An SVD-ANFIS Based Dynamic Pattern Recognition System for Cardiac Signal Classification

N. Dharani, K. Hemalatha, B. Karpakam, G. Oviya and S. Ravindrakumar*
Sr. Asst. Professor*
Department of Electronics and Communication Engineering
Chettinad College of Engineering and Technology, Karur, India.

ABSTRACT

This paper describes the application of Adaptive Neuro-Fuzzy Inference System (ANFIS) model with SVD for classification of Electrocardiogram (ECG) signals into one of the few known categories, and to arrive at a diagnostic decision regarding the condition of the patient. The proposed architecture is a combination of Singular Value Decomposition (SVD) filtering method and ANFIS model. The ECG signal is extracted and denoised using SVD filtering and the patterns are classified by ANFIS classifier. This method is applied to both simulated and real time ECG signals and the performance of the ANFIS model was evaluated in terms of training performance and classification accuracies. The results are to be compared to find a better method for ECG classification.

Keywords: ECG, ANFIS, SVD, MIT-BIH

I. INTRODUCTION

An electrocardiogram is a bioelectrical signal which records the patient’s heart electrical activity versus time. It is an important diagnostic tool for assessing heart functions. ECG monitoring enables accurate measurement of cardiac performance including transient or permanent abnormalities of rhythm. The interpretation of ECG signal is an application of pattern recognition. The techniques used in this pattern recognition comprise: signal pre-processing, QRS detection, feature extraction and ANFIS for signal classification. In this project, signal processing and ANFIS toolbox will be used in MATLAB environment. The signal source came from the Massachusetts Institute of Technology Beth Israel Hospital (MIT-BIH) arrhythmia database which was developed for research in cardiac electrophysiology. This project is focused on finding the best Adaptive Neuro-Fuzzy Inference System (ANFIS) model for ECG classification.

II. WAVES AND THEIR INTERVALS

The ECG signal consists of five waves each with definite time period and amplitude.

A. P wave

The P wave is the first wave of the electrocardiogram and represents the spread of electrical impulse through the atrial musculature (activation or depolarization). Its duration of not more than 0.11 seconds and amplitude of not more than 3mm in height and gently rounded, not pointed or notched.
B. **QRS complex**
Probably the most important complex in the electrocardiogram is the QRS. It represents the spread of the electrical impulse through the ventricular muscle (depolarization). The first negative deflection is the Q wave. The first positive deflection is the R wave. The negative deflection following the R wave is the S wave. Its duration is from 0.08s to 0.12s.

C. **ST segment and T wave**
The S-T segment follows the QRS complex. Its level is relative to the baseline. The T wave represents the period of recovery for the ventricles (repolarization). The normal shape of the T wave is slightly rounded and slightly asymmetrical.

D. **Intervals**
The time period between the successive R peaks is the R-R interval. Its normal duration is from 0.6s to 1.2 s. The time period from the onset of P wave and onset of R wave is the P-R interval. Its duration is of 0.05s to 0.12s.

III. **DISEASES DUE TO DISORDERS IN ELECTRICAL ACTIVITY OF HEART**

A. **Bradycardia**
In this diseases due to the reduction in heart rate R-R interval becomes greater than 1.5s.and the p waves are found to be wider.

B. **Tachycardia**
Ventricular tachycardia is a pulse rate of more than 100 beats per minute. The R-R interval is less than 0.5s.

C. **Ventricular fibrillation**
During ventricular fibrillation, blood is not removed from the heart. There may be lack of QRS complex in the ECG signal.

D. **Atrial fibrillation**
This is a rapid and irregular heart arrhythmia, caused by chaotic electrical impulses in the atria of the heart.

E. **Atrial septal defect (ASD)**
This is normally an opening between the upper chambers of the heart (the right and left atria) which occurs when the septum is not closed during the birth.

F. **Ventricular septal defect (VSD)**
This is a hole in the part of the septum that separates the lower chambers of the heart (the ventricles). This causes the heart to become enlarged.

G. **Fetal hypoxia**
It occurs as a result of deprivation of the fetus of oxygen during parturition, because it is delayed or the umbilical cord pinched off.
H. Pulmonary stenosis
Pulmonary stenosis is a narrowing of the valve that lets blood flow from the lower-right chamber (the right ventricle) into the lungs. When this valve narrows, the right ventricle has to work harder and it becomes enlarged.

I. Transposition of great arteries
In this, the normal position of the arteries is reversed. The aorta comes out of the right ventricle (instead of the left ventricle), and the pulmonary artery comes out of the left ventricle (instead of the right ventricle). The problem with this set-up is that oxygen-rich blood returns to the lungs while oxygen-poor blood gets carried to the rest of the body.

IV. FILTERING USING SVD
Singular value decomposition (SVD) is quite possibly the most widely-used multivariate statistical technique used in the atmospheric sciences. The technique was first introduced to meteorology in a 1956 paper by Edward Lorenz, in which he referred to the process as empirical orthogonal function (EOF) analysis. Today, it is also commonly known as principal-component analysis (PCA). The purpose of singular value decomposition is to reduce a dataset containing a large number of values to a dataset containing significantly fewer values, but which still contains a large fraction of the variability present in the original data. Often in the atmospheric and geophysical sciences, data will exhibit large spatial correlations. SVD analysis results in a more compact representation of these correlations, especially with multivariate datasets and can provide insight into spatial and temporal variations exhibited in the fields of data being analyzed.

There are a few caveats one should be aware of before computing the SVD of a set of data. First, the data must consist of anomalies. Secondly, the data should be de-trended. When trends in the data exist over time, the first structure often captures them. If the purpose of the analysis is to find spatial correlations independent of trends, the data should be de-trended before applying SVD analysis. In linear algebra the (SVD) is a factorization of a real or complex matrix, with many useful applications in signal processing and statistics. It is very important decomposition of a matrix and tells us a lot about its structure. It can be computed using the Matlab command svd. After applying SVD on noisy signal, the singular values matrix achieved is described as follows.

\[
S = \begin{pmatrix}
S_a & 0 & 0 \\
0 & S_{err} & 0 \\
0 & 0 & S_n
\end{pmatrix}
\]

The equation for SVD is

\[
\alpha_i = \begin{cases}
1 & 1 \leq i \leq 3 \\
e^{-(i-4)/4.5} & 4 \leq i \leq 15 \\
0 & 16 \leq i \leq 40
\end{cases}
\]

The first measuring method to investigate the efficiency of the proposed method is SNR, so we have:
In which $x_{org}$ is indicating clean signal and $x$ is indicating the enhanced one.

V. ADOPTED METHODOLOGY

An SVD-ANFIS based classifier is presented as a diagnostic tool to aid physicians in the classification of heart diseases. ANFIS using a strategy of hybrid approach of adaptive neuro-fuzzy inference system, we compose these two intelligent approaches, it will be achieve good reasoning in quality and quantity. In other words we have fuzzy reasoning and network calculation. The feature vectors were applied as the input to an ANFIS classifier.

The experimental procedure involved in the pattern recognition of bio-medical signal is as follows:

1. Signal acquisition
2. Pre-processing
3. Feature extraction and selection
4. Classifier design
5. Optimization/diagnostic decision

Signal Acquisition
The source of the ECG is obtained from MIT-BIH Arrhythmia Database (MITDB) which is a set of over 4000 long term Holter recordings. From this database variety of data including normal and abnormal cases extracted.

Preprocessing
The obtained ECG signal is preprocessed by SVD for the removal of noise components to enhance the quality of bio-signals and help us to detect significant signal events.

Feature extraction and selection
Extraction of salient features from the ECG to allow detailed waveform analysis. The features, which represent the classification information contained in the signal are used as inputs to the ANFIS classifier.

![Figure 1 Block diagram of proposed method](image-url)
Classifier design
Design an intelligent system to automatically classify the shape of the ECG waveform and interpret shape changes by using an appropriate classifier model. Then the training algorithm is used to train and test the input signal and classify them into different categories.

Optimization/Diagnostic decision
To validate the findings and show agreement between the system and human experts. The performance of the ANFIS classifier is evaluated in terms of training performance and classification accuracies. All the necessary algorithms are implemented in MATLAB with ANFIS toolbox.

VI. RESULTS AND INFERENCE
The ECG data is extracted from MIT-BIH database and denoised using SVD filtering process. From the obtained output, the QRS peaks are detected and sent as an input to ANFIS classifier. The output waveforms are shown below:

![Fig.2 Output waveform of SVD filtering](image)

<table>
<thead>
<tr>
<th>Noise (dB)</th>
<th>SNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>0.2301</td>
</tr>
<tr>
<td>50</td>
<td>2.6257</td>
</tr>
<tr>
<td>40</td>
<td>2.8831</td>
</tr>
<tr>
<td>30</td>
<td>2.9322</td>
</tr>
<tr>
<td>20</td>
<td>2.9621</td>
</tr>
</tbody>
</table>

![Fig.3 Fuzzy rule processor](image)  
![Fig.4 Fuzzy rule viewer](image)

VII. CONCLUSION AND FUTURE WORK
The classification of ECG using SVD filtering is done and the patterns are yet to be classified using ANFIS classifier. The performance of the classifier is to be obtained by comparing it with other algorithm and we hope that our classifier will give better accuracy. The long term aim of this project is to develop a user friendly, intelligent decision support tool for FECG waveform analysis to assist the clinicians.
REFERENCES


[9] George Qi Gao(May 2003), ‘ Computerised detection and classification of five cardiac conditions ’ May 2003


[16] Soumya Ranjan Mishra And K Goutham ‘ Real time classification of ECG wavwforms for disease diagnosis


[22] www.ecglibrary.com