THE LATEST ELEVATOR GROUP SUPERVISORY CONTROL SYSTEM

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ABSTRACT

The group control system which applies an expert system and fuzzy theory was originally developed in 1988 and now the latest group control system which applies a neural network is in development. This paper first describes the group control system which applies a neural network and next the new group control system which adopts a hall call assignment algorithm for double-deck elevators, and a destination-oriented car allocation service to improve service during the morning rush hour.

1.0 INTRODUCTION

Recently, building traffic has become more and more diversified and complicated due to buildings becoming more intelligent, and for the elevator group control, which bears the vertical transportation, the demand for highly developed features and various functions has increased. The group control system which applies an expert system and fuzzy theory of AI technology was developed as a first in the world, so that our company might satisfy these demands.

The purpose of the group control system is to control all the elevators as a group and transport passengers to their destination floors pleasantly and promptly. Its basic function is to select the optimum elevator as an assignment car to a hall call. The selection of the assignment car is a multipurpose, optimization problem because of the many factors which have to be evaluated (i.e. waiting time, energy saving, and simplicity). To solve this multipurpose, optimization problem, a multipurpose control method which converts the physical waiting time and the by-passing by full car into "psychological waiting time", has been adopted.

2.0 THE GROUP CONTROL SYSTEM WITH NEURAL NETWORK

2.1 Presumption of Traffic Flow Pattern

The method of controlling the elevator operation must change according to the varying conditions of the elevator, the traffic flow, and the installation environment. The condition of the elevator, according to the installation environment, etc., can be observed, or is a known value. However, the traffic flow cannot be observed and handling it is a problem. Traffic flow is a concept that indicates the condition of the elevator; it can be described by the number of passengers, the passenger generation intervals, and the Origin and Destination procession. This traffic flow is divided into a number of distinct patterns. The conventional system which applies fuzzy theory to the hall call assignment algorithm, shortened the waiting time by forecasting the car positions after a specified time using strategic overall assignment. The conventional system adapted to the traffic flow, different in each building, by gathering the macro traffic data using the learning function. However, it was not enough in the point of recognition of the traffic flow.

The new group control system currently development, is able to recognize the change of traffic flow during a decided time zone in a day using a neural network and adapts the group control for the differing traffic flow in each building.

2.2 System Configuration

Fig.1 shows the configuration of the group control system which applies a neural network. It consists of the hall call assignment module which performs the basic function; the traffic control module which operates the all elevators; and the traffic pattern selection module which activates the traffic pattern. Additionally, the system is composed of the traffic data gathering module which gathers the data necessary for neural network learning and distinguishing output; the training data production module which extracts the training data from gathered traffic data; the data base in which the neural network and the training data are stored; the learning module which trains the neural network regularly, and the traffic flow distinction module which distinguishes traffic flow in real time using the neural network.

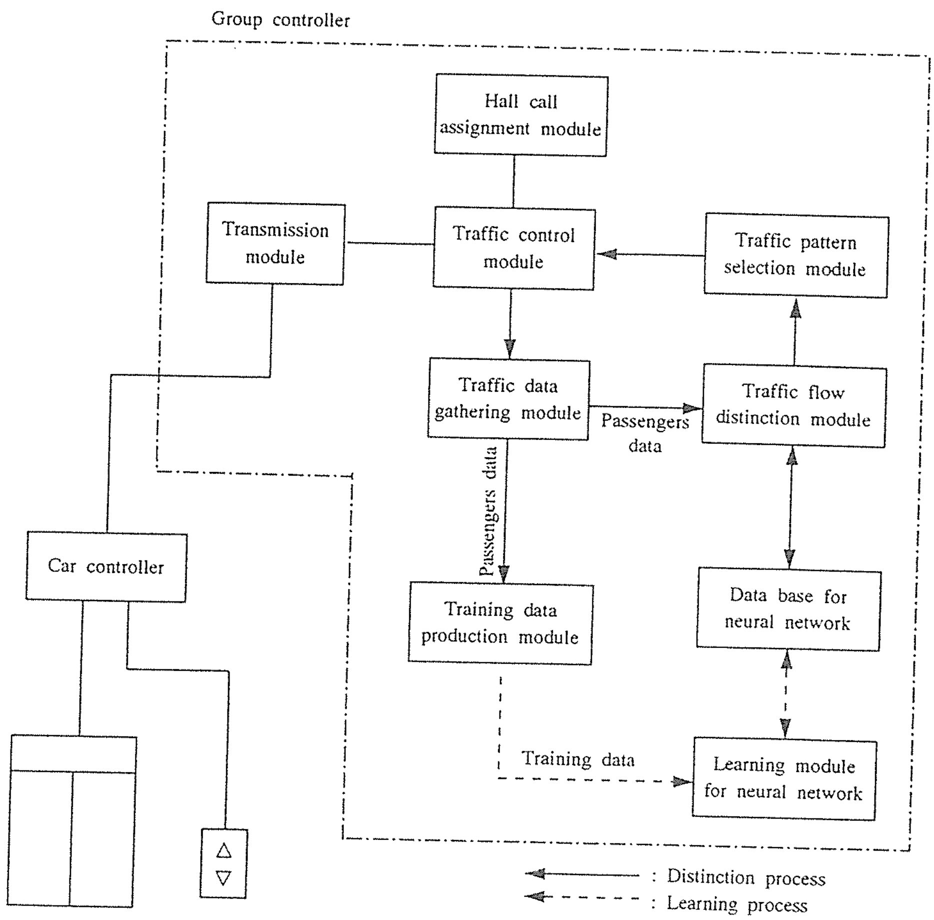

Fig.1 System configuration of group control with neural network.

2.3 Explanation of the Activation of Recognizing Traffic Flow

The procedure which distinguishes the traffic flow using the neural network is described as follows. Fig.2 shows the configuration of the neural network. For instance, in an office building three peak time zones usually appear. One in the morning, one at lunch time, and one in the evening. A neural network which recognizes each peak is prepared for each of these three time zones. The "get-on" loads and "get-off" loads according to direction for each of three building zones are input to each neural network. The building zone mentioned here is a group of specified floors. Then the system trains the neural network. For instance, if the output from a neuron in the output layer for the correct traffic pattern equals 1, and then the output from the other neurons should equal 0 corresponding to the input data. Moreover, if two or more output level exceed the threshold value or no mode exceed the threshold value, a filter is used. The standard type neural network is stored beforehand and the system regularly repeats the learning process, based on the traffic data gathered from the actual building.

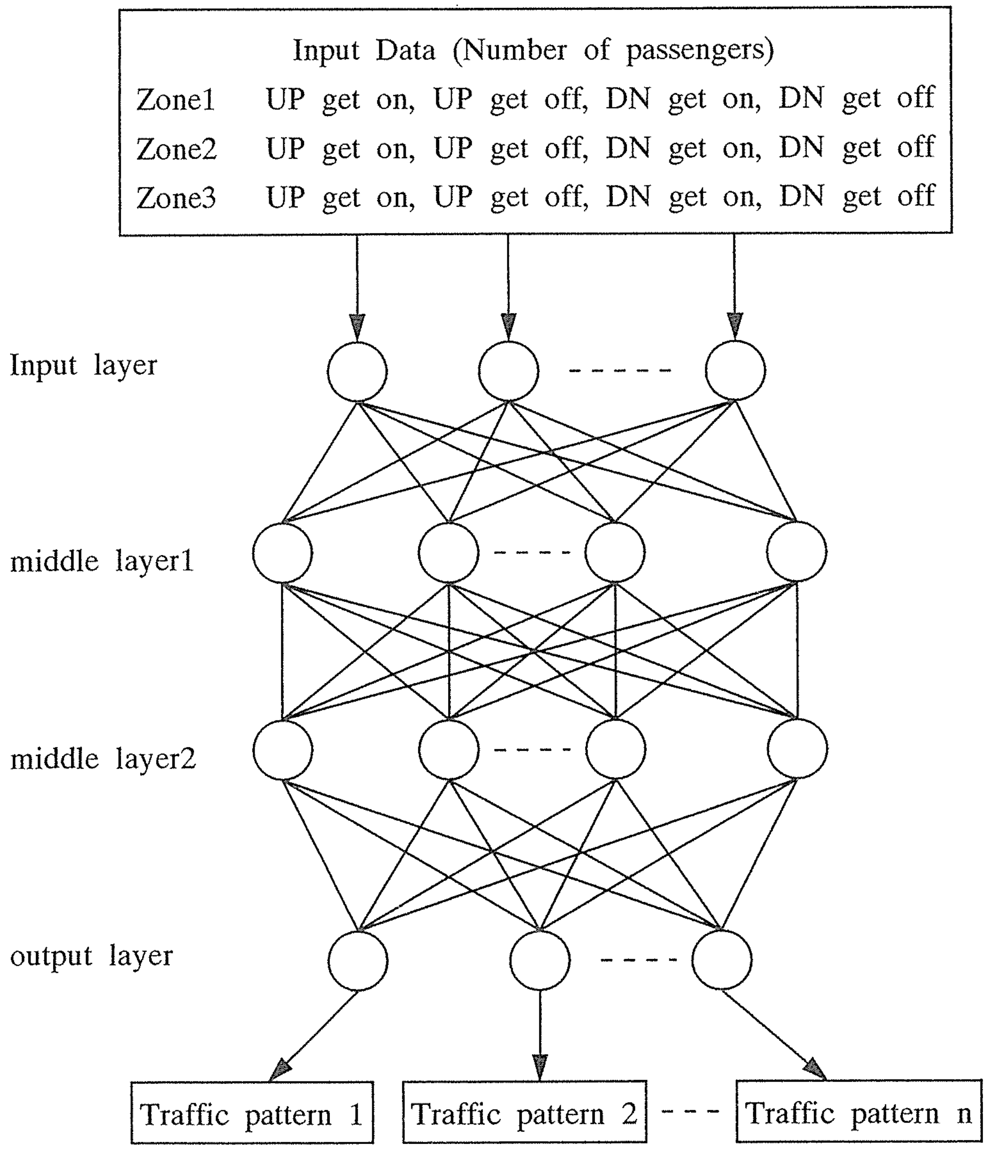

Fig.2 Configuration of neural network.

The neural network operates according the following procedures.

(1)The traffic data for a number of days is stored and training data is extracted from that data.

(2)The neural network is repeatedly trained using training data for a designated period (for instance, every two weeks). The neural network is updated only when the results improve over the previous network.

(3)The appearance of the traffic peak is distinguished in real time by the most recently trained neural network.

(4)For each distinguished traffic mode the corresponding effective operation is executed.

The effective operation mentioned in (4) is for example, multiple car assignment to a congested floor and changing the number of assignment car and the timing according to the traffic conditions.

2.4 Verification of Effectiveness by Simulation

To evaluate the performance of the group control system which applies a neural network according to the previously mentioned technique, we used extensive computer simulation. First, we gathered traffic data for several days from actual buildings and extracted the training data from the traffic data and trained the neural network with this data. Then we compared the performance with the conventional system for the generated real traffic. Fig. 3 shows the simulation results. According to these results, the new group control system can shorten the average waiting time by 10%, and reduce the long waiting rate of 60 seconds or more by 20% compared with conventional system.

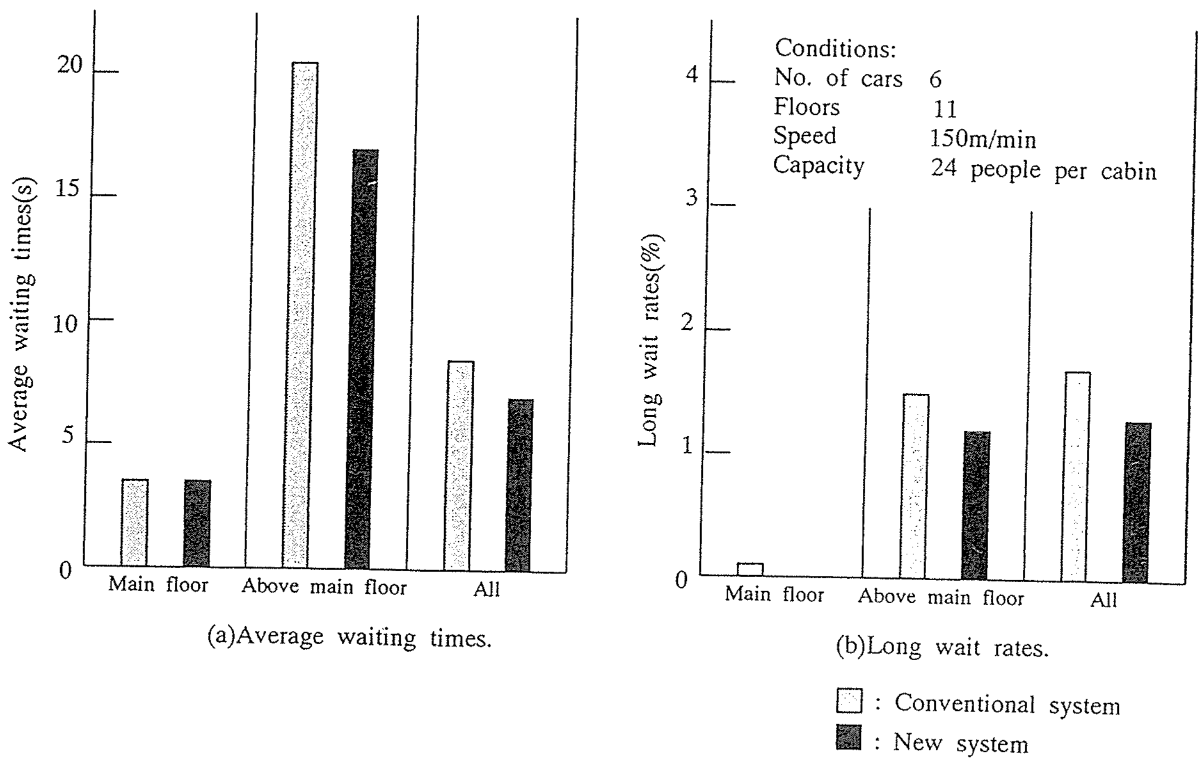

Fig.3 Elevator simulation results.

3.0 THE GROUP CONTROL SYSTEM FOR DOUBLE-DECK ELEVATORS

3.1 Definition

A double-deck elevator car consists of two separate cabins built into a single unit. With twice the passenger capacity of a conventional car, double-deck elevators can reduce travel time. They can also save floor space by serving the same number of passengers with fewer elevators. Our double-deck elevators offer three operation modes suited to different traffic conditions shown as Fig.4.

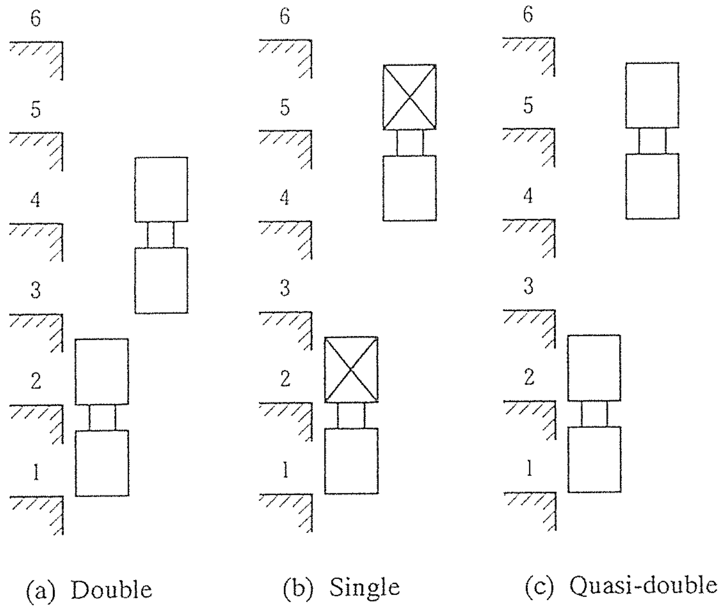

Fig.4 Operation modes.

3.2 Operation Modes

DOUBLE MODE. In this mode one cabin serves the odd floors and the other serves the even floors. This mode effectively doubles the rated passenger capacity. The number of stops required to make a round trip is also approximately halved, so that the time spent waiting at landings is shorter. One disadvantage of this mode of operation is that passengers must use a stairway to travel between odd and even floors.

SINGLE MODE. This operation mode is identical to that of a conventional single-deck elevator car. One cabin serves passenger traffic on all floors, while the doors to the other cabin remain closed. This mode offers no increase in carrying capacity.

QUASI-DOUBLE. In this combined strategy, passengers entering the building via the main hall use separate landings to travel to odd and even floors. However, passengers entering either cabin at intermediate floors are taken to their desired destination floor, regardless of whether it is odd or even.

Each mode has its merits. Fig.5 shows the results of a computer simulation of the average waiting time in the different modes under various passenger loads. The results suggest scheduling double-mode operation during the morning rush hour, quasi-double-mode operation to serve interfloor traffic during the day, and single-mode operation for light traffic at night or on holidays.

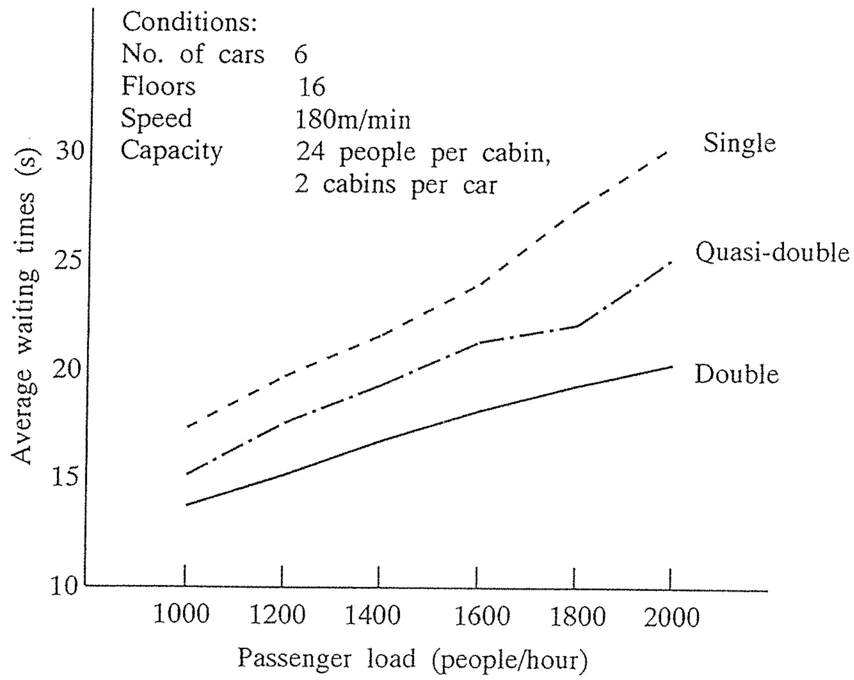

Fig.5 Average waiting times.

3.3 Assignment Methods

In all of the above operation modes, a group control algorithm is required to assign the optimum car to service successive hall calls. Complications arise in the quasi-double mode because both upper and lower cabins may need to let off passengers at the same floor, a condition we refer to as a "double stop." The group control system minimizes double stops and the associated delays by assigning the car in two steps. (1) When a passenger pushes a call button at a landing, the system immediately assigns an elevator to service the call, activating the appropriate hall lantern and chime to prepare passengers for boarding. (2) Immediately prior to stopping, either the upper or lower cabin is assigned to service the call, the choice being made to minimize the number of stops.

The call-assignment strategies for double or single-mode operation are handled by the same algorithm by simply limiting the choices available. During double-mode operation, cabins are restricted to stopping at either odd or even floors. In single-mode operation, service is limited to one cabin.

3.4 Voice Announcement

One cabin may have to wait with doors closed while passengers board or exit the other cabin. To forestall passenger irritation, we activate a text indicator and voice announcement unit that says, "Please wait for passengers on the upper (lower) deck."

The group control system for double-deck elevators described above is operating effectively in a Tokyo office building and has received favorable comments from the customer.

4.0 DESTINATION-ORIENTED CAR ALLOCATION SERVICE

This strategy increases passenger transport efficiency during morning rush-hour traffic. The elevator landing at the building's main entrance (often the ground floor) has floor destination buttons and indicators above the elevator doors that shows the area each car servicies(Fig.6). When passengers press the desired destination button, the group-control system allocates the call to an appropriate car, immediately activates the corresponding hall lantern and chime to show the passenger where to go, and updates the service-area indicators if necessary.

A previous rush-hour strategy divided the floors into upper and lower zones, and assigned elevators to these zones. However, this strategy can lead to a shortage of services if one zone is substantially busier than the other.

Compared to this strategy, our simulations indicate that the new strategy can reduce the average waiting time for servicing calls at the highest floors by 30~50%, and the overall waiting time by 5~10%.

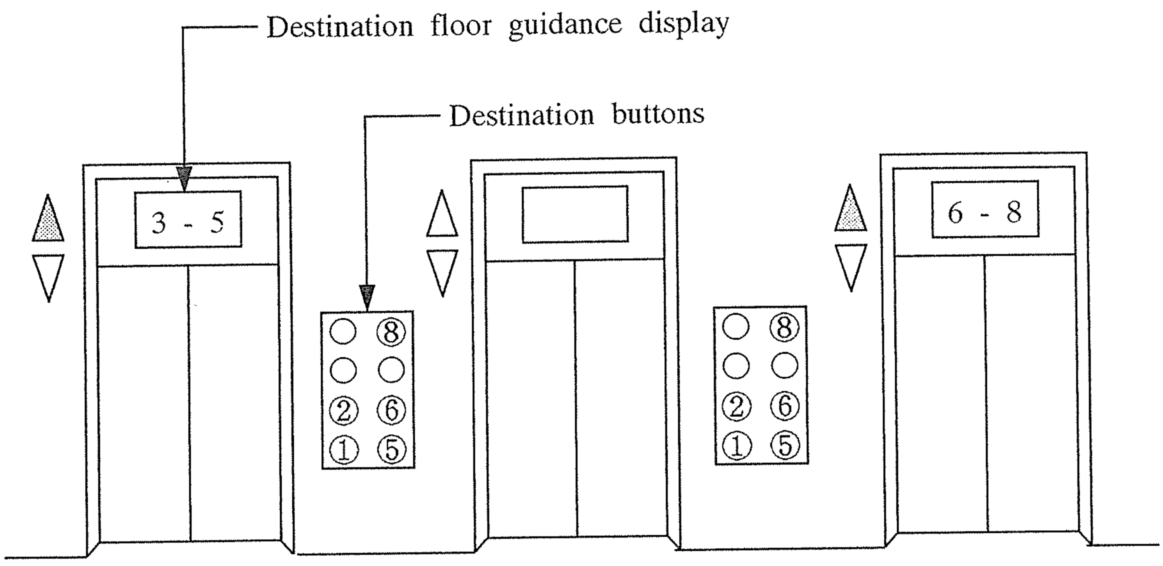

Fig.6 Entrance floor equipment for destination-oriented car allocation service.

5.0 TRAFFIC SURVEY UNIT

This equipment, based on a personal computer, assists quantitative analysis of the group control system performance during actual operation. Connected to the group control computer via a serial interface, it records hall call and car movement data on a hard disk for later analysis. The data collected with the traffic survey unit are processed by a workstation and the resulting statistics and the analysis are output. The performance of the group control system operating in an actual building can be quantitatively evaluated based on these output results.

6.0 CONCLUSION

The latest elevator group supervisory control system has been described above. In the future, we hope to continue to improve the features of the group control system which applies a neural network, including double-deck elevators and destination-oriented car allocation service, and developing even more efficient group control systems.

BIBLIOGRAPHY:

M.Iwata, S.Hikita and K.Komaya: Presumption of traffic flow pattern which uses neural network.
Measurement control automatic operation academy system of the 20th times symposium
The 20th times intelligence system symposium
Neural Network of the 5th times work symposium
Break-up of the 14th times event system society
Joint symposium collected papers, PP 269-276 1994.

H.Ujihara and M.Amano: The Latest Elevator Group Control System.
Mitsubishi Electric ADVANCE, Vol.67/Jun. 1994.

M.Yamazaki and K.Onishi: The Latest Group Control System for Double-Deck Elevators.
Mitsubishi Electric ADVANCE, Vol.67/Jun. 1994.

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