Design of an Elevator Group Supervisory Controller using Ordinal Structure Fuzzy Logic with Context Adaptation

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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 this paper, the simplicity of ordinal structure fuzzy logic in making crucial supervisory control decisions is demonstrated. In addition, in order to further improve the performance, a new approach of ordinal structure fuzzy logic with context adaptation is demonstrated to implement an elevator group supervisory controller for a building with 15 floors and 4 elevator cars. Simulations comparing ordinal structure fuzzy logic algorithm with and without context adaptation, show that the former performs better.

Keyword: Elevator group supervisory controller, fuzzy logic, ordinal structure model, context adaptation.

1. INTRODUCTION

Most buildings are equipped with an elevator group installation comprising two to eight cars [1]. Passengers interact with these systems by pressing hall call buttons, which in many cases, indicate their desired travel direction. When the elevator arrives, passengers enter the car and press the desired floor car call buttons. In traffic control of elevator systems, two-level control hierarchy must solve two different control problems. The lower 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. This problem is solved by means of a group supervisory control system with the aid of a group supervisory control strategy (the set of rules defining the control policy) [2]. The main requirements of a group control system in serving both, car and hall calls, should be: 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 move from one floor to another and to serve as many passengers as possible in a given time [3].

There have been many researches in this area utilizing numerous approaches in designing the most effective elevator supervisory controller. For instance, C. B. Kim et al. proposed a fuzzy model to determine the area-weight, which is one the important variables in the hall call assignment method. The hall call assignment method assigns a new hall call to the elevator having the smallest evaluation function value among all the elevators. The area-weight is a parameter which affects the evaluation function values of the elevators in the area close to the hall call [4]. In another work, a control strategy generation method and fuzzy elevator group control system (FEGCS) was proposed. The control strategy of FEGCS is made using the classification of the passenger traffic and system manager's requirements, and the hall calls are assigned to suitable elevators by the generated control strategy [5]. R. Gudwin et al. introduced a fuzzy group supervisory controller with context adaptation, to accommodate different traffic patterns. Here, context adaptation is to adjust universes in such a way that what is meant to be, e.g., High or Low, depends on the traffic intensity [2]. Besides fuzzy logic, genetic algorithm has also been identified as a beneficial tool in the elevator problem. A. Fujino et al. proposed an on-line parameter tuning method using genetic algorithm, for the floor attribute control method. In this method, the tuning was aimed at minimizing the waiting time and seven control parameters related to multi-objective control which were encoded into the chromosome [6]. Realizing the tedious and troublesome approach which would arise from multi input fuzzy logic controller design, K. K. Tan et al. [7, 8] proposed an elevator control system using fuzzy logic algorithm based on the ordinal structure theory [9]. In this method, fuzzy rule base is described in one dimensional form [7, 8], which promises simplicity in forming the rule base, in cases where many fuzzy inputs have to be considered.

In this paper, a simulator has been developed to verify the feasibility and effectiveness of the technique as in [7, 8]. Additionally, an elevator group supervisory controller using ordinal structure fuzzy logic with context adaptation that promises a better performance is proposed.

2. DESTINATION BASED ELEVATOR CONTROL SYSTEMS

When destinations are known in advance and no floor buttons can be pressed by passengers traveling inside a cabin, nearly complete and reliable information about a given traffic situation is available, making the dispatching problem much more amenable to combinatorial search techniques. The first destination control system, Miconic-10^{TM}, was introduced by Schindler to the market in 1996. A ten digit keypad is installed in front of the elevator group where passengers indicate the floor to which they wish to travel [1]. Upon receiving the destination, the elevator control system selects an elevator to transport the passenger using a heuristic allocation algorithm [11]. A display informs passengers of the elevator to which they have been allocated. Given the entry and destination floor of this passenger, the algorithm attempts to fit the new passenger into the current travel routes of all cars at the earliest time possible [1]. In this project, an elevator group supervisory controller is designed for a similar destination oriented elevator system as illustrated in Fig. 1.

Figure 1: Telephone-like Ten-digit Keypad and Display in Destination Oriented Elevator Systems [1].

3. ORDINAL STRUCTURE FUZZY LOGIC (OSFL)

The conventional fuzzy inference rules are described as follows:

R^i: If x_1 is A_{i1} and x_2 is A_{i2} the y_i is B_i
(i = 1, 2, ..., n) [10] (1)

Using the moment method [12], the inferred value is obtained as:

$$y = \frac{\sum_{i=1}^{n} \mu_i c_i S_i}{\sum_{i=1}^{n} \mu_i S_i} \text{ [10]} \quad (2)$$

where, R^i is the i-th fuzzy rule. A_{i1}, A_{i2} and B_i are fuzzy variables. y_i is the inferred value. μ_i is the truth value of R^i in the premise. c_i, S_i are the central position and the area of the membership function with the fuzzy variable B_i, respectively [10].

For an n-input one-output system, the ordinal structure model simplified from the original model which was proposed by Ohnishi [9] is described as the following:

R^i: If x_1 is A_{i1} the y_i is B_i
R^j: If x_2 is A_{j2} then y_j is B_j
(i, j = 1, 2, ..., n) [10] (3)

Using the moment method,

$$y = \frac{\sum_{i=1}^{n} w_i \mu_i c_i S_i + \sum_{j=1}^{n} w_j \mu_j c_j S_j}{\sum_{i=1}^{n} w_i \mu_i S_i + \sum_{j=1}^{n} w_j \mu_j S_j} \text{ [10]} \quad (4)$$

where, R^i is the i-th fuzzy rule with the input x_1 and R^j is the j-th rule with the input x_2. w_i is the weight of the rule R^i and, w_j is that of R^j [10].

The ordinal structure of the rules is defined as a set of rules ordered by their importance. Since each rule is described in each single dimensional space, this inference method is simple regardless of the number of the inputs [10].

4. OSFL ELEVATOR GROUP SUPERVISORY CONTROLLER

An elevator group supervisory controller simulator has been developed for a building with 15 floors and 4 elevators, using a high level programming language, Visual C++.

In order to achieve good traffic performance, the elevator fuzzy control system uses six kinds of parameters as the control inputs and one parameter for the output. These parameters represent the criteria or objectives to be optimized in this elevator system which are as follows:

Waiting Time (wt):-
- Total time an elevator needs to travel from its current position to the new hall call.

Riding Time (rt):-
- Total time a passenger spends in the elevator.

Loading (ld):-
- Number of stops that has to be made by an elevator.

Traveling Distance (td):-
- Distance that passengers have to travel.

Hall Call Area Weight (hcaw):-
- Area weight of an elevator with respect to the floor where a new hall call is generated.

Destination Area Weight (daw):-
- Area weight of an elevator with respect to the destination floor of the new hall call.

Priority:-
- Output of the fuzzy controller, where an elevator with the highest value will be assigned [8].

The membership functions of the inputs and output, as well as fuzzy inference rules (and associated weights) are given in Fig. 2, 3 and Table 1 respectively.

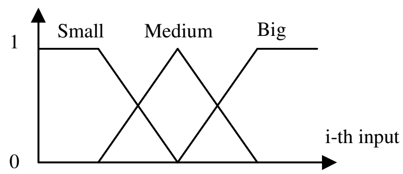

Figure 2: Membership Functions of the Inputs.

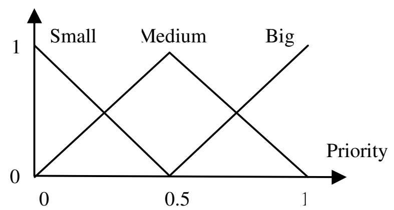

Figure 3: Membership Functions of the Output [8].

Table 1: Fuzzy Inference Rules

Inference Rules	Weights
If wt is Short then priority is B	0.7
If wt is Medium then priority is M	0.7
If wt is Long then priority is S	0.7
If rt is Short then priority is B	0.7
If rt is Medium then priority is M	0.7
If rt is Long then priority is S	0.7
If ld is Small then priority is B	0.1
If ld is Medium then priority is M	0.1
If ld is Big then priority is S	0.1
If td is Near then priority is B	0.05
If td is Medium then priority is M	0.05
If td is Far then priority is S	0.05
If hcaw is Small then priority is B	0.6
If hcaw is Medium then priority is M	0.6
If hcaw is Big then priority is S	0.6
If daw is Small then priority is B	0.5
If daw is Medium then priority is M	0.5
If daw is Big then priority is S	0.5

5. PRELIMINARY SIMULATION RESULTS AND ANALYSIS

To represent a situation of an elevator system, the following information has to be provided to the simulator, to acquire an appropriate elevator dispatch:

- Current position, direction, car calls and assigned hall calls (and destinations) of each elevator.
- New hall calls and destinations.

A series of simulations have been carried out in the following elevator environment:

Building and elevators:

- 15 floors and 4 elevator cars

Timing:

- Elevator velocity: 1floor/s.
- Stop time: 4s

The preliminary simulation results are listed in Table 2.

Due to space limitation, only seven of the simulation data and results are shown in Table 2. As

Table 2: Preliminary Simulation Results

Situation	Elevator			
	1	2	3	4
Data 1				
Pos.	1	9	4	14
Dir.	Up	Down	Nm	Nm
Cc	15	1	-	-
Assign. hc	(6,12) (6,4)	(8,12) (6,4)	-	-
New hc	Priority			
(8,14)	**0.9888**	0.6584	0.9299	0.8882
Data 2				
Pos.	15	8	1	10
Dir.	Down	Down	Up	Up
Cc	10, 1	1	1, 15	14
Assign. hc	(13,5)	(1,4) (12,13) (15,10)	(12,14) (15,6)	(6,1)
New hc	Priority			
(8,14)	0.4624	0.6060	**0.9886**	0.4425
(8,3)	0.8803	0.5062	0.5262	**0.8893**
Data 3				
Pos.	8	8	8	8
Dir.	Up	Down	Nm	Down
Cc	14	1	-	5
Assign. hc	(15,6)	(4,8)	-	(2,5)
New hc	Priority			
(8,9)	**1.0000**	0.6834	**1.0000**	0.6895
(8,14)	**0.9888**	0.6881	**0.9888**	0.6638
(8,1)	0.6853	**0.9838**	**0.9838**	0.9828
Data 4				
Pos.	2	10	13	5
Dir.	Up	Up	Down	Down
Cc	1	11	12	4
Assign. hc	(5,8)	(14,9)	(10,13) (8,4)	(4,11)
New hc	Priority			
(8,9)	0.8890	0.8311	0.6693	**1.0000**
(2,1)	0.6895	0.6101	0.8101	**1.0000**
(15,14)	0.6625	**1.0000**	0.5428	0.8308
Data 5				
Pos.	8	1	11	15
Dir.	Up	Up	Down	Down
Cc	9, 10, 11	2, 3, 4	8, 9, 10	12, 13, 14
Assign. hc	(10,11) (13,11)	(8,4)	(15,3)	(2,6)
New hc	Priority			
(1,15)	0.4002	**0.8484**	0.8163	0.5158
(15,1)	0.6108	0.5285	0.6520	**0.8484**
Data 6				
Pos.	1	8	3	15
Dir.	Up	Up	Down	Down
Cc	3	14	1	9
Assign. hc	(12,8)	(8,1)	(1,9)	(4,6) (6,4)
New hc	Priority			
(1,9)	0.9636	0.5845	**0.9814**	0.5810
(8,9)	0.9989	**1.0000**	0.9234	0.5994
(14,9)	0.8804	**0.9936**	0.6355	**0.9936**
Data 7				
Pos.	3	10	14	6
Dir.	Up	Up	Down	Down
Cc	6, 14	15	9, 10	4
Assign. hc	(10,14)	(2,8) (6,4)	(8,14)	(8,12) (6,4)
New hc	Priority			
(8,15)	0.8628	0.5012	0.8852	**0.9828**

Pos. – position, dir. – direction, cc – car call, assign. hc – assigned hall call, nm – not moving, (i,j) – (departure floor, destination floor).

could be seen in the table, priorities of the elevators are calculated for each of the new hall call-destination pair. An elevator with the highest priority will be assigned to serve a new hall call. However, there are cases, like for instance Data 3 and 6, where more than one elevator could have the highest priority. In these cases, it is unfair to choose either one the elevators, as this problem is due to improper values of the upper and lower bounds of universes of discourse. For certain values of the inputs, similar values of the fuzzy sets are fired, caused by inappropriate values of the bounds. This erroneous outcome is more likely to occur, when the input values are very much close to each other. The following sections are dedicated to solve this problem.

6. CONTEXT ADAPTATION (CA)

One of the most challenging areas of investigation concerning fuzzy information processing is the adjustment of membership functions to best represent concepts in real environments. The fine tune of such membership functions is critical when evaluating the effectiveness of fuzzy solutions to engineering problems.

Context determination may be viewed as a kind of learning. The main idea behind the definition of a context is the idea of restriction. When a context is fixed, what is being made is a restriction of the working universe of a system. In spite of working in the whole universe, the context restricts the system to a particular universe, with its own behavior. The fact of working in a restricted universe modifies perception [2]. In this research, the 'absolute limit context determination' is used to solve the problem as described earlier. In absolute limit method, the lower bound is just the lower instance of sample set, and upper bound is the highest instance of sample set [2].

8. RESULTS AND ANALYSIS

The software developed earlier, was further modified to accommodate CA and the flow of the supervisory control process is shown if Figure 4. As illustrated, before performing the fuzzy logic algorithm, the 6 inputs have to be calculated based on conditions of the 4 elevators. Then, for each new hall call-destination pair, the maximum and minimum values of inputs among the 4 elevators are identified and set as upper and lower bounds of the universes of discourse, respectively. This is then followed by calculation of assignment priority for each elevator.

The data in Table 2 was simulated again but this time the upper and lower bounds of the universes of discourse are set as in Table 3. The simulation results are listed in Table 4. Comparing Table 2 and 4, it could be verified that from simulation of Data 1 and 2, elevator 1, and elevator 3 and 4 have been selected with or without CA, respectively. This clearly shows that by applying CA, the results of previous simulations where multiple selections did not occur, are preserved.

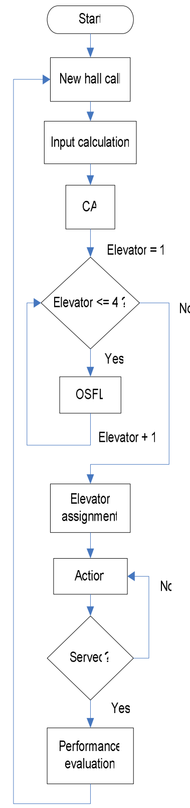

Figure 4: Flow Chart of the Proposed Elevator Supervisory Control Process.

Besides that, another interesting result is obtained by applying CA. Referring to Data 4 in Table 2, for hall call-destination pair (8,9), elevator 4 was selected. For the same case however, after applying CA, elevator 1 has the highest priority. The reason for this discrepancy could be investigated by analyzing the inputs and bounds as listed in Table 5. Comparing elevator 1 and 4, it could be deduced that waiting time and hall call area weight of the latter is 'better' than the former and the reverse is true for loading and destination area weight. Since the difference of hall call area weight for both elevators is too small, it does not contribute to the selection problem. After applying CA, loading and destination area weight of elevator 1 falls in the extreme regions of fuzzy sets Small respectively. This factor together with the fact that now elevator 4 only have one advantage over elevator 1, thus contributed most of the weights that led to the selection of elevator 1.

Also, as apparent in Table 4 for Data 3 and 6, the problem encountered above was solved by using CA, where only one elevator has the highest priority for each of the new hall call.

Obviously, CA enables further distinction to select the best elevator. To prove this statement, a series of continuous simulations have been carried out to compare the performance of the elevator system with and without CA. The performance evaluation index (PEI), used for the comparison is given by (5) and the simulation results are listed in Table 6.

Table 3: Upper and Lower Bounds

Fuzzy Inputs	Elevator 1	Elevator 2	Elevator 3	Elevator 4	Bounds (lower, upper) Default	Bounds (lower, upper) CA
Data 1 (8,14)						
wt	3.5	11.5	2.0	3.0	(0.0, 30.0)	(2.0, 11.5)
rt	3.0	3.0	3.0	3.0	(0.0, 30.0)	(0.0, 3.0)
ld	1.0	0.0	0.0	0.0	(0.0, 15.0)	(0.0, 1.0)
td	6.0	6.0	6.0	6.0	(0.0, 15.0)	(0.0, 6.0)
hcaw	7.0	15.0	4.0	6.0	(0.0, 30.0)	(4.0, 15.0)
daw	1.0	13.0	10.0	12.0	(0.0, 30.0)	(1.0, 13.0)
Data 2 (8,14)						
wt	26.5	18.5	8.5	24.0	(0.0, 30.0)	(8.5, 26.5)
rt	3.0	11.0	8.0	3.0	(0.0, 30.0)	(3.0, 11.0)
ld	0.0	1.0	2.0	0.0	(0.0, 15.0)	(0.0, 2.0)
td	6.0	6.0	6.0	6.0	(0.0, 15.0)	(0.0, 6.0)
hcaw	21.0	13..0	8.0	24.0	(0.0, 30.0)	(8.0, 24.0)
daw	13.0	1.0	0.0	13.0	(0.0, 30.0)	(0.0, 13.0)
Data 2 (8,3)						
wt	11.5	41.5	26.5	9.0	(0.0, 30.0)	(9.0, 41.5)
rt	6.5	2.5	6.5	6.5	(0.0, 30.0)	(2.5, 6.5)
ld	2.0	0.0	1.0	1.0	(0.0, 15.0)	(0.0, 2.0)
td	5.0	5.0	5.0	5.0	(0.0, 15.0)	(0.0, 5.0)
hcaw	8.0	28.0	21.0	10.0	(0.0, 30.0)	(8.0, 28.0)
daw	2.0	8.0	3.0	2.0	(0.0, 30.0)	(2.0, 8.0)
Data 3 (8,9)						
wt	0.0	15.0	0.0	18.0	(0.0, 30.0)	(0.0, 18.0)
rt	0.5	0.5	0.5	0.5	(0.0, 30.0)	(0.0, 0.5)
ld	1.0	0.0	0.0	0.0	(0.0, 15.0)	(0.0, 1.0)
td	1.0	1.0	1.0	1.0	(0.0, 15.0)	(0.0, 1.0)
hcaw	0.0	14.0	0.0	12.0	(0.0, 30.0)	(0.0, 14.0)
daw	5.0	1.0	1.0	4.0	(0.0, 30.0)	(0.0, 5.0)
Data 3 (8,14)						
wt	0.0	15.0	0.0	18.0	(0.0, 30.0)	(0.0, 18.0)
rt	3.0	3.0	3.0	3.0	(0.0, 30.0)	(0.0, 3.0)
ld	1.0	0.0	0.0	0.0	(0.0, 15.0)	(0.0, 1.0)
td	6.0	6.0	6.0	6.0	(0.0, 15.0)	(0.0, 6.0)
hcaw	0.0	14.0	0.0	12.0	(0.0, 30.0)	(0.0, 14.0)
daw	0.0	6.0	6.0	9.0	(0.0, 30.0)	(0.0, 9.0)
Data 3 (8,1)						
wt	15.0	0.0	0.0	0.0	(0.0, 30.0)	(0.0, 15.0)
rt	8.5	3.5	3.5	8.5	(0.0, 30.0)	(3.5, 8.5)
ld	1.0	1.0	0.0	1.0	(0.0, 15.0)	(0.0, 1.0)
td	8.0	8.0	8.0	8.0	(0.0, 15.0)	(0.0, 8.0)
hcaw	14.0	0.0	0.0	0.0	(0.0, 30.0)	(0.0, 14.0)
daw	5.0	0.0	8.0	1.0	(0.0, 30.0)	(0.0, 8.0)
Data 6 (1,9)						
wt	0.0	18.0	1.0	19.0	(0.0, 30.0)	(0.0, 19.0)
rt	8.0	4.0	4.0	12.0	(0.0, 30.0)	(4.0, 12.0)
ld	1.0	0.0	1.0	1.0	(0.0, 15.0)	(0.0, 1.0)
td	8.0	8.0	8.0	8.0	(0.0, 15.0)	(0.0, 8.0)
hcaw	0.0	20.0	2.0	14.0	(0.0, 30.0)	(0.0, 20.0)
daw	3.0	8.0	0.0	3.0	(0.0, 30.0)	(0.0, 8.0)
Data 6 (8,9)						
wt	7.5	0.5	8.5	23.5	(0.0, 30.0)	(0.5, 23.5)
rt	0.5	0.5	0.5	0.5	(0.0, 30.0)	(0.0, 0.5)
ld	0.0	1.0	1.0	0.0	(0.0, 15.0)	(0.0, 1.0)
td	1.0	1.0	1.0	1.0	(0.0, 15.0)	(0.0, 1.0)
hcaw	7.0	1.0	9.0	15.0	(0.0, 30.0)	(1.0, 15.0)
daw	3.0	5.0	0.0	3.0	(0.0, 30.0)	(0.0, 5.0)
Data 6 (14,9)						
wt	10.5	3.5	15.5	0.5	(0.0, 30.0)	(0.5, 15.5)
rt	6.5	2.5	2.5	2.5	(0.0, 30.0)	(2.5, 6.5)
ld	1.0	0.0	0.0	1.0	(0.0, 15.0)	(0.0, 1.0)
td	5.0	5.0	5.0	5.0	(0.0, 15.0)	(0.0, 5.0)
hcaw	13.0	7.0	15.0	1.0	(0.0, 30.0)	(1.0, 15.0)
daw	1.0	2.0	10.0	0.0	(0.0, 30.0)	(0.0, 10.0)

Table 4: Simulation Results

Situation	Elevator 1	Elevator 2	Elevator 3	Elevator 4
Data 1				
Pos.	1	9	4	14
Dir.	Up	Down	Nm	Nm
Cc	15	1	-	-
Assign. hc	(6,12) (6,4)	(8,12) (6,4)	-	-
New hc	Priority			
(8,14)	**0.6649**	0.0377	0.5283	0.5283
Data 2				
Pos.	15	8	1	10
Dir.	Down	Down	Up	Up
Cc	10, 1	1	1, 15	14
Assign. hc	(13,5)	(1,4) (12,13) (15,10)	(12,14) (15,6)	(6,1)
New hc	Priority			
(8,14)	0.3019	0.4814	**0.7458**	0.3019
(8,3)	0.6792	0.3019	0.3764	**0.6908**
Data 3				
Pos.	8	8	8	8
Dir.	Up	Down	Nm	Down
Cc	14	1	-	5
Assign. hc	(15,6)	(4,8)	-	(2,5)
New hc	Priority			
(8,9)	0.4906	0.2264	**0.7170**	0.0377
(8,14)	**0.6792**	0.0929	0.5553	0.0377
(8,1)	0.0241	**0.9434**	0.7925	0.6792
Data 4				
Pos.	2	10	13	5
Dir.	Up	Up	Down	Down
Cc	1	11	12	4
Assign. hc	(5,8)	(14,9)	(10,13) (8,4)	(4,11)
New hc	Priority			
(8,9)	**0.6324**	0.1337	0.2264	0.4906
(2,1)	0.0832	0.0377	0.3090	**0.7170**
(15,14)	0.3340	**0.7170**	0.2067	0.4547
Data 5				
Pos.	8	1	11	15
Dir.	Up	Up	Down	Down
Cc	9, 10, 11	2, 3, 4	8, 9, 10	12, 13, 14
Assign. hc	(10,11) (13,11)	(8,4)	(15,3)	(2,6)
New hc	Priority			
(1,15)	0.3019	**0.6579**	0.6093	0.3102
(15,1)	0.3526	0.3870	0.5052	**0.6792**
Data 6				
Pos.	1	8	3	15
Dir.	Up	Up	Down	Down
Cc	3	14	1	9
Assign. hc	(12,8)	(8,1)	(1,9)	(4,6) (6,4)
New hc	Priority			
(1,9)	0.6933	0.3019	**0.9434**	0.2032
(8,9)	0.4797	**0.4906**	0.4843	0.1341
(14,9)	0.2523	0.8434	0.3019	**0.9434**
Data 7				
Pos.	3	10	14	6
Dir.	Up	Up	Down	Down
Cc	6, 14	15	9, 10	4
Assign. hc	(10,14)	(2,8) (6,4)	(8,14)	(8,12) (6,4)
New hc	Priority			
(8,15)	0.6792	0.3019	0.7531	**0.7531**

Table 5: Inputs of Data 4, To Investigate the Difference in Elevator Selection before and after CA

Fuzzy Inputs		Elevator 1	2	3	4
wt		11.0	17.0	18.5	6.5
rt		0.5	0.5	0.5	0.5
ld		0.0	0.0	0.0	1.0
td		1.0	1.0	1.0	1.0
hcaw		6.0	10.0	13.0	5.0
daw		1.0	2.0	1.0	2.0
Priority	Default	0.8890	0.8311	0.6693	1.0000
	CA	0.6324	0.1337	0.2264	0.4906

$$PEI = \frac{0.7wt + 0.7rt + 0.1ld + 0.5daw}{0.7 + 0.7 + 0.1 + 0.5} \qquad (5)$$

Table 6: Comparison of Elevator Performance with and without CA.

Simulation time (minute)	Hall call generation time (second)	Average PEI (without CA)	Average PEI (CA)	Improvement (%)
30	5	5.47	4.99	8.78
30	10	5.18	4.77	7.92
30	rand (0-5)	7.91	7.66	3.16
30	rand (0-10)	5.47	5.35	2.19
35	rand (0-10)	5.46	5.40	1.10
45	rand (0-10)	5.41	5.27	2.59
60	rand (0-10)	5.44	5.24	3.68

rand – random

Referring to the first row of Table 6, the simulator has been run for 30 minutes with random hall calls being generated every 5 seconds, and 8.78% of improvement is obtained by using CA. As listed above, hall call generation time, rand (0-10)s, would generate random hall calls every randomly generated instant between 0-10s. By doing this, a closer random nature approximation of the elevator system, could be simulated. For simulation durations of 45 minutes and 60 minutes with the same hall call generation time, implementation of CA made improvements of 2.59% and 3.68% respectively. Evidently, for all the simulation and hall call generation time listed in Table 6, the OSFL with CA provided improvements to a certain extent.

By utilizing CA, it is not troublesome anymore to determine the possible maximum values of the inputs to be set as the upper bound. Also, in cases where the input values are close compared to each other, CA distributes the values evenly throughout the universes of discourse, and enables distinction, for proper elevator dispatch. Furthermore, correct and accurate elevator group supervisory control is possible with the implementation of CA.

8. CONCLUSION

In this research, a simulator of a fuzzy logic elevator group supervisory controller has been developed. To model the complex system as close as possible, and to improve multiple control objectives, OSFL has been used. By using OSFL, fuzzy inference rules of systems with multiple inputs, could be formed with minimum effort. Further improvements have been made, by introducing CA to solve the multiple selections problem. Implementation of CA promises an effective and accurate elevator group supervisory control. As a conclusion, OSFL algorithm with CA provides a simple yet operative mechanism for elevator dispatch, which could optimize multiple performance indexes.

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