SENG_492/CMPE_492
Graduation Project

Multidisciplinary Delivery Assesment

TEDU Software/Computer Engineering Department

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Prepared by

Ahmet Hakan Aksoy	**Student ID : 30649805858**
Anıl Çelik	**Student ID : 29407012522**
Mustafa Karakuş	**Student ID : 48034466522**

Advisor:	**Elif Kurtaran Özbudak**
Jury:	**Tansel Dökeroğlu**
	Özlem Albayrak
	Venera Adanova

1. Introduction

Millions of people around the world live with neurological disorders such as Dementia and Alzheimer's. These diseases cause serious symptoms such as memory loss, disorientation and physical vulnerability in individuals. This situation brings with it vital risks such as patients getting lost, not being able to express themselves or not being able to ask for help in emergency situations. Especially elderly individuals going out on their own can cause serious security problems.

This project aims to develop a specially designed smartwatch to make the daily lives of dementia patients safer and more sustainable. This device to be developed will include vital features such as real-time GPS tracking, heart rate and health status monitoring, fall detection and sending alerts via SMS in emergency situations. Thanks to these features, relatives of patients will be able to reach the current location and health status of their loved ones; this will allow for timely intervention and assistance.

The project is based on an interdisciplinary approach and combines the common knowledge of software engineering and electrical-electronic engineering. While electronic engineering covers topics such as hardware design, circuit installation and sensor integration; The software engineering side covers user interface development, embedded software design and data communication protocols. In this way, it is aimed to create a system that is both technical and user-friendly. In addition, the project includes social responsibility dimensions such as sustainability and the use of recyclable materials.

2. Overview

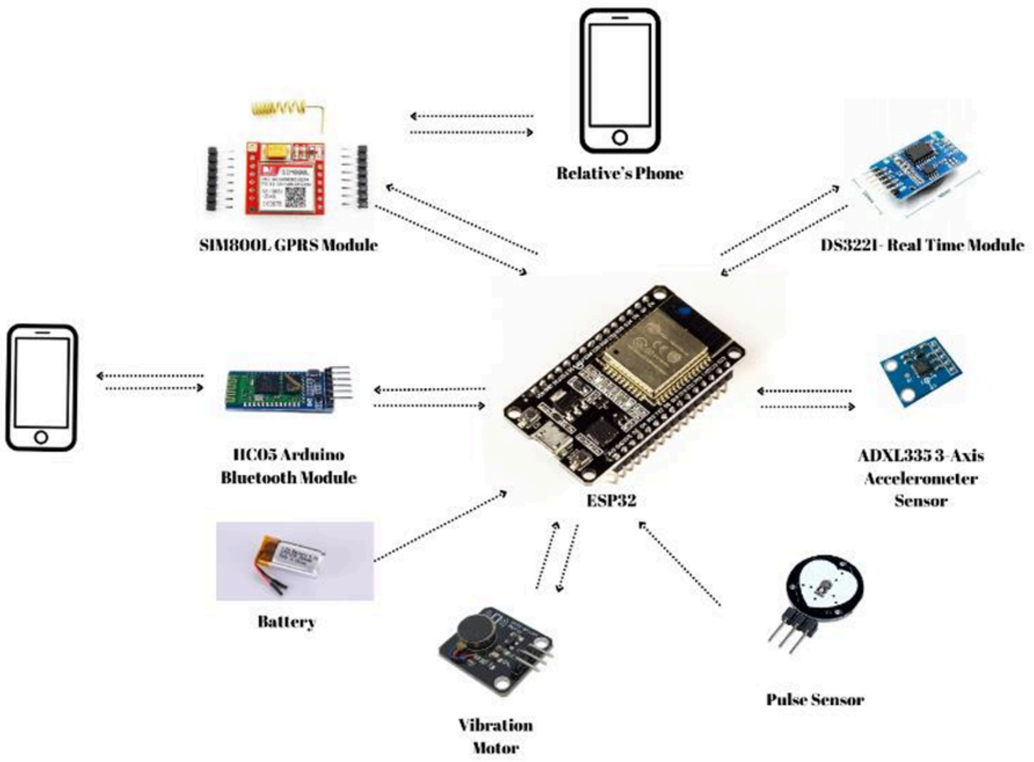
The main purpose of this project is to develop a smartwatch specially designed to increase the quality of life and safety of dementia patients. This watch includes some vital basic functions that will provide great convenience to the user and their relatives. These functions include features such as real-time location tracking (GPS), heart rate monitoring and fall detection. Thanks to these technologies, timely information transfer can be provided in cases where patients get lost, experience sudden health problems or require urgent intervention, and life-saving measures can be taken.

While the watch can transmit data over the mobile phone network with the GSM module used in the device; the GPS module collects the patient's location information instantly and transmits it to the relevant people. The Bluetooth module, on the other hand, provides data synchronization or alternative notification systems by establishing short-range connections with mobile devices when necessary. This system is designed to work independently without being connected to any smartphone. This makes it possible to safely monitor dementia patients without having to use complex devices.

This report presents the details of this multifaceted study carried out in collaboration with the disciplines of software engineering and electrical-electronics engineering. On the hardware side, processes such as the selection of sensitive sensors, the integration of low-power microcontrollers, and PCB design were included; on the software side, critical tasks such as processing sensor data, developing the user interface, and coding communication protocols were performed.

In addition, this project is not only a technical product development process, but also a user-friendly, ergonomic, and daily use device design process. Therefore, issues such as miniaturization of the device, increasing energy efficiency, and design aesthetics are also important focal points of the project. With the combination of all these goals, it is aimed to create a product that is both technically strong and practical and safe for the end user.

3. Prototype



The prototype of the smart watch is shaped on a PCB (Printed Circuit Board) specially designed for the project. The basis of this board is two powerful microcontroller alternatives that are frequently preferred in embedded systems: ESP32 and ATMega328p. Both microcontrollers offer advantages such as low power consumption, wide input/output options and easy integration with external modules. While the ESP32 model provides more flexibility in terms of wireless communication thanks to its internal Bluetooth and Wi-Fi modules, the ATMega328p has the advantage of simplicity and low cost.

In this prototype, the patient's current location is determined with the GPS module and this information can be sent to the patient's relatives via SMS thanks to the SIM card module. While short-range data transfer can be provided with the Bluetooth module, the system also includes multiple health sensors. These include modules such as a heart rate monitor (MAX30102), an accelerometer (BMA400), an ambient light sensor (BH1750) and a barometric pressure/temperature sensor (BMP280).

The device's case is designed to be lightweight, durable and suitable for long-term use, considering user comfort. In this way, dementia patients can easily carry the watch in their daily lives and use it on their wrist without discomfort. The ergonomic and aesthetic design minimizes the need for the patient to remove the device, ensuring that the device works continuously.

During the prototyping phase, the electrical connections of the circuits were tested in detail. The reliability of the system was evaluated by testing the accuracy and consistency of the sensors. In addition, comprehensive tests were conducted on communication protocols such as SMS communication, Bluetooth connection and GPS signal accuracy. These tests are critical to see how effectively the device works in real-world conditions.

This prototype was designed to form the basis of the final product and is the result of a multi-faceted engineering study that combines design, production, integration and software tests.

4. Design (Hardware-Software)

4.1 Hardware Design

Key components:
- ESP32 microcontroller for main operations and connectivity
- GPS Module (Quectel L96) for real-time tracking
- SIM800L for GSM communication
- BMA400 for fall detection
- MAX30102 for heart rate and SpO2
- BH1750 for ambient light measurement
- XC6209 regulator for power conversion
- MCP73831 for battery charging
- Custom-designed PCB using KiCad software

4.2 Software Design

The software infrastructure of the smart watch was developed in the Arduino IDE environment using the C programming language in a way that is fully compatible with the hardware components. This software is structured to manage all sensors on the microcontrollers, collect and process data, and transmit it to the user or the patient's relative when necessary. The developed software is optimized to ensure that the system operates with low power consumption and is based on the basic principles of embedded system programming.

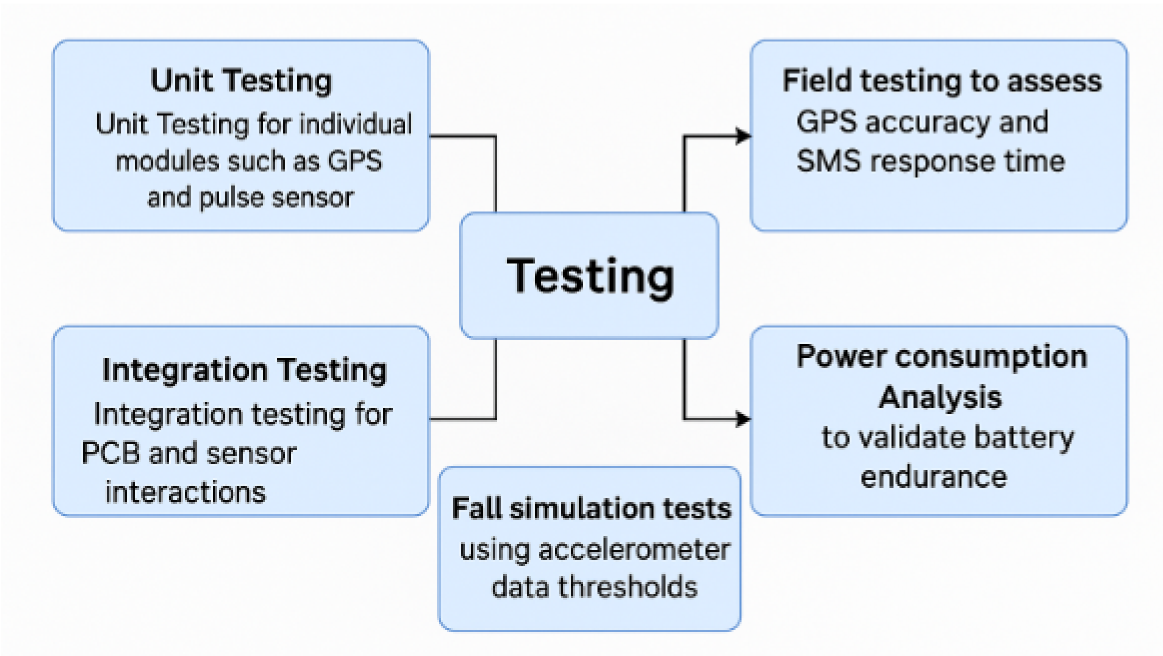
The user interface is designed using Qt for MCUs (Microcontroller Units). Qt is a powerful and flexible tool for developing user interfaces in embedded systems. Touch screen support is provided with Qt for MCUs, and the visual presentation of sensor data is facilitated. Thus, the user can access information such as heart rate, temperature, and time through a simple and intuitive interface.

The device software can recognize incoming SMS commands and take action according to these commands. For example, when the patient's relative requests location information, the device processes the data it receives from the GPS module and sends it back via SMS via the SIM module. Likewise, when a certain health condition is detected (for example, a fall or a sudden change in pulse), the system can automatically send information to a predefined emergency contact number.

In the main loop of the software, sensor data is continuously read and analyzed by comparing it with certain threshold values. In this way, critical situations such as fall detection and abnormal heartbeat detection are evaluated in real time. The system prioritizes user safety with both its reliability and rapid response.

This software design is at the exact intersection of electronic engineering and software engineering; it makes it possible to build a user-friendly and stable system that understands the language of hardware.

5. Testing



In the smart watch project developed, a comprehensive testing process was implemented in order to evaluate the accuracy, reliability and user suitability of the system. This process covers many stages, starting from module-based tests to holistic testing of the entire system. The purpose of the tests is to ensure that the system operates without errors and to ensure that it performs all necessary functions without compromising user safety.

The testing process consists of the following stages:

Unit Testing: Each component of the project (GPS module, heart rate sensor, accelerometer, SIM card module, etc.) was tested individually. In these tests, it was checked whether each module worked correctly on its own. For example, questions such as whether the GPS module can establish a satellite connection in a certain period of time, whether the heart rate sensor can read data correctly were answered at this stage.

Integration Testing: All modules were brought together and tested to work together on the PCB. In this stage, delays, communication problems and electrical incompatibilities that may occur in data exchange between modules were observed. Short circuit possibilities and signal interference on the circuit were also evaluated at this stage.

Field Testing: Tests were conducted in an outdoor environment to see the usage performance of the device in real life. Performance criteria such as the location accuracy of the GPS module in different places, SMS sending time and network connection stability were analyzed in these tests. These tests are of great importance in terms of showing how efficiently the device works in practice.

Power Consumption Analysis: The battery life of the device was analyzed through power consumption scenarios. How many hours or days the battery used can keep the device active, the effect of low power modes and energy management were tested.

Fall Simulation Tests:A fall detection algorithm was developed via the accelerometer and the reality of this algorithm was tested. It was observed whether the system generated the alarm correctly in controlled falls made from different angles and heights.

Each of these tests are steps that must be performed before the device is ready for use. When the system successfully completes these stages, it is considered a safe device in terms of both technical and user aspects.

6. Recommendations

1. Collaborate with Industrial Design students to improve aesthetics and ergonomics.
2. Integrate BLE (Bluetooth Low Energy) for enhanced connectivity.
3. Explore solar charging options for sustainable power.
4. Consider adding speech output for visually impaired patients.
5. Develop a caregiver mobile app for real-time notifications.

7. Conclusion

This report comprehensively presents a multidisciplinary engineering collaboration carried out in the development of a smartwatch specifically designed for dementia patients. The project was shaped by bringing together the knowledge and skills of different disciplines such as electrical-electronics engineering, software engineering and user experience design. Thanks to this collaboration, a product that is not only technically functional but also practical and safe for the end user has been created.

While important engineering decisions such as the selection of a microcontroller with low power consumption, sensor integration and special PCB design were made on the hardware side, studies such as embedded systems programming, user interface development and implementation of wireless communication protocols were carried out on the software side. The user interface of the device was designed to be simple and intuitive so that it can be used easily by elderly individuals.

The tests performed confirmed the device's operability in real-world scenarios; especially the consistency of vital functions such as fall detection, GPS accuracy and location transmission via SMS were successfully evaluated. These test results demonstrate the reliability of the device and show that it has a high potential in terms of patient safety.

With optimizations and more extensive tests to be carried out in the next stages of the project, it is aimed that this smartwatch will play an important role in improving the quality of life of dementia patients and alleviating the burden on their relatives. It is anticipated that this product, which is both technically and humanely strong, will make a significant contribution to the field of health technologies.

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