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Research Article

IoT Band: A Wearable Sensor System to Track Vital Data and Location of Missing or Earthquake Victims

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Abstract:

Natural disasters, especially earthquakes, have caused and still cause serious loss of life in our country. Since many of our cities are located on fault lines, earthquake or collapse risks threaten our lives. In this study, a wearable sensor and tracking system has been developed to prevent or minimize the loss of life after a possible earthquake. The presented system consists of a wristband prototype designed to instantly monitor the vital data and location of victims trapped under the rubble. The wristband prototype includes a GPS module, a temperature sensor and a pulse oximeter. While the vital data of the victim is monitored by the temperature sensor and pulse oximeter, the location information of the victim is received via GPS. The data read from these sensors via a controller is transferred to a display screen through a wireless communication module. A computer and a mobile application were developed as the display screen. A Wi-Fi module was preferred for wireless communication. As an alternative to the Wi-Fi module, a GSM module was added to the wristband prototype. Thus, the order and time of rescue interventions for people trapped under the rubble can be determined. The presented work can be used not only for collapse and earthquake victims but also for Alzheimer's patients or people with poor mental development thanks to the GSM module. In this case, the patient's vital data and location will be transmitted to the user's relatives.

1. Introduction

Natural disasters are a threat to our lives today as well as in the future. Especially earthquakes have taken and continue to take a high number of lives today. If precautions specifically for earthquakes are not increased, these casualties may increase [1]. If the earthquake is considered in 3 stages, precautions should be increased for all 3 stages of a possible earthquake. These stages are 1) before the earthquake, 2) during the earthquake and 3) after the earthquake.

In case of natural disasters, the expeditious identification of individuals who have survived within structures that have collapsed is of the utmost significance. The prevailing approach for searching is reliant upon the accounts of survivors, to ascertain the conceivable existence of casualties beneath the debris. To reduce mortality after a natural disaster, it is important to monitor vital data of a person trapped under rubble [2, 3].

Zhang et al. [4] proposed a system consisting of a CO_2 sensor, a thermal camera and a microphone to detect people trapped under rubble. However, CO_2 detection in open air is difficult. Also, thermal cameras alone are not very reliable in detecting people behind various obstacles such as piles of metal. Instead of these sensors, the vital data of people under the rubble can be tracked with alternative sensors. These sensors are mostly found in health monitoring systems. Demirtas et al. [5] developed a patient monitoring system that enables instant recording of data from biomedical sensors such as ECG, heart rate, temperature, movement, etc. Baig and Gholamhosseini [6] provide an overview of smart health monitoring systems in their research. They discuss the design and modeling of smart health monitoring systems and provide an overview of the different types of sensors used in these systems. Pantelopoulos and Bourbakis [7] conducted a survey on wearable sensor-based systems for health monitoring and prognosis. They provide an overview of the different types of wearable sensors used in health monitoring systems and discuss the challenges associated with these systems. Anikwe et. al. [8], synthesized research efforts on mobile and wearable sensors for health monitoring. They categorized health monitoring systems as dual sensor-based studies that utilized two sensor modules for various health monitoring researches. Kaur et. al. [9], explored wearable sensors for heart rate, pulse rate, ECG, blood pressure, and body temperature for health monitoring purposes. They also discussed personalized medicine and cancer biomarkers in the case of different diseases. Lou et. al [10], discussed wearable health monitoring systems have emerged as the subsequent epoch of personal portable devices for telemedicine implementation. These devices operate on the principle of supervising various types of biological signals exuded by human beings, including but not limited to saliva, urine, respiration, and cutaneous perspiration. Although for different purposes, most of the sensors preferred in health monitoring systems in the literature can be used to detect and rescue earthquake victims under the rubble.

In this study, a wearable sensor and tracking system has been prototyped to prevent or minimize possible loss of life after an earthquake. The sensors on the system consist of a GPS module, an IR temperature sensor and a pulse oximeter. The data read from these sensors through a controller is transferred to a tracking or a monitoring screen via a wireless communication protocol. A mobile application interface was developed as a tracking screen. Sensor data can also be monitored from a web interface created in addition to the mobile application.

2. Material and Methods

The working diagram of the proposed system is given in Fig. 1. The prototyping process was carried out based on this scheme. In the first stage, the sensors in the system were read separately in different scenarios. Thus, sensor data was verified.

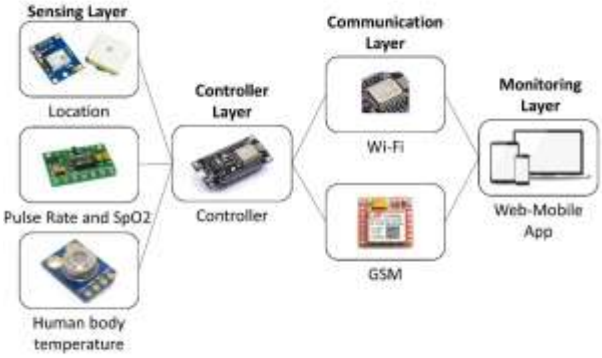
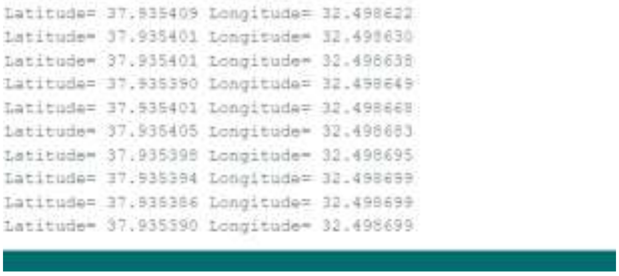


Figure 1. *Workflow schematic of the system*

The system is divided into sensing, control, communication and display layers. The prototyping progressed through these layers.

2.1 Sensing Layer

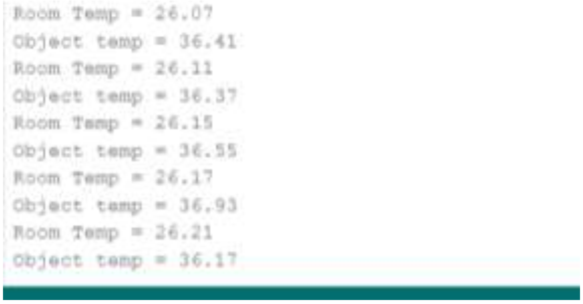
In the first step of the prototyping process, the sensor components in the system were read through a controller. ESP8266NodeMCU was preferred as the controller [11]. Fig. 2 shows the data received from GPS, MAX30102 pulse oximeter [12] and MLX90614 [13] temperature sensor respectively.



```
Latitude= 37.935409 Longitude= 32.498622
Latitude= 37.935401 Longitude= 32.498630
Latitude= 37.935401 Longitude= 32.498638
Latitude= 37.935390 Longitude= 32.498649
Latitude= 37.935401 Longitude= 32.498668
Latitude= 37.935405 Longitude= 32.498683
Latitude= 37.935398 Longitude= 32.498695
Latitude= 37.935394 Longitude= 32.498699
Latitude= 37.935386 Longitude= 32.498699
Latitude= 37.935390 Longitude= 32.498699
```

(a) GPS

(b) Hearth Rate (Beat Per Minute) and percentage of oxygen in blood (SpO2)



```
Room Temp = 26.07
Object temp = 36.41
Room Temp = 26.11
Object temp = 36.37
Room Temp = 26.15
Object temp = 36.55
Room Temp = 26.17
Object temp = 36.93
Room Temp = 26.21
Object temp = 36.17
```

(c) Temperature (^{0}C)

Figure 2. *Sensors data for the validation. (a) GPS data, MAX30102 pulse oximeter data on LCD, and (c) MLX90614 temperature sensor data*

2.2 Wireless Data Transfer and Web Interface

Wi-Fi [14] was preferred to transfer the data of the sensors in Fig. 2. For this, instead of using an external module, the internal Wi-Fi module on the NodeMCU development board was used.

https://espdeneme-1b396-default-rtdb.firebaseio.com

Your security rules are defined as public, so anyone can steal, moc

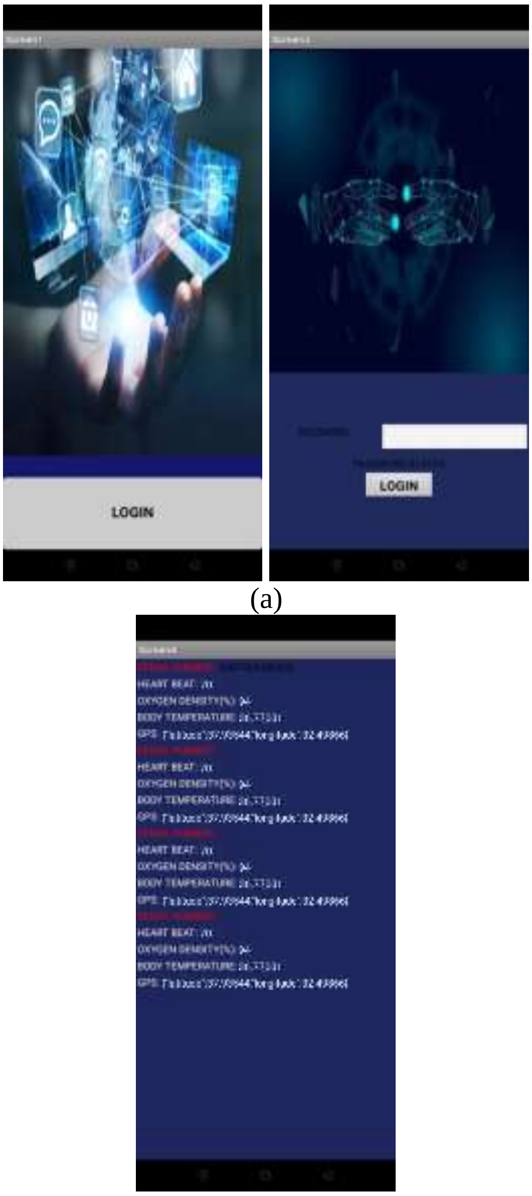
```
https://espdeneme-1b396-default-rtdb.firebaseio.com/
  BPM: 70
  GPS
    latitude: 37.93544
    longitude: 32.49866
  Sp02: 94
  body temperature: 36.770011902
```

Figure 3. *Monitoring sensor data from Firebase database*

The sensor data was sent synchronously via Wi-Fi to the interface created in the real-time database (firebase) [1, 15]. This interface is shown in Fig. 3. In Fig. 3, synchronously read heartbeat, GPS, SpO2 and, body temperature data can be monitored from the firebase interface.

2.3 Mobile Application

A mobile application has been realized in order to monitor the data on the web interface from mobile devices other than PCs. The mobile application was developed in App Inventor environment [16]. The data in firebase is sent to this application in real time. The application was tested on a smart mobile device with Android operating system. The mobile application and its pages are depicted in Fig. 4.



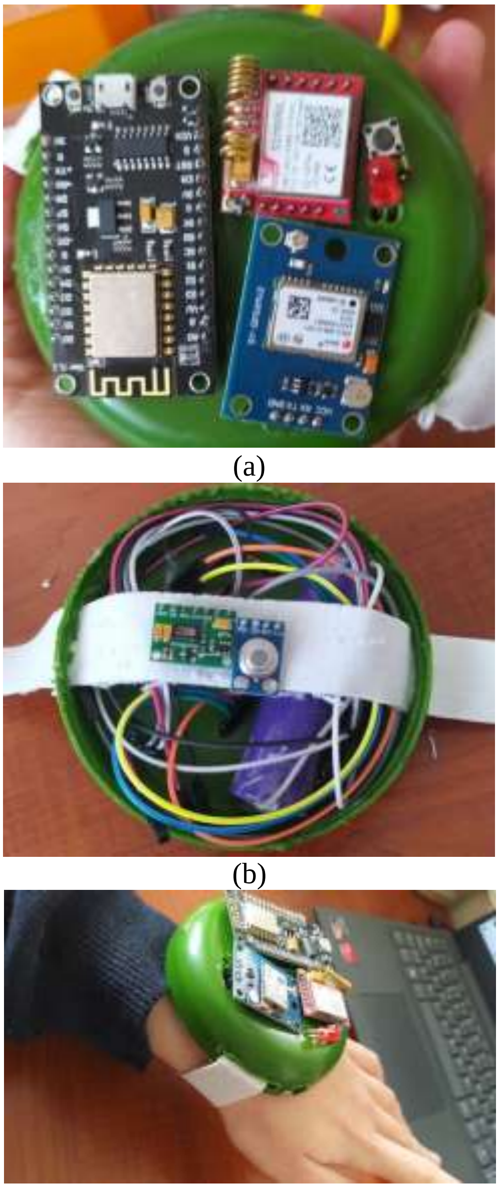
(a)

(b)

Figure 4. *The mobile application pages (a) login page and (b) multi-user data*

2.4 Prototyping

The first prototype was established by integrating the presented system components on a platform that can be wearable on the wrist. This prototype is provided in Fig. 5. The proposed design is available for further development and the efforts to improve this design are ongoing. Apart from the controller and GPS module, a GSM module is integrated on the top side of the first prototype in Fig. 5. Through this module, when there is a disconnection in the Wi-Fi, an SMS notification can be sent over the GSM line. Besides, the Wi-Fi connection can be observed by the user wearing the wristband

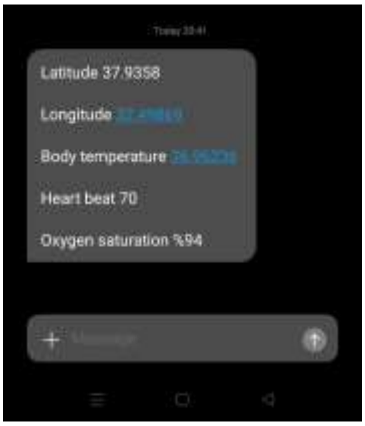

(a)

(b)

(c)

Figure 5. *The first prototype. (a) top, (b) bottom and (c) wrist-worn view of the prototype.*

by means of the LED on the same side. In the event of a possible wreck, this person can press the button next to the led when he/she sees that there is no internet connection and can share his/her instant vital data with smart mobile devices registered. Fig. 6 demonstrates the data sent by the wristband wearer over a GSM line to a pre-registered phone number. The prototype was tested indoor in a home environment. Sensor data was sent to the web interface and the mobile application from different rooms of the house. As a result of this transmission, ±2 m accurate GPS data was obtained. GPS data was verified via Google Maps. Other sensor data was transmitted synchronously without any delay. The measurements were repeated many times and similar measurements were obtained.


Latitude 37.9358

Longitude [illegible]

Body temperature [illegible]

Heart beat 70

Oxygen saturation %94

Figure 6. *SMS with vital data of the wristband wearer*

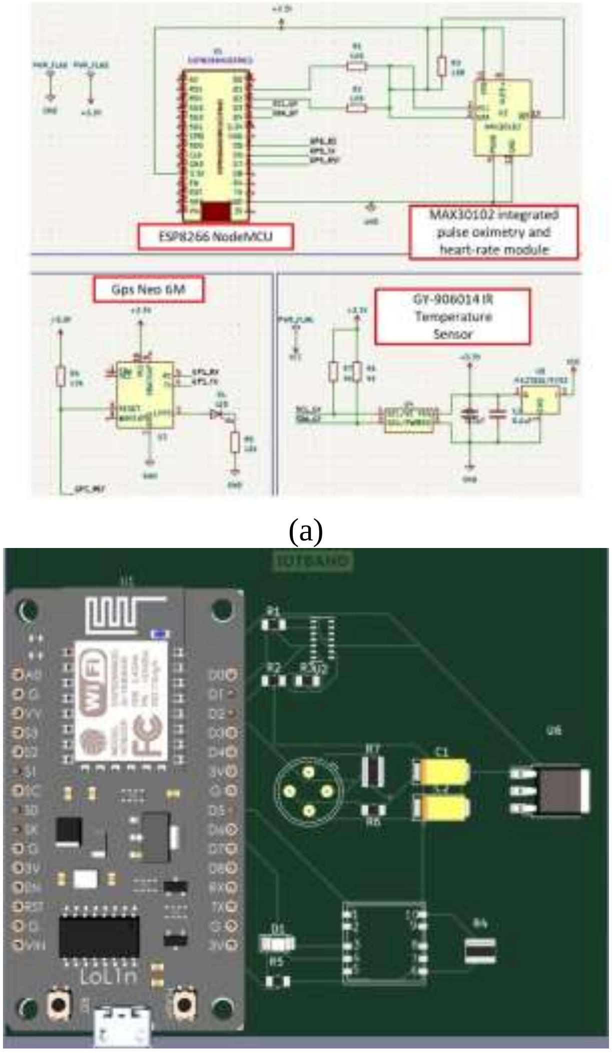
3. Results and Discussions

In the literature, the number of studies in which the sensors on the proposed prototype are combined is scarce. Furthermore, in the literature and in the commercial product market, only bluetooth or Wi-Fi connection can be provided from the related devices. In this study, as an alternative to Wi-Fi connectivity, the ability to send SMS through GSM is addressed.
Most of the studies in the literature have been developed for monitoring diseases such as Covid-19 [12, 17] or blood pressure [18, 19]. In this study, a wristband prototype is proposed to prevent or reduce the loss of life after an earthquake. However, the prototype can also be used to tracking Alzheimer's patients or people with poor mental development. Thus, these people can be prevented from getting lost.

4. Conclusions

In this study, a wristband prototype with a GPS, an IR temperature sensor and a pulse oximeter module is proposed to prevent the loss of life of individuals trapped under the rubble after an earthquake. The proposed prototype is garage-made and tested in a closed indoor environment. The synchronized data provided by the prototype was monitored from a real-time database. A mobile application was developed to facilitate the tracking of this data. The database on the web and the mobile application were accessible from an external source, e.g. by a rescue team. A GSM module was embedded as a backup to the web connection. The prototype is able to instantly measure the user's location, body temperature and pulse rate. The measured values can be shared with external users via a web interface, a mobile application and an SMS when there is no web connection.

Hence, people under the rubble can be intervened as soon as possible and loss of life can be reduced.



(a)

(b)

Figure 7. *Electronic circuit designs. (a) schematic and (b) PCB drawing of the electronic circuit design to develop the prototype*

As future studies, electronic circuit designs are ongoing to improve the mechanics of the prototype. Within the scope of these studies, one of the circuit designs realized through the open source KiCad [20] program is given in Fig. 7. In addition, work is being carried out to improve the web interface and to add features such as logging sensor data and graphical display to this interface.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
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- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

References

[1] Maulidi, R., Kristanto, B. K., & Listio, Y. D. (2020). Earthquake Information Push Notification System in Android Application Using Google Firebase. IJISCS *International Journal of Information System and Computer Science*, 4(2), 98-112.

[2] https://spinoff.nasa.gov/Spinoff2018/ps_1.html. Access Date: 1 April 2023.

[3] Akansel, V. H., & Özkula, G. The 30 October 2020, Mw 6.6 Sisam (Samos) Earthquake: Interpretation of Strong Ground Motions and Post-Earthquake Condition of Nearby Structures. *European Journal of Engineering and Applied Sciences*, 4(2), 66-89.

[4] Zhang, D., Sessa, S., Kasai, R., Cosentino, S., Giacomo, C., Mochida, Y., & Takanishi, A. (2018). Evaluation of a sensor system for detecting humans trapped under rubble: A pilot study. *Sensors*, 18(3), 852.

[5] Demirtaş, M., Tulum, G., Sağbaş, M., & Ayten, U. Multi platform online patient monitoring system. *Sakarya University Journal of Science,* 22(1), 1-7.

[6] M.M. Baig and H. Gholamhosseini, “Smart Health Monitoring Systems: An Overview of Design and Modeling,” *Journal of Medical Systems.*

[7] A. Pantelopoulos, N.G. Bourbakis, “Survey on Wearable Sensor-Based Systems for Health Monitoring and Prognosis,” *IEEE Transactions on Systems Man and Cyberbetics-Part* C: Applications and Review.

[8] Anikwe, C. V., Nweke, H. F., Ikegwu, A. C., Egwuonwu, C. A., Onu, F. U., Alo, U. R., & Teh, Y. W. (2022). Mobile and wearable

sensors for data-driven health monitoring system: State-of-the-art and future prospect. *Expert Systems with Applications*, 117362.

[9] Kaur, B., Kumar, S., & Kaushik, B. K. (2023). Novel wearable optical sensors for vital health monitoring systems—A review. *Biosensors,* 13(2), 181.

[10] Lou, Z., Wang, L., Jiang, K., Wei, Z., & Shen, G. (2020). Reviews of wearable healthcare systems: Materials, devices and system integration. *Materials Science and Engineering: R: Reports*, 140, 100523.

[11] Aziz, D. A. (2018). Webserver based smart monitoring system using ESP8266 node MCU module. *International Journal of Scientific & Engineering Research*, 9(6), 801-808.

[12] Turanli, M., Ilhan, I., & Yavsan, E. (2022) Pulse Oximeter Based System Prototype to Monitor Vital Signs of COVID-19 Patients in Quarantine. *3rd International Conference on Engineering and Applied Natural Sciences (ICEANS'22)*, pp. 1273-1276. July 20-23, 2022, Konya, Turkey.

[13] Jin, G., Zhang, X., Fan, W., Liu, Y., & He, P. (2015). Design of non-contact infra-red thermometer based on the sensor of MLX90614. *The Open Automation and Control Systems Journal*, 7(1).

[14] Kurniawan, A. (2019). Internet of Things Projects with ESP32: Build exciting and powerful IoT projects using the all-new Espressif ESP32. *Packt Publishing* Ltd.

[15] Oo, Z., Lai, T., Ko, S., & Moe, A. (2019). IoT based Weather Monitoring System Using Firebase Real Time Database with Mobile Application. *In International Symposium on Environmental-Life Science and Nanoscales Technology*.

[16] Patton, E. W., Tissenbaum, M., & Harunani, F. (2019). MIT app inventor: Objectives, design, and development. *Computational thinking education*, 31-49.

[17] Al Bassam, N., Hussain, S. A., Al Qaraghuli, A., Khan, J., Sumesh, E. P., & Lavanya, V. (2021). IoT based wearable device to monitor the signs of quarantined remote patients of COVID-19. Informatics in medicine unlocked, 24, 100588.

[18] Ilhan, I., Yıldız, İ., & Kayrak, M. (2016). Development of a wireless blood pressure measuring device with smart mobile device. *Computer methods and programs in biomedicine*, 125, 94-102.

[19] Ilhan, I. (2018). Smart blood pressure holter. *Computer Methods and Programs in Biomedicine*, 156, 1-12.

20] Kanagachidambaresan, G. R. (2021). Introduction to KiCad Design for Breakout and Circuit Designs. In Role of Single Board Computers (SBCs) in rapid IoT Prototyping (pp. 165-175). Cham: Springer International Publishing.