International Journal of Engineering & Technology, *7 (3.33) (2018) 120-123*

International Journal of Engineering & Technology

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

Research paper

Senior Living Space Architecture Design based on Iot Devices Using Vital Sensors

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Abstract

This paper seeks to propose a senior living lab prototype based on the Internet of Things (IoT). Currently, IoT research is actively being conducted in various fields, and the field of IoT healthcare for elderly people is being highlighted with a rapid growth of ageing population. In this paper, a living lab platform was designed to recognize the movements of elderly people in real time and measure the quantity of motion by using Arduino's ultrasonic sensors and to help maintain a comfortable environment by using temperature & humidity sensors, which complemented the shortcomings of living lab based on the IoT healthcare.

Keywords: *Senior, Arduino, Living Lab, IoT(Internet of Things), Ultrasonic Sensor (HC-SR04).*

1. Introduction

With a recent increase in ageing population, the health and medical problems in the elderly are becoming major social issues. Since the greatest concern among elderly people is to check and maintain their health, it makes their lives more convenient to check and solve health-related problems for themselves. Most of the elderly people spend a lot of time indoors rather than outdoors due to their physical limitations[1,2],. As their indoor activities increase, it has become necessary to conduct a study on the smart home that provides monitoring health information, crime prevention and security services for the elderly. To this end, a platform called living lab has been in operation. The living lab can be said to be a 'user-participatory innovation space' where users can solve problems by themselves. In other words, it is a methodology to give feedback regarding problems that may occur after product commercialization to potential users by allowing them to participate in all stages of development, and thus to enhance the completeness of products and systems[3,4,5]. However, the current living lab has its limitation in that it is difficult to check responses and results in real time. To address this problem, users and care givers need to be able to check the measurement and analysis results whenever necessary.

In this regard, this paper investigates the case of a living lab for seniors that ensures real-time measurement and analysis based on the Internet of Things (IoT). In order to perform activity monitoring through the motion detection of elderly people, the living lab is designed to recognize the position based on the network and motion sensors, measure the quantity of motion through the results and maintain a pleasant environment with the use of temperature & humidity sensors, thus to demonstrate the possibility of real-time living lab operation[6,7].

2. Related Research

2.1. IoT

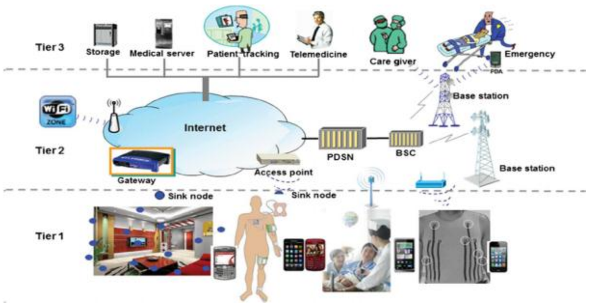

Fig. 1: IoT Healthcare

The Internet of Things refers to the network of physical devices in which tangible and intangible objects are connected together in a variety of ways to provide new services that individual objects cannot provide. The Internet of Things literally menas the network of 'internet connected things' or 'internet composed of things'. Unlike the conventional Internet configured using computers or mobile phones capable of wireless internet access, the Internet of Things is configured by connecting all objects in the world such as desks, cars, bags, trees and dogs. [8,9]

The IoT has recently been utilized in a variety of fields. In particular, the usage of the IoT in the field of healthcare is expected to provide momentum for further growth of the healthcare industry that has continuously created new markets and business areas through the convergence of conventional media with new technologies. It is also expected to contribute to reducing medical expenses and improving service quality by being integrated into healthcare service sectors such as elderly home care and chronic disease treatment and management, and to become a paradigm innovation of the healthcare industry [3, 10,].

2.2. Living Lab

The living lab can be said to be a 'user-participatory innovation space' where users can solve problems by themselves. In other words, it is a methodology to give feedback regarding problems that may occur after product commercialization to potential users by allowing them to participate in all stages of development, and thus to enhance the completeness of products and systems. The actual living lab business has been underway since 2003, but is still in its infancy[11, 12]. In recent years, diverse organizations such as the central government and local governments, the innovative subjects of industry, academic and research institutions, and Seoul Innovation Park have introduced living labs to develop products and services, create public infrastructure, solve social problems and promote local and social innovation. In Korea, the living lab has been emphasized as a model for innovation led by social entities (local residents, users, etc.) and a place for society, field and community-based innovation.

2.3. U-Healthcare System

u-Healthcare is an area of technology that uses a large number of environmental and patient sensors and actuators to monitor and improve patients' physical and mental conditions in a networked system. u-Healthcare system is a system with ubiquitous access to e-health. The service of U-Healthcare system is not restricted only to clinics and hospitals but is available at every place. U-healthcare system is about management of EMR (Electronic Medical Record), PACS (Picture Archiving Communication System), HIS (Hospital Information System), OCS (Order Communication System) and enhancing healthcare by increasing the availability of patient monitoring devices, and various health data of the patients to physicians[13,14].

2.4. Vital Sensing

Sensing part is the place where changes in physical and chemical phenomena that occur in the human body is detected. Many physical and chemical actions occur in the human body to sustain life by homeostasis, and appropriate physical phenomena need to be converted into electric signals that can be processed to measure information about health of individuals, and kind and degree of diseases. The configuration is made to detect the light emitted from the light source using LED and CDS Cell by an optical sensor after being reflected in the living tissues, including blood vessels[15]..

3. Senior Living Space Architecture Design

3.1. Components of Living Space

As aging of the elderly is making progress, the physical function declines and the adaptability to surroundings is deteriorated. So, they cannot but feel discomfort in physical movement and in all areas of life, as well as feel uncomfortable in their own living space. The life experience hall is aimed at drawing the social interest in the elderly, increasing the understanding between the elderly and the would-be elderly, and promoting an intergenerational integration by encouraging young people to experience the physical, mental and social changes in the elderly, including their discomfort caused by such changes.

The experiential process consists of the pseudo-experience of an elderly person, in which the muscular strength of upper and lower body is oppressed by wearing an experiential clothes is realized.

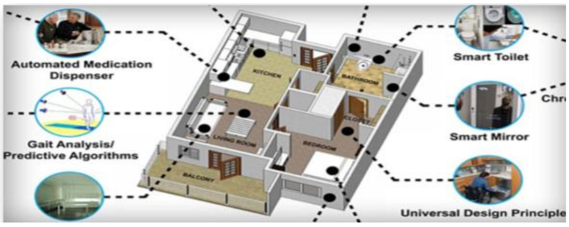

Fig. 2: Senior Living Space aritecure

1) Automated Medication Dispenser
It is a system to give a notice for specific time to the elderly or change the lighting color of the entire house to a specific color so that they can take their medicine on time.
2) Smart Toilet
The automatic stand-up smart bidet prevents the elderly from falling down and getting hurt in slippery places such as toilets. In addition, it helps to manage their health by analyzing their body information when they stand in front of the wash basin in the bathroom.
3) Smart Refrigerator
It analyzes the nutritional status of occupants and ingredients in a refrigerator, and recommends nutrient-rich foods necessary for the health of users.
4) Smart Mirror
It automatically analyzes the body information such as the complexion of face, checks the health conditions and informs elderly individuals of the necessary exercises.
5) Gait Analysis
Walking is something that the average person probably doesn't give much thought. It's our most basic method of transportation, but an inability to walk or be mobile can drastically change a person's life. It can impact our independence and also create significant health problems over both the short and long term.
It performs a gait analysis through the gait sensor and gives advice about healthcare for the elderly. In case of an injury from a fall, the floor detects the impact, which is connected to a medical institution.
Many people can move about with abnormal or asymmetrical gait patterns for years without any symptoms. However, when someone experiences an injury or pain, normal gait can be altered, resulting in abnormal walking that can lead to bigger health issues.
When particulate matters generated during cooking which lead to adverse health effects occur, it detects air pollution and operates the sensor to open the ventilation window.

In this paper, the living lab platform was designed with a focus on gait and air purification systems among those above.

3.2. Measurement of Motion Quantity

An IoT device that can measure the quantity of motion by using the HC-SR04 ultrasonic sensor of Arduino was developed as a system for measuring the motion quantity implemented in this paper. The features of the HC-SR04 module are as follows. [6] ESP8266 was used for the specifications of the IoT device. It is a low-cost Wi-Fi module which is not only small and light, but also affordable to ensure easy access. In addition, it has an advantage in that its production process is simple since the development environment was created using programs written by Arduino Software called sketches.

Table 1: Features of HC-SR04

Working Voltage	DC 5V
Working Current	15mA
Working Frequency	40Jz
Max Range	4m
Min Range	2cm
Measuring Angle	15 degree

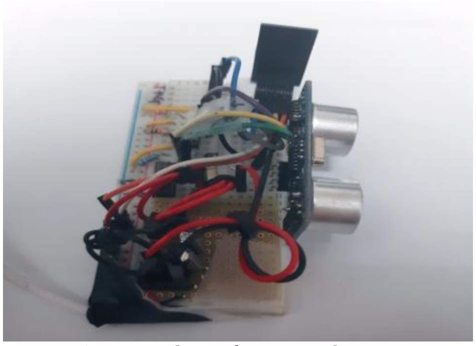

Fig. 3: IoT device for motion detection

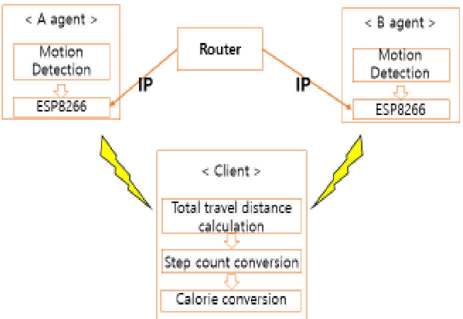

Fig. 4: Flow of communication between IoT device

The router assigns the IP to the ESP8266 of A agent and B agent. When the ultrasonic sensors in each agent detect the movement, the information is passed to the Wi-Fi module, and the agent and the client exchange information with each other. The client server was created using the Processing program. Even if Processing is based on the JAVA programming language, and Arduino is based on C++-, the program is very similar to Arduino IDE, which is relatively easy to use. The client server receives information from the agent and can identify which agent detects the movement.

It is placed inside the house, and then records the movement which is detected within a certain distance and confirms that the elderly enter the location. As a result of the experiment, the following output window shows that when a distance of less than 10cm is recognized at A and B points, they approach the place. Therefore, it is possible to predict the distance traveled between the sections by counting only the number of times that it has been taken accordingly.

In general, walking 10,000 steps a day burns about 300 Kcal, and thus walking 30 steps burns about 1 Kcal per day.[8] Based on this finding, the total quantity of motion can be obtained by measuring the distance between A and B points with the use of values from the experiment results, dividing the number of times sensed at each point by two, and multiplying the number of times and the distance of intervals between them. Therefore, the conversion of the obtained distance value into the number of steps makes it possible to identify the calorie consumption according to the travel distance of the elderly. Under the assumption that the distance between A and B is 4m, the number of round trips is 20, and the walking stride is 40cm, the person walks 8000/40 =200 steps. Since walking 30 steps burns 1 kcal, the person consumes 200/30 = about 7kcal.

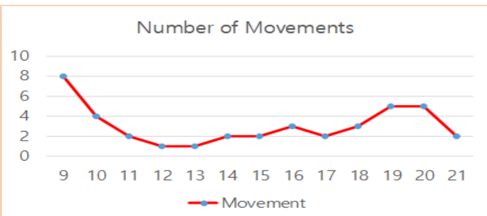

Fig. 5: Simulation of momentum measurement

Fig 5 is a graph based on the experimenter's life style. This indicates the number of moves made between sections. The number of movements combined to predict calorie consumption using the calculation method described above.

The formula for the calorie consumption according to the number of steps is calorie consumption (kcal) = body weight (kg) × number of steps × 5.5. The results can be connected to a smartphone and then be compared with the appropriate quantity of motion for the corresponding age group after measuring the motion quantity of the elderly. In addition, when the data is collected, the change can be confirmed at a glance. Thus, this prototype has its advantages in that it can check the movement at any time and confirm the response in real time unlike the conventional method of measurement and analysis.

3.2.Temperature & Humidity Measurement

The homepage tool of ThingSpeak is utilized to build a temperature & humidity data server. The ThingSpeak homepage is an open source IoT application and API that stores and retrieves data from things by using the HTTP protocol over the Internet or a local area network (LAN). It has advantages in data management and visualization.

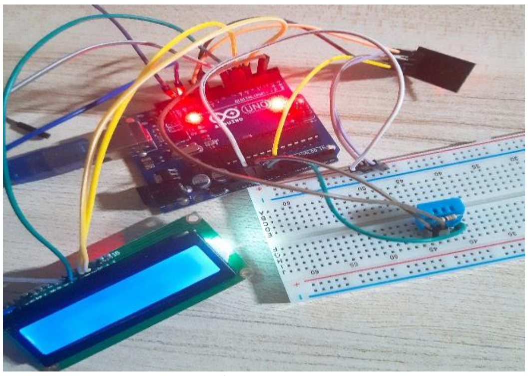

Fig. 6: IoT device for temperature and humidity

The room temperature and humidity can be checked using Arduino Uno as an Arduino board and DHT11 as a temperature & humidity sensor. The DHT11 uses an electrostatic humidity sensor and a thermistor to measure the ambient temperature and outputs the measured value as a digital sensor signal. In the case of the electrostatic humidity sensor, the resistance value changes according to the humidity of the sensor, and the thermistor is a device of which resistance value varies depending on the temperature difference.

The LCD was connected to the Arduino so that the measured temperature and humidity could be checked on the Arduino. [9] Temperature & humidity sensors were attached to the inside of the house to allow users to check the temperature and humidity in real time and provide them with the visualized information of the collected temperature and humidity values. Fig. 7 and Fig. 8 are graphs from the data collected from the device, which are sent to ThingSpeak.

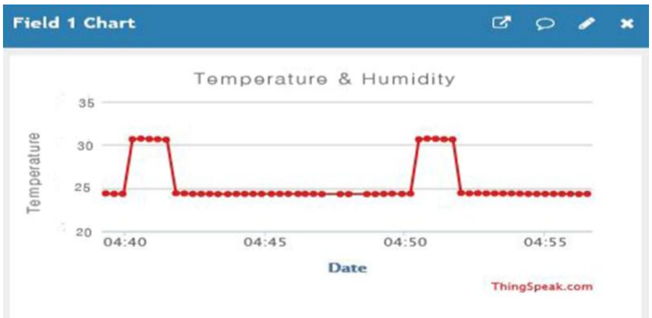

Fig. 7: Temperature measurement

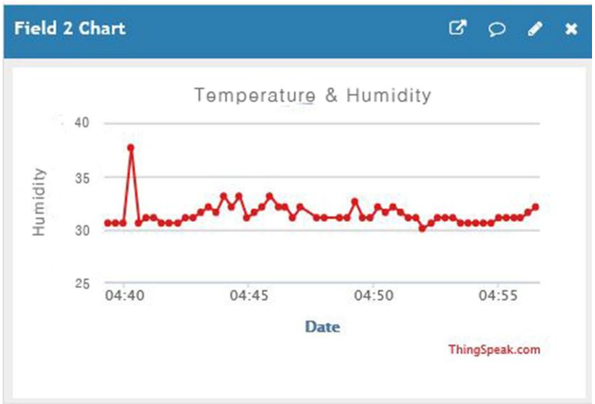

Fig. 8: Humidity measurement

4. Conclusion

This paper investigated the case of a living lab for seniors that ensures real-time measurement and analysis based on the Internet of Things (IoT). First, an IoT device was developed to implement a system that detects the movement of the elderly and calculate the quantity of motion. In conjunction with medical institutions, this system can be connected to the nearest hospital, which provides timely medical treatment when emergency situations occur. Next, a system to identify the room temperature and humidity by using humidity & temperature sensors and then visually show the results was implemented to continuously monitor the room temperature and humidity. In addition, if a problem occurs in the environment, it helps to keep the environment pleasant by suggesting a solution with a notice or automatically operating the ventilation system. The advantage that these systems have in common is that mass production is possible since they are easy to implement and can be configured at a low cost.

Acknowledgement

The project has been possible due to the collaboration of Fine tech water CO., Ltd and Seoungnam Senior Experience Complex 's staff and students as well as many other institutions, companies, individuals and colleagues.

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