International Journal of Engineering & Technology, 7 (2.12) (2018) 316-320

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research Paper

A study on implementation of human-friendly system for providing safety management in IOT environment

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Abstract

This paper suggests the Human-friendly integrated system on the basis of IoT, which can prevent a Haenyeo at work under the sea from an unexpected accident. This system can process thedata based on the stored data, after building the database of the information from Smart Taewak. As a united software, IoT based Haenyeo Safely Managing Software (IOTHSMS) is composed of Data Collection Module, Server Device, Emergency Alarm Module, and Monitoring Program, providing service in various ways. Smart Swimming Goggles collect the information on Haenyeo's activities and gives it to Smart Taewak, which transmits the data to IoTHSMS server. IOTHSMS needs to access to a PC or a Mobile Phone. IOTHSMS divides the information into the location and the condition of Haenyeo to indicate the POSITION information of Haenyeo at work and services provided by privileged permission. The STATE information of Haenyeo is separated into recent information and statistic one. IOTHSMS should not only have a function to manage user's information but also the authority to modify PIN number, telephone number, mobile phone number, affiliated fishing village fraternities, and emergency call number in specifically. This study improves the former goggles and Taewak as Smart goggles and Smart Taewak with an IoT technology, the device to understand and analyze the state and the location information of a Haenyeo every real time by measuring her body condition and diving information.

Keywords: *IoT; Goggles; Taewak; Safety; Management; Software*

1. Introduction

The core agenda of Davos Forum held in January, 2016 was about mastering the Fourth Industrial Revolution. It suggested that convergence science and technology should bring about the new generation industrial innovation and presented the representative technologies such as AI, IoT, Robot Engineering, Big Data, Wearable Computer, Driverless Car, etc. To meet the demands of the time, each country across the world struggles to establish technological strategies which fit for developing a wide range of IT industrial economy. First of all, IoT technology attracts the extraordinary attention, which leads to communicating actively between an object and another object or still another server without any human being's management, and utilizes the IT devices such as a smart phone directly.

As a network, IoT makes connections among a man, objects, and each of dispersed service technologies with one another depending on every circumstance. It consists of an IoT service, a Sensor technology, the technology of Network infrastructure, and so on. Smart farming technology, an example of Sensor technology, is based on the sensor data and the ubiquitous production management environment(Luiset al., 2009).As a network infrastructure technology, Smart Home Service and Solution based on IoT internet attracts consumers (Kim, 2016), which can result in potential profit constantly from now on. IoT service technology is highly efficient in predicting and preventing a misfortune disaster because the technology can predict a disaster precisely to manage all the procedure of the disaster systematically (Jain, 2016).

Gartner Inc. calculates that IoT devices will have been used from 8.4 billion units in 2017 to 20.4 billion in 2020 as shown in Fig. 1(Egham, 2017).

IoT Units Installed Base by Category (Millions of Units)

Category	2016	2017	2018	2020
Consumer	3,963.0	5,244.3	7,036.3	12,863.0
Business: Cross-Industry	1,102.1	1,501.0	2,132.6	4,381.4
Business: Vertical-Specific	1,316.6	1,635.4	2,027.7	3,171.0
Grand Total	**6,381.8**	**8,380.6**	**11,196.6**	**20,415.4**

Source: Gartner (January 2017)

Fig. 1: Iot Units Installed Base by Category.

IoT technology was announced to stand at the highest point on Hype Cycle by Gartner Inc. in November, 2016 as seen in Fig. 2 (Kasey, 2016). According to Hype Cycle, there are three phases during the process of a technology: (1) The first phase, "Innovation Trigger": the potential of the technology reveals itself (2) the second one, "Peak of Inflated Expectations": the technology draws public attention (3) the third one, "Trough of Disillusionment": the technology reaches the limit in itself (Kasey, 2016). The current IoT technology is on the summit of Peak of Inflated Expectations, and afterwards it keeps on taking some level of its position and awareness in the market.

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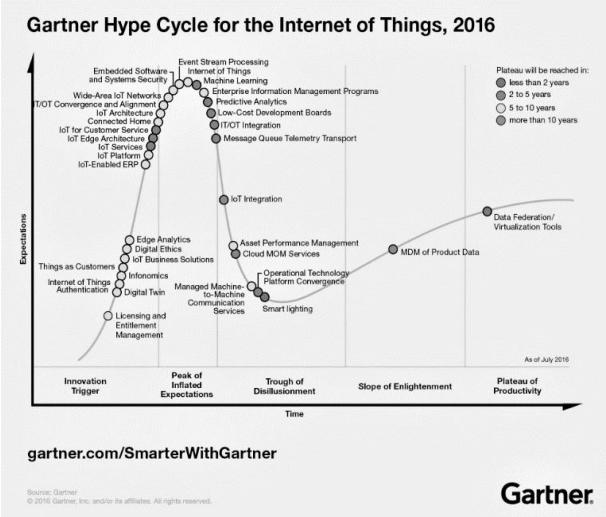


Fig. 2: Gartner Hype Cycle for the Internet of Things.

IoT technology which is good for the accident prevention or the social security is able to be applied to every field in the society. When a worker or a visitor wears a protection gear at the site under construction, for example, IoT technology will be activated, monitoring the motion of the man. An office can install IoT mirror, which is a facial recognition system to forbid an unauthorized person from entering the office. In the case of wearable IoT technology, it can take in a dangerous situation and give an alarm immediately when a subway maintenance worker goes into the screen door.

This paper suggests the software on the basis of IoT, which can prevent a Haenyeo at work under the sea from an unexpected accident, and describes the specific cases to realize the software. Haenyeo was designated as the number one of the national significant fishery heritage and the culture of JejuHaenyeo was registered as UNESCO mankind intangible cultural heritage (KTO, 2016) on November 30th, 2016. And then, Haenyeo standing for a Jeju woman diver was selected as a Korean intangible cultural asset by the Administration of Cultural Heritage on April 21st, 2017. The number of Haenyeo grows smaller and smaller from 14,143 in 1970 to 4,300 in 2015. What's worse, there are negligent accidents every year due to the hard working environment (Choi, 2014). Thus a Haenyeo at work under the sea needs the service system of the information based on IoT so as to perceive herself in danger, turn to the outside for help and result in accident prevention. It is essential that Zigbee and Global Positioning System (GPS) should be used to catch and monitor the location and the state of a Haenyeo while working in the ocean as they play a key role in maintaining security as well as managing health of a Haenyeo. The location chase algorithm technology based on IoT will be widely useful to manage the motion of daily objects in many ways.

2. Related works

Taewak and Diver's Goggles: Haenyeo uses the tools to pick seafood such as Diver's goggles, Taewak, a net attached beneath Taewak, an iron spear, and a hoe. Among them Taewak is an empty gourd (a buoy) foating on the surface of water all the time. A Haenyeo in goggles carries a hoe and a spear in her hand, dives into the deep sea, harvests seafood for about 1-2 minutes, and comes back to Taewak floating on the sea. Taewak devised to inhale air was registered as a patent and utility model for Taewak by Pan-seok Park (Park, 2014) in 2014, which enables Haenyeo to breathe easily despite raging waters. Furthermore, An Emergency Situation Perception and Notifying Apparatus for Underwater Worker devised by Mi-Ja Parkin Fig. 3 (Park, 2016) was registered in 2016, which enables a Haenyeo to press a button and send a signal of help request when she finds herself in danger. Taewak to which any other IT technology is not applied directly, however, plays such a few roles as getting a minute's breathing on the surface, hanging the seafood she's got, or locating the position of an accident.

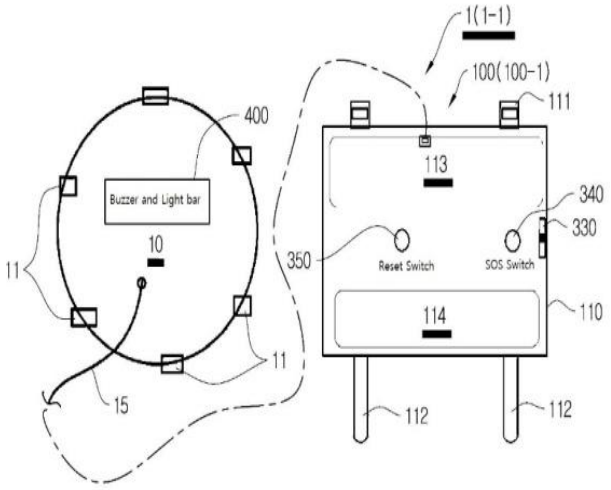


Fig. 3: An Emergency Situation Perception and Notifying Apparatus for Underwater Worker.

Swimming goggles equipped with oxygen bottles by Ho-geolJoo (Joo and Yoon, 2014), a patent in 2014, enables Haenyeo to breathe in and out under water for a few minutes thanks to the oxygen bottle attached to the goggles, which helps pick a lot of seafood. The simple goggles without an IT sensor technology have difficulty in grasping the locating information of a Haenyeo and the state of her mind and body.

Therefore, if IoT technology like GPS and Zigbee is adapted for Taewak and swimming goggles, the necessary tools, they can contribute to monitoring the motion of Haenyeo and to preventing an accident.

GPS and Zigbee Technologies: GPS is a tool to search for location information in Location Based Service (LBS) (Kim and Kim, 2016). LBS is a kind of service to create a new one by keeping on receiving the signals from a terminal unit through a GPS satellite or a mobile communicating network and by catching its location from the received information. Jung (Jung et al., 2015) designs the process system of tourism information acquisition, supplying a mobile tourism platform like destination information, data management, arrangement of an expedition team, and each own team's history management. The location notification system needs API using GPS. Im (Imet al., 2013) suggests the walking trail applications based on GPS to connect cultural and local information with a variety of applications. It is focused on the story telling effect.

GPS technology in this study is designed to collect the coordinates from the location information sensor to grasp the location of smart Taewak, which consists of Application Processor (AP) to process all the data, WCDMA Modem as a long distance mobile communication RF solution, Zigbee Module as a short distance mobile communication RF solution, GPS Module to monitor the location of Haenyeo at work, and power suppliers.

Zigbee provides the sensing information every real time and manages its sensor module. The size of Zigbee is as big as that of a wireless personal communicating network operating on 868MHz, 902~928MHz, or 2.4GHz. On the wireless personal network, it is possible for the devices around it to receive and transmit the data with one another within approximately 50m at the highest rate of 250Kbps.

Gehlot (Gehlotet al., 2016) proposes the street monitoring system which enables street lights and their controller unit to communicate with each other using Zigbee. The distance between street lights and their controller unit is short, while that from the main server to the street lights is far away from each other. Although they are a great distance away, the system can monitor the situation of the street lights in real time. Zigbee protocol determines three types of node such as coordinator(C), router(R), and endde-

vice(E) and needs a coordinator per a network. As shown in Fig. 4(Hasan and Haque, 2016), it is possible that each node gives and takes all data among one another.

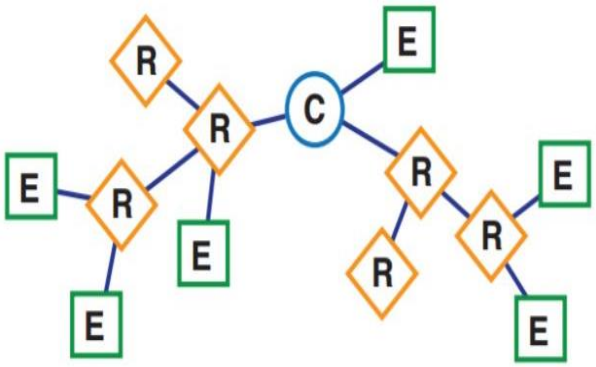


Fig. 4: ZigBee Mesh Network.

Zigbee technology in this study catches and process the data telecommunicated from Smart Swimming goggles near Smart Taewak and then transmits them to Main CPU. Smart Swimming Goggles are equipped with temperature sensor and pressure sensor under water once Haenyeo wears the goggles, which plays a part in a source to collect data. Zigbee Module is in charge of a short distance wireless transmission and reception as well as a data processor.

3. Materials and methods

The Human-friendly integrated system: The Human-friendly integrated system to keep a Haenyeo safe consists of three components as shown in Fig.5: 1) IoT based Haenyeo Safely Managing Software (IoTHSMS) 2) A Smart Taewak 3) A pair of Smart Goggles. The software as a human-friendly system collects much information like diving location and its depth, the body temperature of a Haenyeo and her working time under the sea. In addition, it aims to produce the data of healthcare from such diver's diseases as a decompression sickness. Its information serves as keeping her safe in a quick response while the diver is in danger.

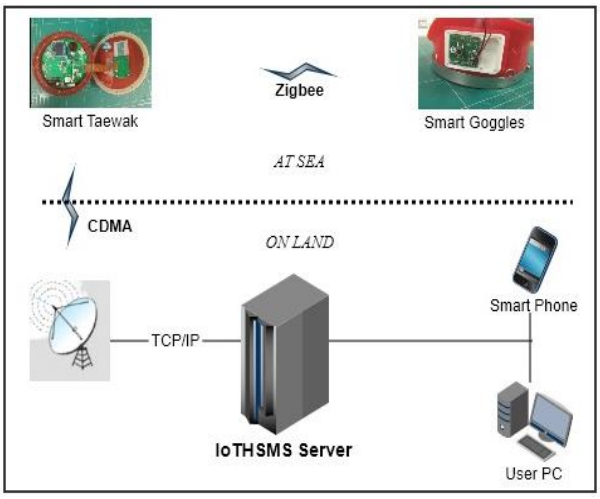


Fig. 5: The Human-Friendly Integrated System.

IoT HSMS gathers and stores the basic standards about Haenyeo's body conditions at the area of the sea in the way of TCP/IP. It also processes the stored data and provides every information necessary to prevent safety accident. Here are the basic standards: the body temperature of a Haenyeo, her submerged frequencies, her working time, her diving depth, and her locating information, SOS signals, etc.After building the database of the information from Smart Taewak, IoTHSMS is able to generate processed data on the basis of the stored data.

As a united software, IoTHSMS is composed of Data Collection Module, Server Device, Emergency Alarm Module, and Monitoring Program, providing service in a wide range of ways. Smart Swimming Goggles collect the information on Haenyeo's activities and gives it to Smart Taewak, which transmits the data to IoTHSMS server. When the server receives SOS notice from Smart Taewak, it sends the notice to Smart Swimming Goggles and makes Haenyeo realize her situation at work.

The Definition of Requirements for IoTHSMS:IoTHSMS needs to access to a PC or a Mobile Phone. IoTHSMS manages the information into the location and the condition of Haenyeo to indicate the location information of Haenyeo at work and services provided by privileged permission. The location information must be zoomed in and out on the screen map. It is necessary that the location information appears along with the user's location. The condition information of Haenyeo is separated into recent information and statistic one. The former shows the latest conditions of Haenyeo that the user can understand easily in many different types. The latter enables the user to check her body temperature, the bottom time, and diving frequencies every hour and to download the data in Excel conversion.

IoTHSMS should not only have a function to manage user's information but also the authority to modify PIN number, telephone number, mobile phone number, affiliated fishing village fraternities, and emergency call number in specifically. The condition information of Haenyeo offers services optionally according to privileged permission. If the user clicks the locating point of Haenyeo, IoTHSMS should present her latest information. Furthermore, it can identify her statistic information, clicking the name of the latest information. It should have functions like SOS sign and sending text message.

The Design of the Functions of Smart Taewak and Smart Swimming Goggles: Hardware consists of a set of Smart Taewak and Smart Swimming Goggles so as to monitor the diving location of Haenyeo obtained from GPS Module attached to Smart Taewak and the body temperature, the submerged depth, and the bottom time of Haenyeo, which Main AP of Smart Taewak processes. Haenyeo's Smart Swimming Goggles are a device equipped with a temperature sensor and a pressure sensor to gather the data of her physical conditions. Zigbee Module processes the data and beams up them to Smart Taewak, as a short distance transmitter-receiver.

4. Software implementation and evaluation

Fig. 6 is the Block Diagram of IoTHSMS, working in a responsive web type. It enables a user to get the diver's locating information and her physical condition on a smart phone or a personal computer.

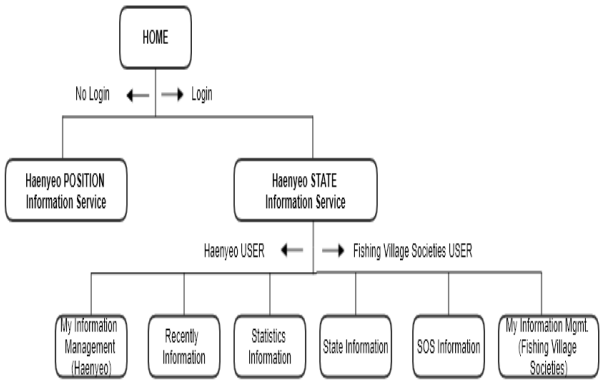


Fig. 6: The Block Diagram of IoT HSMS.

Haenyeo POSITION Information Service supplies the divers' location information to a vessel operator even though he or she cannot log on to it. The service contributes to protecting a Haenyeo under the sea from being run over by a vessel. It has a lot

of main functions marked on the screen map: marking diving position of each Haenyeo at work along with its collecting time, locating the position of the vessel operators and the divers under the sea, displaying the time of collecting the information, and so on.
Haenyeo STATE Information Service is designed to provide the information to only permitted users who log on to the server. It establishes clear-cut lines of authority to Haenyeo USER and Fishing Village Societies USER. Haenyeo USER can receive her own information, and Fishing Village Societies USER can get all the information of all Haenyeos belonging to its community. The service enables the community user to catch SOS and to take an immediate step in emergency. The latest information of the service contains these functions: marking Haenyeo's latest conditions on the screen map and providing a chart and a line graph of her latest conditions.
Statistics information includes the display functions: marking the graphs of user's hourly, daily, and monthlybody temperature information, the graphs of user's daily and monthly bottom time, the graphs of user's daily and monthly diving frequencies, and the graphs of user's hourly, daily, and monthly diving depth.SOS information has the function: displaying fishing village Societies user's daily and monthly SOS signs. Fishing village community user can register the base line information of the community Haenyeo, adding registration management function to the service by recording the details such as Haenyeo's name, affiliated fishing village societies, serial number of Smart Taewak(selective input), telephone number, and mobile phone number, and emergency call number.

tb_monitoring_info (8×1) tb_monitoring_buoy (4×53)

MONITORING_ID	COLLECT_DT	GPS_LAT	GPS_LNG
20151229_T151201003_0000000009	2015-12-29 10:38:10	33.51963179	126.5293471
20151229_T151201003_0000000009	2015-12-29 10:39:10	33.51962697	126.5293451
20151229_T151201003_0000000009	2015-12-29 10:40:10	33.51963172	126.5293498
20151229_T151201003_0000000009	2015-12-29 10:41:10	33.5196317	126.5293492
20151229_T151201003_0000000009	2015-12-29 10:42:10	33.51963067	126.5293504
20151229_T151201003_0000000009	2015-12-29 10:43:10	33.51963278	126.5293539
20151229_T151201003_0000000009	2015-12-29 10:44:10	33.5196303	126.5293504
20151229_T151201003_0000000009	2015-12-29 10:45:10	33.51962798	126.5293464

Fig. 7: GPS Location Coordinates Saved on the DB of IoT HSMS Server.

IoT HSMS is evaluated about how much accurately it inquires information in six fields such as 1) the diving frequencies of a Haenyeo 2) her diving depth 3) her working time 4) her body temperature 5) her diving location 6) SOS information. For instance, both Fig.7 and Fig.8 verifies the accuracy with which the original data collected from Smart Taewak is used for monitoring ordinarily, telecommunicating with IoT HSMS server. After transmitted to IoT HSMS, the saved materials in the Data Base are the same as those of SD memory built in Smart Taewak.

F22 33.51962697

	E	F	G	H
1	Taewak GPS Data			
2	Time(H:M:S)	Latitude	Longitude	
18	10:35:10	33.51963654	126.5293435	
19	10:36:10	33.51963333	126.5293483	
20	10:37:10	33.51963652	126.5293447	
21	10:38:10	33.51963179	126.5293471	
22	10:39:10	33.51962697	126.5293451	
23				

Fig. 8: Gps Location Coordinates Saved On The SD Memory Of Smart Taewak.

It is on the sea in real life situation that Zigbee communication connection between Smart Taewak and Smart Swimming Goggles is tested. The data from the smart goggles is transmitted to the smart Taewak, which sends the event signal and synchronized data in itself to the goggles.Now that it is impossible to connect Zigbee communication in the deep sea, the measured temperature and the bathymetric data from the goggles can be transmitted to Smart Taewak within below 20cm of water level. In addition, the data transmitted from the goggles are sent to Zigbee receiving module on the land, which makes sure that there is no difficulty in simultaneous transmission and reception at the distance of 25~50m. GPS data measuring apparatus measures GPS coordinate every second. The estimated GPS coordinates are stored in the memory every five minutes. The result of the test verifies every coordinate value is all serene by comparing itself to that of latitude-longitude on the map.Every unit function of Smart Swimming Goggles is tested and confirmed in the rea life situation of the sea. Haenyeo's temperature is checked at the interval of 1~3 seconds by measuring Haenyeo's facial temperature into ADC value through NTC temperature sensor. The measured ADC value is converted into the temperature value via Resistance Temperature Table, and the converted value is saved in the inner memory.
Sounding the depth of water is measured with the pressure of the goggles'pressure sensor at the same interval of measuring temperature. The measured pressure value is converted into the depth of water by meter, and the converted value is stored in the inner memory, too.As a whole, the data collected from Smart goggles are sent to Smart Taewak, whose synchronized Data and SOS event signals have no difficulty in being transmitted to Smart goggles from Smart Taewak.

5. Conclusion

New trendy IoT technology is applied to the development of information system to monitor objects' motions and to prevent accidents in many areas of society. JejuHaenyeo, designated as the number one of the national main fishery heritages and a UNESCO mankind intangible heritage, demands the development of IT technological solution to vitalize and last Haenyeo culture as well as to keep fishing operation safe. This is an indispensable solution that facilitates getting the base line Data for managing Haenyeo's health and prevent a safety accident.
This paperproposed the former goggles and Taewak as Smart goggles and Smart Taewak with an IoT technology, the device to understand and analyze the state and the location information of a Haenyeo every real time by measuring her body condition and diving information.Smart Taewak communicates with GPS receiver and the server by modifying the buoy floating on the surface of water while Haenyeo is at work. Smart Goggles, modified swimming goggles, transmit their data collected from underwater to Smart Taewak in Zigbee communication system when Haenyeo sticks her head out of water after working. IoTHSMS continues to collect and manage Haenyeo's diving information and when perceiving danger in the sea, it sends asking help. It also plays a key role in managing Haenyeo's health and safety by using the ways like announcing the location automatically in emergency.Furthermore, it can be desirable to consider it regular monitoring to use a drone which provides wireless LAN support as a way of improving the performance of IoTHSMS in the oceans without communications network. The way has such advantages as not only perceiving and telecommunicating the ocean situation accurately without delay but also recording video information.
Future direction of the research is toward reducing GPS reception error probability of Smart Taewak as a way of increasing the efficiency of the entire system. It will be a good instance to use a digital cell site on the ground. If the site on the ground checks the error of the signal from the satellite, it will make a user get more precise location information than it does at present. In addition, it will be another good one to record the altered location information of Smart Taewak with constant patterns in IoT HSMS. If the differences of the patterns are analyzed in real time, Smart Taewak will contribute to catching more accurate location of Haenyeo than it does up to now.

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