INTEGRATED AND ADAPTIVE TRAFFIC SIGNAL CONTROL FOR DIAMOND INTERCHANGE

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ABSTRACT

New dynamic signal control methods such as fuzzy logic and artificial intelligence developed recently mainly focused on isolated intersection. Adaptive signal control based on fuzzy logic control (FLC) determines the duration and sequence that traffic signal should stay in a certain state, before switching to the next state (Trabia et al. 1999, Pham 2013). The amount of arriving and waiting vehicles are quantized into fuzzy variables and fuzzy rules are used to determine if the duration of the current state should be extended. The fuzzy logic controller showed to be more flexible than fixed controllers and vehicle actuated controllers, allowing traffic to flow more smoothly. The FLC does not possess the ability to handle various uncertainties especially in real world traffic control. Therefore it is not best suited for stochastic nature problems such as traffic signal timing optimization. However, probabilistic logic is the best choice to handle the uncertainties containing both stochastic and fuzzy features (Pappis and Mamdani 1977)

Probabilistic fuzzy logic control is developed for the signalised control of a diamond interchange, where the signal phasing, green time extension and ramp metering are decided in response to real time traffic conditions, which aim at improving traffic flows on surface streets and highways. The probabilistic fuzzy logic for diamond interchange (PFLDI) comprises three modules: probabilistic fuzzy phase timing (PFPT) that controls the green time extension process of the current running phase, phase selection (PSL) which decides the next phase based on the pre-setup phase logic by the local transport authority and, probabilistic fuzzy ramp-metering (PFRM) that determines on-ramp metering rate based on traffic conditions of the arterial streets and highways. We used Advanced Interactive Microscopic Simulator for Urban and Non-Urban Network (AIMSUN) software for diamond interchange modeling and performance measure of effectiveness for the PFLDI algorithm. PFLDI was compared with actuated diamond interchange (ADI) control based on ALINEA algorithm and conventional fuzzy logic diamond interchange algorithm (FLDI). Simulation results show that the PFLDI surpasses the traffic actuated and conventional fuzzy models with lower System Total Travel Time, Average Delay and improvements in Downstream Average Speed and Downstream Average Delay.

On the other hand, little attention has been given in recent years to the delays experienced by cyclists in urban transport networks. When planning changes to traffic signals or making other network changes, the value of time for cycling trips is rarely considered. The traditional approach to road management has been to only focus on improving the carrying capacity relating to vehicles, with an emphasis on maximising the speed and volume of motorised traffic moving around the network. The problem of cyclist delay has been compounded by the fact that the travel time for cyclists have been lower than those for vehicles, which affects benefit–cost ratios and effectively provides a disincentive to invest in cycling issues compared with other modes. The issue has also been influenced by the way in which traffic signals have been set up and operated. Because the primary stresses on an intersection tend to occur during vehicle (commuter) peaks in the morning and afternoon, intersections tend to be set up and coordinated to allow maximum flow during these peaks. The result is that during off-peak periods there is often spare capacity that is underutilised. Phasing and timings set up for peaks may not provide the optimum benefits during off-peak times. This is particularly important to cyclists during lunch-time peaks, when vehicle volumes are low and cyclist volumes are high. Cyclists can end up waiting long periods of time as a result of poor signal phasing, rather than due to the demands of other road users being placed on the network.

The outcome of this study will not only reduce the traffic congestion during peak hours but also improve the cyclists' safety at a typical diamond interchange.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADIFM	Actuated Diamond Interchange Control with Fuzzy Ramp Metering
AIMSUN	Advanced Interactive Microscopic Simulator for Urban and Non-Urban Network
ATOM	Auckland Traffic Operation and Management Unit
DAD	Downstream Average Delay
DAS	Downstream Average Speed
FLC	Fuzzy Logic Control
FLDI	Fuzzy Logic Diamond Interchange Control
GTE	Green Time Extension
HOV	High Occupancy Vehicle
SH1	State Highway 1
MF	Membership function
MOE	Measures of Effectiveness
MOTORWAY	Freeway (US) / Highway
NZMOT	New Zealand Ministry of Transportation
NZTA	New Zealand Transport Agency
PFLDI	Probabilistic Fuzzy Logic Diamond Interchange Control

PFLDIBC	Probabilistic Fuzzy Logic Diamond Interchange Control Incorporating Bicycle Signal
PFPT	Probabilistic Fuzzy Phase Timing
PFRM	Probabilistic Fuzzy Ramp Metering
STTT	System Total Travel Time
TFL	Traffic Light
TTT	Total Travel Time