Study on fuzzy algorithm of Elevator Group Control System

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***Abstract*—Elevator group control system is a complex, random, multi-objective, non-linear, uncertain decision-making problem. Fuzzy control algorithms are suitable for Elevator group control system because its algorithms are multiobjective. The algorithms optimize the elevator group control harmoniously. Simulation mode of elevator group control system is established in MATLAB in light of the property of elevator group control system and Fuzzy Control Theory in this paper. The advantage of elevator group control system using Fuzzy Control is validated by simulation in MATLAB.**

Keywords-Elevator Group Control; Fuzzy control; simulation;

I. INTRODUCTION

Since elevator system was developed, the theory of elevators dispatch has come into being. More and more requirements are put forward in order to improve performance of elevator system with the development of high architectures.

Elevator group control system which deals with dispatch of elevators in intelligent buildings is a complex, random, multi-objective, non-linear, uncertain decision-making problem.

There are a lot of uncertainties in elevator group control system, such as numbers of passengers in each floor are uncertain; the floor each passenger will arrive at is uncertain; calling signal out of elevator is uncertain; traffic situation which is related to circumstance in buildings is uncertain (structure of building and service condition).

Thus, desired performance can't be obtained by conventional methods such as minimum waiting time, section division and so on.

Chang Bum Kim etc. proposed a fuzzy approach to determine the area-weight which is one of the most important parameters of the hall call assignment method in the elevator group control system. They built the fuzzy inference model to determine the area-weight. They simulated the proposed system and a conventional system in order to analyze the performance of the system. [1].

Zong Qun etc. proposed a new multi-objective elevator group control algorithm based on fuzzy logic, describes its structure and realization in detail. The algorithm can change the power vector of the multiple objectives automatically .The effectiveness of the algorithm is confirmed by computation result [2].

Because of the shortcomings of traditional elevator group control system, control system of elevator group based on Fuzzy Control Theory is introduced in this paper according to references and simulation of the system is completed with MATLAB in order to show the advantage of the system. And a better control result is obtained. It aims at decreasing waiting time and energy loss. It optimizes the elevator group harmoniously.

II. CHARACTER OF ELEVATOR GROUP CONTROL SYSTEM

Elevator group system is a very complicated system; its character can be shown as follows.

A. Multiple Objectives:

- The average time for waiting for elevator is as short as possible.
- Ratio to long waiting time is required to be short as possible.
- Energy consumption of the system is lower.
- Average time in elevator (the interval from passenger come into elevator to passenger arriving destination) is required to be short.
- Traffic capacity is high.
- There are not too many people in the elevator.
- Accurate rate of forecasting elevator arrival time is high.

B. Uncertainty

- Passengers' numbers in each floor are uncertain.
- Destination of people calling elevator is uncertain.
- The floor in which calling signal is created is uncertain.
- Traffic situation in the building is uncertain.

C. Nonlinearity

Dispatch of Elevators varies with time for elevators in same group. Elevators the can be dispatched is limited by elevators' number in the system. Capacity of elevator being restricted, elevator will not stop at calling floor when it approaches its rated loading. Elevators will come about frequently when it is running.

D. Disturbanc

Unnecessary stop can be caused by passengers' wrong calling signal and destination.

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The system cannot work because door of elevator being operated by passenger in error cannot be shut

E. *Inaccuracy*

Passengers' number in the elevator can't be obtained precisely with weighing apparatus in the bottom of elevator because people's weight change from one to the other. Thus accurate forecast for degree of congestion in the elevator and time for wanting elevator can't be got resulting in system being difficult to be controlled.

III. SYSTEM STRUTRUE

As descried above, elevator group control system is a complex, random, multi-objective, non-linear, uncertain decision-making problem. So, elevator group control system must be multiobjective in order to get desired performance.

The concepts used in elevators group control system are almost fuzzy, such as passenger waiting time, passengers flow volume, passengers in the car and elevators' response time for calling, which can't be defined precisely with quantitative limits and also hardly dealt with common logic rules. Thus, elevators group control system can be manipulated with fuzzy inference that is based on experts' experiences.

Unlike conventional methods, elevator group control system based on fuzzy control considers traffic flow (up peak mode; down peak hour; normal traffic flow; idle mode), waiting time of passengers, passengers' number and energy consumption. An optimized function then can be designed in order to count optimal solution for Elevators allocation.

The system consists of four units—Traffic flow Pattern recognition unit, sampling unit, fuzzy control unit and counting unit

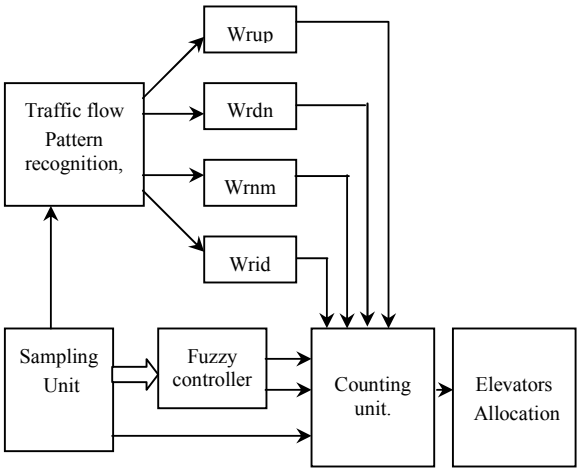

Fig1. System Structure

A. *sampling unit*

- Calling information in and out of elevator

Information that relates elevators' starting times and passengers' location (out of elevator) can be achieved.

- Information of present elevators' state

The information includes degree of congestion in elevators, elevators' location and traffic direction.

All information in sampling unit is transmitted to Traffic flow Pattern recognition unit in order to analyze traffic state.

B. *Traffic flow Pattern recognition*

Elevators are operated in light of four modes: Up Peak mode; down Peak hour; normal traffic flow; idle mode.

Characteristics of elevator group control system can be affected largely by passenger flow volume. Passenger flow volume varies with time a day. Suitable algorithm should be used to improve system's performance. Different algorithm can be selected with traffic flow Pattern recognition module.

There are different requirements in different mode. For example, waiting time is decisive in up or down peak hour for selecting elevators and energy consumption should be focused on in the idle mode. In moral mode, three objectives must be considered simultaneously. So, weighting of three objectives in the system varies with different modes.

C. *Fuzzy control unit*

- Fuzzy control

The first Laboratory application of fuzzy control was described in [Manidani]. Fuzzy control technology was worked out in [Kickert]. The first large-scale realization of a fuzzy controller was a control system for a cement kiln. In 1990 several successful industrial applications were reported from Japan in the domain of consumer products like washing machines, vacuum cleaners as well as in container cranes, lifts and power plants.

Fuzzy control, which is one of the intelligent controls, has features as follows:

It is non-linear control method, especially suitable for controlling non-linear system.

Being utilizing engineering's experience to design Fuzzy controller, it is fit for complex system that can hardly be modeled.

Parameters of fuzzy controller are easily selected and justified arithmetic of control is simple and fast.

- Function （fig. 2）

Information collected in sampling unit are processed in fuzzy control unit after being fuzzified and made an inference with fuzzy rule and defuzzified.

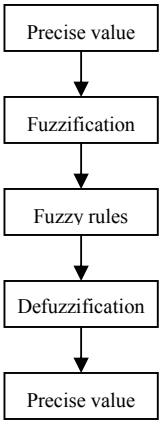

Fig2. Fuzzy control unit structure

- Fuzzy inference systems

There are two Fuzzy inference systems built in MATLAB. One is called waiting time in which input is the waiting time of passengers who call for elevators and output is named Swt which expresses whether waiting time is as short as the passengers expect. The other system is called congestion whose input is passengers' number and the degree of stops and output is called S_{ps} which expresses whether runtimes as short as the passengers in the elevator expect.

The range of three input of the fuzzy control system can be defined as: passengers' number from one to fifteen; passengers' waiting time from one to fifty seconds; number of stops from one to twenty

Similarly, the ranges of two output of the fuzzy control system are from zero to one.

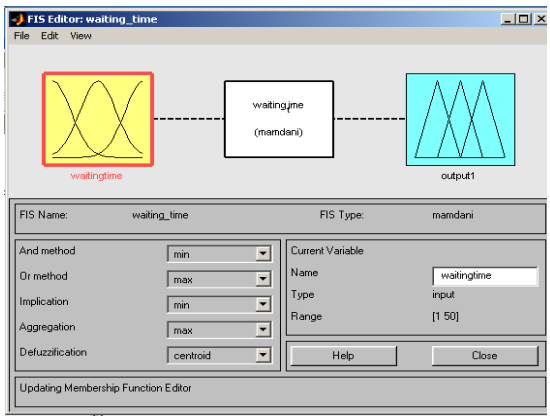

Fig.3 fuzzy system named waiting time

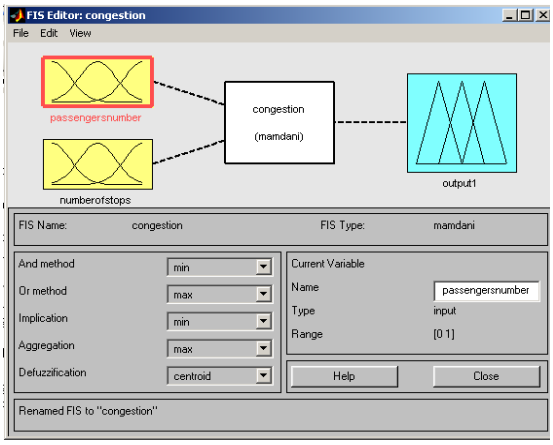

Fig.4 fuzzy system named congestion

- Fuzzy inference

Fuzzy inference is the core of the fuzzy controller. Lingual rules (also called Fuzzy Knowledge Base) should be completed before making fuzzy inference. Practically, fuzzy rulers are achieved by experts' experience. Fuzzy rulers are usually described with the form similar to conditional statement (IF…THEN…) of computer program.

Fuzzy rulers can be expressed as follows.

IF x is A and y is B, Then z is C.

Where, x is A and y is B is called condition and that z is C is called conclusion. Number of fuzzy rulers is decided by that of input and output and system accuracy.

In this paper, the fuzzy rules are depicted according to control objective.

If waiting time is short, then passengers are very satisfactory.

If there are few people in the elevator and number of stops is small, then passengers are very satisfactory.

- Defuzzification

Defuzzification is used to convert fuzzy variables to relating precise values

D. Counting Unit.

In counting unit, the information form fuzzy controller, sampling unit and traffic flow Pattern recognition unit are processed with evaluating function in order to proper dispatch of elevators.

IV. SIMULATION

Simulation of the system is accomplished with MATLAB.

A. Building Fuzzy system with fuzzy Logic Toolbox in MATLAB

The two fuzzy controllers are built in fuzzy Logic Toolbox in Matlab.（fig.3, 4）

B. Building Simulation system in Matlab

Simulation system is built with Simulink Toolbox in Matlab.

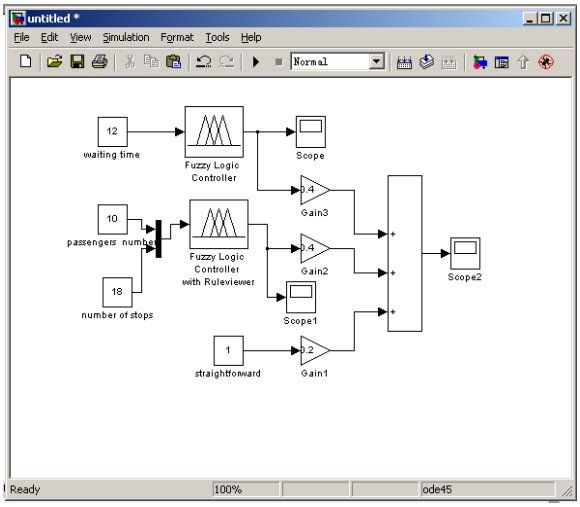

Fig.5 Simulation System

Parameters are set in fuzzy controller after building simulation system in order that fuzzy controller in simulation

system is same as what being built in fuzzy logic box. As mentioned above, there two controllers in the simulation system. There inputs are waiting time, passengers' number and number of stops. Numbers in triangular elements represent weighting of each elevator derived from Traffic flow pattern recognition unit. Moreover, a variable named Seg is used to estimate whether the direction relating to calling signal is as same as elevators is running and there are same indicating floor signal in the elevator corresponding external calling signal, which mainly affect elevators' consumption.

Evaluating function is expressed as follows，

$$S_i = S_{wt}W_1 + S_{PS}W_2 + S_{eg}W_3 \qquad (1)$$

Where, i stand for number of elevators, W_i stands for weighting of elevators.

Parameters are assumed as table1 shows.

TABLE I ELEVATORS INFORMATION

elevator / *Parameter*	*1*	*2*	*3*	*4*
Waiting time	***25***	***15***	***25***	***12***
Passengers number	***9***	***5***	***15***	***10***
Number of stops	***10***	***15***	***5***	***18***
straightforward	***0***	***1***	***1***	***1***

W_i is decided by analyzing traffic flow pattern.

Up peak mode： W=（0.6, 0.1, 0.3）

Down peak mode： W=（0.6, 0.2, 0.2）

Normal mode ： W=（0.4, 0.4, 0.2）

Idle mode ： W=（0.3, 0.5, 0.2）

All the values are input into simulation system. And the result is shown in fig.6.

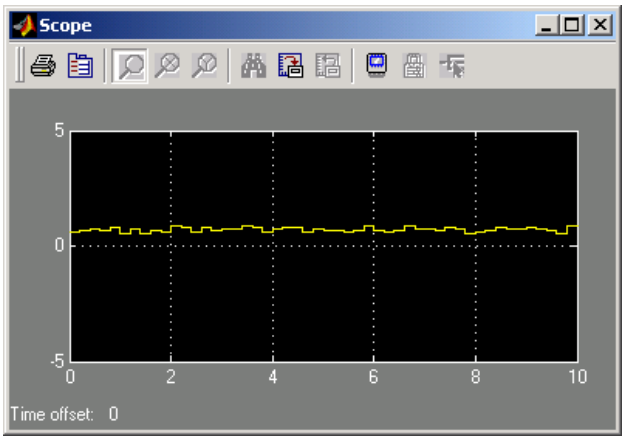

Fig.6 Simulation Result

V. CONCLUSION

Fuzzy algorithm of Elevator Group Control System aims at decreasing waiting time and energy loss. It optimizes the elevator group harmoniously. And a better control result is obtained.

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