InnovAge: Revolutionizing Elder Care through Integrated Health Monitoring and Emergency Response

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***Abstract*—The contemporary trend towards individualistic lifestyles has resulted in increased isolation among the elder members of the family, leading to increased health concerns for the elderly. Addressing the well-being of this demographic requires a sustained monitoring system. Our proposal involves a battery-powered wrist-worn device utilizing Internet of Things (IoT) technology to collect real-time health metrics such as Oxygen Concentration, Body Temperature, Heart Rate, and Blood Pressure. This device aims to provide healthcare professionals and family members with immediate access to health data via SMS and an application, enabling prompt intervention when necessary. Additionally, the device includes an alert system to notify authorities in case of a fall or distress, facilitated by an SOS Button. It incorporates a GPS tracker to locate individuals afflicted with Alzheimer's or prone to wandering. Crucial to its success is ensuring accessibility and user-friendliness for both healthcare providers and elderly patients. By merging technology with compassionate care, this initiative aims to enhance surveillance, expedite emergency responses, and improve the overall well-being of patients, emphasizing the role of technology in advancing patient-centered healthcare solutions.**

***Keywords*— IoT, Elderly monitoring, SOS, health, monitoring, population**

I. Introduction

Due to improvements in medical sciences and technologies, the elderly world population is estimated to increase from 8.5% of the total population in 2015 to 12% and 16.7% in the years 2030 and 2050, respectively [1]. In most countries over the world, the life expectancy has increased dramatically in the last decades. It is because of the advancement in the medical science, diagnostic technology, and increasing awareness about diseases, health and environmental [2]. According to the World Health Organization (WHO), by 2050 the aging population above 65 of age will overstep the number if children within under 14 years of age [3]. Consequently, around 15 percent of the world's population is suffering from various illnesses, within 110-190 million elders receiving remarkable responsive problems [4]. The Population estimate according to UN, is the number of aged persons within the years of 65 and older will surge by 20230 in the world [5]. Figure 1 indicates how death occurs in elderly people every year due to depression and loneliness. Due to the advancing lives of the younger generations, the elders have to stay alone at home and no one is present to look after or to cater for their needs in case of an emergency. More often than not, cardiac arrest takes away the life of an elder because of untimely care and response. Hence, a solution is required for this issue. Technological advancements, particularly in the realm of wearable devices and the Internet of Things (IoT), offer promising avenues for improving the quality of life and safety for the elderly population. This paper presents a research study on the development and implementation of a battery-powered, wrist-worn device designed to monitor real-time health metrics for older adults, including oxygen concentration, body temperature and heart rate. Leveraging IoT technology, this device transmits health data to healthcare professionals and family members via SMS and a dedicated application, enabling prompt intervention when necessary. The unique point of this device is fall detection. The concerned authorities, i.e., either families or the hospital can immediately be informed if the person wearing it falls down or meets some sort of an accident involving a direct blow. Additionally, the device features an alert system with an SOS button for emergency situations, as well as a GPS tracker to assist in locating individuals with Alzheimer's or those prone to wandering. The battery will be rechargeable and the device will be sensing oxygen concentration and the heart rate using MAX30100, the device uses MPU6050 for fall

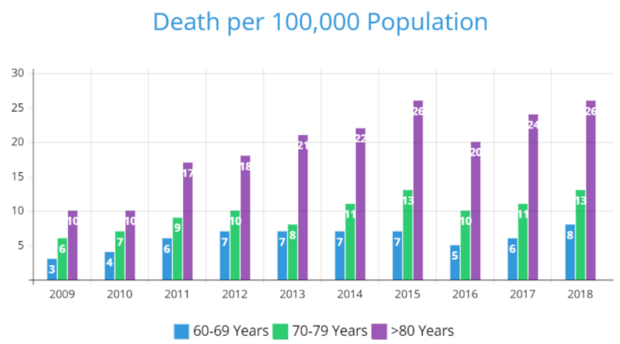

Figure 1: Graph of Death per 100,000 population of adults every year.

detection and temperature sensor, the device makes use of ESP-32 as the Wi-Fi- Module. GSP Neo-6M module is used for GSP Tracking. In order to send SMS to the concerned authorities GSM Module is used for sending SMS to the concerned authorities.

II. RELATED REVIEW STUDY

Paper [6] describes some research exploring the use of IoT technologies to address the challenges of remote elderly monitoring, such as optimizing power consumption, reducing network latency, and improving data processing efficiency. Sensor performance has been improved and cloud dependency has been reduced by using strategies like edge computing and adaptive sampling. These studies show that local gateways are increasingly being used for data processing and storage, which is consistent with the use of a local Human Motion Processing (HMP) in our proposed system. One strategy to improve system efficiency and expedite data collecting is to apply Compressive Sensing (CS) for power-saving fits fulfilling the need for further scalability to accommodate larger populations.

The CloudDTH platform emerged to bridge real and virtual healthcare as introduced in paper [7]. This framework integrates big data along with the technology of digital twin tech as introduced in 2003. It also integrates cloud computing, and health IoT into eight levels, catering to the healthcare needs of seniors. While promising to enhance medical efficiency, it overlooks resource allocation inequalities and crisis alerting for senior patients. Moreover, it lacks consideration of scalability and implementation challenges, focusing mainly on theoretical aspects and neglecting ethical and privacy concerns.

Another research [8] reviews a machine learning-based fall detection system for older adults, emphasizing challenges with simulated datasets and advocating for a design rooted in real activities. The system shows low false positive rates and strong sensitivity for both wrist-worn and neck-worn devices. However, it lacks in-depth analysis of computational complexity and integration into wearable technology. Moreover, it provides scant details on the adaptability of the machine learning approach across various environmental conditions and demographic groups, and overlooks potential training and testing challenges with real-world data.

In the paper [9], a wearable triaxial accelerometer is used to detect falls efficiently while conserving power. This sensor captures acceleration along three axes, detecting vibrations, motion, and orientation changes in three dimensions. The system employs a quaternion algorithm to identify falls and alert caregivers to the wearer's location promptly. However, the algorithm's reliance on rotation patterns may trigger false alarms during routine activities. Integrating additional sensors to detect human stride could increase power consumption, complicating algorithm development.

Wearable technology has become crucial to the care of the elderly since it collects a variety of data to track activities and health, improving quality of life and facilitating timely interventions. It [1] creates new avenues for study in innovative fields like integrated applications and robotic technologies. However, issues like compatibility among various IoT devices might make integration and data sharing difficult in settings providing senior care. Furthermore, before IoT devices are widely adopted, serious privacy and security issues about the sensitive health data they collect must be addressed.

WeCare [10] is an IoT-based healthcare system for seniors, detecting falls and monitoring vital signs. It features a wearable wristband and a web app for data collection and alerts. With a 12-day battery life and a 60-meter operational range, it issues out-of-range alerts. However, real-world performance may vary. Future plans include scalability testing, privacy considerations, and additional sensors for heart rate and blood pressure.

In today's world, as in [2] human life expectancy is declining, the elderly may require immediate and intensive medical care, which can sometimes result in life-threatening consequences. Monitoring the physiological parameters and behaviours of senior citizens can help avert such dire emergency scenarios. The development of physiological sensors and low-power wireless networks has led to the development of remote patient monitoring systems for the elderly, offering affordable means of monitoring health and well-being. These systems decrease the need for hospital visits by enabling real-time monitoring of older people at home using wearable sensors, medical devices, and contemporary communication technologies.

Paper [11] introduces WISE, a real-time health monitoring system within the Body Area Sensor Network (BASN) framework. It allows direct data transmission to the cloud, eliminating the need for a smartphone. Despite its benefits in personalized healthcare, challenges include user discomfort from wearing multiple sensors and limitations in data handling due to sensor node constraints. Additionally, real-time tracking systems like WISE may encounter issues with service discovery and emergency response times.

III. METHODOLOGY

The methodology for implementing the proposed project involves a systematic approach integrating various components for the development of a comprehensive elder care system. The process begins with the identification and procurement of the necessary hardware components, including the 3-axis acceleration sensor (MPU6050), ESP-32 Module, A6 GSM Module, Max 301000 Oximeter Sensor, GPS 6M Neo Module, OLED Display, Buzzer, SOS Button, Skin Temperature Sensor, and Heartbeat Pulse Sensor. Table 1 displays the components that are used in the products.

This paper shows how the product will be implemented using a methodical technical approach that starts with the careful selection and acquisition of hardware components, each of which is picked for its unique features and suitability for the system design. Figure 2 depicts the block diagram of the product where in order to identify dynamic variations in acceleration along orthogonal axes, which are essential for fall detection algorithms, the 3-axis acceleration sensor (MPU6050) is used. The ESP-32 Module as shown in Figure 8 functions as the central processing unit of the system, coordinating the wireless transmission, processing, and collecting of sensor data. The ESP-32 communicates with a range of sensors through the use of SPI and I2C protocols. One such sensor is the Max 301000 Oximeter Sensor as shown in Figure 4, which measures heart rate and oxygen saturation precisely by utilizing pulse oximetry and photoplethysmography (PPG).

Accurate geolocation data is provided by the GPS 6M Neo Module as shown in Figure 6 in tandem, which is essential for emergency response and real-time tracking. Careful cabling and circuitry design are necessary for the integration process to ensure maximum signal integrity and low interference. A key component of the process is firmware development, which entails putting complex algorithms into practice to allow for real-time data processing and analysis. To identify aberrant acceleration patterns suggestive of falls, the fall detection algorithm, for example, uses the raw accelerometer data from the MPU6050 sensor as shown in Figure 5 and subjects it to advanced signal processing methods like Fourier transforms and digital filters.

Additionally, to extract accurate oxygen saturation and heart rate readings, the oximetry algorithm installed on the ESP-32 processes raw signals from the Max 301000 sensor using adaptive filtering and artifact removal methods. Signal processing techniques are designed to operate smoothly in contexts with limited resources by maximizing computational efficiency and minimizing power usage. Simultaneously, the incorporation of an emergency response system necessitates the careful arrangement of the SOS Button and Buzzer, which are essential elements for triggering quick alerts and distress signals. Figure 9 shows OLED displays which offer unmatched contrast, vibrant colours, and flexible designs, ensuring immersive viewing experiences, energy efficiency, and superior visuals for next-generation displays.

When the ESP-32 is turned on, it initiates a series of preset emergency protocols that include receiving GPS coordinates, sending SMS messages via the A6 GSM Module as shown in Figure 7, and sounding an alert through the Buzzer. The firmware incorporates sophisticated error detection and correction techniques to minimize transmission faults and guarantee data integrity. Strict testing protocols, including extensive simulation scenarios and stress tests, confirm that the system is reliable, accurate, and responsive in a variety of operating environments.

The code for the product is written in C language in Arduino IDE. Figure 3 depicts the schematic diagram of the product where all the components are connected to each other. A SOS Button is present in the device which can be used by the elders if they feel uneasy and not well and they want it to be informed to the concerned authorities. SMS will be sent to them about the status of the condition and the exact google location of them will be sent to the family members.

The concerned people could track the live health of the elders through the website that gives real time monitoring of their SpO2 level, heart rate, temperature.

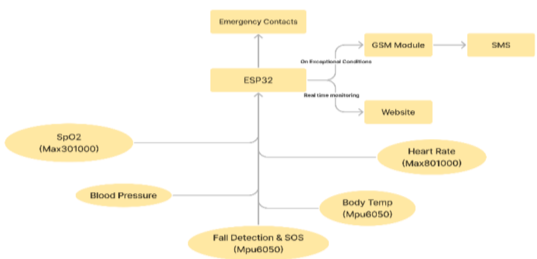

Figure 2: Block Diagram to show the connections of each component.

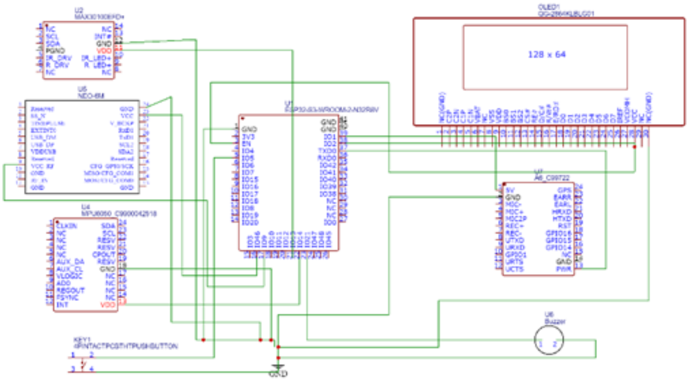

Figure 3: Schematic Diagram to show the pin connections of each component.

Figure 4: MAX301000

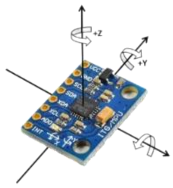

Figure 5: MUP6050

Figure 6: GPS Neo-6M Module

Figure 7: GSM Module

Figure 8: ESP-32

Figure 9: OLED Display

COMPONENT	DESCRIPTION
3-axis acceleration sensor OR mpu6050	Fall Detection and Temperature Sensor
ESP-32	Wi-Fi Module
Max 301000	Oximeter Sensor and Heartrate Sensor
GPS Neo-6M Module	GPS Tracker
OLED Display	To display all the readings
Buzzer	SOS Button
GSM MODULE	To send SMS to the concerned authorities

Table 1: Components List

IV. RESULT AND DISCUSSION

In conclusion, the escalating trend in the global elderly population necessitates a proactive response to address the burgeoning healthcare needs of older adults. This research endeavours to meet this challenge head-on by focusing on the development and implementation of a wrist-worn health monitoring device, strategically leveraging advancements in wearable technology and IoT.

The devised solution is not merely a product but a comprehensive system designed to enhance the quality of life and safety for older adults. By seamlessly integrating vital sign monitoring, emergency response functionalities, and GPS tracking capabilities, the device offers a multifaceted approach to elder care management. Through meticulous hardware selection, firmware development, and rigorous testing, the system has been engineered to deliver reliable and accurate performance across diverse real-world scenarios.

At its core, this research underscores the transformative potential of technology in revolutionizing elder care. By providing timely intervention and support, the developed system aims to mitigate health risks, enhance independence, and promote overall well-being among older adults. Moreover, it serves as a testament to the power of innovation in addressing complex healthcare challenges and driving positive societal impact.

The device thus developed is a compact wearable health monitoring device integrates accelerometers, heart rate, oxygen saturation sensors, and GPS for real-time tracking. With wireless connectivity to a smartphone app, it provides vital health data to caregivers. Powered by a rechargeable battery, it features user-friendly firmware written in C within the Arduino IDE, ensuring efficient data processing and transmission.

In essence, this research represents a significant step forward in the pursuit of a more inclusive and supportive healthcare ecosystem for older adults. By harnessing the potential of technology, we can empower older adults to live healthier, more independent lives, while also providing peace of mind to their caregivers and loved ones.

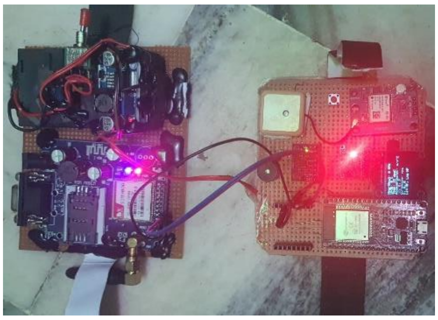

Figure 10: Final hardware product

Figure 10 shows the final hardware that is developed which can be worn by the elders for real time monitoring of their health and fall detcection.

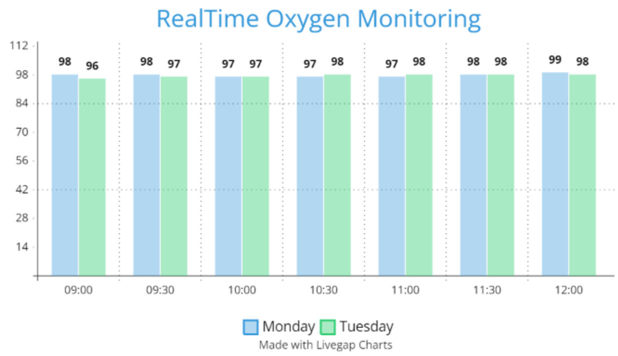

Figure 12: Graph to show real time oxygen monitoring.

Figure 12 shows the Graph of real time monitoring of oxygen in the elderly. The concerned authorities could keep a track of this data from the website that is created and thus draw a conclusion accordingly.

Figure 13: Output being shown.

Figure 13 shows the output that is being displayed on the OLED display which showcases the Body Temperature, Oxygen Concentration, three axis acceleration and Heart Rate.

V. CONCLUSION

In conclusion, as the global elderly population continues to expand, there is a pressing demand for innovative healthcare solutions tailored to their unique needs. This research endeavor has been dedicated to the development of a wrist-worn health monitoring device, leveraging advancements in wearable technology and IoT.

The objective extends beyond mere technological innovation; it strives to significantly enhance the quality of life and safety for older adults and their caregivers. Through the integration of vital sign monitoring, emergency response functionalities, and GPS tracking, the device presents a multifaceted approach to elder care management. Extensive efforts in hardware selection, firmware development, and rigorous testing have culminated in a system characterized by reliability and effectiveness in real-world scenarios.

However, this work represents but a milestone in the ongoing pursuit of comprehensive elder care solutions. Future endeavors may delve into further refinement of the device, exploration of expanded functionalities, and strategies for broader accessibility.

In essence, this research underscores the pivotal role of technological innovation in addressing the complex healthcare challenges faced by an aging population. By fostering independence, safety, and peace of mind, the developed elder care system strives to make a meaningful impact on the well-being of older adults and their families.

References

[1] Tun, Soe Ye Yint, Samaneh Madanian, and Farhaan Mirza. "Internet of things (IoT) applications for elderly care: a reflective review." Aging clinical and experimental research 33 (2021): 855-867.

[2] K. Guizani and S. Guizani, "IoT Healthcare Monitoring Systems Overview for Elderly Population," 2020 International Wireless Communications and Mobile Computing (IWCMC), Limassol, Cyprus, 2020, pp. 2005-2009, doi: 10.1109/IWCMC48107.2020.9148446.

[3] World Health Organization. "Are you ready? What you need to know about ageing." World health day 2012 (2012).

[4] Disability and Health, [online] Available: http://www.who.int/mediacentre/factsheets/fs352/en/.

[5] K. Giannakouris, "Population and social conditions regional population projections europop2008: most eu regions face older population profile in 2030", Eurostat: Statistics in focus, 2010.

[6] Boukhennoufa, Issam, et al. "A novel gateway-based solution for remote elderly monitoring." Journal of biomedical informatics 109 (2020): 103521.

[7] Liu, Ying, et al. "A novel cloud-based framework for the elderly healthcare services using digital twin." IEEE access 7 (2019): 49088-49101.

[8] Saleh, Majd, et al. "A reliable fall detection system based on analyzing the physical activities of older adults living in long-term care facilities." IEEE transactions on neural systems and rehabilitation engineering 29 (2021): 2587-2594.

[9] Wu, Falin, et al. "Development of a wearable-sensor-based fall detection system." International journal of telemedicine and applications 2015 (2015): 2-2.

[10] Pinto, Sandro, Jorge Cabral, and Tiago Gomes. "We-care: An IoT-based health care system for elderly people." 2017 IEEE International Conference on Industrial Technology (ICIT). IEEE, 2017.

[11] Wan, Jie, et al. "Wearable IoT enabled real-time health monitoring system." EURASIP Journal on Wireless Communications and Networking 2018.1 (2018): 1-10.