Utilising Crowd Information of Tourist Spots in an Interactive Tour Recommender System

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Abstract

Although the congestion of tourist spots has a huge effect on tourist experiences, few studies have discussed crowd information in the research field of recommender systems for tour planning. This study developed a recommender system that utilises crowd information interactively to support tour planning. The study created a bar graph about relative crowdedness in a day based on the idea that the measures required for a crowd vary depending on each tourist. This research conducted user experiments to examine how tourists are conscious of crowds. The proposed system can provide alternative plans in 70% of cases when tourists wish to visit a spot when it is not crowded. Furthermore, the results imply the importance of focusing on differences in tourists with regard to a sightseeing spot. The sightseeing experiences of tourists may be enhanced by conducting expectation management for sightseeing using ICT.

Keywords: recommender system; service design; crowding data; FIT

1 Introduction

Strides in information and communication technology (ICT) have helped to enrich tourism experiences. Tourists can prepare their tour plans in detail using ICT. However, at a practical level, tourists may still be unable to tour as planned and have a good experience because of congestion in many popular tourist spots. For example, Kyoto in Japan is one of the world's most famous destinations for people to enjoy Japanese traditional culture, such as through visiting shrines and temples. However, Kyoto faces a serious problem on a daily basis: public transportation facilities do not function efficiently owing to the rapid increase in inbound tourists [1]. Meanwhile, congestion of tourist spots does not always have a negative influence. Moderate congestion can enhance tourism experience and satisfaction [2, 3]. Since ICT has made detailed planning possible, information on congestion in planning has increasingly affected on-site tourism experience. Crowding data are increasingly relevant to a tour recommender system.

However, in studies on tour recommender systems, little attention has been paid to offering support for tour planning with respect to congestion [4]. Tourists become aware of congestion through unverified methods. Indeed, few tourists denote their preference for each crowded situation and are conscious of congestion at the beginning of their planning. Therefore, an interactive tour recommender system that repeats the proposed tour plans and considers the needs of tourists for avoiding congestion is required.

This study aimed to develop a tour recommender system that interactively and iteratively utilises crowd information. The concept that providers and tourists co-create value together has become popular, gradually replacing the practice of one-sided provision by providers [5]. In the service design, incorporating the concept of co-creation involving tourists in the tour planning and in the actual sightseeing affects the tourism experience. This study clarifies the awareness of tourists of the congestion issue through the co-creation of tour planning, thereby contributing to the development of service design research for tour planning using ICT.

2 Literature review

2.1 Tour Recommender system

Many studies on personalised travel plan support have been conducted [6]. Based on tourists' restrictions and the attractiveness of points of interest (POIs), these studies formulate sightseeing plans [7-9]. For example, Gavalas [8] allows a user to arbitrarily set the start / arrival point. In general, the Orienteering Problem (OP) [10] is used to derive sightseeing plans [11]. Alghamdi [12] extends the OP and takes into consideration the time spent at each location.

Tour recommender systems are classified on the basis of various views. One of these classifications is whether the process of recommendation is one-shot or interactive. In one-shot recommendation schemes [13, 14], users input their profiles (e.g. age, sex, and job) and then a system creates user models based on their profiles. Then, the system recommends tour plans to match the preferences estimated from the user models. Users can directly input their characteristics [15]. In an interactive recommendation system [16], users are able to revise their preferences during interaction with the recommender and are recommended tour plans after browsing some of the system's initial suggestions.

Another classification is from the viewpoint of function, such as recommender systems that prepare destination/tourist 'packs' and suggest attractions, trip planners, and social aspects [17-19]. Tour recommender systems have also been traditionally classified into content-based, collaborative, and demographic systems [20-22] according to the analysis of user information and filtering of list items. Collaborative systems make recommendations based on groups of users with similar preferences [23]. Demographic-based systems rely on the demographic data of the user (e.g. age, country of origin, and level of studies). In this case, generated recommendations are not based on the user's interests and preferences but on his/her personal characteristics [24].

Meanwhile, content-based systems calculate the degree of similarity between users and items to be recommended. For example, the City Trip Planner [4] recommends a plan suitable for tourists based on conditions input by users, such as travelling time, departure and arrival place, and degree of interest in the sightseeing categories. The CT-Planner (Collaborative Tour Planner; http://ctplanner.jp/) [25] also recommends plans based on the conditions requested by users. It is an interactive recommender system. Therefore, the planning process on the CT-Planner is completed by reflecting the repeated feedback from the user.

2.2 Crowding research

Karanikolaou [26] conducted an analysis to understand human crowd behaviour developed in 'human-centred participatory sensing'. Congestion in sightseeing has been studied from the viewpoint of route allocation of tourist buses, considering the influence of traffic congestion for tourist buses [27, 28]. Uchida [29] generated a set of tour schedules where the sum of all users' utility considering congestion is the highest, using simulation-based optimisation. In a study of the role of crowdedness in urban tourism in Florence, Popp [30] indicated that tourists' perception of crowds is strongly influenced by their tourism experience. Crowding may work positively for sightseeing experiences, unless the threshold for negative crowding is exceeded. In other words, perceived crowdedness depends not only on individual tourists but also on the purpose of a trip for the same tourist.

Therefore, a tour planning system that deals with crowd information requires the following specifications.

- Crowding should not be dealt with at a general level in the tour recommendation; it depends on the tourist and context.
- An interactive process is necessary to obtain tourists' preferences for each crowded situation.
- The obtained preference should be interactively incorporated into the tour recommendation in a content-based manner.

3 Proposed system

3.1 Reference system

This research used CT-Planner [25] as an interactive and content-based tour recommender system. The CT-Planner estimates the value of individual POIs for each user, and then calculates the most efficient plan under given constraints that maximises the sum of the estimated values of the POIs to be visited in the tour. The calculation of the most efficient plan under the given time and start/goal constraints is formalised as a selective travelling salesman problem [31], which is an NP-hard combinatorial optimisation problem. Thus, a genetic algorithm is adopted to derive semi-optimal solutions within a short time. This system combines optimisation techniques with manual modification by users so that users can clarify their requirements and create personalised tour plans interactively.

3.2 Modelling of tourists' perception of crowds

This study sought to shed light on crowd perception. Figure 1 shows a graph for a given spot, with the horizontal axis representing the time zone, and the vertical axis representing the number of people. Tourists have varying definitions for crowd volume as being 'the border of uncomfortable by congestion (congestion line)' and 'the border of enjoyable than this is (bustling line)' for each sightseeing spot. The number of people between these two standards is the appropriate crowdedness,

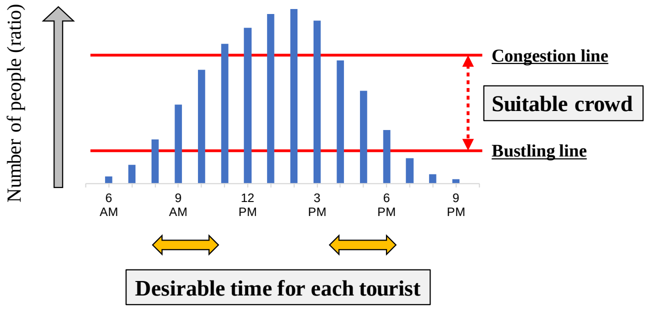


Fig. 1. Model of tourists' perception of crowd

whereas the time zone corresponding to the limited crowdedness is the desirable visiting time.

3.3 Crowd data

This study used Google's 'popular times' as a data source for crowd information. Google provides this information based on anonymous data aggregated from users who have Google location history enabled on devices such as smartphones. Since 'popular times' information is based on data averaged over a few weeks and is a graph relative to the peak hour for each spot [32], a comparison between different spots using absolute values is impossible. However, as the avoidance of the crowded spots themselves is not the objective of computer-aided planning, Google data are enough to obtain the relative population on one day in each spot. The degree of crowdedness is smoothed by averaging over several weeks, including data on large crowds, such as crowds during festivals and events, where the staying time is longer than usual. In addition, when tourists themselves participate in festivals and events, the staying time also changes considerably.

Queueing time is not considered in this study. Queueing time is determined not only from the number of visitors but also from supply volume, such as the number of employees. Therefore, objective data on queueing time of the day cannot be obtained for most spots.

3.4 Proposed process to incorporate crowd information into planning

This study enhanced the CT-Planner by adding congestion information. The proposed system provides crowd information to the interactive process of the CT-Planner in an interactive and stepwise manner, and accounts for incorporating tourists' crowd perception into the planning (Fig. 2). In this process, while grasping the preference of a tourist for coping with crowdedness at a specific visiting spot, the system incorporates the feedback from the tourist and creates a new revised plan. The steps of the procedure are elaborated as follows.

(1) Making a provisional plan based on initial travel conditions

The system first prepares a provisional plan based on the tourism preferences of users (tourists). This step is carried out in the same manner as in the conventional CT-

Planner. Apart from the travel duration and required tour characteristics, the starting time and day of the plan are specified in this step.

(2) Narrowing down spots to show crowd information to the tourist

In the recommendation mechanism of the CT-Planner, the match degree between each spot (P = {p_1, p_2, …}) and tourist is calculated as the expected utility of the spot. Accordingly, this step checks the crowdedness of spots to be visited at the scheduled time in the provisional itinerary, limited to the top 30% of spots ($P^c \subseteq P$) with high expected utility. This limit helps the user easily focus their attention.

(3) Confirming crowd information and providing crowd option

The user may check the crowd information of the limited spots ($p_i^c \subseteq P^c$); the system presents daily crowd graphs. Multiple options to cope with the crowdedness of p_i^c are listed for the tourist to choose from, as follows. These options draw out the perception of the tourist to the crowd of p_i^c. The determination of whether the spot p_i^c is crowed is explained in detail in Section 3.5.

A) Want to visit if not crowded

B) Want to visit regardless of crowd

(4) Selection for coping with the crowdedness and re-computation of the revised plan

When (A) is selected by the user, optimisation calculation is performed by the system after adding a constraint of possible visiting time frame to p_i^c for avoiding congestion. If a semi-optimal visit plan during the limited time period can be devised, the plan will be presented to the user as an alternative plan. Otherwise, another plan that excludes visiting the spot will be presented to the user. In both cases, the system will inform the user on how the itinerary has changed.

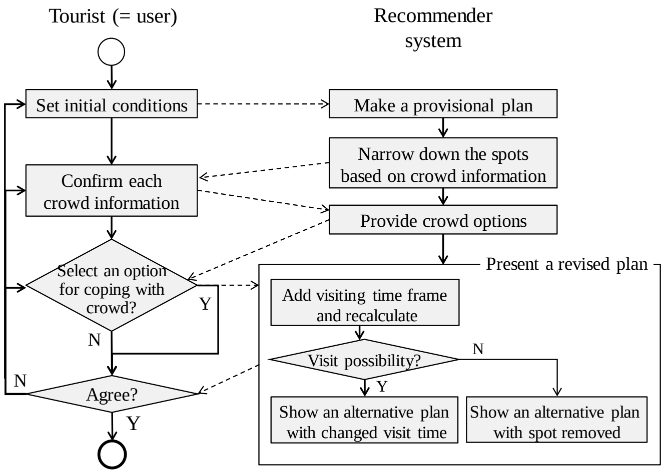


Fig. 2 Interactive process of the proposed system

3.5 Setting the visiting time frame

This section describes the programming for incorporating crowd information into the proposed process. To set a provisional congestion line, as shown in Figure 1, the system focused on the evaluation score of ‘quiet/lively’ of each spot on the CT-Planner. This parameter indicates whether the spot has a lively charm or is tranquil, which is ranked by experts in five grades from -2 to 2. A score of -2 indicates that ‘it attracts tourists by having a calm atmosphere’, whereas a score of 2 indicates that ‘it attracts tourists by being bustling’. Crowdedness becomes problematic in spots where quietness is deemed attractive, but not in spots with a lively charm.

This study attempted to determine a congestion line. Spots with an evaluation score of -2 to 0 (i.e. quietness as attractiveness) was set to 60% of the peak for a congestion line. A spot with an evaluation score of 1 to 2 was set to a peak line of 70%. These values were set to ensure an appropriate visiting time frame. If the congestion line is lowered too much, for example to 50%, the visiting time frame will be of 1 to 2 hours and the ratio of an alternative plan with the changed visit time will be very low in the planning. On the other hand, if the congestion line is set high, most spots will not be considered congested and the crowd information will not be presented. During actual planning by tourists, the congestion line is not directly shown to the tourists in order not to attract their consciousness too much. As described in Section 3.2, the line is only used to narrow down the possible spots for the awareness of tourists. The visiting time frame to avoid congestion is utilised in the proposed calculation.

The method of recalculation adds a visiting time frame. The CT-Planner algorithm calculates plans so that all the staying time falls within the business hours. We create virtual business hours to be used in the planner. When ‘(A) want to visit if not crowded’ is selected, the system changes the business hours of the target spot, according to the end of the visiting time frame and the staying time there. The recalculation is as follows.

A) The end of the visiting time frame is the same as the closing time of the spot.

Let the visiting time frame be virtual business hours of the spot.

B) The end of the visiting time frame is different from the closing time of the spot.

Let ‘the end of the visiting time frame + expected time of stay / 2’ be virtual business hours of the spot. If there are multiple visiting time frames (as in the two-peak crowd graph), A and B are combined. If congestion avoidance is done in 50% or more of the staying time, the utility would be satisfied. Taking the case of Table 1, the plan will be derived only when visiting by 11 am in the 10:00–12:00 visiting time frame. Thus, the visiting time frame would be substantially narrowed.

Table 1. Case of changing business hours (crowded between 10 am and 12 am)

Case	Staying time	Regular business hours	Visiting time frame for adequate crowdedness	Virtual business hours in computation
1	60 min.	10:00 to 18:00	15:00 to 18:00	15:00 to 18:00
2			11:00 to 13:00	11:00 to 13:30
3			10:00 to 12:00 or 17:00 to 18:00	10:00 to 12:30 or 17:00 to 18:00

4 Implementation

The study implemented the proposed method on CT-Planner. As shown in Figure 3, a humanoid icon is displayed above the sightseeing spot name. When this icon is clicked, a window as shown in Figure 4(a) is displayed, and the crowd graph and choices are displayed. When options are selected, a visiting time frame is added and the plan is recalculated; then the window displays whether the visit is possible or not and the difference in the new plan, as shown in Figure 4(b)(c).

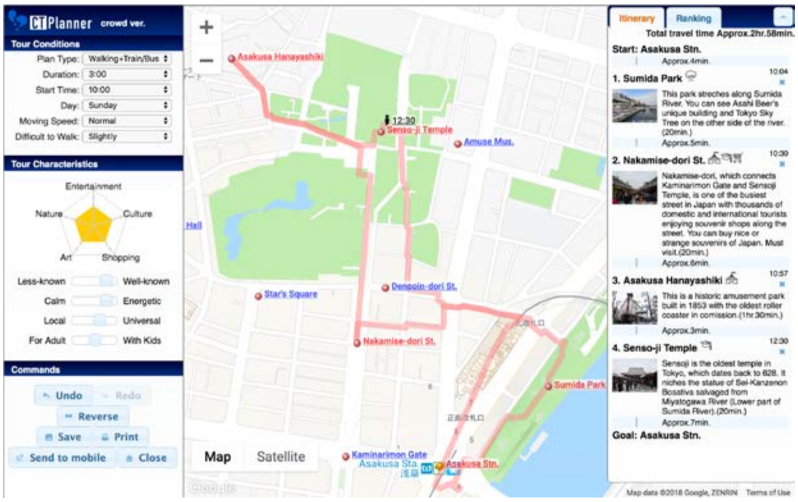
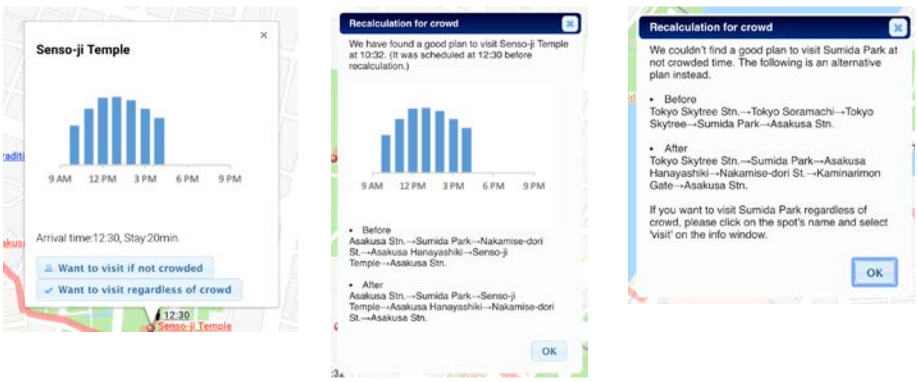


Fig. 3. Notification of crowd information in the current plan



(a) Detailed crowd information and choices displayed to users

(b) Succeed in visiting the spot in not crowded time

(c) Failed in visiting the spot in not crowded time

Fig. 4. Example results of recalculation to avoid crowds at a spot

5 Verification

To verify the effectiveness of the proposed method and the influence of the presentation of crowd information on users, the study examined data preparation and conducted a user experiment.

5.1 Availability of crowd data

This study investigated how much and what kind of crowd data can be collected via Google's 'popular times' described in Section 3.3. Analysis of crowd data for 32 destinations and 1,007 spots registered in CT-Planner showed that 48% of spots had crowd data for 31 destinations (excluding one region of the isolated island).

In addition, the shape of the obtained crowd graphs (as in Fig. 2) could be classified into 'one-peak' and 'two-peaks' types. The average ratio of the two-peaks type graphs in each destination was 27 ± 16%. Therefore, more one-peak type graphs were obtained compared with the two-peak type. The average and standard deviation of peak time in one-peak type graphs were analysed in each destination. The earliest average peak time was 13:00 and the latest was 15:20. Thus, according to users' selection, the developed system may work well to help them avoid congestion and create alternative plans by controlling for visiting time.

5.2 User experiment

This study conducted a comparative experiment between the original CT-Planner explained in Section 3.1 [18] and the proposed CT-Planner. The participants were eight tourists aged from 20 to 50 years. The target destinations were Osaka and Asakusa for the following reasons: they are popular cities that attract many tourists; and tourists can go around on a one-day tour because the tourist spots are closely located. The participants were divided into four groups to counterbalance the usage order of destination and system. In the experiment, each participant was asked to plan a six-hour tour for each destination. That is, four times of planning were carried out in total per participant.

The experiment was conducted to verify the user's perception of the crowd information as aided by the interactive planning support. The participants were told that Osaka and Asakusa are very likely to be crowded on Sunday. Operation data by each participant user on the tool were recorded for investigating the relationship between the user's selection, motivation for selection, and satisfaction of planning through a questionnaire survey and a retrospective interview. In the questionnaire, we asked users which system you wanted to use in the future. We conducted a retrospective interview on their planning process comprising the following three questions:

- The reason to change the intention to visit by presenting crowd information
- Thinking about choosing options
- Impression on a crowd graph

5.3 Experiment results

User's choices on crowded situations

Among spots of which the user confirmed the crowd information, the proportion of choosing among options for dealing with crowd requests was 90%. Among them, 58% chose 'want to visit if not crowded' and 42% chose 'want to visit regardless of crowd'. Therefore, as this study supposed, users do not always want to avoid crowds. According to the interview results, four participants tended to accept the congestion at popular spots.

Retrospective interview

We listed representative answers to three questions. Regarding the change of intention to visit by presenting crowd information, a user answered: *'I came to want to go there if not crowded'*.

When users who used the choices A and B in a certain spot were asked about the impact on their thinking process, a user answered: *'My congestion acceptance was broadened when I was aware of crowdedness in advance'*. In addition, four users answered similar contents: *'I do not care much even if a famous spot is crowded'*.

As for the fact that the crowd graph was presented, a user answered: *'Unlike subjective information such as word of mouth, objective data like this are useful'*.

Generated alternative plans and completed plans

Next, the study examined how the crowd information affected the subsequent planning by users based on operation data. The spots where the user confirmed the crowd information remained in 70% of final plans. These tourist spots are thought as being of high interest for tourists, and the proposed CT-Planner could deal with crowd information effectively. The proposed CT-Planner provided alternative plans according to users' visit time for 70% of the cases. The number of spots in the completed plans was 6.6 ± 1.2, whereas the number of spots for which users checked crowd information was 2.4 ± 1.1.

Satisfaction of users

Six of the eight participants answered in the questionnaire that they would like to use the proposed CT-Planner in the future. User satisfaction tended to be higher for the proposed CT-Planner incorporating crowd information. Seven of the eight participants indicated that crowd information makes their planning effective.

6 Discussion

6.1 Availability of crowd data

The crowd graph can be obtained for 48% of tourist spots; this proportion accounts for sightseeing spots where congestion can be a problem. Sightseeing spots whose crowd graph could not be obtained can be classified as less intensive spots. Both classifications are not invalid; they can be used for planning that considers tourist crowds. In addition, the shape of the crowd graph can be classified into having either one or two peaks. In the case of two peaks, the visit time frame can be set as in the one peak cases. Measures include suggesting the time between peaks as a vacant time. The peak of each spot and the time period with the highest tendency of being crowded can be ascertained from the average visiting time and standard deviation, leading to users' grasp of the degree of concentration of tourists. The peak for spots with a small standard deviation indicates a higher concentration of people. These findings are useful for considering the variance in the number of visitors. In the absence of big data on tourists, it is possible to gather data with the cooperation of local residents. Crowd graph can be created based on experiences; fluctuations in the number of visitors of each spot can be included, because 'crowd' is a relative number.

6.2 User experiment

From the participants' user selection and interview results, we found that 90% of users' selections reveal the option to deal with crowds at spots for which they have confirmed crowd information. That is, tourists do not always want to avoid congestion even when they click humanoid icons and confirm the crowd information. From the interview results, half of the users allowed for congestion in their planning for visiting popular spots. Therefore, it is important to consider the perception of crowd for each tourist rather than strict congestion avoidance. According to Bosque [33], positive emotions are likely to occur when tourists' expectations are high; the higher the frequency of positive emotions during the travel experience, the higher the satisfaction level. Therefore, from the viewpoint of expectation management, it is possible to increase the satisfaction of tourists during sightseeing by indicating crowd information interactively and helping them prepare for possible congestions. From the interview results, in terms of crowd information, objective data may be more reliable than subjective data such as word of mouth. Moreover, crowd information other than visit time is also important.

User has not confirmed the crowd information at random from the results of the relationship between the number of spots that clicked icon and the number of spots included in the completed plan. Therefore, the number of spots with indicated crowd information must be narrowed down. Moreover, since the proposed CT-Planner provided alternative plans for 70% of the cases when tourists wanted to visit a spot if it was not crowded, the tentatively set congestion line was appropriate to ensure a visiting time frame. In future work, more appropriate congestion lines could be set through social implementation. We will also conduct experiments when the congestion line is visualised and the user can freely adjust it. Moreover, analysing the accumulated data through social implementation [34] will lead to the understanding of the relevance of tourists' selection to crowd information and spot characteristics.

7 Conclusion

Although congestion affects tourist experiences, it has not been sufficiently discussed in the research field of recommender systems. This study developed a recommender system that indicates crowd information interactively to support sightseeing planning, based on the idea that the measures required for crowds vary depending on each tourist. To create a crowd graph from big data and reflect it in planning, the appropriate crowd level was defined per spot. Verification of the proposed system showed it can provide alternative plans in 70% of the cases when tourists want to visit a spot if it is not crowded. Furthermore, the results of the user experiment suggested the importance of focusing on the differences of each tourist in sightseeing spots rather than implementing uniform measures, such as based on the name recognition of sightseeing spots. In other words, it is important to enhance the sightseeing experiences of tourists by conducting expectation management for sightseeing using ICT.

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