Monitoring Tourists' Behavior Using a Mobile Phone Equipped with a GPS

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Abstract - **This study aims to develop systems for providing tourist support information based on self location. A social experiment was carried out in order to verify the accuracy and reliability of location measurement by a mobile phone equipped with a GPS and to establish methods of evaluating tourists' behavior. The experiment revealed that the use of the mobile phone equipped with a GPS for behavioral measurement was accurate and practical. Correspondence analysis and basket analysis of tourists' behavior were shown to be helpful for identifying tourist support information.**

INTRODUCTION

The promotion of tourism plays an important role in revitalizing local economies. A White Paper on Tourism [1] reported that the production ripple effects of tourism in 2001 reached 48.8 trillions yen. Not only the Ministry of Land, Infrastructure and Transport of Japan, but also most local governments cite the promotion of tourism as an important policy.

It is important to increase convenience for tourists from the perspective of hospitality, and the provision of tourist support information is one way to achieve this. Tourist support information can be classified into six categories: (1) road transportation information, (2) public transportation information, (3) town information, (4) event information, (5) pedestrian support information, and (6) emergency information.

This study therefore aims to develop tourist support information provision systems using a mobile phone equipped with a GPS, because detailed information based on self location may improve convenience for tourists. This paper reports the results of a social experiment conducted in Ise City of Mie Prefecture to verify the reliability and accuracy of location measurement and proposes methods of evaluating tourists' behavior, leading to the selection of tourist support information to be provided during sightseeing.

METHODS

Participants

Twelve people (six males and six females) aged 30-39 years living in Mie or neighboring prefectures participated in the experiment. The average ages for male and females were 36 (SD = 3.3) and 34 (SD = 2.6) years old, respectively. All of the participants had experience of visiting Ise City, and of using a mobile phone and email.

Experimental Procedures

The experimenter instructed the participants on how the experiment would be conducted. They were asked to visit the sights of Ise City during four to five hours with a mobile phone. The experimenter sent them a sightseeing pamphlet for Ise, and asked them to plan tour routes in advance. They were able to do whatever they liked, such as sightseeing and shopping, provided those actions were performed during sightseeing. When they started an action, they were requested to send the information using the mobile phone. Nine actions were prepared, and the participants selected one of them displayed on the mobile phone. The actions were (1) sightseeing (outdoors), (2) sightseeing (indoors), (3) travel on foot, (4) travel by vehicle (5) travel by rail, (6) waiting, (7) lunch, (8) break, and (9) others.

Because the mobile phone was equipped with a GPS, the location information of starting the action was automatically transmitted when the action information was transmitted. The information of action and location was automatically transmitted at intervals of one minute if the same action was continued.

Development of Systems for Presenting Tourists' Behavior

We developed a system of presenting tourists' behavior loci using GIS to visualize and understand the sightseeing routes of each tourist and overall tendencies. Figure 1 illustrates an example of behavior loci. Different colors indicate different actions.

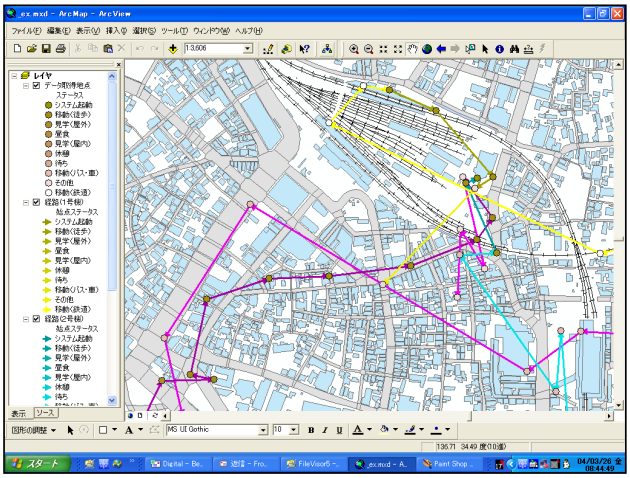

Figure 1. Presentation of behavior loci.

DATA ANALYSIS

Accuracy and Reliability of Location Measurement

The collected data included the information on date, time, latitude, longitude, accuracy, and action. Among these items of information, the accuracy depended on the location measurement by the GPS, and was graded into three categories: A, B, and C. Accuracy A is the most accurate, in which four satellites are employed for measurement. Use of fewer than three satellites and one base station was classed as Accuracy B, and use of only base stations was classed as Accuracy C.

Cross tabulation was performed between accuracy and the locations of measurement such as indoors and outdoors to evaluate the effects of locations on accuracy.

To evaluate measurement variances for each grade of accuracy, a mobile phone was fixed in one place and the locations of an identical place were measured ten times. The distances between each location coordinate and the average over ten location coordinates were calculated. The average of the distances and standard deviation were computed.

Analysis of Tourists' Behavior

Correspondence analysis was used to classify tourists and the places they visited. Additionally, association rules were extracted using basket analysis. An association rule means that a person who visits A (rule head) is likely to visit B (rule body) as well. Basket analysis is a technique to find useful association rules. There are four approaches to discovering useful association rules [2]:

(1) The higher the probability of the rule head, the better.
(2) The higher the conditional probability, the better.
(3) The higher the joint probability, the better.
(4) The lower the probability of the rule body when compared to the conditional probability, the better.

RESULTS

Accuracy and Reliability of Location Measurement

Figure 2 shows the result of location measurement with Accuracy A. The average over the distances was 11.5 m (SD = 6.1 m). The averages of the discrepancies for Accuracy B and Accuracy C were 118 m (SD = 51.5 m) and 157 m (SD = 25.6 m), respectively.

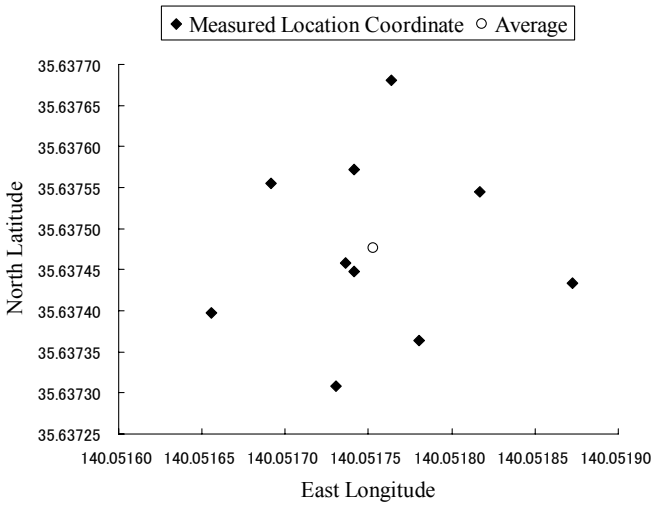

Figure 2. Measured location coordinates and average for Accuracy A.

Table 1 illustrates the cross table of the accuracy grade and location. This table shows that more than 90% of the location information acquired outdoors, inside a vehicle, or inside a ship was measured with Accuracy A. On the other hand, in the case of indoors, 57% of the data was measured with Accuracy A, and 43% with Accuracy B or C. These results indicate that the surrounding environment such as whether indoors or outdoors affects the measurement accuracy. Additionally, the experiment revealed that the battery of the mobile phone lasted for more than five hours.

From these results, a mobile phone equipped with a GPS can be used to measure and monitor tourist behavior if they are measured with Accuracy A, because it is accurate and reliable.

Table 1: Cross Table of Accuracy and Location

			Location			
			Outdoors	Inside vehicle	Inside ship	Indoors
Accuracy	A	Frequency	997	290	34	326
		Percentage of location	94.1	89.0	91.9	57.0
	B	Frequency	53	34	1	157
		Percentage of location	5.0	10.4	2.7	27.4
	C	Frequency	10	2	2	89
		Percentage of location	0.9	0.6	5.4	15.6
Sum		Frequency	1060	326	37	572
		Percentage of location	100	100	100	100

Analysis of Tourists' Behavior

Figure 3 indicates percentages for the frequency of places visited. The twelve participants visited 23 places in total. Among them, nine people visited Ise-Inner Shrine, followed by Okage Yokocho and Oharaimachi. Six out of the 23 places were visited by more than two participants.

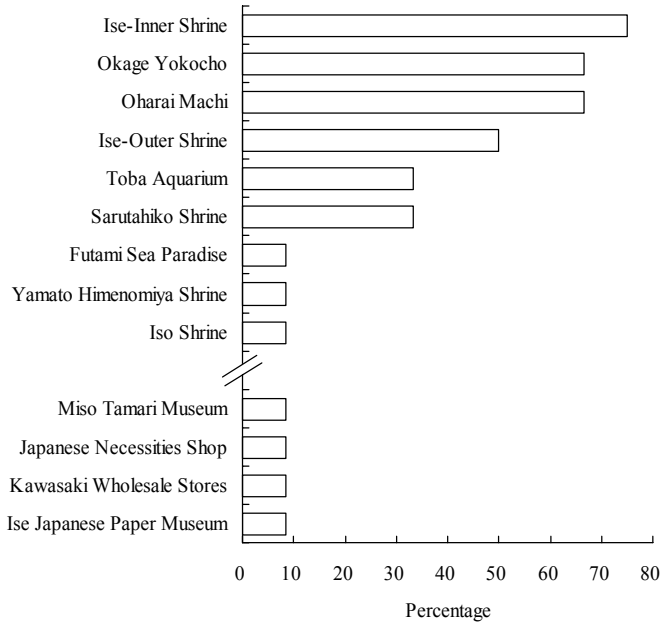

Figure 3. Percentage for places visited.

Figure 4 shows the ratio of the time taken for the nine actions during sightseeing for each subject. The average time taken for overall sightseeing was five hours. This figure shows that overall travel time and waiting time accounted for 45% and 8% of the total time, respectively. The provision of public transportation information may be useful to reduce travel related time, because a major purpose of tourism is sightseeing.

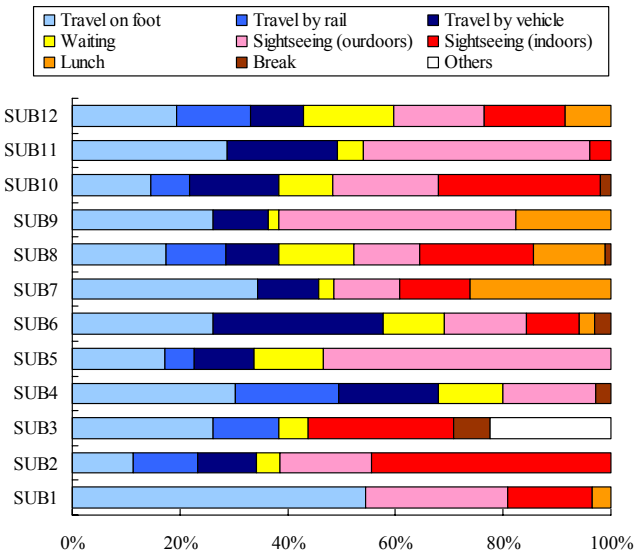

Figure 4. Ratio of time taken for actions during sightseeing.

Figures 5 and 6 are scatter diagrams of tourists and places visited for axis I and axis II, respectively. Figure 5 shows that Subject 7 has a characteristic tendency regarding axis I, because he or she is positioned far from the other. Similarly, Subject 3 has a specific tendency regarding axis II. The fact that most of the subjects concentrate around the center implies that they visited similar places.

Likewise, Figure 6 indicates that Kawasaki Nanakusa Shrine, Bon Vivant Restaurant, Matsuo Kannon, and Jingu Art Museum have a characteristic tendency regarding axis I. Ise Bay is specific regarding axis II.

The correspondence between Figure 5 and Figure 6 shows that Subject 7 visited Kawasaki Nanakusa Shrine and Subject 3 made an excursion around Ise Bay. These findings reveal that correspondence analysis is a powerful tool for classifying tourists and places visited, and discovering the tendencies of sightseeing.

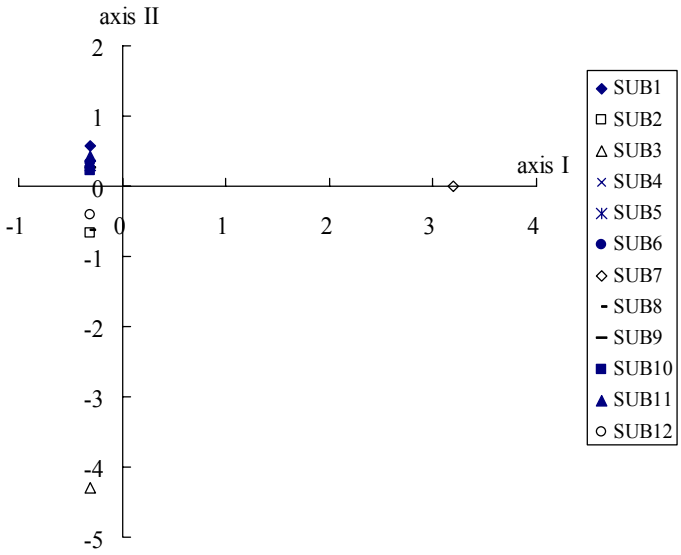

Figure 5. Scatter diagram for subjects.

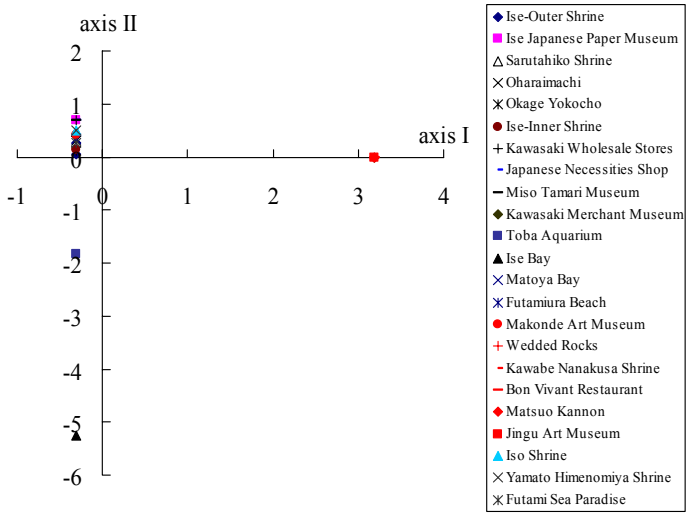

Figure 6. Scatter diagram for places visited.

Table 2 indicates the association rules derived from basket analysis. This table reveals the following:

(1) Females are more likely to visit Toba Aquarium than males because the conditional probability for females is higher.
(2) Males who go to see Ise-Outer Shrine tend to visit Ise-Inner Shrine because the conditional probability is higher.
(3) Similarly, males who visit Ise-Outer Shrine are more likely to visit Sarutahiko Shrine.

Table 2: Association Rules Derived by Basket Analysis

A (Head Rule)	→	B (Head Body)	Probability of Head Rule, p(A)	Conditional Probability, p(B/A)	Probability of Body Rule, p(B)
Male	→	Toba Aquarium	0.5	0	0.33
Female	→	Toba Aquarium	0.5	0.67	0.33
Ise-Outer Shrine	→	Ise-Inner Shrine	0.5	0.83	0.75
Female × Ise-Outer Shrine	→	Ise-Inner Shrine	0.5	0.67	0.75
Male × Ise-Outer Shrine	→	Ise-Inner Shrine	0.5	1	0.75
Ise-Outer Shrine	→	Sarutahiko Shrine	0.5	0.5	0.33
Female × Ise-Outer Shrine	→	Sarutahiko Shrine	0.5	0.33	0.33
Male × Ise-Outer Shrine	→	Sarutahiko Shrine	0.5	0.67	0.33

These findings suggest methods of providing tourist support information. Information on Toba Aquarium should be provided to females rather than males, because the probability of females visiting Toba Aquarium is higher than that of males.

Information of Ise-Inner Shrine should be given to males who visit Ise-Outer Shrine, because the probability that males who call on Ise-Outer Shrine also visit Ise-Inner Shrine is higher. Similarly, information on Sarutahiko Shrine should be provided to males who visit Ise-Outer Shrine.

These findings imply that basket analysis can be used to analyze tourists' behavior and to derive methods of providing tourist support information based on behavior.

DISCUSSION

The average distance from the mean for Accuracy A was 11.6 m. The purpose of using a mobile phone equipped with a GPS is to identify the tour route and places visited. The measurement of the width of 15 city blocks around Ise-shi Station and 13 city blocks in Oharaimachi showed that the average width of city blocks was 31.8 and 34.5 m, respectively. Since the measurement error of the GPS is 11.6 m, which is less than one-half of the city blocks, the routes along which tourists passed can be presumed, even though a discrepancy occurs. Therefore, location can be measured sufficiently accurately using a mobile phone equipped with a GPS to identify travel routes and places visited, if it is measured with Accuracy A.

The cross table of the location and accuracy showed that 43% of data gathered indoors was measured with Accuracy B or C. However, with behavior loci, indoors does not always need to be identified, but only the place visited should be identified. It may therefore be effective to measure location outside a building before going inside to identify the place visited. Thus, almost all tourist behavior can be measured with Accuracy A.

Nine out of twelve people visited Ise-Inner Shrine, followed by Okage Yokocho and Oharaimachi. According to the result of a questionnaire survey conducted in 2001, among sightseeing spots in Ise, Ise-Inner Shrine was ranked first by the number of visitors, followed by Okage Yokocho & Oharaimachi, and Ise-Outer Shrine. Therefore, the tendencies of the places that the participants visited in the experiment were close to the general trend.

Correspondence analysis can classify subjects and places visited, and match them to the places. Specifically, this technique can identify the tendency of who visits where. Such findings are helpful for providing tourist support information in an effective way.

Useful association rules were derived by basket analysis. Although correspondence analysis does not consider the frequency of visitors, this is possible with basket analysis. Specifically, this technique can narrow down conditions by deriving association rules. Such conditions enable the provision of information that fits individual characteristics.

Although twelve people participated in the experiment of this study, thousands of samples are required to model the behavior of tourists visiting Ise. Techniques used in the field of data mining are powerful methodologies to analyze and derive useful information from enormous volumes of data. This study revealed that techniques such as basket analysis are effective for deriving information from behavior data.

As future tasks, samples should be increased to generalize the tendencies of tourists' behavior and rules. Additionally, the contents of tourist support information and its provision methods should be considered, and the effects should be verified through social experiments.

ACKNOWLEDGEMENTS

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REFERENCES

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[2] Toyoda, H. Statistics for digging up a gold mine, Kodansha, Tokyo, 2001.