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Proceeding Paper

Implementation of a LoRa and IoT-Based Health Monitoring and Alarm System for the Elderly †

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Abstract: The world's population is ageing, and older people are more likely to have chronic illnesses with the need for ongoing monitoring and medical support. This paper proposes a health monitoring and alarm system for elderly people based on LoRa communication technology. By leveraging Long-Range (LoRa) technology and connecting to an IoT network, the system incorporates various sensors to capture real-time vital signs consisting of heart rate and body temperature of elderly individuals. This enables family members, medical experts, and authorized entities to access the health status of the system users and attend to their immediate needs. The research indicates the viability of leveraging the LoRa gateway and other support infrastructures, such as the Internet of Things (IoT), to deploy sensor networks for elderly monitoring. The IoT infrastructure is involved in data storage and transmission to the IoT Network for monitoring users' critical metrics. The system utilizes two Lora WAN radio modules for long-range wireless communication, an ESP32 Wireless Module for the IoT feature, a microcontroller, temperature and pulse rate sensors. Raw data from the temperature and pulse rate sensors are sent to the receiver LoRa board and IoT platform from which medical personnel can monitor. Additionally, the system has an alarm feature that, in the event of any unusual readings, alerts caretakers or medical experts. The LoRa communication technology provides long-range and low-power wireless communication, making it suitable for healthcare applications with various added advantages to the system such as continuous monitoring of vital signs, timely intervention to prevent emergencies, cost-effectiveness and easily integrated into existing healthcare systems.

Keywords: LoRa technology; IoT; sensors; alarm systems

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1. Introduction

Healthcare on any scale is a task that is not trivial. The incapacity of medical professionals to continuously monitor critical metrics such as body temperature, blood pressure, heart rate, blood glucose and body humidity in real time and in sufficient amounts so as to prevent medical emergencies is a common concern; they either do not provide enough or provide slower and more expensive devices to carry out the task. So, incorporating a low-cost, long-range technology, such as a LoRa communication technology-based monitoring and alarm system for elderly people utilizing IoT technology, has the ability to make the process less labor-intensive and thus results in a better life.

Recent advances in wireless communication technology, such as LoRa communication technology, have provided new opportunities to develop healthcare systems that can provide continuous monitoring of vital signs in real-time. LoRa communication technology is a low power and large range wireless communication technology suitable for healthcare applications where battery life is a critical concern. Several studies have shown the effectiveness of using LoRa communication technology in healthcare applications.

LoRa, a wireless technology known as Low-Power Wide Area Network (LPWAN), has garnered significant attention in healthcare research due to its affordability, energy efficiency, and impressive long-range capabilities. [1]. The energy-efficient, cost-effective, high level of security and dependable nature of LoRa technology makes it an ideal choice for essential smart healthcare applications. LoRa devices use advanced encryption techniques to protect data, ensuring that it cannot be intercepted or tampered with. Implementing IoT solutions with LoRa-based sensors and gateways enables continuous monitoring of high-risk patients or critical systems, ensuring that health and medical safety are prioritized without any oversight [2]. In one research conducted by Lu et al. (2020), a wearable device based on LoRa technology was designed to effectively track the heart rate and body temperature of elderly individuals. The study reported that the device provided reliable and accurate monitoring of vital signs with a battery life of up to 90 days [3].

Heart related diseases are the major cause of death in the world, with up to 17.9 million fatalities each year, of which 85% are attributed to heart attacks and strokes [4–6]. To prevent further health deterioration, a system is required that can continually monitor the health state of elderly people, identify any changes or abnormalities, and deliver prompt interventions through information and communication technologies [7]. The proposed LoRa communication technology-based health monitoring and alarm system for elderly people aims to address this problem.

One effective approach to healthcare challenges is the implementation of healthcare monitoring systems, as it enables health organizations to transition into more streamlined, coordinated, and patient-centric systems, ultimately reducing costs associated with long-term healthcare [8,9]. In regions affected by epidemics, there arises a pressing need to introduce, improve, or develop new methods of delivering healthcare services from a distance [10]. Specifically, this has spurred a strong drive to explore innovative approaches for remote and efficient monitoring of patient health status [11], Embracing remote health monitoring technology emerges as a favorable solution to monitor these patients effectively, ensuring their well-being while maintaining a safe distance [10,12]. During pandemics, the importance of healthcare monitoring systems has become even more [11]. In a range of medical settings, systems specialized in monitoring of patients can be used. Data production outside of a medical organization places a great demand on the systems' flexibility [13]. Technology has made remote patient monitoring simpler since, as is often remarked, the fundamental goal of technology is to make our lives easier. Artificial intelligence (AI) and IoT have greatly helped healthcare systems. Utilizing technology, it is possible to continuously monitor a patient's vital signs and offer prompt treatment [14].

There are many kinds of patient monitoring [15] such as cardiac, temperature, respiratory and blood glucose monitoring [16,17]. Remote patient monitoring arrangements enable observation of patients outside of typical clinical settings [10,18]. IoT considerably facilitates health monitoring by enabling us to connect medical sensors to collect patient health data and process it to potentially avert life-threatening scenarios [19]. When creating IoT-based health care systems, attention must be taken to use them in a way that improves patient safety, quality of life, and lessens the incidence of emergency health attacks. It's possible that while the patient is asleep, we are unaware of their health [20]. With IoT health monitoring, we may have a database of the changes in the patient's health parameters, which is extremely useful when we need to monitor, record, and keep track of changes in those parameters over time [21]. IoT [22] offers a vast array of networked devices, cloud-based software and services, and a number of cooperative mechanisms [23] based on the fusion of the right standardization, efficient wireless protocols, improved sensors, more affordable and low-power microprocessors, and wireless technologies to address the health issues [9,24].

A proposal has been made by Mdhaffar et al. [25] highlighting the utilization of LoRa sensors in the medical sector for patient monitoring, aiming to address the mentioned challenges. The proposal consists of three steps: acquiring the patient's physical metrics through medical sensors, transmitting the data using LoRa sensors and gateway, and sending the data to the cloud for further processing of medical records. While this system has successfully measured diabetes and arterial hypertension, it faces limitations in capturing continuous medical data, which hampers the evaluation of ECG data.

Prashant Salunke, et al. [26] utilized wearable sensors for managing and recording a patient's physiological information over an extended period. By implementing the system, patients can minimize their visits to the doctor each time they need to check their ECG, temperature, and pulse oxygen levels in the blood. Real-time data collected on the cloud platform can be leveraged by doctors and hospitals to provide prompt and efficient solutions. This system lacks the ability to address data security measures, data encryption techniques, and privacy protection to ensure the confidentiality and integrity of patient data.

The lack of a reliable and cost-effective solution for monitoring the health status of elderly people leads to delayed diagnoses, poor management of chronic diseases, and a reduced quality of life. To prevent further health deterioration, a system is required that can continually monitor the health state of elderly people. This research is aimed at the development of a LoRa communication technology-based health monitoring and alarm system for elderly people. The objectives are to design and physical implement the circuit for the LoRa based health monitoring system and develop a user-friendly web interface for data management.

2. Materials and Methods

The IoT and LoRa based health monitoring system is divided into two distinctive parts: The transmitter side which supports both IoT and LoRa based communication; and the receiver side which only supported LoRa based communication. The design modeled a patient-doctor health monitoring system, the transmitter would read the patient body vital parameters, upload the readings to an online platform and send the readings also to the receiver end at the doctors monitoring channel which is done through LoRa communication technology. Emergency alerts are equally sent to the receiver. The block diagram as shown in Figure 1.

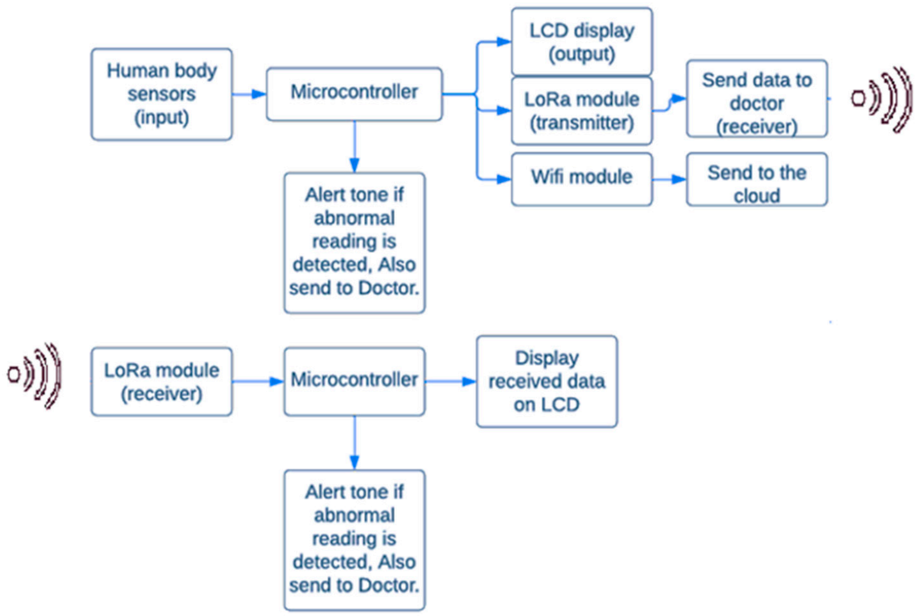


Figure 1. Block Diagram for the transmitter and receiver.

The materials include a microcontroller which controls the overall operation, LoRa WAN radio module to enable long-range communication, energy module to ensure reliable power supply, ESP32 wireless module which allows for additional local connectivity options, the sensing modules, which includes the Digital humidity and temperature sensor (DHT) and the pulse rate sensor to captures health parameters. The following components are used: Two LoRa Modules (Ra-02), ESP32 development board, Arduino nano, LiPo charging module, LiPo battery, switch, 1604 LCD screen, 0.92-inch OLED, Pulse rate sensor and DHT11. The components are shown in Figure 2. The construction of the system was done by soldering the circuit components on a Veroboard.

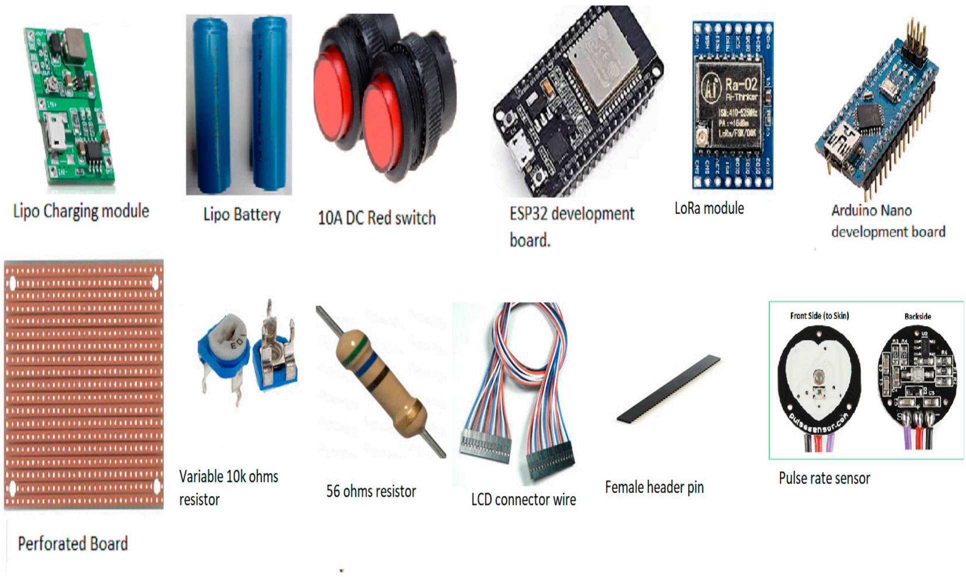
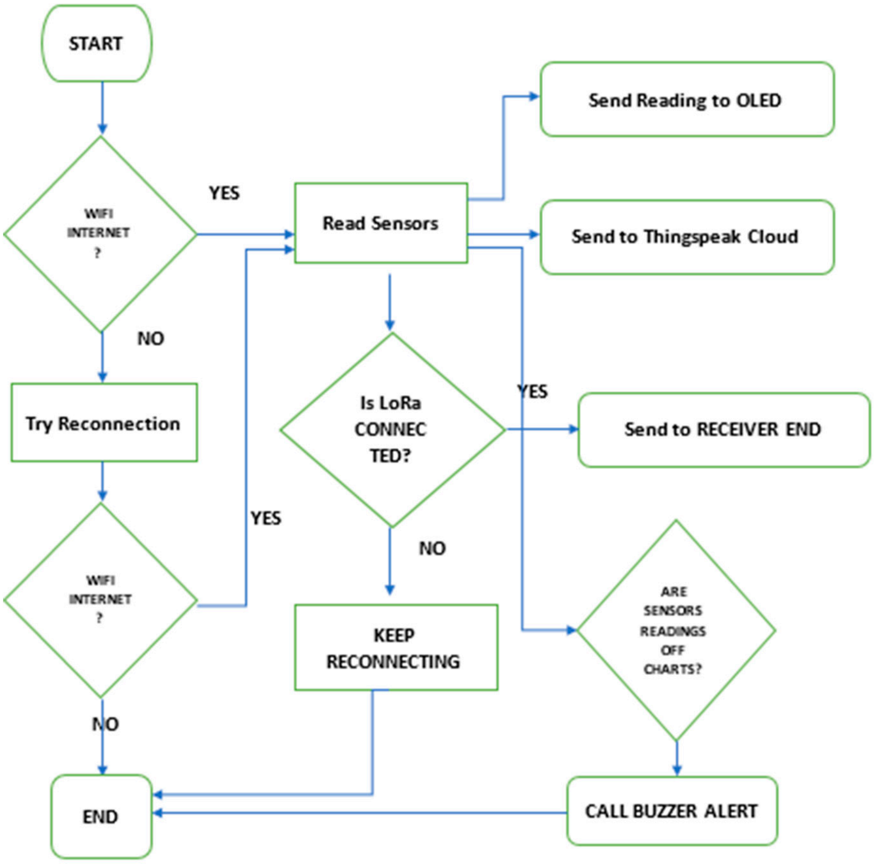
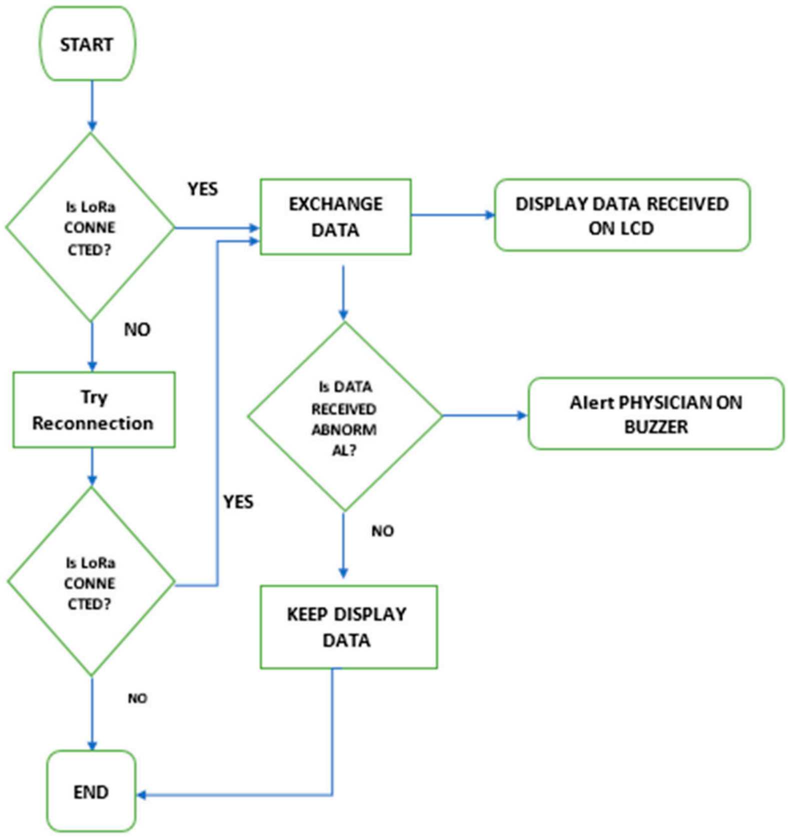


Figure 2. Circuit Components for the LoRa and IoT-Based Health Monitoring and Alarm System.

The transmitter circuit connects automatically to the internet when turned ON, if there is Wi-Fi then it starts to read the sensors and send the readings to the OLED and also to the ThingSpeak cloud platform [27] and if there is no WIFI it will try reconnecting, after reading the sensors, it confirms if the LoRa transmitter is connected to the receiver circuit, if not, it keeps trying to reconnect. If the LoRa connects, the transmitter sends sensor data and displays it to the receiver end. If the sensor reading is abnormal, a buzzer alert is triggered. When the receiver circuit is ON, it confirms if the LoRa module is connected and there is an exchange of data from the transmitter with the received data displayed on the LCD screen. If connection to the LoRa fails, a reconnection request is sent by resetting the receiver circuit. Once the data exchange is done, if there are abnormal readings, an alert is sent to the physician and if not, the sensor data keeps displaying on the screen. The flowchart for both the transmitter and receiver are shown in Figure 3a,b.



(**a**)



(**b**)

Figure 3. (**a**). Flowchart for LoRa Transmitter Circuit; (**b**). Flowchart for LoRa Receiver Circuit.

3. Results

Figure 4 shows the monitoring of vitals an individual using the prototype with temperature and pulse rate displayed on the transmitter screen. These readings are sent to the receiver, which is displayed on the received end. The data is not only exchanged between the transmitter and receiver but also sent to the ThingSpeak cloud for storage and data analysis as shown in Figure 5.

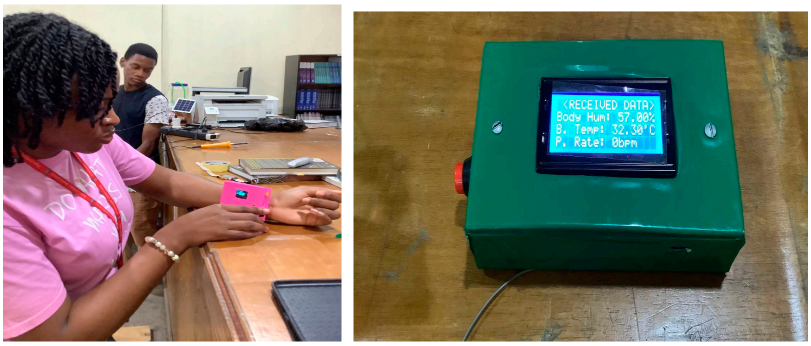


Figure 4. The use of the vitals monitoring prototype at the transmitter which is also displayed at the receiver end.

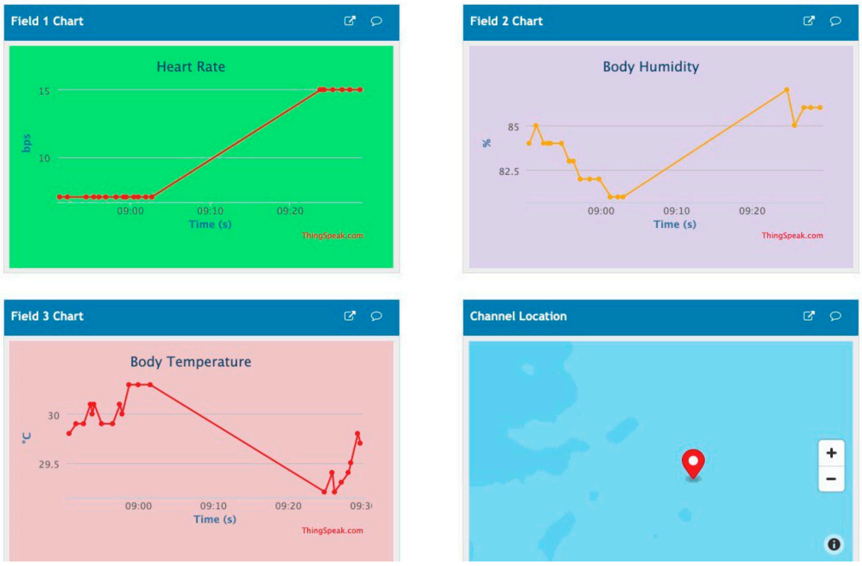


Figure 5. The ThingSpeak IoT platform showing pulse rate, humidity and temperature monitoring in real time. This data can be accessed from anywhere by the medical doctor of the patient.

4. Conclusions

The design a patient health monitoring system that could monitor patients' health vitals outside the hospital, to give way for continual tracking regardless of the user's geographical location was carried out. Two sensors were utilized, the DHT 11 and Pulse rate sensor, which collected heart rate, body temperature and humidity readings. With the aid of the ESP32 microcontroller, the data from the sensors were able to be transferred to the IoT platform which enabled easy retrieval of data from the ESP32 and easy access to the data through a website, from anywhere in the world. The LoRa Module Ra-02 served as a communication channel between the receiver and transmitter end devices, with the added advantage of long-range communication and low power consumption. Future research will include the monitoring of more health parameters as well as a reduction in the system's size and weight.

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