Heart Sound Diagnose System with BFCC, MFCC, and Backpropagation Neural Network

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Heart Sound Diagnose System with BFCC, MFCC, and Backpropagation Neural Network

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Abstract--- human heart produce 2 different sound which are lub-dub. Abnormal heart sound would produce additional sound such as whoosing, roaring, rumbling or turbulence fliud noise between the normal heart sounds. In general, diagnosing heart abnormalities is relying on doctors' experience by hearing heart sound through stethoscope or using ECG. This research is using heart sound recording from The Pascal Classifying Heart Sound, Dataset B[1] as learning and testing data. Diagnosing heart sound with BFCC (Bark Frequency Cepstral Coefficients), MFCC (Mel Frequency Cepstral Coefficients), Modified BFCC, and Modified MFCC as feature extraction method and Backpropagation Neural Network as learning method. Heart sound recognition from The Pascal Classifying Heart Sound, Dataset Bwith BFCC is up to 79.167%, MFCC is up to 87.5%, Modified BFCC is up to 70.83%, and Modified MFCC is up to 95.83%.

1. Introduction

The human heart is an organ that pumps blood throughout the body via the circulatory system, supplying oxygen and nutrients to the tissues and removing carbon dioxide and other wastes. [2]Heart disease is a very dangerous disease in the world. In 2014 in Southeast Asia, especially in Indonesia, the mortality rate accounted for 35% or about 1.8 million cases of death caused by heart disease.According to several studies recorded by the World Health Organization (WHO), states that every 6.5 seconds in the world one person dies caused by active smokers. [3]

Abnormalities in the heart sound (murmur) can also indicate the presence of heart disease. This murmur has a repetitive cycle that each cycle has a time span called the sample duration. [4]. The most common human heart disesase which is caused by abnormalities is the abnormality of the valve and congenital abnormality of the septum.

Stetoschope is used to listen for the heart beat and to diagnose the sound from the heart beat. The accuracy of the diagnosis depends on experience and ear sensitivity of the doctor who listens and diagnose the heart sound. MFCC and BFCC which is usually used for speech recognition will now be used to try diagnosing heart sound.

2. Theoritical Review

The heart sound diagnosis system is using Backpropagation Neural network method as it's learning method. The learning method is divided into 2 steps which is training process and testing process.

The learning process of Backpropagation Neural Network method needs to use BFCC and MFCC method to get the cepstral coefficient which then will be used by Backpropagation Neural Network to do pattern recognition. The value will then be used as dependencies weight and stored in dependencies weight database.

The testing process of Backpropagation Neural Network method also use the BFCC and MFCC method to get the cepstral coefficient value which will be used by Backpropagation Neural Network to do pattern recognition using dependencies weight from the learning process. Bark Frequency Cepstral Coefficients (BFCC) method has never been used to recognize heart sound. This method is best used to emphasize sound in certain emotion from human voice. BFCC method is expected to recognize heart sound just as well as detecting emotion. MFCC extraction method has been used to recognize heart sound. This method is very renowned and usuallt used as speech recognition.
In this research, BFCC and MFCC feature extraction method will also be modified by adding or removing steps in both of the methods. The process flow of BFCC, MFCC and both of the modified version can be seen at Fig. 1 and 2. Heart beat produces 2 different sounds that can be heard from stethoscope. That 2 sounds is S1 which is lubdan S2 which is dub. Lub sound is the first heart sound which is caused by turbulence caused by the closure of mitral and tricuspid valves at the start of systole.

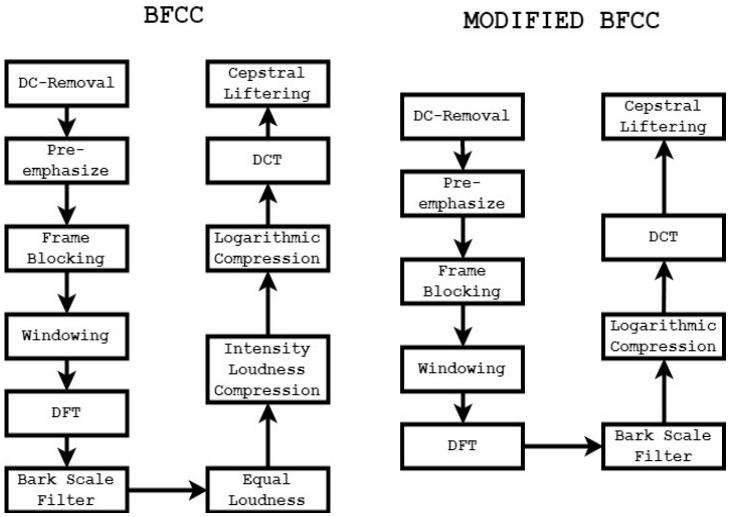

Figure 1. Comparison between BFCC with modified BFCC

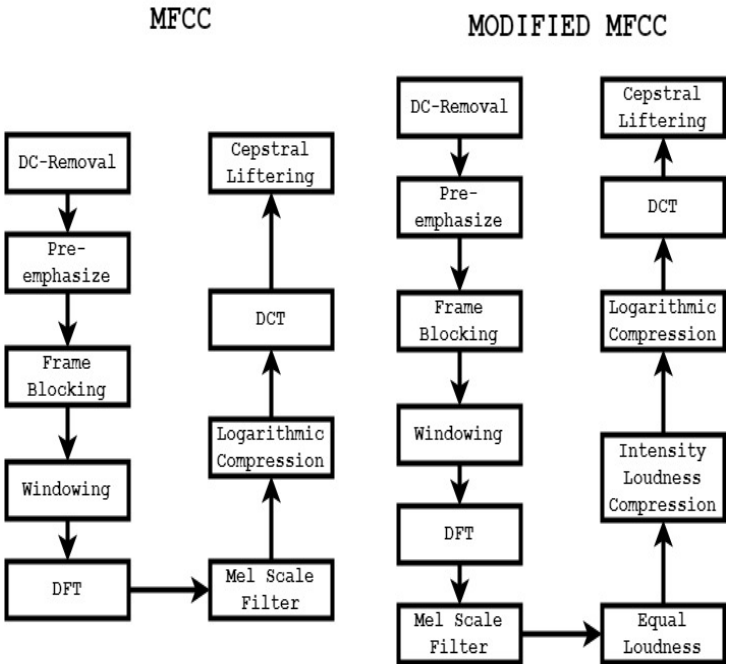

Figure 2. Comparison between MFCC with modified MFCC

Dub sound is the second heart sound and is caused by the closure of aortic and pulmonic valves, marking the end of systole. Murmur sound is produced when there is abnormal or turbulent in blood flow. Using a stethoscope, doctor maybe able to hear heart mumur during physical checkup. Not every heart murmur is abnormal or life threatening, but it could be a sign of a structural abnormalities in heart. [5]

An abnormal heart produce an extra voice called murmur which is caused by the valve incomplete opening or stenosis or regurgitation because of the incomplete closing of the valve which then cause the backflow of blood. In each case, the sound is caused by rapid blood flow going through a narrow opening. [5]

A normal heart sound pattern is a clear "lub dub, lub dub", with the sound “lub” to “dub” shorter than the time needed for “dub” to the next “lub”(if the heart beat does not exceed 140 heart beat per minutes). The temporal description of “lub” and “dub” location is illustrated as this: [1]

...lub ..... .dub .....lub .....dub .....

Heart Mumur sounds as if there is a “roar, turbulence” in any of the two temporal location: between “lub” and “dub”, or “dub” and “lub”. Below is an example of the murmur happening with * as a mark in location the possible murmur happened.[6]

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

Extrasystole sound may occur occasionally and can be identified because there is an extra heart beat, for example a “lub-lub dub” or “ lub dub-dub”, which is not the same as Extra Heart Sound because this occurences doesn’t happen regularly. Extrasystole may not be a sign of illness but in some situation, extrasystole can be cause by a heart disease. If this disease is detected before hand, the treatment is often more effective. Below is a temporal description of extrasystole sound.[1]

….....lub…….dub……..…….lub.……..…….dub……

lub.lub……..…….dub…….

(or)

…lub…….dub.....…….lub.……dub.dub……

lub……..…….dub.……

3. Results Methods

3.1. Training

The research method of heart sound abnormality diagnosis program is using Bark Frequency Cepstrum Coefficients (BFCC) method dan Mel Frequency Cepstrum Coefficients (MFCC) method as it’s feature extraction method, and it’s learning method is Backpropagation Neural Network (BPNN). Euclidean Distance is also used as a way to compare accuracy (learning rate) with the Backpropagation Neural Network(BPNN). Before the sound heart abnormalities is recognized, a learning phase is needed in the way of signaling the hear beat from The Pascal Classifying Heart Sound [1] which it’s coefficient value then calculated with feature extraction using BFCC and MFCC. After that, Backpropagation Neural Network (BPNN) and Euclidean distance method is used to recognize the pattern from the heart sound which feature extraction has been stored in the database.

3.2. Testing

Testing is done with opening a sound file in the program and using a feature extraction with Bark Frequency Cepstrum Coefficients (BFCC) and Mel Frequency CepstrumCoefficicients (MFCC) method. Euclidean Distance method is then used to find the nearest distance between the training data in the database and the testing data, while Backpropagation Neural Network (BPNN) will use testing algorithm to diagnose the heart sound abnormalities using dependencies weight from the learning process before which is stored in the dependency weight database for Bark Frequency Cepstrum Coefficients (BFCC) method andMel Frequency Cepstrum Coefficients (MFCC) method.

3.3. Data Analysis Technique

As the data which is provided by The Pascal Classifying Heart Sound is limited, this research is using Cross Validation method for the learning process and data tesing. Cross Validation is a model validation technique to rate how the result of a statistical analysis will generalize and independent data set [7]. Cross validation is usually used where the target is a prediction and the accuracy of the predictive working model needs to be predicted. The main reason of using cross validation than conventional validation is limited data and to prevent overfitting.

Overfitting is the cause of the bad performance in machine learning. Overfitting is the production of an analysis that corresponds too closely or exactly to a particular set of data, and may therefore fail to fit additional data or predict future observations reliably. [8] An overfitted model is a statistical model that contains more parameters than can be justified by the data. [9] Overfitting happens when a model learns the detail and noise in the training data to the extent that it negatively impacts the performance of the model on new data. [10] This means that noise or random fluctuation in training data is taken and learned as a concept by the model. The problem is that these concept does not applied in the new data set and gives a negative impact to the model ability to generalize. One of the ways to prevent overfitting from happening is to use cross validation.

How the cross validation works is by combining the data which is provided for training process and data which is provided for testing process. These combined data is then divided to 4 section that is A, B, C, and D. A quarter $(^1/_4)$ of that combined data will then be used as a testing data, and the rest will be used as it's learning data. For example if section A, B and C is used for the learning data, then section D will be used as it's testing data. After doing the training and testing with that combination, the process continues but with different testing data and learning data. For example section C will be used as the testing data and section A, B and D will be used as the learning data. The process will be repeated until every section has become a testing data. Only some cross validation with the best result or with the best accuracy is chosen in every cross validation done. Below is and illustration as how the cross validation process is done in this research.

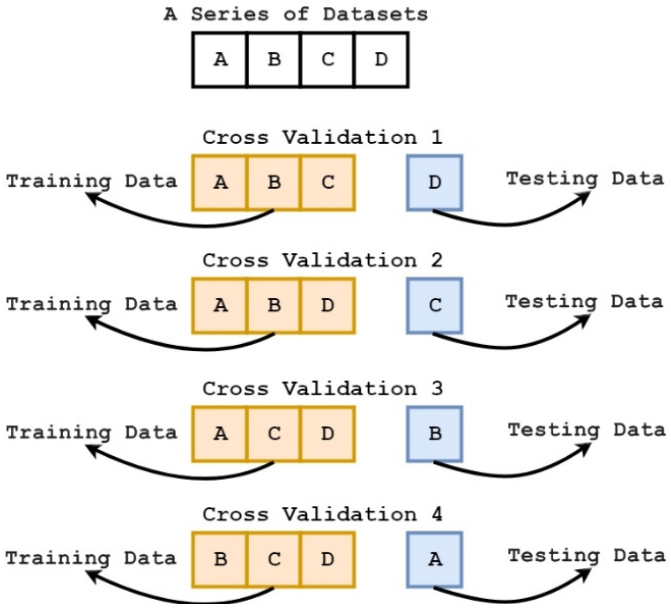

Figure 3. Cross Validation Illustration

4. Result

In this voice recognition system, testing with training data and testing data which is provided from Dataset B of The Pascal Classying Heart Sound with the same number of training data with 4 types of

cross validation data with BFCC, MFCC, Modified BFCC and Modified MFCC feature extraction method and with Backpropagation Neural Network and Euclidean Distance classification method.

4.1. Testing with Dataset B

Below is an outline from test result on Dataset B which is separated into 4 cross validation data set. Comparison between accuracy in every cross validation data set can be seen at Table 1 which is test result with BPNN, and Table 2 is test result using Euclidean Distance.

Table 1. Test Result With BPNN

Set Data Cross Validation	**Accuracy Precentage**			
	BFCC	MFCC	Modified BFCC	Modified MFCC
1	45.83%	41.67%	45.83%	33.33%
2	62.5%	75%	66.67%	66.67%
3	79.167%	87.5%	70.83%	95.83%
4	50%	50%	41.67%	50%
Average	59.37%	63.54%	56.25%	61.45%

Table 2. Test Result with Euclidean Distance

Set Data Cross Validation	**Accuracy Precentage**			
	BFCC	MFCC	Modified BFCC	Modified MFCC
1	33.33%	33.33%	33.33%	41.67%
2	25%	29.167%	29.167%	25%
3	25%	25%	25%	20.83%
4	33.33%	37.5%	37.5%	45.83%
Average	29.17%	31.25%	31.25%	33.33%

4.2. Discussion

Upon testing the heart sound diagnosis system, the best accuracy on Dataset B is from the third cross validation data set with Modified Mel Frequency Cepstrum Coefficients (MFCC) feature extraction method and with Backpropagation Neural Network (BPNN) classification method. The Accuracy rate with training data as testing data is 100% while accuracy rate using the third cross validation data set as the testing data is 95.83%.

Modified MFCC method is sometimes better than the MFCC method itself. The average accuracy with BPNN and Eculidean distance as the classification method shows that MFCC is better than modified MFCC.

5. Conclusion

After doing some test in this research, some things can be concluded:

1. MFCC method is better suited for heart sound diagonosis than BFCC method, shown from Dataset B with the best testing accuracy 87.5% and averaging at 63.54%
2. The accuracy result from modified MFCC method on the third cross validation data set shows that Modified MFCC method is better than the MFCC method itself with accuracy rate of 95.83%.
3. BFCC method is better than modified BFCC that has 2 removed process from the normal BFCC method. This is because there is an increase in sensitivity to noise in the modified method.

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