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A Genetic Algorithm Based Elevator Dispatching Method For Waiting Time Optimization

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Abstract: Elevator group control is one of the important issues in vertical transportation systems in buildings. For an efficient group control algorithm it is required to overcome some optimization problems. From the perspective of quality of service two fundamental parameters needed to be optimized are waiting time and journey time. Elevator group control algorithms can be developed based on soft computing methods used for optimization. In the last decade Genetic Algorithm(GA) has attracted researchers' attention as the suitability for the encoding car dispatching problem. In this study we enhance a previous study suggested for optimization of waiting time. The proposed method reduces average waiting time and uses a simpler encoding approach which results in efficiency in terms of computational cost. We explicitly demonstrate the method on the referred scenario for the purpose of visualization and insight.

Keywords: Genetic algorithm, elevator group control, elevator dispatching method, waiting time optimization

1. INTRODUCTION

Until 2000s classical methods have been adapted as convention for elevator group control systems (EGCS). With the advance in soft computing, alternative researches using intelligent methods for EGCS have emerged. Tyni and Ylinen (2001) proposed using Genetic Algorithm for car routing in single-deck systems for waiting time optimization. With its suitability for the encoding car dispatching problem Genetic Algorithm has drawn much attention in following studies. Tyni and Ylinen (2006) were also interested in optimization of energy consumption using GA. Sorsa et al. (2003) used Genetic Algorithm for optimal control of double-deck elevator group system. To minimize waiting time, Cortes (2004) gave an explicit definition of fitness function and binary encoding scheme for car dispatching. Ghareib (2005) presented a GA based algorithm for minimization of waiting time, regarding initial car states and preload conditions on an explicit scenario. Bolat and Cortes (2011) using binary coding scheme defined another model based on modified fitness functions for journey time optimization. Tartan et al. (2014) introduced an improved algorithm for waiting time optimization in comparison with the algorithm presented by Ghareib (2005) and conventional duplex method on the same scenario .

The main distinction of applications for time parameter optimization lies in the estimation approach of time parameters that will be used in fitness function. Consequently although their definition seem similar, fitness functions implicitly differs from each other according to definition of estimated time parameter. Another characteristic in GA application is encoding problem into chromosome. This is determined by the definition of chromosome structure. Consequently different models can be developed using GA for the same problem. In this study we present an improved car dispatching method for optimization of waiting time that is based on GA. This model combines some properties of previous studies and improves method presented by Tartan et al.(2014) for waiting time optimization. Briefly this method

- Takes into consideration initial car states and preload conditions
- Uses a more compact decimal encoding scheme instead of binary encoding than the referred study
- Improves fitness function for estimated waiting time

2. TIME PARAMETERS and TRAFFIC MODEL

From the perspective of quality of service an efficient EGCS algorithm should dispatch the cars to the registered hall calls minimizing passengers' waiting time. Barney and dos Santos(1985) emphasizes importance of waiting time as the prime psychological constraint. Waiting time is the time starting from hall call registration until a car reaches that floor. Other parameters related to quality of service and hence time, are passenger Average Travel Time (ATT) and passenger Average Journey Time (AJT). Travel time starts from the arrival of the elevator at the floor where passenger is waiting and ends at the arrival at destination floor. As stated by Barney and dos Santos(1985) travel time is secondary psychological constraint for passenger. Estimation of travel time is more complex since the uncertainty due to the dependency on incoming calls and their unknown destinations can significantly affect it. Journey is the total

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time starting from registration of call until reaching destination floor and is calculated as the sum of journey time (JT) and waiting time (WT) (1).

$$JT = WT + TT \qquad (1)$$

Although car trip time and journey time can exhibit a correlation with waiting time and decrease in waiting time can be achieved by optimization of these parameters, as shown in example by Tartan et. al (2014) decrease in car trip time does not always result in reducing other time parameters. In this study we directly focus on waiting time aiming to optimize and use it for evaluation of ECGS algorithm's performance.

According to passenger profile, building type and time of the day a dominant traffic pattern can be observed. In particular, during work days high rise commercial buildings exhibit such patterns at different time intervals. In the mornings traffic is upwards from ground floor to office floors and therefore named as up-peak. On the contrary in residential buildings people leaving for work result in a reversed pattern in the mornings and similar pattern can be observed in commercial buildings during work out in evenings. Another specific pattern can be observed at noon is lunch peak. General traffic that includes random upwards calls and downwards calls is named as interfloor traffic. Here instead of specific traffic patterns we consider a more general, random traffic and investigate interfloor focusing on waiting time optimization leaving other constrains.

3. GENETIC ALGORITHM

Genetic Algorithm is an optimization algorithm inspired by natural evolution process. In GA a population consists of individuals each representing a candidate solution for maximization or minimization of a fitness function. The problem is encoded in individuals (also named as chromosomes) as bit strings. For the evolution process towards better generations GA mimics natural selection, mutation and crossover. According to fitness function values fitter individuals have more probability to be selected to take role in producing offspring population. Selected individuals are mated or not according to crossover probability.If a generated random number if lower than crossover probability crossover is applied otherwise pair of chromosomes remain without change. For diversity and global search, with a low probability mutation operator applies mutation. Finally obtained pair of offspring chromosomes take place in new generation. The creation of new chromosomes is repeated until size of new chromosome population becomes equal to size of initial population. Then population is replaced with the new population. The process of generating populations is repeated until the specified maximum number of generations is reached. The flowchart of algorithm is shown in Fig. 1.

In elevator dispatching problem crossover is applied as mutual replacement of genes which are elevator numbers between two individuals. A sample individual is shown in Fig.2.c. When crossover is applied to a pair, after a randomly selected point in chromosome structure elevator numbers assigned to corresponding to hall calls interchange. In mutation for a single individual a randomly selected gene which represents elevator number is changed with another elevator number.

4. PROPOSED METHOD

We propose an elevator dispatching method based on Genetic Algorithm that dispatches cars aiming to minimize average passenger waiting time. Fitness function for GA is defined as

$$f = 1/T_{av} \qquad (2)$$

$$T_{av} = \left(\sum_{i=1}^{K} WT_i \right) / K \qquad (3)$$

where K, WT_i and T_{av} representing the number of landing calls, estimated waiting time of call i and average waiting time respectively.

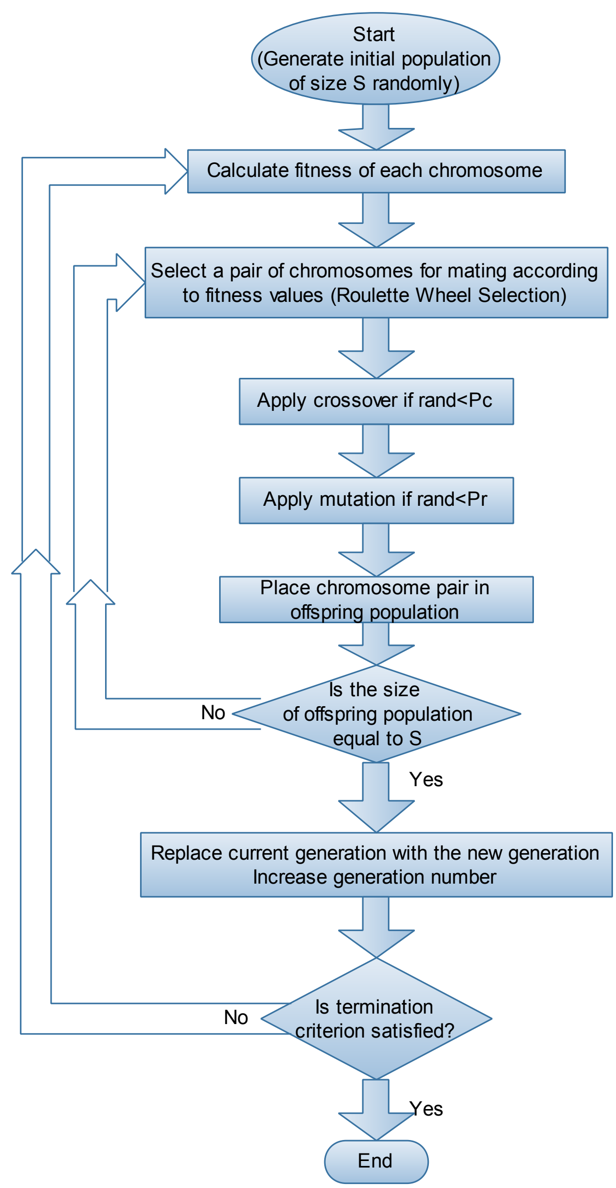

Fig. 1. Genetic Algorithm Flowchart