SMART STETHOSCOPE

Industry Sponsor: Oregon Health & Science University, and Galois Inc.

Objective

The Smart Stethoscope is a collaboration between Oregon Health & Science University and Galois. This project aims to detect, diagnose and determine the severity of cardiac and pulmonary disease. The Capstone team delivers an algorithm to improve signal quality by effectively filter out real-world disturbances from data collected by microphones and providing a reliable and efficient combined signal for accurate diagnosis.

Figure 1: Smart Stethoscope Prototype

Approach:

- Research Background and Methodology
- Algorithm Development with Synthetic Data
- Algorithm Integration with Sample Data
- Test, Debug and Review

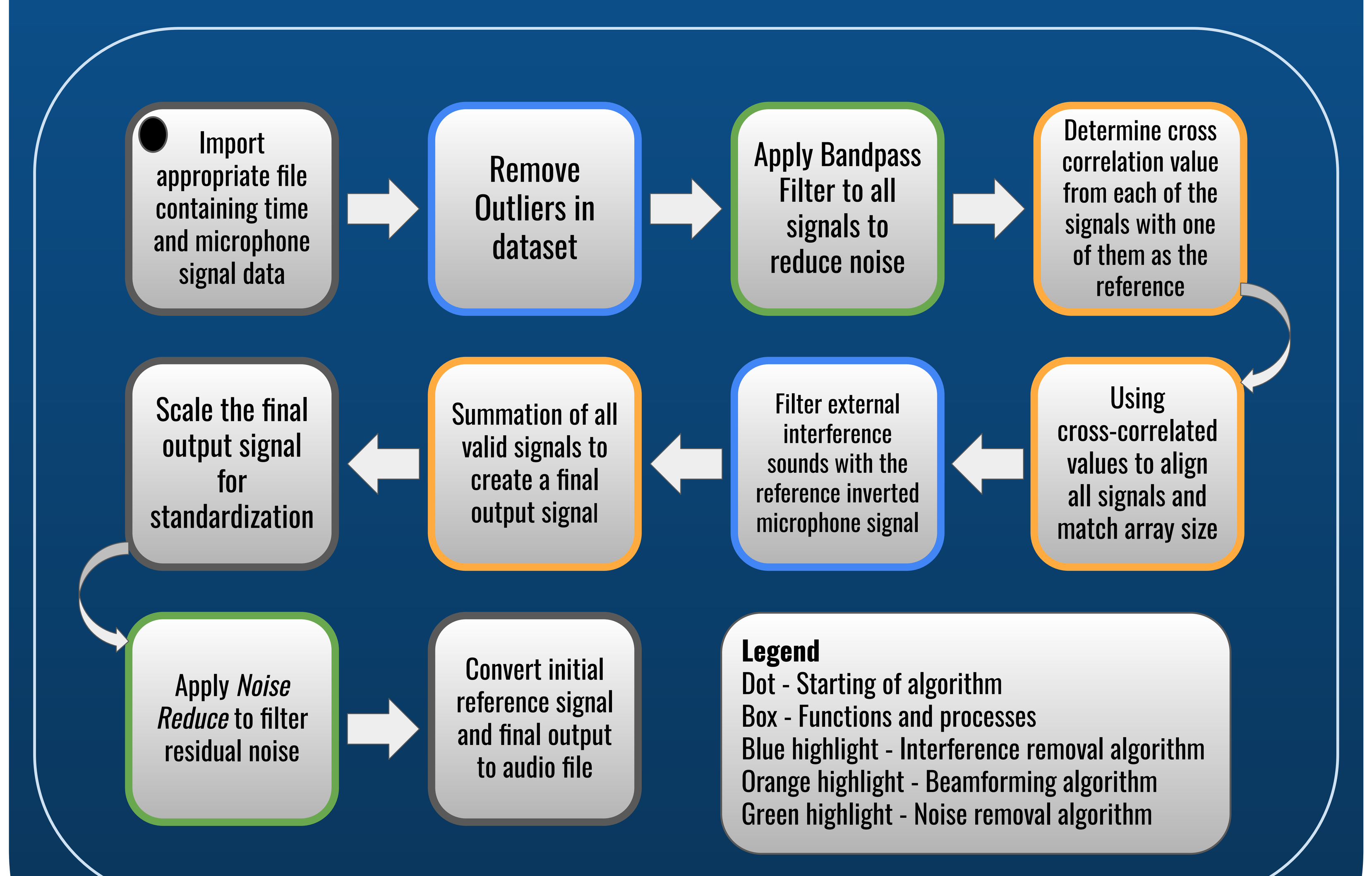

Figure 2: L1 Functional Block Diagram

Algorithm Design

Filtering:

A Butterworth bandpass filter was chosen due to performance of the elimination of noise and external interference. An inverted interference signal is destructively applied to further reduce the interference of the signal to obtain the cleanest signal. The order of the methods & workflow were chosen by visual inspection and through trial and error.

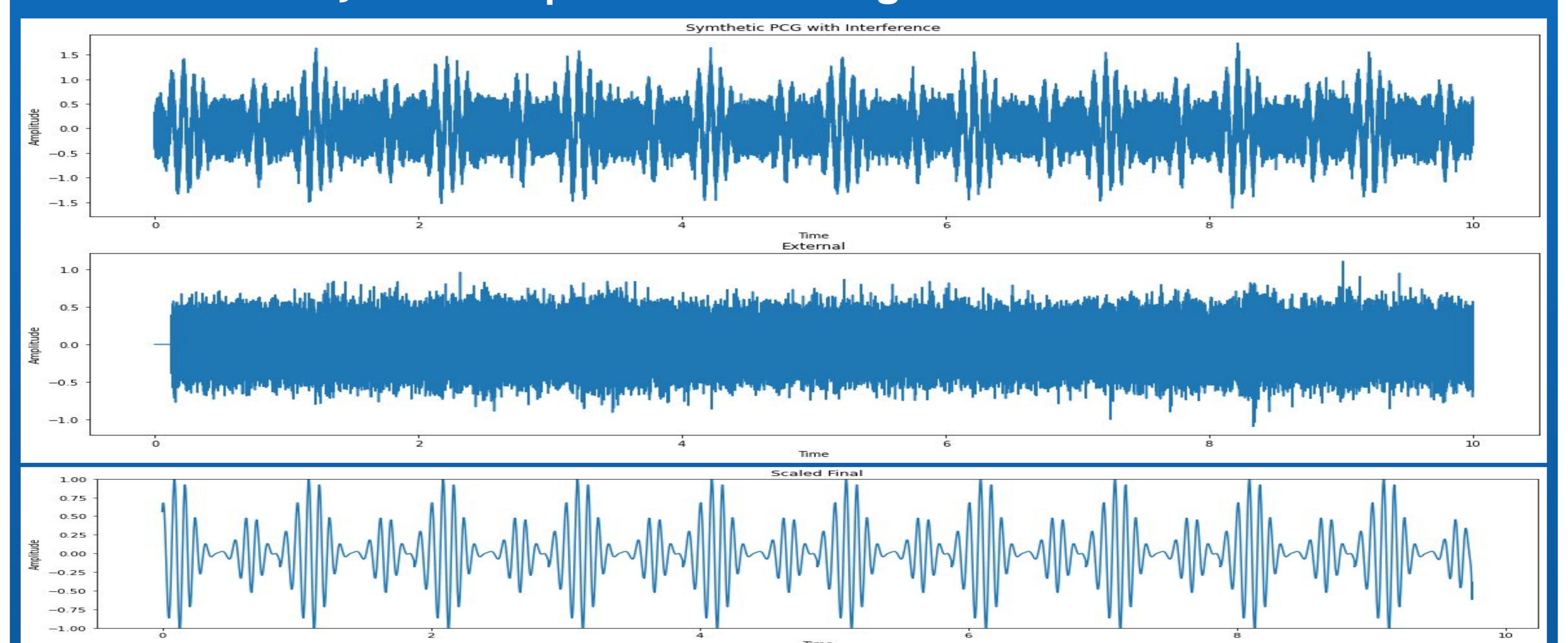

Figure 3: Noise Cancellation/Filtering Unit Test with Synthetic Data

Beamforming:

The received signals have delays built into the signal. We used the delay-and-sum method which uses calculated lags from cross correlation. We then align the signals by removing units according to the calculated delays from the beginning and adjusting the signal sizes uniformly by removing minimal units from the end.

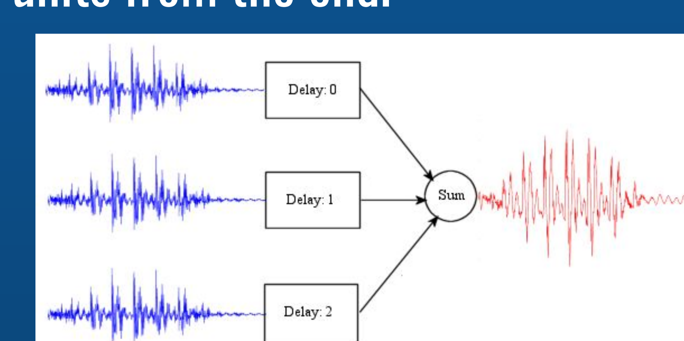

Figure 4: General Delay & Sum Example

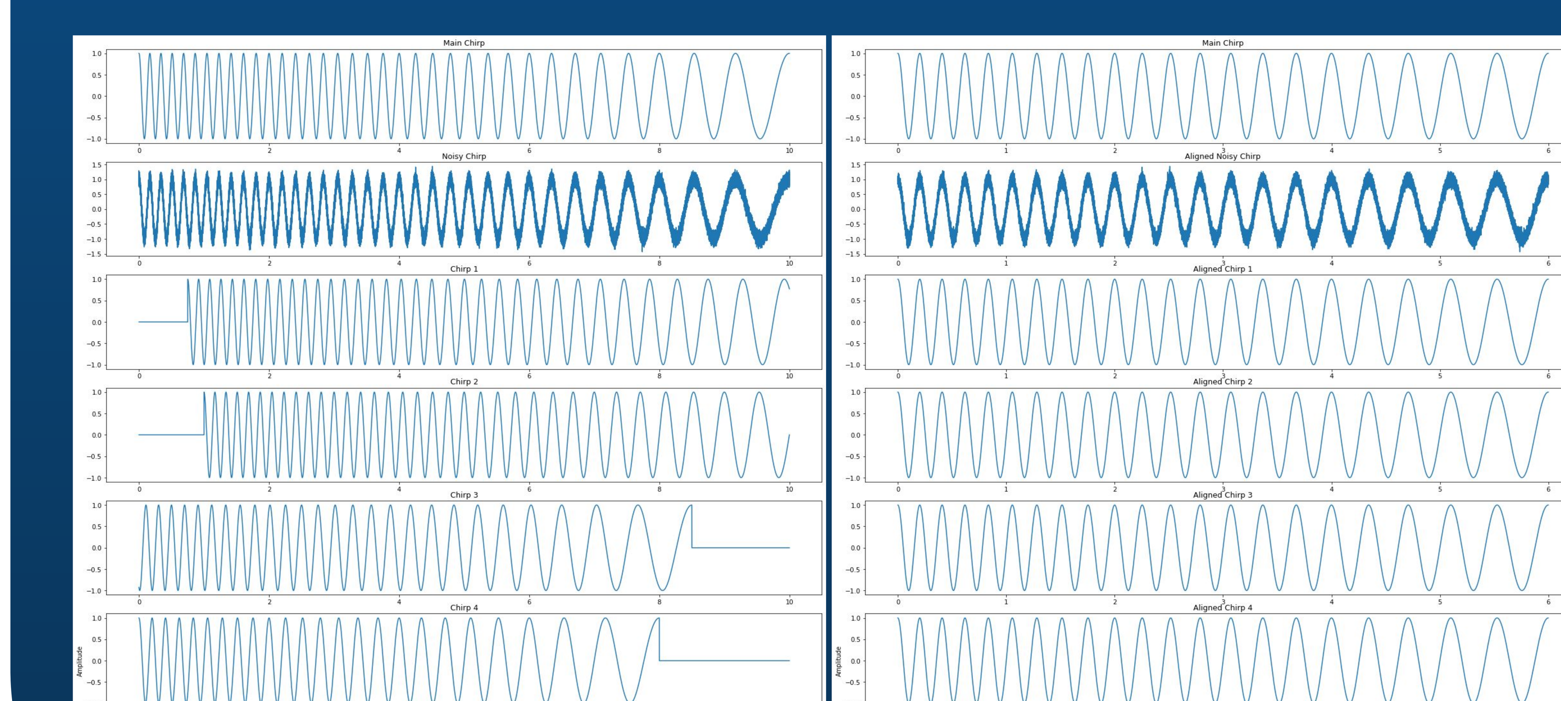

Figure 5: Chirp Beamform Unit Test: The left plot showcases sample chirps with varying delay values. The right plot show the resulting waveforms post-alignment algorithm

Results

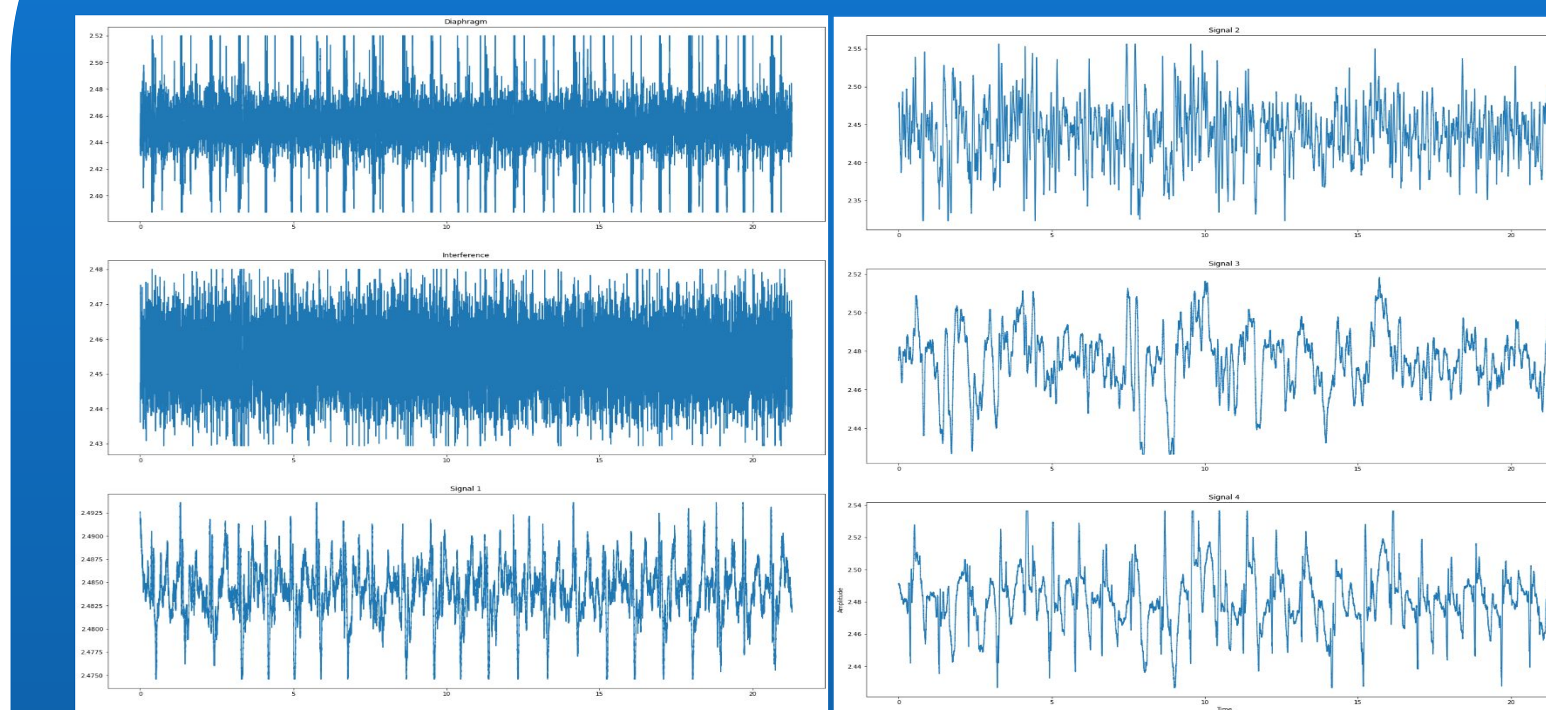

Figure 6: Raw Sample Data

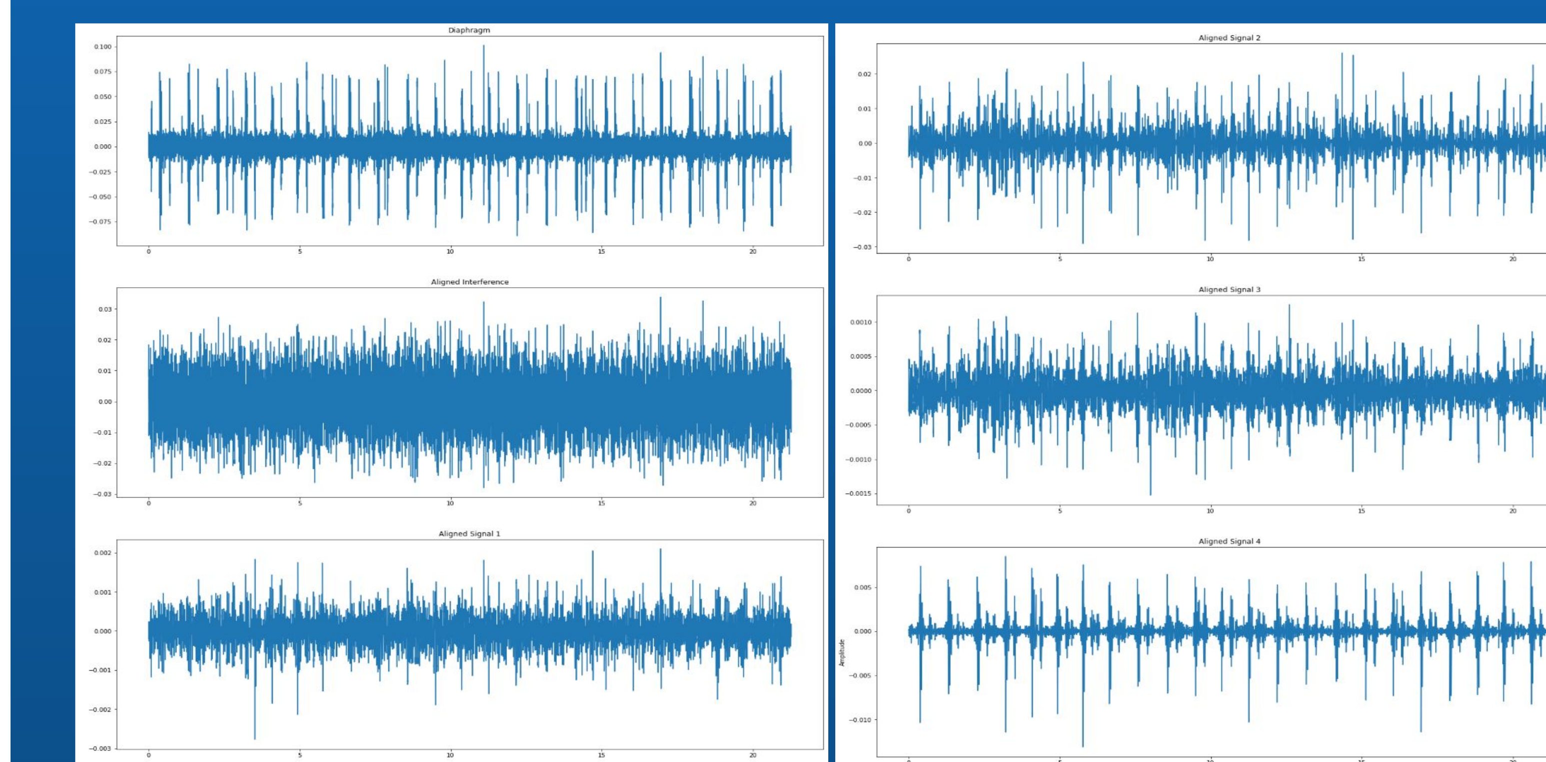

Figure 7: Post Alignment & Filter of Sample Data

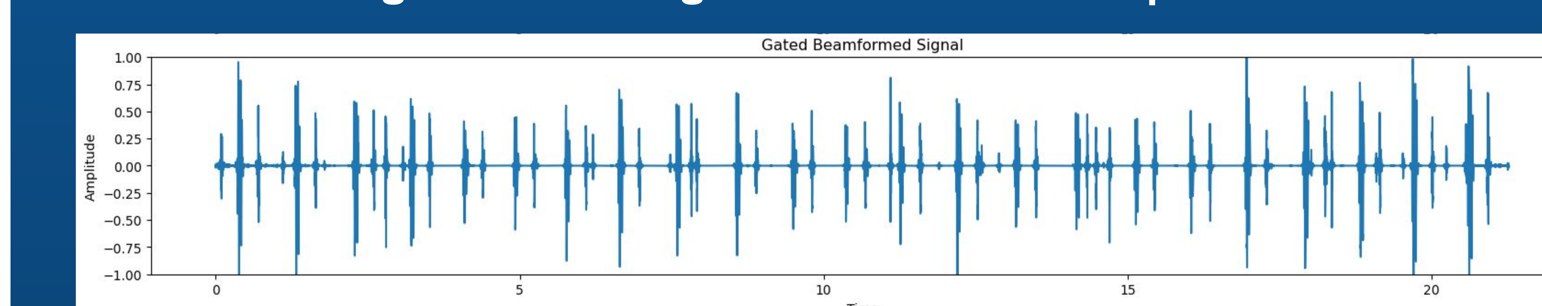

Figure 8: Algorithm Output

Future Work:

According to Figure 8, our trials utilizing destructive interference was a good starting point, but more involved algorithms can potentially produce better results. Our current method does filter out some interference but it is unable to handle extremely noisy signals and we have yet to implement formal verification method (Signal to Noise Ratio).

Other groups may want to experiment with noise gating algorithms, which has lots of parameters that can be tested with to produce better results, but due to time constraints we weren't able to look into this further. Least Mean Squares adaptive filtering algorithms without a reference signal is another concept that can be implemented to improve noise filtering.

Department of Electrical and Computer Engineering

Portland State University
Maseeh College of Engineering and Computer Science