Improving The Recognition of Heart Murmur

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Abstract

In this research we build classification model using HMM model to do chest sounds and heart murmur recognition.We use Mel Frequency Cepestral coefficient(MFCC)as a feature.We use 13 MFCC coefficients.In heart murmur recognition we use 1066 different heartbeats covering(VSD,MR,AS,PDA,PR,Ps and normal sound).Then we separate murmur from the original signal.The overall accuracy equal 98.4%.In chest sound we use 387 sounds covering wheezes,crepitation,bronchial breathing and normal chest sound.The allover accuracy of chest sound recognition model equal 100%.We aim to diagnose patient immediately using this models.

Keywords: Hidden Markov Model,Heart Murmur,Mel Frequency Cepestral Coefficient,Wheezes,Crepitation ,Bronchial Breathing.

1 Introduction

In this paper we will concern on two types of sounds heart sounds and chest sounds.Each type of sounds give specific information about patient situation. Heart sounds are divided into normal and abnormal sounds.Normal sounds include S1 and S2.Murmurs are abnormal heart sounds.That occurs when there is turbulent blood flow [1].

S1(Lub) occurs because of mitral and tricuspid valves closure [2].S2(Dub) occurs when the aortic and pulmonic valves close [2].Heart sound auscultation is reliable in many cases of heart defects.Each type of defects has specific auscultation area according to defect location.Heart murmurs can be systolic or diastolic according to murmur position.Murmur occurs between S1 and S2 called systolic Murmur.Murmur occurs between S2 and S1called diastolic Murmur.Murmur occurs in systolic and diastolic at the same time called continuous murmur.

Murmurs are divided into different types resulting from (mitral regurgitation,mitral stenosis,aortic regurgitation,aortic stenosis,pulmonary stenosis,ventricular septal defect(VSD)and patent ductus arteriosus(PDA)) [1].In this paper we will cover(VSD,PDA,PS(Pulmonary Stenosis),PR(Pulmonary Regurge),MR(Mitral Regurge),AS(Aortic Stenosis),AR(Aortic Regurge)).These murmur differentiate according to occurrence position.We will concern on the above types of murmurs.

The main problem is hard to recognize,hard to hear and the sound is not clear.PDA needs to diagnose immediately to help the patient from other complications.In the other side chest sounds give more information about situation of chest if its normal or not.We will concern on wheezes,crepitation,bronchial breathing and normal chest sound.In this paper we use HMM [3] to recognize the above types of murmurs and we use MFCC(Mel Frequency Cepestral Coefficient) [4]as a feature vector with 13 Cepestral Coefficients.

We built model to recognize the above murmurs with more accurate results.We use MATLAB as a programming language to build model from scratch.We use MATLAB because MATLAB is open source,desktop environment,ability to call external libraries and advanced graphical user interface(GUI).We will evaluate the model according to result accuracy.

2 Related Work

All research papers in heart murmur recognition divided into two areas:1-Heart murmur recognition.2-Suggested method for more accurate murmur recognition.Most paper in the first area focused on recognition of mitral regurge(MR),mitral stenosis(MS),aortic regurge(AR),aortic stenosis(AS),pulmonary stenosis(PS)and normal sound.

Some research used ANN to do murmur classification [5].This research recognized aortic stenosis and aortic regurge.They used 24 normal heartbeats,24 sounds with aortic regurge,24 sounds with aortic stenosis [5].They built databank with 110 sounds from 28 patients [5].Feature vector extracted from spectrogram using average single cycle.Model testing used 7 examples for normal sound,4 examples for aortic stenosis and 4 examples for aortic regurge [5].Accuracy reached to 48.5% with recorded signal and 85% with simulated sound [5].They have small dataset,small testing data and the accuracy of recorded signal is very poor.

Other research recognized mitral regurge(MR),mitral stenosis(MS),aortic regurge(AR),aortic stenosis(AS),pulmonary stenosis(PS)and normal sound using HMM and BPNN [6].They used 600 heartbeats included five types of murmur.Then they used 300 heartbeats for model training and 300 heartbeats for model testing [6].They extracted features using MFCC.HMM Model murmur sounds overall accuracy equal 94.2%and BPNN overall accuracy equal 82.8% [6].

Other research recognized murmur using four standard auscultation area mitral,tricuspid,aortic and pulmonic areas.They extract data from phonocardiographic(PCG)signals.They built database with 200 normal sound and 200 with evidence of cardiac murmur [7].They do recognition using HMM with empirical mode decomposition(EMD)using MFCC and the overall accuracy equal 98.9% [7].

Other paper compared between classifiers according to model accuracy [8].Table 1 show comparison between four algorithms ANN with back propagation techniques,support vector machines SVM,ANN with radial basis function and Adaptive Neuro-Fuzzy Inference System(ANFIS)Classifiers [8].That were used to recognize four types of murmur aortic regurge,aortic stenosis,mitral regurge and mitral stenosis.

Table 1: comparison results between four algorithms.

Classifier	**Accuracy**
Artificial Neural Network With Back Propagation Network	90.8%
Support Vector Machines	95 %
Artificial Neural Network With Radial basis Function	98 %
Adaptive Neuro-Fuzzy Inference System Classifiers	98.33 %

In the other research they recognized seven types of murmur(AR,AS,MR, MS,PS,tricuspid regurge,innocent murmur),with dataset size 211 heartbeats. They used new segmentation method that called wavelet transformation(WT) [9].And specificity equal 95.5% [9].Other research used spectrogram as a feature to separate murmur from original signal.They use singular spectrogram analysis(SSA)to do classification for(AS,MR and PS) [10].Other paper suggest fractal feature used to do classification, dataset contains 164 PCG(81 normal and 83 with murmur),and show accuracy for each detector for different feature set with filtering data and show the result in table 2 [11].

Table 2: accuracy for each detector for different feature set.

Feature Set	**Accuracy**
TV & TF	87.92%
Perceptual	82.03 %
Fractal	97.73 %

Other research paper suggested new method for feature extraction in presence of murmur,they extracted features from different features in PCG [12].Each feature vector contains 7 variable described in table 3 [12].

Table 3: Feature vector variables.

Feature Set	Description
MAX	Maximum Value Amplitude
Positive Area	Sum of Positive Area
Absolute Negative	Absolute Sum of Negative Area
Var	Variance
Energy	Shanon Energy
Bis	Bispectrum
WB	Winger Bispectrum

3 Methodology

3.1 Heart model:

Heartbeats were recorded at 16-bit accuracy and 44100 Hz sampling frequency and stored as wav format.1066 heartbeats were recorded during 7 months.We use 1066 heartbeats included normal and abnormal heart sounds.Abnormal heart sounds include VSD,PDA,MR,PS,PR,AS and AR.We use 50%of total heart beats for training and 50% for testing.At the beginning we recorded the sound according to auscultation areas(Mitral Area,Tricuspid Area,Pulmonary Area and Aortic Area).Each type of murmurs can be heard clear in specific area as we show in figure 1.

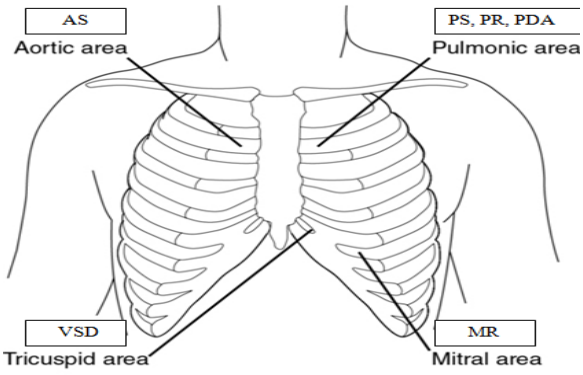

Figure 1: Auscultation Areas.

We separate s1 and s2 from original sound using specific threshold.Each amplitude above this threshold will set 0.We use this threshold to separate murmur sound from original heartbeats as we show in figure 2.

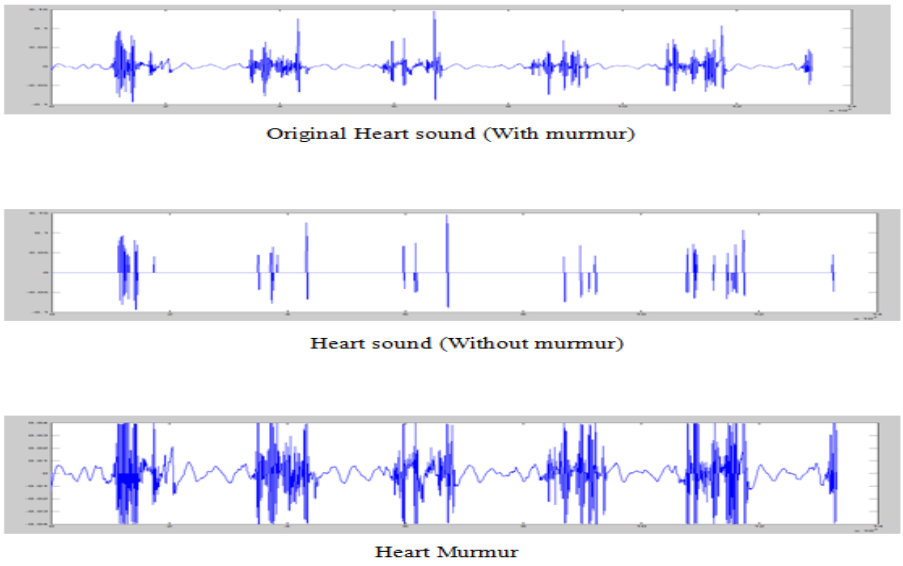

Figure 2: Murmur Separation.

3.2 Chest Model:

We use 387 chest sounds include(Normal,Wheezes,Bronchial Breathing and Crepitation).50% of total sounds used for training and 50% used for testing.

3.3 MFCC:

Then we use MFCC feature to extract feature matrix for each type of heart sound and chest sounds.MFCC computation display in figure 3.In MFCC we use 13 cepestral coefficients for each type of heart sounds and chest sounds.

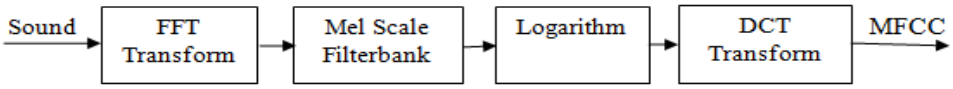

Figure 3: MFCC Extraction.

3.4 HMM:

We use HMM model to do heartbeats and Chest sounds classification in the following steps:
1-we train HMM using MFCC feature matrix.
2-we use Baum-Welch in HMM to produce new parameter estimates that have equal or greater likelihood of having generated the training data.
3-we use Viterbi algorithm to determine the best state sequence that maximizes the probability of generation of the observation sequence (each feature matrix represent one Observation).
4-we use forward-backward algorithm to calculate the probability.

Each Auscultation area has isolated HMM model with related murmurs.We divided auscultation Area into 4 areas to increase HMM model accuracy.Then HMM model display test result.In figure 4 we display model processing.

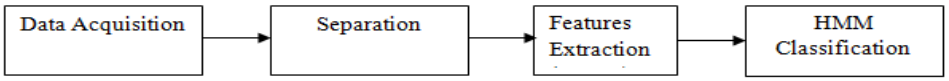

Figure 4: Sound Recognition Processing.

4 Experimental Results

In chest model we use 387 sound divided between normal and abnormal chest sounds(wheezes,crepitation and bronchial breathing).Then we test the model and the result show in table 4.The over all accuracy equal 100%.

Table 4: Chest Model Sensitivity.

Cehst Sinal	**TP**	**FN**	**Sensitivity(TP/(TP+FN))**
Abnormal	131	0	100 %
Normal	64	0	100 %

In Heart Model we use 1066 heartbeats divided into 6 types of murmurs including(VSD,PDA,MR,PS,PR, AS)and normal sound.We test heartbeats using HMM.Test results show in table 5.The overall accuracy equal 98.4%.

Table 5: Heart Model Sensitivity.

Heaert Sinal	**TP**	**FN**	**Sensitivity(TP/(TP+FN))**
VSD	110	0	100 %
MR	29	1	97 %
PS	81	2	98 %
PDA	89	2	98 %
PR	96	3	97 %
AS	61	0	100 %
Normal	138	0	100 %

5 Conclusion

We use HMM model to do heart murmur recognition with new heart murmur types(VSD,PR,PDA)and chest sounds recognition.In heart murmur recognition we divide Auscultation area into four areas.Each type of murmurs was recorded from related area.Each auscultation area has specific HMM model with related murmurs.We use 13 MFCC coefficients.Overall accuracy equal 98.4%.In chest sound recognition we concern on wheezes,crepitation, bronchial breathing and normal chest sound.We use 13 MFCC coefficients.Overall accuracy equal 100%.

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