Efficient Combination Scheme for Arrhythmia Detection using ECG Signals

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Abstract— Arrhythmia is a health problem and it is a drastic cause for many kinds of heart diseases. Some arrhythmia may even cause to death. The main objective of this work is to combine the decision of each classifier in an efficient way to improve the classification accuracy of the classifiers to predict the disease. As different classifiers provide different opinion to the target system, the combined decision will provide more robust and accurate result. The HRV parameters obtained from the ECG of normal and the arrhythmia affected patients is used for classification. Combination of classifiers like k-Nearest Neighbor (k-NN), Principal Component Analysis (PCA), Probabilistic neural network, Decision tree and Adaptive boost classifier is used in this work. The choice or judgment of the efficient classifiers is selected and combined using majority voting system for detection of final classification.

Key words: Arrhythmia, Cardiac arrest, ECG, principal component analysis (PCA), k- nearest neighbor (KNN), probabilistic neural network (PNN)

I. INTRODUCTION

An Arrhythmia is a problem due to changes in rate or rhythm of heart. During arrhythmia heart may beat too fast called Tachycardia. This is harmless and occurs in humans involved in physical activity. If the heart beat too slowly, it is called Bradycardia. This type of cardiac involves big attention when it occurs in patients, it cannot pump blood to brain, heart and other organs leading to life menacing-situation. Arrhythmia is caused due to factors or conditions like heart failure, heart valve disease, High blood pressure, Heart attack and coronary heart disease. Medicines are available to treat few arrhythmias. Medicines used for the treatment of too fast heart beat this changes abnormal heart rhythm to normal and regular rhythm. Some anti-arrhythmia medicine that is used to slow down a fast heart rate are Beta blockers, Calcium channel blockers. Some medicines used to restore a normal heart rhythm are Sotalol, Ibutilide, Dofetilide, Propafenone, and Procainamide. Abnormal slow heart rate is usually treated with pacemakers.

The organization of this paper is as follows, literature survey is discussed in section II. Section III deals with methodology of proposed arrhythmia prediction system. The results are summarized and discussed in section IV. Section V gives conclusion.

II. LITERATURE SURVEY

Haibo He [1] described a SSC algorithm to combine classifier based on signal strength. A clustering based approached for generating ensemble of classifier was described by Ashfaqur Rahman [4] here the decision of a test pattern is derived by finding the decision of the base classifier at each layer. Nicolas Garcia [11] developed an ensemble of classifiers using instance weighted selection. Here boosting by instance selection method was used, here in this work when noise is added to datasets the complexity of the classifier is reduced. Youglin Li [2] evaluates an algorithm to predict arrest with lower accuracy. [5] A. Taquir proposed a non-invasive inductive link model for an Implantable Biomedical Microsystems such as, a pacemaker to monitor Arrhythmic Patients in Body Area Networks.

III. METHODOLOGY

The proposed work comprised of five modules. Figure 1 shows the basic block diagram of the proposed work (arrhythmia detection system). The list of five modules is stated below

(1) Data acquisition
(2) HRV analysis
(3) Segmentation
(4) Classifier selection
(5) Combination using majority voting.

The classifiers used are k Nearest Neighbour, Principal component analysis, Adaptive boost classifier, Decision tree algorithm and Associative rule mining.

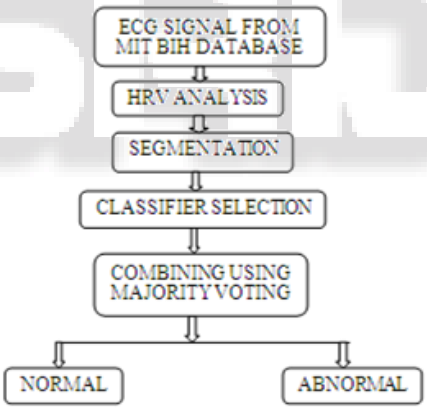

Fig. 1: Basic Block Diagram of Arrhythmia Prediction System

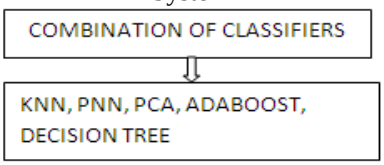

Fig. 2: Combination of Classifier Used In Proposed System

A. Data Acquisition:

The MIT-BIH database consists of many ECG databases of normal sinus rhythm and the abnormal patients. Here two databases of normal sinus rhythm and arrhythmia is selected. The ECG signals were obtained from the MIT-BIH physionet database. PhysioNet [17] provides us free access to large collection of physiologic signals. Physiobank contains digital recordings of physiologic signals. Physiobank archives are used for accessing databases and data files.

B. HRV Analysis:

Heart rate variability (HRV) [14] is due to the effect of stress. The stress in humans causes changes in sequence of heart beat. The beat to beat alterations are mainly involved in analysis of HRV. Using 2 important factors analysis of HRV can be done.

- Detection of R peak
- Normal to Normal interval (NN)

The above two factors are used for the determination of HRV parameters; the parameters include time and frequency domain parameters. The time domain parameters include Standard deviation of NN interval (SDNN), Standard deviation of average of NN interval (SDANN), Root mean square standard deviation (RMSDD).The frequency domain parameters include Low frequency (LF), High frequency (HF), Ratio of LF to HF (LF/HF).

C. Segmentation:

Segmentation is the process of partitioning the data into multiple segments. The goal of segmentation is to simplify/change the representation data more meaningful for analysis of data. Here for the determination of HRV only 5 minutes signal can be used, so the ECG signal is segmented in 5 minutes intervals of time. Finally each segmented signal is given has input to 5 classifiers that is used in this work. Only the efficiency classifiers will be selected and combined.

D. Classifier Selection:

From the combination of 5 classifiers only the first three efficient classifiers is selected using absolute error estimation technique.

E. Combining using Majority Voting:

The decision of the first three efficient classifiers is combined using the majority voting system. Majority voting rule selects the class with more than half of the votes.

F. Combination of Classifiers:

1) KNN:

The k nearest neighbor algorithm is used for classification and regression of data. The k value is always taken in odd for finer classification. If k value is chosen in even, results in equal classification. In this type of situations random group may be selected. These classifiers also dependent on distance metric. It classifies data based on k number of nearest neighbour and does not make any comparisons with the trained data.

2) PCA:

PCA develops small set of variable called principal components, and this produces variances in the original set of variable. The purpose of PCA is to reduce the dimensionality of the dataset by finding new set of variable from the original set of variables. It is used for compression and classification of data. It is also dependent on factors like magnitude, orthogonally to find axis with larger variance. The small set of variable is selected in such a way that it still contains all the information from the original set of variables.

3) PNN:

PNN is a feed forward neural network, derived from the Bayesian network and statistical algorithm called kernel fisher discriminate analysis. This is widely used in classification problems.

4) Adaptive Boosting:

It is a linear classifier. The output of adaptive boosting depends on the log of ratio of likelihood. This boosting model has very good feature selector and generalization properties.

5) Decision Tree Algorithm:

A decision tree is a decision support tool that uses treelike graph or models of decisions. It includes events outcomes, cost of resource and utility. It is a descriptive means for calculating conditional probabilities.

IV. PERFORMANCE EVALUATION

The performance of the 5 classifiers is calculated by finding error rate of each classifier. The error rate is inversely proportional to efficiency. When the error rate increases, the efficiency gets decreased and vice versa when error rate decreases.

The error rate is estimated by,

Error rate = ((Actual class – Determined class)/ (Total number of classes))*100

Using the error estimation technique the performance of each classifier is known clearly. Here in this work, only the efficient 3 classifiers among the total of 5 classifiers will be selected and will be fed has input to majority voting technique.

V. RESULTS AND DISCUSSION

The normal sinus rhythm and the arrhythmia affected ECG signals is used as testing data for each classifiers. These data is derived from the physionet database. As only 5 minutes signal is used for the analysis of HRV segmentation of signal is done in 5 minutes interval of time. Each of the 5 classifiers is fed has input to every segment of ECG signal to get the time and frequency domain parameters. Using this parameters final prediction of result is derived.

		Abnormal	Normal	Total
Input	Training	30	30	60
	Testing	15	15	30
				90

Table 1: Total Input Signal Used In Testing and Training Phase

	Input		Total Input	Output		Total Output	Error		Total Error	Error in %
	Abnormal	Normal		Abnormal	Normal		Abnormal	Normal		
KNN	30	30	60	22	23	45	8	7	15	25
PNN	30	30	60	25	23	48	5	7	12	20
PCA	30	30	60	20	21	41	10	9	19	31.66667
ADABOOST	30	30	60	21	23	44	9	7	16	26.66667
DECISION TREE	30	30	60	25	24	49	5	6	11	18.33333
	150	150	300	113	114	227	37	36	73	24.33333

Table 2: Error Estimation in Classifiers

	Input		Total Input	Output		Total Output	Error		Total Error	Error in %
	Abnormal	Normal		Abnormal	Normal		Abnormal	Normal		
Decision Tree	30	30	60	25	23	48	5	7	12	20
KNN	30	30	60	22	23	45	8	7	15	25
PNN	30	30	60	25	24	49	5	6	11	18.33333
Combined	30	30	60	27	25	52	3	5	8	13.33333
	120	120	180	72	70	142	21	20	38	21.11111

Table 3: Error Estimation While Combining Efficient Classifiers

VI. Conclusion

This work is done mainly for the detection of arrhythmia, arrhythmia causes life threatening situations to avoid this risk factor we go for detection of arrhythmia. Here we use 5 classifiers among which 3 are selected for each segment of ECG signal. By doing this type of selection, we can increase the accuracy of the classification in an efficient manner. The proposed work is the powerful estimation system with good efficiency. The experimental results obtained clearly show that the proposed system is able to achieve satisfactory results.

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