DESIGN OF A SIMULATOR FOR ELEVATOR SUPEVISORY GROUP CONTROLLER USING ORDINAL STRUCTURE FUZZY REASONING WITH CONTEXT ADAPTATION

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To my dearest parents without whom any of these would be merely a dream

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ABSTRACT

An elevator group supervisory controller is a control system that manages systematically two or more elevators in order to serve passengers as required. The elevator cars are assigned accordingly in response to hall calls, so as to optimize waiting time, riding time, power consumption, passengers’ comfort, etc. In order to design a controller that can solve multiple objectives, fuzzy logic would be a good option. However, since in this particular problem, more than three fuzzy inputs have to be considered, complications might arise in forming rule base and fuzzy rule extraction from experts. To overcome this problem, ordinal structured fuzzy logic is to be used where the rules are described in one dimensional space regardless of the number of inputs. In this project, the simplicity of ordinal structured fuzzy logic in making crucial supervisory control decisions is demonstrated. In addition, in order to further improve the performance, a new approach of ordinal structured fuzzy logic with context adaptation is introduced to implement an elevator group supervisory controller for a building with 15 floors and 4 elevator cars. Simulations comparing ordinal structured fuzzy logic algorithm with and without context adaptation, show that the former performs better. An additional improvement is made possible by applying genetic algorithms to tune the weights attached to each of the fuzzy rule.

ABSTRAK

Pengawal penyeliaan kumpulan lif adalah merupakan satu sistem pengawal yang mengurus dengan sistematik dua atau lebih lif bagi tujuan memberikan perkhidmatan kepada pengguna. Lif-lif dibahagikan mengikut panggilan dewan, untuk menjimatkan masa menunggu, masa perjalanan, penggunaan kuasa dan sebagainya. Untuk merekabentuk sebuah pengawal yang dapat mematuhi kesemua objektif, logik fuzi merupakan satu pilihan yang baik. Walau bagaimanapun, untuk menyelesaikan masalah lif ini, lebih daripada tiga masukan fuzi harus dipertimbangkan, yang dapat merumitkan pembentukan peraturan fuzi and pemetikan peraturan fuzi daripada pakar. Bagi mengelakkan masalah ini, logik fuzi struktur bersiri perlu digunakan di mana peraturan-peraturan fuzi dinyatakan dalam ruangan satu dimensi tanpa bergantung kepada bilangan masukan. Di dalam projek ini, keberkesanan logik fuzi struktur bersiri dalam membuat keputusan penting dibuktikan. Untuk meningkatkan lagi prestasi sistem lif tersebut, suatu pendekatan baru logik fuzi struktur bersiri dengan pemadanan konteks diperkenalkan bagi sebuah bangunan 15 tingkat dengan 4 lif. Hasil simulasi perbandingan di antara algoritma dengan dan tanpa pemadanan konteks menunjukkan prestasi yang lebih baik diperolehi daripada algoritma dengan pemadanan konteks. Satu peningkatan tambahan diperolehi melalui penggunaan algoritma genetik yang digunakan untuk melaras pemberat yang disertakan pada setiap peraturan fuzi.

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CHAPTER I

INTRODUCTION

1.1 Project Overview

An elevator system is a system that transports passengers from one floor to another in a building. Passengers are transported in respond to their requests, which consists of hall calls and car calls. A passenger who wants to go to another floor from the current floor presses a direction button (hall call) and waits for an elevator to arrive, then enters the elevator and presses a floor button (car call) in the elevator. Basically, an elevator system is controlled by a two level control hierarchy that must solve two different control problems. The lower level task is to command each elevator to move up or down, to stop or start and to open and close the door. The higher level coordinates the movement of a group of elevators through a set of logical rules crafted to improve the system performance [1]. This problem is solved by means of a group supervisory control system with the aid of a group supervisory control strategy.

Elevator group control systems are control systems that manage multiple elevators in a building in order to efficiently transport the passengers [2]. The main requirements of an elevator group control system in serving both, car and hall calls are to provide even service to every floor in a building, to minimize the time spent by passengers waiting for service, to minimize the time spent by passengers to travel from one floor to another, to serve as many passengers as possible in a given time, to optimize power consumption, etc. A general architecture of an elevator group control system is depicted in Figure 1.1.

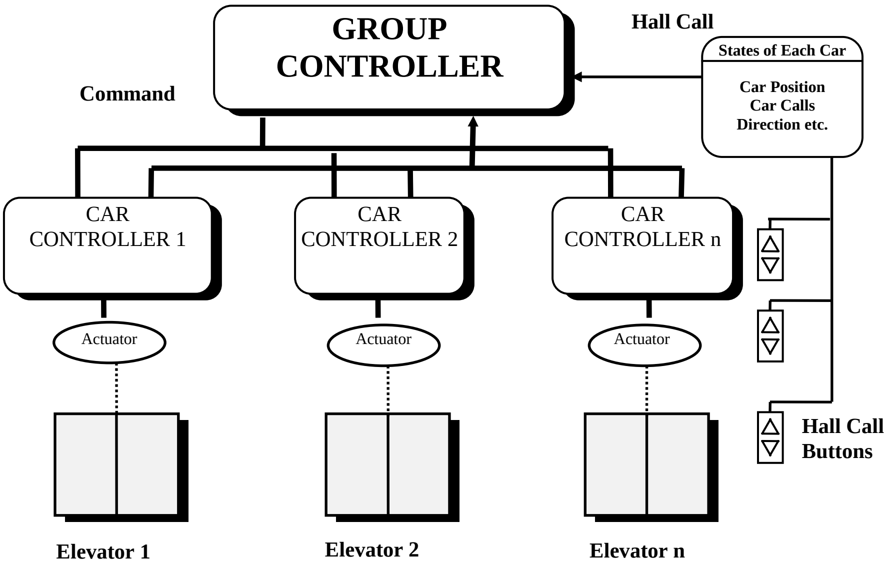

Figure 1.1: A general structure of an elevator group supervisory control system [3].

Numerous conventional algorithms have been used to realize the elevator group controller which are listed as follow:

1. Hall call assignment method
2. Minimum long wait algorithm
3. Area-based control algorithm
4. Car-attribute based evaluation
5. Floor-attribute based evaluation

These conventional algorithms are based on evaluation functions which are calculated each time a hall call is made. An elevator group control system manages elevators so as to minimize the evaluation criteria; it is, however, difficult to satisfy all criteria or to take the actual situation of a building into account. Therefore, it is challenging for the elevator group controller to select a suitable elevator since an elevator system can very complex for the following reasons [2]:

1. If a group controller manages n elevators and assigns p hall calls to the elevators, the controller considers n^p cases.

2. The controller must consider hall calls which will be generated in the near future.
3. It must consider many uncertain factors, such as number of passengers at the floors where hall calls and car calls are generated.
4. It must be possible for a system manager to change the control strategy. Some managers want to operate the system to minimize passengers' waiting time while others want to reduce the power consumption.

In order to overcome these problems, fuzzy theory has been used to make an approximate model when a system is very complex and it is not easy to make an accurate model for the system. Conventional control theory has been applied over many decades. It provides a systematic methodology for designing and tuning of automatic controllers based on heuristic models of processes to be controlled. However, they are suitable to be applied mainly on non-complex and linear systems. This led to the development of adaptive controllers. However, before they can be applied, mathematical models of the processes are necessary to be derived. In many process control systems, it is often difficult to derive their mathematical models due to nonlinearity and other complexities. The emergence of fuzzy technology seems to have some solutions in solving these problems [3]. The following are the advantages of fuzzy logic [3, 4]:

1. Robust nonlinear control.
2. Higher degree of automation.
3. Reduction of development cost and maintenance time.
4. Represents vague language naturally.
5. Enrich not replace crisp sets.
6. Allow flexible engineering design.
7. Improve model performance.
8. Simple to implement.

On the other hand, as the number of fuzzy inputs increases, the complexity of the fuzzy logic system multiplies exponentially. This is due to the difficulty to extract the rules from the experts. Furthermore, as the fuzzy inputs become greater than two, inferencing mechanism becomes more troublesome as the number of rule base will be enormous. This problem could be rectified by using the ordinal structure model for fuzzy reasoning.

In the ordinal structure fuzzy logic, all the fuzzy inference rules are described in one dimensional space for each input and output in the model. Coordination of the rules is done with weights on the rules [5]. In ordinal structure fuzzy logic, it is easy to apprehend the correspondence of the fuzzy inference rules and the inference rules of human beings. Since this model can handle multiple fuzzy inputs, an appropriate model of an elevator system can be represented. This means, inputs such as waiting time, riding time, loading, traveling distance, hall call area weight, destination area weight, etc. can be fed to the system so that precise decisions can be made.

1.2 Objectives of the Project

The following are the objectives of the project:

1. To design a simulator for an elevator supervisory group controller by using ordinal structure fuzzy reasoning.
2. To design a simulator for an elevator supervisory group controller by using ordinal structure fuzzy reasoning with context adaptation.
3. To design a simulator for an elevator supervisory group controller by using ordinal structure fuzzy reasoning with context adaptation tuned by genetic algorithm.
4. To compare the performance of the elevator supervisory group controller using various algorithms as stated above.

1.3 Scope of the Project

The following is the scope of the project:

1. To design a simulator for an elevator supervisory group controller by using ordinal structure fuzzy reasoning for a building with 15 floors and 4 elevators.
2. To design a simulator for an elevator supervisory group controller by using ordinal structure fuzzy reasoning with context adaptation for a building with 15 floors and 4 elevators.
3. To design a simulator for an elevator supervisory group controller by using ordinal structure fuzzy reasoning with context adaptation tuned by genetic algorithm for a building with 15 floors and 4 elevators.

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