Development of an AI enabled Low-cost Digital Stethoscope

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Abstract

This study proposes a low-cost digital stethoscope which leverages on machine learning to distinguish between normal and Cardiovascular disease (CVD) related heart sounds.

Machine Learning (AI) models (KNN, SVM, CNNs) are trained and tested on features derived from the heart sounds or phonocardiogram signals (PCG) by Wavelet scattering and Fast-Fourier Transform (FFT). The overall validation accuracy range was 89.9%-98.5%.

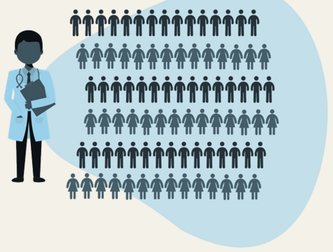
1. INTRODUCTION

CVDs are among the leading causes of death globally[1]. Over 75% of these deaths are in low and middle-income countries like Zambia with low doctor to patient ratios and limited access to advanced healthcare technology.

Acoustic stethoscopes commonly used by doctors for CVD diagnosis require vast clinical experience and concentrated listening skills in order to achieve accurate diagnosis. In the absence such expertise, accurate diagnosis of heart diseases may not be possible. Additionally, sound amplification is limited, and data sharing is unlikely.

There is an unmet need for the development of low-cost modalities for CVD screening and early diagnosis AI, robust signal processing algorithms and wireless transmission.

- **1:12000 Doctor to Patient Ratio**



- **Limited access to advanced healthcare technology**

Eco Digital Stethoscope

ECG Machine

Ultrasound Machine

Objectives

- To develop a relatively low-cost digital stethoscope
- To leverage AI for CVD screening & diagnosis
- To integrate the digital stethoscope in telemedicine

2. METHODOLOGY

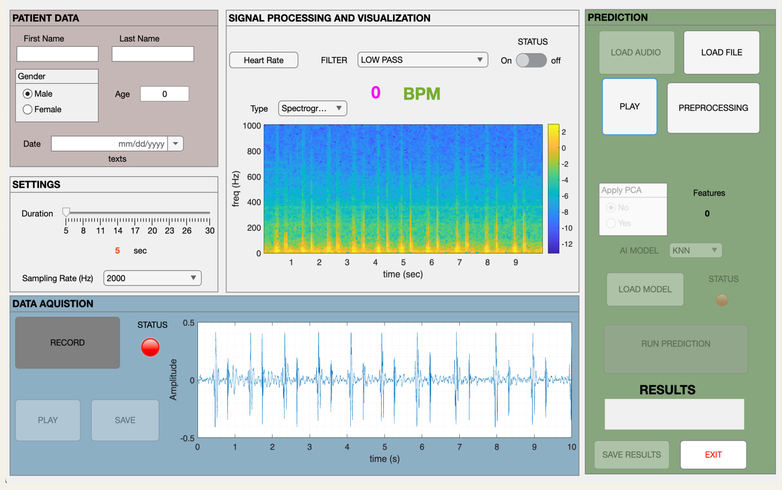
Digital Stethoscope | AI driven app | Tele-medicine

Digital Stethoscope system overview

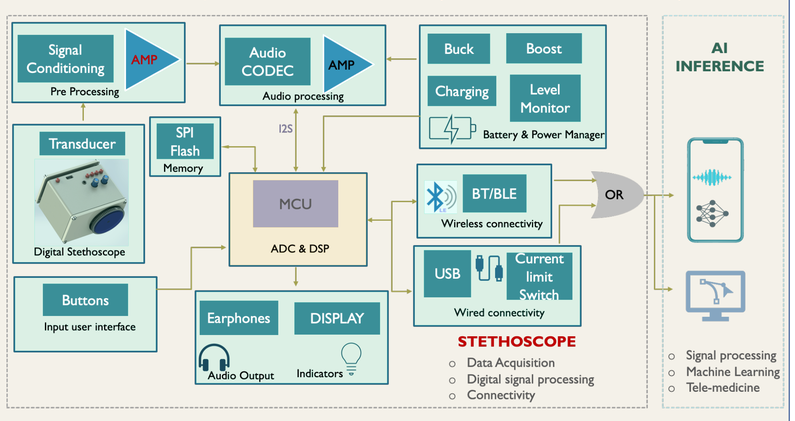
2.1 Proposed Digital Stethoscope

- A low-cost Digital Stethoscope with Bluetooth & USB
- An AI driven CVD screening phone & PC app
- Remote connectivity to specialists (telemedicine)

Digital Stethoscope CAD model & Prototype

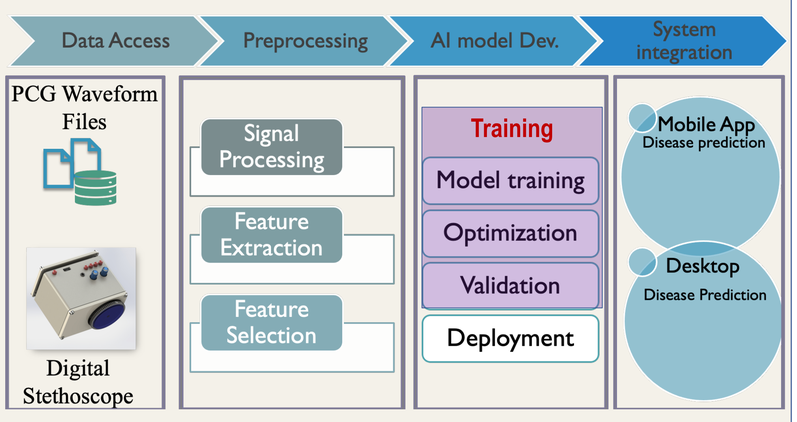


Graphical User interface (PC version -MATLAB)



Digital Stethoscope System Architecture

2.2 Machine Learning pipeline



Data set Description

- **PhysioNet Database[2]** : **3,126** heart sounds files
- **Our Stethoscope**: Wave file recording at 16kHz
- **Classes:** Normal and Abnormal
  - **80%** Training Set, **20 %** Validation

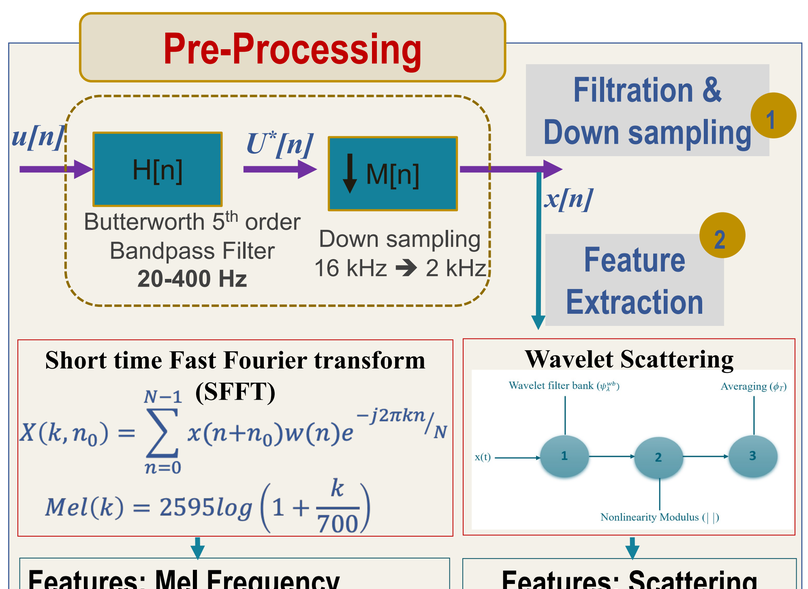
Machine Learning Models

CNN [3](Light-weight Model)

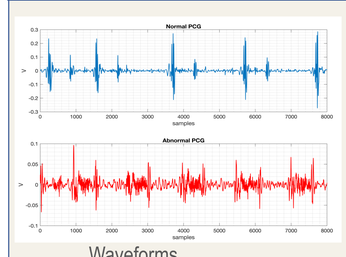
K-Nearest Neighbors (KNN)

Support Vector Machines (SVM)

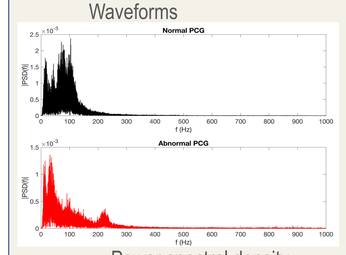
CNN architecture (Keras-Tensorflow)



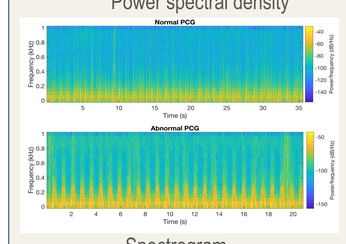
3. PRELIMINARY RESULTS



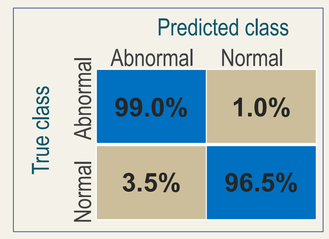
Waveforms



Power spectral density



Spectrogram



Confusion matrices

No	Model	Accuracy % (Validation)	PCA	Training Time (sec)
1	Fine KNN	98.49	Disabled	306.95
2	Gaussian SVM	97.41	Disabled	283.57
3	Fine KNN	96.78	Enabled	6.50
4	Gaussian SVM	92.11	Enabled	8.73
5	CNN	89.90	Disabled	1200.50

4. CONCLUSION & FUTURE WORK

- Developed a Low-cost Digital Stethoscope prototype. (Hardware) + PC- software
- Trained machine Learning Models for CVD prediction.

Future work: Prototype miniaturization, accuracy improvement, Local dataset creation, Smart phone System integration and telemedicine.

Acknowledgements

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