Scheduling of Tour Guides for Tourism and Leisure Industry using Cellular Genetic algorithm

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Summary
Many organizations in tourism and leisure industry arrange a lot of activities and provide some tour guides to lead tourists through the tour process in order to improve service quality. Better service quality needs an increase in the number of tour guides. On the other hand, increasing the number of tour guides result in more cost for these organization. In order to decrease costs, the organizations use a time-based system for paying salaries to personnel according to their service hours in recent years. Therefore, a schedule of tour guides is seriously needed with an objective of minimizing service hours and increasing the on-time service rates. In this paper, the cellular genetic algorithm is applied to schedule tour guides of services centres for tourism industry. Optimal parameters that produce the best performance are experimentally obtained. Our experiments reveal that cellular genetic algorithm is effective to schedule the tour guides of service centres. Beside, a penalty function is beneficial in increasing the on-time service rates of tourist orders.

1. Introduction

Services play an important role in tourism and leisure. The service of higher quality attracts a lot of visitors; therefore there are a lot of competitions between organizations to improve the quality of service to be the best among other their competitors. Moreover, many organizations establish service centres (SCs) with many kinds of interesting activities and provide the qualified tour guides to guide the visitors. The tour guide represents one of the main factors in this field, accordingly there are many organizations employ coordinators to schedule the tasks and activities of tour guides to serve the visitors [7]. All these (SCs) aim to provide the services of good quality and also aim to minimize costs. Tour guides' salaries cost the (SCs) huge amount of money. In the same time, the existence of many tour guides in (SCs) means better service quality. Therefore, many (SCs) needs a mechanism to schedule tour guides without reducing service quality.

The process of scheduling tour guides in (SCs) are dealing with the demand of huge numbers. For instance, the numbers of visitors are varying in holidays and in normal days. The range of visitors can reach tens of thousands and that makes it difficult to schedule the tour guides. Hiring fulltime tour guides is not an economical issue. To solve this problem and meet the unstable demands with saving the labour cost, a lot of (SCs) hiring part-time tour guides are required to fix this gap. The policy of (SCs) for dealing with part-time tour guides regarding payment of their wages differs from one of (SCs) to another. To schedule tour guides well, many of (SCs) request visitors to reserve before their coming date and the big visitors group is divided into subgroups to facilitate the schedule. The higher service levels are required to meet the requirements of customer's needs for on time service rate. This is very difficult, so a scheduling system is needed to achieve it.

In this paper we present the problem of scheduling a tour guide and we use an effective method to obtain good solution. In this study we use cellular genetic algorithm. Over the past decade or so, cellular genetic algorithms (cGA) have been proven to be effective for solving many kinds of optimization problems from both classical and real world settings [8,9,13]. (cGA) has been chosen to solve the problem because it proved high efficiency and accuracy in solving other optimization problems [1,12].

The rest of the paper is organized as follows: Section 2 presents a brief summary of the problem of scheduling a tour guide. Section 3 describes the problem we address. Section 4 presents a set of experiments and analyzes the results. Section 5 concludes this paper and gives some guidelines for future work.

2. Tour guide scheduling of service centres

Tourism industry is the backbone of any country's economic position. It provides the foreign exchange earnings for the country of destination. Also it generates new employment avenues to the native of the country. The development of the county's infrastructure; as it is so important to attract visitors and to provide them with a memorable visit that will lead to a positive word of mouth and a chance of re-visiting the country again. This also could be thought of through an employment angle, as the infrastructure needs buildings, services, and transportation means and ways. The need to provide quality services will arise and will be an important factor. There are a lot of competitions between organizations to offer tourist services. With the rapid growth of this industry and the higher level of living, improving service levels has to be

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an issue of concentration recently. These competitions require the great efforts which dose not work with traditional methods, but need to modern methods such as scheduling to organize services quickly so as to stay ahead with the big competitors. Tour guide scheduling is one of the most important operations. With the good and effective scheduling arrangement, the organization can keep up in modern competing environments. Accordingly, the organization needs to have a good scheduling system which can arrange tour guides for different demands in practices.

Service time is one of the most important factors which affect the scheduling problem of tour guide. Some organizations employ the part-time tour guides to save cost and their wages are calculated on the basis of service time so that the best scheduling tour guide is the one who could give the lower total service time. In the same time, to give this lower service time, the waiting time should be lowered as much as possible. The waiting time is also effective for the total service time, so it should be lowered. Occasionally, the additional time is required if the service sequence of a tour guide is not arranged well. For example there are some procedures which precede other procedures. If these procedures are not arranged in a good sequence, this means that an additional preparation time will be needed to prepare to the next service. And this can be avoided by a good scheduling. To provide a good quality, there must be a balance between the service capacity and the service quality.

One another factor we should consider is the compromise between the capacity of the service and the quality of the service. The tour guide should not be assigned to many visitors so that he can provide the service of good quality. In another side, assigning fewer visitors will cost more because of needing more guides. We assumed to assign 25 visitors per guide.

3. The problem

3.1. Problem Description

The problem can be described as presented in [5] the service centre which provides services. It shows the number of tour guides who guide different visitor groups. A guide has a fixed guide time to serve a visitor group. A large visited group is divided into some smaller subgroups before being served. Each subgroup is assigned to only one tour guide. The tour guides can be categorized into several types; each type has a fixed service capacity and also has a fixed preparation time which is required when the service sequence is in a worse order. There are T tour guides and S subgroups. Fig. 1 shows the assigning of tour guide. Also if the service sequence number of the precede subgroup is higher than the service sequence number of the following subgroup served by certain guide this can lead to an additional preparation time as illustrated in Fig. 2. In this study the problem focused to reduce the preparation time as much as possible to get the minimal total service time.

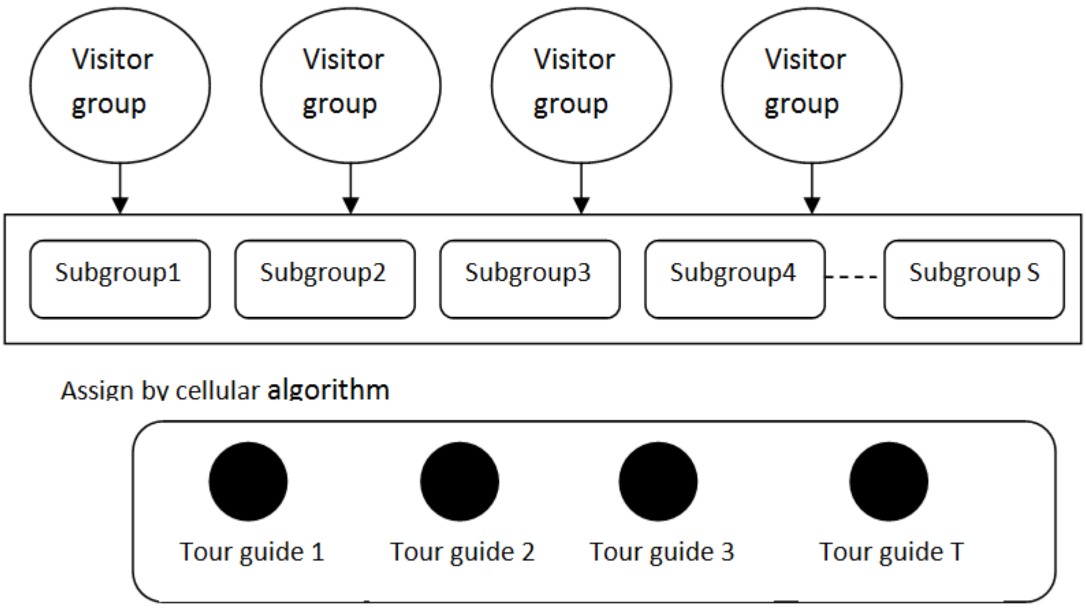


Figure: 1 shows the flow of assigning tour guide process with S subgroups and T tour guides

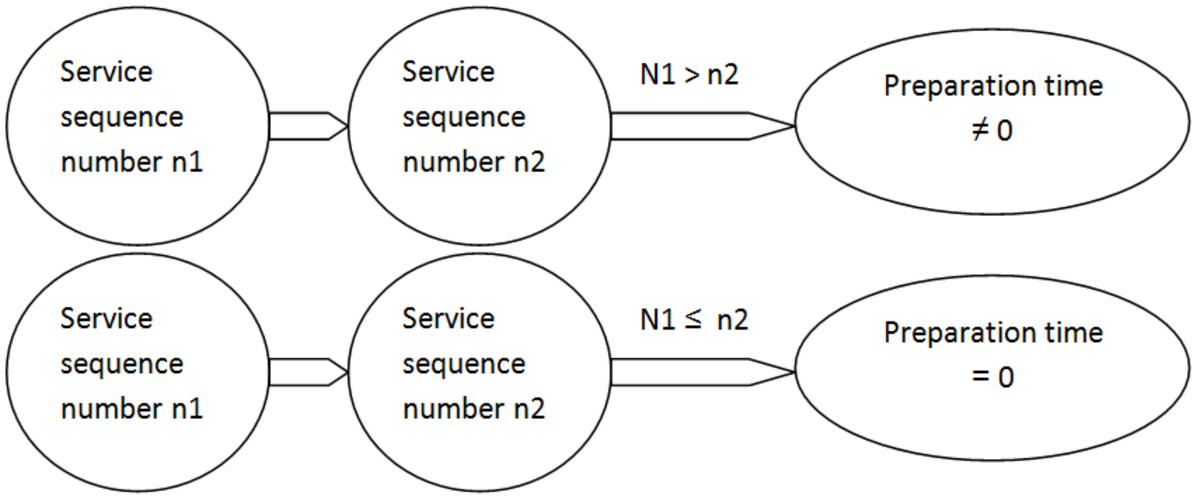


Figure: 2 shows the setup of additional preparation time if the service sequence number of the precede subgroup is higher than the service sequence number of the following subgroup

Let T = {1,2,3,………..x} for tour guide
Let S = (1,2,3,………..Y} for subgroup
For i € T , j € S
We define Eij as the guiding service time by guide i to be assign subgroup j
The mathematical formulation of this problem can be describe as follow

$$Minimize\ F = \sum_{i=1}^{x} \sum_{j=1}^{y} \{E_{ij}A_{ij} + B_i C_i\}$$
eq(1)

$$A_{ij} \in \{0,1\} \qquad \forall i \in T, j \in S$$
eq(2)

$$C_i \in \{0,1\} \qquad \forall i \in T$$
eq(3)

The first part of the equation Eij is the actual guiding time and Aij Take 1 if the guide is assigned to a subgroup and Take 0 if the guide is not assigned to a subgroup. In the second part of the equation Bi the additional preparation time and Ci take 1 if the service sequence number of the preceding subgroup is higher than the service sequence number of the following subgroup served by a certain guide, otherwise they take 0. This is due to the wrong service sequence of arrangement of visitor subgroups. Generally the preparation time differs from a tour guide to another. The experienced tour guide takes shorter preparation time than the new tour guide.

3.2. Assumption

There are some assumptions that assumed to help in solving this problem as presented in [5]

1- The service capacity is fixed for a certain tour guide.
2- The preparation time of a specific tour guide, which results from a poor service sequence of visitor subgroups, is constant.
3- The service sequence can be roughly divided into n categories, where n is a positive integer. Each category is represented by a positive integer, from 1 to n.
4- A visitor group can be divided into some smaller subgroups. Each subgroup is assigned to a tour guide only.
5- The number of tour guides is known.
6- The normal working hours of a day for a guide are 8 hours

3.3. Input data

Before the scheduling process there is some information must be entered. This information consists of the following: Number of visitors who visit the organisation, number of guides who serve those visitors, service capacity which is affected by the different experience of the tour guides. This means that the experienced tour guide works with more visitors than the new tour guide without decreasing service level at a time, the service time is the time that the visit takes.
Moreover, there are data about customer's order like number of visitors, id number, visitor group name and the stay time also will help us in the scheduling process.

Below is some data illustrated in table 1 which entered in the program.

Table 1: Important data needs for visitors		
	Description	Value
No. of visitors	No. of visitors who visit the firm	Positive number
Service sequence no.	There are categories for the service, each has a number and there is a sequence between them. If any sequence precede another one this is lead to an additional preparation time.	1,2,3,…..
Stay time	The time that the visitors will stay	4 – 8 hours

There are also some important data about the tour guides needed as an input data. The service capacity varies from the experienced tour guide to the beginner tour guide. The service capacity for experienced tour guide can be about 25 but for the beginner tour guide the service capacity can be 15. The preparation time also varies from an experienced tour guide to a beginner tour guide. Always the experienced tour guide requires less preparation time. Below is some data illustrated in table 2 about related to tour guides.

Table 2 : Tour guides' input data		
	Description	**Value**
Service capacity	Different from tour guide to another depending on the experience of the tour guide	15,20,25
Preparation time	Depend also on the experience Of the tour guide, the experienced tour guide take less time to prepare than the new one.	1 - 2 hours

3.4. Encoding and fitness function

The chromosome consists of a genes each gene represents the tour guide and subgroup. The encoding of chromosome is illustrated in the figure: 3 represent the sequence number of a gene which is the subgroup index and the value in the gene represents the index number of the tour guide. Each subgroup is assigned only to one tour guide. For instance the first subgroup is assigned to the fourth tour guide and the second subgroup is assigned to the second tour guide and so on.

1	**2**	**3**	**4**	**5**	Subgroup index
4	**2**	**5**	**1**	**2**	Tour guide index

Figure: 3 encoding of the chromosome

The fitness function is the next step after completing the encoding the chromosome. The fitness function measures the performance and the fitness of the minimum total guiding time. The best schedule is the one with the minimum total guiding time.

The fitness function consists of three parts; the first part is representing the actual guiding time, the second part represents the additional preparation time and the third part represents the penalty value which increases the on-time service rate. Dj takes 0 or 1. It takes 1 if there is waiting time for the group to assign to a tour guide who has another group otherwise takes 0.

$$F = \sum_{i=1}^{x} \sum_{j=1}^{y} \{E_{ij}A_{ij} + B_iC_i + L_jD_j\}$$

eq(4)

4. The Proposed algorithm

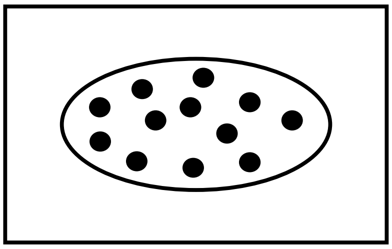
4.1. Solution procedure

Evolutionary algorithms (EAs) are used in many applications to solve the complex problems and produce good results. The onesused in this field have been very intense during the last decade [15]. These algorithms use the principles of selection and evolution to produce several solutions to a given problem and get the best solution. Most EAs use a single population of individuals. On the other hand, there are other EAs that use structured population. In that case, the population is somehow decentralized. Structured EAs most suited to parallel implementation. Using decentralized population of EAs give an example of the search space better than the ones which use single population in improving both numerical behaviour and execution time. The most popular types of structured EAs are the Distributed and cellular EAs figure [4].

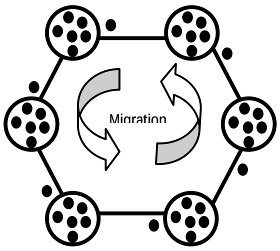
We focus in this work on Cellular Genetic Algorithms (CGAs). Cellular genetic algorithm (cGAs) is a class of EA with a decentralized population in which the tentative solutions evolve in overlapped neighbourhoods [6] [4c]. CGAs use a small neighbourhood concept, which means that an individual may only interact with its nearby neighbours [11]. The overlapped small neighbourhoods of cEAs help exploring the search space because the induced slow diffusion of solutions through the population provides a kind of exploration while exploitation takes place inside each neighbourhood by genetic operations.

4.2. Cellular genetic algorithm

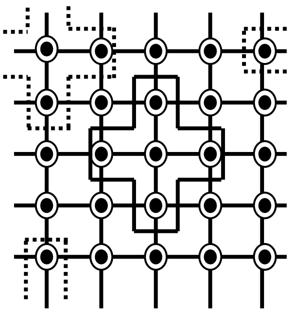
In cGAs the population is arranged in a given grid as illustrated in figure [4c] , the evolution of each individual is restricted in its neighborhood, and each individual is only allowed to genetic operation with the individuals in its neighborhood.



a- single population



b- distributed population



c- cellular population

Figure 4 single (a), distributed (b), and cellular (c) EAs

CGA pseudo-code is presented in Algorithm 1.

A detailed description of a canonical cGA is as follow [10]:

First, create the population (line 2). Then evaluate the fitness function for each individual in the population (line 3). The algorithm works on each individual in the population according to its place orderly (line 5). The current individual can only interact with his or her neighbours (line 6). The current individual parents are chosen from the neighbours by using some selection technique (line 7) then the crossover operators are applied to the current individual with probabilities Pc (line 8) and mutation with probabilities Pm also (line 9). After that, the algorithm computes the fitness values of the offsprings (line 10) then, inserts them or one of them instead of the current individual either in the current population or in a new one according to the chosen replacement policy (line 11). After that we get a new population for the next generation (line 13). The loop continues until termination condition is met (line 4). The termination condition is met either by finding the optimum solution or exceeding the maximum number of calling the evaluation function or composed of both.

4.3. Crossover and mutation

Crossover is an operator that mates the two parents (chromosomes) to produce two offsprings. The two newborn chromosomes may be better then their parents and the evolution process may continue. In this study we implement more than one type of crossover as follow (One point, Two points and Uniform) [2,3,14]. The experiments show that the two points crossover gives the best results.

Mutation is a genetic operator that alters one or more gene values in a chromosome from its initial state. This can result in entirely new gene values being added to the gene pool. With these new gene values, the genetic algorithm may be able to arrive at better solution than was previously possible. Mutation is an important part of the genetic search as help helps to prevent the population from stagnating at any local optima. Also in mutation we implement more than one type as follow (IntegerMutation , OneGeneMutation) [4,13]. The experiments show that the IntegerMutation gives the best results.

Algorithm 1 Pseudo-code of a canonical cGA

```
1:Proc Evolve(cga)
2:GenerateInitialPopulation(cga.pop);
3:Evaluation(cga.pop);
4:While ! StopCondition() do
5: for individual = 1 to cga.popSize do
6:neighbors=calculateNeighborhood(cga, position
(individual));
7: parents =selection(neighbors);
8: offspring =recombination(cga.Pc, parents);
9: offspring =mutation(cga.Pm,offspring);
10: evaluation(offspring);
11:replacement(position(individual),
auxiliary_pop,offspring);
12: End for
13: Cga.pop =auxiliary_pop;
14:end while
15:end proc Evolve
```

4.4. Experiments

In this paper, the cellular GA has been employed to solve the tour guide scheduling problem. Java 1.7 has been used to develop the experiment's software. The operating system was Windows 7. Different crossover and mutation methods have been tested to find the most suitable methods to our experiment. In all experiment: the minimum, maximum, mean, and standard deviation are obtained .All the results in our experiment are based on 30 times calculations.

4.4.1. Optimal Parameters

In order to find optimal parameters, first the influence of variation of generation number with the fitness value was tested. The optimal generation number is chosen based on the best fitness value. The generation number ranges from 100 to 900. The 800 generation number is chosen since it gives the lowest average best fitness value as shown in the following table 3.

Table 3 The influence of variation of generation number g on the F_{best}

Number of generation	Minimum	Maximum	Mean	Std. Deviation
100	2300	2420	2367.07	35.431
200	2120	2300	2231.87	39.882
300	2096	2248	2178.67	35.332
400	2084	2200	2146.67	33.124
500	2040	2180	2109.20	36.948
600	2024	2160	2089.60	32.404
700	2004	2140	2074.40	30.834
800	2008	2124	2061.33	34.734
900	2024	2132	2070.80	25.10447

Three neighbourhood operators were tested (Compact13, Linear5, Compact9). The experiments showed that Compact13 is better than others. The variation of best fitness value with neighbourhood operator is shown in table 4.

Table 4 The influence of variation of neighbourhood operator on the best fitness value F_{best}.

	Minimum	Maximum	Mean	Std. Deviation
Compact13	2008	2136	2075.33	27.754
Linear5	2044	2196	2130.53	31.135
Compact9	2040	2176	2098.40	35.305

Three different crossover operators were tested (single point crossover, two point crossover, Uniform crossover). The experiments showed that two point crossover is better than others. The results of crossover operators are presented in table 5.

Table 5 The influence of crossover operator

	Minimum	Maximum	Mean	Std. Deviation
single point crossover	2224	2494	2355.67	69.286
two point crossover	1979	2079	2027.33	25.303
Uniform crossover	2029	2194	2109.17	38.985

In order to enhance the results, two mutation operators were tested (One Gene Mutation, Integer mutation). The results show that Integer mutation overcomes One Gene mutation in terms of average best fitness value as presented in table 6.

Table 6 The influence of mutation operator

	Minimum	Maximum	Mean	Std. Deviation
One Gene Mutation	1974	2109	2032.50	33.481
Integer Mutation	1939	1994	1963.17	13.136

The crossover rate was set to be 0.5, 0.6, 0.7, 0.8, and 0.9. The results showed that 0.8 is a suitable parameter value because it gives the smallest average best fitness value with a small std. Deviation as shown in table 7.

Table 7 The influence of variation of crossover rate on the F_{best}

	Minimum	Maximum	Mean	Std. Deviation
0.5	2024	2152	2087.87	38.345
0.6	2008	2140	2075.87	31.504
0.7	1974	2089	2039.67	26.869
0.8	1979	2079	2027.33	25.303
0.9	1999	2069	2031.50	21.486

In a similar way, the mutation rate was set to be 0.01, 0.02, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7 and 0.5. The results showed that 0.5 is better than other values. The variation of best fitness value with mutation rate is shown in table 8.

Table 8 The influence of variation of mutation rate on the F_{best}

	Minimum	Maximum	Mean	Std. Deviation
0.01	1974	2064	2013.50	25.608
0.02	1954	2039	1991.50	20.075
0.05	1954	2009	1976.00	14.948
0.1	1939	1994	1964.67	12.438
0.2	1939	1994	1963.17	13.136
0.3	1919	1979	1955.16	11.93974
0.4	1939	1974	1955.33	11.59171
0.5	1939	1974	1950.83	10.37930
0.6	1939	1979	1954.50	9.59076
0.7	1919	1974	1953.00	12.48447

4.4.2. Effects of Penalty function

The non-delayed services rate (The on-time services rate) Ron-time is defined as:

$R_{on\text{-}time}$ = *number of on-time services orders / number of all services orders..........eq(5)*

Increasing Ron-time can be done by using the penalty function Pj as shown in eq(5). When the value of the penalty function is increased, the Ron-time is also increased as shown in table [9].

Table 9 The influence of variation of penalty value on the $R_{on\text{-}time}$

	Minimum	Maximum	Mean	Std. Deviation
1	0.7422	0.8594	0.804948	0.0308762
5	0.8203	0.9297	0.869531	0.0285874
10	0.8750	0.9688	0.915625	0.0238735
15	0.8906	0.9844	0.935677	0.0227247
20	0.9141	0.9766	0.951823	0.0153647
25	0.9063	0.9766	0.953646	0.0144978
30	0.9219	0.9766	0.957552	0.0154466

5. Conclusions and future works

In this paper we present an investigation of the scheduling problem of tour guides in Services Centres. Cellular Genetic algorithm is used to be the analytical tool. This paper's results reveal that cellular Genetic algorithm can solve the scheduling tour guides within short time. A big visitor group is divided into some subgroups with smaller quantities in order to increase the services quality. An additional penalty function is added to obtain a higher on-time services rate. Experiments reveal that as, penalty value increase, the on-time services rate is increased. A comparison between different crossover operators was made to show that two point crossover is better suited with our problem. Moreover, two different Mutation operators were compared to each other the matter which revealed that integer mutation is better suited with our problem. Furthermore, different neighbourhood operators are tested and compact 13 is proved to be the best to our problem. Additionally, optimal parameters including mutation probability and crossover probability which generate good performance are gotten.

As a future work we intend to solve the scheduling problem of tour guides as a multi-objective optimization problem by using MOCELL (Multi-objective optimization cellular genetic algorithm).

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