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Enhancing Mountain Safety: NFC Beacon Technology Implementation

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Abstract: Modern people mainly use their leisure time for socializing with family acquaintances, health care, interpersonal relationships, and the pleasure of self-satisfaction. According to the 2022 National Leisure Activity Survey, leisure time has been increasing since 2016, and hiking is a leisure activity that many people participate in, ranking third in the main activities of the club and ninth in the most satisfactory leisure activities. In addition, according to the 2021 Disaster Yearbook, the number of accidents in 21 is 6,496, the highest number of accidents in the type of accident managed by local governments. The information on hiking safety accidents in the National Disaster Safety Portal only informs emergency measures and behavioral tips such as the size, speed, and climbing time when hiking but provides little information on accident prevention or accident countermeasures. Accordingly, various studies using IT technology, such as location-based services using GPS (GPS: Global Positioning System), beacons, and drones, have been proposed to prevent accidents and rapid action when they occur. Safety systems using IT technology prevent accidents by notifying users by marking areas with many accidents and quickly identifying the accident occurrence and occurrence location in the event of an accident. Safety systems for accident prevention and action are important to locate, and GPS may be disconnected or difficult find depending on the terrain accurately. On the other hand, beacons have the advantage of being able to locate them accurately. In particular, beacons have the advantage of low power consumption and no limit on the number of connectable devices based on Bluetooth Low Energy (BLE). Against the backdrop, numerous studies have suggested utilizing IT technologies to prevent mountain climbing accidents and quickly respond to them. This study aims to design a mountain safety system that uses beacons and short-range communication technology and implement it as a smartphone application to prevent climbing accidents while providing quick actions should accidents occur. The mountain safety system implemented in this paper provides information on danger zones and mountain climbing tips to prevent accidents and sends location information immediately when an accident happens. It is expected that safe leisure activities will be helpful to modern people by using this paper's convenient and highly usable safety system. Future research will be conducted to build a safety system by integrating various IT technologies with current advantages and disadvantages. This will help build safety systems in various fields not limited to mountain safety systems.

Keywords: Near Field Communication Technology, Beacon, Distress Prevention System, Web, Web Application, Safety Technology, Safety System

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1. Introduction

As IT technology advances, wireless communication technology continues to develop, and various services are being developed and used[1]. People value quality life experiences engage in various leisure activities to satisfy their psychological, social, and physiological needs[2]. According to the 2022 National Leisure Activities Survey by the Ministry of Culture, Sports, and Tourism, mountain climbing was among the top 9 most satisfying leisure activities for people[3]. As the number of people enjoying mountain climbing increases, so does the number of climbing accidents and distress[4]. According to the 2021 Disaster Yearbook, the number of accidents in '21' by type of accident managed by local governments was 6,496, with 4,406 cases, which differed greatly from other types[5]. Mountain climbing accidents have continuously raised the need for a mountain safety system and location information services[2].

The South Korean government's official web portal, "National Disaster Safety Portal," which provides disaster-related information and services, only includes information on safety rules for climbing, maintaining body temperature in case of a disaster, and finding directions without a compass, but does not provide information on how to prevent accidents or how to deal with accidents[6]. To address climbing accidents, the Ministry of Public Administration and Security designated 'National Grid Number', which divides the land and the neighboring sea into 10m × 10m intervals and assigns numbers to each grid. The 'National Grid Number' is a new location indication system that people can easily use in uninhabitable areas[7]. However, the national grid number is written on a 'national grid number plate' which can be damaged and cannot be installed in every area. Mountain accidents can be linked to human accidents, so it is necessary to seek solutions actively. In particular, using IT technology such as wireless communication technology or smartphones has various advantages, such as quick response in emergency, immediate communication, health condition monitoring, and location tracking using GPS. In particular, the Bluetooth 4.0 BLE (Bluetooth Low Energy) method minimizes power consumption through low-speed data transmission[8]. In this regard, GPS to track location information and a ubiquitous sensor network to establish a mountain distress rescue system in national parks have been suggested to prevent mountain accidents[9][10].

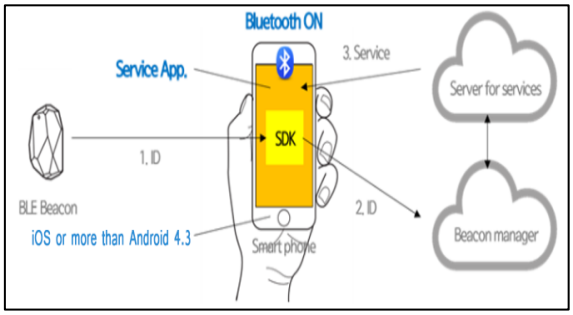
The penetration rate of smartphones for teenagers and adults in Korea was 94.2% as of March 2022. As smartphones have become widespread, they have become not just phones but multipurpose mobile devices[11].

In this regard, this study utilized a smartphone's beacon functions to design and implement a 'mountain safety system', which can provide dynamic and fast mountain information and can quickly help rescue efforts in an emergency. In addition, the system was designed to check users' health to prevent emergencies caused by their physical conditions. Since the system accumulates mountain information as data, it can be used as a new kind of content based on big data, such as the number of mountain climbers in certain weather conditions or seasons, the proportion of accidents. Accordingly, the mountain safety system of this paper aimed to design and implement a convenient and highly usable safety system that consumes less power and is not limited by the number of connected devices by utilizing the wireless communication technology BLE beacon. The results of this study showed that mountain safety systems can be conveniently implemented as smartphone applications that retain all the functions of the systems' original design. The mountain safety system detailed in this paper uses NFC beacons and was designed and implemented as a system that can prevent accidents, provide information along with post-accident measures, and be expanded to other safety systems.

2. Related Research

2.1 Beacon

A beacon is a small device that regularly generates wireless signals, which are the size of Bluetooth Smart. It regularly sends signals to wireless devices located within a base station[12]. A well-known short-distance wireless communications technology is NFC (Near Field Communication). While NFC uses RFID, beacons use Bluetooth. Beacons identify locations within a short distance, providing users with customized information as they move. While it has been a quite long since the beacon has been around, it is currently drawing attention as BLE (BLE: Bluetooth Low Energy), embedded in the Bluetooth 4.0 version, reduces energy consumption and enables simultaneous device connection with an unlimited number of devices. Beacons recognize locations up to 100 m apart and provide users accurate location information even indoors, crowded by many people[13]. [Fig. 3] shows the operation principles of beacons. A beacon is a location-based communication technology. As is shown in [Fig. 1], the beacon attempts one-way Bluetooth communications to the user application SDK[14][15].



[Fig. 1] Operation Principle of 'Beacon'

Beacon sends users' ID values, and the SDK identifies the ID values to communicate with a server. When the beacon enters the working range where the server can determine the entered beacon's ID value, the server starts communicating with the beacon.

In this paper, the beacon's functions were used for the following: an alerting service that informs users of information, a mountain climbing recording service, and a distress recording service.

When a user climbs a mountain, beacon signals recognized by Bluetooth are analyzed to extract a user's ID values, for which data are selected from DB to display a connected page with push messages.

In addition, various mountain climbing activities are recorded and stored to show users information on mountains that they climbed by using beacons, dates, times, and paths.

Lastly, functions for distress were added, which is the most important function for the mountain safety system using beacons implemented in this study. Beacons are installed in spots where distress is easily or expected to occur to send users warnings when they enter the region. GPS coordinates of the beacon are displayed on a map to let users know their location and information, and a compass is displayed so that users can find a trail. Since stored data provides this function, it does not require GPS sensors. When users get injured or need to make a call, they can use a phone feature provided to contact a management office. They can use a call button to contact them through a server if this service is unavailable. In addition, if there is no movement in a certain period or when a user passes a distress position more than twice, he is regarded as being in an emergency. The person's information and location information are sent to a server. This is expected to make a management office easily access the information and quickly respond to situations. To use such functions, users must turn on their Bluetooth while climbing a mountain. The BLE beacon is convenient because it consumes less battery than the existing Bluetooth

protocol[16].

The mountain safety system in this paper can easily provide various information using beacons and quickly identify the exact location without interruption during a safety accident.

2.2 Literature Review

Various studies have been conducted on mountain safety systems using IT technology as the number of accidents caused by mountain climbing activities increases. In the mountain safety system, locating an accident in the event of prevention is important. GPS, beacon, and drone Technologies are often used to find an accident. GPS is a satellite navigation system that calculates the user's current location by receiving signals from GPS satellites, and it is possible to track the user's location in real-time. At this time, a smartphone can be used as a GPS receiver. In the beacon, if a smartphone with Bluetooth enabled is present where transmission and reception are possible, the terminal sends a particular ID, and the smartphone that receives the specific ID can check the location information by delivering it to the beacon server.

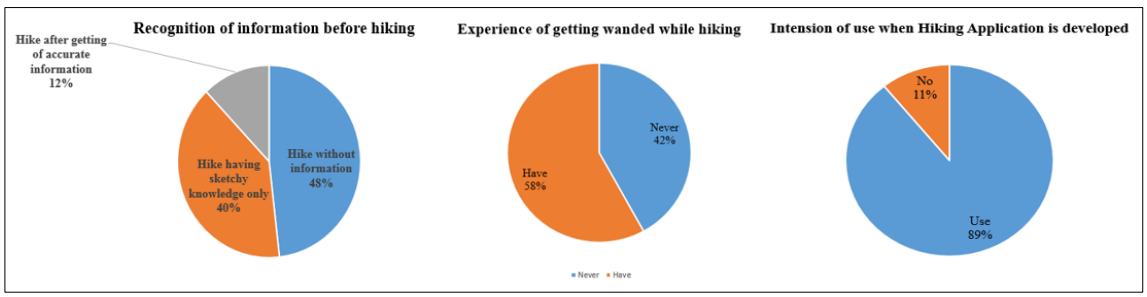
A mountain safety system that uses a specific frequency band transceiver to transmit positional coordinates and generate notifications if the sender is outside the set zone range has also been proposed. The proposed system requires a specific transceiver[4]. The proposed system for measuring the expected location in conjunction with the rescuer's terminal using a GPS-based emergency rescue positioning system aims to reduce the search scope in case of distress[17]. The IoT technology-based mountainous monitoring system uses IoT technology to monitor facility management in mountainous areas and is a facility that does not move to be managed[18]. The safety management service using beacons, sensors, and smartphones implemented a smartphone application that uses the UUID of the beacon as sensor data and recognizes it on the smartphone to generate a notification outside the range specified by the user[19].

3. Research Methodology

The mountain safety system in this paper is a system for promoting the safety of hikers and for providing dangerous sections or information to users. Therefore, it aims to receive quick help in an emergency by immediately transmitting the location.

3.1 Survey

[Fig. 2] shows the survey results to show the necessity of implementing a mountain safety system using beacons. The survey was conducted on 85 people for seven days using NAVER form. The respondents of this survey were 66% for men, 33% for women, 1% for non-response, 12% for teenagers, 59% for 20s, 16% for 30s, and 12% for 40s.



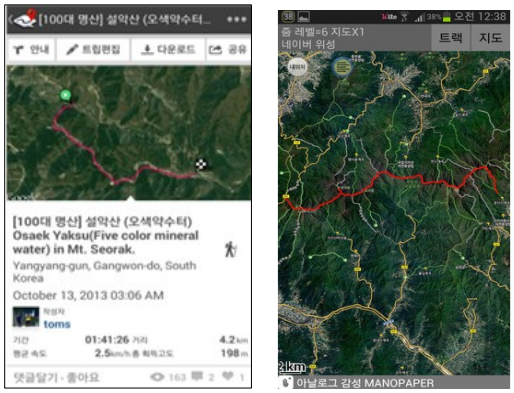
[Fig.2] Survey

The survey was designed to find information on the mountain to climb in advance, whether there was an injury during the hike, how to cope with an injury during the hike, and whether to use the climbing safety app. It turned out that many people need more information on mountains and that 58% of respondents said they had experienced getting injured while climbing a mountain. When they were injured during hiking, 44% contacted 119 and 42% went down the mountain with the help of people around them. 89% of the respondents said they were willing to use a mountain climbing application (if developed) which will provide them with useful information and dangerous situations.

Based on survey results, this study designed an application that records mountain climbing activities and provides users with information such as mountains in the country and distress locations.

3.2 Benchmarking

Many applications regarding mountain climbing are currently developed and used in Korea. These applications used GPS functions to enable location-based services. [Fig. 3] shows ‘Ramblr’ and ‘Nadeuli’, commonly used in mountain climbing applications.



[Fig. 3] Famous Applications for Mountain Climbing

‘Ramblr’ provides not just travel information but also local information. It includes detailed information for each course and measures climbing hours and several exercises. However, new joiners must sign up for a membership to use the application, and leavers cannot use the service. In addition, it does not calculate the number of calories consumed.

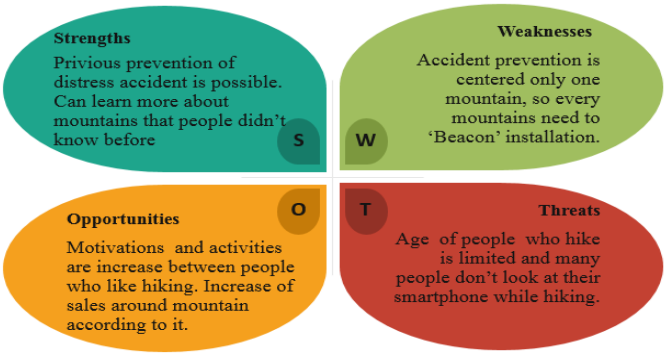
‘Nadeuli’ provides general maps and contour maps of NAVER and DAUM that display the most accurate hiking trails. In addition, users can download the maps to use them offline. Directions automatically rotate the maps. However, category classification could be more accurate, and errors frequently occur while running search functions.

Besides, ‘San’, developed by Friends C&C, provides locations and basic explanations of mountains across the country. However, category classification is not that accurate, and error frequently occurs while running search functions.

After benchmarking numerous mountain climbing applications, the ‘mountain safety system using beacons’ used in this study was implemented in a way that is easy to use, providing users with a quick overview of application information and information on mountain courses, legs, and mountains across the country. In addition, by using beacons, functions providing location information were added to prevent emergencies including distress. Real-time information delivery functions were also added with beacons. Benchmarking hiking apps provides hiking information, but this paper's app is designed and implemented to provide hiking information and to cope with and prevent accidents during mountain climbing.

3.3 SWOT Analysis

[Fig. 4] shows the analysis of the SWOT of a ‘mountain safety system using beacon’.

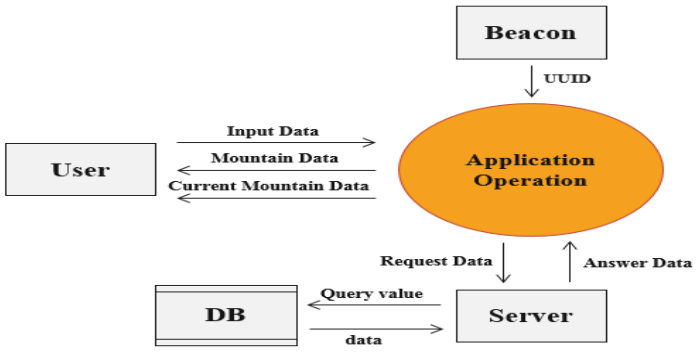


[Fig. 4] SWOT of ‘Mountain Safety System of Beacon’

The system proposed in this paper has the advantage of preventing distress accidents in advance. It can increase motivation and hiking activities for those participating in hiking clubs. However, it has the weakness of installing beacons on each because the prevention of accidents or accidents is only geared to the mountains. The ‘mountain safety system using beacons’ implemented in this study also helps increase demand from climbers for nearby shops. Considering most climbers enjoying mountain climbing are middle-aged, there is a problem with them tending to refrain from using smartphones during climbing. However, accident-preventing functions might effectively prevent accidents among them in advance. Installing beacons requires money and effort. However, installing them to facilitate mountain climbing properly and avoid mountain accidents is necessary.

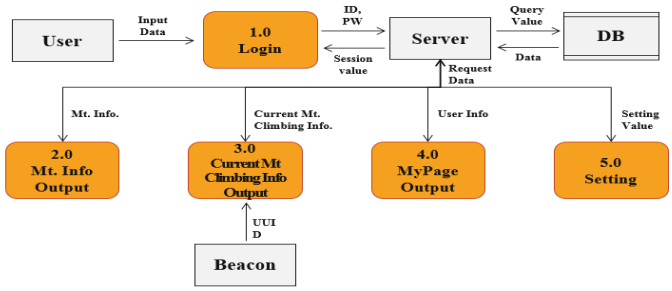
3.4 Data Flow Diagram (DFD)

[Fig. 5] shows the Context Diagram of a system implemented in this study, showing its relations with objects such as ‘Beacon’, ‘Sever’, ‘User’, and ‘Database’.



[Fig. 5] Context Diagram

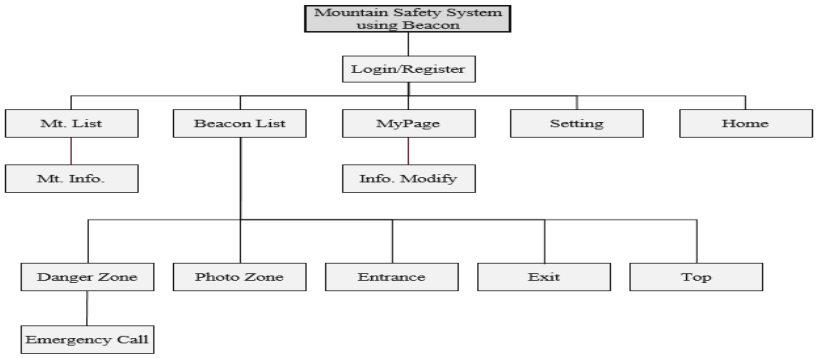
[Fig. 6] shows the top-level diagram of the ‘mountain safety system using beacons’ implemented in this study. Five functions such as ‘Login’, ‘Mountain Information Output’, ‘Current Mountain Climbing Information Output’, ‘My Page Output’, and ‘Setting’ were implemented for the system.



[Fig. 6] DFD Scheme

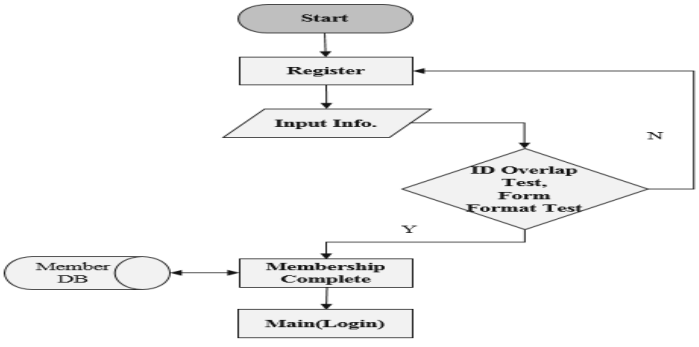
3.5 Flow Chart and Scenario

[Fig. 7] shows an overall system structure of the ‘mountain safety system using beacons’ implemented in this study. This system can be used by logging in through membership registration and is designed to have the functions and detailed functions of 'Sanlist', 'Beaconlist', 'My Page', 'Settings', and 'Home'.



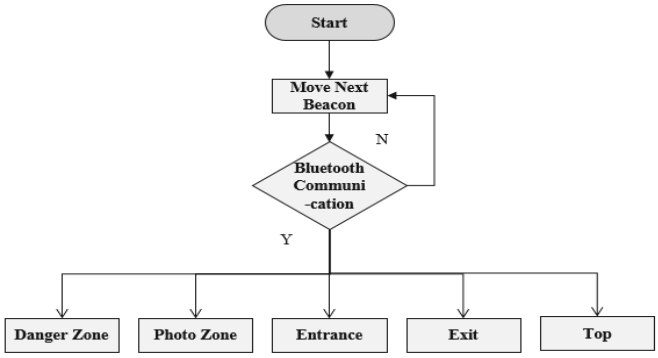
[Fig. 7] Overall System Structure Diagram

[Fig. 8] shows a flowchart of ‘Membership’. A user should provide brief personal information to sign in to be rescued if lost. The login information is maintained in a local section.



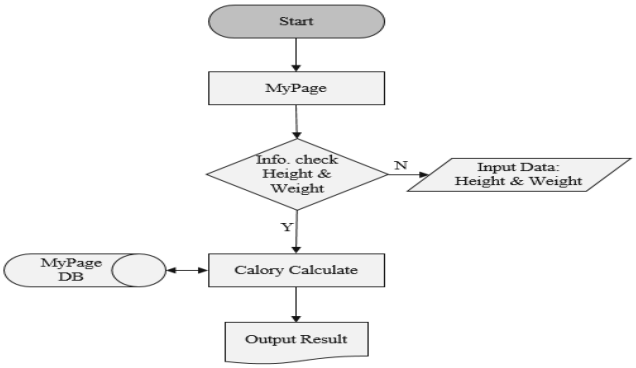
[Fig. 8] ‘Membership’ Flowchart

[Fig. 9] shows a flowchart of ‘Beacon Push Notification’. When a user turns on the beacon function at the entrance and uses the ‘Find Entrance’ function, beacons are recognized. When the beacon is recognized, beacons in the mountain are identified and information on the mountain is provided. Bluetooth is automatically turned on when the climbing starts and turns off when the climbing ends.



[Fig. 9] 'Beacon Push Notification' Flowchart

[Fig. 10] shows the flowchart of 'My Page', which calculates a climber's physical conditions and amounts of exercise to prevent emergencies caused by excessive exercise.



[Fig. 10] 'MyPage' Flowchart

[Table 1] shows the beacons designated for implementing a mountain safety system using beacons. They include 'Entrance', 'Top', 'Photo Zone', 'Danger Zone', 'Distress Spot', and 'Exit'.

[Table 1] Kind of Beacon using System

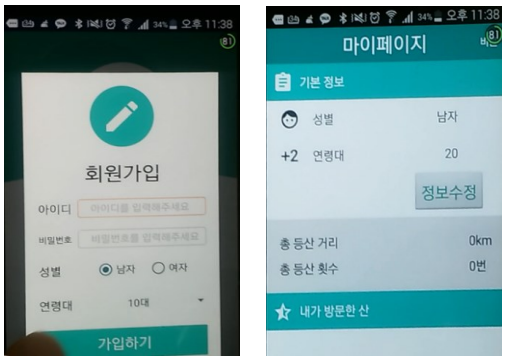
Beacon Name	Function
Entrance	Provide information about the entrance; start counting hiking time
Top	Provide information about the mountain and time of arrival at the top
Photo Zone	Provide around sight as image information, and recommend a good spot for taking pictures.
Danger Zone	TCY road, rockslide section, and steep slope to tell the risk degree of those sections.
Distress Point	Provide map information and compass; provide a calling function
Exit	Identify Beacon, Record saves hiking activities and shows the recording list.

The 'Entrance' beacon counts climbing hours, collects climbing data and recognizes the 'Exit' beacon. 'Danger Zone' beacon informs users of danger areas such as roads covered with ice, rockslide-prone areas, and steep slopes, preventing accidents in advance. When beacons are recognized, push messages linked to the page are sent to users so that users can see dynamic information even when the smartphone screen is turned off.

4. Implementation

The mountain safety system in this paper implemented an application to convert the requested data after catching the beacon signal using Android's Bluetooth library.

[Fig. 11] shows the ‘Login’ and ‘My Page’ of a ‘mountain safety system using beacons’.

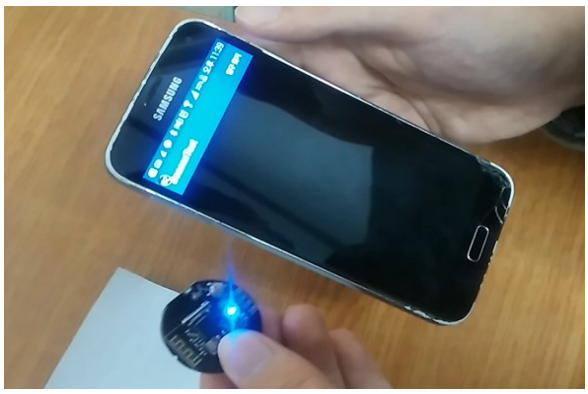


[Fig. 11] ‘Membership’, ‘MyPage’ Implementation

[Fig. 12] shows 'Mountain Information', adding a phone call function so that users can connect to a management office in an emergency.

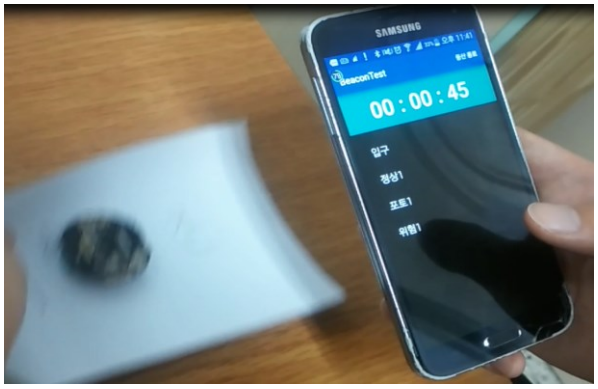
[Fig. 12] ‘Mountain Information’ Implementation

[Fig. 13] shows a screen of users at an ‘Entrance’ beacon. When users arrive at the ‘Entrance’ beacon, the beacon is recognized, and climbing hours to the top are calculated and displayed.



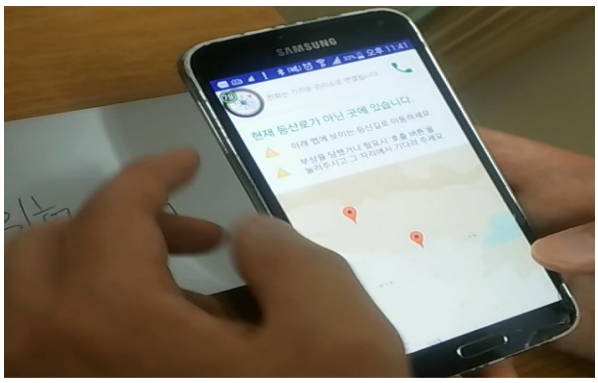
[Fig. 13] ‘Entrance’ Beacon Recognition

[Fig. 14] shows a screen where ‘Danger Zone’ is recognized.



[Fig.14] ‘Danger Zone’ Beacon Recognition

[Fig. 15] shows a screen where the ‘Danger Zone’ beacon is recognized, informing users that they are out of a climbing trail.



[Fig. 15] Action following ‘Danger Zone’ Beacon Recognition

5. Conclusion

In this paper, a mountain safety system using the short-range wireless communication function beacon of a smartphone was designed and implemented for the convenience of users in implementing a mountain safety system to prevent mountain climbing accidents and quick action in the event of an accident. {1-8}Beacon provides user dynamic information without GPS, uses BLE to consume less power, and enables simultaneous connection with unlimited devices. The ‘mountain safety system using beacons’ developed in this study was designed to provide users with information like danger zones to prevent accidents in advance and quickly send their location information to address the situation when an emergency happens. It was investigated that leisure expenditure fell due to the economic downturn, but leisure time increased[20]. Hiking is a highly preferred leisure activity and carries a risk of accidents, and a national designation number is operated to prevent and cope with accidents. However, the national designation number has the possibility of damage, and in this case, it is difficult to cope with accidents. In this paper, a mountain safety system was designed and implemented using a developing IT technology. The safety system using the beacon used in this paper is not limited to a system for mountain safety. Still, it can be used in various fields such as marine safety systems and fall safety systems.

Beacons have the advantage of accuracy, but they have the disadvantage of collision when device installation, personal information infringement, and multiple beacons are operated simultaneously. In the future, to expand to various fields and compensate for the shortcomings of beacons, we plan to study how to integrate technologies such as GPS and drones, which are widely used to identify the basic location of safety systems, and beacon technologies. This study aims to study how to use GPS and beacons together to solve the problems of GPS signal interruption in certain places, such as inside tunnels, and how drones can move quickly after accurately detecting specific areas using beacons. Integrating the existing safety system and beacon technology will help build various safety systems.

In this paper, a safety system using NFC Beacon was designed and implemented to enable seamless and accurate location to cope with hiking accidents, which are highly preferred leisure activities.

The system introduced in the paper is expected to help prevent mountain accidents in advance so that climbers can safely enjoy their leisure activities. This system will also be an ICT integration to replace the existing National Grid Number.

6. Acknowledgments

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