RezQ: A Drowning Detection System with Real Time Alerting and Location Tracking

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Research involving non-human vertebrates or human subjects was conducted under the supervision of an experienced teacher or researcher and followed state and federal regulatory guidance applicable to the humane and ethical conduct of such research

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Introduction

Drowning is a global health crisis and is a leading cause of unintentional injury death worldwide. Annually, 236,000 people encounter fatal accidents involving drowning. Drowning is quite dangerous; although it is just water, waves approach swiftly and silently, affecting the performance of lifeguards and people's awareness on the beach. Traditional safety measures in pools and other smaller bodies of water have been developed to prevent the issue on a smaller scale. However, the beach is where most of these incidents occur. A solution is urgently needed to save people's lives at the pool and the beach. There is no natural and efficient way to stop the waves from coming in so fast, but there is a way to optimize rescue operations for drowning.

This project showcases a wearable wristband designed to detect drowning in real time and notify rescue services. The wristband includes vital monitoring, location tracking, app alerting, and Bluetooth connectivity to create an effective system with excellent accuracy. The band's core contains sensors that track vitals and constantly update it to a cloud where all RezQ devices are connected. When the wearer's vitals, such as heart rate or depth, fall beyond certain thresholds, the device notifies the app users who signed up for notifications. The app then performs the following actions to optimize rescue:

1. Precise Real-Time Location: The app immediately provides the wearer's latitude and longitude. The location updates in real-time and also shows the wearer on a map.
2. Multi-Level Alerting: The app simultaneously alerts multiple parties to ensure a swift and coordinated rescue response:
    - Primary Contact: The app sends a loud alert to the phone connected to the wearer's wristband. Vitals that update instantaneously of the wearer will also be sent.
    - Nearby App Users: The device uses Bluetooth technology to send alerts to people around the area. The app is installed, and notifications are enabled in case bystanders need assistance.
    - Emergency Services: The wristband also contains a SIM that can send alerts to rescue services. The alerts will raise awareness if a lifeguard does not spot a person drowning.

The project aims to evaluate this device's accuracy, effectiveness, and usability. This will be done through various tests to see if the wristband adequately addresses heart rates beyond the threshold. The project's findings will validate a device that has the potential to enhance safety and optimize rescue for drowning so the rate of people drowning can decrease.

Background Research

As drowning became a significant problem, scientists and lifeguards created conventional solutions for swimming pools to solve these issues. Although these solutions are commonly used to prevent drowning, they are not effective or sustainable.

Conventional Solutions

1. Camera Drowning Detection
2. Reverse Current Technology
3. Ocean Barrier

Camera Drowning Detection: Seen as one of the most effective methods to prevent drowning, CDD has some limitations to it. The concept of this device is a tiny camera in the corner of a pool that can see when somebody has been inactive for too long. The first limitation is that it is expensive because these systems need quite a lot of technology and AI to accomplish this task. The second limitation is that since these cameras are small, it is very easy for someone to block this camera when the pool is crowded. The final limitation is that these are impractical for a beach as they do not work in this setting.

Reverse Current Technology: Although this solution is looked at extensively, it has only been implemented in a few beaches for a good reason. RCT uses water pressure to counteract the waves and create a flat pool of water. Many people like to play with the waves, so creating this will ruin the fun on beaches. Another thing is that these machines cost a lot of money and sometimes get clogged. It would take a lot of money to repair, and when it is clogged, it is rendered unusable. RCT is high maintenance and does not guarantee a fully working system.

Ocean Barrier: This solution consists of a big wall or net that stops someone from flowing deeper into the water. It is not outstanding because it destroys the natural habitat of sea creatures, which often get caught in these nets.

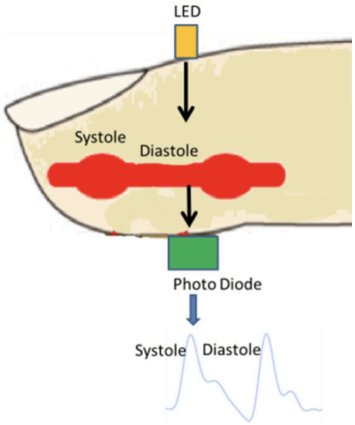
Innovative Solution

The goal of RezQ is to create a low-cost drowning detection device that can accurately inform app users and rescue services that someone is drowning and provide precise location information to optimize rescue. Based on research, RezQ must be environmentally safe and feasible in locations with intense waves.

After some research, it was finalized that the key element of RezQ would be powered by a heartbeat. Generally, when someone is drowning, their heart rate will either be above 144 BPM or below 50 BPM. Considering these numbers, if RezQ can detect when the heart rate goes out of these ranges and classify it as drowning, it will power the device.

Heartbeat Detection Research

- BPM can be detected and reported by the system to see how fast an area with a pulse is going and how the volume of the blood changes.
- This detection method can be powered by a sensor that uses various technologies to detect heart rate.
- Photoplethysmography is the main component of this sensor.
- Photoplethysmography is the process of penetrating green light into the skin to see how the volume changes.
- This process helps detect heartbeats at a low cost and with great accuracy.



Category	Minimum BPM	Maximum BPM
Low Blood Pressure	50	120
Normal Blood Pressure	50	160
High Blood Pressure	50	150
Young	50	180
Teen	50	170
Young Adult	50	175
Middle Aged	50	160
Old	50	145
Underweight	50	170
Normal Weight	50	160
Overweight	50	150
Obese	50	140

Depth Sensing

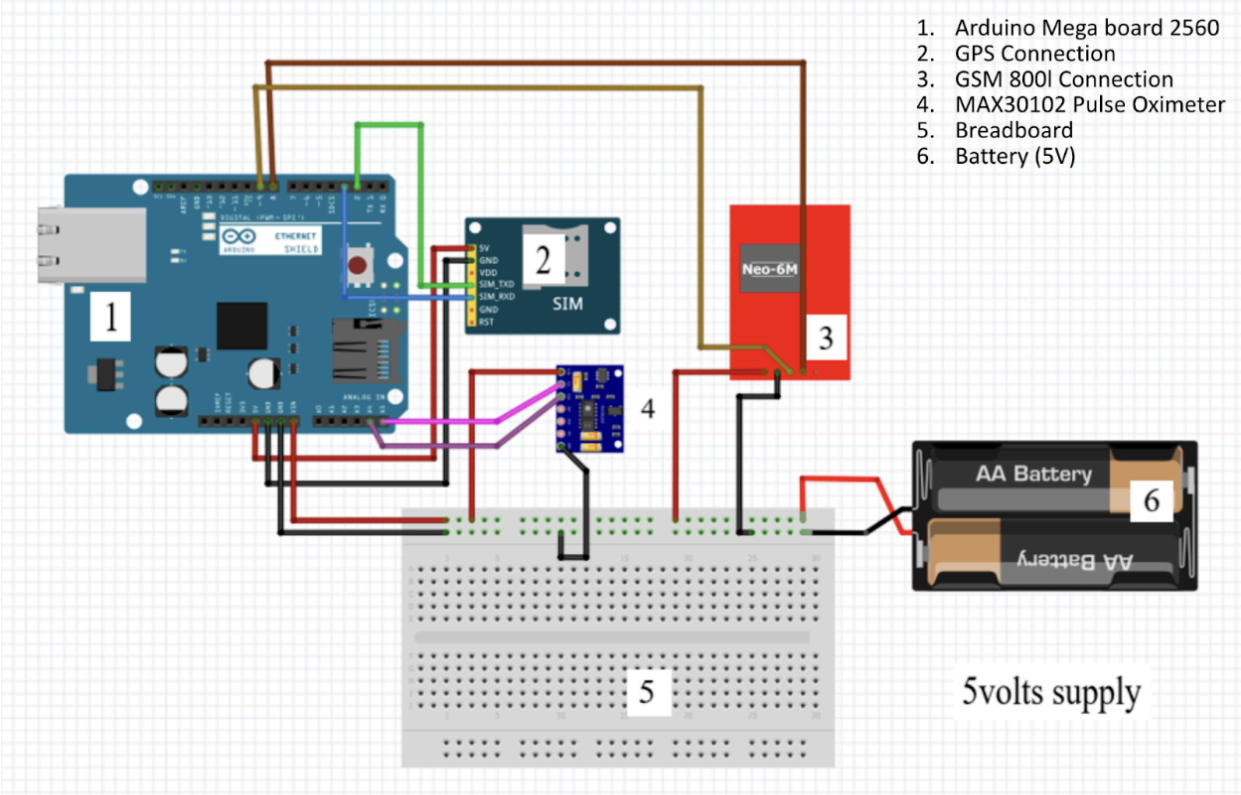
- Ultrasound sensors can be used to see if a user faces a depth change for over one minute. This combined with heart rate, can be used to detect drowning

Materials and Specifications

RezQ is constructed with two primary components. The software and the hardware.

Hardware

The hardware aspect of RezQ is the device itself. Below is a wireframe sketch of all the various parts on the RezQ prototype.



Wireframe, Figure 1.2

Here are the uses of all these parts:

Arduino Mega Board 2560: This is the device's central console that connects the various modules and helps them work together. The code gets inputted to use all the modules to detect drowning, and this board powers that function.

GPS Module: This is used to create a digital map in the app and give a precise location of the drowning person. The precise location is helpful because lifeguards will save time and optimize searching places they do not have to.

SIM: This is used in case the user marks the option to receive alerts by text when the wearer is drowning. For example, if a bystander has the app installed on their phone, they will be alerted that someone is drowning in a specific location and can opt to receive alerts by text.

Pulse Oximeter: This is the main component of the device as it detects the heart rate and sends the data to the Arduino every millisecond to analyze whether the user is drowning.

Battery: This is used to power the device more efficiently in water.

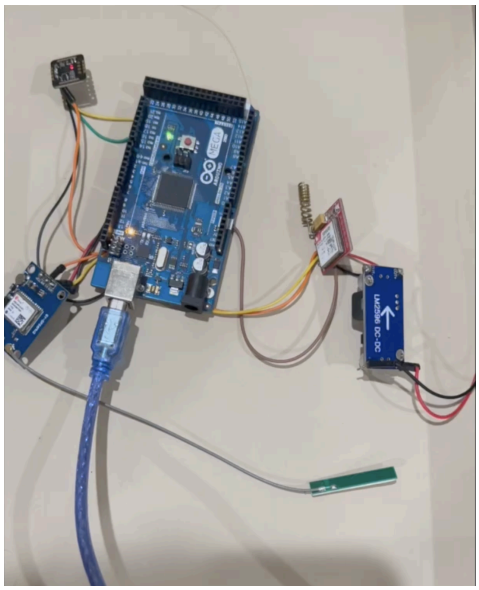


Figure 1.3, Hardware

Software

Firmware Code

```
#include <DFRobot_MAX30102.h>
#include "TinyGPS++.h"
#include "SoftwareSerial.h"

DFRobot_MAX30102 particleSensor;
SoftwareSerial sim800(12, 13);
SoftwareSerial serial_connection(10, 11);
TinyGPSPlus gps;

void setup() {
  // Initialization code
```

```
}

void loop() {
  while (serial_connection.available()) {
    gps.encode(serial_connection.read());
  }

  if (gps.location.isUpdated()) {
    printGPSData();
    particleSensor.heartrateAndOxygenSaturation(&SPO2, &SPO2Valid, &heartRate,
&heartRateValid);
    printHeartRateData();
    sendSMSAlert();
    sendGPSDataSMS();
  }
  delay(2000);
}

void printGPSData() {
  // Print GPS data
}

void printHeartRateData() {
  // Print heart rate data
}

void sendSMSAlert() {
  // Send SMS alert for abnormal heart rate
}

void sendGPSDataSMS() {
  // Send SMS with GPS data
}

void sendCommand(String command) {
  // Send command to SIM800
}

void update serial () {
  // Update serial communication with SIM800
}
```

Figure 1.4, Code

Software Code (Mobile App)

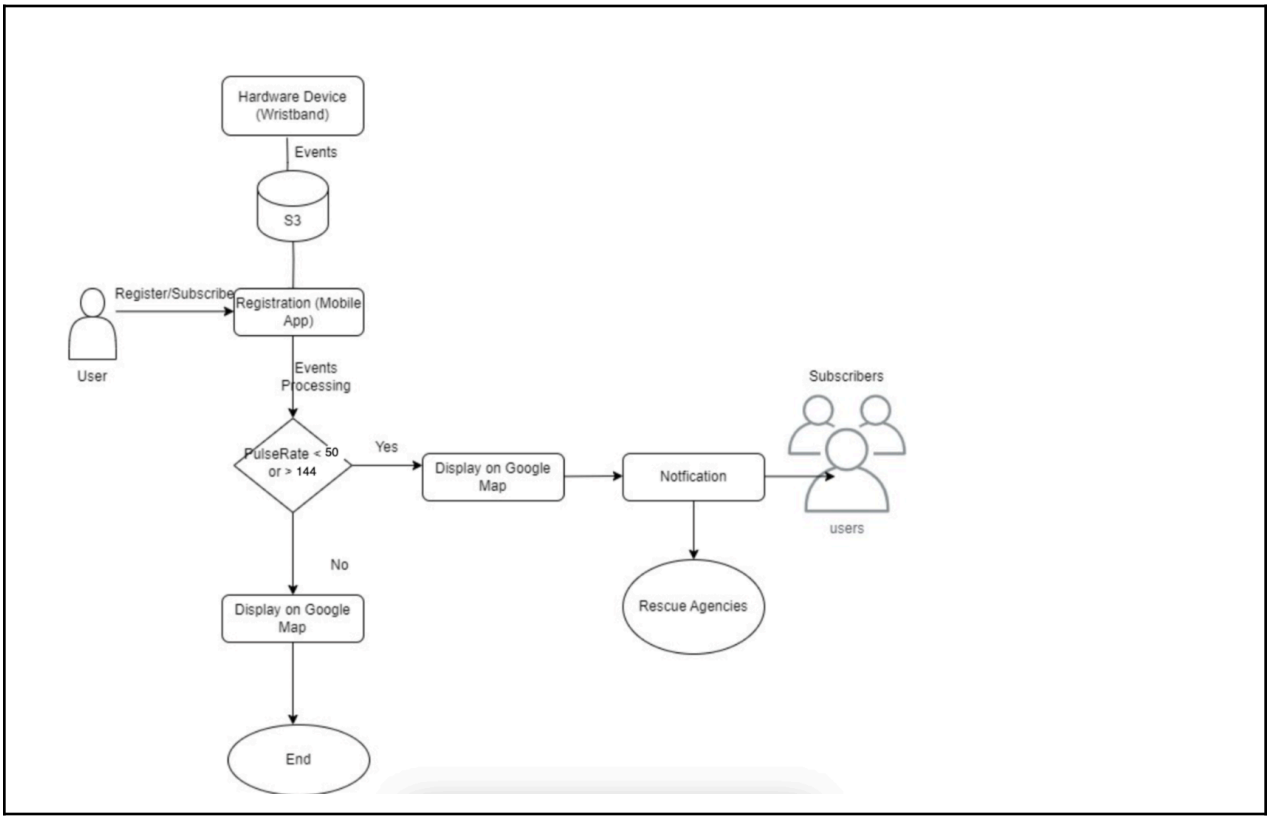


Figure 1.5, Pseudocode, flowchart

Experimental Procedure

1. Calculate the accuracy rate for how many simulated heart rates RezQ identifies as drowning
2. Measure the cost of the device
3. Test my wrist to see if RezQ works.

Results

There are three factors on which RezQ was tested:

1. Accuracy Test
2. Cost of RezQ

3. Proof of Concept

Accuracy Test

For this test, I loaded 10,000 sample heartbeats into the Arduino console.

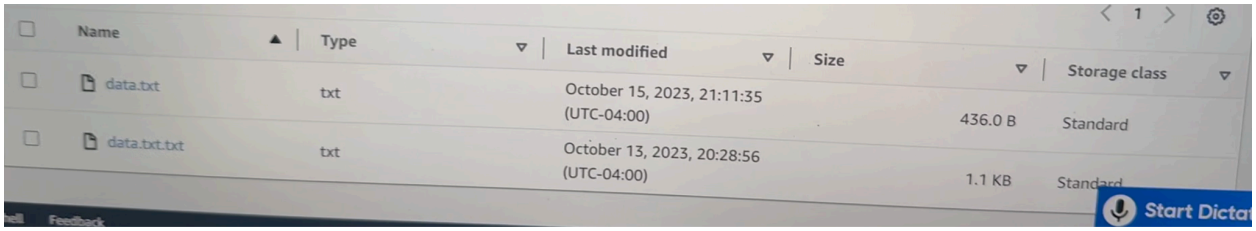


Figure 1.6, 10,000 heart rate files

As presumed in the app, RezQ predicted every heart rate drawing to be drowning. Four thousand sixty-six heart rates were identified as drowning out of 4,066 heart rates classified as drowning in the dataset of 10,000 heart rates. The same goes for the 5,934 heart rates identified as not drowning by RezQ out of 5,934 heart rates classified as not drowning in the dataset. This shows that RezQ has an accuracy rate of 100% and that the algorithm is efficient.

Cost of the RezQ

Category	Part	Purpose	Cost	Comments
Hardware	Arduino Mega Board 2560	Microcontroller	$10	
	MAX 30102	Pulse Detection	$3	
	NEO-6M GPS	GPS Receiver	$3	
	Battery	Power supply	$2	
	SIM 800L	Sending text messages to central	$5	

		SIM		
Software	AWS Cloud/S3	Storage	0	Used Free tier for prototype
Total Prototype Cost			$23	

Proof of Concept

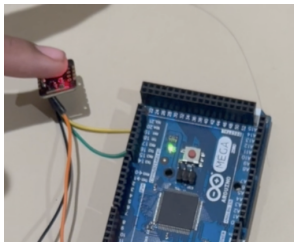


Figure 1.7, pulse point on device

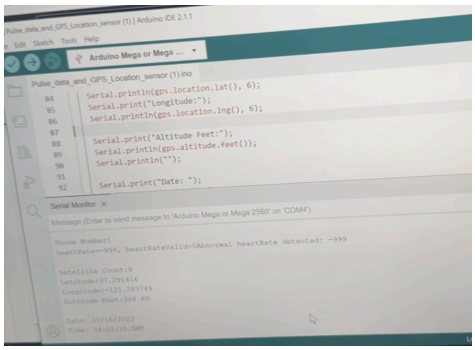


Figure 1.8, pulse loading into the arduino console

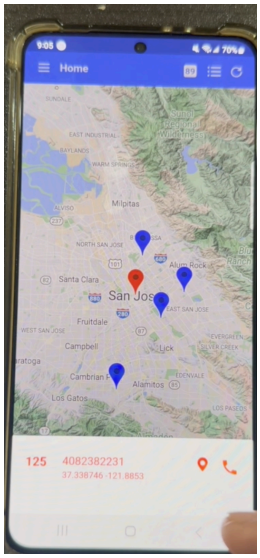


Figure 1.9, pulse data appearing in app

Based on this test, when I put my pulse point on the heart rate module, the heart rate loads into the cloud. Then, it is sent to the app through the cloud, where the system correctly identifies the heartbeat if it is drowning and makes a large beeping noise when a user is drowning. The precise location and nearby lifeguards who have been contacted are also shown on the map.

Discussion

In this project, several factors were tested on RezQ. They are listed below. This section compares and discusses the results.

1. Accuracy Test
2. Cost of RezQ
3. Proof of Concept

Accuracy Test

This test had an accuracy of 100%. This shows that when 10,000 tests are conducted simulating 10,000 people with RezQ in the water at a current moment, the algorithm correctly identifies every single person's status of whether they are drowning.

Cost of RezQ

This device has a manufacturing cost of 23 dollars. Compared to other solutions, such as AngelEye, RezQ has a significantly lower cost. Many modern solutions compared to RezQ have various limitations, and RezQ has a much lower cost. All in all, this device is effective and low-cost. Safety should be accessible by all, and RezQ makes that possible.

Proof of Concept

The concept of RezQ works based on this test. When I checked my pulse through the pulse sensor module, the pulse was updated to the RezQ Arduino console, which was then sent to the AWS cloud system. After that, an alert was received on the phone, and it made a loud noise intended to get the user's attention. After opening the app, we can see the drowning person and their real-time location, tested by seeing if the tracker is moving when the device is moving. Lifeguards modeled by test dummies were also marked in the app, which validated that RezQ is a working prototype.

Conclusion

Based on our discussion, here are the conclusions that can be made about RezQ:

Smart, Wearable Device: We have designed a small, user-friendly, affordable, energy-efficient wearable device. It has sensors and smart technology inside.

Monitoring Your Child: This smart device monitors your child's safety in the water. It watches their movements and vital signs (such as pulse rate) to spot any signs of trouble.

Location Tracking: The device uses GPS to track where your child is in real-time. So you always know where they are.

Easy Mobile App: We developed an easy-to-use mobile app. When the device senses a potential drowning situation, the app sends instant alerts to any application users who signed up for the alerts.

Comfortable for Kids: Our device comes in different colors and an easy-to-strap wristband, making it comfortable for kids to wear while they swim.

Instant Help: When the device detects a potential drowning incident, it contacts the nearby users on their cell phones automatically. There is no need to make a call during a stressful time (potentially can be extended by teaming up with local emergency services in the future)

Improving Accuracy: We are constantly working to make our system better. We use data from the device and your child's habits to fine-tune our safety system. It is like having a personal lifeguard.

Simple Setup: Install the app and turn on the device to get started. Strap it on your wrist, and you are ready to go. It also helps you connect with a community of parents and lifeguards ready to help.

Community Safety: Our product keeps someone safe and encourages the community to pitch in. If there is someone experienced nearby, they can respond to the alerts and help with a rescue. Our product offers a straightforward way to keep someone safe in the water.

Future Research

Regarding future research, I plan to make the device even more affordable.

Another thing is that I will advance RezQ into using more factors for drowning, such as water depth and tension rates, for a lower cost. This will help make RezQ affordable for many while serving its purpose.

Finally, as many people may not have a phone while others do (e.g., one who buys RezQ but does not have a phone to receive alerts), that person can have the option to buy an affordable device that comes with RezQ that will buzz and give alerts that way. In contrast, those with a phone around the drowning person's premises will receive an alert via phone. I plan to make this device effective and accessible to all in the coming months.

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