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Heart Signal analysis on Multi-Domain Features Extraction by SVM Classifier in Smart Monitoring System

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Abstract: ***According to world health organization (WHO) the heart strokes and cardiovascular diseases death rate is increases every year. Heart signal is one of the most predominant physiological signals of our body, including a large number of physiological and pathological information that can reflect the cardiovascular status. This work aims to develop a heart signal quality assessment method by three common case studies of deep breath, speaking and climbing up &down. In data collection, a total features were extracted from domain statistics. Here statistical analysis is employed for reducing dimension of a particular features. For classification of electrocardiogram (ECG) signals cardiac arrhythmias using deep learning model is used by Cubic Wavelet Transform. These parameters are used as input to these classifier with types of ECG signals. A SVM with radial basis kernel function was trained for final signal quality classification. The best effect was obtained on distinguishing resting from climbing up& down and the result showed that the classification performance was significantly improved after feature selection. These results indicate that the proposed method is effective for identifying different cases. The hardware testing was implemented and tested for the same case studies.***

Keywords: ***Signal, heart, multi-domain features, SVM***

I. INTRODUCTION

By beating heart the noises are generated and the resultant flow of blood through it, which plays a major role in detection of heart diseases. Heart sound signals are known as Phonocardiogram (PCG).It can monitor the heart and flow of blood. Most significantly, the heart signal examination can be noninvasive. In biological ECG signal is the weak signal in our body. Denoising is analyzed with the help of wavelet transform [1]. The basic waveform as shown in figure1.

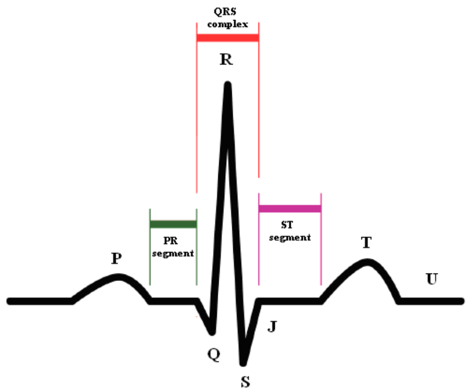

Figure 1 ECG signal with various states like P,Q,R,S,J,T and U

A PCG signal measurement binary quality assessment technique, using energy and level of noise of the PCG was developed [2]. The classifier was able to analyses good and poor recorded PCG signals with accuracy, and those made with the electronic stethoscope [3]. The qualities of the heart sounds that physicians were trained to interpret an algorithm for automated heart sound classification was performed by two step classification [4].

To improve the accuracy of classification results and meet the clinical necessities, more research is needed. In this work, proposed a heart sound signal quality assessment method by using multi-domain features extracted from time, frequency, entropy, energy, high-order statistics and cyclostationarity by SVM classifier. The paper is organized as follows. Section 2 presents methodology, database, feature extraction, feature selection and classification. Results are discussed in section 3&4 followed by conclusion in section 5.

II. MATERIALS AND METHODS

The proposed method of flow diagram is says the classification of PCG recordings, it is shown in figure. Each PCG recording is denoised by filtering techniques. Then it is segmented into four states. In this study, features from multi-domains are extracted from each recording. [5] After the segmentation operation, each heart sound recording was divided into four states: S1, systole, S2, diastole. 20 features in time domain of heart sound from interval and amplitude were extracted. These include mean and standard deviation of each cardiac state length.

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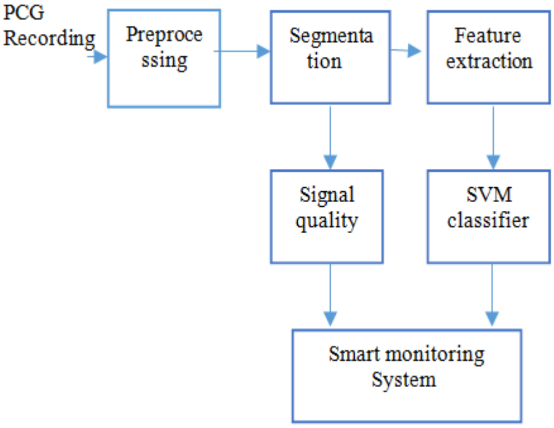

Figure 1. Block diagram of classification through PCG recording

Due to the complexity of clinical environment and the uncertainties' own states which has been proven, as shown in Figure 2, which causes difficulties for subsequent studies.

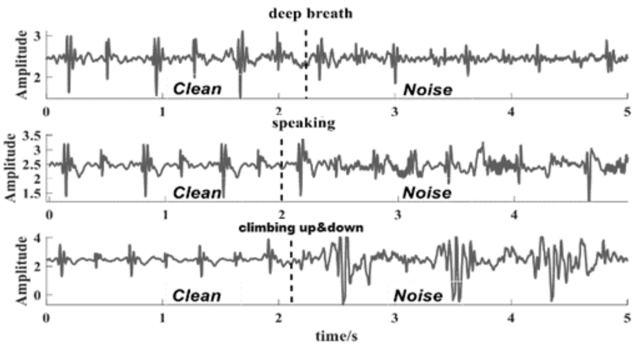

Figure 2. PCG Recordings

Data were collected from 20 healthy students through a heart sound signal acquisition experiment, using a cardiovascular function detection device with sampling frequency of 5KHz.The database is described in detail in Table 1.

Table 1 database

Number of students	11 male/09 female
Age(years)	21
Record length(s)	10

During the experiment, 4 different simulated clinical states, including resting and 3 noise states, i.e. deep breath, speaking and climbing up and down. Each state lasted 10 seconds, resulting in a total number of PCG recordings per subject. Finally PCG records were collected.

Based on a duration-dependent hidden Markov model [6], the heart rate was calculated by a PCG recording. [7] Feature selection techniques aims to find the best describing subset of the input variables, compared to the original set of features. They can be divided into three major categories, filter, and wrapper and embedded methods. Different combinations of feature sets were then fed into the classifier.

This heart sound signal quality classification task is a typically binary classification problem. In view of the excellent performance of SVM in small sample binary classification problems, Support Vector Machine (SVM) was chosen. Hence divided the data into training, testing data and interference data were balanced.

Support Vector Machines (SVM) are developed from the theory of limited samples Statistical Learning Theory (SLT) which are originally designed for binary classification.
SVM classifier with a Radial Basis Function (RBF) defined by

$$k(x_n, x_m) = exp(-\gamma\|x_n - x_m\|^2) \qquad (1)$$

Where γ plays a role in controlling the flexibility of the resulting classifier [11].

To evaluate the classification performance, few metrics are used including sensitivity, specificity, accuracy and mean'. All of them are calculated using TP (true positive), TN (true negative), FP (false positive) and FN (false negative). They are given by:

$$Sensititvity = \frac{TP}{TP + FN} \qquad (2)$$

$$Specificity = \frac{TN}{TN + FP} \qquad (3)$$

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \qquad (4)$$

$$Mean = \frac{2TP}{2TP + FP + FN} \qquad (5)$$

III. RESULTS AND DISCUSSION

The classification performance based on features with statistical differences is shown in Table 2.

It shows that all indexes have been significantly improved after feature selection in Table 2. In contract, the feature subsets produced by statistical difference analysis have little effect on improving classification performance that indicates the results of feature selection are more convincing. Moreover, the recognition of the climbing up- down state has achieved very good results before the feature selection, so there is no evident improvement on distinguishing this noise type after feature selection. And we also can conclude that more features are not always better. The performance will get worse as the number of features increases.

Table 2 Classification performance Comparison various states of features

States	Accuracy	Sensitivity	Specificity	Mean
Deep Breathing	81	82.4	81	80
	81.3	78.4	84.1	78.8
	87.7	84.3	91.8	86
	89	88.7	88.4	88.6
Speaking	88.1	85.5	91.5	86.7
	95	96.7	93	94.6
	98.6	99.1	98.4	98.5
Climbing up& down	99	100	98.3	99
	98.6	99.1	98.4	98.5

IV. HARDWARE TESTING

The hardware is tested with the help of embedded system. It is an android based low cost heart rate and body temperature monitoring system. The device is portable and light weight so that it can be carried easily anywhere. Various sensors are used to monitor the heart rate and convert into digital form. These variables are compared with desired values stored in the processor and displayed on the LCD display and send to android mobile via Bluetooth. Hardware implementation of proposed system is shown in figure 3.

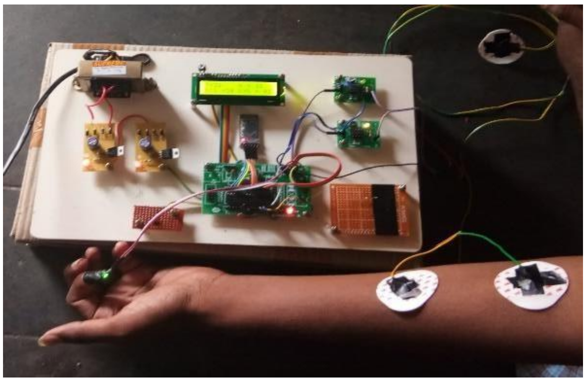

Figure 3. Arduino based health monitoring display

Hardware kit is interfaced to computer with the help of RS232 cable and Output of ECG pulse rate is viewed in the computer by using Lab VIEW software. The patient can monitor as a result their body condition continuously using android mobile phone.

V. CONCLUSION

This paper attempts to recognize noise interferences which always pollute clean heart sound signals. A features were extracted from multi-domains and then sent into a SVM for classification task. It was verified with the help of Lab View software to monitor our heart signal also hardware circuit was tested. The statistical analysis didn't help much. In order to further improve the classification effect and reduce the standard deviation, more data need to be added in the future.

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