A picture containing company name

Description automatically generated

SeizureSafe

Project Engineering

Year 4

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Bachelor of Engineering (Honours) in Software and Electronic Engineering

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**Declaration**

This project is presented in partial fulfilment of the requirements for the degree of Bachelor of Engineering (Honours) in Software and Electronic Engineering at Atlantic Technological University.

This project is my own work, except where otherwise accredited. Where the work of others has been used or incorporated during this project, this is acknowledged and referenced.

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I would like to acknowledge my lecturers over the last four years taught me everything I need to know, as well as my supervisor Ben Kinsella who helped me during my project.

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# Summary

My SeizureSafe project aims to develop a solution for people who have seizure disorders with a real-time seizure and alert system. It monitors heart rate and fall data to detect seizures and sounds alert to people close by with step-by-step guide on how to safety help during a seizure.

The project scope includes three main topics:

* a design for a wearable device
* a website for real-time monitoring, detection, alerts and history data as well as an about page for education
* a mobile application containing the same information as the website with a log in authentication page

SeizureSafe works by detecting sudden changes in heart rate and movement patterns that are characteristic of many seizures.

Features include real-time heart rate monitoring, fall detection, automatic audio alerts, and a user-friendly dashboard displaying heartrate and detection. I also added a 30-second cooldown between alerts to prevent notification overlap and them being incoherent. My project uses React.js for the frontend, Python for backend, and React Native for the mobile application, I use EMQX broker for sending events to backend.

This prototype is a steppingstone for further development to build the device, with potential for expanding with more disorders that need medical alert systems. For future developments I would focus on improving detection accuracy through machine learning and expanding the bracelet’s capabilities to include more comprehensive health monitoring features.

# Poster

A screenshot of a computer

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# Introduction

Epilepsy affects approximately 50 million people worldwide [1]. With many experiencing seizures that can lead to serious injuries if not dealt with properly. My SeizureSafe project was made to address these challenges by developing a real-time seizure detection and alert system, it provides an audio alert when a seizure is detected, providing crucial information to anyone close by to hear the alert to be able to help. The motivation behind this project comes from a personal side, I have friends and family who deal with seizures daily, they have been by themselves in public when they take a seizure and have people thinking they are helping by picking them up, poking them or moving them when it makes it worse. My project gives firsthand information to help in the situation that they have a seizure and are alone with nobody around that knows what to do in their type of situations. Current solutions often rely on people educated on the disorder or having to call emergency services and leave the user waiting for help. SeizureSafe was designed to make an accessible, user-friendly system that can be easily integrated into daily life while maintaining high reliability and accuracy which I feel is not in the current market. In this report I will go into detail the complete development process of SeizureSafe.

# Background

## Epilepsy and Seizure Detection

Epilepsy is a condition that affects your brain and causes seizures (sometimes called fits). It cannot currently be cured, but treatment can often help manage it. [2] According to the World Health Organization, approximately 50 million people worldwide live with epilepsy, making it one of the most common neurological diseases globally.

## Heart Rate Patterns During Seizures

Research has shown that seizures affect the heartrate:

* The heart rate typically increases by 10-20 BPM during a seizure in 73% of seizures [3]

## Existing Wearable Solutions

* Smart watches with heart rate monitoring (Apple, Samsung, Fitbit)
* Basic seizure bracelet just to alert people of the disorder
* Fall detection bracelet, which might not be accurate when detecting a seizure

|  |  |  |
| --- | --- | --- |
|  | SeizureSafe | Smart Watch |
| Real-time Monitoring | Yes | Yes |
| Fall detection | Yes | No |
| Audio Alert | Yes | No |
| Medical Instructions | Yes | No |
| Historical Data | Yes | Yes |
| Mobile App | Yes | Yes |

# Project Architecture

My project is made up of three layers

1. **Mock data simulation layer**

* Mock data of simulated heart rates and fall detection
* MQTT test script for data transmission

1. **Processing layer**

* Backend server for data processing
* MQTT broker for real-time data handling
* Historical data storage

1. **User layer**

* Website
* Mobile application
* Alert notification system

## Data Flow

### Data Simulation

* The Python script generates mock heart rate data
* Simulates patterns for normal and seizure detection

### Data Transmission

* MQTT protocol for real-time updates using EMQX
* Test scripts
* JSON format for readability, structured data, debugging
* Secure WebSocket connections (WSS) for MQTT communication

### Data Processing

* Real-time updates of simulated heart rate patterns using mock data
* Heart Rate spikes over 85 BPM
* Fall detection (30% probability)
* Seizure detection
* Alert trigger

### Technical Stack

1. **Frontend (Web)**

* React.js for UI components
* MQTT.js facilitating real-time communication
* Chart.js for visualisation of data
* Audio Message for alerting

1. **Backend**

* Python for mock data generation
* REST API for data access
* SQLite for data storage
* MQTT broker for message handling
* Uses environment variables for secure user storage

1. **Mobile Application**

* React Native allowing cross-platform support
* Push notifications
* Expo framework for fast development
* Authentication/ login system

### System Requirements

1. **Development Environment**

* Node.js/React for frontend development
* MQTT broker (EMQX)
* Python for mock data generation
* Web browser with WebSocket support

### Mock Data Implementation

1. **Data Generation**

* Simulated heart rate
* Timestamps
* Seizure and fall detection

1. **Testing Scenarios**

* Connection loss scenario
* Fall detection simulation
* Normal heart rate patterns
* Seizure-like patterns

1. **Data Patterns**

* Base heart rate
* Fall detection
* Seizure detection
* Timestamp

A diagram of a computer

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Figure Architecture Diagram

# Technical Implementation

## Frontend development

The web dashboard was developed using React. I was focused on creating a user-friendly interface that could handle real-time data updates. Main components include:

* Connection status indicator
* Real-time heart rate
* Seizure detection alerts
* Historical data display
* About page

The audio alert system was quite a challenge due to browser security restrictions, after figuring out the problem I implemented a solution that:

* Preloads the audio file and has an enable popup for audio
* Implements a 15-second cooldown between alerts to makes sure no alert is missed

## Backend Implementation

The backend system uses Python for mock data generation and MQTT for real-time communication.

**Mock Data**

A screenshot of a computer program

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This code simulates:

* Normal heart rate
* Seizure events every 20 seconds , while the alert cooldown is 15 seconds
* Heart rate spikes over 85
* 30% risk of falls during seizures

**Data Storage**

A screen shot of a computer code

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This database structure allows for:

* Timestamps
* Heart rate tracking
* Fall detection
* Event logging

**API Server**

A screen shot of a computer program

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This server offers:

* Secure MQTT connection
* API endpoints for frontend
* Real time Data processing
* Historical data

**Testing Framework**

A computer screen shot of a program code

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*(backend/tests/test\_backend.py)*

The test covers:

* Data storage and retrieval
* API endpoint functionality
* Invalid data handling
* Simulating realistic seizure data
* Secure data transmission
* Testing

## Mobile Application

The mobile app was developed using React Native and Expo. Key features include:

* Real-time data display
* Push notifications
* User-friendly interface
* Audio alert
* About page

# Testing and Validation

## Testing Methodology

1. Unit testing of front-end components
2. Integration testing of the complete system
3. User experience testing

## Test Results

* Audio alerts worked consistently after initial user interaction
* Mobile app-maintained connection during background operation

# Security Considerations

## Data Protection

* MQTT credentials stored in environment variables
* Secure WebSocket connections
* Input validation on all data points
* Regular security audits

# Challenges

## Audio Alert issues

**Challenge:** Alert wouldn't trigger audio automatically

**What happened:** The alert sound wouldn't play

**How I fixed it:**

* Added a prompt asking users to enable audio
* Made the audio preload when the page loads
* Added error handling

## MQTT Connection Problems

**Challenge:** Connection kept dropping

**What happened:** The website would show "Disconnected"

**How I fixed it:**

* Added automatic reconnection code
* Made the connection status show on screen
* Added error messages to help debug

## Mobile App Notifications

**Challenge:** Push notifications weren't working

**What happened:** The app wouldn't alert when seizures were detected

**How I fixed it:**

* Set up proper notification permissions on app/phone

## Testing Problems

**Challenge:** Tests kept failing

**What happened:** The tests would work one day, fail the next

**How I fixed it:**

* Made mock data more consistent
* Added better error messages
* Writing more specific tests

## Code Organisation

**Challenge:** Code was getting cluttered

**What happened:** Hard to find where things were

**How I fixed it:**

* Split code into smaller files
* Added better comments
* Made the structure clearer

## Alert Timing

**Challenge:** Too many alerts

**What happened:** Users could not understand the alert as it played over each other

**How I fixed it:**

* Added 30-second cooldown
* Made alerts less frequent

# Project Plan

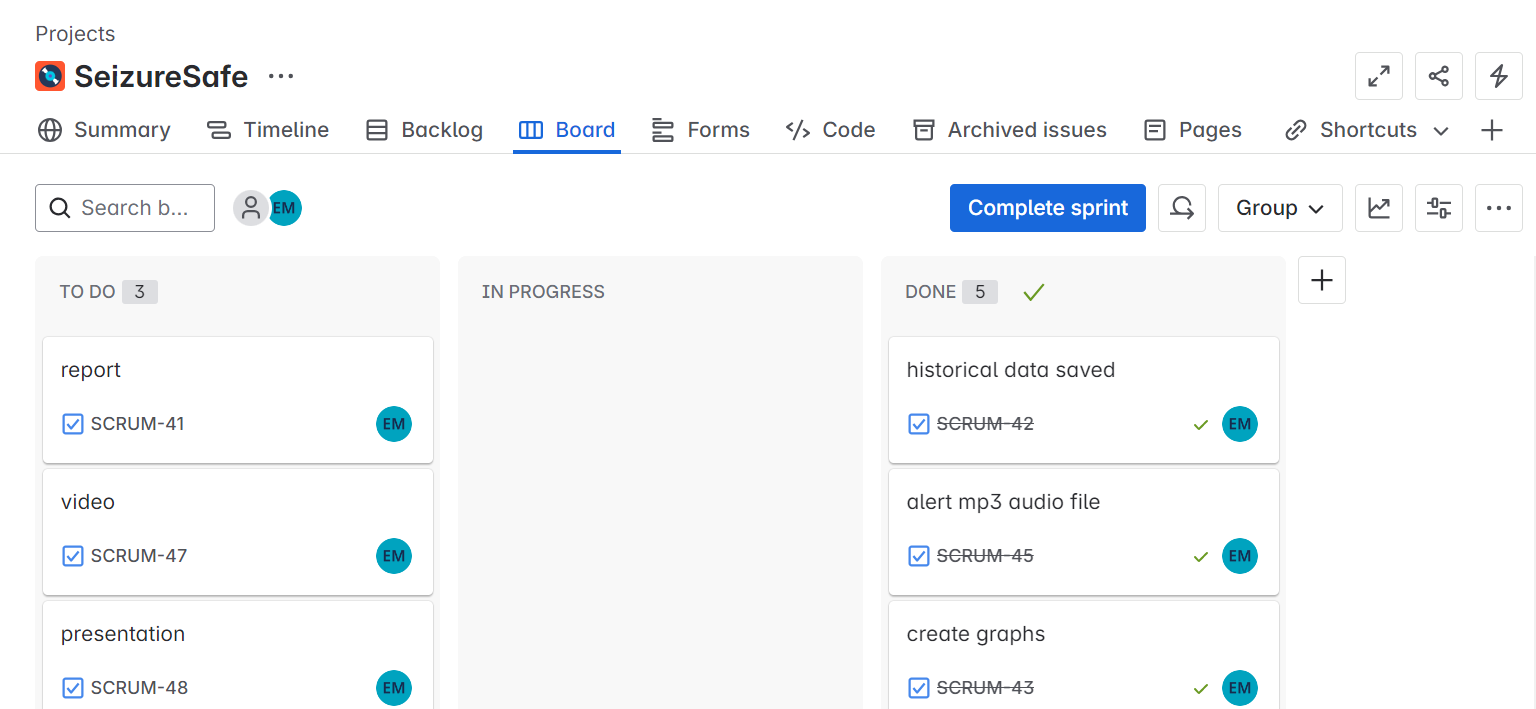
## End Goal

* Project that can detect seizures using heart rate and fall detection
* A website and app that can show real time data and alert system with an about page
* Audio alerts
* A strong foundation that can be expanded on in the future to have hardware

## Project Management

For my project management tool I used Jira, this allows me to create a backlog of all the work I had to complete to complete my project, I broke the work into two/three-week sprits. I ended up restarting my management in January as I wasn’t happy with the way I originally thought I would complete the project. This left a bit of a time crunch to complete the project, Jira allowed me to keep on top of my work. We also had a project notebook/team meetups which we were to update weekly, on any progress made and blockers.

I use GitHub to save my code and make sure to commits important code updates in case something broke I was able to go back to before the errors and still have code that worked and start again.



# Ethics

Working with medical information is always an ethical concern, with privacy and data protection there needs to be strict protection in place, so information is kept confidential, consent need to give to collect the data as well as transparent data usage policies need to be in place. The project must be reliable so no false negatives or positives are detected, it also should be accessible, it should be user friendly.

# Future Development

To expand on my prototype there are many things I would like to add to make market ready. The biggest thing I would add hardware; I would like to develop a wearable bracelet that would be comfortable to wear all day, not something that would stand out but has all the functionality that SeizureSafe needs to work efficiently. the sensors would need to accurately track heart rate and movement, the battery life would have to be a big focus area as with a medical device it needs to be 100% reliable.

I would also love to implement machine learning to make the detection even smarter; by training the system with real seizure data it would better understand patterns and reduce the number of false alarms and might be able to detect a seizure coming on rather than already happening.

To expand on the idea, it would be a further development to add more disorders, having the bracelet to be able to detect several other disorders like panic attack or POTS, it allows more people to get the benefit of the device who need something like this.

The frontend would need to be updated, add things like location tracking, ability to share more medial data to first responders, also add a SMS feature to notify family contact about the seizure would be a bonus as an added feature.

A sketch of a watch

AI-generated content may be incorrect.This is a mock-up of what the hardware would look like, with the face being touchscreen to be able to switch between time and date, to heartrate to other features that are on a typical smart watch, the main feature being an speaker that would play the alert message when seizure is detected, this would be a challenge to get a speaker small enough to fit the design but powerful enough to be hear by people close by

# Conclusion

My SeizureSafe project is a working prototype of a real-time seizure detection and alert system. My project has reached many key elements:

1. A working webpage that displays real-time heart rate data and seizure alerts
2. A mobile application that provides push notifications for seizure detection and alerts
3. A backend system that processes and stores simulated seizure data
4. An effective audio alert system that triggers upon seizure detection
5. A secure MQTT-based communication system for real-time data transmission

The system successfully integrates multiple technologies, including React.js for the frontend, Python for backend processing, and MQTT for real-time communication. The implementation demonstrates reliable seizure detection through simulated data, with a 30-second cooldown between alerts to prevent notification overlapping. Although the current prototype uses simulated data, it is set up to easily add hardware and real data if it was to be developed in the future.

# Appendix

## Installation guide

<https://code.visualstudio.com/> download link for visual studio code

on your phone install Expo Go from play store, allow notifications and audio

## Running My Project

To run my project, you need to open three terminals:

Cd into the backend – run for website

The browser is htpp://localhouse:3000

1. pip install -r requirements.txt – this is for installing the Python packages

for more information about this command follow this link: <https://www.geeksforgeeks.org/how-to-install-python-packages-with-requirements-txt/>

1. python mqtt\_test.py – starts the data simulation
2. python app.py

Cd into the frontend – to run the website

1. npm install
2. npm start

cd into SeizureSafe-Mobile – to run the app on expo

1. npm install
2. npx expo start

After you run these, you will see a QR code in the terminal, on your phone use your camera and scan the code, this will then open the app on the expo app. If it does not work by using your camera on your phone go into the expo app and scan the code from the app.

## Screenshots

A screenshot of a computer

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Figure Website main screen

A screenshot of a phone

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A screenshot of a login form

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Figure Mobile Walk Through

# References

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