Listen to your Heart:
Heartbeat Sound Segmentation & Classification

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SCHOOL OF
ELECTRICAL AND
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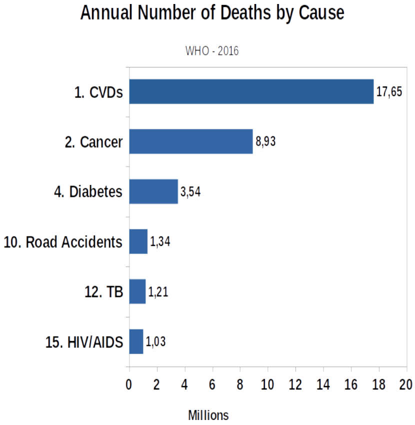
Agenda

Introduction

- CVDs are the leading causes of death globally - WHO.



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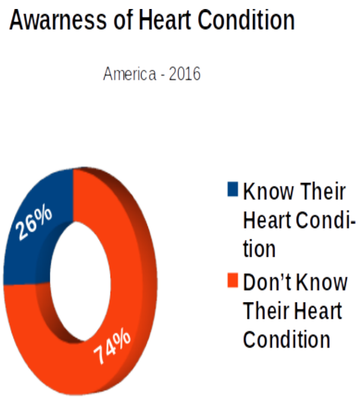
Correct diagnosis using CA in USA, Canada & UK respectively.

Introduction

- CVDs are the leading causes of death globally - WHO.
- Currently used method to check for CVDs is Cardiac Auscultation (CA).
- CA is a difficult skill to acquire.
- People are not aware of their heart conditions.

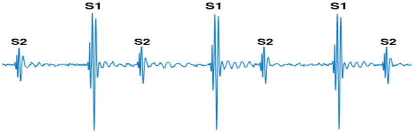


Introduction

Easily accessible & reliable heart diagnosis systems would help reduce deaths due to CVDs.

Objectives

- To segment Heartbeat sounds (HSs) based on the location of S1 (lub) S2 (dub) in Normal HSs.



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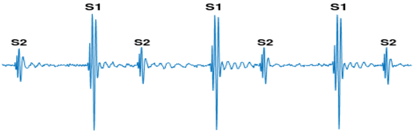
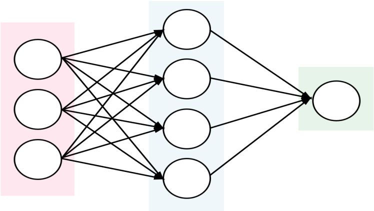


- Create models that will enable preliminary screening of CVDs



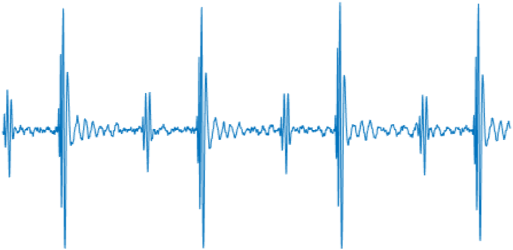
Background
Heartbeat Sounds Categories

This project deals with classifying HSs into the following categories:

1. Normal HSs
2. Murmur HSs
3. Extra Heartsounds
4. Exrasystole HSs
5. Artifact

Normal HSs

`lub...dub.....lub...dub.....`

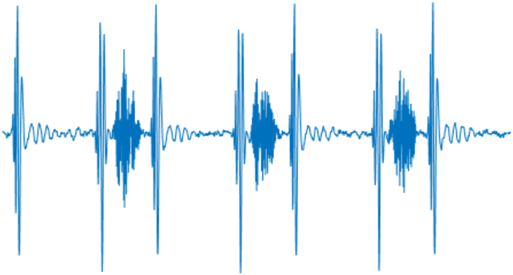


Murmur HSs

```
lub..***..dub.....lub..***..dub......
```

or

```
lub....dub...***...lub....dub...***...
```

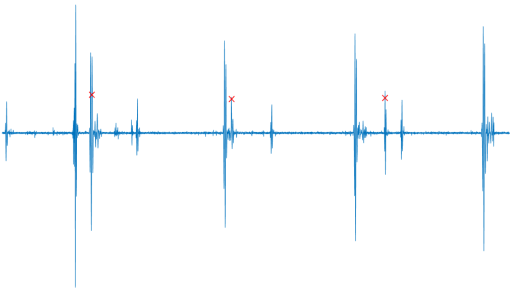


Extra HS

`lub.lub...dub.....lub.lub...dub.....`

or

`lub...dub.dub.....lub...dub.dub.....`

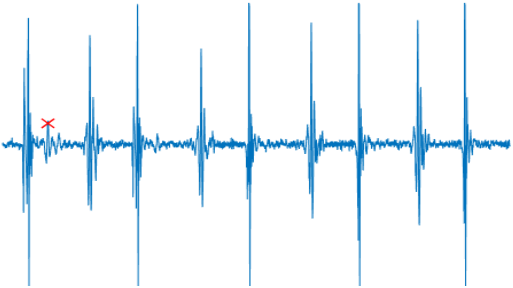


Extrasytole HSs

`lub....dub......lub.lub...dub.....lub....`

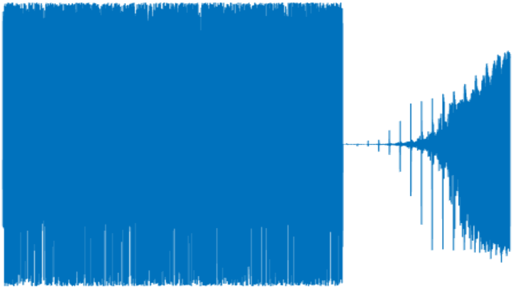
or

`lub....dub.dub.....lub...dub......lub....`



Artifact Sound

Not an actual HSs.

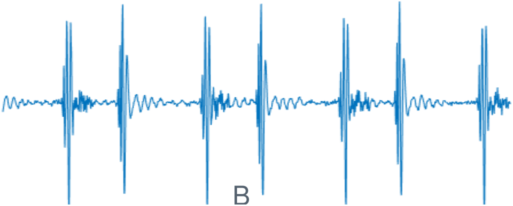


Background

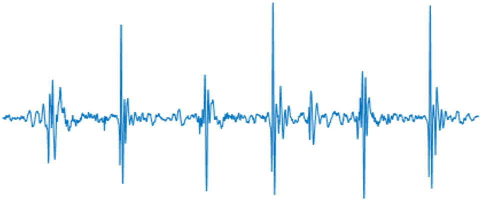
Heartbeat Sounds Categories

Can you guess the categories?

A



B



Background
Related Work

Strunic's attempt to classify HSs with ANN.

85±7.4%

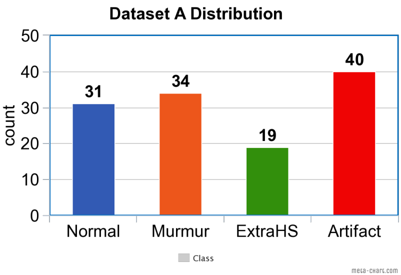
Accuracy when classifying simulated HSs with no noise.

48±12.7%

Accuracy when classifying real life HSs with noise.

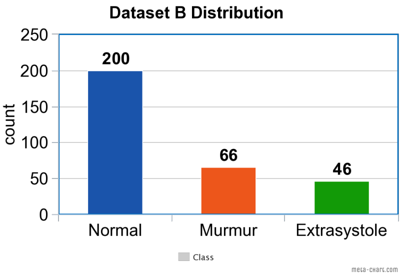
To make this project applicable to real world situations, two datasets recorded in real life settings will be used. Both datasets contain excessive background noise.

Dataset A



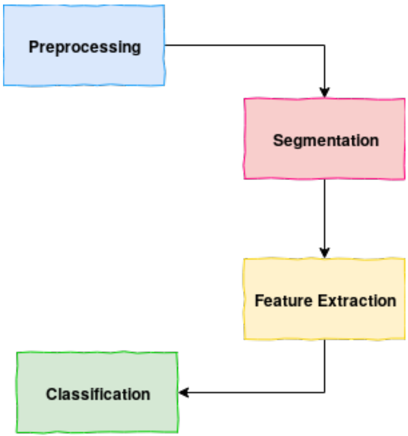
- Recorded by the general public
- Device - iStethoscope Pro Iphone app
- Sampling Freq - 44100Hz
- Contains excessive background noise

Dataset B



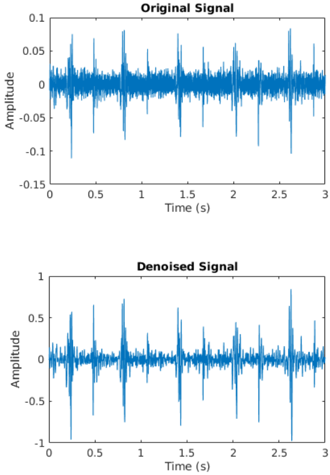
- Recorded from a hospital by Medical Practitioners
- Device - Digital Stethoscope
- Sampling Freq - 4000Hz
- Contains background noise

Methodology
System Overview



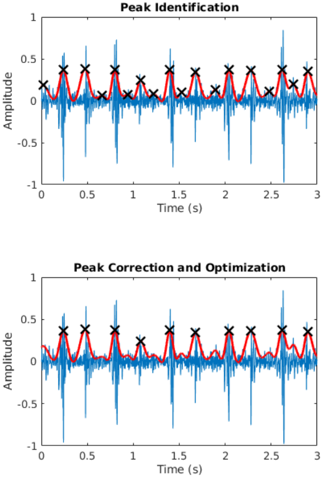
Methodology
Preprocessing

1. Downsample to 2kHz
2. Bandpass Chebyshev filter [30Hz-195Hz]
3. Normalization [-1 1]
4. Wavelet Decomposition (db7 level 5)
5. Refilter with LPF [195Hz]



Methodology
Segmentation

1. Envelope Detection
2. Peak Detection
3. Extra Peak Rejection
4. Peak Correction & Optimization
5. Location of S1 and S2

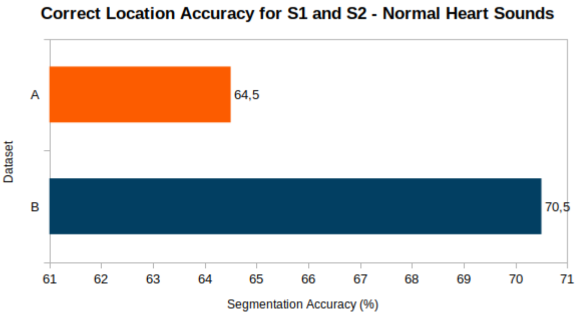


Methodology
Feature Extraction

1. Time Domain
2. Frequency Domain
3. Wavelet
4. Ceptrum

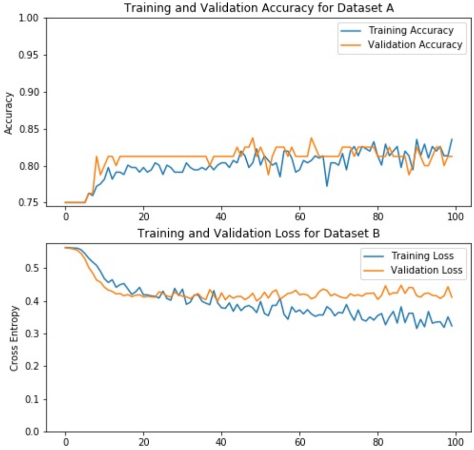
1. ANN (Atrificial Neural Network)
2. SVM (Support Vector Machine)
3. XGBoost (XGradient Boost)

Segmentation



Testing & Results

Dataset A - ANN Performance



Testing & Results

Dataset B - ANN Performance

Classification

Table: Classification Performance Dataset-A

Class (A)	**ANN (%)**	**SVM (%)**	**XGB (%)**	**Literature (%)**
Normal	27	80	71	45
Murmur	88	78	86	31
ExtraHS	67	25	57	11
Artifact	100	57	50	58
Overall Accuracy	**81**	**64**	**68**	**46**

Classification

Table: Classification Performance Dataset-B

Class (B)	**ANN (%)**	**SVM (%)**	**XGB (%)**	**Literature (%)**
Normal	80	77	89	78
Murmur	90	87	75	37
Extrasys	15	0	17	17
Overall Accuracy	**80**	**78**	**79**	**77**

Improvements and Future Work

- Increase dataset

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- Increase dataset
- Use equally distributed dataset

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- Improve recording techniques

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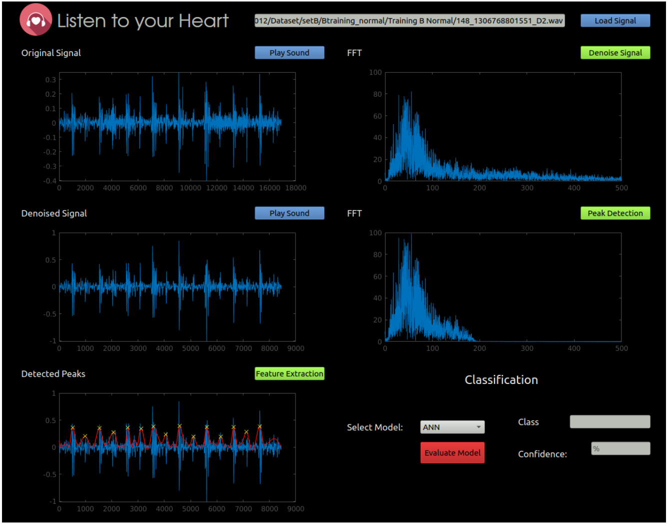
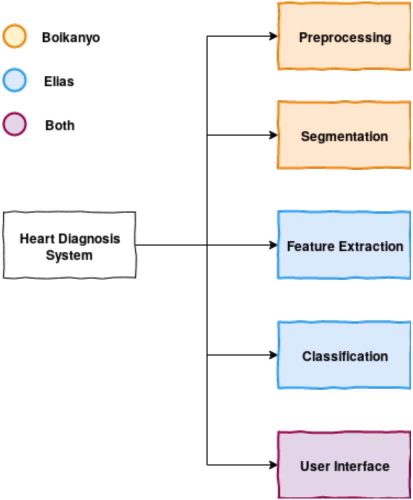
- Increase dataset
- Use equally distributed dataset
- Improve recording techniques
- Improve location of S1 and S2
- Distinguishing features between Extra HS and Extrasystole

User Interface



Work Division



Conclusion

- A method to segment and classify heart sounds into normal and diseased categories has been successfully developed and implemented.
- An accuracy of over 80% and above is achieved for normal heart sounds classification
- Recommendations for future works is presented