Automatic System for ECG Arrhythmia Classification Using Fuzzy Neural Network

Prof. Varsha Bodade, Gopika Tharammal, Aiswarya Radhakrishnan, Shrutika Kalangutkar, Nilima Phalak
Department of Information Technology, Terna Engineering College, Navi Mumbai, India

Abstract: Electrocardiography is a very simple and non-invasive diagnostic method in health care. Our heart generates electric potential on body surface, electrocardiography is based on this phenomenon. An episode of arrhythmia could be produced by changes in the electronic impulse formation or conduction or combination of both. In artificial intelligence, the techniques combining the fuzzy logic and neural network are many times applied together. Combining these two methods could help us to overcome or come out of difficulties and inherent limitation of each isolated method. When they are combined together they are generally known as neuro-fuzzy systems. An automated method could help to accurately diagnose the cardiac diseases with the analysis of ECG signals which is critical in healthcare, most importantly when performing in real time.

***Index Terms* – ECG arrhythmia classification, fuzzy neural network, feature selection, sequential backward selection.**

Introduction

The process of recording the electrical activity of our heart over a period of time with the use of electrodes placed on our skin is called electrocardiography (ECG or EKG). During each heartbeat, the heart muscles produces electro-physiologic pattern which leads to depolarizing and repolarizing electrodes can be used in order to detect these small electrical changes ECG is a very commonly performed cardiology test. The description of waves and internal segments in ECG are as follows:

Description of Waves, Intervals and Segments:

P Wave: P wave comes before QRS complex, it is separated by PQ interval. P wave indicates normal atrial depolarization. In p wave first there is an upward deflection. The duration of p wave is less than 0.1 sec. It is followed by QRS complex.

PR Interval: PR interval represents the atria to ventricular conduction time. The normal duration of PR interval is between 0.12 to 2.0 seconds.

QRS Complex: It represents ventricular depolarization. It is larger than p wave because of greater muscle mass of ventricles. It has duration of about 0.08 to 0.12 seconds.

J point: It is the point where the QRS complex returns to the iso-electric line.

ST segment: ST segment indicates repolarization of ventricles. It extends from J point to T wave

T wave: It represents repolarization or recovery of ventricles. Interval from QRS to apex of T is referred to as absolute refractory period.

QT interval: It is measured from beginning of QRS to the end of the T wave. The duration of normal QT is usually about 0.4 seconds.

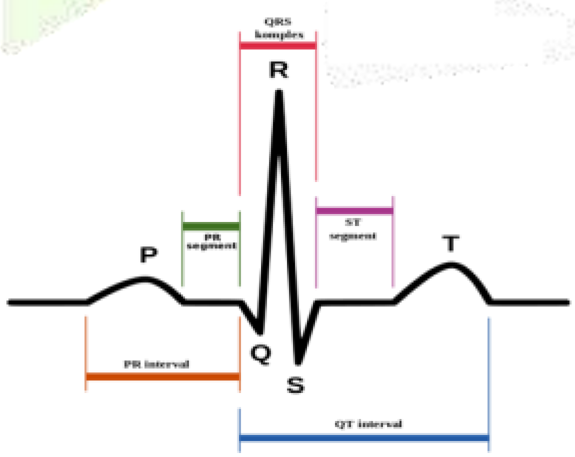

Fig 1. ECG wave structure

A slight variation in the above structure of ECG could be indication of arrhythmia. If the arrhythmia of heart leads to a heartbeat which is too fast or too slow or too weak to supply the body's needs, this manifests as a low blood pressure may lead to light- headedness or fainting or dizziness among many other problems. Automated analysis of ECG could help in building an improved health care system. Fuzzy neural network has the property of adjusting adaptively and also of intelligent information processing.

II METHODOLOGY

This section is split into three sub-sections (II-1, II-2, II-3, II-4).We start with a description for data collection in Section 1. Preprocessing of data in Section 2. Feature selection in Section 3. Applicatio of fuzzy neural network in Section 4.

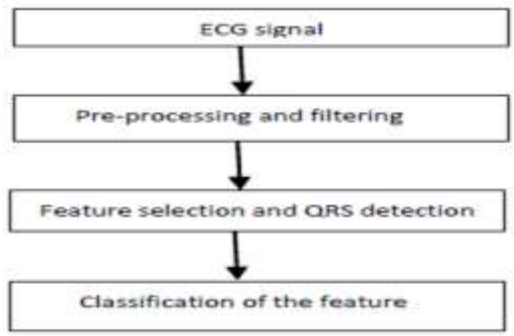

Fig 2. Steps in ECG classification

1. Data Collection

We are using UCI repository datasets for arrhythmia data. The UCI Machine Learning Repository is the collection of data, data generators that are used by the machine learning community for the analysis of machine learning algorithms. Our database contains 279 attributes, 206 of which are linear valued and the rest are nominal. The aim is to distinguish between the presence and absence of cardiac arrhythmia and to classify it in one of the 16 groups. Class label 01 refers to 'normal' ECG classes 02 to 15 refers to different classes of arrhythmia and class 16 refers to the rest of unclassified ones.

2. Data preprocessing

Data pre-processing involves transforming data into an understandable format. Real-world data is often incomplete, inconsistent and contains errors. Data pre-processing is a method of resolving such issues. Data pre-processing prepares the data for further processing. It is required because real world data are generally incomplete like missing attribute values, missing certain attributes of importance, noisy like containing errors. Here we have removed the missing values from our database. We have converted the given data into .arff format which is compatible for use in weka API.

3. Feature Selection:

Feature selection extracts a subset of relevant features to optimize the effectiveness of classification. This process is also known as variable selection or attribute selection. It is used to identify and eliminate unwanted, irrelevant and redundant attributes from the data.It helps in simplification of models and also reduces the time required for training.

We have used sequential backward selection method for feature selection. Here we begin with the full set, sequentially we remove the feature x- which least reduces the value of objective function. Here the objective function which we are considering is accuracy of classification. We start with the entire set where,

$$Y_0=X$$

We remove the worst feature x-. We update the data

$$Y_{K+1}=Y_K-X-;$$
$$K=K+1$$

and repeat the step till we get a constant objective function. It is very suitable in cases where optimal feature subset is very high.

4. Arrhythmia classification:

A fuzzy neural network or neuro-fuzzy system is a learning machine that finds the parameters of a fuzzy system (i.e., fuzzy sets, fuzzy rules) by exploiting approximation techniques from neural networks. It can be represented as a set of fuzzy rules at any time of the learning process. Neural network requires no prerequisite of knowledge. We can start from scratch, whereas in fuzzy systems some basic knowledge about the system is essential. While using neural network, there are several learning algorithms available. Fuzzy systems have simple implementation and interpretation. Combining these two algorithm helps to bring together their advantages. The basic architecture of Fuzzy Neural system has the following stages:

1. Input Layer: The input layer takes the input as crisp values. These values are send to the condition element layer which performs fuzzyfication.
2. Rule layer: In this layer every node represents a single fuzzy rule. We can add more nodes in the layer to represent more rules.
3. Output layer: In this layer the de-fuzzyfication of data is done.

We have used WEKA API for easily implementing learning algorithms. WEKA (Waikato Environment for Knowledge Analysis) is an open source library for machine learning, bundling lots of techniques in a single Java package. Weka is a powerful tool, and helps to delegate to it the responsibility of implementing standard machine learning algorithms. WEKA has predefined methods like FURIA and Multilayered perception for implementing fuzzy system and neural network. FURIA stands for Fuzzy Unordered Rule Induction Algorithm. FURIA learns fuzzy rules instead of conventional rules and unordered rule sets instead of rule lists. A multilayer perceptron (MLP) is a deep, artificial neural network. It is composed of more than one perceptron. They are composed of an input layer to receive the signal, an output layer that makes a decision or prediction about the input, and in between those two, an arbitrary number of hidden layers that are the true computational engine of the MLP. Multilayer perceptions are applied to supervised learning problems. They train on a set of input-output pairs and learn to model the relation between those inputs and outputs.

I. RESULTS AND DISCUSSION

```
==================================================

Correctly Classified Instances        59          86.7647 %
Incorrectly Classified Instances       9          13.2353 %
Kappa statistic                     0.8336
Mean absolute error                   0.037
Root mean squared error                 0.1158
Relative absolute error              24.6775 %
Root relative squared error           42.6057 %
Coverage of cases (0.95 level)        98.5294 %
Mean rel. region size (0.95 level)    26.0695 %
Total Number of Instances              68
```

Fig 3. Fuzzy neural network training result

```
=== Confusion Matrix ===

 a  b  c  d  e  f  g  h  i  j  k   <-- classified as
 7  1  0  0  0  0  0  0  0  0  0 |  a = 10
 0 17  3  0  0  0  0  0  0  0  0 |  b = 1
 0  1 16  0  0  0  0  0  0  0  0 |  c = 2
 0  0  0  4  0  0  0  0  0  0  0 |  d = 16
 0  0  0  0  9  0  0  0  0  0  0 |  e = 9
 0  0  0  0  0  2  0  0  0  0  0 |  f = 5
 0  1  0  0  0  0  0  0  0  0  0 |  g = 6
 0  0  1  0  0  0  0  0  0  0  0 |  h = 14
 0  0  0  0  0  0  0  0  4  0  0 |  i = 3
 0  0  1  0  0  0  0  0  0  0  0 |  j = 8
 0  0  1  0  0  0  0  0  0  0  0 |  k = 4
```

Fig 4. Confusion matrix after prediction

The above figures gives the statistics after training of the model. As stated in the figure we are able to get an accuracy of 87% after applying the algorithm.

II. CONCLUSION

We propose a system that combines artificial neural network and fuzzy classification for ECG beat classification. An automatic system integrating the artificial intelligent methods could classify the normal sinus rhythm (NSR) and arrhythmic types from the continuous ECG signals. The adaptive adjusting property of fuzzy neural network will help in getting more accurate result.

REFERENCES

[1] Hoda Tonekabonipour, Ali Emam, Mohamed Teshnelab Comparison of neuro-fuzzy approaches with artificial neural networks for the detection of Ischemia in ECG signals. IEEE Conference. Systems, man and cybernetics (SMC) 10-13 Oct. 2010

[2] R. Silipo, G. Bortolan Neural and traditional techniques in diagnostic ECG classification 21-24 April 1997

[3] S.Osowski, Tran Hoai Linh. ECG beat recognition using fuzzy hybrid neural network. IEEE Trans. Biomed. Eng., vol. 48, pp. 1265 - 1271

[4] Book: Fuzzy Neural Network Theory and Application by Puyin Liu and Hongxing Li