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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

ABSTRACT	ii
ACKNOWLEDGMENTS	iv
LIST OF TABLES	ix
LIST OF FIGURES	xi
LIST OF ABBREVIATIONS	xiv
CHAPTER 1 - INTRODUCTION.....	1
1.1 Diamond Interchanges Problems	1
1.2 Adaptive Signal Control.....	1
1.3 Fuzzy Logic Signal Control.....	2
1.4 Probabilistic Fuzzy Logic Control	3
1.5 The importance of Bicycle Signal at a Diamond Interchange	4
1.6 Objectives of The Thesis	5
1.7 Thesis Overview	6
CHAPTER 2 – LITERATURE REVIEW	7
2.1 Traffic Signal Control Fundamental	7
2.2 Fuzzy Control in Traffic Management	10
2.3 Bicycle Literature Review.....	11
2.3.1 Policy	13
2.3.2 Safety and Compliance	15
2.3.3 Bicycle Operation Fundamental	18
2.3.4 Cyclist Crash Prediction Modeling.....	19
2.3.5 Bicycle Intersection Control.....	21
2.3.6 Traffic Operation Bicycles Affect	21
2.4 Summary	23

CHAPTER 3 – PROBABILISITC FUZZY DIAMOND INTERCHANGE	24
3.1 Methodology	24
3.1.1 The Interchange and Detectors Placement	24
3.1.2 The Interchange Signal and Phasing	25
3.1.3 Probabilistic Fuzzy Signal	27
3.1.4 Design of Probabilistic Fuzzy Logic for a Diamond Interchange	28
3.1.5 Probabilistic Fuzzy Ramp-metering (PFRM)	30
3.2 Algorithm Implementation	39
3.2.1 Parameters for Implementing PFLDI Algorithm	39
3.2.2 Framework of PFLDI Algorithm Implementation	40
3.3 Using Simulation To Evaluate The PFLDI Algorithm	42
3.3.1 Simulation Evaluation Procedure	42
3.3.2 Microscopic Traffic Simulation Model	42
3.3.3 Calibration of Selected Simulation Model	46
3.3.4 Traffic Turning	47
3.3.5 Simulation Assumption	47
3.3.6 Driver and Vehicle Information	47
3.3.7 Detector Type and Placement	48
3.3.8 Dynamic Scenario Setup	50
3.3.9 Simulation of the PFLDI Algorithm in AIMSUN	51
3.4 Comparisons of Different Signal Control Methods	55
3.4.1 Overview	55
3.4.2 Performance Measure of Effectiveness	55
3.4.3 Simulation Pictures	56
3.4.5 Traffic Demand Information	57
3.4.6 Comparison for Low Traffic Demand	58

3.4.7 Comparison for Medium Traffic Demand	60
3.4.8 Comparison for High and Extreme Traffic Demand	61
3.5 Summary	63
CHAPTER 4 – CYCLIST SAFETY AND PLANNING	66
4.1 Safety.....	66
4.1.1 Safety	66
4.1.2 Compliance	67
4.2 New Zealand Bicycle-Vehicle Crashes Statistics (2004-2008)	69
4.3 New Zealand Cyclist Safety Statistics	70
4.4 Types of Crash	73
4.5 Bicycle Planning	73
4.6 Current Bicycle Infrastructure in Auckland Region	75
4.7 Bicycle Design Guidelines	79
4.7.1 Major Bicycle Way through Intersections with Barnes Dance Layout	79
4.7.2 Major Bicycle Way through Intersections with Adapted Dutch Design	80
4.7.3 Major Bicycle Ways Intersection with Protected Bicycle Ways	81
CHAPTER 5 – PROBABILISTIC FUZZY LOGIC CONTROL AT	
DIAMOND INTERCHANGE INCORPORATING BICYCLE SIGNAL	83
5.1 Methodology	83
5.1.1 Detectors placement	83
5.1.2 Bicycle crossing request button	84
5.1.3 Bicycle Signal and Phasing	85
5.1.4 Probabilistic Bicycle Fuzzy Logic Signal Control.....	86
5.1.5 Design of Probabilistic Bicycle Fuzzy Logic Signal Control for a	
Diamond Interchange	87
5.1.6 Probabilistic Fuzzy Variables and parameters.....	88

5.1.7 Objectives of the Probabilistic Fuzzy Logic Algorithm	88
5.1.8 Probabilistic Fuzzy Rules Base	88
5.2 Using Simulation to Evaluate the PFLDIBC Algorithm	90
5.2.1 Simulation Evaluation Procedure	90
5.2.2 Calibration of Selected Simulation Model	91
5.2.3 Simulation Assumption	92
5.2.4 Dynamic Scenario Setup	92
5.2.5 Simulation of PFLDIBC Algorithm in AIMSUN	94
5.2.6 Performance Measure of Effectiveness	94
5.2.7 Traffic Demand Information.....	94
5.2.8 Demand Scenarios and Analysis Procedure	94
5.2.9 Comparison for Low Traffic Demand	95
5.2.10 Comparison for Medium Traffic Demand	107
5.2.11 Comparison for Extreme Traffic Demand	107
5.3 Summary	102
CHAPTER 6 – SUMMARY AND CONCLUSIONS	109
6.1 Summary of the Thesis Research	109
6.2 Major Contributions and Conclusions	109
6.3 Future Research	110
REFERENCES.....	109
APPENDIX A: PFLDI C++ CODE.....	109
APPENDIX B: PFLDIBS C++ CODE	109
VITA	109
PUBLICATIONS.....	109
UPPER HARBOUR DIAMOND INTERCHANGE DESIGN	109

LIST OF TABLES

Table 3.1 Signal timing data for ADI, PFLDI and FLDI.....	27
Table 3.2 Terms of the fuzzy sets for inputs and outputs for PFRM module	31
Table 3.3 Rules and its weighting for PFRM module.....	36
Table 3.4 Rules and its weighting for PFPT module.....	37
Table 3.5: Probabilistic Fuzzy Green Time Extension	38
Table 3.6 Calibration data for AIMSUN simulation model.....	45
Table 3.7 Traffic demand data for Scenario 1 (3348 vehicles per hour) - Low.....	58
Table 3.8 Traffic demand data for Scenario 2 (3752 vehicles per hour) – Low	59
Table 3.9 Measure of Effectiveness between models (Scenario 1)	59
Table 3.10 Measure of Effectiveness between models (Scenario 2)	59
Table 3.11 Traffic demand data for Scenario 3 (3348 vehicles per hour) - Medium	60
Table 3.12 Traffic demand data for Scenario 4 (3752 vehicles per hour) – Medium.....	60
Table 3.13 Measure of Effectiveness between models (Scenario 3)	61
Table 3.14 Measure of Effectiveness between models (Scenario 4)	61
Table 3.15 Traffic demand data for Scenario 3 (3348 vehicles per hour) – High	61
Table 3.16 Traffic demand data for Scenario 2 (3752 vehicles per hour) – Extreme.....	62
Table 3.17 Measure of Effectiveness between models (Scenario 3)	62
Table 3.18 Measure of Effectiveness between models (Scenario 3)	62
Table 3.19 Average delay time comparison (second per vehicle)	64
Table 3.20 Total travel time comparison (hour)	64
Table 3.21 Downstream average speed comparison (km/hr).....	64
Table 4.1 Bicycle–vehicle crashes at selected sites (2004–2008) (Excerpt from: Turner et al 2012).....	69

Table 4.2 New Zealand pedal cyclist casualties and population statistics – historical, year ending 31 December (Excerpt from: LTSA 2002).....	71
Table 5.1 Signal timing data for PFLDI with Bicycle Signal	86
Table 5.2 Rules base for PFLDIBC	89
Table 5.3 Calibration data for AIMSUN simulation model.....	91
Table 5.4 Traffic demand data for Scenario 1 (2924 vehicles per hour) - Low	96
Table 5.5 Traffic demand data for Scenario 2 (3720 vehicles per hour) - Low	96
Table 5.6 Measure of Effectiveness between models (Scenario 1)	96
Table 5.7 Measure of Effectiveness between models (Scenario 2)	96
Table 5.8 Traffic demand data for Scenario 3 (4608 vehicles per hour) - Medium.....	97
Table 5.9 Traffic demand data for Scenario 4 (6301 vehicles per hour) - Medium	97
Table 5.10 Measure of Effectiveness between models (Scenario 3)	97
Table 5.11 Measure of Effectiveness between models (Scenario 4)	98
Table 5.12 Traffic demand data for Scenario 5 (7981 vehicles per hour) - Extreme.....	98
Table 5.13 Traffic demand data for Scenario 6 (8831 vehicles per hour) - Extreme	98
Table 5.14 Measure of Effectiveness between models (Scenario 5)	99
Table 5.12 Measure of Effectiveness between models (Scenario 6)	99

LIST OF FIGURES

Figure 2.1 Fundamental diagram for bicycle flow (Miller and Ramey, 1975).....	18
Figure 2.2 Illustration of Bicycle’s Affects on Vehicle Traffic Operation in an At-grade Intersection (Heng et. al. 2003)	22
Figure 3.1 Aerial view of Upper Harbour Interchange in Auckland (Google Earth) ...	24
Figure 3.2 Upper Harbour Interchange Detectors.....	25
Figure 3.3 Typical Phasing and Signal Groups at Upper Harbour Interchange.....	25
Figure 3.4 Phase Sequence for Upper Harbour Interchange.....	26
Figure 3.5 PFLDI model illustrations	28
Figure 3.6 The overall framework of the PFLDI algorithm.....	29
Figure 3.7: Probabilistic fuzzy membership functions of local speed, flow, occupancy, downstream speed, v/c ratio, and check-in and queue occupancy	31
Figure 3.8 Scaled fuzzy ramp-metering Rate.....	32
Figure 3.9 Total Arrival membership functions (Phase B).....	33
Figure 3.10 Total Queue membership functions (Phase B)	34
Figure 3.11 Auckland Traffic Operations and Management (ATOM) timing plan for Upper Harbour Interchange.....	34
Figure 3.12 Fuzzy green time extensions in current running phase.....	35
Figure 3.13 Detectors placement in Upper Harbour Diamond Interchange’s two middle intersections.....	39
Figure 3.14 Detectors placement along the on-ramps and motorway mainstreams	40
Figure 3.15 Framework of PFLDI Algorithm in detail.....	41
Figure 3.16 Simulation evaluation procedures.....	42
Figure 3.17 AIMSUN 6 environment (Excerpt from: TSS-GETRAM Extension User Manual, 2002)	43

Figure 3.18 Geometric layout of Upper Harbour Diamond Interchange (Excerpt from: NZTA)	45
Figure 3.19 Turning traffic observed	46
Figure 3.20 Turning traffic values in AIMSUN.....	46
Figure 3.21 Detectors setup for PFR system in AIMSUN.....	48
Figure 3.22 Detectors setup for SH1 Upper Highway Diamond Interchange in AIMSUN.....	50
Figure 3.23 Simulations of the PFLDI / FLDI Algorithm in AIMSUN via GETRAM Extension.....	51
Figure 3.24 Interaction between AIMSUN and its API module (Excerpt from: TSS- GETRAM Extension User Manual, 2002).....	53
Figure 3.25 (a) (b) (c) State Highway 1 Upper Highway Interchange AIMSUN simulation pictures	56
Figure 4.1 Proportion of Bicycle-motor vehicle crashes, by type (2004-2008) (Excerpt from: Turner et al 2012).....	70
Figure 4.2 Number of cyclists killed in NZ per year, 1970 – 2002 (LTSA 2003a).....	70
Figure 4.3 Percentage of cyclist deaths and injuries in motor vehicle crashes by road type (2007-2011).....	71
Figure 4.4 Types of crash in New Zealand (Excerpt from: MOT Bicycle crash fact sheet 2012)	72
Figure 4.5 Guide to Choice of Facility Type for Cyclists (Excerpt from: GTEP14).....	74
Figure 4.6 Vehicle positions on road carriage way associated with Exclusive Bicycle Lanes (Excerpt from: GTEP14)	74
Figure 4.7 Cyclist holding area (Albany).....	75
Figure 4.8 Typical Bicycle lane design at intersection (Albany).....	75
Figure 4.9 Bicycle lane – car park design (Albany).....	76

Figure 4.10 Bicycle with protected lanes at Custom Street, Auckland CBD	76
Figure 4.11 Bicycle with protected lanes overlapping with vehicle left-hand-turning at Custom Street, Auckland Bicycle lane.....	77
Figure 4.12 Cyclist traveling across the intersection at Custom Street, Auckland CBD.	78
Figure 4.13 Dutch intersection with Bicycle Barnes dance (CCDG 2013)	79
Figure 4.15 The adapted Dutch Bicycle lane layout at an intersection (CCDG, 2013)..	81
Figure 4.16 Example of a vertical edge marker	82
Figure 5.1 Bicycle detectors placement	84
Figure 5.2 Similar cyclist crossing request button	84
Figure 5.3 a) (b) Phasing and Signal Groups at Upper Harbour Interchange with Bicycle signals	85
Figure 5.4 The framework of PFLDIBC and PFLDI algorithms at a diamond interchange	87
Figure 5.5 Green Time Extension for Bicycle and Vehicle	87
Figure 5.6 Simulation evaluation procedures.....	90
Figure 5.7 Bicycle parameters setup in AIMSUN	92
Figure 5.8 Cyclist reaction parameters setup in AIMSUN	98

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