Boston University

Electrical & Computer Engineering

EC463 Capstone Senior Design Project

Second Prototype Test Report

Personal Alert Device

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by

Team 19

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1 Required Materials Summary

For the hardware portion of the Personal Alert Device, the required equipment included the XIAO nrf52840 sense microcontroller, MAX30102 Heart-Rate Sensor, B57703M0103A018 thermistor, prototype housing/wrist-strap, and wireless charging power system. Additionally, the built-in 6-axis IMU and PDM microphone integrated in the microcontroller. The goal with these hardware components was to demonstrate core sensor functionalities, accurate speech recognition using machine learning from PDM audio input, and overall form factor of the device. We were able to successfully validate sensor efficacy by reading accurate and consistent heart rate and temperature results. Additionally, we successfully demonstrated wireless charging functionality by measuring the voltages across the power system's transmitter and receiver, confirming a steady 5V output from the receiver. We were able to accurately detect a verbal "send help" request and classify it accordingly as opposed to unknown or background noises. Finally, we demonstrated our prototype enclosure and wrist-strap to conceptualize how the end product is to be worn and interfaced with.

The equipment necessary for the software portion of the prototype was a laptop with internet access. Using this laptop, we were able to access Android Studio which housed an emulator for our native application. Additionally, we were able to access Google Firebase where we saw authenticated users and both user and sensor data stored in the Firestore database. Furthermore, the laptop established a means of communication between all the components of our project via Bluetooth Low Energy (BLE).

Overall, our equipment was consistent with our prototype's test plan. All sensors were powered successfully, and recorded accurate data. Additionally, all communication between components functioned as expected. Finally, the power system and mobile app worked as expected.

2 Setup Summary

The setup was divided between the hardware and software aspects of the Personal Alert Device. The hardware portion of our setup required the functionality of various sensors including the MAX30102 Heart-Rate Sensor and B57703M0103A018 thermistor, which will allow us to determine emergencies related to the user's health. The thermistor was placed in contact with the wrist in order to ensure accurate readings of skin temperature. The heart rate sensor was similarly placed on the skin in a manner that prevents interference from external light. We then ran the sensor test code via Arduino, which displayed temperature readings from the thermistor and heart rate and blood oxygen saturation level readings from the heart rate sensor. Once the sensors recorded data, the data was uploaded to a Firestore collection, which provided our database with observable real-time updates. We tested speech recognition by saying "send help" into the PDM microphone and having the deployed model classify the speech accordingly, which will later be used to trigger an emergency response when the user needs help. For the power system, we began by plugging the transmitter system into a wall outlet and measuring the voltage across the battery using a multimeter, which was approximately 500mV. Then, we positioned the receiver on top of the transmitter and measured its output voltage, confirming a steady 5V.

The software portion, an Android native application, serves as an interface between the user and the device, gathering important information dynamically. We ran the application on the emulator using Android Studio to view various pages, such as the profile, contacts, and how to page. We then accessed Google Firebase to view authenticated users and sensor data stored in the Firestore database. We also showed that the data stored in Firebase was not deleted if a user signed out of their account and was not overwritten when we signed into the same account again. Compared to the first prototype design, we showed the improved database management by storing all user specific data in one container instead of having data from different sensors in individual containers.We also established communication between the app and the device via LightBlue, a BLE scanner, to send data from the sensors to Firestore.

3 Measurements Taken

The prototype test measurements include heart rate data (BPM) from the MAX30102 sensor, blood oxygen levels (SpO2), speech inferencing accuracy, and body temperature (°C) from the B57703M0103A018 thermistor. Our live heart rate reads around 70 BPM, which is an expected value. Our body temperature was around 36 degrees celsius, which was expected as skin temperature measured on the wrist ranges from 33 to 37 degrees. Finally, our Sp02 reading was around 96%, also in the expected value of 95%-100%. Thus, our test measurements taken confirmed the accuracy and functionality of our vital sensors. Additionally, power system measurements were recorded, including voltage readings for both the battery and the transmitter module. Voltage read on the receiver module showed 5V when wirelessly "charged" with the transmitter which confirmed that the charging test was working as expected. Finally, we measured the accuracy of our machine learning model for speech recognition. When our keyword, "send help", was spoken, the model successfully classified the term with 99% accuracy. Furthermore, the request was reflected in Firestore under the unique user identifier with an appended time stamp. Throughout the test, the inference was running continuously and no false positives from background noise or other spoken words occurred. Thus, the speech recognition test was successful.

For the mobile application, we measured the success of various application functionalities. Such functionalities included: successful Google Single Sign-On, user data stored in unique Firestore collection, user added to Firebase Authentication, screen navigation using buttons, user name and profile picture displayed on the home page, request permission to access contacts, adding designated emergency contacts, contacts stored in respective Firestore collection, logging out, editing profile, changing profile picture, and having user data persist throughout application refresh, close, or sign out. All these tasks were successfully performed during testing.

4 Conclusions

Coming into the spring semester, our primary focus was prioritizing our project's hardware portion, ensuring that we had functioning sensors and could store data from those sensors in our database. Through our prototype testing and measurements taken, we can conclude that our standalone vital sensors are consistent and accurate, and our mobile app, power system, and speech recognition work as expected. Although we have made significant progress this semester on the hardware aspect of the project, there is still a decent amount of work to be done before the customer installation. We plan on finalizing an enclosure design, integrating the sensors on our microcontroller, enabling notifications to be sent out from the mobile device, improving our ML model for fall detection, and improving our power system. Furthermore, after the second prototype design review, we received feedback on gathering sensor data for our heart rate sensor and input regarding the placement of specific sensors. For example, in our current design, the heart rate and temperature sensor are stored in the wristband itself, but we may look to store the sensors in the enclosure going forward. Although this seems like a lot of work to achieve in the coming weeks before customer installation, we have evenly distributed the work between group members and believe we will be able to meet all of the requirements for the product. The final design for the enclosure is already underway and integrating the rest of the sensors should not take long.