模糊邏輯大眾運輸優先號誌控制模式—遺傳演算法及螞蟻演算法之應用

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摘　要

所謂大眾運輸優先號誌，係指於交通號誌系統中提供適當之控制方法，以利具高乘載特性之大眾運輸車輛優先通過路口，減少其於號誌路口之停等延滯。惟由於大眾運輸優先號誌係犧牲競爭方向之綠燈資源，故當競爭方向之車流量大時，可能反使整體路口之控制績效惡化。因此，實施大眾運輸優先策略之前，有必要妥善評估該策略對整體路口系統（包括大眾運輸車輛及其他所有運具）之影響，以避免對路口整體系統之控制績效產生負面效果。基此，本研究發展基因模糊邏輯控制（Genetic Fuzzy Logic Controller, GFLC）及螞蟻—基因模糊邏輯控制（Ant-Genetic based Fuzzy Logic Controller, AGFLC）兩種模式，在整體路口系統總人延滯最小之目標下，構建大眾運輸優先號誌控制模式，其中包括綠燈延長及紅燈中斷兩種策略。本研究以假設之簡例及實際路口交通量資料，分別在獨立路口及連續路口之模擬環境下，分析 GFLC 與 AGFLC 模式之控制結果，並與絕對式大眾運輸優先號誌及無實施大眾運輸優先號誌之定時時制進行比較，同時，本研究亦針對不同交通量情境及大眾運輸車輛承載率進行敏感度分析。研究結果顯示，在獨立路口環境下，本研究所構建之 GFLC 與 AGFLC 優先號誌模式之控制績效優於絕對式優先號誌，且 AGFLC 模式之績效略優於 GFLC 模式。敏感度分析結果顯示，GFLC、AGFLC 優先號誌及絕對式優先號誌在低交通量時之控制績效較佳，且在大眾運輸車輛承載率較高時，控制績效亦較佳，而當交通量增加時，綠燈延長策略之控制績效優於紅燈中斷策略。同時以實際路口交通量資料之模擬結果亦顯示，GFLC 與 AGFLC 優先號誌模式之控制績效優於絕對式優先號誌。另在連續路口之環境下，模擬結果顯示大眾運輸優先號誌在遞亮連鎖系統下之控制績效最佳，同亮連鎖系統次之，互亮連鎖系統最差。而在控制績效之比較、敏感度分析及實例分析部分，所得到之模擬結果則與獨立路口類似。綜合分析結果顯示，本研究所提出之 GFLC 與 AGFLC 模式可適用於構建大眾運輸優先號誌控制系統，並能有效改善整體路口系統之控制績效，可作為相關單位推動大眾運輸優先號誌控制系統之參考。

關鍵詞：大眾運輸優先號誌、模糊邏輯控制、遺傳演算法、螞蟻演算法。

Fuzzy Logic Transit Preemption Signal Controller: Genetic Algorithm and Ant Colony Optimization Approaches

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Abstract

Transit preemption signal (TPS) is to give transit vehicles, such as trams and buses, passing through the signalized intersections on surface roads with preferential treatment. The reduction of overall delays in transit moving direction, however, can be offset by the increase of overall delays at the competing approaches. Without a vigilant design, the negative impacts to the vehicles at competing approaches might outweigh the benefits to the vehicles in transit moving direction. Therefore, appropriate design of the control mechanism becomes an important issue if one intends to introduce such preferential scheme to favor the transit operation.

This study develops novel TPS control models based on Genetic Fuzzy Logic Controller (GFLC) and Ant-Genetic based Fuzzy Logic Controller (AGFLC), respectively. These models consider the traffic conditions at the signalized intersection to minimize the total person delay. Due to the powerful ability of Genetic Algorithm (GA) and Ant Colony Optimization (ACO) for solving hard combinational optimization problems, the GFLC and AGFLC models are able to automatically equip a FLC with the compromising fuzzy rules and membership functions.

To examine the proposed models, TPS strategies including green extension and red truncation are implemented at an isolated intersection and at two consecutive intersections along an arterial. Studies on an exemplified example with sensitivity analyses and a field case are conducted, respectively, both under the isolated intersection and the arterial. The simulation results at the isolated intersection reveal that the proposed GFLC and AGFLC conditional TPS models perform better than unconditional TPS and the AGFLC performs even better than GFLC. As for the sensitivity analyses, both the GFLC and AGFLC models perform better in low traffic than in high traffic. Moreover, green extension strategy performs better than red truncation strategy as traffic increases. When bus loading factor gets higher, the performance of the GFLC and AGFLC models would be enhanced. In the field case study, the proposed GFLC and AGFLC still perform better than unconditional TPS. Furthermore, the simulation results of studies on the two consecutive intersections along an arterial show that implementing TPS under progressive coordinated signal system would have the best performance, followed by simultaneous system and then by alternate system. The results of performance comparisons, sensitivity analyses, and field case study are similar to those at the isolated intersection. In conclusion, the simulation results suggest that the proposed GFLC and AGFLC models are effective, robust, and applicable to implement TPS at an isolated intersection and at two consecutive intersections along an arterial.

Keywords: Transit preemption signal, Fuzzy logic controller, Genetic algorithm, Ant colony optimization.