HM-Detect: Murmur Detection and Classification Methodology Using A Novel C^2-LSTM Architecture for Multi-Modal Signals

Sivaraman, Ram (School: Acton Boxborough Regional High School)

Heart murmurs are abnormal sound signals generated by turbulent blood flow and are closely associated with specific structural heart disorders. Current murmur analysis methods only look towards murmur detection but fail to recognize that qualifying murmur characteristics like timing is critical for creating cardiac diagnoses. To address this challenge, I have developed HM-Detect, a novel methodology to not only detect but also accurately characterize heart murmur features (timing, location, etc.) through signal processing and machine learning techniques. The methodology incorporates several key innovations. First, it analyzes heart sounds using a new combined set of sound features–namely filterbank energies and spectral subband centroids. These features along with their statistical moments are used as inputs for building a machine learning model, which incorporates time-varying aspects of heart sounds. Inspired by heart signals with multiple frequency modes (coming) from fundamental heart sounds and murmur sounds, a breakthrough “multi-modal” long short-term memory (C^2-LSTM) neural network-based architecture is developed to detect and classify murmur features. Finally, C^2-LSTM uses two memory channels and combats the unwanted interdependencies that arise in signals with different frequency modes. The HM-Detect methodology was validated on signals from the clinically verified CirCor DigiScope dataset, achieving a performance accuracy of around 90% and having an F1 score of 0.91 and a test accuracy of 87%. Further, the C^2-LSTM architecture has been generalized to “n” number of memory channels, correspondingly called C^n-LSTM. The C^n-LSTM lays a foundational framework for signal processing with any number of independent frequency modes.

Awards Won: