A Service Model using Bluetooth Low Energy Beacons

-To Provide Tourism Information of Traditional Cultural Sites -

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***Abstract*—A large amount of information is not always appealing to tourists. While the provision of information may lessen the anxiety experienced by tourists, the promise of the unexpected is one of the things that make travel attractive. We developed a new application using Bluetooth Low Energy (BLE) beacons that not only provides a guide to a specific location but also summarizes the traditional customs and history of the area. A trial at the Nikko world heritage site in Japan demonstrated the effectiveness of the BLE beacon for sightseeing on foot. The application made tourists notice new points on the route. Owners of shops en route to the main shrine cooperated by providing information regarding their goods and information on local traditions. Our system enhanced the tourist experience of a traditional cultural city, especially for foreign visitors and young Japanese.**

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

I. INTRODUCTION

We introduce our remarkable points 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 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 audience for this information should be. Before using big data by GPS signals for tourists, we should re-inspect and analyse the information contents.

In this study, we investigated the information needs of tourists in Nikko and tested the provision of information using a Bluetooth Low Energy (BLE) beacon system.

This study was selected as one of the research themes of SCOPE [1] and was funded by the Ministry of Internal Affairs and Communications of Japan [2].

B. Psychology of Tourists

Many previous studies have investigated environmental psychology and tourism. Pearce and Stringer [3] 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 [4]. 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. Cultual 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, travelling 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 the previous literature. Section 3 sets out our proposal. In Section 4, we report the results of our trials and explain the role-played in Nikko. Finally, we discuss ways of providing information appropriate to traditional cultural sites and suggest future studies.

 ISBN: 978-1-61208-459-6

II. RELATED WORKS

A. Our Previous Work

Students go on school trips in Japan [5]. 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 [6]. To address this problem, we developed a new learning model for outdoor study [7][8].

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

Many sightseeing applications for smartphones already exist in Japan [9], 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 [10]. 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 [11] 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.

III. SERVICE PROPOSAL

We administered questionnaires to the visitors to Nikko [12], 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. 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 and price of hotels	.307	.039	.771
Transportation	.116	.147	.639
Prices	.279	.346	.477

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

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. 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:

- A group who valued its own active experiences
- A group who valued nature, history, or traditional factors
- A group who valued the quality of accommodation or the price of goods and services

Using Ward's method, the data were then classified into five clusters. As only three persons belonged to the 5th cluster, we classified the results into the following four clusters, as shown in Fig. 1.

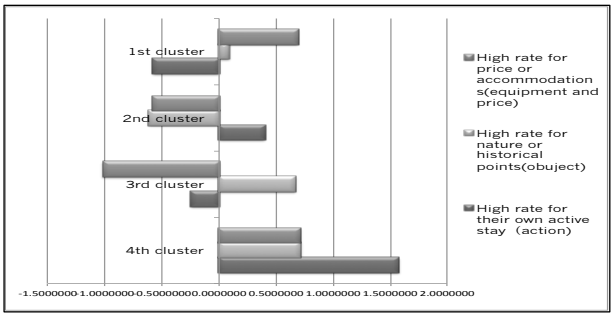

Figure 1 Evaluation of the preferences of the four clusters.

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

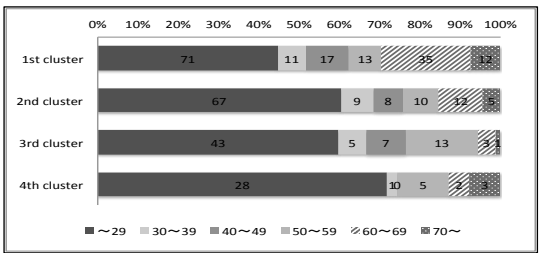

Figure 2 Ages of tourists in the four clusters (%).

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

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.

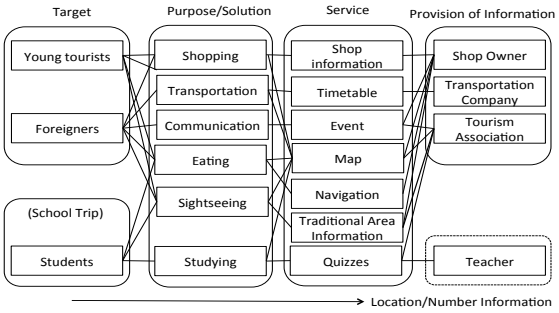

Figure 3 Service flow.

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. In addition, we devised several quizzes using the Zeigarnik effect, aimed at young students on school trips. Shop owners could then access customer traffic diagrams, and teachers could monitor the location of their students.

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. 4. We assumed the following design constraints:

TABLE II. FUNCTIONS AND DEVICES IN A SMART PHONE

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

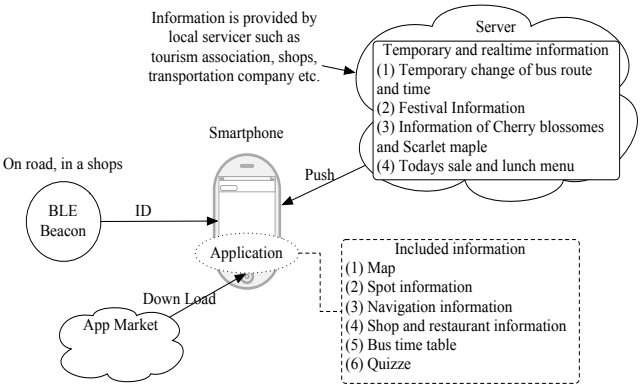

Figure 4 System diagram.

(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 of 2.3–10 m [13], which transformed an anonymous road into a zone immersed in Japanese culture.

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

Figure 5 Beacon map at Nikko.

Beacons send advertising messages at prefixed intervals using channels 37, 38 and 39. iBeacon, defined by Apple, sends advertising messages every 100 ms [14]. 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

Fig.6 displays screenshots of the application. This application was implemented on iPhone (5 or later models).

Figure 6 Screenshots of our application.

Fig.7 explains the software components of this application. In the operating system (OS), BLE access function 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.

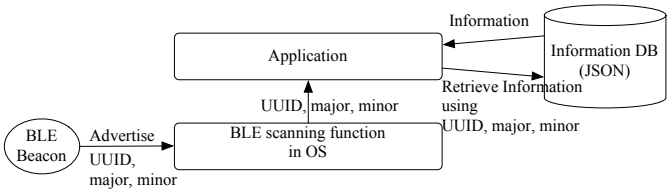

Figure 7 Software design to use BLE beacon

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.

E. First Trial: Discovery of Beacons

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

1) Discovery of the 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

 ISBN: 978-1-61208-459-6

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.

F. Second Trial: The Zeigarnik Effect

Using the same beacons, we created quizzes about the road. These were 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. This study was based on a previous experiment using the Zeigarnik effect [15]. The participants were also asked to draw a map and to check some points on it. It is said that memory is mainly visual [16].

After the walk, the participants were first asked to complete a questionnaire and to draw a map of the area [17]. 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.

Fig. 8 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.

Fig. 9 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.

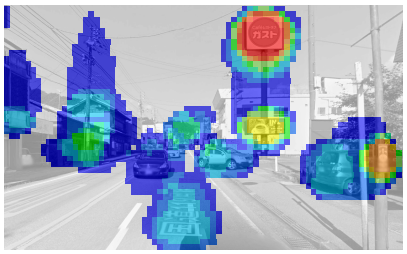

Figure 8 Heat map on the way to the main shrine.

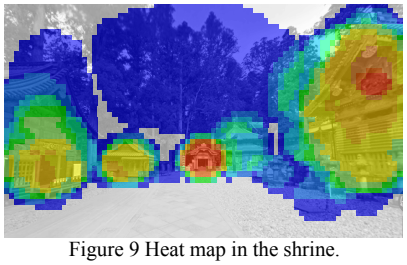

Figure 9 Heat map in the shrine.

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.

 ISBN: 978-1-61208-459-6

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.

V. 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.

We are planning a collaboration with Toshogu, the main shrine at Nikko. Each autumn, a portable shrine is carried along the 'SANDOU' route to the Toshogu Shrine in a procession of one thousand samurai. We will use our beacon technology and application to provide descriptions and explanations of the traditional clothing and customs. In this case, the participants in the procession will carry the beacons.

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. We are planning to extend our collaboration to other world heritage sites as well.

ACKNOWLEDGMENT

We would like to express special thanks to Mr. Funakoshi (Nikko Tourism Association), members of the 'Study group on School Trip', Mr. Yoshida (Hatsuishi-kai: An association of Nikko shopping streets), Mr. Nakagawa (Kounritsuin Temple) and Mr. Takao Masuda (Chuo Univ.).

This research was performed as a SCOPE (Strategic Information and Communications R&D Promotion Programme) project funded by the Ministry of Internal Affairs and Communications (MIC) in Japan.

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