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LifeGuardian; A Smart Bracelet for Visually Impaired Elderly

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ABSTRACT

This study investigates the utilization of Internet of Things (IoT) as a promising technology to monitor and enhance individuals' well-being. The study aims to achieve a comprehensive understanding of the main objectives, namely, to assess the effectiveness of health bracelets in tracking vital signs and physical activity especially in the case of visually impaired people, to evaluate their impact on health outcomes, and to identify potential limitations and challenges. The study employs an agile-method approach, combining data analysis from a diverse sample of participants and qualitative research regarding health, into creating a unique Arduino device that utilises IoT and various sensors to track wearer's vitals. Results indicate that LifeGuardian accurately measures heart rate, temperature, and valuable insights into individuals' overall health status. Moreover, wearing the LifeGuardian for an extended period has been associated with improved health activity levels and enhanced awareness of personal health. The discussion highlights the need for further research to address these limitations, as well as the importance of customization and personalization features in future bracelet designs. Overall, this study contributes to the growing body of knowledge on LifeGuardian and offers insights for researchers, practitioners, and developers to enhance the effectiveness and user experience of these wearable devices.

1. Introduction

About 285 million people worldwide are visually impaired, of whom 39 million are completely blind, according to the World Health Organization. Inadequate monitoring of current health can bring an unforeseen risk of health dangers for these visually impaired people as they might not be able to know what is happening. These include the potential risks associated with undiagnosed health conditions, delayed medical interventions, insufficient monitoring capabilities, and inadequate health education [1]. Many health conditions can go unnoticed without regular monitoring, leading to serious consequences [1]. Lack of timely intervention can result in critical situations such as heart attacks or sudden cardiac arrests. The rapid advancements of technology, particularly Internet of

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Things (IoT) allows for ground breaking applications into smart health monitoring that allows for anyone to track their health. The integration of Arduino and Internet of Things (IoT) has led to the development of innovative solutions aimed at improving personal health monitoring. This project focuses on taking pre-active steps into monitoring health through the use of a health monitoring bracelet, and its technical aspects.

The next section will discuss the comparisons of the project with other similar devices followed by the description of every phase of the methodology used in the project in section 3, which discusses the method of our project followed by results and discussion as well the as conclusion as the last section of this paper.

2. Literature Review

LifeGuardian was developed to cater to the healthcare needs of older adults in an aging society especially the visually impaired as we have notification that can cater to alert their loved ones in case of emergency and this device which are susceptible to heart disease [2]. It is a user-friendly wearable device that utilizes sensors such as a heart rate sensor, a temperature sensor, an accelerometer, and an emergency button. These sensors combine to enable continuous health monitoring, early detection of health issues, enhance safety, and provide instant health insights [3]. The bracelet empowers wearers by offering real-time data on vital signs, facilitating timely intervention, and ensuring peace of mind during emergencies. Overall, Additionally, the presence of the emergency button enhances wearer safety by enabling them to easily summon assistance during emergencies. Referring to the topic of smart health bracelets, there are several similar devices that share the same principles of LifeGuardian. To stand out, comparisons have been documented to create a unique and better device.

Table 1 shows that most of the project used similar items in the realm of Arduino projects, health monitoring systems have gained significant popularity. This to provides a comparative analysis of three such Arduino projects: MyBotic Durian UNO, MountDynamics Health Monitoring System, and Ut Go Health Monitoring Wristband. The analysis focuses on their advantages and disadvantages, enabling readers to make informed decisions when choosing a suitable health monitoring solution, whilst also giving the project team a foundation to base the initials ideas upon.

Table 1
Differences between the existing projects

Differences Project	Advantages	Disadvantages
MyBotic Durian UNO - Smart Patient Monitoring System [4]	Contains LCD display for displaying user health metrics.	Does not have an emergency button.
	Includes SpO2 sensor for blood oxygen level monitoring, including BPM monitoring.	Large in size.
	Includes LM35 Temperature Module, enabling body temperature tracking.	Lacks a battery to be fully portable and worn.
Pulse Oximeter! Measure Heart Rate and Oxygen Saturation using Max30102, Arduino and Oled Display [5]	Contains a similar LCD display to the MyBotic system.	Lacks a temperature sensor.
	Tracks and measures BPM and SpO2 levels.	Push button can be seen as unnecessary and should've been used as an emergency button.
	Includes a push button that acts as a display navigator.	Unable to be worn, lack of a proper strap.
Heart beat monitoring wrist band. Is it possible to make using MAX30102 module [6]	Comes with similar heartbeat sensing capabilities as other Arduino projects.	No SpO2 sensor for blood oxygen level monitoring.
	Smaller LCD display that project current wearer's readings.	Lack of an emergency button.
	Smallest size footprint amongst the bunch.	Similar to the other Arduino projects, with no distinguishing feature.

3. Methodology

The methodology that is used in this study is the Agile methodology as shown in Figure 1, which is an iterative and incremental approach to project development that prioritises adaptability, collaboration, and continuous improvement [7]. Unlike traditional waterfall methods, agile methodologies emphasis user collaboration, frequent feedback, and the delivery of working software in short development cycles called sprints. Agile projects are divided into phases, each with its specific objectives and deliverables.

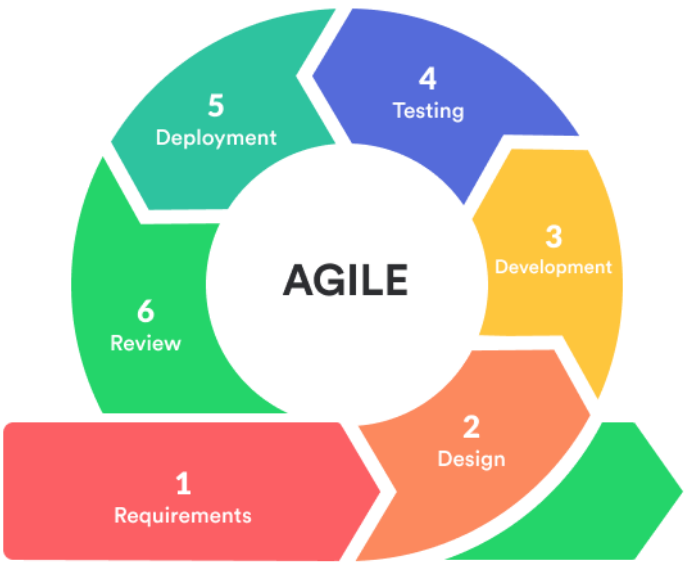


Fig. 1. Phases in Agile Methodology

3.1 Requirements

The requirement phase serves as a crucial starting point for the project. The phase involves gathering essential knowledge to create a main framework of ideas for the LifeGuardian project. This phase is key to setting the stage of a successful development journey in revolutionizing the wearable devices that have emerged as valuable tools for monitoring and improving personal health.

3.2 Design

During the design phase, requirements are obtained and collected to begin creating an innovative health tracking bracelet. This phase also acts as the architectural stage, which follows a top-down technical approach. Various diagrams, such as the context circuit diagram, and flowchart, are used in this scenario to describe how the LifeGuardian bracelet would work, from receiving input to processing and providing the final output.

Figure 2 shows function circuit diagram is a simplified graphical representation of how different components in a circuit are connected. The diagram details the wiring and connections that are connected to create the circuit of the LifeGuardian bracelet.

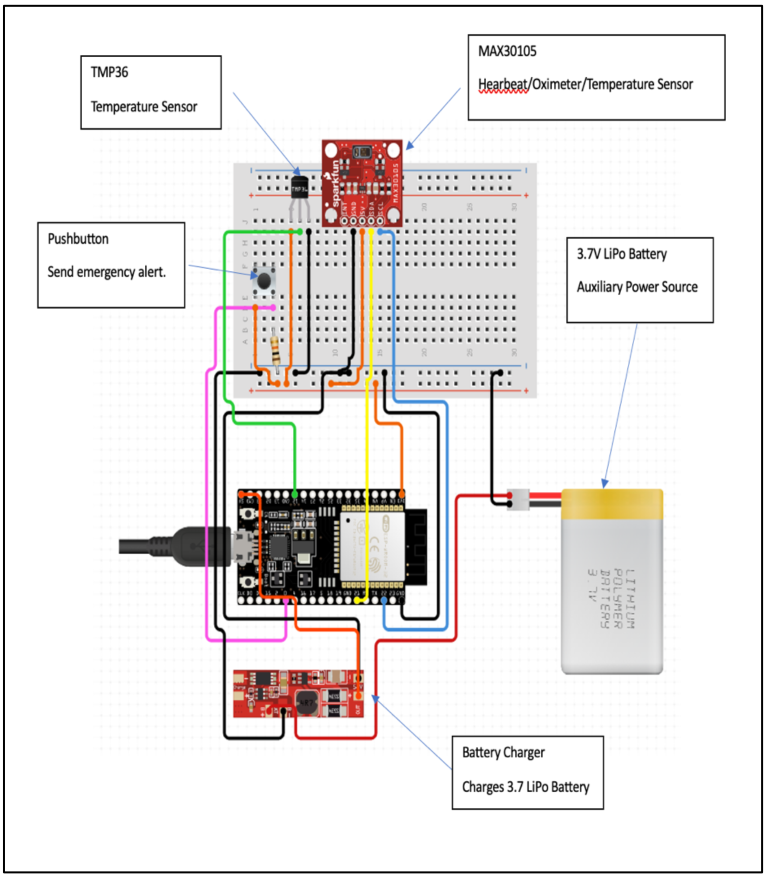


Fig. 2. Circuit diagram

The ESP32 Arduino board acts as the main board that all sensors are connected to transmit data, whilst the main power source is from the 3.7 LiPo battery. Figure 3 shows function flowchart is a visual representation of the steps or actions that need to be performed to achieve a specific task or function. The flowchart represents the series of steps and procedures the LifeGuardian bracelet executes throughout its use.

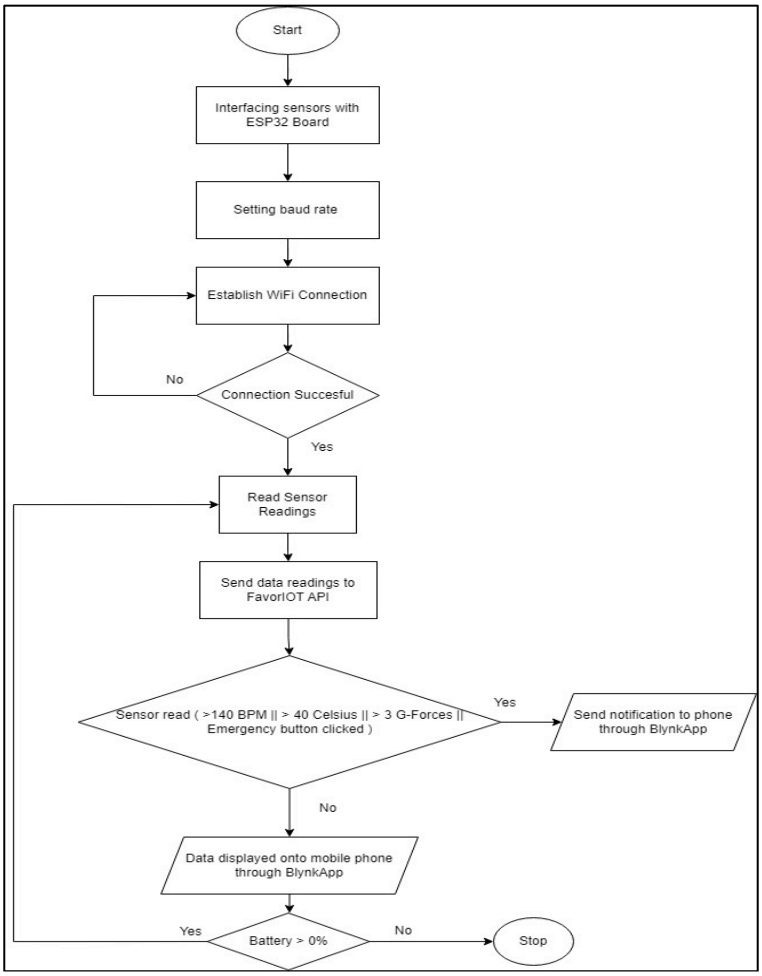


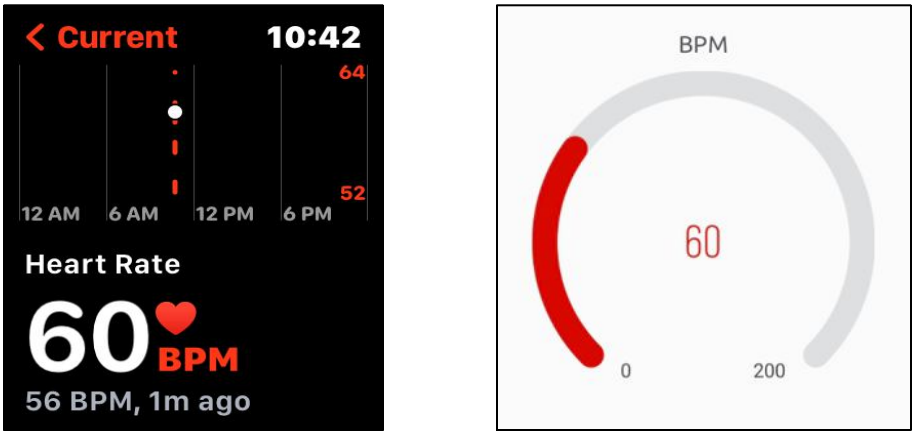
Fig. 3. Flowchart diagram

3.3 Development

After the design phase, the project is set to be developed. All planning, component specifications, and desired functionalities of the project are developed following increments for each separate functionality including the heart rate tracker, body temperature tracker, emergency button, impact and fall detection, mobile application synchronization, and notification functionalities. Development consists of creating the main code that interfaces with all components and synchronizes with a mobile phone for sensor readings to be interpreted and displayed. The LifeGuardian bracelet will be implemented feature by feature, tested to assure functionality, and then integrated and combined into a cohesive, fully functional wearable bracelet band.

3.4 Testing

The testing phase of LifeGuardian development is crucial for ensuring its accuracy, reliability, and performance in measuring health data. This phase involves functional testing to validate the functionalities of the bracelet, including its sensors and features such as temperature, heartbeat, emergency button, and notifications. Figure 4 shows the reading of the Apple Watch, a high-end smartwatch that has a heart rate tracking capability. The high accuracy sensor of the Apple Watch provides readings like those of the LifeGuardian while being significantly cheaper.



(a) Apple Watch BPM reading (b) LifeGuardian BPM reading

Fig. 4. Comparison reading of Apple Watch and LifeGuardian

Performance testing conducted to ensure the accuracy and dependability of these sensors, comparing their readings with calibrated devices of similar functions. Compatibility testing is also conducted to ensure the bracelet works seamlessly across end devices, uncovering any issues related to data synchronization, connectivity, or performance. Thorough testing is done to identify and uncover future issues that may arise and take pre-active actions to eliminate further anomalies which guarantee precise and trustworthy data.

3.5 Deployment

The deployment phase of the project follows an iterative approach. Iterative deployment involves small, frequent releases based on user feedback and priorities. User acceptance testing validated integration and deployment, with feedback driving further improvements. Deployment procedures assisted in completing the process, and continuous monitoring provided real-time data for ongoing enhancements. Through Agile methodology, LifeGuardian achieved seamless integration and deployment into successfully creating and delivering a high-quality bracelet that tracks the wearers health metrics and provides a warning system for guardians.

3.6 Review

The primary objective of the review phase is to assess the implemented features, identify any gaps or discrepancies, and validate their alignment with the project's requirements. During review meetings, the team presents the completed work, demonstrating the functionality and usability of the LifeGuardian. Feedback and suggestions from the target scope are gathered, and necessary adjustments or improvements are noted for implementation in subsequent sprints.

4. Results and Discussion

4.1 Results

Figure 5 shows the main dashboard that displays the current health metrics of the wearer. The wearer’s heart rate (BPM), and body temperature (Celcius) are displayed as a gauge for the current readings, in addition to a chart that shows the patterns of the readings.

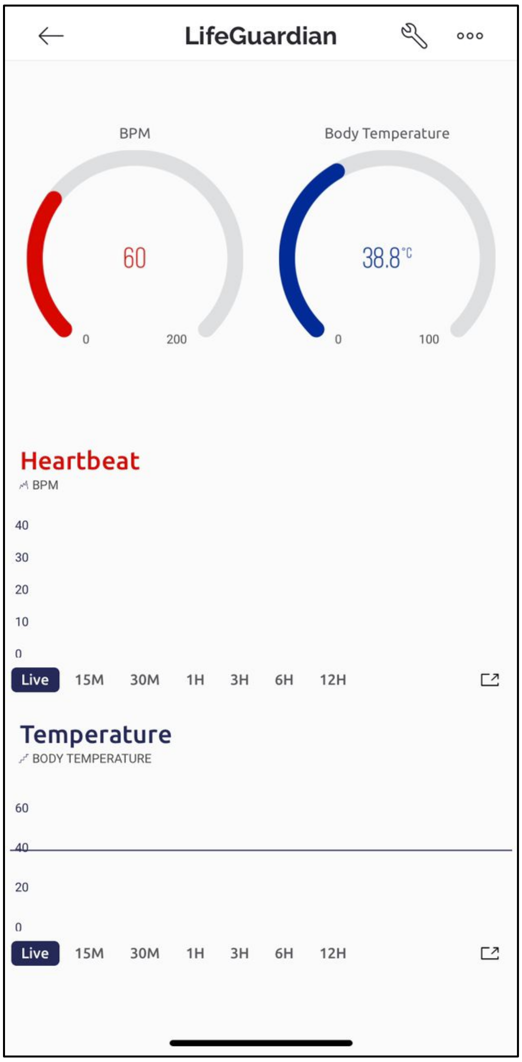


Fig. 5. Main dashboard

Figure 6 showcases the notification that is sent to the connected mobile phone, in the case that the wearer is having an emergency and presses the emergency pushbutton on the bracelet. While, Figure 7 displays the notification that is sent to the mobile phone when a fall by the wearer is detected by the LifeGuardian bracelet.

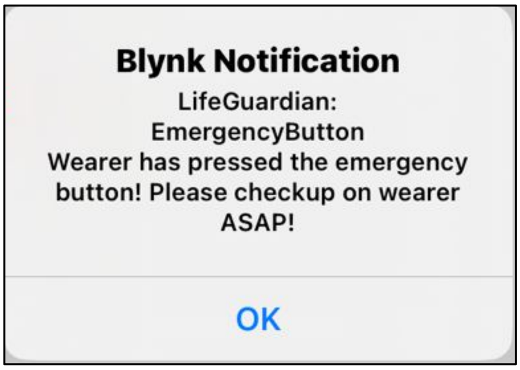


Fig. 6. Emergency button alert

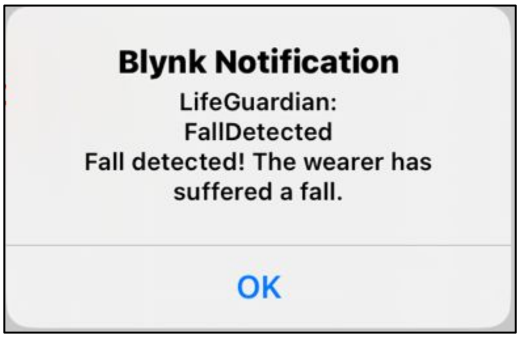


Fig. 7. Fall detection alert

According to Figure 8, the data provided, individuals under the age of 18 account for 16.1% of the respondents who filled out the form. This indicates that there is a significant portion of the population in the younger age bracket. Furthermore, those above the age of 18 make up 41.9% of the participants, suggesting a larger representation of adults in the survey.

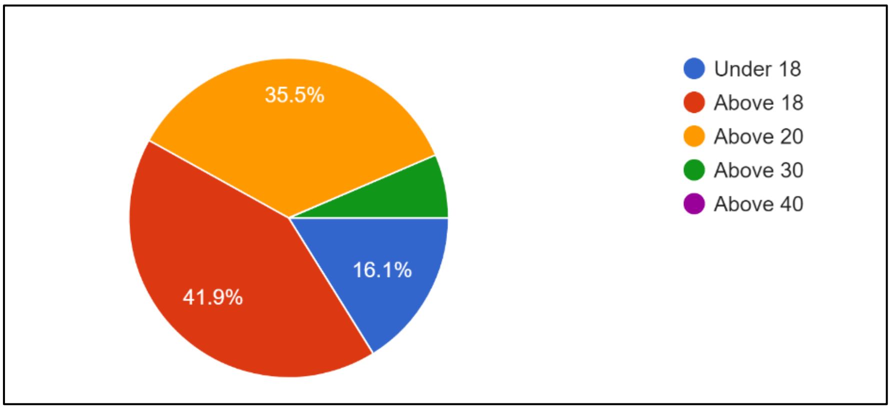


Fig. 8. Age respondents

Additionally, when considering respondents above the age of 20, they comprise 35.5% of the total. This shows that there is a substantial number of individuals in their twenties who have taken part in the survey. Finally, the remaining percentage is allocated to those above the age of 30. Although the specific proportion is not provided, it can be inferred that the majority of respondents fall into this age group since it encompasses the leftover percentage.

Overall, based on the given data, it can be concluded that a significant majority of the individuals who filled out the form belong to the age group of adults. This suggests a potential focus on capturing the perspectives and insights of this specific demographic within the survey or study.

4.2 Discussions

The team engages in collaborative brainstorming sessions to identify areas where the bracelet's functionality, performance, and user experience can be further enhanced. Potential improvements may include the integration of additional health metrics, such as oxygen saturation or stress levels, or the exploration of advanced machine learning techniques to provide personalized health insights. By envisioning and discussing these future improvements, the project group aims to lay the groundwork for continuous innovation, ensuring that the LifeGuardian remains at the forefront of innovating the health monitoring technology and continues to make a positive impact on the lives of individuals susceptible to heart disease.

5. Conclusion

In conclusion, the objective to develop a health product that uses the IoT concept was achieved by producing a new model of wearable device which can give many benefits for people to keep track of their health. Through the testing, this project was proven to reach the expected outcome which fulfilled the objective of this project. As for the future improvements, a few recommendations such as adding few sensors and other features would be considered in the project to develop a better product to reach a broader scope and to benefit their health and wellbeing. Besides that, as the scope of this is addressing the need of the visually impaired, the testing should be conducted with the visually impaired to identify full potential. However, due to the time constraint, that were not conducted in this study and should be considered in future.

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