Link Analysis among Sightseeing Spots based on Geo-Image Analysis –Towards Majority-based Route Recommendation in Sightseeing–

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***Abstract*—In recent years, photo sharing sites such as Flickr, Picasa and others have become popular. These sites are open to public and many photographers upload their photos to share them with family, friends and people in the world. Each photo has several types of metadata including date, time, tags, geo-locations and others, which are automatically produced by a camera or manually provided by the owner. Researchers are interested in such a large-scale image database and use it for image analysis, image annotation, scene understanding and other purposes. Our research focuses on sightseeing images. Analysis of these images shows not only famous sightseeing spots but also links between several sightseeing spots, i.e., popular sightseeing routes. We extract such information through analysis of image metadata. Furthermore, we characterize the sightseeing spots by link type. We developed application software for smartphones in which recommendation information based on the above analyses are displayed. We performed several field tests of real scenes, finding that the recommendation information is useful to travelers.**

***Keywords*–user-generated contents; big data analysis; sightseeing spot; sightseeing links; characteristic analysis.**

I. INTRODUCTION

There are many kinds of User-Generated Contents (UGCs) on the web, such as Twitter, Facebook, Picasa [1], Flickr [2], YouTube,and WiKi. UGCs provide an opportunity to share our daily activities with family, friends and/or people in the world. In recent years, many researchers have been attracted to UGCs. They wish to create new social value through analysis of the great number and types of people's activities.

Our research focused on the UGC Flickr, which has a large image database, for analyzing activities in sightseeing. Many people upload photos taken during sightseeing, on which they put text labels. Moreover, each photo has geo-location information regarding where the photo was taken. We used such "tagged images" for analysis of sightseeing activities. Among these images, our method finds sightseeing spots and link strength. Characteristics of each location are classified into four types. The analyzed information is very useful for route recommendation, navigation systems and others. We developed an application available to Android smartphones, and used it for field testing in the city of Nagasaki, Japan. In this paper, we present the potential of the large image database for application to the sightseeing recommendation system.

II. RELATED WORK

There are several research works regarding recommendation systems for sightseeing. Zheng, Zhang, Xie and Ma [3] estimated sightseeing routes from GPS logs. In addition, they determined sightseeing spots of interest to many people. The advantage of their approach is exact route estimation using GPS. However, existing GPS datasets are not as large as image datasets on the web, so there is difficulty in performing large-scale analysis.

Cao et al. [4] proposed a recommendation system for sightseeing spots at global scale. Their system receives a keyword query from a user. Then, some images related to the keyword are selected. Finally, the system recommends certain images as candidate sightseeing spots. Arase, Xie, Hara and Nishio [5] analyzed sightseeing behavior from pictures taken by tourists. These approaches focused on a relatively large area.

In contrast, our approach focuses on city or town areas to ascertain the behavior of tourists more precisely. We use photographer information, photo time and location information from the metadata. We also analyze characteristics of each sightseeing spot and relative strength (see explanation below) between spots, and assist route choices. We do not determine a sightseeing route solely to recommend it. Instead, we recommend consecutive sightseeing spots from the place where a tourist stays, by analyzing spots with strong connection to the location of that stay.

III. OVERVIEW OF THE PROPOSED IDEA

Fig. 1 shows an overview of the processing flow. First, a large number of geo-tagged images are collected from Flickr (Step 1). The images are divided into rough groups in terms of city or town levels. Second, geo-clusters are made from the images in each group (Step 2). We regard each geo-cluster as a sightseeing spot. Third, the number of people who moved from one spot to another is counted within all combinations of spots (Step 3). This number is used for calculating the strength of a link between two sightseeing spots. Furthermore, the sightseeing route of an individual is assessed by referring to the owner's ID and timestamp of each geo-tagged image. Finally, characteristics of each spot are investigated according to the strength of inflow and outflow links (Step 4).

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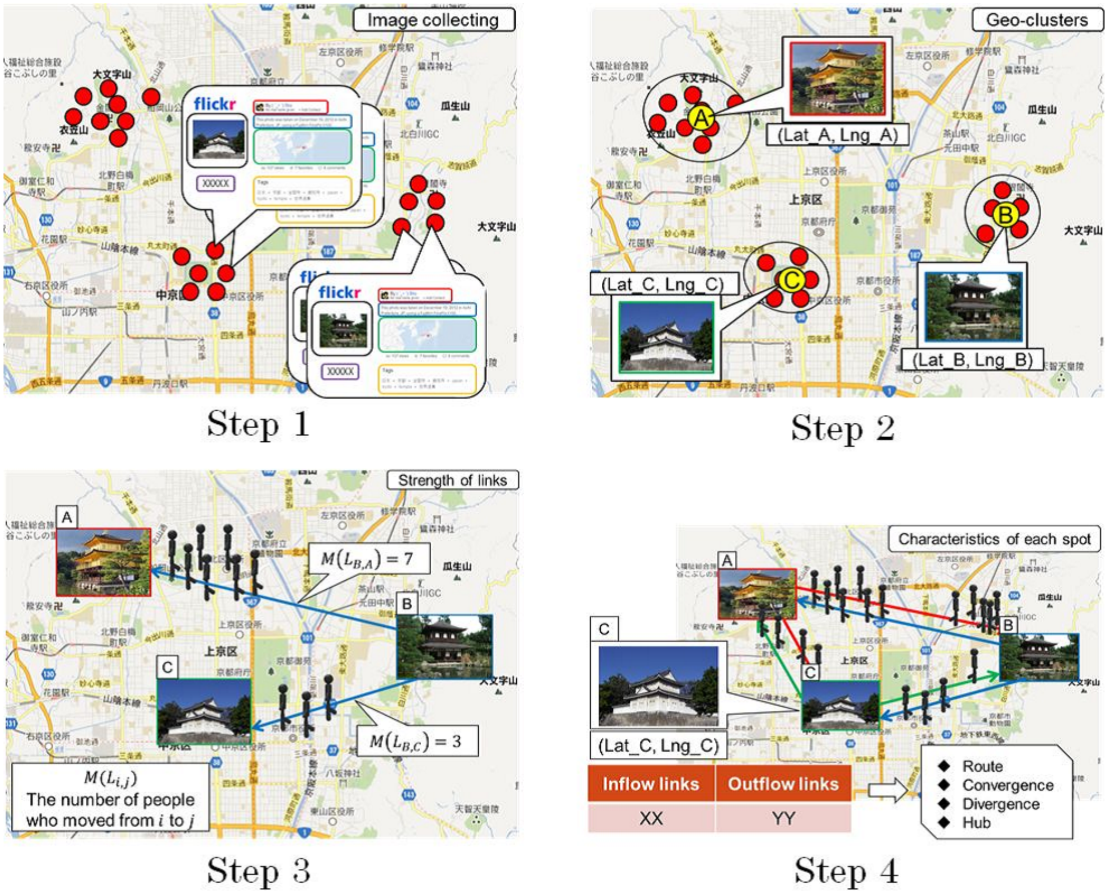

Figure 1: Flow of the proposed method

IV. Link and Characteristic Analysis

A. Dataset Property

Flickr provides not only a large image dataset but also attributes called “Exif”. For example, representative attributes are owner ID, geolocation (latitude and longitude), timestamp, and others. These items were the most important information in our research. Therefore, we collected images including this information.

B. Discovery of Sightseeing Spots

Sightseeing spots are discovered by clustering the collected images. The geolocation of each image is investigated to construct geo-clusters. We cluster the geolocation in using the nearest neighbor method. This is because the number of sightseeing spots is unknown. We continue clustering until the closest distance is greater than a threshold. Although image composition should be investigated to generate more accurate clusters, based on recent research it is difficult to identify an object among images. This is why we used geolocation only for generating geo-clusters. The latter are regarded as sightseeing spots.

C. Link Strength Estimation

We represent a directed link between two sightseeing spots by $L_{i,j}$, where i and j indicate individual sightseeing spots. $L_{i,j}$ and $L_{j,i}$ are distinguished to consider the direction from i to j and j to i, respectively. $L_{i,j}$ is determined by the owner ID and timestamp of the image. For instance, if two images are taken by the same owner at sightseeing spots i and j and the timestamp of the image at i is followed by the one at j, we establish a directed link between $L_{i,j}$.

The strength of the directed link $L_{i,j}$ is defined by $M(L_{i,j})$ and is calculated by counting the number of people who moved from i to j. A larger value of $M(L_{i,j})$ indicates strong connection between the two sightseeing spots, i.e., many people tend to visit these spots consecutively.

D. Characteristic Analysis

We analyze characteristics of each sightseeing spot based on the directed links explained above. First, the number of directed links is summed. With consideration of link direction, we sum two types of links. One is inflow, which denotes all links connected from any spot to spot j. The other is outflow, or links flowing out from spot j. The calculation is done as follows.

$$S_{in}(j) = \sum_{i \in \mathcal{I}} M(L_{i,j}) \tag{1}$$

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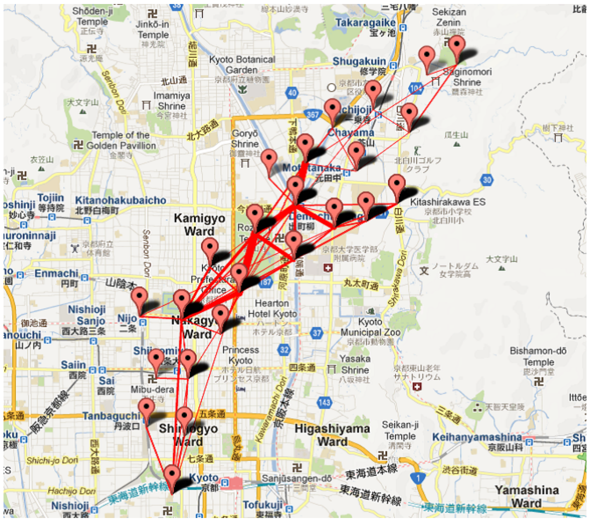

Figure 2: Estimated spots and links in Kyoto

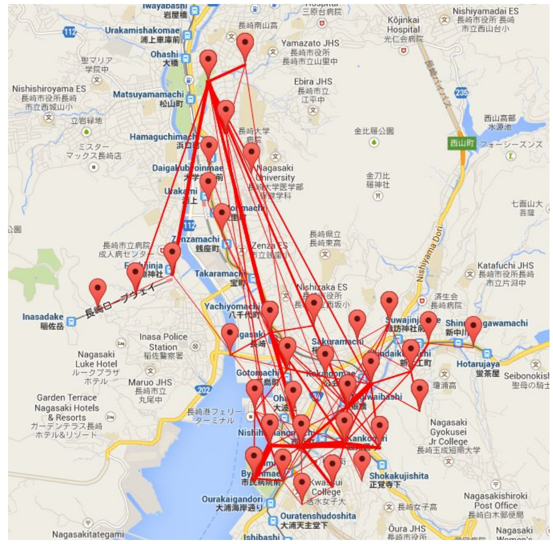

Figure 3: Estimated spots and links in Nagasaki

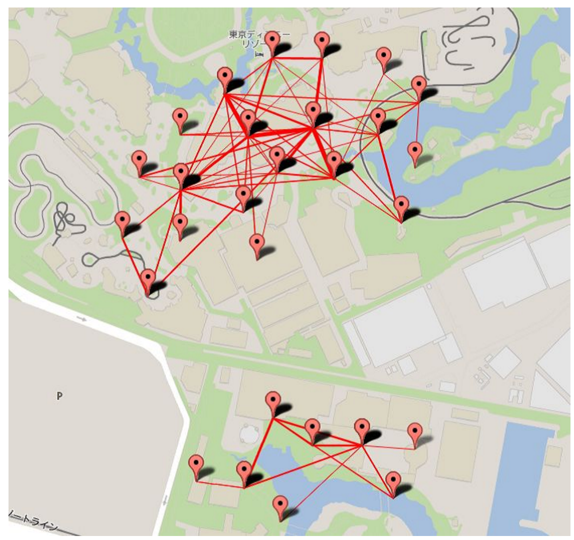

Figure 4: Estimated spots and links in amusement park

$$S_{out}(j) = \sum_{i \in \mathcal{O}} M(L_{i,j}) \quad (2)$$

, where $S_{in}(j)$ and $S_{out}(j)$ are inflow and outflow scores of spot j, respectively.$\mathcal{I}$ is a set of inflow links from any spot i to the focused j, and $\mathcal{O}$ is a set of outflow links from spot j to any other spot.

Next, we classify a characteristic of each spot into four types, based on $S_{in}(j)$ and $S_{out}(j)$ ”

Route Type
: A spot whose $S_{out}(j)/S_{in}(j) \approx 1$ and S_{in} is a small value, with few inflows and few outflows.

Convergence Type
: A spot whose $S_{out}(j)/S_{in}(j) \ll 1$, with many inflows and few outflows.

Divergence Type
: A spot whose $S_{out}(j)/S_{in}(j) \gg 1$, with few inflows and many outflows.

Hub Type
: A spot whose $S_{out}(j)/S_{in}(j) \approx 1$ and S_{in} is a large value, with many inflows and many outflows.

V. Experiment

A. Outline

We investigated the effectiveness of the proposed method in three situations. Two focused on sightseeing in the cities of Kyoto and Nagasaki in Japan, The other one focused on people’s activities in an amusement park (Tokyo Disney Resort [6]). We collected 16,210 images of Kyoto taken by 934 owners, 10,144 images of Nagasaki by 209 owners, and 16,250 images of the amusement park by 240 owners.

B. Estimated Spots and Links

There were 33 estimated spots and 82 links in Kyoto, whose strengths $M(L_{i,j}) \geq 2$ are shown in Fig. 2. Thick lines denote stronger links. Thirty-three sightseeing spots and 111 links were discovered in Nagasaki, as shown in Fig. 3. Twenty-eight spots and 91 links were discovered in the amusement park, as shown in Fig. 4. We found that most estimated spots were at famous sightseeing places. We discuss details of the results in the following subsection.

C. Estimated Type of Sightseeing Spots

We analyzed characteristics of estimated sightseeing spots in the two cities and amusement park. Given the page limitation, we show only results for Kyoto. Representative results of each type are shown in Table I and Fig. 5. These results are discussed in the next subsection.

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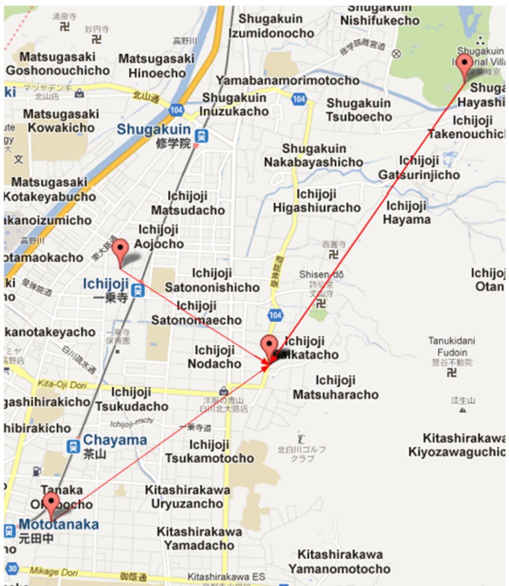
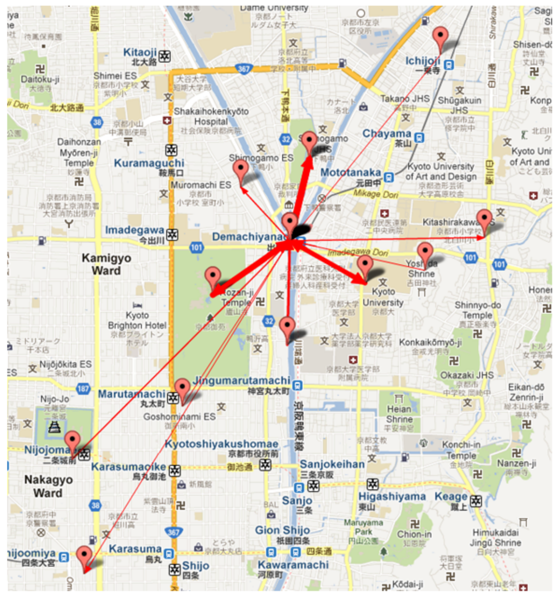
Route type: Nishi Hongan-ji Temple

Divergence type: Yoshida Shrine



Convergence type: Konpuku-ji Temple



Hub type: Demachi Bridge

Figure 5: Estimated type of sightseeing spots

TABLE I: Characteristics of sightseeing spots in Kyoto

Type	In	Out	O/I	Sightseeing spot
Route	1	1	1	Nishi Hongan-ji
Convergence	3	0	0	Kinpuku-ji
Divergence	2	4	2	Yoshida Shrine
Hub	8	7	0.875	Demachi Bridge

D. Discussion

1) Discussion of experimental results: We now address one of the results shown in Fig. 6. We put famous sightseeing spots on a map and found that the estimated spots nearly matched actual locations. A strong link was assessed between Nijo Castle and Kyoto Gosho. These spots are close, and some magazines introduce them as recommended spots in their area. This is why many people moved between the two spots. A strong link was also established between Demachi Bridge and Shimogamo Shrine. In the festival season, many people walk around these spots in Kyoto. The spot of Demachi Bridge was determined as a hub type, as shown in Fig. 4. There are bus stops and a subway station around this bridge, so this location is often used for connection between several sightseeing spots. The estimated results reflect such actual situations. Also, we address another one of the results shown in Fig. 7. A strong link was assessed between Dejima and Shian Bridge. It is possible to access by one tram. Thus, these spots likely to be visited together. The estimated results reflect such actual situations.

On the other hand, some estimated spots did not correspond to any famous places. Some are failure cases caused by images in the dataset with no relation to sightseeing. If we introduce

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image processing for filtering out such negative samples, this kind of problem will be reduced. Other cases are “secret” spots found by tourists. Such information is not listed in sightseeing magazines. The proposed method therefore has great potential to mine such latent spots.

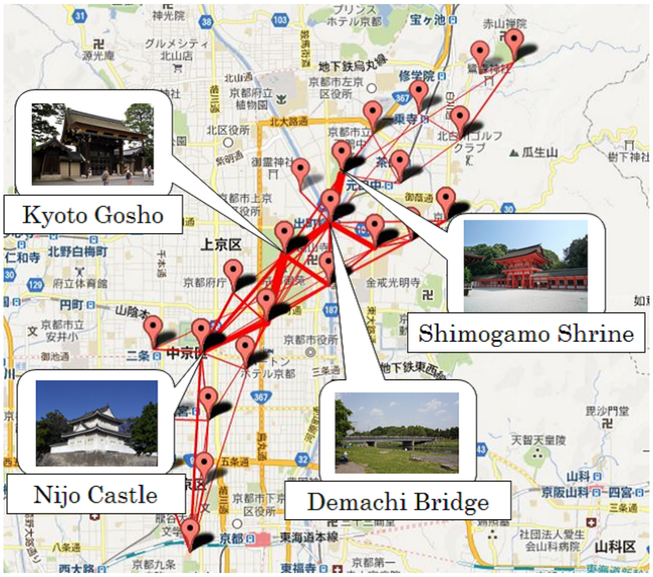

Figure 6: Strong links between sightseeing spots in Kyoto

Figure 7: Strong links between sightseeing spots in Nagasaki

2) Comparison with Other Methods: Here, we compare the related methods with ours. In most research recommending sightseeing information to tourists, strength of relationship between sightseeing spots is not taken into account. In our method, we use this strength, thereby providing more detailed information for tourists.

Okuyama and Yanai [7] recommended sightseeing routes to tourists using images with metadata. In their research, the presence of relationships among sightseeing spots was considered, but not their strength. With only presence, it is impossible to prioritize selected sightseeing spots. When we consider the selection of one spot from multiple candidates, our method is superior because it is possible to rank by a clear element of strength of relationship.

Zheng, Zhang, Xie and Ma [3] recommended sightseeing routes using strength of relationship among sightseeing spots in addition our method. However, their method differs from ours because they uniquely determined sightseeing routes. Furthermore, this method has a problem in that it may propose sightseeing spots in which tourists are not interested for part of the route. An absence of choice causes this problem. In contrast, we recommend multiple sequential sightseeing spots from the location where a tourist stays, by analyzing spots with strong connection to the stay location. Thus, tourists can select among candidates in which they are interested. As mentioned above, existing GPS datasets are not as common as image datasets on the web, making large-scale analysis difficult. Therefore, when we consider the variety of route selection and amount of data, our method is superior to that of Zheng, Zhang, Xie and Ma.

Lu [8] also recommended sightseeing routes using strength of relationship among sightseeing spots. They suggest a recommend route based on staying time of each tourist. This idea considers each tourist’s characteristics in terms of staying time, but the recommended route does not always meet the demand of the tourist since it is not easy to make a plan of staying time in advance. On the other hand, our proposed approach can suggest several candidates of recommended routes for decision making.

E. Field Test

We developed a prototype route recommendation application that works on smartphones. The application is now available on the Android 4.X OS with a GPS sensor. A smartphone acquires location information (latitude and longitude) via the GPS, and then the location is sent to the server. The server retrieves several routes close to the current user location. Finally, the smartphone receives the route information and shows it as recommended routes on the display (Fig. 8). The application shows several arrows to suggest the next sightseeing spots from the current location. Thicker arrows indicate strong links (i.e., a strongly recommended place based on the analysis).

We conducted a field test in Nagasaki. About fourty people joined the experiment. The application was installed on their smartphones, and the people enjoyed sightseeing in Nagasaki. Note that the displayed arrows are just recommendations, and a user need not follow them.

We conducted questionnaires before and after the experiment. In the pre-questionnaire, we asked the subjects two questions:

Q1 Have you ever enjoyed sightseeing in Nagasaki?
Q2 Have you already planned where to go during this sightseeing?

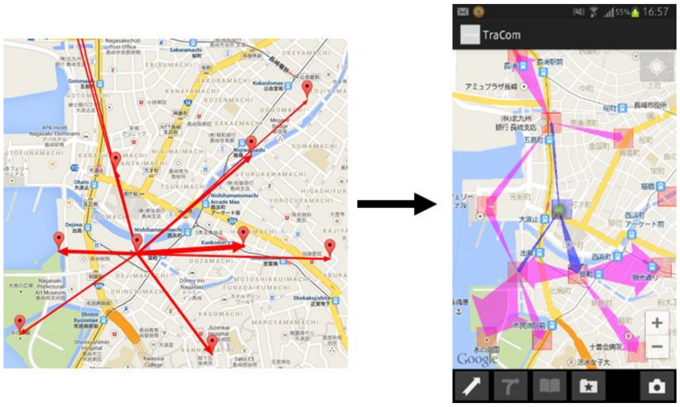

Figure 8: Application screen

TABLE II: Results of a questionnaire

Group	Q1	Q2	Ratio
Type 1	Yes	Yes	30%
Type 2	Yes	No	54%
Type 3	No	Yes	13%
Type 4	No	No	13%

We made four groups according to their answers, as shown in Table II. The rightmost column lists the ratios of people belonging to each group.

According to the post-questionnaire, we discovered that people in Type 1 and Type 3 tended to follow the recommendation more than those in Type 3 and Type 4. Please note that a displayed arrow navigates a user to a major sightseeing spot because it came from majority analysis. This is why people with no advance planning were affected by the arrows. Nonetheless, we think that sightseeing spots determined by a minority will be also useful information for people of Type 1 and Type 2, since they would like to visit “mysterious” spots that they have never seen. We are certain that the proposed method can be easily extended to find such minority-determined spots.

VI. Conclusion

In this paper, we proposed a new method to determine sightseeing spots and link their strengths. A large number of images collected from Flickr were analyzed for establishing the spots and link strengths. In addition, characteristics of the sightseeing were also assessed. This information was acquired from analyses of metadata that were attached to images shared in a large image database. We are certain that these types of information are applicable to route recommendations for sightseeing. We developed a prototype route recommendation application on smartphones and conducted onsite experiments in the city of Nagasaki. Through questionnaires and interviews of test subjects, we found that route recommendations displayed on the smartphone are useful, especially for people who did not decide sightseeing routes in advance.

In future work, we will tackle the following issues.

- We will introduce image and label processing to filter out non-useful images. The current system used all images from around the sightseeing areas. Some of these were unrelated to sightseeing. Such images can be filtered out if they are categorized using image contents and labels. Furthermore, image analyses will provide representative photos that are frequently taken around sightseeing spots. Such information will be helpful to determine subsequent visitation spots.
- We will improve the application design. The current application shows several arrows from the current location to major sightseeing spots. Through the questionnaire in the field test, we found that minority-determined spots are also useful for visitors. Therefore, it is important to change recommendation information in terms of visitor characteristics.

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