

Smart Elderly Health monitoring Device Via Internet-of-Things (IoT)

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Abstract

The ageing global population has led to a rise in older adults living alone, increasing their risk of accidents and medical emergencies. Traditional monitoring methods are often inadequate, resulting in delayed intervention and compromised care. Thus, this study proposes an IoT-based smart healthcare device designed for continuous and remote monitoring of the geriatric elderly. The system integrates multiple sensors, including temperature, pulse, accelerometer, and fall detection to assess vital signs and identify abnormal events. The system is linked to Telegram, a software that alerts the caretaker to any abnormal occurrences, such as abnormal temperature and heart rate, as well as a fall. Results show that the device is capable of sending an immediate alert notification once a sudden increase in heart rate of 12.5%, a fall, or a decrease or an increase of 2% in body temperature.

Keywords: Elderly, Health monitoring, Internet-of-Things, Smart device

1. Introduction

Chronic illnesses among the elderly raise challenges that significantly strain health care and the country's economy [1]. Many elderlies live alone, but for seniors with deteriorating cognitive ability, living alone can be challenging [2]. Any abnormalities of their health or

sudden fall without quick treatment can lead to severe injuries or death.

In recent years, IoT-based projects have been launched for health monitoring. Tamilselvi *et al.* used temperature, heartbeat, eye blink, and SPO2 sensors to measure the patient's body temperature, coronary heart rate, eye movement, and oxygen saturation percentage [3]. Islam *et*

al. [4] designed a smart healthcare system that capable to monitor patient's vital sign. Kanagaraju *et al.* [5] proposed IoT based system to periodically monitor physiological indications of patient's body. An alert will be issued to the treating physician and the patient's caregiver if any of the sensor's current threshold values are exceeded the safe limit. Even though these projects were used for hospital patients, the same concept can be applied for monitoring the elderly at home.

Kit *et al.* [6] indicate that a fall incident requires an immediate emergency reaction. The authors proposed the implementation of accelerometer sensor to detect and alarm any fall. The elderly are also exposed to experiencing falling incidents at home, especially in the bathroom, where the floor is wet and slippery. Therefore, this study proposed to add this element to the health monitoring system.

2. Methodology

2.1. Development of the smart elderly health monitoring device prototype

Figure illustrates the proposed portable smart elderly health monitoring prototype This study utilised ESP32 as the microcontroller, MLX90614 as the body temperature sensor, MAX30102 as the heart rate sensor and MPU 6050 as the falling detection sensor. Before usage, all sensors were calibrated using Arduino IDE to ensure their accuracy and reliability. To construct this monitoring and warning system, the sensors were linked to the ESP32. The microcontroller is responsible for reading sensor data, analysing the data, and triggering the alarm if necessary. In addition, the microcontroller is programmed to dynamically adjust the thresholds based on the user's activity level or other circumstances that impact the sensor data.

When sensor data exceeds the preset threshold, an alarm is delivered to notify the user or caretaker via the Telegram messaging application. The message includes the time, and the type of alert such as temperature warning, abnormal heart rate and fall detection. Other than Telegram, users or any person with access can monitor the elderly by using ThingsBoard dashboard in mobile application by simply download ThingsBoard application from the Google Apps Store. ThingsBoard is generally used to organise and display data. It offers a selection of tools and services for gathering, analysing, and visualising data, making it simple for users to learn and control their IoT systems.



Figure 1 Smart elderly health monitoring prototype

2.2. Temperature, heart rate, and fall detection sensors threshold

When the patient's body temperature falls below 34 degrees Celsius or climbs beyond 37.5 degrees Celsius, an alert message will be sent through Telegram notification. This temperature range is considered abnormal and may suggest a fever or other condition requiring medical care. To determine heart rate, the time interval between two heartbeats, RR is required [7]. The unit for RR is in milliseconds. The heart rate is determined by dividing 60 seconds by the RR interval in seconds. If the average heart rate calculated by the equation falls below 60 or exceeds 110 beats per minute (BPM), it may indicate a potential health issue, hence alert will be sent. A fall is assumed to occur when the roll angle obtained by the accelerometer is exceeds ± 50 degrees. The angle of inclination is set at ± 50 since it has reached a point where it is likely that a person may fall. When the sensor reaches this value, the caretaker will be alarmed.

2.3. Experiment procedure

The experiment is carried out by comparing the data from the developed device with the data taken from the medical-grade equipment. The aim is to ensure that the proposed system can be a dependable tool for temperature and heart rate monitoring. The temperature sensor is compared with tympanic thermometer while the heart rate sensor is compared with pulse oximeter. Figure 2 shows an experimenter wearing the proposed prototype on his wrist and arm. On the other hand, the system's viability for detecting falls is also studied. The monitoring system detects fall by evaluating the acceleration data and roll angle, which can offer information on rapid body position and orientation changes. The analysis of the time taken for the alert notification to be send out is also conducted.

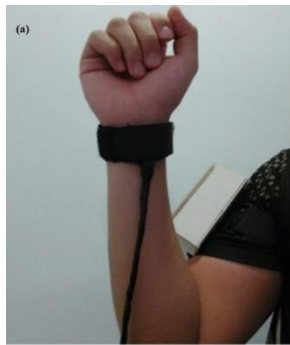
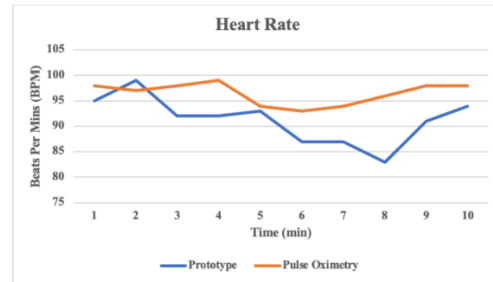


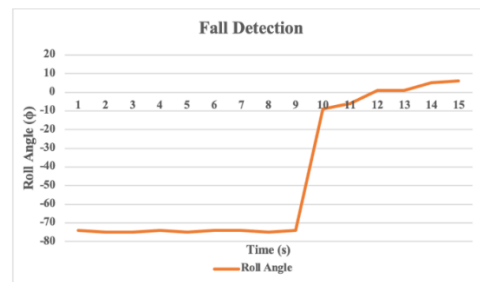
Figure 2 The developed smart elderly health monitoring prototype

3. Results and Discussion

Figure 3a shows the results for temperature monitoring. The average temperature recorded by the tympanic thermometer is 36.04 °C, while the average score recorded by the proposed prototype is 35.90 °C. Although the output values by the prototype are not as accurate as tympanic thermometers, it still can offer a decent idea of the elderly’s temperature trend over time, which is essential for monitoring fevers and other abnormalities. Figure 3b shows the comparison of heart rate reading between pulse oximetry and the prototype. The pulse oximetry, had an average heart rate of 97.8 BPM, as opposed to 92.2 BPM for the prototype. The deviation between both devices is 5.6 BPM which can be considered as acceptable. This indicated the capability of the prototype to produce similar heartbeat value with the medical-grade equipment. According to Figure 3c, there was no big changes in roll angle until 9s which indicated that there was no fall incident occurred. At 9s, the roll angle rose until more than 50 degrees. This caused the fall detection system to be activated as it treated it as a fall. The alarm system alerts the caretaker when specific conditions are met, such as low or high body temperatures, aberrant pulse rates, or falls. Figure 3d shows the examples of Telegram notification messages when the temperature, heart rate and roll angle pass the threshold.



(b) Heart rate monitoring result

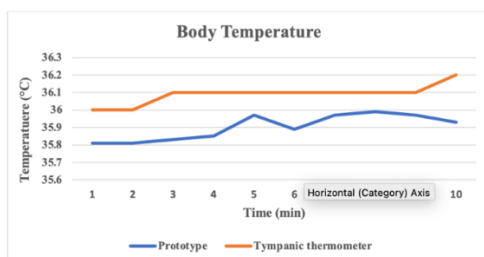


(c) Fall monitoring result



(d) Alert notification via Telegram

Figure 3 Results of (a) temperature, (b) heart rate, (c) fall monitoring, and (d) alert notification



(a) Temperature monitoring result

4. Conclusion

In conclusion, as the population ages, the demand for increased support to help seniors maintain their independence while ensuring their safety and well-being increases. However, a lack of proper monitoring systems may lead to poor treatment, delayed therapy, missed opportunities for early intervention, and a breakdown in coordination and communication between family members and medical professionals. This study successfully developed a smart elderly health monitoring prototyped via IoT which is capable to give immediate alert notification through Telegram when an aberrant occurrence, such as abnormal temperature and heart rate, as well as a fall. In future works, future innovations may incorporate with lower-power sensors, energy-saving technologies, and smaller components. There may be a need for additional communication channels to guarantee

that all users, regardless of their technological proficiency, have access to the system.

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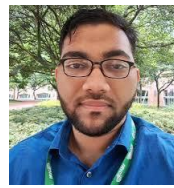
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