CHAPTER 7 CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

By integrating artificial intelligence and optimization technologies, the innovational SOURCAO optimizes the traffic signal near railroad grade crossings under the consideration of promoting grade crossing safety. The independent simulation evaluation by TSIS/CORSIM in a case study demonstrates that the objectives are reached. While the safety of grade crossing was promoted, the average network delay for 20 runs of simulation evaluation is reduced by over eight percent by a $t$-test with a significance of 0.046. The sensitivity analysis demonstrates that SOURCAO works efficiently under both light and heavy volume load. SOURCAO could adapt to different grade crossing closure time as well.

The logic of an inference engine works as intended through the simulation validation and evaluation: when the queue backs onto a grade crossing, it triggers the inference engine safety feature embedded in the system. The system responds a preemption call, chooses the appropriate phase and clears vehicles on the railroad tracks. The inference engine dynamically responds to grade crossing status and traffic surveillance data. It skips the unnecessary phases during HRGC closure time. The visual exam of an average case demonstrated summation of unsafe time, during which the queue backs onto the grade crossing and the gate is closed to highway traffic, is reduced significantly. The safety of grade crossings is promoted.

SOURCAO is established on a proposed delay model, which takes the surveillance detector data and grade crossing closure information as the input. Therefore, the system is highly transferable to the real work environments once the surveillance detector data and grade crossing information are available. The comparison of the delay model with CORSIM QDELAY shows that it is closer to control delay of HCM than CORSIM QDELAY is.
A multilayer perceptron neural network is applied to forecast traffic delays based on the proposed delay model. The training of neural network is converged to a satisfactory accuracy in both training data set and verification data set. The program architecture makes the multilayer perceptron network expandable to other neural network architecture.

The optimization algorithm (Successive Quadratic Programming) is implemented through mixed language function calls (C++/FORTRAN). SQP is proven successful in reducing the network traffic delays with the variables (phases length) constrained by safety consideration. One of the test cases shows that the timing needed to perform the optimization in 98% of cases satisfies the real time constraints (3 seconds are considered as the criterion).

The software architecture complies with advanced computer software engineering requirements such as being portable to different platforms, standard ANSI C++ code to different compilers, and compatible with the FHWA’s next generation of simulations. Currently, SOURCAO has only been evaluated and tested through TSIS/CORSIM.

In addition to the above characteristics, the application of SOURCAO seems to be promising. The proposed delay model takes the detector data so it could be applied to the other scenarios. For example, it could be used to gather the control delays to determine the Level of Service for intersections.

As indicated in the literature review, there is no decision-support tool to choose the preemption elements (advanced warning time and interconnection distance). With some enhancements of SOURCAO, it could be applied to assist in determining whether the highway traffic signal needs to be interconnected to the railroad (interconnection distance).

Another major potential application of SOURCAO is to invest the possibility of compensating the defects of HCM in calibrating the phase length for traffic signals near
an HRGC. Since HCM assumes the random arrival nature of traffic, the primary findings in the evaluation indicate that HCM might not be applicable to the traffic signal phase calibration for signals near grade crossing. By applying SOURCAO to generate optimized phase length, the phase length could be analyzed and applied back to the pre-timed control in a simulation. If the simulation and/or field-test prove that the new phase plan is superior to the one calibrated by HCM, SOURCAO generated phase plan could be applied.

7.2 Recommendations for Future Research

7.2.1 Refinement of Current System

The proposed system is only tested in one location in a simulated environment due to the limited time and resource constraints. It is suggested that the proposed system could be tested in other cases to further validate the software and evaluate the effectiveness of the methodologies.

Each part of the system needs to be refined. For example, the delay model could be validated and tested by the field test data that might already be available; the inference engine could be re-designed so that it can be adaptive to different configurations and automatically generate deduction rules. A better and faster neural network training algorithm should be searched.

Since the SQP algorithm is implemented in the FORTRAN library, there are reasons to improve the algorithms or choose another algorithm so that it can better fit the specific objective function of proposed system and real time constraints. SQP algorithm could better suit the specific objective function and optimization time constraints. Further enhancement of SOURCAO could investigate the differences between the “global optimization” and the local algorithm of the signal phase length.
In addition to program SQP algorithm, a comprehensive review and test of the non-linear algorithms can better approach the time constraints. Possible combination of several optimization algorithms could result in a faster algorithm to fit the solution of the particular traffic signal optimization algorithm. For example, by combing the Lagrange Multiplier (Bazaraa and Sherali 1993), Gradient Projection Method (Bazaraa and Sherali 1993) and Nazarech Inexact Search (1977) algorithms, Zhang and Deng (1993, 1993 and 1991) successfully solve the railroad geometry design optimization involving hundreds of variables.

The MLP neural network could be improved to reduce the number of surveillance detectors since neural network weights are supposed to store the pattern of some detectors.

7.2.2 Future Research

In the proposed system, grade crossing information is assumed known. However, in order to build a complete system, there should be a grade crossing closure prediction algorithm to be developed to incorporate with PTC and the NAIT. Therefore, grade crossing closure prediction should be developed prior to applying SOURCAO to any field test.

The hardware in-loop validation and the evaluation of the system are the next steps before a traffic signal could be deployed in field for testing. The system could take full advantage of the FHWA’s Traffic Research Laboratory’s hardware and software in-loop facilities.
REFERENCES


160


VITA

Li Zhang was born on April 24, 1963 in Jiangbei County, Chongqing City (Capital City of China in World War II), China. He received his BS in 1983 and MS in 1986, both in the Civil Engineering Department at Shanghai Tiedao University, Shanghai, China. In 1998, he received his MS in Computer Science and Applications at Computer Science Department at Virginia Polytechnic Institute and State University.

From 1986 to 1994, he taught as a Lecturer and Assistant Director of Education, Road and Railroad Engineering Department, Civil Engineering College, Southwest Jiaotong University, Chengdu, China. He actively did researches on Railroad Location Optimization and other projects. He achieved recognized results.

Starting from 1994, he took his Ph.D. studies at Civil Engineering Department, Virginia Polytechnic Institute and State University, Blacksburg, VA. During 1994 – 1997, he also worked as a part time Research Assistant within the Department and the Center for Transportation Research within the University. He contributed the FHWA, the FTA and the FAA research projects involving airspace simulation, neural network bus travel time forecasting studies and Global Positioning System application to transit bus.

From 1997 to 1998, he received the US DOT Dwight David Eisenhower (DDE) Transportation Fellowship Grant and was doing his Ph.D. research at the Federal Railroad Administration in Washington, DC. In the second half year of 1998, he transferred to the Traffic Research Laboratory (TReL), Turner Fairbank Highway Research Center at McLean, VA. Upon finishing his research at DOT, he received Superior Achievement Award, from DDE Fellowship Program, US DOT, in 1998.

He joined ITT Industries, Systems Division in January 1999. The various responsibilities of his position offered the opportunities to support the TReL on-site, analyze CORSIM requirements, develop traffic model, propose the research projects, conduct traffic control and safety research on Highway Railroad Grade Crossing, manage and configure all hardware and software in TReL, and program simulation software components there.

He is a member of Institute of Transportation Engineers and a member of American Society of Civil Engineers.