Technical science and innovation

Volume 2022 | Issue 1 | Article 2

4-15-2022

Development of a Wearable Device for Monitoring and Predicting Human Health in Emergencies

Mukhriddin Arabboev
Tashkent universityof information technologies named after Muhammad al-Khwarizmi, mukhriddin.9207@gmail.com

Shohruh Begmatov
Tashkent University of Information Technologies named after Muhammad al-Khwarizmi

Khabibullo Nosirov
Tashkent University of Information Technologies named after Muhammad al-Khwarizmi

Jean Chamberlain Chedjou
University of Klagenfurt

Kyandoghere Kyamakya
University of Klagenfurt

Recommended Citation

Arabboev, Mukhriddin; Begmatov, Shohruh; Nosirov, Khabibullo; Chedjou, Jean Chamberlain; and Kyamakya, Kyandoghere (2022) "Development of a Wearable Device for Monitoring and Predicting Human Health in Emergencies," *Technical science and innovation*: Vol. 2022: Iss. 1, Article 2.
DOI: https://doi.org/10.51346/tstu-01.22.1-77-0158
Available at: https://btstu.researchcommons.org/journal/vol2022/iss1/2

UDC 811.111:004.8

DEVELOPMENT OF A WEARABLE DEVICE FOR MONITORING AND PREDICTING HUMAN HEALTH IN EMERGENCIES

M. Araboev[1], Sh. Begmatov[1], Kh. Nosirov[1], Ch.Ch. Jean[2], K. Kyandoghere[2]
[1]Tashkent University of Information Technologies,
Amir Temur St, 108, 100200, Tashkent city, Republic of Uzbekistan
[2]Department of Transportation Informatics (TIG), University of Klagenfurt, Klagenfurt city, Austria

Abstract: *In recent years, natural disasters and various similar emergencies have caused many people to leave this world early. The need for the use of modern technologies in emergencies is growing day by day. Various modern devices, techniques and methods are used in post-disaster search and rescue operations. The issue of finding a survivor is very important in post-disaster operations. The vital signs of humans are very important in determining the survival of humans. Heart Rate (HR), Blood Pressure (BP), Respiration rate (breathing rate), and Body Temperature (BT) values are considered four essential vital signs that must be measured regularly. In this paper, we develop a wearable device that can monitor essential vital signs and also generate an emergency alarm when human health status is deteriorating. This device consists of sensors that monitor blood oxygen saturation, heart rate, body temperature, and also alarm sensor. The device is capable of monitoring a human body temperature, blood oxygen level and heart rate. The system also generates a strong alarm signal when human health is deteriorating and humans are in a difficult situation (in a mountain, in a reserve, etc.), so that in emergencies those around can search for the survivor.*

Keywords*: Health monitoring; Vital signs; Emergency; Wearable device.*

INTRODUCTION. In recent years, due to technological advances, the chances of saving lives in emergencies, post-disaster search and rescue operations are increasing. In post-disaster search and rescue operations, various devices are used to determine human survival, human health status. During the past decades, several scientists have focused on the development of health monitoring systems and wearable devices. Health monitoring system for ambulance is developed in [1]. The proposed system is aimed at collecting patient data and sending it to the hospital before the ambulance arrives at the hospital, where appropriate measures can be taken at the hospital to treat the patient well and effectively.

Monitoring the patient’s health from this distance reduces the time spent collecting patient data. Collected data more accurate than the usual data collection from collected sensors. The recommended framework can be used for emergency vehicles in motion. It is developed a smart ambulance rescue system with patient health monitoring using IoT in [2]. The proposed device could help to avoid lateral arrangements in the hospital. The status of the victim’s body was obtained automatically via a sensor and GPS location sent to the cloud and the administrator server.

Details on the biometric system are collected from a centralized database. Notification of the accident will be sent to the doctor as well as to the victim’s family. It is developed a mobile health monitoring system called care for the elderly in [3]. It is used wireless body sensors and smartphones to monitor the well-being of the elderly. When an emergency is detected, the smartphone automatically alerts pre-assigned people who may be elderly family and friends and calls an ambulance.

It also works as a personal health care system and medical service a single communication platform and medical database, so family and friends service people can collaborate with doctors to care for a patient. Rayed et al [4] develop a device to detect hypothermia. The device consists of a temperature sensor, pulse sensor, and accompanied by heating elements based on a wireless body area network (WBAN). It is developed a wireless nurse call system with a web server is designed, developed and implemented in [5]. The system could help admitted patients in hospitals. The system is also capable to generate an emergency alarm. It is proposed an emergency health monitoring system for an ambulance in [6]. The proposed system could offer the data from monitored vital signs of a patient in an ambulance to be sent to the emergency department through the internet using GSM network and website-based data transmission.

Another interesting study is found in [7]. It is proposed a mountaineering-assisted wearable device and emergency rescue system architecture which comprises a wearable device, a piece of mobile device application software, and a backend management platform [7]. The wearable device is equipped with a heart rate monitor that reminds climbers of symptoms of altitude sickness and an inertia sensor that signals a fall. In addition, the device is equipped with Bluetooth and can thus connect to mobile devices.

The app on the mobile device can transmit geographic data and data on the wearable device via the mobile devices to the backend control system. In [8], it is proposed an intelligent emergency rescue assisted mountaineering system and combines the mountaineering assisting wearable device with a mobile device, to help the climbers climb mountains more safely. The proposed system architecture prevents mountain accidents effectively (in altitude sickness, hypothermia, missing, accidental fall). It is proposed a patient medical emergency alert system (PMEAS) that monitors the heart rate and body temperature of a user and alerts the user when these values are abnormal [9].

The system basically consists of two components, a wearable hardware block and an android app. The wearable hardware sensors that monitor the user’s heart rate and body temperature, which are displayed on an LCD display. It is presented a smart patient monitoring system for emergency situations in [10]. The main convenient position of the proposed system is to reduce the time of patient intercession in a crisis situation. An innovative patient monitoring system that integrates an application and wearable devices to monitor the patients’ critical physiological data is presented in [11]. It also uses a global positioning system (GPS) so that patients and healthcare providers can track each other.

It is tested the proposed system and the results show that the system could send vital physiological information as well as patient location information to a remote medical service provider with high accuracy. The system also generates alarm signals for patients and helps patients locate health care providers in the immediate area. Location information is automatically updated with patient behavior. It is discussed the use of a Kalman filter-based method to identify fall events during rock climbing activity in [12]. It is reviewed personal emergency response system as a technology innovation in primary health care services in [13].

The study provides an overview of the results of research on this well-established telecommunications solution is important for different actors in terms of adopting this technology and using public care services. It is proposed to verify the alarm and send user feedback using a smart device or smartwatch application so that a user can respond to whether the alarm is true or false [14]. It is presented a concept of force-moment sensing of multi-position mechatronic modules of intelligent robots in [15-16]. This robot could be used in the medical sphere. It is also presented a user-feedback system for use in activity recognition to mitigate and improve possible false alarm situations, which will consequently result in helping sensors to reduce the frequency of transactions and transmissions in wireless body area networks.

It is reviewed smart wearables for cardiac monitoring in [17]. The review focused on the real-world use and evolution of these devices for other arrhythmias, cardiovascular diseases and some of their risk factors beyond atrial fibrillation. It is developed a health monitoring system that can transmit the vital signs of a patient through an ad-hoc wireless sensor network for a mass causality emergency application in [18]. The system should be placed on the injured victim during an emergency and act as a sensor node to connect to a wireless dedicated network to transmit vital information to the patient. Finally, [19] develops a health monitoring system based on the proposed architecture for elderly patients' health monitoring in the home, ambulance, and hospital environment.

The proposed system could detect and notify deteriorating conditions to the authorities based on biomedical sensors for faster interventions. For monitoring body temperature, heart rate, blood glucose level, and patient body position wearable biomedical sensors are used. Overall, the overview of the previous contribution on health monitoring and emergency alarm systems witness the tremendous attention devoted during the past decades to the development of various sensors and wearable devices. However, none of the aforementioned contributions ([1] - [19]) is likely to integrate health monitoring and emergency alarm approaches as the proposed device developed in this work.

We address the issue of integrating biomedical sensors with emergency alarm signals by developing a wearable device. The device presented in this paper has been used to monitor a patient's vital signs, which is essential for human health. The device also generates a strong alarm signal automatically when human health is deteriorating and human in a difficult situation when rescue is needed. This technique is useful as it could help to inform others if there is a need to find survivors in emergencies.

MATERIAL AND METHODS. The proposed wearable device uses the following sensors and modules: OLED display; Arduino Nano board; MAX30102 heart rate sensor; Battery. OLED display. OLED, Organic Light Emitting Diode, is a relatively new technology that has the ability to replace current LCD and LED TVs, monitors, and cell phone displays. It is more complex than traditional LEDs and uses organic, carbon-based semiconductor materials rather than silicon or germanium for the emission region. An OLED module display is made up of many layers; first it is sealed on the top or bottom by a transparent material, usually glass or plastic.

On each side is placed either an anode or a cathode, one of which must also be transparent for the light to be emitted effectively. Finally, within the anode and cathode are the organic LED compounds, called an emissive layer on the cathode side and conductive layer on the anode. When a positive voltage is placed on the anode, holes jump across the emissive conductive barrier and join with electrons, which produces a photon of light [20]. The OLED display uses an I2C bus to communicate with the Arduino. The I2C bus supports multiple devices, and each device on the I2C bus has a unique location.

Fig. 1. OLED display

The Arduino code uses this address to communicate with the OLED display and sets its internal registers and memory to display the data on the screen [21]. The proposed wearable device uses 0.91-inch OLED display. This screen size is large enough to read data coming from sensors. The smaller the screen size, the less energy it consumes. The main purpose of using an OLED display on the proposed wearable device is to display the data coming from the sensors.

Arduino Nano*.* The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328-P. It offers the same connectivity and specifications of the Arduino Uno board in a smaller form factor [22-26]. The Arduino Nano has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provide UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An FTDI FT232RL on the board channels this serial communication over USB and the FTDI drivers (included with the Arduino software) provide a virtual com port to software on the computer.

Fig. 2. Arduino Nano

Heart rate sensor*.* Heart rate is also an important vital sign, so regular to monitor of heart rate is essential. MAX30102 sensor is a heart rate sensor that helps to determine the health of a person by counting strokes [27]. The MAX30102 is an integrated pulse oximetry and heart rate monitor biosensor module. It includes internal LEDs, photodetectors, optical elements, and low-noise electronics with ambient light rejection. The MAX30102 has an on-chip temperature sensor for calibrating the temperature dependence of the SpO2 subsystem. The MAX30102 provides a complete system solution to ease the design-in process for mobile and wearable devices.

The main purpose of using the MAX30102 sensor in the proposed wearable device is that this sensor can monitor heart rate, blood oxygen saturation and body temperature at the same time. This battery has a capacity of 200mAh. The main purpose of using the battery in the device is to provide the device with the required power. The battery used in the device can provide enough power to the device because the device does not have too many sensors and modules.

Fig. 3. MAX30102

Battery*.* A lithium polymer battery, or more correctly lithium-ion polymer battery is a rechargeable battery of lithium-ion technology using a polymer electrolyte instead of a liquid electrolyte. 3.7V lithium polymer rechargeable batteries are thin, light and powerful.

RESULTS AND DISCUSSION. A wearable device for health monitoring and emergency alarm is developed using all the sensors and modules mentioned above interconnected. This device could perform real-time heart rate, blood oxygen saturation and body temperature monitoring. The data obtained on these three vital signs are displayed on the display of the device. The device could generate a strong alarm when a patient's health status was deteriorating. In addition, when a person needs help in an emergency, they can produce an alarm signal by pressing a button on the device. This makes it easier for rescuers to find survivors in search and rescue operations in emergencies. The proposed wearable device for health monitoring and emergency alarm is presented in Figure 4.

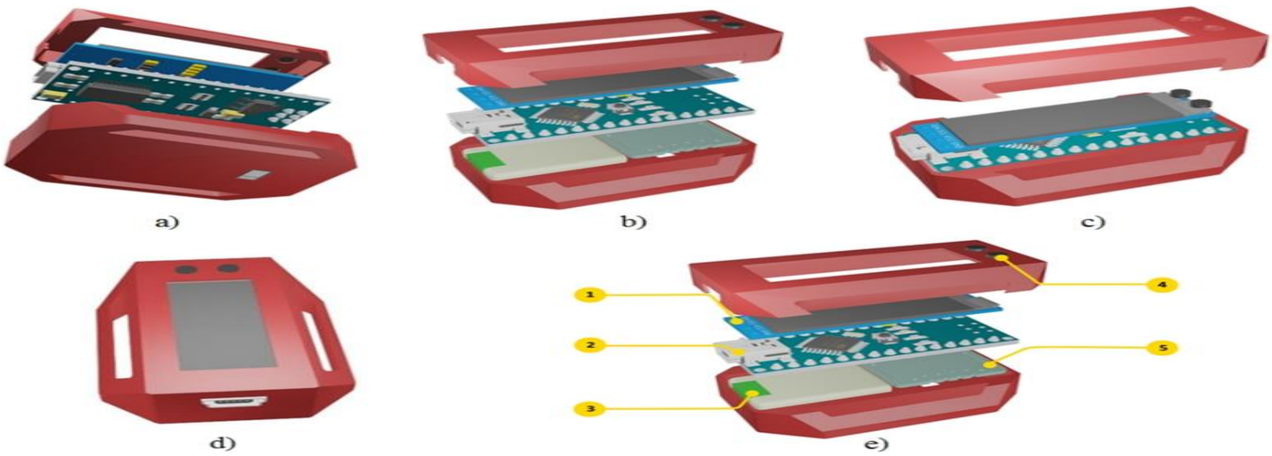

Fig. 4. 3D view of the proposed wearable device: (a) 3D layered view of the device from the bottom; (b), (c) 3D layered view from the side of the device; (d) 3D layered view from the top of the device; (e) 3D layered view of the device with marked numbers.

According to the figure (see Fig. 4 (e)) shown above each number means components of the wearable device for health monitoring and emergency alarm:

1) OLED display;
2) Arduino Nano;
3) Battery;
4) Power button and buzzer;
5) MAX30102 sensor.

The device can be used in two ways. In the first method, the device is attached to a human hand. In this method, the device monitors a person's heart rate, blood oxygen saturation and body temperature. If a person's health status deteriorates, i.e. vital signs show abnormal values, the device automatically generates an alarm signal. As a result, the person will be aware of his / her health status and will be able to consult a doctor to recover his / her health. Also, if a person needs help in an emergency, he or she can create a strong alarm signal by pressing a button located on the device and use it to give a warning signal to the rescuers around him/her about himself/herself whereabouts. In the second method, the device is used by rescuers. Rescuers will be able to get information about the health status of survivors by wearing the device to the survivors in search and rescue operations in emergencies. As a result, it will be easier to separate the survivors. It saves time in searching for and rescuing rescuers, thereby saving the lives of more people.

CONCLUSION. In this paper, a wearable device for health monitoring and emergency alarm is developed. Compared to other similar devices, the device has its own advantages, low cost, low power consumption, convenient design, generating emergency alarm signals directly. In the future work, we will focus on the following: collect data from volunteers of different ages and sexes; and analyze the effect of body temperature, blood oxygen saturation on the heart rate; testing the device for alarm generation in a real environment.

References:

1. K.M. Arpita, M. Janvi, T. Ashwan, K.S. Asha, M.P. Sunil, *“Health monitoring system for ambulance,” international journal for research in applied science engineering technology”*. **2019**. 1055.
2. S.I. Sherly, A.M. Sobitham-Princy, S. Monisha, K. Nandhini. “Smart ambulance rescue system with patient health monitoring using”. *“International journal of advanced research in science, engineering and technology”.* **2019**. 8222.
3. Z. Lu, F. Xia, G. Wu, L. Yao, Z. Chen, “Care: a mobile health monitoring system for the elderly”. *“Conference on green computing and communications conference on cyber, physical and social computing”*. **2010**. 699.
4. M. Udin, A.R. Harun, S. Sukaridhoto, A. Sudarsono, A. N. Kaffah. “*Design and implementation of hypothermia symptoms early detection with smart jacket based on wireless body area network”*. **2020**. 155.
5. M. A. Majumder, “Low cost wireless nurse call system with webserver pager”. *“Global journal of computer science and technology”*. **2016**.
6. S.H. Lee, J.C. Ni, Y.G. Zhao, C.S. Yang. “A real-time emergency rescue assistance system for mountaineers”, *“International conference on consumer electronics (ICCE)”*. **2017**. 106.
7. S.H. Lee, C.Y. Hsu, C.S. Yang. “An intelligent emergency rescue assistance system for mountaineers”, *“International journal of internet technology and secured transactions”*. **2018**. 1.
8. B. Kommey, S.D. Kotey, D. Opoku, “Patient medical emergency alert system” *“International journal of applied information systems”*. **2018**. 8.
9. H. Chau, S.K. Gupta, R. Gupta. “Patient healthcare monitoring system for emergency situations” *“International journal of innovative technology and exploring engineering”*. **2019**. 287.
10. E. Nour, M. Tarique, D. Foyez, L. Hassan, A. Rashed, “Location aware health monitoring system for emergency cases”, *“International journal of scientific technology research”*. **2019**. 1247.
11. A. Tonoli, R. Galluzzi, E.C. Zenerino, D. Boero, “Fall identification in rock climbing using wearable device”, *“Proceedings of the institution of mechanical engineers, part p: journal of sports engineering and technology”.***2016***.* 171.
12. R. Stokke, “The personal emergency response system as a technology innovation in primary health care services an integrative review”, *“Journal of medical Internet research*”. **2016**.
13. J. Kang, H. Larkin, *“Application of an emergency alarm system for physiological sensors utilizing smart devices*”. **2017**. 26.
14. K.N. Nazarov, T.O. Rakhimov. "The concept of force-moment sensing of multi-position mechatronic modules of intelligent robots", *“Technical science and innovation”*. **2021.**
15. J. Khollhujayev, N. Abdukarimov, J. Mavlonov, N. Abdivahidova. "Non-contact point measuring equipment for robotic systems of automobile industry", *“Technical science and innovation”*. **2020.**
16. D. Duncker, W.Y. Ding, S. Etheridge, P.A. Noseworthy, C. Veltmann, X. Yao, T.J. Bunch, D. Gupta. “*Smart wearables for cardiac monitoring-real-world use beyond atrial fibrillation. sensors”*. **2021**. 2539.

17. Imran, N. Iqbal, S. Ahmad, D.H. Kim, *“Health monitoring system for elderly patients using intelligent task mapping mechanism in closed loop healthcare environment”*. **2021**. 1.
18. M.M. Arabboev, F.D. Gulomov, R.Sh, Radjabova “Design of a model for intellectual multi-parametric analysis of human health monitoring and disease prediction device”, “*Descendants of Muhammad al-Khwarizmi scientific-practical and information-analytical journal”*. **2020**. 3.
19. K. Nosirov, Sh. Begmatov, M. Arabboev, J.C. Chedjou, K. Kyamakya, K. Abhiram P. De Silva. “*Real-time multi parametric human health monitoring and prediction system”, world scientific proceedings series on computer engineering and information science, developments of artificial intelligence technologies in computation and robotics*”. **2020**. 639.
20. K. Nosirov, S. Begmatov and M. Arabboev, "Design of a model for multi-parametric health monitoring system," 2020 international conference on information science and communications technologies (ICISCT)”. **2020**. 1.
21. K. Nosirov, S. Begmatov and M. Arabboev. "Analog sensing and leap motion integrated remote controller for search and rescue robot system”, *“International conference on information science and communications technologies (ICISCT)*”. **2020**. 1.
22. Kh.Kh. Nosirov, A.Sh. Shakhobiddinov, M. Arabboev, Sh. Begmatov, O.T. Togaev. *"specially designed multi-functional search and rescue robot," bulletin of TUIT management and communication technologies*”. **2020**. 1
23. K. Nosirov, S. Begmatov, M. Arabboev, K. Medetova. "*Design of a model for disinfection robot system," 2020 international conference on information science and communications technologies (ICISCT)”.* **2020**. 1.
24. M. Arabboev, L. Ra based health monitoring and emergency alarm device. JournalNX. *“Multidisciplinary Peer Reviewed Journal”*. **2021**. 106.