BlueSpy

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Background/Motivation

Accelerometers are prevalent in many devices, such as AirTags, Fitbits, and your own phone. Lockheed Martin has noticed the increasing number of unadvertised sensors in devices. The potential of onboard accelerometers in IoT devices extracting audio data from unsuspecting users without a microphone necessitates exploring the audio recording capabilities of accelerometers.

Device	Frequency	Type
Airtag	Unfiltered - 2kHz Filtered - 1000Hz	Bosch BMA280
GoPro Hero 1	200 Hz	3-axis
Omega ACC301A	10kHz	3-axis

Figure 1: Accelerometer sampling rate comparison across devices

Proposed Solution

- Focuses on accelerometer usage in realistic and ideal scenarios, with emphasis on low power IoT devices.
- Bosch BMA580 accelerometer, related to the Apple AirTag's Bosch BMA280.
- Fitbit Sense Fitness Tracker Accelerometer.

Figure 2: BMA580 Accelerometer

We utilize Fitbit Development Kit and Android Studio to create an application to retrieve data from the watch via Bluetooth. We then utilize Python and C to send/receive data from Bosch BMA580 directly to host device via serial connection while also using Audacity to enhance the amplitude of the audio to make voices more prominent.

System Design

1. Fitbit app: Gathers and sends accelerometer data.
2. Android app: Collects and downloads accelerometer data.
3. Bosch application: Collects BMA580 accelerometer data and downloads data. Creates legible accelerometer recordings.
4. Sound conversions: x-axis, y-axis, and z-axis conversions with magnitude.

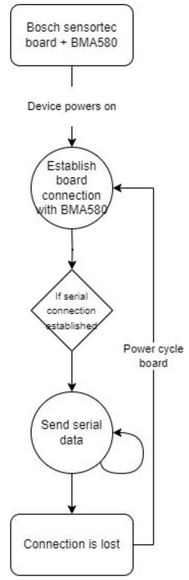

Figure 3: System Dynamic Design

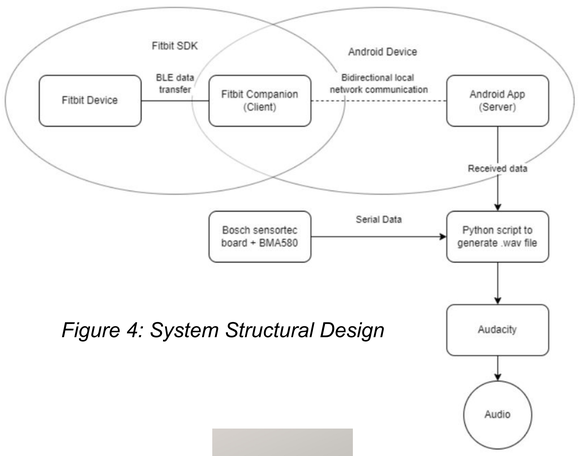

Figure 4: System Structural Design

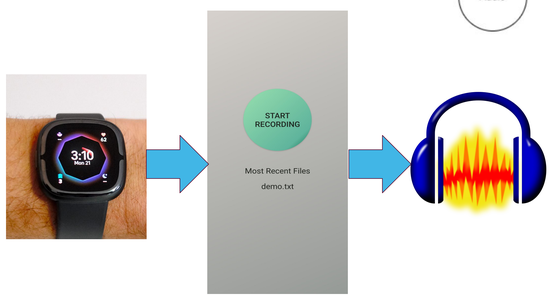

Figure 5: Fitbit to Android App to Audacity

Quantitative Results

User acceptance test results from users listening to the Bosch audio show that most users are able to identify the type of music the accelerometer recorded, and that the gender speaking was able to be determined fully. Additionally, some users were able to identify the words spoken in the recordings.

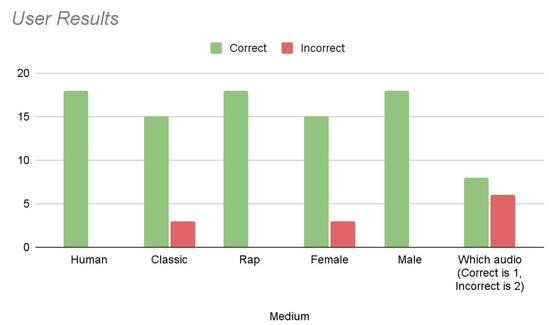

Figure 6: User test results for BMA580

Comparing recordings from a microphone and an accelerometer provide resources to configure audio enhancements.

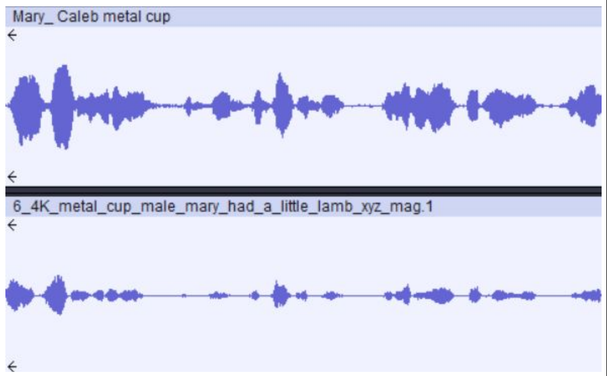

Figure 7: Displays how the accelerometer data is processed. Upper line is the audio recorded by a microphone and the lower line is the accelerometer recorded audio.

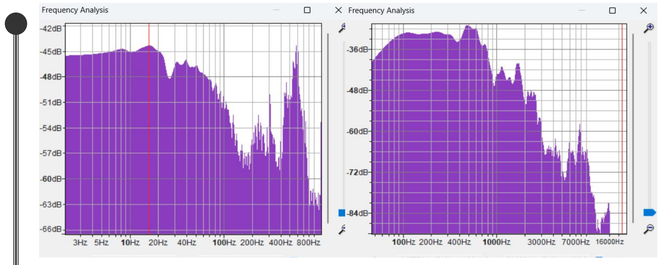

Figure 8: Frequency spectrogram analysis comparison of audio Bosch accelerometer (left) and microphone (right).

Conclusion

An unrestricted accelerometer (Bosch BMA580) could reach 6.4KHz and produce legible audio in an ideal environment with conversions among the 3-axis data recordings. The Fitbit Sense could only record at 100Hz, due to limitations placed by the hardware and software SDK. A working application was created that collects 3-axis accelerometer data from the Fitbit and transfers the information to the mobile device where the data file can be converted into audio. In terms of the Fitbit, the audio produced was not sufficient to be used, but future pathways utilizing the device were identified.

References

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2. Kröger, J. L. et al., (2019). Privacy implications of accelerometer data: a review of possible inferences. Proceedings of the 3rd International Conference on Cryptography, Security and Privacy, 81-87.

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