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Beacon-based tourist information system to identify visiting trends of tourists

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Abstract

In this study, we propose a system that provides tourist information and obtains trends of visiting tourists using beacons and cloud service. As part of our research, we are working on the promotion of local area tourism in cooperation with a local community. A low energy Bluetooth device is used as a beacon to transmit a universally unique identifier. In addition, beacons are placed at sightseeing spots and tourist facilities. Our proposed system comprises two application programs; one is a client-side application program that provides area-specific tourist information corresponding to the detected beacon. The other is a server-side application to record time and location information of the detected beacons. In this paper, we describe the scheme of our system, and present the results of experiments conducted using the prototype system in the local tourist area. In addition, we discuss an open platform for information collection services using beacons.

Keywords: Tourism promotion, IoT, Bluetooth beacon, Stamp rally, Cloud service, Local community cooperation

1. Introduction

Tourism promotion is considered to be an important regional activity for revitalizing regional exchange and intergenerational communication.[1)] As part of our research, we cooperate with the local community to promote local tourism in Shingu, Japan.[2)] Although Shingu has many potential tourism resources, for example, a many natural beauty and historic sites, these tourism resources are not well known.

There are two approaches to using information technology in tourism promotion. One is to provide tourist information using the Internet and the other is to collect tourist information, for example, trends in the numbers of tourists and the order in which they visit sightseeing spots. Recently, beacon technology using Bluetooth low energy devices has become very popular and various applications have been studied.[3)] This technology could provide information about places visited by tourists and collect tourist trends.

In this study, we propose a beacon-based system that provides tourist information and obtains visiting trends of tourists using beacons and a cloud service. A prototype of the proposed system was developed for Ainoshima Island in Shingu. We then performed field tests using the developed prototype system. In addition, we discuss an open platform for information collection services using beacons.

2. Beacon-based Tourist Information System

In the following sections, we present an outline of the proposed beacon-based tourist information system and method for identifying sightseeing spots using beacon and Global Positioning System (GPS) information.

2.1. *Outline of the Proposed System*

Our proposed system consists of two parts: a client-side application (the client) and a server-side application (the server). A schematic drawing of the proposed system is shown in Fig. 1. Beacons are placed at the targeted sightseeing spots beforehand.

The server consists of the tourist information database (TIDB) and visiting tourists database (VTDB). Tourist information for the targeted spots and facilities are stored in the TIDB with their corresponding beacon ID. Beacon detection events for each client are stored in the VTDB as a record (user ID, beacon ID, time, and location).

The basic procedure of the proposed system is as follows:

(1) Beacon detection: The client detects the beacon when it enters the range of the target beacon.

(2) Beacon information storage: The client sends the detected beacon ID, client ID, time, and location to the server, where it is stored in the VTDB.

(3) Tourist information retrieval: Visited sightseeing spots are identified using the beacon ID, and the corresponding area-specific tourist information is retrieved from the TIDB on the server.

(4) Identified spot notification: The client is notified when a spot is identified.

(5) Area specific tourist information retrieval: If the client user wants to obtain area-specific tourist information about the identified spots, the client downloads it from the server.

Using this procedure, data about the sightseeing spots visited by each client are accumulated in the VTDB on the server. We can then use these data to identify tourist trends at sightseeing spots and the order in which tourists visit these spots.

2.2. *Identification of Sightseeing Spots Using Beacon and GPS Information*

In this research, a low energy Bluetooth device with iBeacon technology[4)] is used as a beacon. A sightseeing

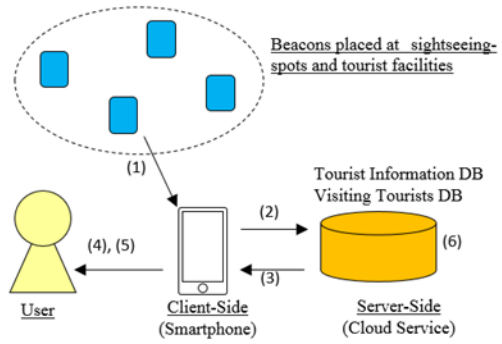

Fig. 1. Schematic drawing of the proposed beacon-based tourist information system: (1) beacon detection, (2) beacon information (user ID, beacon ID, time, and location) storage, (3) retrieval of tourist information corresponding to the beacon ID, (4) identified spot notification, (5) retrieval of area-specific tourist information, and (6) identification of visiting trends from stored data.

spot where the beacon is installed is identified by the beacon ID and GPS information. In iBeacon technology, a beacon ID consists of a universally unique identifier (UUID: 128 bits), major value (16 bits), and minor value (16 bits). In this research, the UUID is assigned an application-specific number and we use the same UUID through our proposed system. The major value identifies the area in which the beacon is placed. A unique minor value is assigned for each sightseeing spot. We can then identify sightseeing spots by the three values UUID, major value, and minor value. The identification is validated by GPS information.

To handle sightseeing spots where we cannot put beacons, for example historical monuments in outdoor fields, we introduce a "pseudo beacon" using GPS. The pseudo beacon also has a UUID, major value, and minor value like a normal beacon. When the client's GPS position is near the sightseeing spot where the pseudo beacon is assigned, the client behaves as if it has detected a normal beacon. In order to implement this pseudo beacon, it is necessary to obtain the information about the pseudo beacons in the target area beforehand.

3. Development of the Prototype System

As a prototype of the proposed system, we developed a beacon-based tourist information system for Ainoshima Island in Shingu. The client is implemented as an Android application. The server is implemented using a cloud service. In this prototype system, the TIDB is implemented in the client.

The implemented functions of the prototype system are as follows:

(a) Tourist information function: The sightseeing spots of Ainoshima are listed (Fig. 2(a)) and the user can see tourist information about the selected spot (Fig. 2(b)).

(b) Map function: The user can see the location of sightseeing spots where beacons are installed. Spots identified by beacon detection are highlighted using a colored marker (Fig. 2 (c)).

(c) Stamp rally function: The spots listed in Table 1 are assigned virtual stamps and the user obtains the stamp when the client detects the corresponding beacon. This function is implemented for use in tourism events of the local community. [3,5]

(d) Notification function: When the beacon is detected, the user is notified that the sightseeing spot has been identified (Fig. 2 (d)). After the notification, the user is not notified of identifications of the same spot for an hour to avoid frequent notifications.

(e) Log function: Beacon detection information is stored on the server. New beacon detections of the same beacon are ignored for 10 min after a previous detection to avoid frequent communication with the server.

4. Field Test of the Prototype System

In order to test the developed prototype system and evaluate the performance of the tourist data collection, a field test was performed on Ainoshima. The preparation of the field test (beacon installation) and results are presented below.

4.1. *Installation of Beacons*

For 20 sightseeing spots in Ainoshima and Shingu town, eight beacons were installed in indoor spots and 12 pseudo beacons were assigned to outdoor spots. The major sightseeing spots are listed in Table 1. An Aplix MyBeacon MB004 AC-DR1 was used as the beacon. This beacon is compliant with iBeacon technology. The advertising interval of the beacon was set to 1,285 ms to reduce electric power consumption. The measured power, which is the expected received signal strength indicator (RSSI) at a distance of 1 m from the beacon, was −63 dB.

Fig. 2. Screen shots of the prototype client: (a) list of sightseeing spots, (b) tourist information of the selected spots, (c) map of where the location of the spots are indicated by markers, and (d) example of beacon detection notification. (Map data ©2016 ZENRIN and Google)

4.2. *Results of the Field Test*

In the field test, a total of nine users used the prototype system on Ainoshima. They visited the sightseeing spots listed in Table 1 in any order for about 2 h. As a result, all the spots in Table 1 were identified by the detected beacons. In total, 223 beacon detection records were stored on the server. Using these data, we can identify the tourist path of visited sightseeing spots, as shown in Table 2 and Fig. 3.

Table 1. Major sightseeing spots in Ainoshima.

Beacon ID (minor)	Sightseeing Spot	Beacon Type
1001	Maruyama restaurant	normal
1002	Waiting place of Ainoshima Port	normal
1003	Ainoshima Tourist Information	normal
1004	Wakamiya-jinjya (Shrine)	normal
1005	Kizuna-Kan (Disaster support facility)	normal
1006	Jingu-ji (Temple)	normal
1007	Waiting place of Shingu Port	normal
1008	Ferry boat “Shingu”	normal
1009	Tsumiishi-duka (Tumulus Cluster)	pseudo

5. Discussion

In this research, we proposed a beacon-based tourism information system. The prototype system was developed for Ainoshima Island, Shingu, Japan. The developed system worked well in the field test and tourists’ paths were identified.

The tourist paths identified by our system are based on beacon detection log data. In comparison to identification using GPS only, our system has two advantages. One is that amount of data for the identification is reduced, as our system uses log data only for sightseeing spots where beacons are installed or pseudo beacons are assigned. The other is that identification is possible for indoor spots where beacons are installed.

To use our system in practice, it would be necessary to increase the participation of local communities and extend the supported area. An open platform for information collection services using beacons is one potential solution for this purpose. If an open Web API to retrieve beacon and tourist information and a management system for registered information are provided, local communities could build their own information collection service by themselves. To construct such an open system is one of our future tasks.

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Table 2. Example of logged data for one test user.

Time	Visited sightseeing spots
11:19	Ferry boat “Shingu”
11:51	Maehato (Ruin of Port)
11:52	Ainoshima Tourist Information
11:53	Waiting place of Ainoshima Port
12:28	Ainoshima elementary school
12:43	Tsurugi-jinjya (Shrine)
12:49	Tsumiishi-duka
13:08	Ainoshima elementary school
13:20	Maruyama restaurant
13:25	Waiting place of Ainoshima Port
13:26	Ainoshima Tourist Information
13:27	Wakamiya-jinjya
13:37	Jingu-ji
13:41	Wakamiya-jinjya
13:42	Kizuna-Kan

Fig. 3. Identified path of visited sightseeing spots from the logged data shown in Table 2. (Map data ©2016 ZENRIN and Google)

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