Sound Wave Extraction from Background Accelerometer Readings

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Introduction

Accelerometers are necessary in modern mobile devices. Access to their data, however, is not protected in the same way recordings from a microphone or camera would be.

- Previous studies have shown that machine learning models can detect 'hotwords'.
- Discrete Fourier Transforms and their inverse functions can be used to decompose frequencies from sound waves.

  Discrete Fourier Transform Formula
  $c_k = \frac{1}{N} \sum_{j=0}^{N-1} f_j e^{-ijk2\pi/N}$, $k = 0, \ldots, N-1$

- When a device is stationary and excluded from interfering forces, the accelerometer data is greatly simplified.

Goal

This study aims to use Fourier Transforms to extract sound waves from stationary device accelerometer data.

Methodology

Phase 1: Proof of Concept

- Prove that the presence of sound can be detected from accelerometer data.

Phase 2: Standard Trend Identification

- Establish an acceleration magnitude threshold.
- Collect a sample of data that does not exceed the threshold.
- Use this sampling to cancel out noise.

Phase 3: Sound Wave Extraction

- Expand data cleaning processes
- Apply standard and inverse Fourier transforms.
- Identify interference signals. Cancel them out.

Phase 1

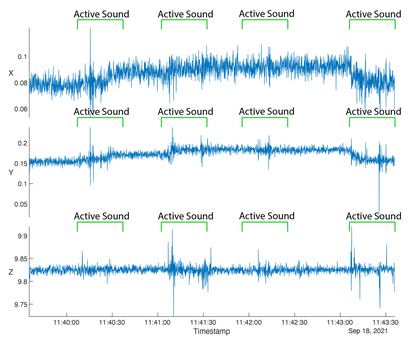

Figure 1:Acceleration Data

Phase 2

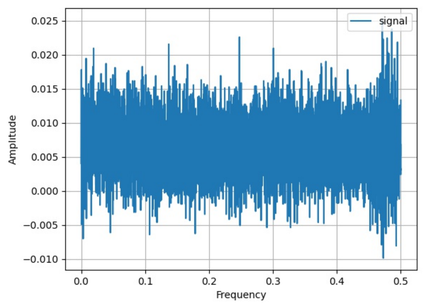

Figure 2:Example of Standard Random Data

Phase 3 Results

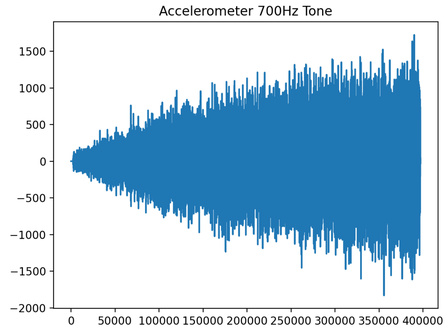

Figure 3:Accelerometer 700 Hz

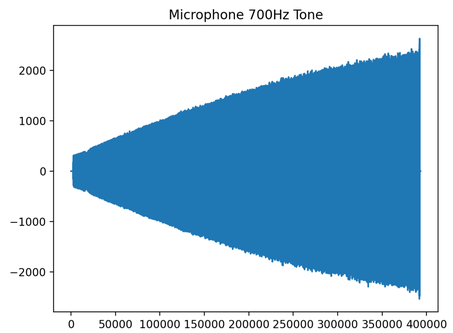

Figure 4:Microphone 700 Hz

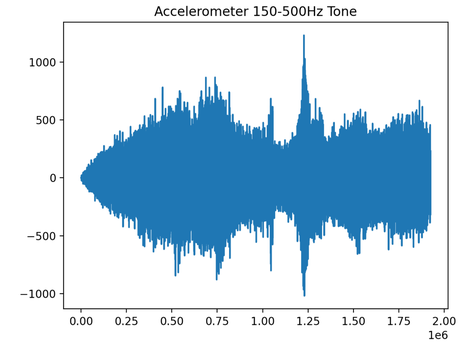

Figure 5:Accelerometer 500 Hz

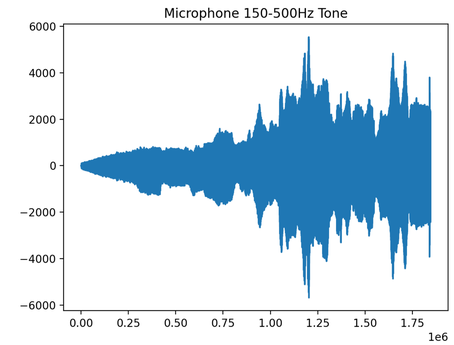

Figure 6:Microphone 500 Hz

Discussion

What is the problem here?

- Sensitive information can be extracted from accelerometer data without the need for approval.

What has been shown?

- Sound waves can be extracted from accelerometer data.
- Formal methodology needs to be further established.

Where does the study go from here?

- Implementing a more strategic method for applying standard and inverse Fourier transforms.
- Clearly identifying interference constants.
- Applying machine learning models to analyze wave decompositions and inform proceeding steps.

References

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