our paper, we can assert that the fuzzy control principles are quite competitive in multi-phase traffic signal control.

Keywords: Traffic signal control, fuzzy control method, traffic prediction.

1 Introduction

Many subjects in transportation engineering are often characterized as subjective, ambiguous, and vague. Traditionally, such problems have been dealt with in a framework of mathematics based on binary logic. Although it has already been over 30 years since Zadeh [1] introduced the fuzzy set theory, this theory has witnessed an increasing level of acceptance in transportation engineering during the last decade. The FUSICO (Fuzzy Signal Control)-research project was started in 1996 at the Helsinki University of Technology (Pursula [2], Niittymäki et al. [3]). In traffic signal control, several traffic flows compete for the same time and space, and different priorities are often set to different traffic flows or vehicle groups. Normally, the optimization includes several simultaneous criteria, like average delays, maximum queue lengths and percentage of stopped vehicles. Hence, in practice, traffic signal control is based on tailor-made solutions and adjustments made by traffic planners. The modern programmable signal controllers with their great number of adjustable parameters are well suited to this process. For good results, both an experienced planner and fine-tuning in the field are needed. Fuzzy control has proven to be successful in problem areas where exact mathematical modeling is hard or impossible, but the process can also be controlled by an experienced human operator. Thus, traffic signal control seems to be a suitable task for fuzzy control. Indeed, one of the oldest examples of the

B. Cao, T.-F. Li, C.-Y. Zhang (Eds.): Fuzzy Info. and Eng., Volume 2, AISC 62, pp. 1621–1627.
springerlink.com

potential of fuzzy control is a simulation of traffic signal control in an intersection of two one-way streets. Even in this very simple case, the fuzzy control was at least as good as the traditional adaptive control (Pappis and Mamdani [4]). Generally, fuzzy control has emerged as one of the most promising areas for research in the application of fuzzy set theory, especially in areas that lack quantitative data regarding input-output relations such as traffic signal control. The theory of fuzzy sets is based on concepts graded to handle uncertainties and imprecision in a particular domain of knowledge. The graded concepts are useful since real situations are very often neither crisp nor deterministic, and cannot be described precisely. Furthermore, fuzzy sets are manipulated by the set theoretic operations of union, intersection and complement via their membership functions. The use of fuzzy sets provides a systematic way of manipulating vague and imprecise concepts by introducing linguistic variables, fuzzy relations and fuzzy logic (Kikuchi [5]).

In general, fuzzy control is found to be superior in complex problems with multi-objective decisions (Kosko [6], Jarkko Niittymaki[7], Jarkko Niittymäki [8]). In this paper, we solve the problem of multi-phase traffic signal control by use of fuzzy control.

2 Main Results

2.1 Fuzzy Control Method

The fuzzy phase selector decides the next signal groups. Then the fuzzy green extender makes the decisions about exact timing and the length of the green phase. So, the main function of the fuzzy controller is to give correct orders for the signal groups. The queue length and the delay time are taken into account in the planning phase. Let a queue length in [0, 32], delay time in [0,140]. By using the queue length and the delay time to establish two triangle fuzzy control functions follow as:

The degree of Queue Length membership:

$$f_1 = \begin{cases} 1 & x \le 0 \\ (16-x)/16 & 0 < x \le 16 \\ 0 & 16 < x \le 32 \\ 0 & x > 32 \end{cases} \qquad f_2 = \begin{cases} 0 & x \le 0 \\ x/16 & 0 < x \le 16 \\ (32-x) \div 16 & 16 < x \le 32 \\ 0 & x > 32 \end{cases}$$

$$f_3 = \begin{cases} 0 & x \le 0 \\ 0 & 0 < x \le 16 \\ (x-16)/16 & 16 < x \le 32 \\ 1 & x > 32 \end{cases}$$