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Applying Genetic Algorithm to Schedule the Cosmetic Tourism

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Abstract*—Cosmetic surgery is now very common in many countries. In Asia, cosmetic surgery has become an accepted practice, and China has become Asia's biggest cosmetic surgery markets. The cost of most cosmetic surgeries in Taiwan is much lower than the cost of the same cosmetic surgery in the United States, and even other Asian countries. Taiwan is famous for its towering mountains, eco-tourism, culture, heritage, hot springs and night markets. Generally, the infrastructure in Taiwan is sufficient for providing international medical treatments and offering short-term vacations. Furthermore, many overseas tourists will require specific post-cosmetic care after they have finished the cosmetic treatments and may prefer to take a short-term vacation in the area. Generally, post-cosmetic care during such a vacation is important for the effectiveness of cosmetic treatments. In this paper, we aim to explore technical models for serving the overseas tourist and realizing the collaborative business services of cosmetic treatment and tourism. The proposed Cosmetic Tourist Guiding Model, which includes the Genetic Algorithm scheduling function for planning suitable trips and remote pre-assessable functions, can provide overseas visitors with convenient service and allows for cooperation between business owners of medical treatment facilities and travel agencies.

Index Terms— **genetic algorithm, tour scheduling, cosmetic service, tour guiding**

I. INTRODUCTION

In recent years, the medical industry has embraced the trend of providing international medical services in some developing countries such as Korea, Thailand, Singapore, India, and Hungary, among others. These countries earn income by exploring the overseas market and cooperating with travel agencies at the same time. The medical skills of some developing countries are almost on par with those of developed countries. Medical costs, however, are relatively low in the developing countries. For example, cosmetic surgery and health examinations are relatively economical in developing countries. Moreover, some transplant operations, such as surgical knee joint, are also cheaper. On the market demand side, people in advanced countries have higher expectations for overseas medical treatment when economic development is gradually becoming outstanding. The medical quality and instruments in Taiwan are almost on par with those of most developed countries. The doctors are experts in their fields. The average cost of medical treatment is also relatively reasonable. Generally, the infrastructure in Taiwan is a convenient reason for the development of international medical treatments and for fostering cooperation with short-term vacation tours.

This study aims to explore technical models that can be used to realize multi-enterprise, such as cosmetic treatments and tourism. The proposed model, which includes the Genetic Algorithm (GA), will be able to provide overseas visitors with convenient services and create opportunities for cooperation among the business owners of medical treatment centers and travel agencies. The relevant technologies to satisfy these targets are intelligent scheduling, lightweight mobility, cosmetic care and touring knowledge. We focus on the technical model and scheduling technology. In addition, cosmetic care and touring knowledge are obtained by interviewing relevant domain experts, such as cosmetic doctors and travel agencies in Taiwan.

II. RELATED WORK

In this section, the related algorithms that are probably applicable to scheduling tours are carefully introduced. The strengths and weaknesses are compared for the final choice. The popular algorithms for arranging tours are as follows:

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A. Genetic Algorithm (GA)

The **Genetic Algorithm** is a computing technique used in probing the optimization solution of problem domains. The GA technique is inspired by evolutionary biology genetic phenomena, such as inheritance, mutation, selection and crossover. The GA methods are categorized as global search heuristics that belong to one particular class of evolutionary algorithms. When GA technologies are realized in a computer simulation, the solution evolves towards optimization along with a set of abstract chromosomes (i.e., key factors of the problem) in successive generations. The evolution usually starts from a random generated solution and occurs within generations. In each generation, the fitness of each solution is evaluated, and then multiple solutions are reproduced. They will be selected from the current solutions based on their fitness and modified through recombination or random mutation to form a new solution. The new solution is then used in the next iteration. The next solutions are propagated towards elimination in each generation [1-6]. This behavior is similar to the propagating plant with slow intelligence system [7]. The difference is that the GA is generally terminated when either a maximum number of generations have been reproduced or a satisfactory fitness level has been achieved for the inherited solution. The general GA flow is shown in Fig.1.

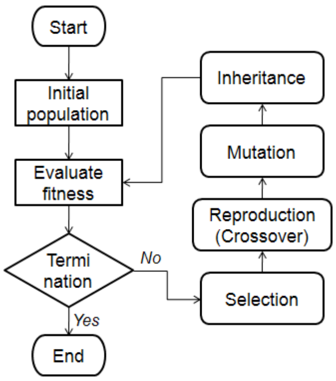

Fig.1 General Flow of the GA process

B. Ant colony optimization algorithm (ACO)

The **ant colony optimization algorithm** is a probabilistic technique for solving computational problems that can be transformed into geometric graphs used for finding the relevant paths. The ACO was designed to progress in a manner similar to the behavior of ants seeking a path between their colony and a food source [8]. The first ACO was proposed by Marco Dorigo in a Ph.D. thesis in 1992 [9-10]. The idea involved some meta-heuristic optimizations and aimed to search for an optimal path in a graph. The original idea has been diversified to solve a wider class of numerical problems. As a result, several problems have emerged, drawing on the various aspects of the behavior of ants.

C. Tabu search algorithm

The **tabu search** algorithm is a mathematical optimization method that can be used for solving combinatorial optimization problems. Tabu search belongs to the class of local search techniques, such as the traveling salesman problem. Tabu search improves the performance of a local search method using memory structures: once a potential solution has been determined, it is marked "taboo" to prevent the algorithm from visiting that possibility repeatedly. Tabu search was initially proposed by Fred W. Glover in 1989 [11-12]. It utilizes a neighborhood or local search process to move iteratively from a solution x to a solution x' in the neighborhood of x until some stopping criterion is satisfied [13]. It is also used to explore regions of the search space that will be left unexplored by the local search process.

D. Simulated annealing (SA)

Simulated annealing is a generic meta-heuristic method for the global optimization problem of applied mathematics. SA seeks a locating approximation to the global minimum through a given function in a large-scale search space. Moreover, it is often used when the search space is discrete (e.g., all tours visiting a given set of cities or spots). For certain problems, SA may be more effective than exhaustive enumeration, provided that the goal is merely to find an acceptably good solution in a fixed amount of time rather than the best possible solution [14-15].

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For large-scale problems, GA and SA have better performance than ACO and Tabu. However, ACO is the most stable. GA's stability is also better than that of Tabu and SA [16]. The characteristics of these algorithms are compared in Table 1. The existing tour scheduling models, like the multi-agents for city travel [17], are not applicable in this cooperative business. For the tour scheduler in our system, we surveyed related technologies and compared their conveniences or lack thereof. The scheduler in our system characteristically requires a large amount of data to arrange tours for visitors. Therefore, the proper algorithms should either be GA or SA. Furthermore, the GA solution has better precision than SA. Thus, we finally chose the GA algorithm for the scheduling tours and implemented it in the kernel of the proposed system.

Table.1 Algorithm comparison

Algorithm	Performance	Stability for precision	Adaption for Problem scale
GA	Fast	Stable	Large
ACO	Normal	High stable	Middle
Tabu	Slow	Normal	Small
SA	Fast	Normal	Large

III. PROPOSED ALGORITHM DESIGN

This section describes how the GA is applied to tour scheduling. In the GA data structure and evolution, the definitions of chromosome and genes play the most important roles. Therefore, the chromosome representation and the genes are illustrated first. The factors affecting the genes are then exposed in detail. The solution is iteratively improved through evolution by the generation of the next chromosome. The fitness function is the criterion used to stop the evolution. Thus, the fitness function is also defined in this work. Finally, the GA flow is expanded to explain evolutionary progress in a step-by-step fashion.

A. Chromosome representations

A chromosome is composed of a number of genes. A gene is a minimal unit in heredity. In our chromosome representations, the genes in the left chromosome represent the sequence of the tourist attractions that visitors intend to visit. The final evolution sequence represents the most proper tour schedule for visitors. The genes in the right chromosome represent how long the visitors will stay at the attractions identified in the left sequence of the chromosome. The genes in the middle chromosome represent the time when the visitors start their daily tour. To work out the arrival and departure time for each attraction, the function *f(p1,p2)* is utilized to calculate the delay time of the whole tour. The delay time can be approximately calculated from Google maps.

A chromosome example in our algorithm is shown in Fig.2. The visitors start their daily tour at 8 o'clock in the morning as the gene in the middle is equal to eight. Thus, the *Ts* value is equal to 8 o'clock. The function *f (S, B) = 1* represents the traffic time from *S* to *B* of one hour. According to function *f*, the algorithm can derive the arrival time at scenic spot B as 9 o'clock. Furthermore, the stay time at spot B can be defined as three hours in the gene next to the middle gene by a travel agent in advance. Thus, the difference in time between the left and right gene *B* is three hours. In the same way, the time 12:30 is derived based on *f (B, A) = 0.5*. In this example, the sequence plan of this tour can be transformed to a user-friendly interface and used to guide the visitors from scenic spot B to A, from A to D, and finally from D to C. The visitors will arrive back to the hotel at 11 o'clock in the evening.

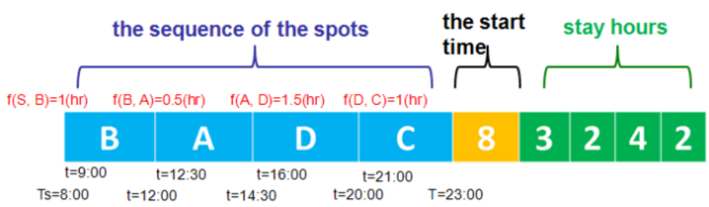


Fig.2 Chromosome representations

B. Fitness function definition

The fitness function is designed to derive the fitness value when a user visits a scenic spot. The factors in the fitness function are as follows: attraction, category, and stay time at a scenic spot. The visitor's hobbies and medical treatments are also included in the factors of the function. The specific definitions are represented as follows:

$\mathbf{ATTRACTION}_p(t)$ = *attraction of the spot P at time t*
$\mathbf{USER}_{attraction}(P)$ = *attraction of the spot P for the user*
$\mathbf{STAY}p(T)$ = *fitness value of staying t hours at spot P*
$\mathbf{Environment}_p\ (t)$ = *environmental factor of the spot P at time t, e.g.,* $\mathbf{Light}_p(t)$ *represents the sunshine factor*
$\mathbf{USER}_{\ environment}\ (x)$ = *fitness of a visitor when he/she stays at environment x, e.g.,* $\mathbf{USER}_{\ light}\ (x)$

The environmental factors can contain sunshine, temperature, humidity, ultraviolet rays and wind force, among others. However, based on the interviews with cosmetic doctors, we chose sunshine as our key environmental factor to implement our fitness function. The fitness value in our GA function is defined as follows:

$$f = \sum_{all\ p} \{ USER_{ATTRACTION}(p) \times \{ STAY_p(T) + \sum_{t=arrival}^{level} [USER_{light}(LIGHT_p(t)) + ATTRACTION_p(t)] \} \} \quad (1)$$

The fitness value of a scenic spot will be different at different times because sunshine varies accordingly. This is true in a real situation in the real world. The estimated fitness of a spot at time t is used to leverage the fitness value discretely during arrival and departure times. Furthermore, the final fitness of a spot at time t is the product of the estimated fitness and a visitor's hobby. Finally, the total fitness value of this tour for the visitors is the sum of the fitness of all the spots.

C. The characteristic evolution in GA flow

Selection: The selection in each generation is based on the fitness value, which is generated by the fitness function. AT higher fitness value has a better chance to be selected for reproduction than the lower one. The higher fitness value can be selected for reproduction on a large scale in the next generation. Meanwhile, the lower fitness is eliminated step by step. For each new solution to be reproduced, a pair of previous solutions is selected for breeding from the previous selection pool. By reproducing the next solution, using the crossover and mutation methods, a new solution is created.

Crossover: In our algorithm, the position-based crossover (POS) method is chosen to perform crossover in the GA flow. The POS is explained as follows:

(1) To initially select two chromosomes as parents of next generation chromosomes.

1	2	3	4	5	6	7	8	9
5	6	9	8	7	1	4	2	3

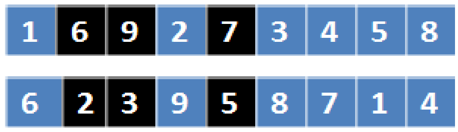
(2) To choose randomly three genes (i.e., 2, 3, 5) in the chromosomes.

1	2	3	4	5	6	7	8	9
5	6	9	8	7	1	4	2	3

(3) To exchange the genes of the two chromosomes.

	6	9		7				
	2	3		5				

(4) To fill in the other genes.



Mutation: Mutation is the change of genes with probability in a chromosome. In our GA function, we chose exchange mutation by exchanging two or more genes in a chromosome. For example, the mutated chromosome is shown in Fig.3.

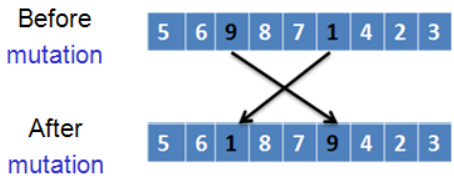


Fig. 3 Chromosome mutation

IV. COSMETIC TOURIST GUIDING MODEL (CTGM) ARCHITECTURE

The CTGM was designed to include three parts: remote server, mobile user and medical service. The CTGM architecture is shown in Fig.4. The remote server is a back-end server with a scheduling engine and a personal reminder. The engine is constructed by the generic algorithm mentioned in Section 3. The personal reminder is used to generate personal care information according to scenic spots, medical care information and personal needs. The mobile secretary can query the necessary information from the reminder and tour database and then send the information to the user's mobile device. Furthermore, the secretary could also feedback the user's location to the scheduling engine and thus generates a personal reminder during the visitor's tour. Therefore, the scheduling engine can reschedule according to feedback, if necessary.

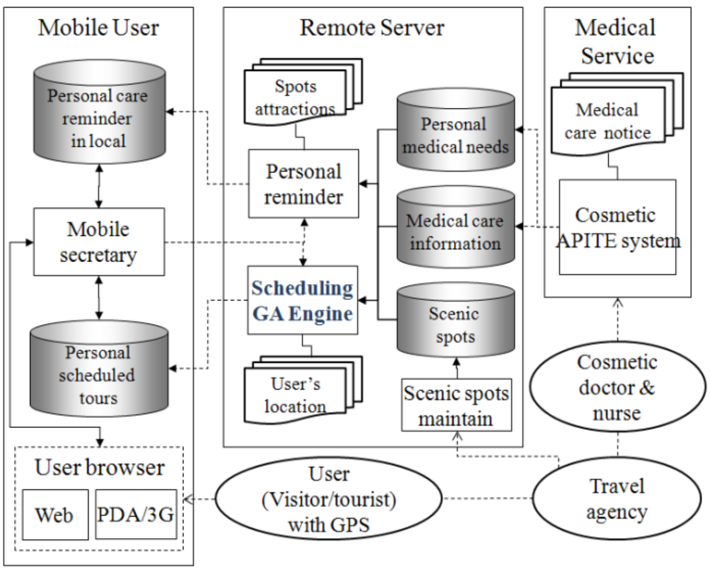


Fig.4 CTGM architecture

The cosmetic doctor can recommend a user's medical notice through the APITE system, which is a remote consulting system for cosmetic users and doctors. Some facial expression technologies are applicable to the consulting system. The user can acquire his/her touring schedule and other information, including medical concerns, through the user browser in mobile devices. The travel agency can maintain the scenic spots in the CTGM and schedule the guest's tour through the user interface provided by the CTGM. From a business perspective, the whole system is indeed applicable to some product, and the results in some businesses can be beneficial if the medical provider and travel agency agree on a specific service level agreement.

Furthermore, the remote server in the CTGM can provide general business web services that can support GA service to enhance service quality. For example, there are additional components such as user registration and login service, user authorization, global positioning service, real-time weather query service and suggestion feedback service.

The GA function that includes other factors is a high complexity function. Mobile devices are usually equipped with low computing capabilities and limited power. Moreover, the GA function in the server has high maintainability and extensibility. Owing to these perspectives, the GA is designed to execute from a remote back-end server and dispatch computing results to a user's mobile device.

If a user triggers the scheduling function on the schedule webpage, the scheduling service will be remotely called on to invoke a GA object in the server side. Meanwhile, the related factors (i.e., genes) are pre-loaded into the memory through the db_gpsdata object to enhance performance. The db_gpsdata is an object that queries the necessary data from the database. This preloading activity must be executed before the GA is initialized. In each GA generation loop of the GA evolution, the GA instance executes the following steps: fitness evaluation, selection of two parents, crossover and random mutation. The sequence diagram is shown in Fig.5.

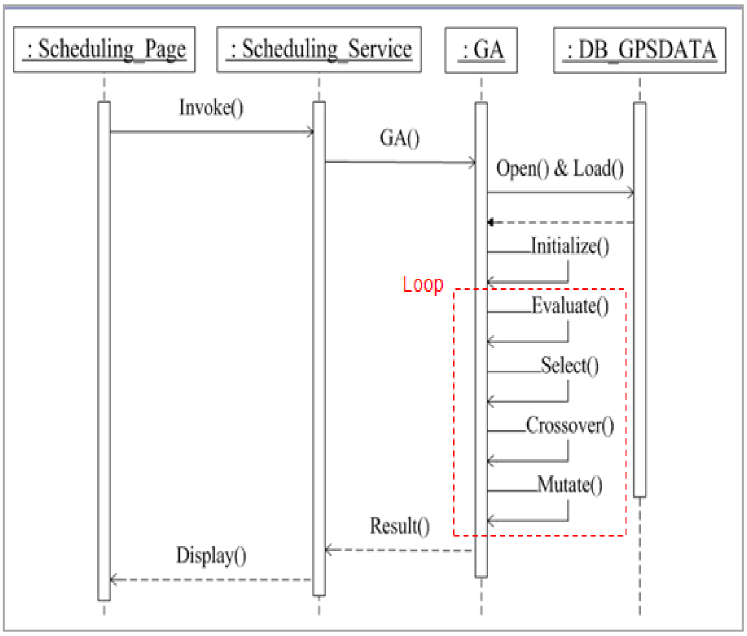


Fig.5 The GA sequence diagram

V. RESULTS

The components in both the server and mobile sides were developed using Microsoft Visual C#.NET 2008. They were expressly encapsulated as Web Services for network communication. The server components were installed in an IIS 7.5.7600 server, and the computing data were stored in a MySQL database. The designed GA function was installed in the server side and was used to communicate with the components in the mobile side through web service protocols.

To evaluate the proposed GA function, we scheduled the various spots of a one-day tour in southern Taiwan for visitors. A tour schedule was simulated by combining various numbers of scenic spots, such as 5, 7 and 10 spots, in a one-day tour. For each case, the various results were collected by executing the GA functions 10, 20, 30, 40 and 50 generation times. The GA accuracies of the cases of 5, 7 and 10 spots are shown in Fig.6.

As seen in the curves, accuracy will keep on increasing significantly if the generation times are less than 30. On the other hand, the accuracy of the results will remain stable if the generation times of the proposed GA are up to 30.

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Comparing different curves in the same generation times, the accuracy of 5 spots is higher than that of 7 and 10 spots. The higher complexity resulting from more spots accounts for this. Therefore, the highest accuracy occurs when 5 spots are scheduled in a one-day tour.

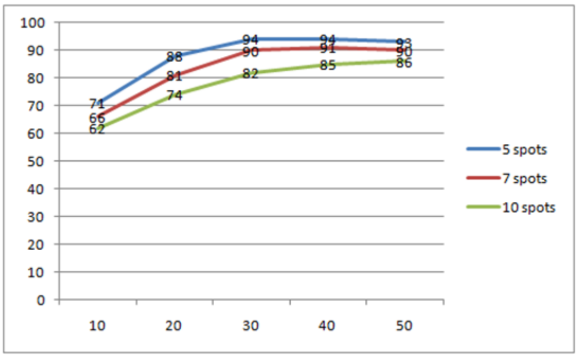

Fig.6 GA: Accuracy (%) vs. generation (#)

VI. CONCLUSIONS AND FUTURE WORK

An overseas tourist will require specific post-cosmetic care after he/she has finished cosmetic treatments and may prefer to have a short-term vacation in the area where the treatment takes place. Generally, post-cosmetic care during such a vacation is important to the effectiveness of cosmetic treatments. In this paper, we aimed to explore technical models, including the GA to realize the combinative business of cosmetic treatment and travel tourism for serving the overseas tourist. The proposed CTGM was connected to the GA and other technologies, and was successfully extended to construct a cosmetic tourist guiding system. The CTGM is composed of the necessary functions, and therefore it is useful in the business domain of international cosmetic tourism. The relevant technologies in the CTGM are GA, lightweight mobility, cosmetic care and touring knowledge. Cosmetic care and touring knowledge were obtained by interviewing relevant domain experts, such as cosmetic doctors and travel agents, in Taiwan. In the future, the CTGM model will be extended to provide overseas visitors with convenient services. The model will also be enhanced to provide an open platform for business owners to collaborate with each other over the Internet.

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