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PSO AND TABU SEARCH APPROACHES FOR THE CAR ALLOCATION PROBLEM IN MULTI-CAR ELEVATOR SYSTEMS

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ABSTRACT
Heavy vertical traffic conditions appear in high-rise buildings especially during the rush-hour period. So, offered service provided by multi-car elevator systems for such buildings during that period is expected to work fast, efficiently and without long waiting times for users. The approach of our work focuses on reducing the passengers travel and waiting times. To do so Particle Swarm Optimization (PSO) and Tabu Search (TS) algorithms are applied to multi-car elevator control systems that are usually implemented in such buildings. In this paper, PSO and TS algorithms are proposed to optimize the controller of such elevator control systems and successful simulation results are provided for an illustrative example.
Keywords: Elevator, elevator group control system, algorithm.

1. INTRODUCTION
Nowadays, modern many buildings have more than five floors, so that the use of elevator in high-rise building has become necessary. The number of floors increased, the duty of elevators are also increasing. It is expected to elevators give a high quality and reliable service to passengers who come from buildings. To ensure that the number of cars in elevator system in building should be sufficient and their traffic must be well controlled. Generally the elevators in the conventional system are serving with "first in, fist out". Although the aim of this is to provide minimum waiting time for first passenger, sometimes passengers wait for a long time. To minimize passenger waiting and travel time (total of these time called average journey time), it should be applied optimal control system. Most researcher and elevator companies study on this subject. Examples of them, in this field one of the most relevant contributions was Closs[1], knowledge based systems, e.g. Prowse et al.[2]; fuzzylogic, e.g. Ho and Robertson [3], dynamic programming [4]; expert systems [5], neural networks [6], and genetic algorithm[7-13] and tabu search algorithm [14] showing an appreciated suitability to the problem.

In this paper, we deal with research on Tabu Search (TS) and Particle Swarm Optimization (PSO) algorithms. Both algorithm searches for minimizing the average journey time of passengers. We tested for a high-rise building from 10 to 24 floors with 6 cars.

2. MULTI - CAR ELEVATOR GROUP CONTROL SYSTEMS FOR HIGH RISE BUILDINGS

In generally, elevator should serve on more than one car in high-rise building traffic. When more than one car, it must decided which a car assigned hall call. This management is done by Elevator Group Control System (EGCS). The main duty of the EGCS must identify the elevator which is most suitable to serve the passenger. To tackle this problem, EGCSs implement complex algorithms based on soft computing techniques. We applied the TS and PSO in this paper.

TS is to derive and exploit a collection of principles of intelligent problem solving. TS which is founded on ideas proposed by Glover [15, 16] is based on selected concepts that join the fields of artificial intelligence and optimization. The basic principle of TS is given Table 1.

Table 1.The basic steps of the TS algorithm

1. *Create random initial solution*
2. *Evaluate the fitness function*
3. *Apply the TS (neighborhood, aspiration criteria, tabu list)to create the next generation of population*
4. *Evaluate the fitness function for new generation*
5. *Find the best solution or go to step2.*

PSO presented in Kennedy et al. [17] is a population based stochastic optimization technique inspired by social behavior of bird flocking or fish schooling. The basic principle of PSO is given Table 2.

Table 2.The basic steps of the PSO algorithm

1. *Create random initial solution*
2. *Evaluate the fitness function*
3. *Apply the PSO (particle position, velocity)to create the next generation of population*
4. *Evaluate the fitness function for new generation*
5. *Find the best solution or go to step2.*

Both algorithms start with the randomly initial solution according to the hall call allocation from the passenger's demands, solutions are encoded binary encoding. The fitness function is given

Table 3. Fitness function depending on the traffic pattern

Case I	$f_i=0$
Case II	$f_i = \left[t\left(\Psi_2 - \Psi_1\right) + t_p\left(\Psi_3 - \Psi_1\right)\right]$
Case III	$f_i = \left[t\left(\Psi_4 - \Psi_1\right) + t_p\left(\Psi_5 - \Psi_1\right)\right]$
Case IV	$f_i = \left[t\left(\Psi_4 - \Psi_1\right) + t\left\|\left(\Psi_2 - \Psi_4\right)\right\| + t\left\|\left(\Psi_2 - \Psi_6\right)\right\| + t_p\left\|\left(\left(\Psi_3 + \Psi_5\right) - \Psi_1\right)\right\|\right]$

where Case I : there is not any hall call in the system
Case II : there are only down hall calls
Case III : there are only up hall calls
Case IV : there are up and down hall calls

Then the average value is calculated as (1):

$$f_{group} = \frac{\sum_{i=1}^{n} f_i}{n} \text{, being } n \text{ the number of cars in the group} \tag{1}$$

The final fitness value is computed as (2):

$$f = k_1 \cdot f_{group} + k_2 \cdot \left(Hct - Lct\right) \tag{2}$$

where

Ψ_1 : ground floor level, Ψ_2 : highest down hall call level, Ψ_3: number of down hall calls between Ψ_1 and Ψ_2, Ψ_4: highest up hall call level, Ψ_5: number of up hall calls between Ψ_1 and Ψ_4, Ψ_6: lowest down hall call level, t: door opening and closing time, t_p: passenger transfer time, *Hct*: Highest car trip time, *Lct*: lowest car trip time

2.1. Simulation scenario and results

High-rise buildings from 10 to 24 floors with 6 cars were selected for our case study. The specifications of the buildings and elevators are given in Table 3.

Table3. The specifications of the 24-floor buildings with 6 cars

Floor distance 3,3 m	Car Capacity 8 people	Speed 3 m/s
Time for opening door 3 s	Time for closing door 3 s	Time for passenger transfer 3 s

We tested according to Table3 and we have compared with PSO and TS algorithm. The result of algorithms is given Table 4.

Table 4. AJT with 6 cars configuration (in seconds)

Number of floors	Average AJT		Best AJT		Average Comp.Time	
	PSO	TS	PSO	TS	PSO	TS
10	24,0	29,5	21	24	0.11459	0.31517
11	30,5	36.5	30	33	0.11604	0.29796
12	34.5	39.5	30	33	0.11742	0.3311
13	40.5	49,0	39	45	0.11915	0.31696
14	43.5	55.5	42	42	0.11971	0.33321
15	44,0	62.5	42	51	0.12072	0.32129
16	52,0	71,0	48	63	0.12209	0.33816
17	57,0	76,0	54	69	0.12292	0.35357
18	58.5	81,0	54	75	0.12324	0.34916
19	62,0	86,0	60	75	0.12438	0.3559
20	69,0	84,0	60	72	0.1254	0.37479
21	77,0	104,0	69	96	0.12666	0.35121
22	81,0	115.5	78	96	0.12708	0.37179
23	93.5	113,0	78	75	0.128	0.37377
24	86,0	121,0	72	105	0.12875	0.3799

Table 4 allow us to state that PSO test results are better than TS and average computational time is also better than TS.

3. CONCLUSION

We have presented two algorithms which are used in engineering problems to optimize the car call allocation strategy of the controller in EGCS. Both algorithms were applied successfully and results were better attending to the average journey time as well as attending to the algorithm computational times. The results show us that PSO has better results in a faster and capability to be adjusted with very few parameters.

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