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THE MODERN LIFT CONTROL SYSTEMS IN MULTI-STORES BUILDING

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ABSTRACT
Lift traffic control systems have become more complicated because of their nature of intelligence. Evolutionary algorithm methods employing genetic algorithms have been proved to be successful in many different fields. They have been applied to basic problems in lift traffic control systems, such as the reduction of passenger's waiting time. In particular, genetic algorithms can offer better solutions to the passenger hall call allocation process when compared to the conventional traffic control methods. Lift control algorithms utilizing genetic algorithms aim at optimizing the most suitable cars to the floors by considering the passenger service demand. In this paper, the passenger's waiting time has been reduced by using genetic algorithms and the lift control systems must be optimum.
Keywords: Genetic Algorithm, Vertical Transportation, Lift Traffic Control System.

1. INTRODUCTION
There are several control methods which have been used to the lift traffic in multi-stores building. In lifts operating in a group, a number of cars serve the waiting passengers at different floors. The waiting passengers at a floor can be served by any of the lifts in this group. The lift group control optimized the best one car, which only sent to serve a floor, to serve the waiting passengers.

The variation of the passenger movement results in a traffic pattern to be built up in a building. Although this is not the same for different buildings, there is a generalized five type of lift traffic pattern, up-peak traffic, down- peak traffic, two way traffic, four way traffic and random or balanced inter-floor traffic [1, 2]. The development of lift traffic handling theory has mostly concentrated on up-peak, since it is the worst traffic situation from the lift capacity point of view [3]. During up-peak, the majority of passengers travel randomly at a main terminal to upper floors. Generally, this occurs due to the morning rush hour and a lesser extent at the completion of the lunch time period. Our task is to control all the lifts as a group and transport passengers to their destination floors pleasantly and promptly [4].

There are many of published studies on artificial intelligence techniques applied to the conventional lift traffic control [5-12]. All of these studies' aims have reduced the passenger's waiting time, the system response time and the passenger's journey time on the group control of lift systems. One of the new techniques is Genetic Algorithms which applied in this study and gave a better result when compared to the conventional lift traffic control methods [11].

Lift control has become a major field of application for AI technologies. This study is an exploration in the possibilities of the various fields in which Genetic Algorithms can be applied in lift control. Genetic Algorithms are based on the concept of natural selection of biological species and usually applied in many large complex problems where other methods have experienced difficulties. Genetic Algorithms also work with a population of strings known as chromosomes. The chromosome should in some way contain information about solution which it represents. The most used procedure of encoding is a binary string. The solutions from one population are taken and used to form a new population that the new population will be better than the old one. These solutions (offspring) are selected according to their fitness values which the task is to search for an optimal state that gives the minimum value. The search for the optimal state starts with a population of randomly selected chromosomes [1] and three operators of Genetic Algorithms called reproduction, crossover and mutation are applied.

The main task of reproduction is selected two parent chromosomes from a population according to their fitness values. There are various methods how to select the best chromosomes, such as roulette wheel selection, Boltzman selection, tournament selection, rank selection, steady state selection and the others. The crossover operator is applied the parents to form a new offspring. If no crossover was performed, offspring is an exact copy of parents. The mutation operator is to introduce genetic diversity into the population. It is applied to chromosomes which is selected randomly and is replaced by another character from the chromosome. The basic steps of Genetic Algorithms are outlined in Table 1.

Table 1. The basic outline of Genetic Algorithms.

Step 1 : Create the initial population randomly Step 2 : Compute the fitness function Step 3 : Apply the genetic operators to create the next generation of population (selection, crossover and mutation) Step 4 : If not converged, go to Step 2

In this study, the simulation program is executed on a building with 24 floors over the main terminal 6 cars with various contact capacity are used to service the whole building. Thus, average waiting time is obtained by using a simulation program.

2. ESTIMATING THE AVERAGE WAITING TIME

The average waiting time in seconds that a passenger waits for service measured from the instant a passenger registers a call (or could register a call) to the instant the passenger enters a lift car [4]. The passenger waiting time would be the best indicator of the quality of service that an installed lift system could provide. Passengers tend to be upset, if they are made to wait too long [5]. To calculate the average waiting time according to car loads, one can find

$$AWT = \left[0{,}4 + \left(\frac{1{,}8P}{CC} - 0{,}77^2\right)INT\right] \qquad \text{If car loads between 50 and 80\%} \qquad (1)$$

$$AWT = 0{,}4INT \qquad \text{If car loads less than 50\%} \qquad (2)$$

where *INT* is interval and one can find

$$INT = \frac{2Ht_v + (S+1)t_s + 2Pt_p}{L} \quad (3)$$

where P is the number of passengers enter the car at the main terminal, CC is the contract or rated capacity of a lift car, H is the highest reversal floor, S is the expected number of stops, t_s is stopping time, t_v is the single floor transit time, t_p is passenger transfer time and L is the number of lift cars within a lift group.

3. REDUCING THE AVERAGE WAITING TIME

The quality of service in multi-stores building is indicated by the average passenger waiting time. Thus, our aim is reduce the average waiting time in high-rise building for the different traffic pattern. For this reason, we have prepared a program applied genetic algorithms techniques. In this program are used a specific fitness function and various crossover techniques. An illustrative example is conducted under the velocity is 1,0 m/s, 6 cars with 8 people for 24 stories office building. This example was executed for morning peak, in other words, up-peak traffic conditions as illustrated in Figure 1. Average waiting time is obtained for 5 minute period, according to the hall call allocation. The chromosomes, which formed the population, coded binary encoding. Every chromosome consists of the up-down allocations and evaluated by fitness function. The roulette wheel method is applied as a reproduction operator. After this, crossover and mutation operators are applied the population randomly.

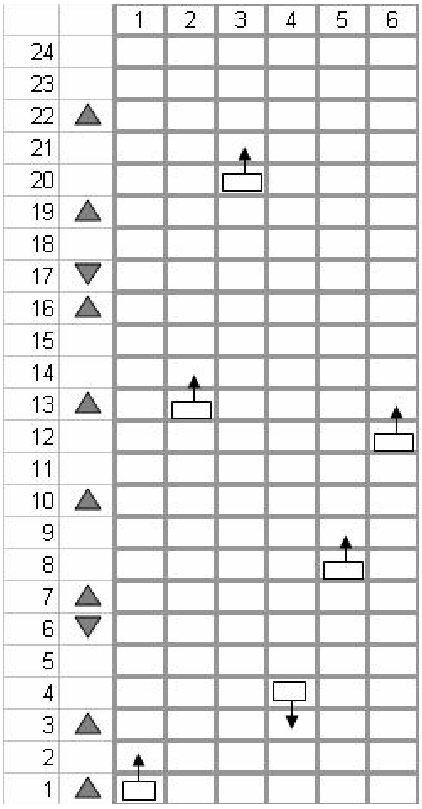

Figure 1. The upward traffic during the morning peak.

The values of average waiting times obtained from various crossovers and conventional calculation according to number of floors over the ground floor of the building are plotted in Figure 2. Each line in Figure 2 shows the change of the average waiting time when different crossover techniques are applied. It is clearly seen that the single-point crossover technique is the best in the solutions, except 22, 23 and 24 floors.

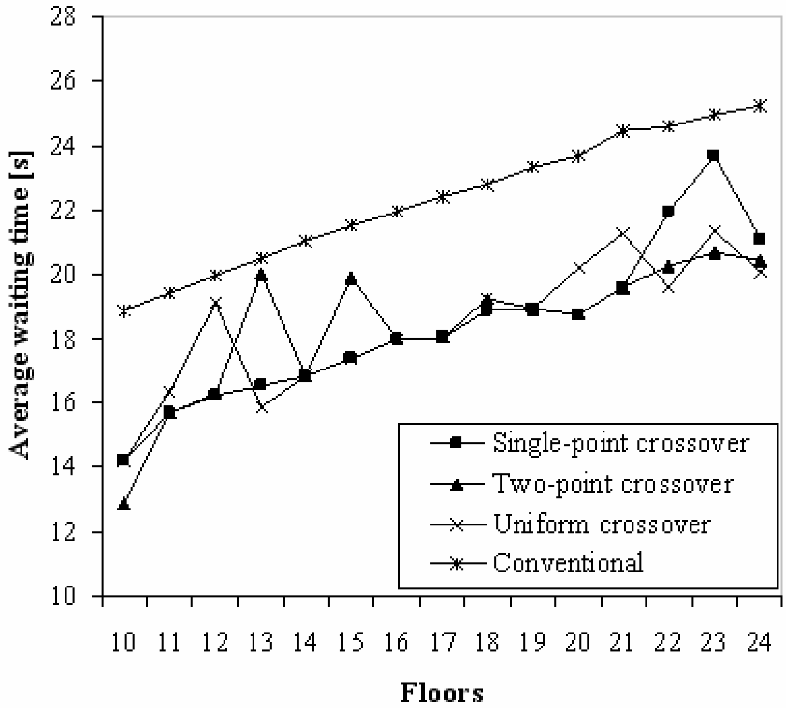

Figure 2. The average waiting time vs. number of floors of building.

4. CONCLUSION

In this paper, the outline of a program with preparing genetic algorithms has been introduced. It has been seen that the average waiting time which defines lift performance goes down satisfactorily thanks to the genetic algorithms applied to lift control systems and that it gives better results compared to conventional control methods. In the future, we hope to improve the quality of the group control system (efficiency, safety and comfort) are more increase.

5. REFERENCES

[1] Tsang P.W.M.: A Genetic Algorithm for Affine Invariant Object Shape Recognition, Proc Instn. Mech. Engrs, 211 (1), 385-392, 1997.
[2] Imrak C.E.: Traffic analysis, design and simulation of elevator systems, Ph.D.Thesis, Istanbul Technical University, Istanbul, Turkey, 1996. (in Turkish).
[3] Siikonen M.L.: Customer Service in an Elevator System During Up-Peak, Transpn Res.-B, 31 (2), 127-139, 1997.
[4] Barney G.C., Dos Santos S.M.: Elevator Traffic Analysis Design and Control, Peter Peregrinus, 1985.
[5] Barney G.C.: Elevator Traffic Handbook Theory and Practice, Spon Press, London, 2003.
[6] Closs G.D.: The computer control of passenger traffic in large lift system, Ph.D. Thesis, UMIST, UK, 1970.
[7] Chan W.L., So A.T.P.: Dynamic Zoning for Intelligent Supervisory Control, Int. to Elevator Engineering, 1, 1-10, 1996.
[8] Prowse R.W., Thomson T., Howells D.: Design and Control of Lift Systems Using Expert Systems and Traffic Sensing, Proc. of ELEVCON 1992, 219- 226, 1992.
[9] Ho M., Robertson B.: Elevator Group Supervisory Control Using Fuzzy Logic, Canadian Conference on Elevator and Computer Engineering Vol. 2, 825-828, 1994.
[10] Qun Z., Ding S., Yu C., Xiaofeng L.: Elevator Group Control System Modelling Based on Object Orientated Petri Net, Elevator World, 49 (8), 99-105, 2001.
[11] Barney G.C., Imrak C.E.: Application of Neural Networks to Lift Traffic Control, Elevator World, 49 (5), 82, 2001.
[12] Bolat B., Imrak C.E.: Genetic Algorithms Embedded Elevator Traffic Control System, Proceedings of trans&MOTAUTO'05+, Veliko-Tarnova, Bulgaria, 241-244, 2005.