Challenges in User-Adaptive Tour Planning Systems

Yohei Kurata

SFB/TR 8 Spatial Cognition, Universität Bremen
Postfach 280334 Bremen, Germany
ykurata@informatik.uni-bremen.de

Abstract. User-adaptive tour planning systems are tourist information systems that can make tour plans customized for individual users. Several systems have been already proposed, but such usability issues as frustrating preference/personality registration process and lack of sense of participation still remain. In this paper, we review these usability issues and discuss the following challenges for more practical user-adaptive tour planning systems: collaborative tour planning, smart detection of user's preferences, more realistic settings of tour optimization problems, and mobile-oriented service.

Keywords: tour planning, user's preference, selective travelling salesman problem, candidate/critique model, trajectory-based preference detection

1. Introduction

Tourism is a spatial activity that depends highly on the preferences of individual tourists. Naturally, tourist information systems are desired to provide information adapted to individual users, especially when the users' destination is a tourist city where many types of *points of interest* (*POIs*) exist densely and tourists have to decide which POIs to visit without sufficient prior knowledge. Indeed, a number of user-adaptive tourist information systems have been proposed before. For instance, some systems sort or filter POIs based on the user's preference (e.g., [1-3]). However, even if the user is informed about which POIs will be interesting for him/her, designing an efficient tour plan remains a hard task. Thus, several tourist information systems, including ours [4, 5], were equipped an ability to design tour plans customized for individual users [4-8]. These tour planning systems still have several usability problems, such as frustrating process of preference registration and lack of sense that the user participates in the planning. In this paper, we review these problems and discuss some challenges to achieve more practical user-adaptive tour planning systems.

The remainder of this paper is structured as follows: Section 2 reviews the previous user-adaptive tour planning systems. Section 3 discusses the problems and challenges in user-adaptive tour planning systems. Finally, Section 4 concludes the discussion.

2. Tour Planning Systems

Most tour planning systems have similar three-step structures: preference setting, evaluation of POIs, and route optimization. As an example, screenshots of our system [4, 5] are shown in Figs. 1a-e. In this system, the user specifies his/her interest through a questionnaire (Fig. 1b), from which the system judges the user's preference. Based on this preference, the system calculates the expected value of each POI. Finally, the system computes a tour plan that maximizes the total values of POIs to be visited (Figs. 1c-d). The system can also show the information about POIs (Fig. 1e).

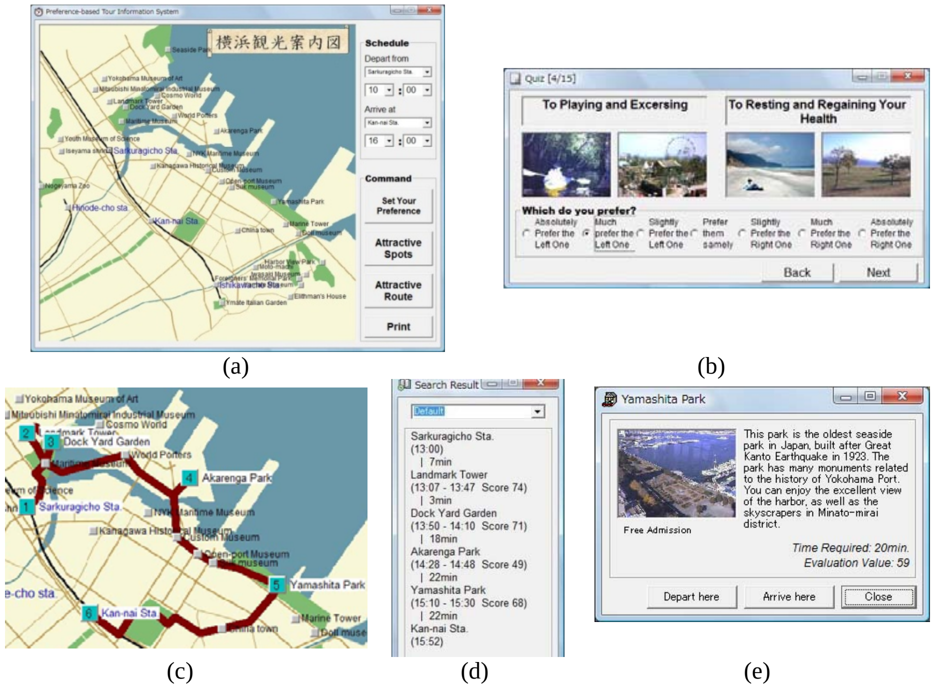

Fig. 1. Screen shots of our tour planning system [4, 5]: (a) its main screen, (b) a question asking users' preference over two tour purposes, (c-d) a customized tour plan shown on a map and by text, and (e) information about a POI

Setting of the user's preference is a problematic process. Traditional decision-support systems ask the user to specify his/her preference on several criteria manually, for instance by sliders [9]. This approach frustrates the users because they are forced to evaluate their own preference on obscure scales. Thus, our system took an alternative approach based on *AHP* (*Analytical Hierarchical Process*) [10], in which the user is given fifteen questions that ask which tour purpose is preferable (Fig. 1b) and from his/her answers the system calculates the user's weights on ten tour purposes (Fig. 2). We considered that the weights on these ten tour purposes represent the user's tour preference. This comparison-based process is easier than the slider-based approach, but the questionnaire takes a lot of time. To realize more quick setting of user's preference, some systems ask the user to input age, gender, occupation, and so on, assuming that the tourists with demographically similar properties have similar tour interests [1, 8]. This approach, however, also frustrates the users, making them feel that their privacy is offended or that the system has a stereotypical view of their preferences.

Once the user's preference is modeled, the system evaluates all POIs in the target area based on this model. The value of each POI may be evaluated from the user's weights on several criteria and the POI's scores in these criteria [4, 5] or based on the evaluation by other tourists with similar preferences/properties [1, 8]. In our previous system, each POI is rated in ten criteria, which corresponds to the ten tour purposes (Fig. 2). Thus, by weighting the ten criteria with the weights on the ten tour purposes, the score (value) of each POI is calculated.

Finally, the system computes an optimal tour plan. Normally, this problem is a variation of the *Selective Traveling Salesman Problem* (*STSP*) [11] and defined, for example, as follows:

> *Given a complete graph* (V, E)*, the utility (value) of each node* u_i*, the time spent at each node* ${t^{visit}}_i$*, the travel time between two nodes* ${t^{travel}}_{ij}$*, origin* $v_{ori} \in V$*, destination* $v_{goal} \in V$*, and time constraint* T*, find a series of nodes to be visited* $v_{a_1}, \dots, v_{a_k} \left(v_{a_i} \in V\right)$ *that maximize the some of utilities under a time constraint* T*.*

$$\begin{aligned} \text{maximize} \quad & \textstyle\sum_{i=1}^{k} u_{a_i} \\ \text{s.t.} \quad & \textstyle\sum_{i=1}^{k} {t^{visit}}_{a_i} + \sum_{i=0}^{k+1} {t^{travel}}_{a_i a_{i+1}} \le T \\ & v_{a_0} = v_{ori},\ v_{a_{k+1}} = v_{goal} \end{aligned} \tag{1}$$

Since this problem is NP-hard, we developed a heuristic algorithm for approximate solutions, in which we gradually increased the time constraint up to *T* while revising the tour plan repeatedly [4]. Alternatively, P-Tour [6] adopted a genetic algorithm for approximate solutions. We, however, believe that strict solutions may be derived in a practical time by dynamic programming, since the scale of the problem is usually small (for instance, a tourist rarely visits more than ten POIs in one day).

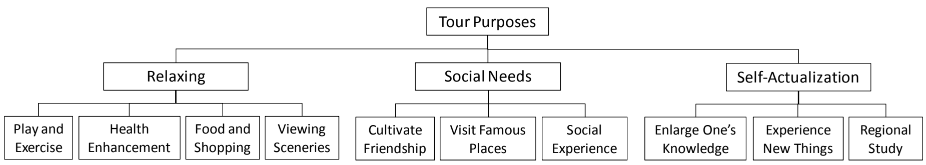

Fig. 2. Hypothesized structure of ten tour purposes used in [4, 5]

3. Problems and Challenges

We asked 25 human subjects to test our prototype system [4]. Almost all users agreed that the customized tour plans matched their preferences, even though they could not tell whether the recommended plans looked the *best* for them. Some users complained about the inability to modify the recommended plans—for instance, removing the POIs that they had visited before. Some users complained about the questionnaire, as it took long time and seemed not directly linked to the planning process.

Actually other tour planning systems have similar problems, as they also impose certain frustrating preference/personality registration processes and do not allow manual modification of recommended plans. Exceptionally, P-Tour [6] avoids the preference/personality registration process, leaving the evaluation of POIs entirely to users. Thus, the user has much freedom to express what he/she does and does not want to visit. As a drawback, the user is forced to estimate the value of POIs that he/she has never been. We, therefore, consider that the desirable approach is a *hybrid* one; that is, the system coordinates the tour planning while the user is allowed to modify the plan and participate in the planning. The system also learns the user's preference from his/her involvement and makes use of this information to revise tour plans. We are going to explain this idea more explicitly.

3.1. Collaborative Design of Tour Plans

How can we encourage the participation of the users, without increasing their obligations? One possible solution is the use of the *candidate/critique model* [12]. Imagine that you are shown several plans: one fits the *tentative* model of your preference, while others follow different interests. Then, you are asked to compare the plans and specify which you prefer. If you choose one of the alternatives, then the system infers what criteria you emphasize, revises the model of your preference, and recomputed tour plans. This process is repeated until you agree with the recommended plan. This approach is preferable for the user, since he/she can learn available choices and clarify his/her needs through the comparison of actual plans. Even though this approach may be time-consuming, the user probably gets high satisfaction in the final plan. Fig. 3 shows the interface design of an envisioned tour planning system that will enable such collaborative tour planning. For simplification, it shows only two plans on a screen, but the user can see various alternative plans with different characteristics by clicking the buttons in the right-bottom.

For more flexible tour planning, it is also desirable that the system allows the user to express which POIs he/she wants to visit or avoid. Even if the user does not want to estimate the value of all POIs, he/she may want to specify his/her request about certain POIs. For instance, a tourist, who usually likes art museums but not historical monuments, may request to visit Palace of Versailles because it is world-famous, while he may also request not to visit Musée d'Orsay because he has been there several times. The tour planning system should be able to accept such case-by-case requests, just like a human tour coordinator can do. The interface design in Fig. 3 also considers the support of such requests. Addition/removal of a POI can be realized by dragging its name tag to the three icons labeled "*add to tour*", "*not attractive*", and "*visited before*". We distinguished "*not attractive*" and "*visited before*" because dragging to the former icon may be used to revise the user's preference model, while dragging to the later icon does not.

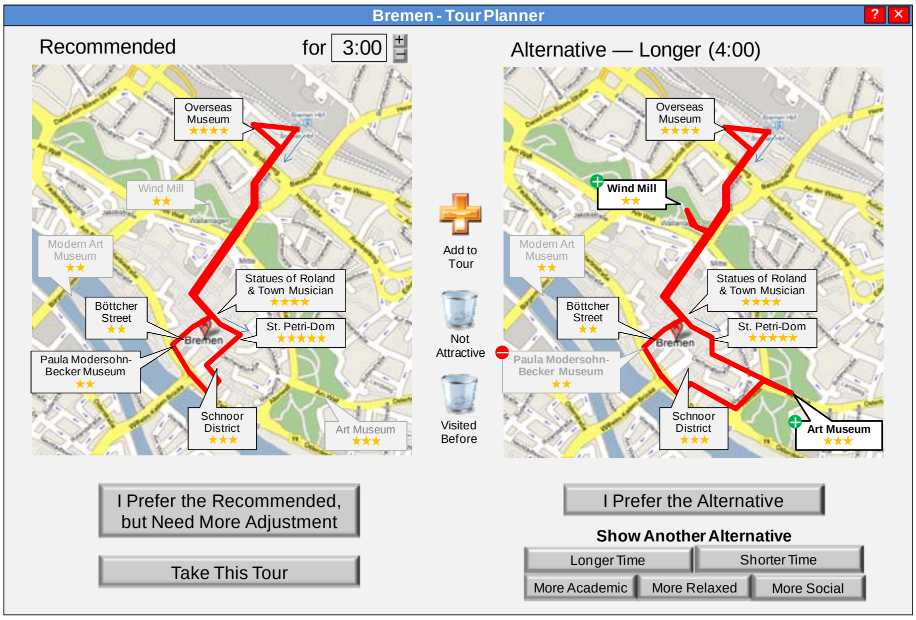

Fig. 3. An image of a new tour planning system that realizes collaborative tour planning

In Fig. 3, the value of each POI is shown by 1- to 5-stars, as the stars are more intuitive than quantitative scores (e.g., Fig. 1e). On the other hand, the total values of the recommended plan and alternative plan are not displayed, because the total values, calculated from an incomplete model of the user's preference, may confuse the user's choice of two plans.

3.2. Smart Detection of Users' Preference

How can we avoid the preference/personality registration process? One potential solution is, as introduced in the previous section, that the system seeks the user's preference from the choice of alternative plans through iterative interactions. The second potential solution, which is effective in mobile use, is to ask the user to evaluate each POI after a visit and to revise the model of the user's preference according to the user's response. Of course, the evaluation of POIs easily becomes an annoying process during an actual tour. Thus, we should carefully design the interaction process, such that the evaluation is easy (e.g., selection from one-star to five-star) and its frequency is minimized.

Another potential solution in mobile scenarios is to learn the user's preference from his/her trajectory. Where the user visits and how much time he/she spends there *may* tell something about his/her preference, especially when it is compared with the data of ordinary people. Schmidt-Belz *et al.* [2], however, questions this trajectory-based approach, saying that the visit to a church may be not because of the tourist's interest in churches, but because of a concert in the church, an exceptional view from its tower, or even a little café in the aisle. Yet, we believe that the trajectory-based preference detection is still useful, especially if we can tell from the micro-level trajectory whether he is actively involved in sightseeing or, say, taking a rest in a POI. Kiefer and Schlieder [13] discusses the method to infer the user's intentions by parsing his/her trajectory. Such *mobile intention recognition* techniques are useful for inferring the user's touring behaviors from his/her trajectories.

3.3. More Realistic Settings of Tour Optimization Problems

Although it is not apparent in our user test, one weak point of our previous system is its too simple setting of the tour optimization problem. To make the problem more realistic, we can think about the following extensions:

1. To assign values not only POIs, but also links
2. To allow the temporal/seasonal fluctuation of POIs' values;
3. To regard the travel time between POIs as a fuzzy value;
4. To adapt the estimated time spent at each POI to each user;
5. To take weather conditions into account; and
6. To give lower scores to 'monotonous' tours.

By Extension 1, the attractiveness of routes between POIs is incorporated into tour planning. This extended problem is a sort of *EPTP* (*Enhanced Profitable Tour Problem*), whose approximate solution algorithm is already proposed in [14]. Of course, how to evaluate the attractiveness of routes remains as a research question.

Extension 2 is critical for practical tour planning. For instance, museums have zero value when they are closed. Some overlooks have more values at sunset, while losing their values when the sunlight comes from the front. Botanical gardens are attractive in summer, but not in winter. In this way, POIs' values vary from time to time and such temporal fluctuation is not ignorable. Matsuda *et al*. [15] already tackled Extensions 2 and 3. They formulated *FORPS* (Fuzzy Optimal Routing Problem for Sightseeing) and proposed a heuristic algorithm for its approximate solutions. Extension 3 is also important for supporting the variation of travel time due to traffic jams or infrequent service of public transportation.

For Extension 4, we have to develop a model for estimating the time spent at a POI from the tourist's preference and the POI's characteristics. For this, we have to analyze the statistical data of tourist behaviors.

Extension 5 is also essential for practical tour planning. For instance, if the weather forecast predicts rain in the afternoon, it is better to plan a tour such that outdoor attractions are visited in the morning while museums are left for the afternoon. Even after the tour has started, the plan should be modified flexibly in case of a sudden rail. These problems can be handled by the techniques used for Extension 2.

As for Extension 6, current systems evaluate POIs individually, but not as a combination. As a result, for instance, if the user likes museums, the systems tend to recommend a plan that visits museums for all day—which may be boring even for this user. Thus, it is desirable that the systems can evaluate the monotony of visited POIs and utilize it for tour planning.

3.4. Mobile-Oriented Service

In the big trend to mobile computing, tour planning systems will be used more often in mobile context. A key question is how to provide the service tailored to mobile devices. For instance, the mobile version of P-Tour [16] monitors the user's location by GPS and warns the user if he/she is out of the route or behind schedule [16]. The capability of such schedule monitoring and real-time tour re-planning is a potential strength of tour planning systems in mobile use. Trajectory-based preference detection (Section 3.1) is another possibility of mobile-oriented tour planning systems. Furthermore, the potential of tour planning systems is more expanded if it is combined with other intelligent mobile technologies, such as smart route navigation (e.g., *route-specific route instructions* [17]) and location-based querying (e.g., *iPointer*® [18]), to form a comprehensive tour support system.

4. Conclusions

Tourist information systems should meet a large variety of user's needs. At the same time, the systems should not provide too much information to the users, as overwhelming amount of information makes their decision more difficult. We already have several user-adaptive tour planning systems, but, they still have room for improvement. We discussed several challenges for the future tour planning systems; they are (i) collaborative tour planning, (ii) smart detection of user's preference, (ii) more realistic setting of tour optimization problems, and (iv) mobile-oriented tour planning service. In addition, the validity of the tourist preference model in the previous tourist information systems (e.g., that in Fig. 2) should be examined carefully for the improvement of the tourist information system.

Smart detection of user's preference/needs/personality is a key technology for all kinds of user-adaptive information systems. Among these systems, mobile information systems can make use of the user's locational information for profiling the users. The idea of trajectory-based preference detection is applicable to other user-adaptive spatial information systems. For instance, bike navigation systems may learn from the trajectory what kind of routes that the user prefers. The information about where and how long the user spend time during shopping may be useful for adapting advertisements to the users. We, therefore, believe that the research on trajectory-based preference detection will expands the capability of spatial assistance systems.

Acknowledgement

Yohei Kurata's work is supported by DFG (Deutsche Forschungsgemeinschaft) through the Collaborative Research Center SFB/TR 8 Spatial Cognition.

References

1. Ricci, F., Arslan, B., Mirzadeh, N., Venturini, A.: ITR: A Case-Based Travel Advisory System. In: Craw, S., Preece, A. (eds.): ECCBR 2002, Lecture Notes in Artificial Intelligence, vol. 2416, pp. 613-627. Springer, Berlin/Heidelberg, Germany (2002)
2. Schmidt-Belz, B., Nick, A., Poslad, S., Zipf, A.: Personalized and Location-Based Mobile Tourism Services. In: Workshop on Mobile Tourism Support Systems (2002)
3. Ardissono, L., Goy, A., Petrone, G., Segnan, M., Torasso, P.: Intrigue: Personalized Recommendation of Tourist Attractions for Desktop and Handset Devices. Applied Artificial Intelligence: Special Issue on Artificial Intelligence for Cultural Heritage and Digital Libraries 17(8-9), 687-714 (2003)
4. Kurata, Y.: Development of a Preference-Based Tour Planning System. Bachelor Thesis (in Japanese). Department of Urban Engineering, University of Tokyo, Tokyo, Japan (2000)
5. Kurata, Y., Okunuki, K., Sadahiro, Y.: Development of a Preference-Based Tour Planning System. In: Papers and Proceedings of the Geographic Information Systems Association (in Japanese), vol. 9, pp. 199-202 (2000)
6. Maruyama, A., Shibata, N., Murata, Y., Yasumoto, K., Ito, M.: A Personal Tourism Navigation System to Support Traveling Multiple Destinations with Time Restrictions. In: 18th IEEE International Conference on Advanced Information Networking and Applications, pp. 18-21 (2004)
7. Goy, A., Magro, D.: STAR: A Smart Tourist Agenda Recommender. In: Configuration Workshop at ECAI 2004, pp. 8/1-8/7 (2005)
8. Lee, J., Kang, E., Park, G.-L.: Design and Implementation of a Tour Planning System for Telematics Users. In: Gervasi, O., Gavrilova, M. (eds.): ICCSA 2007, Lecture Notes in Artificial Intelligence, pp. 179-189. Springer, Berlin/Heidelberg, Germany (2007)
9. Hochmair, H., Rinner, C.: Investigating the Need for Eliminatory Constraints in the User Interface of Bicycle Route Planners. In: Cohn, A., Mark, D. (eds.): COSIT'05, Lecture Notes in Computer Science vol. 3693, pp. 49-66. Springer, Berlin/Heidelberg, Germany (2005)
10. Saaty, T.: The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. McGraw-Hill, New York, USA (1980)
11. Laporte, G.: Tour Location Problems. European Journal for Operations Research 106, 2-3 (1996)
12. Linden, G., Hanks, S., Lesh, N.: Interactive Assessment of User Preference Models: The Automated Travel Assistant. In: Jameson, A., Paris, C., Tasso, C. (eds.): Sixth International Conference on User Modeling, pp. 67-78. Springer (1997)
13. Kiefer, P., Schlieder, C.: Exploring Context-Sensitivity in Spatial Intention Recognition. In: Gottfried, B. (ed.): Intl. Workshop on Behavioral Monitoring and Interpretation, TZI-Bericht, vol. 42, pp. 102-116. Technogie-Zentrum Informatik, Universität Bremen (2007)
14. Joset, M., Stille, W.: A User-Aware Tour Proposal Framework Using a Hybrid Optimization Approach. In: 10th ACM International Symposium on Advances in Geographic Information Systems, pp. 81-87. ACM Press (2002)
15. Matsuda, Y., Nakamura, M., Kang, D., Miyagi, H.: An Optimal Routing Problem for Sightseeing with Fuzzy Time-Varying Weights. In: IEEE International Conference on Systems, Man and Cybernetics, vol. 4, pp. 3665-3669 (2004)
16. Shiraishi, T., Nagata, M., Shibata, N., Murata, Y., Yasumoto, K., Ito, M.: A Personal Navigation System with Functions to Compose Tour Schedules Based on Multiple Conflicting Criteria. IPSJ Digital Courier 1, 528-536 (2005)
17. Richter, K.-F., Klippel, A., Freksa, C.: Shortest, Fastest, – but What Next? A Different Approach to Route Directions. In: Münsteraner GI-Tagen 2004, pp. 205-217. IFGI prints, Münster, Germany (2004)
18. Frank, C.: An Egocentric Spatial Data Model. Department of Spatial Information Science and Engineering, Master Thesis. University of Maine, Orono, Maine, USA (2003)