

The Latest Elevator Group Control System

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Key Words: elevator group control, artificial intelligence, real-time simulator, destination call entry system

ABSTRACT

Mitsubishi Electric has developed a new elevator group control system named Sigma AI-2200. This system has two major features. The first one is a newly proposed group control logic, which tunes the group control rule-sets dynamically, using a built-in real-time simulator. The second one is a kind of destination call entry system, applying new hall operation panels and some other devices. This paper introduces the functions of Sigma AI-2200 as the most advanced of these systems. And also simulation results are shown to verify the group control performance.

1. INTRODUCTION

An elevator group control system controls a multiple of elevator cars to improve the traffic efficiency in the building (Barney and Santos 1985).

In the recent group-control systems, AI (artificial intelligence) technologies, such as the fuzzy theory and the neural network technology have been applied.

In this paper, we introduce the newly developed elevator group-control system named "Sigma AI-2200", in which the latest AI technologies are applied.

1.1 Basic function of elevator group control

The most basic function of the elevator group control is to allocate appropriate elevator cars to generated hall calls. That is, when a hall call is registered, the group-control system immediately selects and allocates an optimal elevator car. And it informs to the passengers which car to enter, with a hall lantern installed at the hall.

This method is called as "Immediate prediction method", and has generally been adopted especially in the multistory buildings.

To select optimal car becomes a kind of multi-objective decision making problem, since it has many items to be evaluated, such as waiting time, prediction accuracy, overload bypass and so on. And it should make a decision in a very short time, under the mentioned immediate prediction method.

The calculation time is an important constraint, since a large amount of arithmetic operations will be needed for the allocation control. Therefore, the calculation speed is one of the important points to design the group-control system.

1.2 Group supervisory control system in recent years

We have applied the "Psychological Waiting Time Evaluation" to solve the above-mentioned multipurpose optimal decision making problem.

This method uses a specific evaluation function and evaluates passengers' irritations as "Psychological waiting time", which may be caused by long waiting time, prediction errors and full-load bypassing and so on. And the car to be allocated will be selected based on the totally evaluated psychological waiting times.

Moreover, only by the evaluation function of the above-mentioned psychological waiting time, there were some difficulty to deal with the various traffics, which will change dynamically.

As one of the solutions for this problem, we have applied expert system technology. The system decides the assignment car using the rule-base, which applies a fuzzy theory. This system is called "AI group control" (Ujihara and Tsuji 1988, Tsuji et al. 1989).

Here, to select and allocate an optimal car, it is important to recognize the traffic in the building. Therefore, we have applied the neural network technology, which is a kind of AI technologies, to recognize the traffic pattern in the building. Furthermore, the system forecasts and estimates OD (Origin and Destination) data of traffic flow in the building, using the neural network technology (Amano et al. 1995, Iwata et al. 1995).

In this paper, we introduce a new group control system named Sigma AI-2200, which uses further AI technologies more than the conventional systems.

It has following three major features.

- (1) "**Dynamic Rule-set Optimizer**", which is a further improved AI method.
- (2) "**Destination Oriented Prediction System**", which is a destination call entry system, and has an improved ease of use.

Moreover, Sigma AI-2200 system has adopted the high speed RISC processor.

As a result, the calculation speed increases to about ten times than that of the conventional system, and a large amount of arithmetic operation has been enabled as described later.

The main technologies and the features of this system are introduced as follows.

2. FEATURES

2.1 Dynamic Rule-set Optimizer

In the conventional system, a general rule-set for each traffic pattern has been used, such as a rule-set for morning peak, another rule-set for lunchtime and so on.

On the other hand, Sigma AI-2200 has a multiple rule-sets for each traffic pattern. This system uses a built-in real-time simulator and evaluates the system performance in case each rule-set is applied. The optimal rule-set, which makes the best system performance, will be selected based on these evaluations.

This is the concept of "Dynamic Rule-set Optimizer".

Hereafter, we explain this feature minutely along the Figure 1.

2.1.1 Rule-based System

Sigma AI-2200 stores a lot of knowledge and procedures necessary for group control as the

rules in the rule-base.

In general, the method, which makes a control using the rule-base, is called rule-based system. An important point to apply the rule-based system is to decide which rules should be used for the group controls according to the traffics.

Extremely speaking, the rules which act effectively in the morning peak period cannot improve the traffic efficiency if those are applied in the evening peak and so on.

The following technologies are used to apply effective rules at the appropriate time.

2.1.2 Neural Network

The neural network is a kind of AI technologies, and has a feature of improving its performance ability by learning itself.

Sigma AI-2200 has two kinds of neural networks, for the traffic pattern distinction and for the traffic flow forecasting.

These make their learning using the observed traffic amount data (number of boarding and alighting passengers) and the elevator operation trace data. And the system makes following controls using the neural networks whose learning process have been completed.

The neural network for the traffic pattern distinction is input the measured traffic amount data, and classify the traffic in the building into some traffic patterns, such as morning peak, daytime, lunchtime and so on.

Based on this traffic pattern classification result, the system withdraws some rule-sets from the rule-base. For instance, some rule-sets for morning peak will be extracted when the traffic is classified as the morning peak.

Moreover, neural network for the traffic flow forecasting is inputs the traffic amount data of tents of minutes, and estimates the several minutes' future traffic flow (OD data).

This traffic flow (OD) is different from the traffic amount data. It means the number of passengers who moves from some floors (Origin) to some floors (Destination) in a unit time.

2.1.3 Real-time Simulator

Sigma AI-2200 has many rules, which are divided for each traffic pattern, such as morning peak. And these rules for each traffic pattern are subdivided and classified into some rule-sets.

The predicted traffic flow data from the neural network and each subdivided rule-set mentioned above are input to the real-time simulator, and it simulates and calculates waiting time and so on.

This process is made for each rule-set, and the rule-set which obtains the optimal system performance will be selected. And the actual operation will be executed using the selected rule-set.

Dynamic Rule-set Optimizer performs simulations based on the predicted traffic flow data, and selects the optimal rule-set among some rule-sets. Therefore, it is anytime possible to make more appropriate operation using the appropriate rule-set compared with the conventional system.

The advantage of this method is shown in the Figure 2. In this figure, each graph shows the change of the average waiting time when each rule-set 1-3 is applied. It is clear that the rule-set1 is the best, that is, the average waiting time is the smallest in the period [T1, T2]. And the rule-set2 is the best in the period [T2, T3], and rule-set3 in [T3, T4].

When Dynamic Rule-set optimizer is applied, the optimal rule-set is selected in each period. Therefore, it always obtains the smallest waiting time.

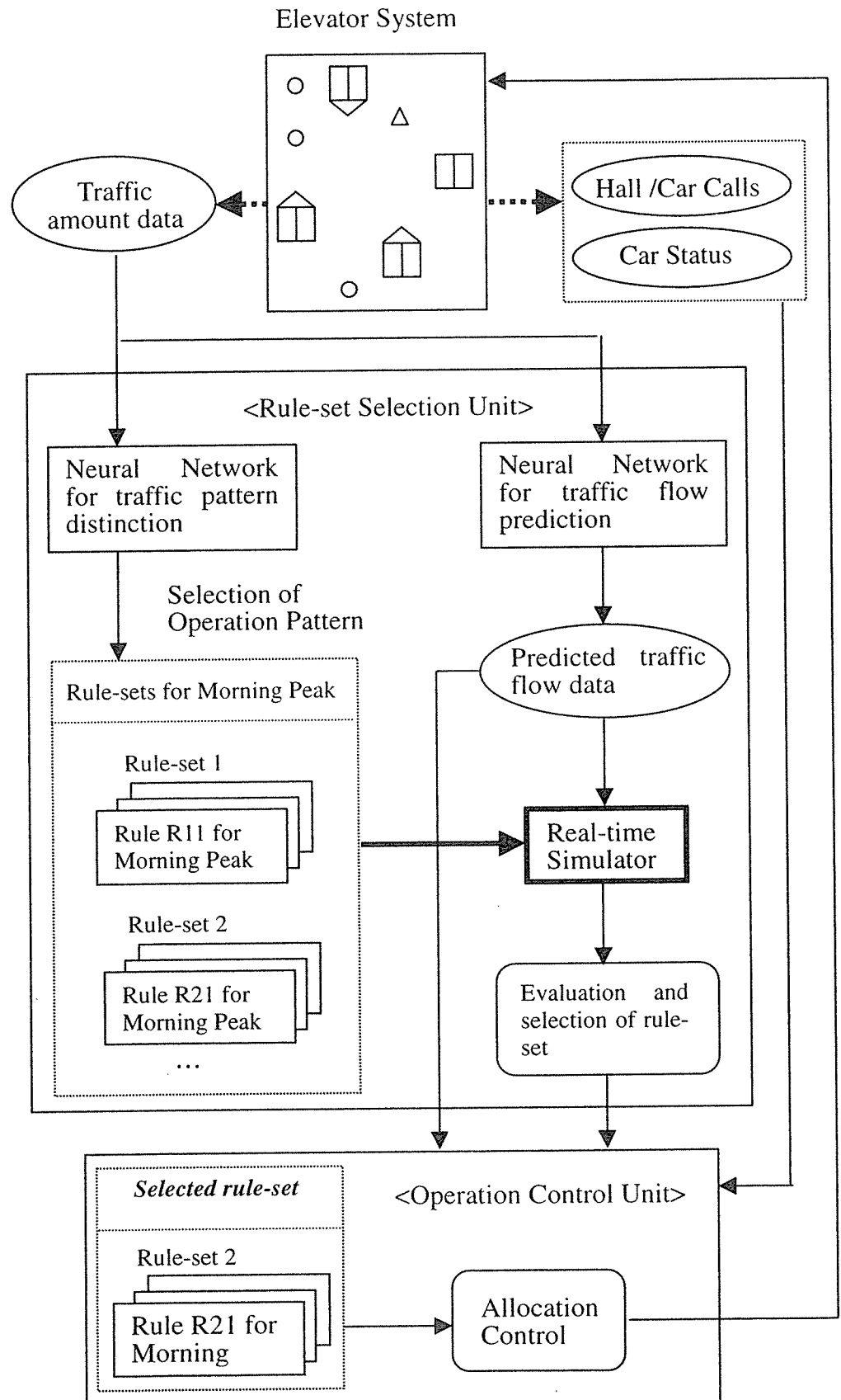


Figure 1. Concept of Dynamic Rule-set Optimizer

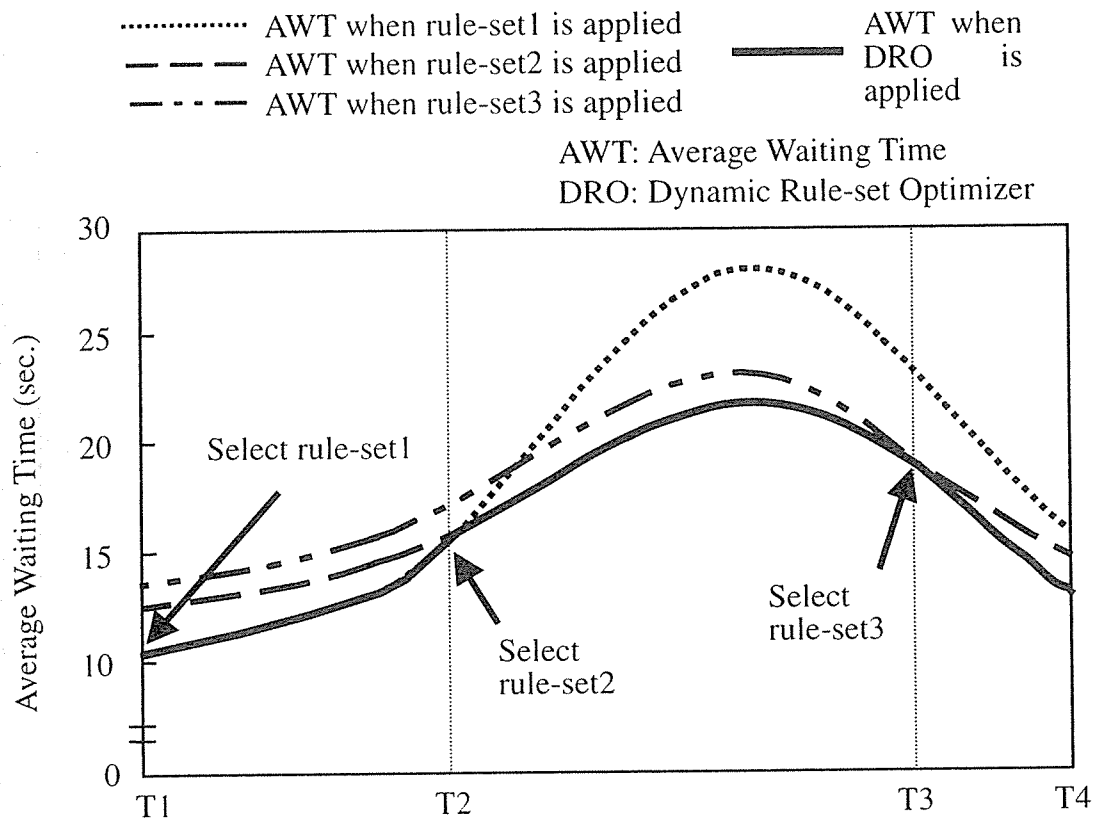


Figure 2. The Advantage of Dynamic Rule-set Optimizer

2.1.4 High Speed RISC Processor

The concept of the Dynamic Rule-set Optimizer is very simple as mentioned above.

However, a CPU that enables the high-speed arithmetic operations is needed to make a real-time simulation, which is the core technology of this method.

For this reason, we have adopted a high-speed RISC processor. It has about ten times faster the arithmetic operation speed compared with the main CPU in the conventional system.

2.2 Destination Oriented Prediction System

2.2.1 Hall operation panel

Hall operation panels and destination floor indicators rather than conventional UP/DN buttons can be installed at the floors, as shown in the Figure 3.

When a passenger presses a destination floor button, the identity of the responding car is immediately indicated at the side of the pressed button. At the same time, the hall lantern is illuminated and the destination floor is indicated at the destination floor indicator of the responding car.

For example, as shown in the Figure 3, when the 11th floor button is pressed, car A is highlighted at the side of the floor button. In the same way, the 13th floor is served by car A, and 4th floor by car B. Passengers can easily recognize which car to enter.

Also, when the passengers enter the car, the floors selected from the hall have already been

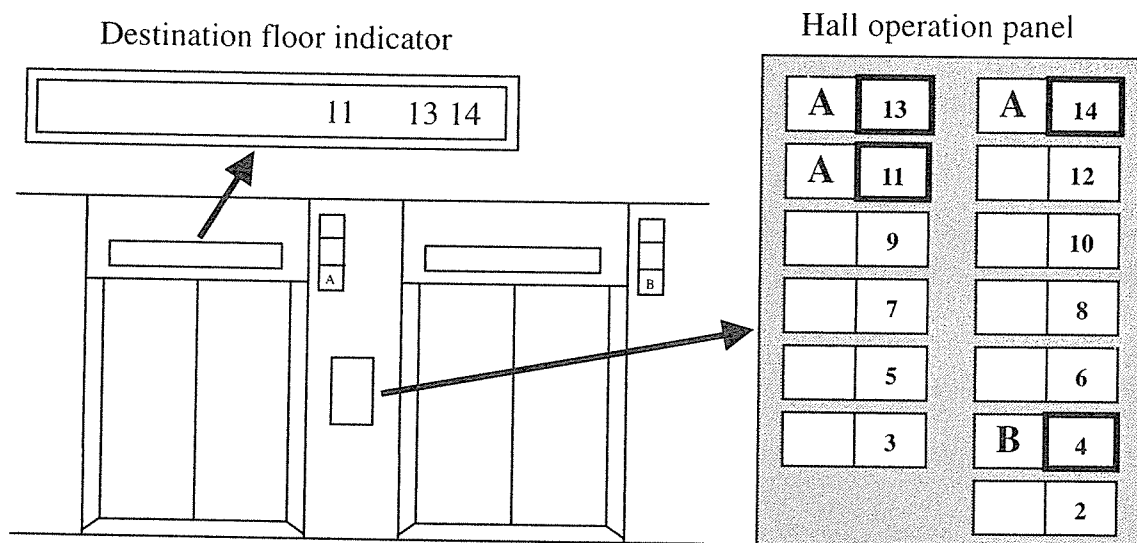


Figure 3. Hall image at the lobby floor

registered. Therefore, it is not necessary to press the floor button after boarding.

2.2.2 Operations under Destination Oriented Prediction System

When hall operation panels are installed at the lobby floor, a following operation will be applied.

The system selects and allocates the optimal car to the destination floor call registered by the hall operation panel. This allows passengers with the same destination to use the same elevator as much as possible.

In a conventional UP/DN button system, passengers get on the car in the order of arrival. This can result in a single car being dispatched to many different floors as shown in the Figure 4 (a), thereby increasing the round trip time of each car.

In the Sigma AI-2200 system, the passengers can be transported in less trip time due to the effect of Destination Oriented Prediction System. This increases elevator traffic efficiency, especially in the UP Peak period.

2.2.3 Penalty operation

When Destination Oriented Prediction System is applied, if passengers get on cars, which are not indicated on the hall operation panel, the traffic efficiency will be decreased.

Even though the system tries to make passengers recognize the cars to enter as much as possible, some may ignore the indication intentionally.

The system has a penalty operation for such passengers. Only in the up peak period, the car operation panel will be invalid after a car starts from the lobby floor. Thus, only the destination calls registered at the hall can be registered as car calls then.

Also, after the car stops at some floor, the car operation panel will be available and any car call can be registered. This is for the passengers who get on from the intermediate floors.

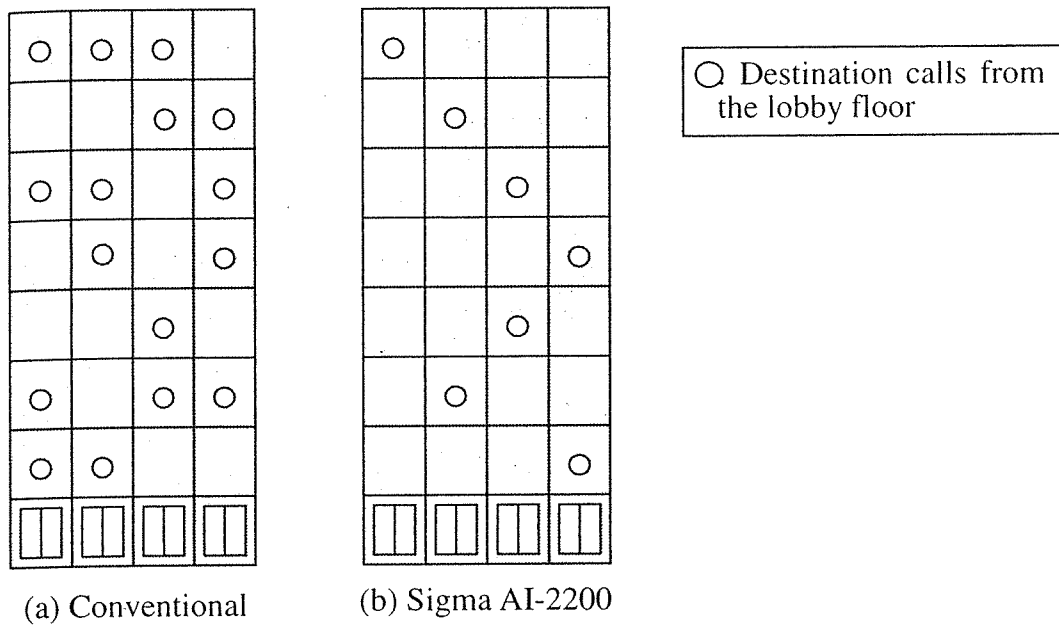


Figure 4. The advantage of Destination Oriented Prediction System

3. SIMULATION RESULTS

An example of simulation result is shown in the Figure 5. Each experiment was conducted under the following conditions.

[Conditions]

- Velocity 3.0 m/s, 24 persons, 6 cars.
- 16 stories office building.

Experiments were executed for Morning Peak, Day Traffic, Lunchtime and Evening Peak in an office building. In the Figure 5, the white graph shows the result of a conventional system, and gray denotes the performance of Sigma AI-2200. By this graph, you can see the traffic efficiency is improved for each traffic pattern.

Table 1 shows the improvement rate of Sigma AI-2200 from the conventional system.

Table 1. Improvement rate

	Morning Peak	Other periods
Average Waiting Time	15 - 30 %	10 - 20 %
Long Wait Ratio*	30 - 60 %	20 - 40 %

(*: 60 seconds or more)

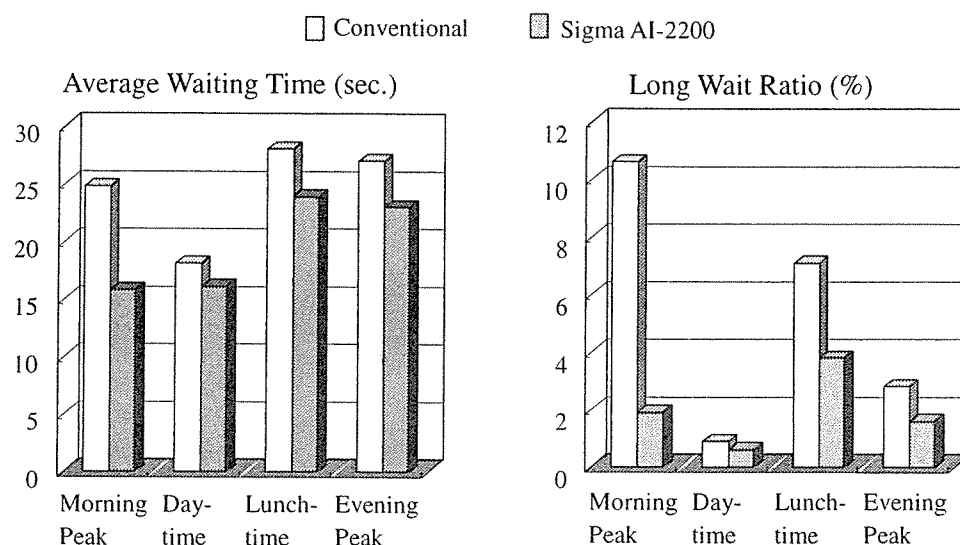


Figure 5. An example of Simulation Results

4. CONCLUSION

In this paper, the outline of newly developed group-control system Sigma AI-2200 has been introduced.

In the future, we hope to continue to improve the features of the group control system. Moreover, we are aiming to develop elevator systems, which has high quality in the area of efficiency, safety and comfort.

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BIOGRAPHY

Shiro Hikita has joined Mitsubishi Electric Corp. in 1984. Then he has served at central research laboratory and at Inazawa works in 1995. He has been chiefly engaged in the research of AI technologies and its applications to elevator systems.

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