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Diagnostic the Heart Valve Diseases using Eigen Vectors

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Abstract — ***Heart disease is cause more health problem to the humane and may be lead of death. Then in this paper, we propose novel techniques for heart disease classification using Eigenvector technique and feature parameter extraction based on MFCC. Eigenvector approach is seemed to be an adequate method to be used in recognition due to its simplicity, speed and learning capability. In this research we achieve low computational overhead for the feature recognition stage since we use only 11 weighted MFCC. The effectiveness of proposed techniques leading to higher recognition accuracy of 86%.***

Keywords —- Auscultation, Heart sound and murmurs, digital signal processing, Heart Sound Signal, Mel Frequency, Campestral Coefficients (MFCC), Feature Extraction.

I. Introduction

Auscultation it is the most common and widely recommended method to screen for structural abnormalities of the cardiovascular system. Detecting relevant characteristics and forming a diagnosis based on the sounds heard through a stethoscope, however, is a skill that can take years to acquire and refine.

The ECG record which is the result of heart function has always been a favorite none-aggressive and at the same time safe and fast approach for the diagnosis of the heart status and its diseases over the past years. The PCG signal also includes some data with regard to the function of the heart and they are the result of mechanical vibrations. The sounds of the heart are made by the heart valves and also the murmurs. Therefore, useful information about the situation of the valves, the types of the diseases or the possible openings in the walls of the ventricle and vestibule can be obtained thanks to the process of PCG signal. Then here the efficiency and accuracy of diagnosis based on heart sound auscultation can be improved considerably by using digital signal processing techniques to analyze phono cardio graphic (PCG) signals [1,2].

Most of heart valve diseases have an effect on the heart sound of patients. Classification can be applied to detect whether the patient's heart sound signal is patient or not, and also can detect the type of the heart disease in sick patients [3]

In this research , we propose a technique for classification of heart sounds disease to assist in the evaluation of heartbeats to detect abnormal sounds using the Mel Frequency Cepstral Coefficients (MFCC), as features and Eigen vector as a classification method .The database of Heart sounds consist of 40 signals 8 four each of the following classes of heart sounds: *normal , diastolic atrial gallop, ejection murmur, Late Systolic Murmur,PansystolicMurmur* . For each class, 4 patterns for training and 4 for tasting. In The following ,Show the steps of our work

II. Features extraction

The MFCC is the most evident example of a feature set that is extensively used in sound recognition. As the frequency bands are positioned logarithmically in MFCC. Technique of computing MFCC is based on the short-term analysis, and thus from each frame a MFCC vector is computed. In order to extract the coefficients the speech sample is taken as the input and hamming window is applied to minimize the discontinuities of a signal. Then DFT will be used to generate the Mel filter bank. According to Mel frequency warping, the width of the triangular filters varies and so the log total energy in a critical band around the center frequency is included. After warping the numbers of coefficients are obtained. Finally the Inverse Discrete Fourier Transformer is used for the cepstral coefficients calculation [4]. It transforms the log of the frequency domain coefficients to the frequency domain where N is the length of the DFT. MFCC can be computed by using the formula [5][6].

$Mel(f)= 2595*\log10(1+f/700)$ ………(1)

In the following figure (1) shows the steps involved in MFCC feature extraction.[7]

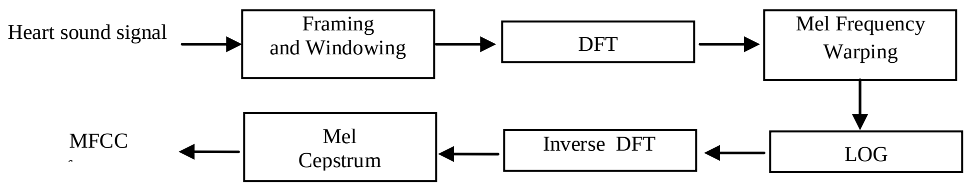

Figure. 1 shows the steps of calculate MFCC

For the normal heart signal as in figure 2, the first MFCC coefficient of the signal showing in Figure(3).

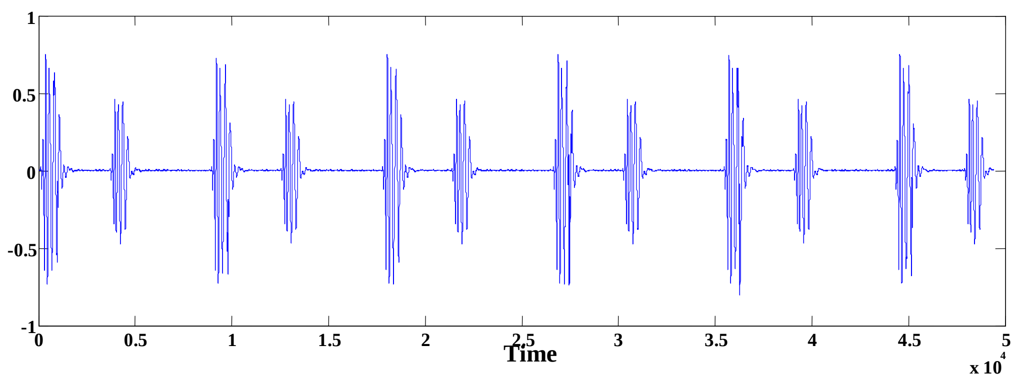

Fig. 2 normal heart signal

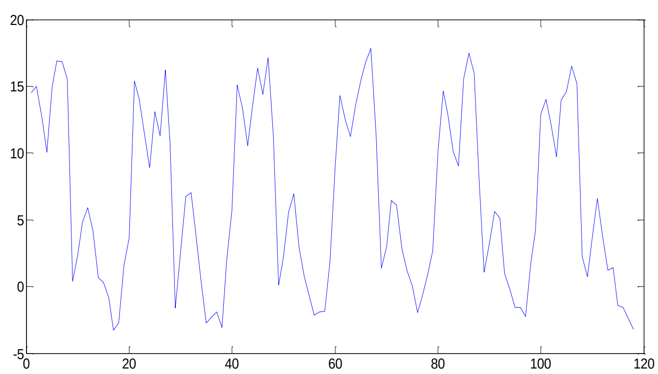

Fig. 3 the first MFCC coefficient

In our research, We are found the length *11 of coefficients* is appropriate . Then for each input heart signal the result is array of features of MFCC coefficients of size NxM where (N=25 is no. of frames, and M=11 the length of coefficients) .

III. Eigen vectors and Eigen values

The entire subject of used the statistics is based around the idea that you have the set of data, and you want to analyze that set in terms of the relationships between the individual points in that data set eigenvectors and Eigen values.

An eigenvector of a matrix is a vector such that, if multiplied with the matrix, the result is always an integer multiple of that vector. This integer value is the corresponding eigen value of the eigenvector. This relationship can be described by the equation $\boldsymbol{M} \times \boldsymbol{u} = \boldsymbol{\lambda} \times \boldsymbol{u}$, where $\boldsymbol{u}$ is an eigenvector of the matrix $\boldsymbol{M}$ and $\boldsymbol{\lambda}$ is the corresponding eigen value.

An eigenvector of a square matrix A is a non-zero vector v that, when the matrix is multiplied by V, yields a constant multiple of v, the multiplier being commonly denoted by λ [8]. That is

$AX = \boldsymbol{\lambda} X$ ... .(2)

The number λ is called the eigen value of A corresponding to v.where λ is called the corresponding eigen value. The only changes the length of X,not its direction, see figure(4)

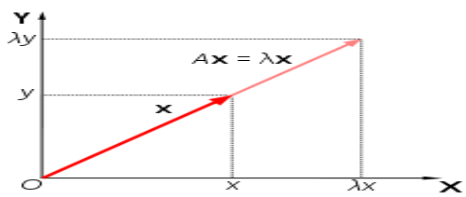

Fig. 4 Relationship eigenvector and eigen value

Matrix *A* acts by stretching the vector *X* , not changing its direction, so *X* is an eigenvector of *A*[9,10].

A. Computation of the eigenvectors

The following steps show the main steps to calculate eigenvectors:

1. Obtain $I_1, I_2, ..., I_M$(training set)
2. Represent every Ii as a vector Γ_i
3. Compute the average vector Ψ:

$$\Psi = \frac{1}{M}\sum_{i=1}^{M}\Gamma_i \ldots\ldots\ldots\ldots\ldots (3)$$

4. Subtract the mean from each signal:

$$\emptyset_i = \Gamma_i - \Psi \ \ldots\ldots\ldots\ldots\ldots (4)$$

5. Compute the covariance matrix C:

$$C = \frac{1}{M}\sum_{n=1}^{M}\emptyset_n\emptyset_n^T = AA^T \quad (N2\text{x}N2 \text{ matrix}) \quad \ldots\ldots(5)$$

Where $A = [\phi_1, \phi_2, \ldots, \phi_M]$($N^2xM$ matrix)

6.compute the eigenvectors u_i of AA^T .The matrix AA^T is very large then:

a. consider the matrix A^TA (MxM matrix)

b. compute the eigenvectors vi of A^TA

$A^TAv_i = \mu_i v_i$ ……..(6)

where

$A^TAv_i = \mu_i v_i \Rightarrow AA^TAv_i = \mu_i Av_i \Rightarrow$

$CAv_i = \mu_i Av_i$ or $Cu_i = \mu_i u_i$ where $u_i = Av_i$

Thus, AA^T and $A^T A$ have the same eigen values and their eigen vectors are related as follows: $u_i = Avi$

c. compute the *M* best eigenvectors of AA^T: $u_i = Av_i$……(7)

B.Discussion of using Eigenvectors to diagnostic the heart signal

In this section we give an explanation of calculate eigenvector with applying of the heart signal data.
There are 5 classes of disease ,each class have:

1. *4 pattern* of heart signal for training
2. and *4 pattern* for testing,

In Training phase :the following the steps of calculate the Eigenvector for training our data:

1-After calculate MFCC ,we obtain for each input signal array A of MFCC, where A_{MN} array of size (25x11) .Then the result are A_1,A_2,..,$A_4$of each class
2-Then convert each the A_{MN} to a vector of dimension M × N, so that a typical array of size 25 × 11 becomes a vector B of dimension 275.
3- Then calculate the mean of all these vectors B(in one class) as in figure 5 ,the result is mean array AVG be a one dimension of 275 .

$$AVG_i = \frac{1}{4}\sum_{j=1}^{4} B_i(i,j), \dots\dots\dots\dots (8)$$

Where i=1 to 275.

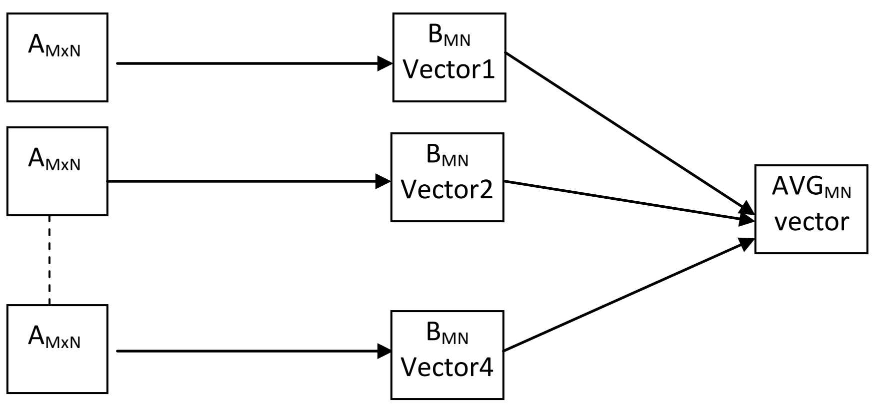

Fig. 5 The mean of vectors B in one class.

4- For each class of heart disease *K*, The average vector AVG is subtracted from each vector B :

$$\phi_{ij} = B_i - Avgk\ , \quad where\ i = 1\ to\ 275\ , \qquad j = 1\ to\ 4\ and\ k = 1\ to\ 5 \dots\dots (9)$$

5- For each class, Calculate the covariance C in the following manner as in equation (5), where $A = [\phi_{1,}\phi_{2,} \dots, \phi_4]$.
Then the result C is size of 275x275.
6-Calculate the eigenvectors of the covariance matrix C as following:

a. $L_K = A^T A\ \ (4 \times 4\ matrix)$……….(10)

Table I the result of $A^T A$

L_k	1	2	3	4
1	23.869389793	-24.92194691	-0.7205276179	1.7730847352218
2	-24.92194691	99.046331423	-51.589455909	-22.53492860281
3	-0.720527617	-51.05894559	50.1062245581	2.2037589695651
4	1.773084735	-22.53492860	2.20375896956	18.5580848980299

b. Find the eigen vectors ,U_k of L_K. The result in table II applying on L in table I

Table II the eigenvector of L in table I

U_k	1	2	3	4
1.	0.18066357026	0.62465344410	0.57198666868	-0.500000000
2.	-0.8370722288	-0.2136258224	0.06061428539	-0.50000000
3.	0.48825837397	-0.6952587596	0.1679851699	-0.50000000
4.	0.16815028465	0.2842311380	-0.800586124	-0.50000000

In mathematical terms, the eigenvectors of the covariance matrix of the set of signals in one class, treating an signal as point. Each heart signal location contributes more or less to each eigenvector. Eigenvector can be viewed as a sort of map of the variations between these sound signals

c. Now calculate the V_k where:

$V_k = \phi_{k(275x4)} * U_{k(4x4)}$,

Now The final result V_k are input to test phase

In Testing phase :

the Euclidean distance has been used to calculating the distance between the input heart signal and training heart signals as following:

1- For new heart sound to testing , the MFCC is calculated and save in X
2- Then convert the $X_{25 \times 11}$ to a vector Y of size 275
3- The average vector AVG of each class of heart disease is subtracted from the test vector Y :
$\beta_{ik} = Y_i - Avg_{iK}$, $where\ i = 1\ to\ 275\ and\ k = 1\ to\ 5$
4- Find the projection for the testing signal P
$P_k = V_k' * \beta_{ik} where\ i = 1..275$, k=1….5
5- Now the minimum distance is observed from the set of values, where the Euclidean distance (ED) has been computed between the *standard deviation* of P and *standard deviation* of V_k of each murmur classes, and the minimum Euclidean distance based classification is done to recognize the class disease of the input heart sound. The formula for the Euclidean distance is given by :

$$D = \sqrt{\sum (P - V)^2} \quad , k = 1\ to\ 5 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

IV. CONCLUSION

In our research the heart disease diagnostic system is developed using Principle component technique and MFCC features . Some kinds of heart disease is classify as reviewed in this paper. Through the experiments ,we are concluded that using MFCC and eigenvectors provide efficient classification system, where give good performance and accuracy, where the efficiency is 86%.The coding of our methods has been done using MATLAB.

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