CHAPTER 6 CONCLUSIONS AND SUGGESTIONS

This chapter summarizes and presents the major findings of this study. Directions for further studies are identified.

6.1 Conclusions

This study develops novel TPS models based on GFLC and AGFLC, respectively. These models consider the traffic conditions on all approaches at the signalized intersection to minimize the total person delays. Two TPS strategies including green extension and red truncation are analyzed. The general conclusions for the model development in this study are addressed as follows.

(1) A FLC with the ability to conclude the degree of necessity of giving transit priority under consideration of traffic flows and queue length at the signalized intersection is designed in this study. With the development of the fuzzy logic TPS controller, the complexity of evaluating the benefits and impacts of implementing the TPS has been reduced successfully.

(2) An iterative GFLC model applying GA to select fuzzy rules and to tune membership functions in sequence is developed. Fuzzy rules and membership functions are properly encoded into chromosomes for the evolution.

(3) An iterative AGFLC model selecting fuzzy rules by ACO and tuning membership functions by GA in sequence is also developed. For the adaptability of ACO to rules selection problem, we reformulate the problem into a clustering problem which divides an antecedent of fuzzy rules into a corresponding consequent to form a complete fuzzy rule.

To investigate the effectiveness, robustness and applicability of the proposed models, studies on an exemplified example and a field case are conducted at an isolated intersection. The major results are addressed as follows.

(4) Comparing to the pre-time signal without TPS, the AGFLC can curtail the largest *TPD*, followed by the GFLC, in both green extension strategy and red truncation strategies. Unconditional TPS can curtail *TPD* in green

extension but cause larger *TPD* in red truncation. It indicates that the proposed two conditional TPS models perform better than unconditional TPS. Moreover, the AGFLC model performs even better than GFLC model.

(5) In the sensitivity analyses of the exemplified example, the AGFLC and GFLC still perform better than unconditional TPS for all traffic scenarios and all bus loading factors analyzed, and the AGFLC performs even better than the GFLC. Furthermore, both unconditional TPS and conditional TPS (including GFLC and AGFLC) perform better in low traffic than in high traffic. Moreover, green extension would perform better than red truncation with the increase of traffic. This indicates the advantage of implementing green extension under high traffic and red truncation under low traffic. When bus loading factor gets higher, the effectiveness in reducing *TPD* would be enhanced by all unconditional and conditional TPS models. It reveals the advantage to implement TPS in the high bus loading factor situation.

(6) In the field case, comparing to the current pre-timed signal of the field intersection, the AGFLC can curtail the largest *TPD*, followed by the GFLC both in green extension and red truncation. Unconditional TPS can also curtail *TPD* both in green extension and red truncation. It indicates that although each of the three different TPS models could have a significant improvement, the AGFLC and GFLC still perform better.

To further investigate the applicability of the proposed models, an exemplified example and a field case are then conducted at two consecutive intersections along an arterial under three coordinated signal systems including simultaneous, alternate, and progressive systems. The major results are listed as follows.

(7) In study of exemplified example, the progressive system has the lowest *TPD*, followed by simultaneous system, and then by alternate system. Comparing to the pre-timed signal without TPS, the AGFLC and GFLC perform better than unconditional TPS for all of the three coordinated signal systems analyzed and the AGFLC performs even better than the GFLC.

(8) In the sensitivity analyses of the exemplified example, the simulation results under progressive coordinated system show that the AGFLC and

GFLC still perform better than unconditional TPS for all traffic scenarios and all bus loading factors. The AGFLC still outperforms. All three TPS models perform better in low traffic than in high traffic and perform better in high bus loading factors than in low ones. Moreover, the performance of green extension is also better than that of red truncation as traffic increases.

(9) In the field case, comparing to the current timing plan, the AGFLC can curtail the largest *TPD*, followed by the GFLC both in green extension and red truncation. However, unconditional TPS would deteriorate the *TPD* both in green extension and red truncation. It indicates the applicability of implementing the TPS by the proposed models instead of unconditional TPS model.

In sum, the results of exemplified example and filed case suggest that the proposed GFLC and AGFLC models are effective, robust, and applicable to implement TPS at an isolated intersection and along an arterial.

6.2 Suggestions

Some directions for future studies can be identified as follows:

(1) This study considers the TPS along one direction only. The competition of transit priority from all approaches of the intersection could be further considered in the future. More criteria need to be included to determine that the priority should be given to which approach. Moreover, TPS strategies other than green extension and red truncation also deserve to be explored in the proposed GFLC and AGFLC models in the future.

(2) The objective function represented by total person delay is estimated by the analytical fluid approximation method in this study. Other intersection delay estimation techniques which are more accurate than the above-mentioned method could also be considered in further studies. Other formations of the objective function such as the square of *TPD* could be also considered to strengthen the reduction on person delays of the proposed models. Besides, other state variables such as transit passengers onboard are worthy of further investigating to improve the performance of the proposed models. Moreover, the before/after analysis of various traffic situations by field investigation of practical installing the proposed models into field intersections could be further conducted in the future.

(3) With the development of the proposed models, the traffic adaptive TPS control mechanisms could be trained offline with similar traffic conditions and then applied online by easily adding these rule-based mechanisms into the traffic signal controller. A user-friendly interface for the establishment of the TPS systems could be further developed to facilitate the practical operations needed by the traffic engineers. Besides, although the proposed model ensures the benefit of implementing the TPS, the construction cost is not discussed in this study. It is suggested that the guidelines of establishing the TPS system by analyzing the cost and benefit could be further formed for the practical operation needs.

(4) The AGFLC model still employs GA to tune the membership functions. In the future, it is interesting to develop an ant-based method to tune the membership functions. However, due to the network-based behaviors of ant searching, it may require a large modification. Moreover, the AGFLC model defines reasonability as the heuristic information in the tour construction of an ant. Other definitions of heuristic information could also be further tried and investigated in the future.

(5) The proposed TPS control mechanism with the compromising fuzzy rules and membership function learned by the GFLC and AGFLC models could be installed into appropriate traffic simulation software to further validating the effectiveness and applicability in the future.

(6) The interpretation of the learning results of the proposed models, including the selected fuzzy rules and tuned membership functions, are worthy of further investigation. Furthermore, comparisons among GFLC, AGFLC and other similar models in terms of control performance could also be further studied in the future.

(7) For the simplicity of the simulations, this study assumes H and L to be a constant for each actuated bus without the consideration of different traffic situations encountered. Future studies could employ more sophisticated traffic simulation techniques to accurately predict H and L under various traffic conditions so as to further enhance the practical applicability of the proposed model.