Research Article

Smart Health Safety Clothes using Motion Capture

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Abstract: Recently, the general public's sports activities have become common and people's scope of movement and location have become broader, so the frequency of an unexpected accident during sports and exercise activities regardless of time and place has increased accordingly. Therefore, the need of a training suit equipped with various healthcare functions was raised. There is also a growing need of smart training suit enabling the communication with various devices in accordance with the 4th Industrial Revolution era. Therefore, this study intends to design and implement a system using IoT technologies, Arduino, GPS, and motion capture technologies for a training suit that can collect and analyze various health data of the wearer and prevent the occurrence of an unexpected accident. It is expected that the wearer can check his/her own health at anytime and anywhere and reduce the risk of unexpected accidents.

Keywords: IoT, Arduino, Sensor, Motion Capture System, GPS

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1. Introduction

The result of the Actual Condition Survey of Sports Safety Accidents conducted by the Korea Sports Safety Foundation showed that 64.3% of the people in korea suffered an injury during exercise. The main reason for such injury was 'immoderate movements' for both normal people and professional athletes and the second reason was 'slip and fall down' for normal people and 'collide with another person' for professional athletes. In particular, in case of mountain climbing which is a type of recreational sports enjoyed by many people, 13,864 accidents with 10,396 casualties occurred during the last two year. This shows that anyone can face an unexpected accident at anytime and anywhere while enjoying sports **(Seok-Min Shin, 2007).**

In this study, a relatively inexpensive arduino was used to implement a system that can prevent a sudden accident which may occur during sports activities as much as possible and immediately respond to such accident when occurred **(Jong-Min Eun, et. al, 2018; Jeong-Joon Kim, et. al, 2017).** A system that collects health data of a wearer through temperature and body temperature biosensors, identifies the wearer's problem using motion capture system, analyzes all data, and sends an emergency relief request signal to the nearest hospital to the wearer through a built-in GPS was designed and implemented **(Byung-Wook Jin, et. al, 2016; Soowook Lee, 2017).**

2. Related Works

2.1. IoT(Internet of Things)

An IoT environment that supports the connection between people as well as the communication between a person and an object and between objects without human intervention using a terminal such as a computer and smartphone is emerging. In the IoT environment, an object that exists in a physical world senses by itself and the sharing of sensing information through Internet becomes available and various services can be provided through the interaction between a person and an object and between objects. To realize such IoT environment, many electronic and communication companies as well as university research laboratories are actively conducting researches on IoT technologies **(Hong Eun Jung, et. al, 2018; Quoc, et. al, 2018).**

2.2. Arduino

Arduino is an open source-based single board microcontroller and it controls I/O devices connected to this controller and signals and carries out responses. Arduino is connected to a PC through a USB connector, and a program developed in PC can be uploaded to the flash memory on the board without a separate additional system. It enables an easy development without complicated program loading steps for general embedded programming and additional systems **(Kyeong Hur, 2017; Joonseok Jung, et. al, 2017; Young-Hyun Chang, et. al, 2017).**

2.3. Motion Capture System

The motion capture system collectively means systems and technologies for selecting an object including living things such as people and animals and other moving objects and extracting certain information related to the movement of such objects including location, speed, and direction. The system for capturing a motion provides various functions such as 3D visualization, editing, saving, and analysis for obtained data using exclusive software. Such obtained specific information is called motion capture data. Motion capture data is used in a broad range for producing smooth movements of a character in media such as 3D animation, movies, and games or analyzing various movements of people including walking and movements in virtual reality and tracking the location of an object **(Eun-hye Sung, 2014; Eun-So Choi, et. al, 2017; Seong-Jae Lee, et. al, 2018).**

2.4. GPS

GPS is an abbreviation of Global Positioning System that uses a satellite, and this system obtains the position of an observation point by receiving a radio signal sent by a satellite that knows an accurate position and measuring the time taken to the observation point **(Woo-Seong Jeon, 2006; Yong Jun Yang, et. al, 2018; Yu-Jin Kim, et. al, 2016).**

3. Smart Drinking Control System

3.1. System Design

In this study, a wearable smart training suit was produced using Arduino board; heartbeat sensor and electromyogram sensor to measure the wearer's heartbeat and electromyogram; motion capture sensor for collecting motion data of the wearer; Bluetooth communication for linkage with a smartphone or a desktop PC; and GPS module to determine the wearer's location. A system that can identify the target information and location on a smartphone or a desktop PC using such system is suggested. The relevant system design drawing is as shown in Figure 1.

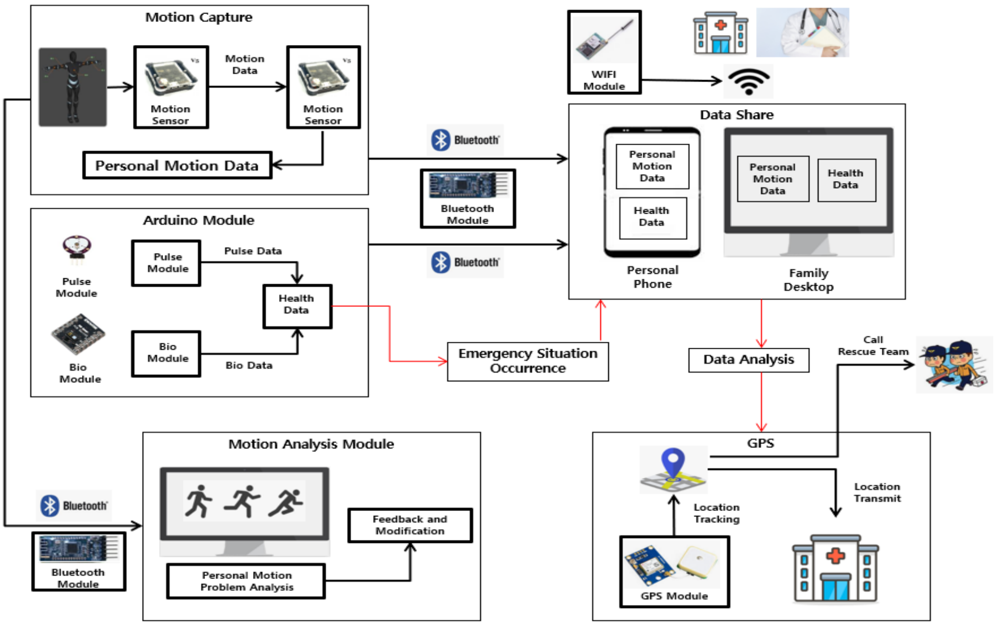

Figure 1. System Architecture

This design drawing presented a system that can identify the information on a smartphone or a desktop PC using various Arduino body biosensors, motion capture sensor, Bluetooth communication, and GPS. The heartbeat and electromyography sensor collects the wearer's health data through Arduino. The motion capture sensor collects motion data obtained when the training suit wearer carries out an exercise. The GPS module identifies the wearer's latitude and longitude values. The collected data are sent to the connected smartphone or desktop PC through Bluetooth. Through this, a person (either the wearer or his/her family members) who has a device connected through Bluetooth can check and analyze health data at anytime and anywhere.

3.2. System Implementation

The system in this study was implemented on Microsoft Windows 10 Home Premium K 64bit operating system. Figure 2 shows an overall performing algorithm that uses Arduino's heartbeat, electromyogram sensor, Bluetooth, GPS module, and motion capture sensor. When a wearer begins exercising, the motion capture sensor collects the wearer's action data and heartbeat and electromyogram sensors collect the wearer's health data, then the system sends such data to a laptop PC or cellphone via Bluetooth module so that the wearer can view and analyze his/her own health. If the wearer's heartbeat data is higher than 100 and the electromyogram for contraction and relaxation is 280 or higher and 780 or higher, respectively, the wearer can lower the level of his/her exercise with caution and if the values are serious, the system sends the wearer's location data obtained through GPS module to a hospital.

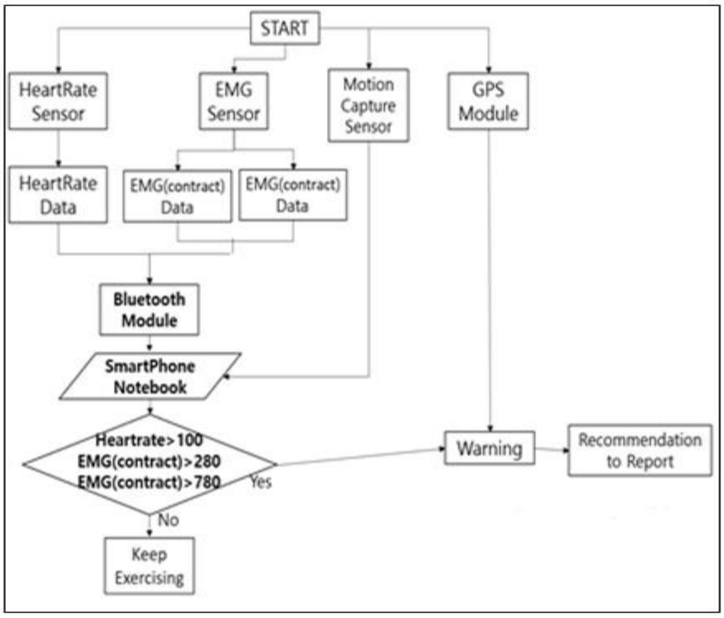

Figure 2. Execution Algorithm

3.3. System Implementation Results

The system implementation result suggested in this study is as shown in Figures 3, 4, 5, and 6. Figure 3 shows Arduino Uno, heartbeat sensor, and electromyogram sensor connected and linked with a laptop PC, allowing the wearer to check his/her own health data. This linked system can be applied to previous training suits to receive health data in the same way.

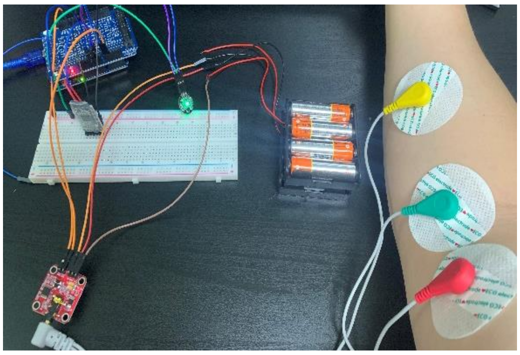

Figure 3. System Implementation Results 1

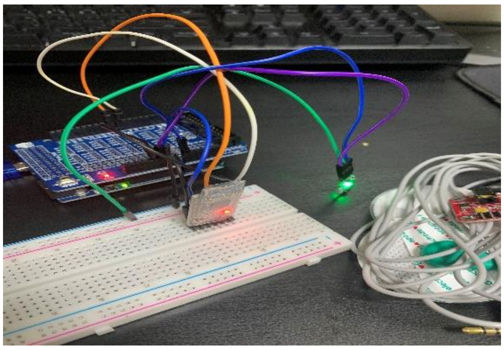

Figure 4. System Implementation Results 2

Figure 4 shows the implementation result of the wearer's health data obtained through the implementation result shown in Figure 3 to allow the wearer to check his/her own health data in real time using a cellphone through Bluetooth communication, and it is possible to respond to the occurrence of the wearer's health issue or emergency situation by analyzing the received data.

Figure 5 shows the activation result of GPS module and the location of a wearer can be received using a laptop. As the most important function of this training suit, the location information obtained through GPS module can be sent to the wearer's family members or a hospital to prepare for an emergency situation if it is judged that the health data of the wearer indicates a problem.

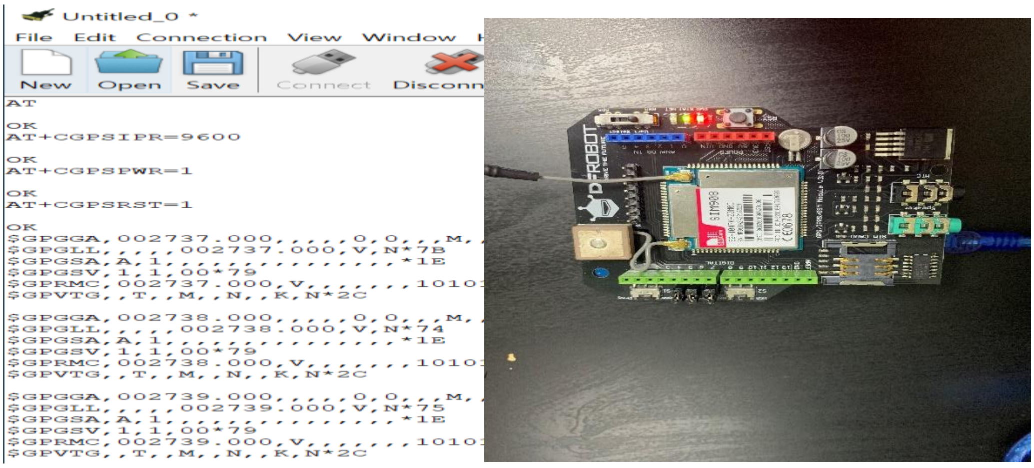

Figure 5. System Implementation Results 3

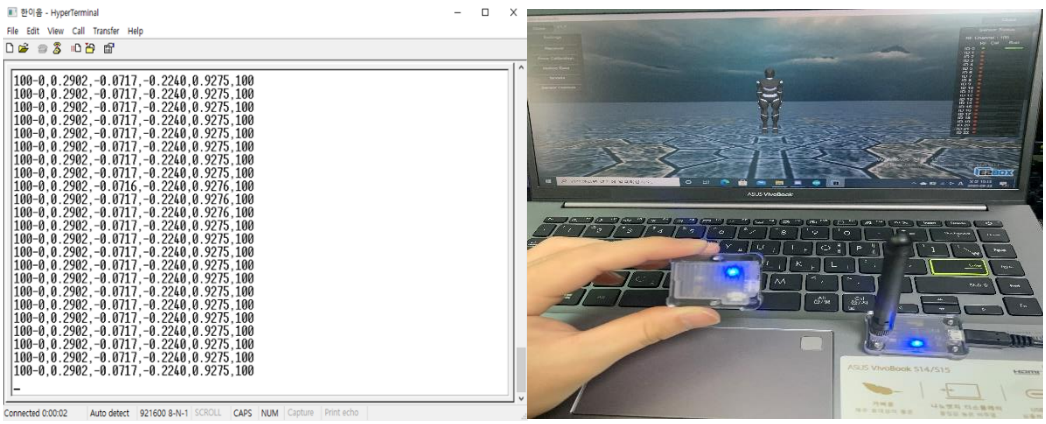

Figure 6. System Implementation Results 4

Figure 6 shows the implementation result of the function to collect the wearer's action data through motion capture data receiver and motion capture sensor, and computer graphic data obtained through the sensor can be converted into text data and such data can be received through terminal.

4. Performance Evaluation

In the performance evaluation of the wearable smart training suit using Arduino, GPS module, and motion capture sensor, the wearer's heartbeat and electromyogram, the accuracy of GPS module, motion capture data, and GPS module's location data (latitude, longitude) were measured. The result shown in Table 1 is health data measured using heartbeat and electromyogram sensor during simple arm exercise, and the heartbeat was maintained between 61 and 80 which was the ordinary heartbeat level of a person and the maximum heartbeat of 110 was recorded at the time of exercise. Electromyogram was maintained consistently at the average value for both contraction (Average: 200, maximum: 260) and relaxation (Average: 530, maximum: 700) at the time of exercise, ensuring the reliability of the data.

Figure 7 shows data obtained from Table 1 into a graph. As shown in the graph, average heartbeat value is recorded continuously and electromyogram data for both contraction and relaxation is similar to an actual value. Table 2 shows the difference between actual location values and values measured using GPS module for both latitude and longitude. There is a slight difference between actual values and measured values but the error is not significant, so accurate location information can be provided when the location information of the wearer is measured using GPS signal.

Table 1. Measurement Comparison

	HeartRate						
num	1	2	3	...	48	49	50
ASCII CODE	AA (65)	AA (65)	AA (65)	...	CC (67)	CC (67)	BB (66)

	Electromyography						
num	1	2	3	...	48	49	50
EMG (contract)	220	215	223	...	229	240	218
EMG (relaxation)	576	589	600	...	560	577	530

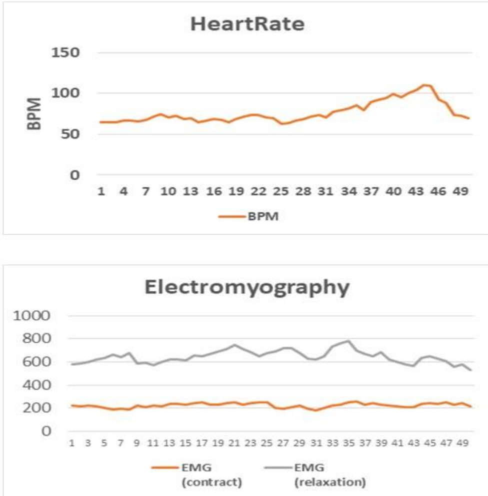

Figure 7. Measurement Comparison

Figure 8 shows the location data of the wearer obtained from Table 2 into a graph. This shows a very slight error between the measured values and actual location values for both latitude and longitude.

Table 2. Error of GPS Measured Position

	Current Latitude	Measurement Latitude	Latitude error
1	37.530533	37.530512	−0.000021
2		37.530498	−0.000035
...		...	...
29		37.53213	−0.001597
30		37.53056	−0.00002

	Current Longitude	Measurement Longitude	Longitude error
1	127.131294	127.131276	−0.000018
2		127.131250	−0.000044
...		...	...
29		127.14510	−0.013806
30		127.12121	+0.010084

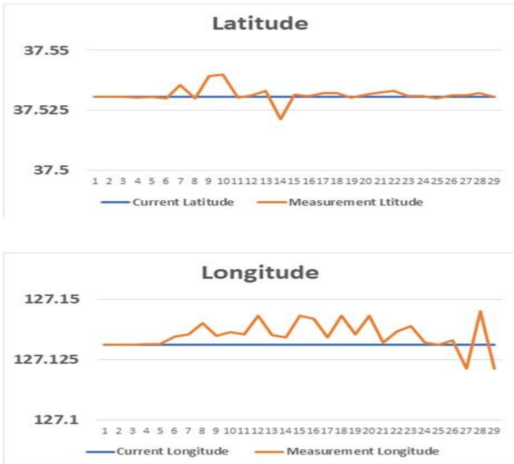

Figure 8. Error of Measured Position

5. Conclusion

In this study, the wearable smart training suit system was designed and implemented using Arduino board, heartbeat sensor, electromyogram sensor, Bluetooth communication module, motion capture sensor, and GPS module. This system sends health data of a wearer obtained through Arduino heartbeat and electromyogram sensors to a smartphone, desktop PC or laptop PC through Bluetooth module, checks the health and action data of the wearer in real time, examines and analyzes system data with the wearer's action data obtained through the motion capture sensor, gives a feedback immediately or judges that there is a problem if a certain level of data is measured, and sends location data to a near-by hospital through GPS and an algorithm. This measure was presented in order to reduce and prevent unexpected accidents during sports activities.

Currently, the system is implemented to send health and action data of a wearer to a smartphone, desktop PC or laptop PC through Bluetooth so that the wearer can view and judge his/her own data. It is planned to supplement the system in the way that the system sends such data to a hospital in real time, enabling a doctor to make an accurate judgment regarding the wearer's health in the future.

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