Fuzzy logic based controller for elevator system in buildings

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ABSTRACT

The design criteria of an intelligent elevator control system would include optimizing elevator movement with respect to average waiting time, overall distance travelled, optimal load carried, etc. When only the average calls service time is optimized, long 'tails' in the hall call time distribution will appear. These tails can be cut by optimizing the average waiting time or by giving priorities to the old hall calls. Calls with high priority are given fast service and the long call times are cut. Instead of one target, multiple targets are optimized.

In this work, a fuzzy based controller is designed to reduce the average waiting time and the total distance travelled. The result is compared to that of an elevator running under a conventional controller. Simulations have verified that the intelligent controller can bring about considerable improvements in the average waiting time and the total distance travelled in comparison with conventional methods. Experimental verification has established that optimization of average waiting time and total distance travelled leads to considerable energy savings, as vertical transportation is an area with significant energy consumption in any building investment.

INDEX TERMS

Fuzzy controllers; Intelligent elevators; Energy conservation; Target optimization

INTRODUCTION

In a single elevator system the elevator control handles all the equipment. With the advancement of intelligent computerized buildings in recent years, there have been strong demands for intelligent elevator control with more sophistication and diverse functions. These may be for the sole aim to reduce energy costs, bring down maintenance and wear and tear, and to increase the level of comfort. These can be done through two methodologies. One is proper design and use of material in the making of an elevator and the other is by applying logic to its working. The 'logic' means the methodology that makes a controller decide upon the steps to implement strategies in order to improve elevator performance at the same time reduce energy and increase comfort levels for the passengers. This is done through optimizing the call algorithms and the decisions to entertain those calls. With microprocessors technology, mathematical methods and sophisticated call allocation algorithms are used to optimize hall calls to the elevators. In this paper we are using fuzzy based intelligence to improvise its performance. Fuzzy logic is a combination of both numeric and symbolic techniques. It excels in producing exact results from imprecise data and is especially useful in computer and electronic applications. In traditional or conventional logic an object takes on a value of either ON or OFF. In fuzzy logic, a statement can assume any real value between 0 and 1, representing a degree to which an element belongs to a given set. The human brain can reason with uncertainties, vagueness and judgements. Computers can manipulate precise valuations. Fuzzy logic is an attempt to combine these two techniques.

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METHODS

The elevator system in this work has one elevator car. At any given time, there is one elevator in operation between '*n*' numbers of floors. An elevator will be on a particular floor, numbered 1 through *n*. An elevator may be empty or contain one or more passengers. For the purposes of this paper, there is no upper bound on the number of passengers an elevator may contain.

An elevator *call* may be issued from any floor; once a call has been issued, it is *outstanding* until an elevator arrives at that floor. There is a single controller, which is responsible for managing the simulation. The controller will:

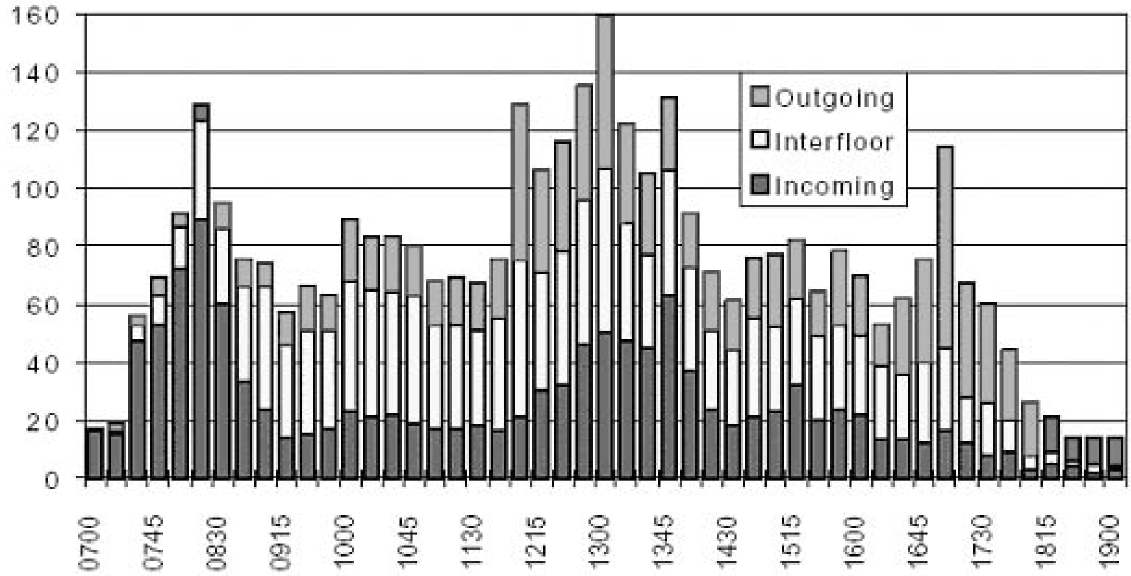
- Maintain a simulated clock storing the official simulation time.
- Keep track of which floors have outstanding calls for an elevator.
- Cause all components of the simulation to update themselves on ticks of simulated clock.

The elevator and Floors are numbered sequentially starting from zero. The elevator:

- Keeps track of a list of its current passengers and their destinations.
- Keeps track of the current destination it (the elevator) is attempting to reach.
- Keeps track of the time delay when it stops to load/unload passengers (specified below).
- Keeps track of the time delay when moving between adjacent floors (specified below).
- Keeps track of its current location. This may be more complex than a floor number.
- Keeps track of its current direction of movement (if any).
- Updates its state when the simulated clock 'ticks'.

Some of these require data members and associated operations; others are computed when needed from other data values that are maintained continuously. In addition, the operation of elevator must be governed by the set of Simulation Rules given below.

The simulation is inherently time driven and is managed by simulating the passage of time and updating relevant objects on each 'tick' of the simulated clock. Input to the simulation is provided in an input file that is printed in a prescribed format at runtime and can be read by the simulation program when invoked. The data of the passenger traffic are programmed to follow Poisson's distribution.



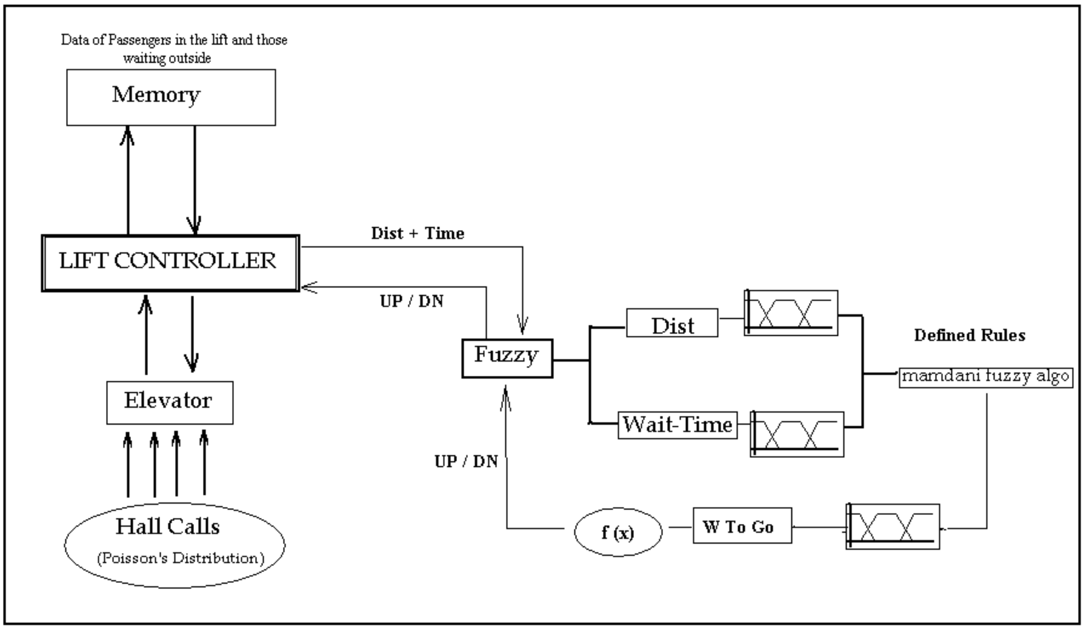
Traffic component during daytime from 7:00 a.m. to 7:00 p.m.
(Graph Plotted from the Sample data)

Each command is recorded when the simulation time reaches the timestamp of the command; this changes the state of the system, and eventually causes some actions to be taken. These Data are utilized to know the direction of travel. The call command contains the caller floor, destination and the time at which the call is activated. The destination value at the moment is only a member value in this function and is not used till the calling passenger has entered the elevator. Once the person enters only then is this destination data stamped as the destination floor of the particular person.

The elevator 'remembers' a call at a floor and stops to entertain it, if and only if, the direction of travel of both is the same. Else the elevator will continue to travel in its direction till it reaches its highest or the lowest floor in the building or the highest or the lowest floor of all the calls registered depending upon the direction of travel. Only after a call is entertained, it is cancelled from the waiting list. The elevator car will continue to ply unless and until all the calls are exhausted and no call is waiting. The elevator then travels to the lowest floor and waits for further instantiation.

HEURISTICS

The choice of minimization target in the cost function is important when considering the overall elevator performance and the service level. The most general optimization target in elevator control has been the minimization of the average waiting time, overall distance travelled and the optimal load carried. A number of costs, such as call time, passenger waiting and journey times, car load factor, energy consumption, transportation capacity, and number of starts, can be considered during the call allocation and prioritizing. The optimization targets are given weights according to the importance of the optimization targets. The customer gives the weight factors, for instance, with an external device. When optimizing one target, the other features may suffer. For instance, when optimizing the energy consumption, the passenger waiting times may increase. Several optimization targets can be optimized within one control if the most suitable target is switched according to the prevailing traffic patterns.



Control flow diagram

WaitingListUp = list of passenger calls in upward direction recorded but not entertained.

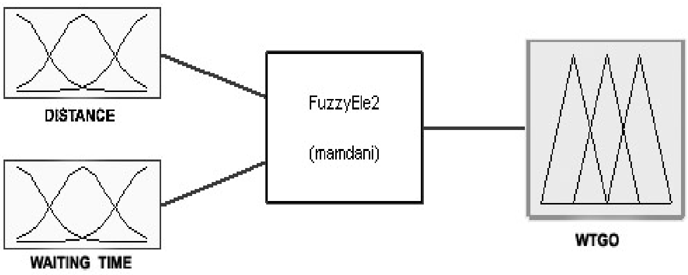
WaitingListDn = list of passenger calls in Downward direction recorded but not entertained.

After the passengers board the Lift, their waiting time is calculated and stored to further calculate the Average waiting Time:

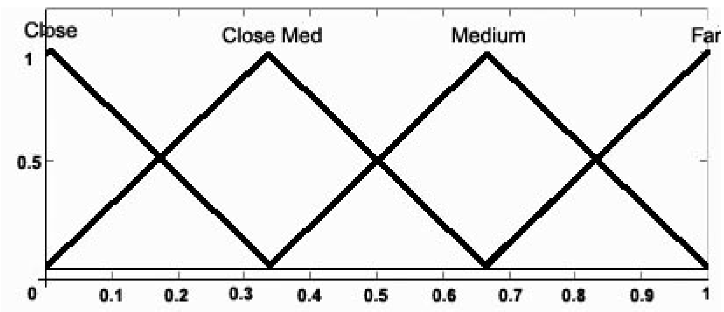
Function: CallFuzzy ( )
If (WaitingListUp AND WaitingListDn) is NOT_EMPTY
Case 1. Consider WaitingListUp, calls placed above location of the elevator and consider all the calls in waitingListDn
Case 2. Consider WaiitngListDn, calls placed below the location of the elevator and consider all the calls in WaitingListUp

Take each parameter mentioned below:
1. Number of floors between the present position of the elevator and the hall call floor.
2. Their waiting time, i.e. (current time – hall call time).
Interpolate the parameters from 0 to 1
Sent to mamdani fuzzy file

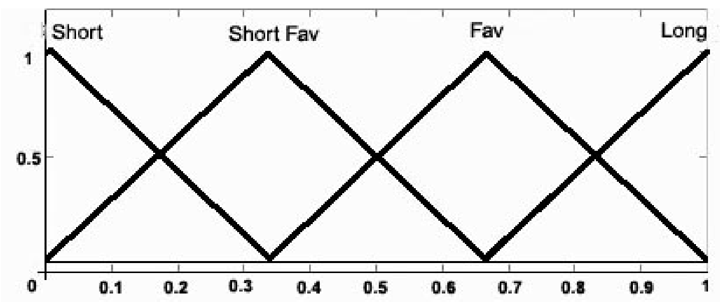
FUZZY FILES



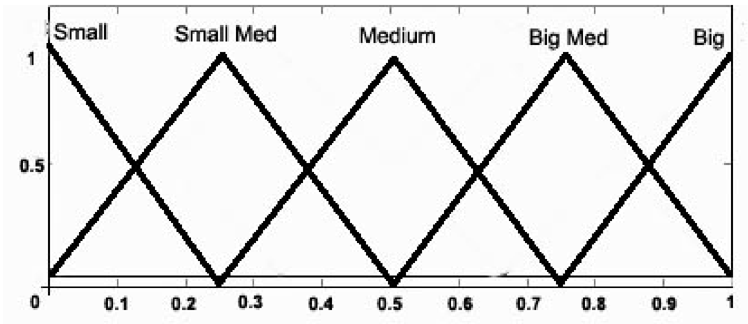
INPUT-MAMDANI Fuzzy – OUTPUT



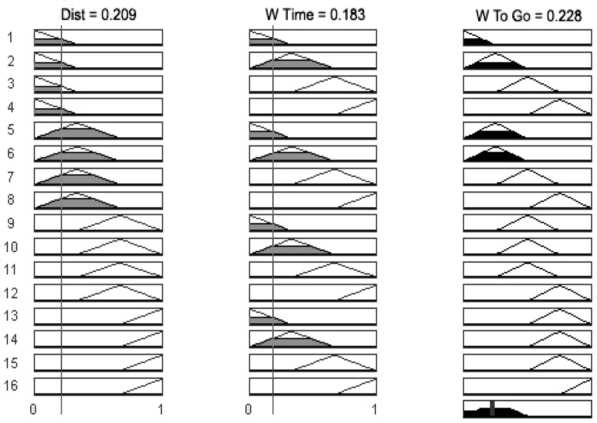
Distance (INPUT)

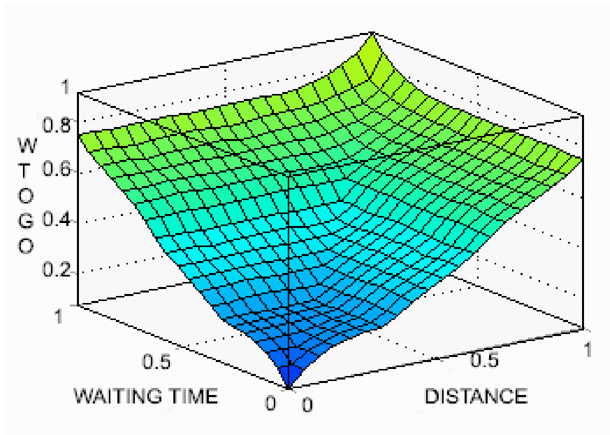


Waiting Time (INPUT)



WtoGo (OUTPUT)





Firing of Fuzzy Rules SURFACE VIEW:

X (Input) Dist　Y (Input) Wtime　WtoGo
X-Grids 20　Y- Grids 20

FUZZY RULES

R. no.						
1.	IF	Dist is Close	AND	Wtime is Short	THEN	WtoGo is Small
2.	IF	Dist is Close	AND	Wtime is ShortFav	THEN	WtoGo is SmallMed
3.	IF	Dist is Close	AND	Wtime is Fav	THEN	WtoGo is Medium
4.	IF	Dist is Close	AND	Wtime is Long	THEN	WtoGo is BigMed
5.	IF	Dist is CloseMed	AND	Wtime is Short	THEN	WtoGo is SmallMed
6.	IF	Dist is CloseMed	AND	Wtime is ShortFav	THEN	WtoGo is SmallMed
7.	IF	Dist is CloseMed	AND	Wtime is Fav	THEN	WtoGo is Medium
8.	IF	Dist is CloseMed	AND	Wtime is Long	THEN	WtoGo is BigMed
9.	IF	Dist is Medium	AND	Wtime is Short	THEN	WtoGo is Medium
10.	IF	Dist is Medium	AND	Wtime is ShortFav	THEN	WtoGo is Medium
11.	IF	Dist is Medium	AND	Wtime is Fav	THEN	WtoGo is Medium
12.	IF	Dist is Medium	AND	Wtime is Long	THEN	WtoGo is BigMed
13.	IF	Dist is Far	AND	Wtime is Short	THEN	WtoGo is BigMed
14.	IF	Dist is Far	AND	Wtime is ShortFav	THEN	WtoGo is BigMed
15.	IF	Dist is Far	AND	Wtime is Fav	THEN	WtoGo is BigMed
16.	IF	Dist is Far	AND	Wtime is Long	THEN	WtoGo is Big

Sum all the weightings outcome from the fuzzy file resulting out of case 1
And then from case 2
Find the maximum summed weightage.
The case with the maximum summed weightage is the prioritized direction of the elevator.

RESULTS

Output of Test Simulations

SIMULATION FOR A DAY
No of floors in a building, 6
Simulation Start time, 07:01:01
Stat display and Simulation end time, 07:59:59 (after 12 h from the start time)

Output

Controller	Total distance travelled	Average waiting time
Conventional	15 105	49
With Fuzzy	14 547	44

Result Gains

Parameters	In units	Percentage
Distance travelled (m)	558	3.69
Average waiting time (s)	5	10.3

DISCUSSION

Failure to properly implement simulation rules and other assumptions will almost certainly cause results that are inconsistent with this specification, and such results may probably not give best results.

CONCLUSION AND IMPLICATION

In this paper control algorithm for elevator control has been developed. This algorithm is developed using fuzzy logic to improve multiple control objectives. The performance of the proposed intelligent elevator controller has been compared to a conventional controller and its average waiting time and total distance travelled compared for similar traffic generated as input for both the cases. Its is been witnessed that intelligent controller has improvised performance with result gains of 3.69% for the total distance travelled which would save energy and wear and tear, and 10.3% on the average waiting time which would improve the comfort level for passengers waiting. The result directly implies that energy consumption in the form of electrical cost can be effectively reduced with enhanced comfort level for the passengers.

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