A Study of Designing Service Model for Sightseeing Using BLE Beacons -To Provide Tourism Information of Traditional Cultural Sites -

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***Abstract*—We have developed a new smartphone application for helping tourists using Bluetooth Low Energy (BLE) beacons. The application not only provides a guide for a specific location but also explains the traditional customs and history of the area. There are several smartphone applications for sightseeing and are usually designed to provide extensive information through photos, detailed explanation and users' comments. Such applications are convenient. However, a large amount of information is not always appealing to tourists. If tourists feel that they have to know many things about an area, is the travel attractive anymore? The promise of the unexpected is one of the things that make traveling attractive. Our trials in Nikko, one of the world heritage sites in Japan, demonstrate the effectiveness of the BLE beacon for sightseeing, especially for foreign visitors and young Japanese people, who walk around the area on foot. The application displays information near each beacon. Beacons on the route to the main shrine provide information regarding the local tradition and history of that area. However, the exact location of the beacons is unknown to the tourists before they visit the area. It might be a surprise like an Easter eggs for tourists. Shop owners install beacons in their shops and provide information regarding their products and menus. The people living the area help the tourists engage in local cultural activities, enhancing the tourists' experience of a traditional cultural city. In addition, we have created a quiz function focused on specific landscapes. This application is aimed at becoming a gateway to understanding traditional culture. Through trials, it was proved that our service model using smartphone and BLE beacons were very useful to support sightseeing.**

Keywords–Location-Based Service; BLE Beacon; Local information; Smartphone Application; World Heritage; Zeigarnik effect.

I. INTRODUCTION

The main purpose of this study is to develop a system to help the tourists engage in local cultural activities, enhancing the tourists' experience of a traditional cultural city. We introduce our remarkable points of our service model for tourist information and technology.

A. Services using Information and Communication Technology

Information and communication technology (ICT) is widely used for travel and tourism and has now made considerable information available. Tourists get information about maps, shops, accommodations, museums, events etc. However, the plethora of information available on the Web and SNS is not always appealing to tourists. We have to consider what information is appealing to tourists, when they should receive it and who the target users of this information should be. Before using big data in cloud by GPS signals for tourists, we should re-inspect and analyze the information contents.

We have been studying a service model for tourist using Bluetooth Low Energy (BLE) beacon [1]. In this paper, we investigated the information needs of tourists in Nikko and describe the result of experiments of provision of information using a BLE beacon system in detail.

This study was selected as one of the research themes of SCOPE [2] and was funded by the Ministry of Internal Affairs and Communications of Japan [3].

B. Psychology of Tourists

Many previous studies have investigated environmental psychology and tourism. Pearce and Stringer [4] studied the issue from the viewpoint of physiology, cognition and individual variation. It has been shown that among the factors that drive people to travel to new places, the expectation of experiencing the extraordinary plays a leading role [5]. The term 'extraordinary' here means experiences clearly different from the usual lifestyle. Thus, busy workers may crave relaxation, while bored young people may crave excitement. Therefore, separately identifying specialized target audiences and providing them with the unique information that matches their expectations is necessary.

C. Cultural Differences

Tourism involves encounters with people and places. Each place has its own characteristic culture, and these differences between cultures make travel interesting and exciting. However, some tourists do not recognize the cultural significance of traditional sites.

For example, Japan has ancient temples, many of which are located far from train stations. While this may at first appear to make visits inconvenient, traveling the route to the temple has traditionally been a central feature of the visit. There are often a series of wells en route to the main temple, at which visitors to the shrine purify themselves by washing their hands and their hearts, as well as smaller temples surrounding the main one. Tourists who are unaware of this tradition

may not sense the full experience. Information on this is, however, difficult to find on the Web, and if it exists, it is often buried among the numerous photographs and comments left by visitors unfamiliar with the location.

The rest of this paper is structured as follows. Section 2 discusses related works. Section 3 sets out our proposal based on user research in Nikko. In Section 4, we propose a service proposal for young tourists and foreigners, and provide outline of system design. Section 5 provides the result of experiments and display the effect and usefulness of our service model and smartphone application including quizzes to give satisfaction to visitors of Nikko. At last, in section 6, we summarize this research and discuss future studies.

II. Related Works

A. Our Previous Work

Students go on school trips in Japan [6]. While such outdoor activities are valuable, students cannot fully grasp the artistic or cultural value and meaning of the objects or scenery by simply viewing them [7]. To address this problem, we developed a new learning model for outdoor study [8] [9].

Human beings do not always recognize what they see. For example, in the game of photo hunt, we may not be able to tell the difference between two similar photographs. However, once a particular object is noticed, our attention is focused on it. We exploited this concept by developing a quiz to be used as a trigger to draw attention to a particular object in the scenery that the students were viewing. The quizzes encouraged positive responses. We argue that such methods will be beneficial for other tourist groups as well.

B. Related Works

1) Application for sight seeing: Many sightseeing applications for smartphones already exist in Japan [10], which allow tourists to access information about restaurants, souvenir shops and local weather, as well as to download maps. Counting only local applications, 666 such applications were identified in a 2015 study. Although 96% of these were free, 91% were downloaded only 10,000 or fewer times [11]. The EU's TAG CLOUD project (Technologies lead to Adaptability and lifelong enGagement with culture throughout the CLOUD) used smartphone technology to provide information about traditional cultural sites [12] and to investigate ways of enabling cultural engagement using cloud-based technologies. While the TAG CLOUD uses a cloud-based service, our application was designed to work without requiring access to the cloud, since Internet connections may be limited in rural areas.

2) Beacon system: There are several types of indoor location services offered through Wi-Fi APs. However, using them is difficult since the location information using a Wi-Fi AP is not accurate enough. One reason for this is the low number of APs. Usually, there are not enough APs in a space such as a shopping mall.

Recently, iBeacon [13] has become popular for location-based services. The iBeacon function is provided in an iOS framework and is suitable for location-based services. From a technical viewpoint, iBeacon uses BLE that is a very low-power device working on batteries. On the contrary, Wi-Fi APs usually require AC power. Furthermore, iBeacon is cheaper than Wi-Fi APs. Therefore, installing BLE beacon in a target area is very simple.

Moreover, there are several iPhone users in Japan. 50.2% of the smartphone users in Japan have bought iPhones (January 2016) [14]. This is another reason that iBeacon is popular in the Japanese market.

BLE beacons are mainly used for indoor location-based services to indicate locations and display information. For example, they are set in shopping malls or museums. When smartphones receive signals from a beacon, product information or pictures are displayed on the screen. In addition, distributing coupons using beacons in a shop is possible. BLE Beacons are also used for control systems helping in maintaining bus records etc.

Therefore, there are many related papers about the indoor use of the BLE beacon [15][16][17][18]. For example, there is a service for migrating signage displays and the movement of its users. This system tracks specific movements of users and provides Web contents to them. To track a user, this system estimates the position of the user based on the Bluetooth signal strength [19].

As a novel approach, we have been using BLE beacons outdoor [1] [20]. We can transmit local information using beacons or push technology, which makes it is useful for tourists and shop owners to send local or seasonal information. The beacon system is useful for tourists from the viewpoint of power supply as well.

III. Service Proposal

We administered questionnaires to the visitors to Nikko [21], in order to know the focus points for our new system, on September 2014. A total of 606 questionnaires (534 in Japanese and 72 in English) were completed. Table I shows the results of the rotated matrix.

TABLE I. Rotated Matrix.

	Component		
	1	*2*	*3*
Nature/Landscape	.008	.810	.189
History/Culture	.017	.853	.053
Street	.478	.680	.049
Traditional performing arts	.473	.676	.122
Food	.644	.269	.157
Activity	.716	.173	.226
Shopping	.835	.154	.093
Night spot	.760	-.005	.209
Personal exchange	.647	.053	.294
Easy booking	.151	.037	.868
Quality & price of hotels	.307	.039	.771
Transportation	.116	.147	.639
Prices	.279	.346	.477

Extration Method:Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization
a. Rotation converged in 5 itertion

Cluster analysis was used to confirm this pattern. Respondents were asked to evaluate sightseeing activities in Nikko on a scale of one to five. As shown in Table I, the responses were clustered into three main groups:

- People who focus Food, Activity, shopping, Night spot, Personal exchange $\Rightarrow$ A group who valued its own active experiences

- People who focus Nature/Landscape, History/Culture, Street, traditional performing arts ⇒ A group who valued nature, history, or traditional factors
- People who focus easy booking, Quality and prices of hotels, Transportation, Prices ⇒ A group who valued the quality of accommodation or the price of goods and services

We used these 3 components. Using Ward's method, which is an alternative approach for performing cluster analysis, the data was then classified into five clusters with these 3 components. As only three persons belonged to the 5th cluster, we classified the results into the following four clusters, as shown in Fig. 1.

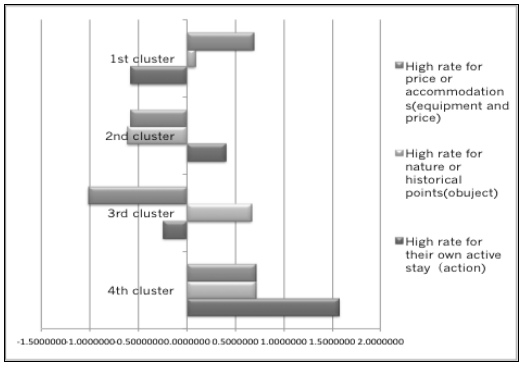


FIGURE 1. EVALUATION OF THE PREFERENCES OF THE FOUR CLUSTERS.

1) Tourists who do not wish to be active, or who are mainly concerned about prices and accommodation (n = 140).
2) Tourists who do not have any special interests, but who wish to stay active (n = 103).
3) Tourists interested in nature or history (n = 62).
4) Tourists who give a high rating to almost everything in Nikko or who particularly wish to stay active (n = 37).

Tourists in the 1st cluster would like to visit the famous hot springs in Nikko and are unlikely to be interested in extensive information about Nikko, since they visit Nikko primarily for rest. Tourists in the 4th cluster are active and have many interests, but are less numerous than those in the 1st cluster.

The age composition of the groups is shown in Fig. 2. Over 70% of those in the 4th cluster were under 30 years old.

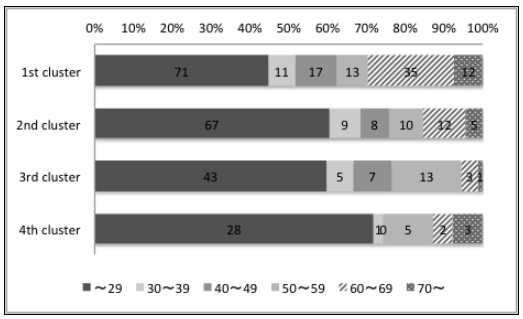


FIGURE 2. AGES OF TOURISTS IN THE FOUR CLUSTERS (%).

Young tourists tend to plan active trips to Nikko. Their characteristic tendencies are as follows:

- They come to Nikko by train and navigate Nikko by bus or on foot.
- They are smartphone users.
- They know little about traditional culture.
- They like to experience new things.

A key finding was that young people reported that they would like to have enjoyed Nikko more completely and that most of them were smartphone users. According to the survey of Ministry of Internal Affairs and Communications in Japan, 94.1% of 20's use smartphone in 2014 [22].

Responses from foreign tourists showed the same profile.

IV. SERVICE PROPOSAL FOR YOUNG TOURISTS AND FOREIGNERS

We explain our system and report the results of our trials and explain the role-played in Nikko.

A. Service Flow

Tourists who know little about the area and the history currently exchange comments using SNS. We therefore addressed the use of beacons to allow residents of the tourism area to recover information from such tourists. We designed our service system as shown in Fig. 3.

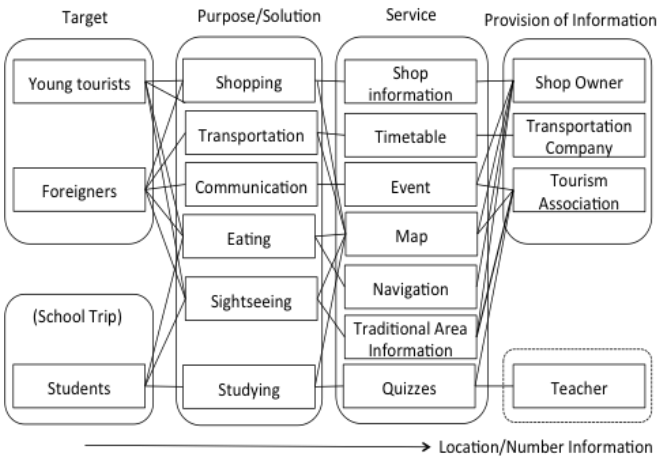


FIGURE 3. SERVICE FLOW.

Shop owners gave us information about the goods they stock, seasonal festivals and other information. Tourists could access this near the beacon, which was located in front or at the entrance of the shop. Bus timetables were furnished by the local bus operator and information about local attractions was supplied by the tourist association. This information was displayed on a map in the smartphone application (Fig. 4).

In addition, we devised several quizzes using the Zeigarnik effect [23], aimed at young students on school trips. This is a psychological effect. We, human beings remember better an unfinished event or an incomplete one. If students answer a quiz, they might keep thinking about it till they look at the object, the answer of the quiz near iBeacon.

Shop owners could then access customer traffic diagrams, and teachers could monitor the location of their students.

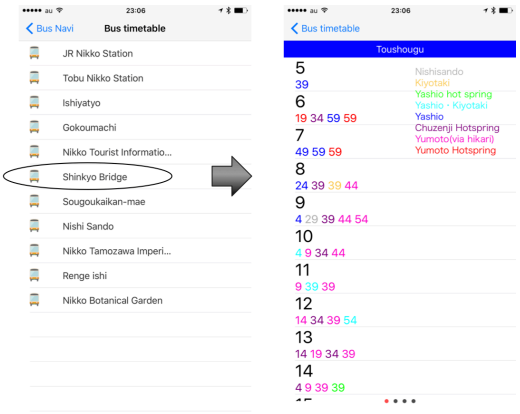


FIGURE 4. BUS TIMETABLE.

TABLE II. FUNCTIONS AND DEVICES IN A SMART PHONE.

Functions	*Devices in a smart phone*	*Relation between tourist information*
Communication	3G/LTE	Download Info.
	WiFi	Download Info./Find Location (Indoor)
	BT	Find Location (Indoor)
Location	GPS	Find Location (Outside)
Near Field Communication	NFC	Get Short Information
	RFID	
	BLE	
Motion Sensor	Accelerometer	Detect Steps
	Gyro	Detect Movement
	Compus	Detect Direction
Picture	Camera	Get picture/Get Short Information through 2D barcode

B. Comparison of Technologies that can be used for Sightseeing in Historic Areas

Current smart phones incorporate a range of sensors. Table II lists the functions of these devices and their potential use in tourist information services. Several of the devices can be used to collect information and identify the location of smartphone users.

However, foreign tourists rarely use roaming data communication services because of their high cost, so we also designed a service that did not require the use of 3G/LTE. As both GPS and the camera quickly deplete the battery, we designed our service to work without them. The use of AR was a potentially interesting alternative navigation method; however, it proved impossible to run this in the background. The final design of our application was as shown in Fig. 5. We assumed the following design constraints:

1) Information should be displayed using the BLE beacon. For near-field communication, NFC and RFID may also be used. NFC requires activating a tag, which is inconvenient for tourists. RFID works in a similar way to a BLE beacon, but no smartphone has the RFID function.
2) If 3G/LTE is not available, it must be possible to download applications and information using Wi-Fi. In the Nikko area, the City of Nikko provides a free Wi-Fi service at the railway station and in some shops, allowing tourists to download applications. Wi-Fi provides location data, in order to replace GPS.
3) The application should provide a full range of information including location, shopping information and bus timetables. Real-time information such as temporary changes to bus routes because of festivals or the blooming of cherry blossom should be downloadable using free Wi-Fi.

C. Information on Nikko as a World Heritage Site

Using beacons, we sent location-specific information within a range between 2.3 and 10 m [24], which transformed an anonymous road into a zone immersed in Japanese culture. (Refer to Fig. 6)

This reflects the traditional Japanese method of attending services of worship, in which the journey to and from the

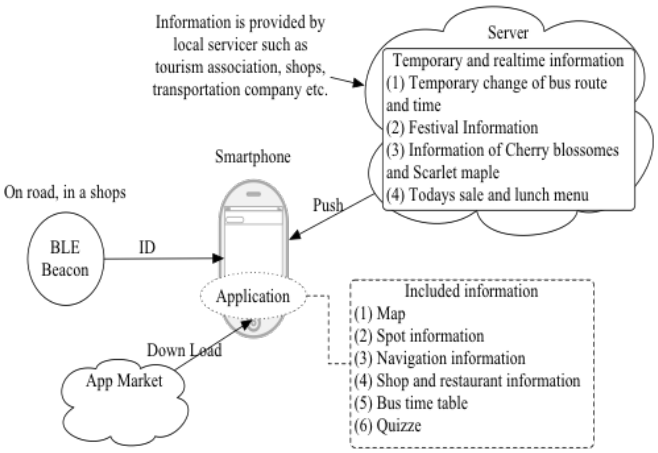


FIGURE 5. SYSTEM DIAGRAM.

FIGURE 6. BEACON MAP AT NIKKO.

service are not the same. Before entering a temple or shrine, tourists purify themselves. After leaving the shrine, they eat or go shopping. This is an established Japanese cultural custom, which has long been taken for granted.

The erection of signboards is seldom permitted in Nikko, following the Convention Concerning the Protection of the World Cultural and Natural Heritage (UNESCO, 1972). Using beacons, we were able to show the information on a smartphone. We created a traditional road, 'SANDOU' (it means a road approaching the main temple or shrine in Japanese), for the Nikko cultural heritage site. Using our beacon system, tourists could pause on the road, some to read information about the traditional temple there and others to find shops selling Japanese sweets, while young students answered a quiz. The road became a pilgrimage route to the shrine.

D. Designing the Application and Locating the Beacons

Many trials using BLE beacons have been reported in which location-specific and shopping information was provided in shopping malls and train stations. However, the BLE beacon has rarely been used for outdoor sightseeing.

Beacons send advertising messages at prefixed intervals using channels 37, 38 and 39. iBeacon, defined by Apple, sends advertising messages every 100 ms [13]. An important characteristic of BLE is its low power consumption. BLE requires only 1/10 to 1/100 the power of classic Bluetooth signalling, and a beacon may function for a year or more without a battery change.

To improve the visitor experience, we imposed the following requirements on the system:

- Reduce power consumption by avoiding the use of GPS.
- Provide sightseeing information related to the BLE beacon location.
- Have navigation operate in both foreground and background while displaying the distance from the station to the Shinkyo Bridge entrance to Toshogu (the main shrine).
- Display a timetable of main bus routes.

FIGURE 7. SCREENSHOTS OF OUR APPLICATION NAMED "NIKKO KAMEN NAVI".

Figure 7 displays screenshots of the application named "NikkoNavi". This application was implemented on iPhone (5 or later models).

Figure 8 explains the software components of this application. In the operating system (OS), BLE access function

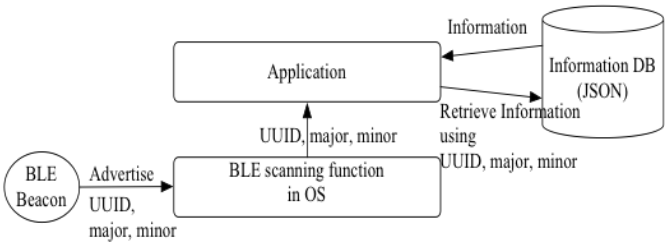


FIGURE 8. SOFTWARE DESIGN TO USE BLE BEACON.

always scans advertising message. If the OS catches an advertising message, the information of the advertising message is forwarded to the application. For example, Core Location framework of iOS (7 or later) provides three properties such as proximity UUID, major and minor.

Android 5.0 or later also provides similar function. If the information such as UUID, major and minor is received from a beacon, the application retrieves information that matches triples (UUID, major and minor). For example, if UUID=cb86bc31-05bd-40cc-903d-1c9bd13d966a, major=1, minor=1, the information relating to the beacon located in the Nikko Station is retrieved from DB and it is displayed on the screen of the smart phone. Each beacon provided information related to its location. For example, when the application received a signal from beacon #13, it displayed 'On the left, there is a slope. At the end of the slope, there is an old temple named Kannonji; 180 m to Shinkyo Bridge and 1,250 m to Nikko train station'. The visitor could use this information to find a small, historic temple.

To ensure stable reception of signals between the Nikko station and Shinkyo Bridge, we calculated the distance between the beacons as follows. In order to receive a signal from a beacon in the background, a smartphone must receive the signal for one minute or longer. We set a beacon to send a one-directional message using a steel signboard.

V. EVALUATION

In this section, we discuss the effectiveness of our system.

A. First Trial: Discovery of Beacons

Six students and three faculty members participated in the first trial, conducted on November 9, 2014.

1) Discovery of Beacons: We tested the beacons under three scenarios:

Scenario 1:Walking from Nikko station to Shinkyo Bridge
Scenario 2:Taking a bus from Nikko station to Shinkyo Bridge
Scenario 3: Walking to the Nikko visitor centre from Shinkyo Bridge while visiting shops where a beacon was located

In Scenario 1, users located approximately 95% of the beacons while walking. The beacon system worked as expected.

In Scenario 2, the results were prima facie unstable. If the user sat in the back of a bus, the smartphone was located near the window, but if the user sat in a front seat, the smartphone was below the window. In the former case, the smartphone could easily capture signals from beacons, but in the latter

case, the metal body of the bus blocked the signal. As the smartphone captured the beacon signal once a minute, the signals from some beacons were missed. Detailed testing of the relationship between the position at which the smartphone is held and the bus speed is a subject for future study.

In Scenario 3, about 80% of the beacons were found, although in one case, only 33% were found. This suggests that the beacon system works best when users have already decided which shops to visit.

2) User awareness of the beacons: We asked subjects to monitor their awareness of the vibration and sound emitted by the smartphone when a beacon was found. The results showed that if users were holding the smartphone in their hand, awareness of the beacon was high, at approximately 60%. However, if the phone was in the user's pocket, awareness fell to about 40%. Because it is dangerous to use a smartphone while walking on the road, different ways must be found to alert users to the beacon. In this regard, wearable devices such as smart watches might prove useful. This will be addressed in the next phase of our study.

3) Overall evaluation: We asked the participants to record their overall impression of sightseeing using the BLE beacon. The most common responses were 'useful' and 'fun'.

The map, in particular, contributed to a feeling of safety (2.77 in 3 grades) and the information about shops was appreciated (2.70 in 3 grades). Key comments on the 'SANDO' (a Japanese road approaching the main shrine) included the following: 'I found a small spring on the road' and 'The information on the little temple was good'. The participants appreciated the information triggered by the beacon.

B. Second Trial: The Zeigarnik Effect

1) In order to evaluate the Zeigarnik Effect: Detailed navigation systems are commonly created for trips. Going further, we have deliberately created a function to provide incomplete experiences for students using the Zeigarnik effect.

The Zeigarnik effect carries the name of Bluma Zeigarnik, a Lithuanian-born psychologist. This effect explains that completed tasks are less recalled than uncompleted tasks.

Using the same beacons, we created quizzes about history and tradition of Nikko in order to make some uncompleted points memory and to evaluate d the results consequence of the Zeigarnik effect.

FIGURE 9. THE SCREENSHOTS OF QUIZZES.

We intended to design this tool for students undertaking a school trip. Figure 9 shows screenshots of our quiz function. The screens were designed using Japanese traditional patterns, and we used some traditional words inform the Edo periods (200-400 years ago). However, those words are used by elderly people now and young people just understand the meanings. We wanted students to experience an old atmosphere using this function on a smartphone that is a symbol of cutting-edge technology. This function was used as an entrance to find some secret of Nikko by attempting to solve quizzes containing traditional cultural information.

This was tested on September 26 and 27, 2015. Twenty-eight students participated in the test, of whom 23 completed ten quizzes on the road to Toshogu Shrine and a control group of five students walked the route without the application. The participants were first asked to complete quizzes about the area, whose answers could be found by observing objects at the site.

Before and after the walking using this application, the participants answered questionnaires as followings.

1) Before the test
   - Evaluations about factors for travel
   - Evaluations about Nikko (1)
2) Immediately after the test
   - About the evaluation of the application
   - Drawing a map from the Nikko station to the main shrine
3) After one month
   - Checking three points on a photograph
4) After two months
   - Evaluations about Nikko (2)

After the walk, the participants were first asked to complete a questionnaire and to draw a map of the area [25]. Drawing a map is said that memory is mainly visual [26]. The answers given by users of the application were more concrete than those of the control group. Application users were able to place an average of 9.18 objects on the map from the station to the shrine, whereas the controls identified an average of only 5.80. Application users could not only remember the answers to the quiz questions but could also recall the shops near the beacon sites where they had answered the quiz.

After a gap of a month, the participants completed another questionnaire and checked three points on a photograph from the route they had walked in Nikko. Heat maps were created on the basis of the responses. Four photographs of the route to the main shrine were used: two in the main shrine itself and two showing several characteristic points.

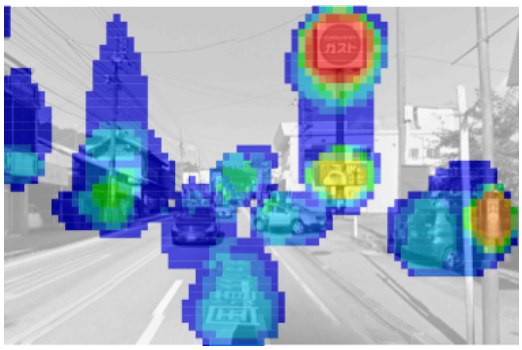


FIGURE 10. HEAT MAP ON THE WAY TO THE MAIN SHRINE.

Figure 10 shows a heat map of the route to the main shrine. The participants paid no heed to the architecture along the route. This is in contrast to the photographs in the shrine where the gaze of the participants was directed to lettering.

The red point is a restaurant sign with very big letters. Attention was also paid to written signs on the road. The street was recognized as the way to the main shrine. The yellow point shows that little attention was given to the BLE beacon in which no letters were present in the photograph.

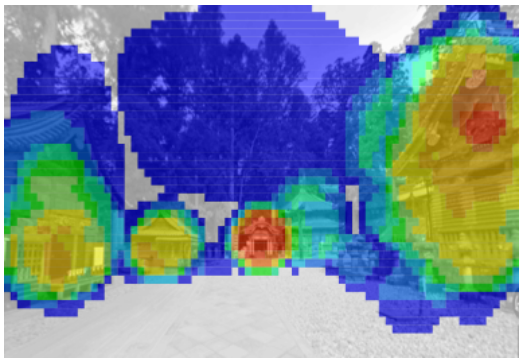


FIGURE 11. HEAT MAP IN THE SHRINE (QUIZ USERS).

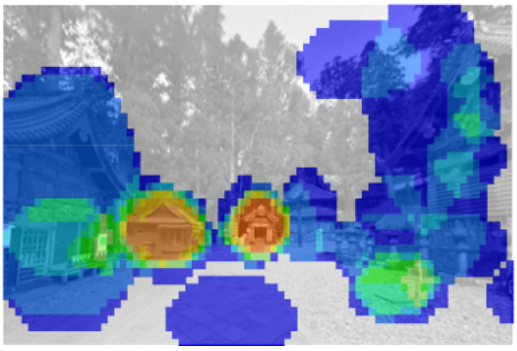


FIGURE 12. HEAT MAP IN THE SHRINE (NON QUIZ USERS).

Figure 11 shows that the participants paid heed to the architecture of the shrine, particularly to the upper part on the right side. This was in contrast with the approach route.

Figure 12 is the heat map by non-application users (n=19). That is the same photo as Fig. 9. Comparing Fig. 9 with Fig. 10, the upper part on the right side is significantly different.

The results confirmed that the use of the quizzes exploiting the Zeigarnik effect improves recall. Students remembered both the BLE beacon and the objects used in the quizzes.

The use of quizzes in the application helped users to recall the shops around the beacons immediately after the trial. In the future, we will expand the scope of our study to include 'SANDO' on the route to the main Toshogu Shrine.

2) The Results of Data Analysis: We compared two same questionnaires, before and two months after to the trip in Nikko.

The evaluations of Nikko changed as described in Fig. 13. Before the trip, in accordance with tourist psychology [5],

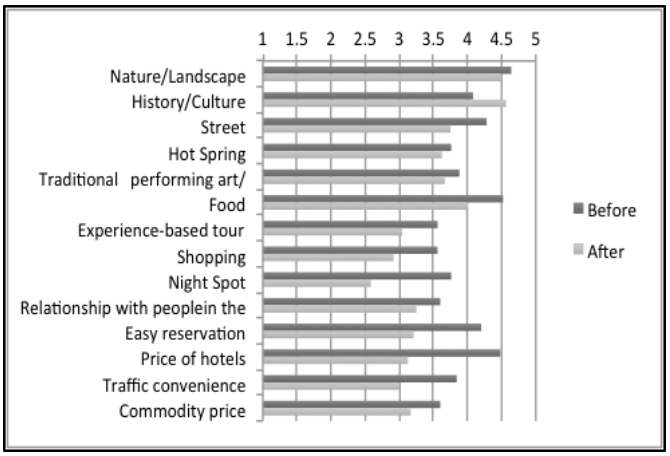


FIGURE 13. THE EVALUATION ABOUT NIKKO BEFORE AND AFTER THE TRIP (5 POINTS' LIKERT SCALE).

the participants expected to gain some new experiences. After the experience, their expectations decreased, except for the subject of 'History/Culture', which was remarkable. Using our application, the participants evaluated the traveling experience higher after the trip than before the trip on this point.

In addition, we analyzed their answers to questionnaires regarding our application. The results of the cluster analysis are shown in Table III. Using Ward's method, the data were then classified into tree clusters. Cluster 1 tended to evaluate tangible factors of our application. Cluster 2 tended to evaluate general impression. Cluster 3 evaluated contents (quizzes) and the map that was being used for the quizzes' rally. Each colored article reflected the highest numerical value in the tree clusters.

We compared two evaluations on the traveling parameters of each cluster (Refer to Table IV).

TABLE III. THE EVALUATIONS OF OUR APPLICATION (COMPRISING CLUSTER ELEMENTS).

	Cluster 1	*Cluster 2*	*Cluster 3*
Impression	3.29	4.57	3.25
Interface	4.00	4.14	3.25
Usability	3.00	3.71	3.25
Font size	4.14	4.00	4.00
Sound	4.43	3.29	3.25
Color	4.57	4.29	3.25
Expression	4.29	3.86	3.25
Contents(Quizzes)	3.14	4.14	4.25
Visibility of the Map	3.43	3.29	5.00

There are remarkable features in cluster 3. They evaluated six factors higher after the trip than before the trip. In the other two clusters, they evaluated only two or three factors higher. In cluster 3, particularly, they evaluated 'History/Culture' high; the numerical value increased by 1.5 points after the trip, in the five-points' Likert scale. However, the 'interaction with the local people' was lower than in the other two clusters.

After two months, the impressions of this application and evaluation of user interface faded out in cluster 1. However, according to the answers in cluster 3, the quizzes' contents made the area more attractive than before.

TABLE IV. THE EVALUATIONS OF OUR APPLICATION (COMPRISING CLUSTER ELEMENTS).

	(A) Before the trip			(B) 2 months after the trip			Incremental difference (B-A)		
Cluster	1	2	3	1	2	3	1	2	3
Nature/Landscape	5.00	5.00	3.75	4.43	4.83	4.50	-0.57	-0.17	0.75
History/Culture	4.29	4.71	3.25	4.43	4.80	4.75	0.14	0.09	1.50
Street	4.43	4.29	4.50	4.00	3.83	4.00	-0.43	-0.45	-0.50
Hot Spring	4.14	3.71	3.50	3.57	3.50	3.25	-0.57	-0.21	-0.25
Traditional Performing Art /Specialty	3.86	4.00	3.75	3.71	3.83	4.00	-0.14	-0.17	0.25
Food	4.71	4.43	4.25	3.71	3.83	4.75	-1.00	-0.60	0.50
Experience-based tour	3.43	3.57	2.50	3.00	2.83	3.75	-0.43	-0.74	1.25
Shopping	4.14	3.14	3.50	3.00	3.17	3.75	-1.14	0.02	0.25
Night Spot	3.71	3.00	4.50	3.00	2.67	3.00	-0.71	-0.33	-1.50
Relationship with people in the area	2.83	3.29	3.00	3.71	3.33	3.00	0.88	0.05	0.00
Easy reservation	4.00	3.29	3.75	3.00	3.17	3.00	-1.00	-0.12	-0.75
Price of hotels	4.57	3.71	5.00	3.00	3.17	3.50	-1.57	-0.55	-1.50
Traffic convenience	4.71	4.43	4.50	3.29	3.50	1.75	-1.43	-0.93	-2.75
Commodity price	4.14	3.57	3.75	3.00	3.83	3.25	-1.14	0.26	-0.50

3) About the contents of quizzes using iBeacons: The previous section has shown that playing a quiz rally with our application remained in the memories of the participants. We would like to describe these quizzes in detail in this section.

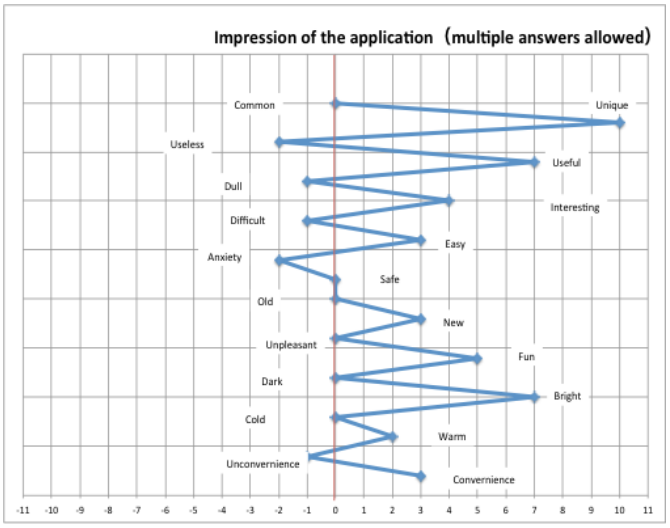


FIGURE 14. IMPRESSIONS OF QUIZZES FUNCTION.

Our quiz rally function of the application made the participants gain positive impressions (Fig. 14). They felt the application was unique, useful and smart. Their answers leaned toward the right side in the figure, which means they were favorable impressions.

There is a characteristic point in their answers. Two types of responses to the quizzes were observed; some quizzes were taken up by several participants, whereas others were not selected by any. Some users evaluated the quizzes as interesting, while others mentioned that they were difficult. However, the quizzes certainly attracted their attention. On the contrary, no one mentioned some quizzes.

The answers pertaining to the quizzes were very interesting.

The quizzes about just history were not highly evaluated. In contrast, participants highly evaluated quizzes on traditions and the local culture related to the actual daily life of the local people or in comparison to the other nation's customs and traditions. For example, they were interested in a quiz about height above sea level of their location. Participants were urged to compere with the places they have known in their ordinary lives. The answer showed them the place they were is as tall as the Tokyo Sky Tree, the highest tower in Japan. To compere with their already known place made them to feel how the location was high and were surprised. If the answer showed only the number of height above sea level, they would not be interested in the quiz so much. The explanation of the quiz told them that the holy places are established at higher place than usual lives.

They seemed to enjoy the cultural gap among them.

4) Additional Research: This quiz function was designed for school trips in Japan. Before the trip, students gained insights about the destination such as history, traditions and specific art monuments in the area and created some quizzes for the other classmates. They did not know what types of quizzes were being prepared by the other students. The students prepared for their outdoor excursion as an incomplete experience. Such an incomplete experience arouses human interest in the object.

Therefore, we conducted additional research on high-school students. Eleven students participated in our test on 5th of December 2015. Before the test, they had created several quizzes for our application, and they had already added them into our application.

They answered the same questionnaires as in our previous test (not all, but two questionnaires: the evaluation of our application and the evaluation of Nikko). The data from nine students was valid. Two of them lived near the Nikko area; thus, we did not use these data.

According to the results of the questionnaires, high-school students remembered objects in the area better than the previous participants did. Moreover, they answered that they were satisfied with our application more than previous participants were. In addition, most of them chose 'interesting' as their impression of our application (eight out of nine high-school students). However, the data numbers were few to analyze with statistical significance. Therefore, we aim to continue our research on this subject.

C. The Results of the Research for Foreign and Japanese Tourists

We asked tourists to install our application named 'Nikko Kamen Navi' at the Tobu Nikko Station on the 29th-30th August, 26th-27th September and 8th November 2015. Some

users voluntarily answered the web questionnaire after using this application.

The total number of participants was 57:15 of them were English-speaking foreign visitors, and 42 were Japanese tourists. Both foreigners and Japanese tended to answer that our application was convenient, interesting and helpful. However, foreigners chose these words on a larger percentage than Japanese; A total of 47.62% (20 people) of the Japanese tourists and 73.33% (11 people) of the foreigners answered that this application was convenient.

Figure 10 shows a heat map of the route to the main shrine. Japanese students paid attention to the Japanese letters in that photo. They walked while looking at signboards on the way to the main shrine. However, those inscriptions were only in Japanese. There were no signboards for foreigners because the area belongs to the world heritage site, and it was difficult to place some new signboards. Foreigners had little information on the way to the main shrine. Therefore, providing them with basic information using such an application proved to be necessary.

VI. Conclusions

Smartphone sightseeing applications offer several types of information. However, tourists visit sites to see real places and experience the real environment, while the smartphone is only a tool to enhance the experience. Thus, the information provided to the target audience must be refined. Tourists are not primarily motivated by convenience; in fact, unfamiliar experiences or inconvenience may actually arouse their curiosity.

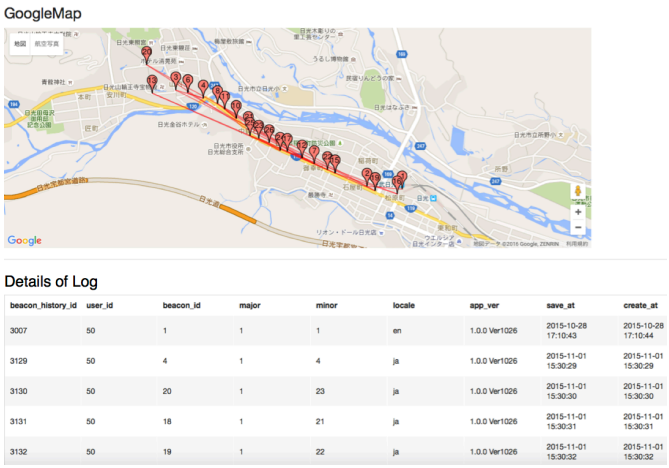
Traditional cultural locations have special historical or cultural significance. Introducing tourists to relevant cultural information about these locations helps to create a strong impression. Our application aims to provide such information. Owners of shops en route to the main shrine provided us with not only information concerning their shops but also local traditions and seasonal events, enriching the information available to tourists. A web questionnaire showed that tourists found the information about shops useful. In the survey, 89.2% of the respondents were under 30 years of age. Foreigners could access the information using the English pages.

Local information can be used to attract visitors to other cultural sites around the world, particularly in world heritage sites designated as special protection areas, where signboards are banned.

Japanese students studied the history and specific artworks of the area before their school trip. By creating quizzes for their classmates and tackling quizzes that the others had prepared, interest was sparked. This provided the basis for our use of the Zeigarnik effect, in which completed tasks are less well-remembered than uncompleted tasks. Thus, we deliberately created incomplete experiences.

From a technological viewpoint, we are planning to introduce two new functions. One will allow the beacon to function on a solar battery; the other is to enhance the positioning system. We can get the time information to reach the beacon points now (refer to Fig. 15). However, these data still cannot be used for ships on the way to the main shrine.

It is possible to develop a PDR assisted by BLE Beacon. We measured the change in the strength of the beacon signal around a beacon. Figure 16 shows that near the beacon, the



beacon_history_id	user_id	beacon_id	major	minor	locale	app_ver	save_at	create_at
3007	50	1	1	1	en	1.0.0 Ver1026	2015-10-28 17:10:43	2015-10-28 17:10:44
3129	50	4	1	4	ja	1.0.0 Ver1026	2015-11-01 15:30:29	2015-11-01 15:30:29
3130	50	20	1	23	ja	1.0.0 Ver1026	2015-11-01 15:30:30	2015-11-01 15:30:30
3131	50	18	1	21	ja	1.0.0 Ver1026	2015-11-01 15:30:31	2015-11-01 15:30:31
3132	50	19	1	22	ja	1.0.0 Ver1026	2015-11-01 15:30:32	2015-11-01 15:30:32

Figure 15. Log data of the application.

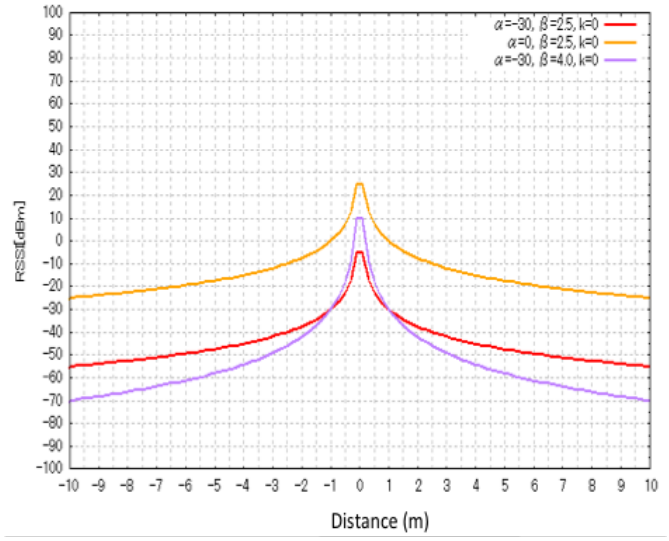


Figure 16. Models for PDR.

strength of the signal increases. At this point, correcting the PDR error is possible if the PDR system has the data of exact position (longitude and latitude) or the signal contains its location data (longitude and latitude). We have developed a test application that can measure such data. We are planning to conduct some tests using this application.

Such improvements will be useful for shop owners in order to use tourist information. There are two different types of users of this application. If we hope to continuously use this application, we have to consider not only tourists but also local users, i.e., the shop owners. They will install this application and sometimes input seasonal information, advertisements or other announcements. It is important for the application to renew the seasonal information; thereby making the information more relevant and useful.

In addition, this system will be useful during times of disaster, letting people know the location of the nearest safe

place via the map. Communication traffic often occurs after a disaster. Our application can be used without requiring Internet access.

We are planning a collaboration with the other world heritage site in Kyusyu, the south area in Japan. We will use our beacon technology and application to provide descriptions and explanations of the traditional places and customs. In some cases, someone will carry a beacon and participants are going to look for it. There are many methods to use beacons. It is easy to put beacons at some events, too.

Our main goal is to inform tourists about traditional cultures. Our system allows knowledge of the culture of a location to be transmitted to the next generation and to foreigners. Such travel information will inspire tourists and encourage them to treat the culture respectfully.

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