CHAPTER 1 INTRODUCTION

1.1 Motivation

Safety and efficiency is the most important issue in transportation. Non-recurring congestion is affected by incidents, like traffic accident, disabled vehicles, spilled loads, weather condition, and other special or unusual events, which are not predictable about when and where they will happen. The incidents usually disturb the normal traffic flow and cause the queues and motorist delay. More seriously, they may cause bottlenecks or even secondary accidents. Cheu and Ritchie (1995) have shown that "the capability of incident management to effectively respond to incidents depends heavily on an efficient and reliable incident detection technique. Early detection of incidents is vital for formulating effective response strategies such as timely dispatch of emergency services and incident removal crews, control and routing of traffic around the incident location, and provision of real-time traffic information to motorists". To reduce traffic flow delay, damage to life and properties and social cost, and to increase efficiency and safety in transportation system, this research focuses on non-recurring congestion and develops the automatic incident detection (AID) algorithm.

Real-time automatic incident detection and characterization is an important issue for advanced transportation management and information systems (ATMIS) in urban areas (Sheu and Ritchie, 1998). They are also the importation function of a freeway traffic management center. The most important problem in urban freeway traffic operations is the timely detection of unscheduled incidents. Humans most readily observe incidents and this is, perhaps, the most compelling reason for the recent proliferation of surveillance cameras in urban areas. However, the work force necessary to completely survey urban traffic rapidly becomes cost prohibitive. This has led the industry to seek automatic incident detection algorithms from data derived from measurements made at stations along the freeway (Weil, *et. al.*, 1998). The key to the automatic incident detection algorithm is its ability to detection incidents precisely, reliably, rapidly, and with a low false alarm rate using the traffic data derived from the present detectors.

Research in automated incident-detection techniques started in early 1970s with the implementation of inter-state freeway systems. These techniques typically divide the freeway zones into sections of 500-1000 meters in length. Inductive loop detectors are placed in individual lanes at the boundary of each section to collect traffic volume, occupancy and average speed. The data collected from upstream and downstream detector stations of each section is transmitted to a traffic management centre at regular intervals of 30-second for analysis and detection (Srinivasan, *et. al.*, 2000). The substantial incident detection algorithms, using inductive loop detectors as input such as flow, speed, occupancy and so on, have been developed and are being deployed in freeway systems over the past decades. With regard to the traffic data used in incident detection, flow, speed and occupancy are still as the major decision variables in related algorithms since they can be readily collected. However, the relationship of incident and change of traffic data is unclear and indistinct and some unusual situations such as unstable arrival patterns, low volume cases, and high detection rates associated with high false alarm rates correspond serious limits to the conventional incident detection algorithms. In contrast to most current incident detection algorithms, this research proposes the fuzzy-neural-based incident detection algorithm, which is used to deal with the uncertain context, using the traffic data directly collected as input. Simultaneously, this research attempts to use the change in chaotic traffic parameters, which are derived from the data of traffic flow, to examine the existence of incident and identify incident characteristics.

1.2 Objectives and Scope

The major purposes of this research are:

(1) To analyze the impact and relation of traffic flow parameters and chaotic parameters before and after incidents and to identify the characteristics of incident and incident-free traffic condition.

(2) To develop automatic incident detection algorithms to enhance detection rate properly and to decrease false alarm rate and detection time effectively.

(3) To examine the sensitivity of the incident detection algorithms, such as model structures, parameters of the models, input data quality, number of detectors.

(4) To compare the difference of algorithms using traffic flow parameters and chaotic parameters and to elucidate the rational implement.

This research aims to develop appropriate approaches to detect incident precisely, reliably and timely. The incident detection approaches are designed to apply the freeway section incident detection. The fuzzy-neural-based approaches, which using the traffic data directly collected by detectors, and chaotic-based approaches, which using the chaotic parameter derived from time series flow data to distinguish the incident and incident-free characteristics to check the existence of incident, are established simultaneously. The performance validation using the simulation data (Off-line test), which are calibrated based on a real incident case. The sensitivity analyses are generated to inspect the performance of modifying the network structures and rolling-trained rules, and the robustness of the approaches by reducing the input parameters. Furthermore, considering the same simulation data, the comparisons are made between fuzzy-neural-based and chaotic-based approaches to emphasize the adaptability and rational implement in practice.

1.3 Framework of the Research

The following elaborates the procedures for this research, shown as Figure 1-1.

(1) Problem definition

First, the motivations, objectives, scope of this research are identified.

(2) Literature review

The second step is to review related studies in automatic incident detection, including macroscope and microscope.

(3) Field investigation and simulation

To recognize the performance of the proposed incident detection algorithms, this chapter conducts the simulated data by Paramics for network training and algorithms evaluation. A real but short-lasting traffic incident during a weekday afternoon rush hour is deliberately experimented to fine-tune the Paramics to fix the real traffic environment and then the calibrated Paramics is used to generate adequate data for the empirical studies.

(4) Fuzzy neural network approach

The fuzzy neural network approach is developed to detect freeway incidents. Off-line validation tests have demonstrated that our proposed FNN approach is capable of detecting the freeway incidents with rather high accuracy. Sensitivity analysis further shows that altering the FNN structure by reducing the number of detectors or number of input traffic parameters only slightly deteriorates the detection performance, implying a high fault tolerance of the proposed FNN incident detection system.

(5) Rolling-trained fuzzy neural network approach

The core logic of rolling-trained fuzzy neural network approach is to establish a fuzzy neural network and to update the network parameters in response to the prevailing traffic conditions through a rolling-trained procedure.

(6) Chaotic diagnosis approach

A new approach for traffic incident detection -- chaotic abnormal traffic diagnosis is proposed. The underlying theory for this new approach is to measure the change in chaotic traffic parameters, including largest Lyapunov exponent, correlation dimension, relative Lz complexity, correlation time, and Hurst exponent, to examine the existence of traffic incidents.

(7) Conclusions and suggestions

The major findings from the empirical cases (FNN, RTFNN and chaotic diagnosis) are summarized and the directions for future studies will be suggested.

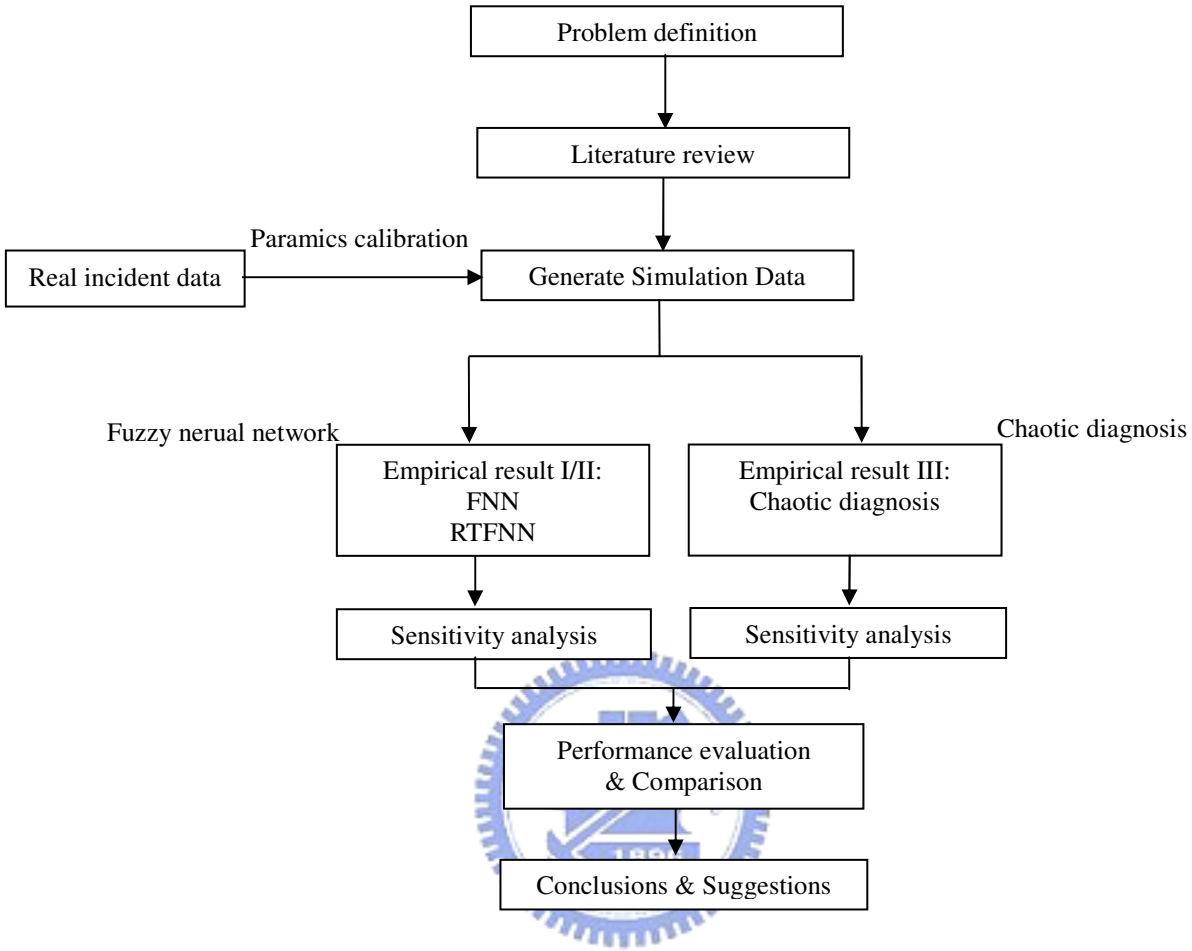

Figure 1-1 Research procedure

1.4 Chapter Organization

This research is organized as follows. Chapter one briefly points out the importance of freeway incident detection studies. Chapter two reviews the previous related works on automatic incident detection algorithms. Chapter three elaborates the proposed methodologies, including fuzzy neural network, rolling training procedure, chaotic diagnosis. Chapter four carries out the field observation with a deliberately real incident case. The calibration of Paramics is based on the field observed data. The calibrated Paramics is used for generating the data for the validation of incident detection

performance. Chapter five constructs the fuzzy neural network approach and discusses the sensitivity of network structure. Chapter six further establishes the rolling-trained fuzzy neural network which is enhanced by adaptively adjusting the network parameters in response to the traffic variations. A comparison of FNN and RTFNN approach is performed. Chapter seven reports the chaotic diagnosis and conducts the performance comparison with RTFNN approach. Chapter eight summarizes the major findings and addresses the issues for further studies.