ELEVATOR TRAFFIC FLOW PREDICTION USING ARTIFICIAL INTELLIGENCE

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ABSTRACT

Elevator traffic flow prediction is essential part of the modern elevator group control system to enable controller apply the best dispatching strategy based on predicted traffic flow data to achieve optimum operation with the aim to reduce average waiting time of passenger for arrival of elevator to serve them. Generally, elevator traffic flow has high complexity and passenger flow possesses nonlinear feature which is difficult to be expressed by a certain functional style. In this thesis, artificial intelligent technique radial basis function neural network (RBF NN) is used to develop elevator traffic flow prediction model. RBF NN is selected because it is suitable to model nonlinear system and can be trained using fast 2 stages training algorithm assures fast convergence. The past interval traffic flow data and traffic flow data at same time on previous days are used to train RBF NN so that it could predict traffic flow ahead. Neural network toolbox that incorporates newrbe and newrb functions in matlab software is employed to develop algorithm and program of RBF NN. Optimum spread constant that will yield minimum mean square error is obtained and become input to the RBF NN. Ten cases with different k and p are studied to evaluate performance of RBF NN. Given training data collected from field, RBF NN is able to predict elevator up peak traffic flow occur at 8:15 a.m. (in 5 minutes interval) which is short term traffic fairly accurate. Mean square errors from simulation results are small and some of them could be neglected. The maximum mean square error is 2.82 for case that use past 3 interval data on 4^{th} day and past 3 days (1^{st},2^{nd} and 3^{rd} day) data to predict traffic flow on 5^{th} day executed by using newrb function. It is concluded that RBF NN is an effective artificial intelligent technique to build elevator traffic flow prediction model.

ABSTRAK

Ramalan aliran traffik lif adalah bahagian penting dalam sistem kawalan lif kumpulan moden supaya pengawal melaksanakan strategi pengangkutan terbaik berasaskan data ramalan aliran traffik untuk mencapai operasi optimum dengan tujuan mengurangkan masa tunggu min penumpang. Amnya, aliran traffik lif mempunyai kekompleksan yang tinngi dan aliran penumpang memiliki cirri taklinear yang sukar dinyata oleh corak fungsi tertentu. Dalam tesis ini, teknik kepintaran buatan *radial basis function neural network* (RBF NN) digunakan untuk membangunkan model ramalan aliran traffik lif. RBF NN dipilih sebab ia sesuai untuk membentuk sistem taklinear dan boleh dilatih dengan algoritma perlatihan 2 peringkat cepat yang menjamin penumpuan cepat. Data aliran traffik selang masa lepas dan data aliran traffik pada masa yang sama pada hari-hari lepas digunakan untuk melatihkan RBF NN supaya ia dapat meramalkan aliran traffik akan dating. *Neural network toolbox* yang mengandungi fungsi newrbe dan newrb dalam perisian matlab digunakan untuk membangunkan algoritma dan aturcara RBF NN. Pemalar menyebar optimum yang menghasilkan ralat kuasa dua min (minimum diperolehi dan dijadikan input kepada RBF NN. Sepuluh kes telah dikaji untuk menilai percapaian RBF NN. Dengan membekalkan data latihan yang dikumpul dari tempat kajian, RBF NN mampu meramalkan aliran traffic puncak atas yang berlaku pada 8:15 a.m. (dalam selang masa 5 minit) iaitu traffik jangka masa pendek dengan agak tepat. Ralat kuasa dua min dari keputusan-keputusan simulasi adalah kecil dan sebahagiannya boleh diabaikan. Ralat kuasa dua min maksimum ialah 2.82 untuk kes yang menggunakan 3 data lepas pada hari keempat and data 3 hari lepas (hari pertama, kedua dan ketiga) untuk meramalkan aliran traffk pada hari kelima dilaksanakan dengan fungsi newrb. Ianya dirumuskan bahawa RBF NN ialah teknik kepintaran buatan yang berkesan untuk membina model ramalan aliran traffik lif.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Elevators are installed in the buildings to satisfy the vertical transportation needs. It is stipulated in Building Bylaws that elevator(s) shall be installed in the building that contains four or more floors to facilitate traffic flow. Architect and building service engineer play the role in designing elevator system for new building. Elevator traffic flow is fundamental element in elevator group control system. Accurate elevator traffic flow prediction is crucial to the planning and dispatching strategy of elevator group control system. During the peak traffic period, performance of elevator group control system depends on prediction of traffic flow. For instance, Mitsubishi Electric Co. has successfully developed an intelligent elevator group control system AI-2200C which is recently available in market. It incorporates neural network based traffic flow prediction module as shown in Figure 1.1. The role of traffic prediction module is to precisely recognize current traffic flow in real time and predict traffic flow in the next several minutes based on both past and current operating data. The predicted traffic flow data is then feedback to rule-set selection module to simulate rule sets in group controller in order to achieve optimum dispatching of elevators to serve passengers.

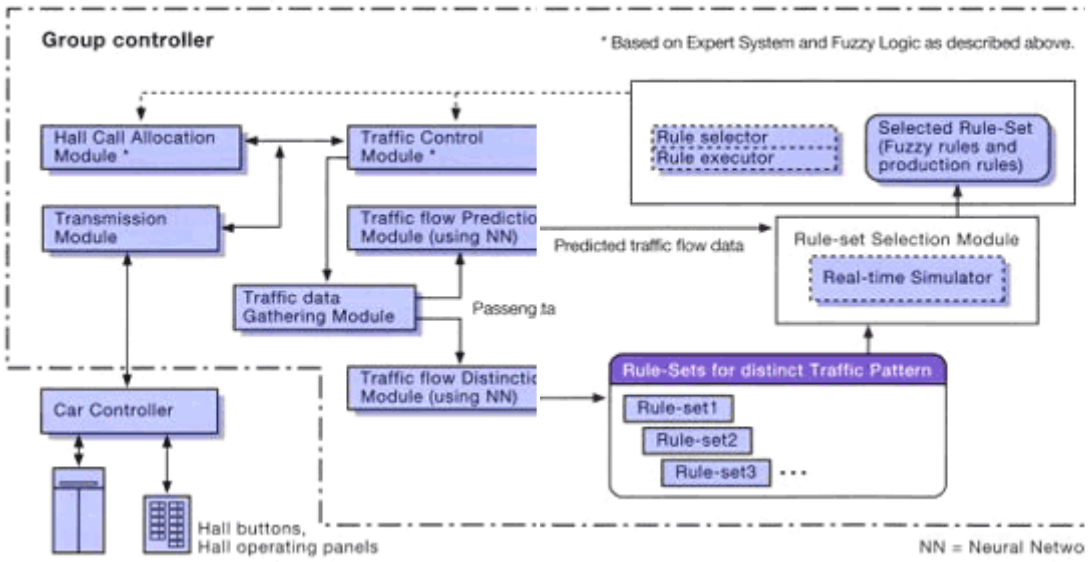

Figure 1.1 Block diagram of AI-2200C elevator group control system.

Hitachi Elevator Engineering Co. developed FI series artificial intelligence elevator group supervisory control systems to improve transportation efficiency in building. FI series control system incorporates traffic flow recognition module. The module could learn traffic flow pattern of individual building and stored in database. Control system will employ this data to forecast traffic flow and assign more lifts to serve floor with heavy traffic flow.

In recent research to design a elevator group control system based on multi-agent coordination approach (Zong *et al,* 2006a), traffic flow prediction function is also incorporated into coordination mechanism (core structure) so that the system could reduce the average waiting time of passengers at most of the traffic flow pattern. The block diagram of multi-agent coordination based elevator group control scheduling is illustrated in Figure 1.2. From the above examples, it could be concluded that traffic flow prediction module is the very important element in elevator group control system.

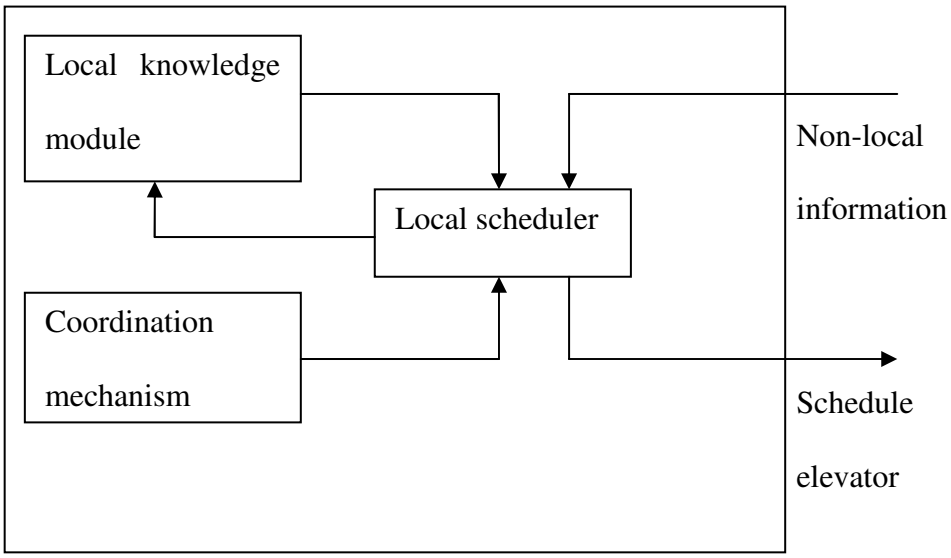

Figure 1.2 Block diagram of multi-agent coordination based elevator group control scheduling.

The elevator traffic flow fluctuates significantly in morning, lunch hour and evening. Generally, elevator traffic flow possesses non linear feature which is very difficult to be expressed by a certain functional style. Various methods have been employed as a fundamental to design elevator traffic flow prediction model. These methods include Morlet wavelet function, support vector machine, least squares support vector machine and wavelet support vector machine. Most of the articles related to elevator technology are published by researchers from China due to strong growth of elevator market as stated in 2006 annual report of Kone Corporation.

1.2 Objective of Project

Objective of this project is to develop an algorithm to predict short term up peak elevator traffic flow in building by using radial basis function neural network (RBF NN).

The radial basis function is one of the common architecture of artificial neural network. The RBF NN is chosen because it has been widely used for non-linear function approximation. A minimal RBF NN has been developed by Lu Y. *et al*. (1997) to identify time-varying non-linear system. Besides that, capability of RBF NN has also been further enhanced. The two stages training procedure adapted in numerous RBF NN applications usually yields satisfactory result (Husain, 2002).

Nowadays, there are only limited research and development works related to elevator technology being carried out in Malaysia. Tan Kok Khiang (Tan, 1997) and Kumeresan (Kumeresan and Khalid, 2005) from Universiti Teknologi Malaysia have developed elevator group control system based on ordinal structure fuzzy reasoning method which performs better than conventional elevator group control system with hall call assignment approach and it is believed that the system could be further enhanced if traffic flow prediction module is incorporated to form a complete intelligent elevator group control system.

1.3 Scopes of Work and Research Methodology

Scopes of work for this project are to study elevator traffic flow and develop RBF NN based algorithm by using matlab software to predict up peak traffic flow of elevator. A case study is carried out to evaluate performance of RBF NN elevator traffic flow prediction model. Traffic flow data is collected in one commercial building as training data and testing data. Up peak traffic flow pattern at morning will be studied and analyzed. Data is collected from 7:30 a.m. – 10:00 a.m (150 minutes) because it covers working hour starts at 8:00 a.m. to 9: 30 a.m. As sufficient data is needed to train the RBF NN, data is collected for five working days continuously. The overall scopes of work in sequence are listed as followings:

- To study fundamental of elevator traffic analysis.

- To acquire knowledge in radial basis function neural network (RBF NN) and further understand its application especially in traffic flow prediction.
- To review past researches related to elevator traffic flow prediction.
- To acquire skill of using matlab software.
- To develop RBF NN based algorithm by using matlab software to predict up peak traffic flow of elevator in office building.
- To collect data at field. The number of passengers that will use elevator in five minutes interval shall be recorded as it represents traffic flow.
- To train the developed algorithm by using collected data.
- To simulate the developed algorithm by using collected data and verify the simulated results by comparing with experimental result.

1.4 Thesis Outline

This thesis consists of 5 chapters. Chapter 1 gives a brief introduction of the project. The importance elevator traffic flow prediction module in modern elevator control system is discussed. Besides that, chapter 1 also covers objective and scope of project.

Chapter 2 discusses types of elevator traffic flow and intelligent elevator control system. Characteristics of incoming, inter-floor and outgoing traffic are reviewed. Various intelligent elevator group control systems (EGCS) are also being discussed to provide better understanding of application of artificial intelligent techniques in elevator engineering. From the researches and development quoted, fuzzy logic and neural network play important role in intelligent elevator group control system to provide quality service to elevator users.

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