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Smart Tourism Monitoring Device Based on IoT Technologies

Jin Sung Kim, Hyeon Jun Kang, Jeong Woo Jwa

Abstract*: For sustainable tourism development, sustainable use of tourism resources should be ensured by appropriate development and utilization considering environment protection and nature conservation. In Jeju, 169 Oreums out of the 368 Oreums are hard to maintain and manage because of lack of manpower and budgets. The climbing path and crater of Oreum are being damaged as the number of visitors to Oreums increases to 22.7 million per year. Jeju special self-governing province has conducted a nature rest period for major Oreums and has installed an expensive system to measure the number of visitors by the pilot project. In this paper, we developed the smart tourism monitoring device to measure the number of visitors and environmental data of sightseeing spots such as fine dust amount, temperature and humidity, wind speed, snowfall. The field data measured by the device will be provided to the user via a big data analysis.

Index Terms: Internet of Things (IoT), Smart Tourism, Tourist Attractions, sustainable tourism, Oreum.

I. INTRODUCTION

Internet of Things (IoT) is very important in smart tourism that supports tourist activities before, during, and after the trip [1]-[4]. Smart tourism system can provide tour information by mobile apps based on the tourism big data analytics. The Jeju special self-governing province deploys free WiFi APs on major tourist spots and buses to provide free internet access service [5][6]. The user can use the wireless Internet service for free by one-time authentication. The Jeju special self-governing province develops the tourist big data platform and has analyzed the WiFi access data of tourists [6,10-16]. The Jeju special self-governing province provides data on the travel route analysis of tourists. Analysis of tourists' travel route is very important data in Jeju tourism policy establishment and personalized smart tourism service. In Jeju, the most famous sightseeing spot in Korea, it is required to establish policies for sustainable tourism due to the problems of economic costs such as transportation measures, waste and sewage disposal costs due to rapid increase in the number of tourists. The problem of environmental destruction has been raised with the rapid increase of visitors to Mt. Halla and Oreums of the parasitic volcano. Jeju special self-governing province has implemented a nature rest period for major Oreums to systematically manage the Oreums and considers the policies such as the total number of visitors and the pre-visit reservation system.

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Smart tourism provides tourism services based on the key technologies of the 4th industrial revolution. The tourism big data analytics is required to develop the smart tourism services for individual tourists. We have been developed smart tourism services using the tourism big data analytics of call data records of mobile communication network and access logs of WiFi APs and Beacons and tourist's credit card usage [7][8]. We also developed the multilingual audio tour guide system using the server-based TTS engine based on GPS and BLE Beacons [9]. In order to provide safe and satisfactory tourist services in mountains and Oreums with severe changes in natural environment, real-time environmental information of tourist sites should be provided to tourists. In addition to the fine dust concentration at tourist sites, information such as snowfall and temperature in winter and temperature, humidity and wind speed during summer should be known to tourists. In this paper, we develop devices that can provide smart tourism services using IoT technology in walking tourist attractions areas such as mountains, Oreums and forest trails. The developed smart tourism monitoring device provide the number of visitors to walking sightseeing spots and measures the fine dust amount, temperature, humidity, wind speed, snowfall required for walking tourists.

II. IOT ENABLED SMART TOURISM MONITORING DEVICE

There are 368 Oreums and more than 216 of them can be climbed in Jeju. The 46 Oreums are located in Hallasan National Park, which is managed systematically, but 169 Oreums are difficult to maintain and manage due to lack of manpower and budget. The number of visitors to Oreums increases to 22.7 million per year and the climbing path and crater of the Oreum are being damaged. Jeju special self-governing province is conducting an Oreum rest period to prevent damage to Oreum trail and crater of the summit and to protect plants and animals around the Oreum. In order to systematically preserve and manage Oreums, Jeju special self-governing province is considering not only the natural rest years but also the policy such as limitation of the total visitor amount and the pre-visit reservation system. Equipment is required to accurately measure the number of Oreum visitors to establish policies to protect and systematically manage Oreum, Jeju special self-governing province has installed a high-cost visitor counting system for major Oreums as a pilot project to count visitors.

In this paper, we have developed equipment for counting the number of visitors to Oreums and measuring the environmental information of tourist attractions and providing them to visitors.

Figure 1. Oreum doorway for horse and cow grazing

We use two devices to count the number of visitors as shown in Fig. 2. In Fig. 2, d_a represents the distance from the first device to the person and d_b the distance from the second device to the person, d_w the width occupied by people passing through both devices, respectively. Figure 3 shows the circuit diagram of the two devices. The first device consists of two Arduinos as shown in Fig. 3(a)(b). The second device consists of an Arduino, an ultrasonic sensor, and two Bluetooth modules as shown in Fig. 3(c). In Fig. 3(a), Arduino measures d_a using the ultrasonic sensor, while the other Arduino measures fine dust concentration, temperature and humidity, wind speed, and snow height. The second device computes d_b with an ultrasonic sensor and transmits it to the first device using the Bluetooth module. The first device calculates d_w by using the d_a measured by the ultrasonic sensor and d_b received from the second device, and calculates the number of vi

sitors by Eqn. (1).

Figure 2. Smart tourism monitoring device using IoT technologies.

(a) The first device consists of an Arduino, an ultrasonic sensor, and 3 Bluetooth modules

(b) The first device has another Arduino, a fine dust sensor, two Bluetooth modules, a temperature and humidity Sensor, a wind speed sensor, and an ultrasonic sensor

(c) The second device has an Arduino, an ultrasonic sensor, and two Bluetooth modules

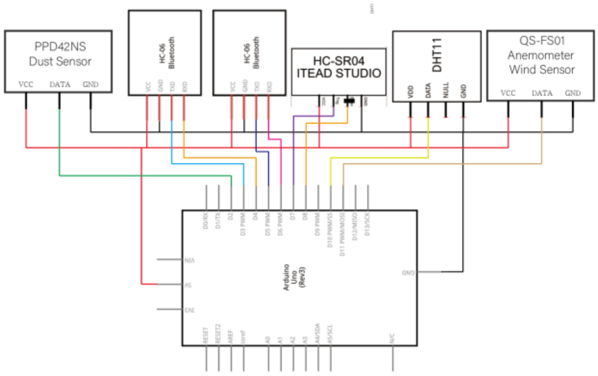

Figure 3. The circuit diagram of the two devices.

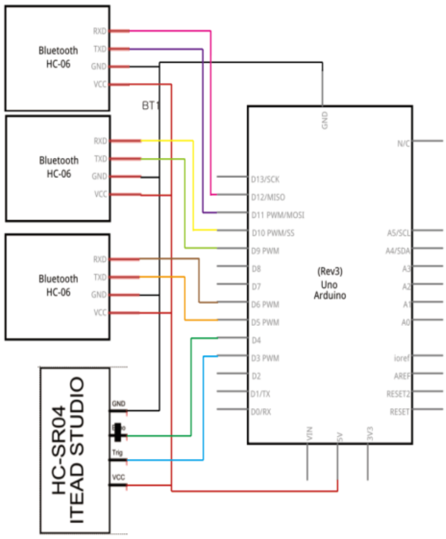

Figure 4 shows Arduino sources to count the number of visitors in two devices. Arduino of the first device detects the visitor using ultrasonic sensor. In this paper, we determine that visitors are detected if the d_a value is less than d_{max} -50 as shown in Fig. 4 (a). When the first device detects a visitor, it instructs the second device to transmit the measured d_b with the ultrasonic sensor as shown in Fig. 4 (b).

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```
void loop() {
   digitalWrite(trigPin1, LOW);
   delayMicroseconds(2);
   digitalWrite(trigPin1, HIGH);
   delayMicroseconds(10);
   digitalWrite(trigPin1, LOW);
   // measure d_a using the ultrasonic sensor
   duration1 = pulseIn(echoPin1, HIGH);
   da = duration1 / 58.2;
   if (da<(d_max-50) && da>0) {   // detect visitors
     // Motion detection
     if (!(da>(da_old-15) && da<(da_old+15))) {
        BTSerial.print('b');  // Send the letter 'b' to the second device
        // read d_b from the second device
        db = BTSerial2.read();
        if (db<(d_max-15) && db>0) {
           dd = da + db;
           // calculate d_w from d_a and d_b
           dw = d_max – dd;
           // calculate the number of visitors using d_w
           N =  dw / 50;
         // The number of visitors is transferred to the third Arduino
         // to provide services.
           BTSerial3.print(N);
        }
     } else {
       da_old = da;
       BTSerial.print('a');
     }
   }
}
```

(a) Arduino source to count the number of visitors in the second device.

```
void loop() {
   char a = BTSerial.read();
   // When the character ‘b’ is received from the second device,
   // the ultrasonic sensor operates.
   if (a == 'b') {
      digitalWrite(trigPin, LOW);
      delayMicroseconds(2);
      digitalWrite(trigPin, HIGH);
      delayMicroseconds(10);
      digitalWrite(trigPin, LOW);
      // measure d_b using the ultrasonic sensor
      duration = pulseIn(echoPin, HIGH);
      db = duration / 58.2;
      Serial.println(db);
      //  The measured value d_b is transmitted
      // to the second device to count the number of visitors.
      BTSerial2.write(db);
   }
}
```

(b) Arduino source to measure the value of da in the first device.

Figure 4. Arduino source to count the number of visitors.

The first device calculates the number of visitors using the d_a value measured by the ultrasonic sensor and the d_b value received from the second device as follows:

$$N = d_w / 50 \tag{1}$$

where 50 represents the average width of one person. The width of people d_w is calculated as follows:

$$d_w = d_{\max} - (d_a + d_b) \tag{2}$$

where $d_{\max}$ represents the distance between two devices. The number of visitors is measured by the d_a value measured by the first device after the visitor has passed through the device. In this paper, we determine that visitors have passed through the device if d_a is changed by more or less than 15 for the previous measured value as shown in Fig. 4(a). Interference signal between ultrasonic sensors can occur when two devices are used to count the number of visitors. In this paper, we solve the interference problem by using the Bluetooth module in each device. When the first device detects the visitor, it sends the character ‘b’ to the second device. When the second device receives the character ‘b’ from the first device, it measures d_b with an ultrasonic sensor.

The Korea Meteorological Administration (KMA) issues a fine dust warning to refrain from going out if the concentration of fine dust is high. The device measures the concentration of fine dust on walking tour sites and is provided to visitors as a smart tourist app. The fine dust concentration data measured at walking sightseeing sites are provided as environmental data of tourist sites through big data analysis. The device provides wind speed data measured at a walking destination. The instrument measures fine dust at key points in the tourist destination and provides fine dust concentrations before or during visits to tourist sites. Jeju walking sightseeing spot is located in the middle mountain area, so the temperature is lower than the general walking sightseeing spot. Walking spots can be relatively humid because the forests are lush. The device provides temperature and humidity data at major points of interest to visitors to the summer tourist destination. The user can receive the environmental data measured in conjunction with the device by using the Bluetooth communication function of the smartphone. We provide users with environmental information and data analysis results of real-time tourist sites through smart tourism apps as shown in Fig. 5.

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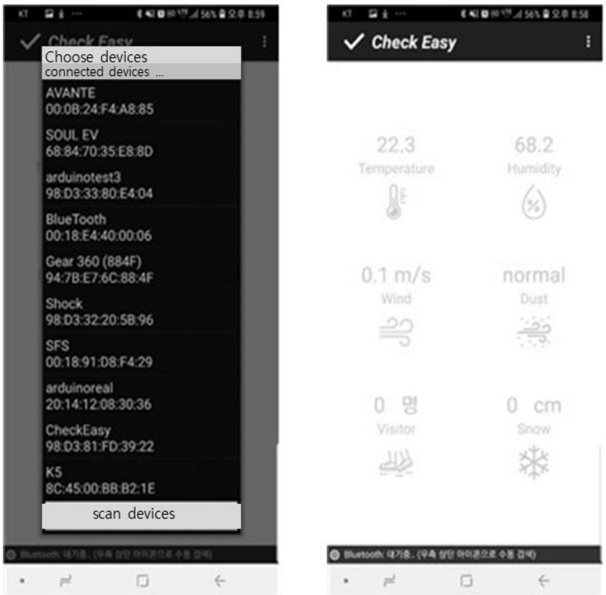

Figure 5. Smart tourism app based on IoT technologies.

Table 1. Power consumption of Arduino and sensors.

Arduino and Sensors	Voltage (V)	Current (mA)	Power Consumption (mW)
Ultrasonic sensor (SR-04)	5	2	10
Bluetooth(HC-06)	5	8	40
Fine dust sensor (Grove)	5	90	450
Temperature and Humidity Sensor (DHT-11)	5	2.5	12.5
Wind speed sensor	7	20	140
Arduino	5	46.5	232.5

The two devices are powered by solar panels and auxiliary batteries. We use an auxiliary battery with the capacity of 25,000mAh and 92.5Wh. Table 1 shows the power consumption of the Arduino and sensors used in two devices. We used three Arduinos and sensors within two devices. The first and second Arduino in each device are used to count the number of visitors with the Bluetooth module and an ultrasonic sensor as shown in Fig. 3(a)(c). The second Arduino provides users with measured data from a fine dust sensor (Grove), a temperature and humidity sensor (DHT-11), and an airflow sensor, an ultrasonic sensor through the Bluetooth module as shown in Fig. 3(b). The second Arduino also provides the number of visitors using the Bluetooth module. The power consumption of the first device is 1,277.5mW and the power consumption of the second device is 322.5mW.

III. CONCLUSIONS AND DISCUSSION

The number of tourists visiting Jeju Island has risen rapidly to 14.75 million in 2017 compared to 5.42 million in 2007, economical problems such as congestion cost, waste treatment cost and sewage treatment cost due to traffic congestion are occurring. The number of walking tourists visiting Halla mountain, Orum, Olle road, natural recreation forest, and the road around the Halla mountain (Halla trail) is also increasing. In Jeju there are 368 Oreums, which are parasitic volcanoes, of which more than 216 can be climbed. Jeju special self-governing province is conducting an Oreum resting year to prevent damage to the Oreum trail and summit crater due to increased visitors and to protect plants and animals around the Oreum. Jeju special self-governing province. Jeju special self-governing province has installed a high-priced system to measure the number of visitors to major Oreums. In this paper, we developed the IoT enabled tourism monitoring device installed in tourist attractions. The developed device not only counts the number of visitors, but also measures the data necessary for visitors such as the concentration of fine dust, temperature and humidity, wind speed, and snowfall. The data measured by the device will be provided to visitors through a big data analysis. We plan to supplement our designs eco-friendly and complement the inter-device communication capabilities.

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