International Journal of Soft Computing and Engineering (IJSCE)
ISSN: 2231-2307, Volume-3, Issue-4, September 2013

Finding a Suitable Nonlinear Technique to Distinguish Between HRV Data of Cardiac & Non - Cardiac Diseased Subjects

CH.Renu Madhavi, A.G.Ananth

Abstract— The objective of this paper is to find a nonlinear technique which has better resolution in distinguishing between healthy, cardiac and Non-cardiac diseased subjects. Heart Rate Variability (HRV) data of healthy, cardiac disease and Non-cardiac diseased subjects are analysed using nonlinear techniques. The nonlinear techniques such as Approximate Entropy (ApEn), Sample Entropy (SampEn), Symbolic Entropy (SymbEn), Spectral Entropy (SE) and Correlation Dimension(CD) are applied to the HRV data and the corresponding nonlinear parameters are estimated and compared. Comparison of the estimated parameters revealed best resolution for SampEn to distinguish between healthy, cardiac and Non-cardiac diseased subjects. Further among the Non-cardiac diseased subjects also, SampEn showed higher resolution to distinguish between them. The lowest values of Nonlinear parameters for Non-cardiac diseased subjects when compared to cardiac diseased subjects indicated higher risk of sudden cardiac death for Non-cardiac diseased subjects when compared to cardiac diseased subjects.

Index Terms— Cardiac disease, Non-cardiac disease, nonlinear techniques, Thyroid, Depression.

I. INTRODUCTION

Extensive research has been carried out on Heart Rate variability (HRV) specially using nonlinear techniques. The Nonlinear analysis of HRV has been found very useful for the study of various Cardiac and Non-cardiac diseases. One of the main causes of human death is the Cardiac dysfunction. This dysfunction can be identified with the symptoms of severe chest pain, breathlessness, sweating etc. The ANS dysfunction indirectly effecting the functioning of the heart may also cause death. One such disease detected was Diabetic Neuropathy. There are many cases where ANS has led to a possibility of cardiac problem. HRV can be an effective non-invasive tool for detecting and diagnosing the cardiac disorders and sudden cardiac arrest. For example the subjects suffering from Thyroid and Depression problems may lead to cardiac disorders caused by ANS.

The relationship between the autonomic nervous system (ANS) and cardiovascular mortality has been recognized during the last decades, and it has motivated the development of quantitative markers of autonomic activity. Among them, the Heart Rate Variability (HRV) is the vital. HRV is defined as the variation in the interval between consecutive heartbeats that occurs in the heart as a consequence of a complex internal dynamic balance. Since HRV signal allows a non-invasive study of the state of the autonomic Nervous system (ANS) and of several related diseases also it gives indications about the present diseases and alarms about the hidden diseases.

Manuscript received September, 2013.

CH.RenuMadhavi, Instrumentation Technology, Visweswaraiah Technological University,RV College Of Engineering, Bangalore, India.

A.G.Ananth,Department of Telecommunication Engineerin, Visweswaraiah Technological University,RV College Of Engineering, Bangalore, India.

Thyroid dysfunction is associated with changes not only in cardiac or vascular function but also believed to change autonomic regulation of cardiovascular system [1] Early diagnosis and treatment does have significant effect on cardiovascular autonomic activity and can help in reducing the risk of cardiovascular diseases [2].Depression disorder is reported to be associated with increased cardiovascular morbidity and mortality [3].Early detection can prevent such mortality.

This paper is designed to characterise the nonlinear parameters derived using HRV data of subjects suffering from (a) Cardiac diseases such as Congestive heart failure and Atrial Fibrillations and (b) Non-cardiac diseases such as Thyroid and Depression in comparison to that of .Healthy subjects

1.1Motivation

Depression and Thyroid are the usual disorders which generally exist in many people where people will neglect the treatment of the same as they are the most common disorders. Further it is known that the cause for these disorders stems through ANS which in turn associated with HRV. Hence and it is thought that the increase in sudden cardiac deaths may be associated with these disorders so investigate it and if it is true, the sudden cardiac deaths can be controlled by controlling thyroid and depression.

1.2Research gap

Earlier research [16] has been done HRV analysis on Thyroid subjects and Depression subjects separately. HRV analysis has not done for thyroid an depression subjects together. No evidence of study among Thyroid and depression investigating which is more prone to sudden cardiac death

1.3Problem statement

To investigate the higher cardiac risk group among cardiac diseased verses noncardiac diseased subjects and further to investigate among the noncardiac diseased subjects. So to find out this one needs to know the best nonlinear method. Hence the principle objective of this paper is to find the best suitable nonlinear technique to distinguish between various cases with better resolution..

II.METHODOLOGY

The following steps describe the methodology In the steps of the methodology given the authors have done work on various nonlinear techniques with cardiac disease and noncardiac disease subjects. This paper is an extension of the work done by the authors

1. Heart Rate Variability (HRV) data from reasonable number of healthy, Cardiac diseased such as CHF and AF and Non-cardiac diseased subjects such as

Thyroid and Depression subjects for detailed analysis has been generated[6]-[8]

2. Determined various entropy parameters such as ApEn, SampEn, SymbEn using HRV data and compare the entropy parameters for Healthy, Cardiac diseased and Non-cardiac diseased subjects[8],[10],[13],[14],[15]
3. Compare the Average Entropy, SE and CD parameters for both Cardiac and Non-cardiac diseased subjects and analyse the results for arriving at definite conclusions. [8],[13].
4. To predict the higher probability of occurrence of cardiac failures amongst the different diseased subjects using established medical evidences.

Interested reader may refer [1],[2],[3],[4],[5],[6],[7] and [16] for detailed understanding about various nonlinear techniques and literature review.

II. RESULTS AND DISCUSSION

In this paper the results derived from non linear analysis of HRV parameters namely Entropy, Spectral Entropy and Correlation Demension techniques for Healthy, Cardiac and Non cardiac diesased subjects[8,9,10,11] are summarized and discussed in detail for drawing the necessary conclusions in the light of medical research findings.

The Entropy parameters such as ApEn,SampEn and SymbEn, SE and CD derived using HRV data analysis of Healthy and Dieased subjects are summarized in table 1 and displayed in figure 1 Since the ApEn, SampEn and SymbEn entropy parameters shows similar treands for Healthy and diseased subjects the three entropy values are averaged and shown as Average entropy (%) in the same table.

Table1 I Comparison of all parameters

Subject	ApEn (%)	Samp En (%)	Sym bEn (%)	Average Entropy (%)	SE (%)	CD (%)
Healthy	100	100	100	100	100	100
Thyroid	35	37	56.	43	23	68
Depressio n	42	57	63.	53	35	45
CHF	46	70	78	65	42	68
AF	107	120	131	119	60	116

A closer examination of the parameters listed in the table 7.1 and shown in figure .1 clearly demonstrates that for Cardiac (CHF) and Non cardiac diseased subjects (Thyroid and Depression) the Average entropy , SE and CD parameters derived from all the non linear techniques display significantly lower values compared to healthy subjects indicating that the information content of HRV for the diseased subjects is much lower than the healthy subjects.

Further it is seen from the same table that between the Cardiac and Non cardiac subjects, the Averaged entropy and SE parameters show much lower values for Non cardiac diseased subjects (Thyroid and Depression) compared to Cardiac (CHF) diseased subjects. The results suggest that Non cardiac diseased subjects (Thyroid and Depression), are more prone to cardiac attacks compared to Cardiac diseased subjects.(CHF)

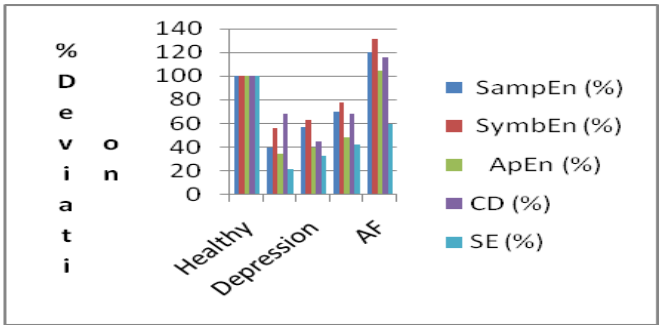

Figure .1 %Deviation of various parametrs of all types of subjects

It is also can be seen from the table 1 that, amongest the Non cardiac diseased subjects, the Average entropy and SE parameters show the lowest values for Thyroid subjects suggesting that amongest Non cardiac diseased subjects Thyroid subjects are more prone to cardiac attacks compared to Depression subjects.

However the same table.1 shows that AH subjects show higher values for the Average entropy parameters and CD parameters and lower values for SE parameter compared to healthy subjects indicating that the Cardiac disease such as AF is caused by abnormal hyper activity of the heart compared to healthy subjects and fibrillation activities of the heart.may lead to cardiac arrest .

It may be noted that the CD parameters derived from the HRV data for diseased subjects in the present analysis do not distinguish between the Non cardiac and Cardiac diseased subjects and shows opposite behaviour compared to Entropy parameters indicating that the CD values are low for Depression subjects compared to Thyriod subjects This suggests the limitation of CD techniques in distinuishing between the Cardic and Non cardiac diseased subjects suggesting that the CD techniques may not be suitable for distuinguishing between diseased subjects as these techniques may be be addressing to different aspect of cardiac dysfunction.

The power spectral density parameters (SE) can also be used effectively for distinguishing between various Cardiac and Non cardiac diseased subjects.

Further It is important to note from the table1 that the amongest the entropy techniques used for HRV analysis the SampEn Entropy parameters displayed highest varaiations between Cardiac and Non cardiac subjects found to be more sensitive compared to ApEn and SymbEn techniques. The SampEn techniques are found to be more efficient for unambiguously distinguishing between the Cardiac and Non cardiac diseased subjects.

The lower entropy values in the case of thyroid subjects may be attributed to the possible mechanisms where Thyroid hormone has direct effect on vascular smooth muscle as result the mean arterial pressure when it is sensed in kidneys, and increases renal sodium absorption. Thyroid hormone (T3) also increases red cell mass, the combined effect of these changes result in rise in blood volume.

The lower entropy values in the case of depression subjects may be attributed to the possible mechanisms due to which depression subjects have increased cardiovascular mortality are namely affected ANS, Platelet Activation and endothelial dysfunction, and inflammatory cytokines was well documented in the medical literature.

The subjects used in this study were hypothyroid subjects whose HRV was reduced and which was reflected in the entropy and CD values. Investigation of the quantised entropy values and CD values indicated the ANS dysfunction It can be concluded that cardiovascular mortality is associated thyroid subjects due to the attribution of ANS dysfunction[3].This is supported/ confirmed by the physiological mechanism leading to cardiovascular mortality which was explained above Similarly for the depression subjects

IV. CONCLUSIONS

From the analysis, results and discussions presented in sections I and II the following conclusions can be drawn The non linear analysis is found to be very effective for distinguishing between the Healthy, Cardiac and Non cardiac diseased subjects. The Entropy parameters such as ApEn, SampEn, SymbEn and the Averaged entropy indicate that the entropy parameter show either much lower values for the Cardiac and Non cardiac diseased subjects and higher values for AF subjects compared to healthy subjects.

The power spectral Entropy (SE) parameters indicate that the entropy parameters is very low for the Cardiac, Non cardiac and AF diseased subjects compared to healthy subjects The Correlation Dimension (CD) parameters indicate that the CD values are lower for the Cardiac and Non cardiac diseased subjects and higher for AF subjects compared healthy subjects.

The Entropy and SE parameters for the Non cardiac subjects indicate lower values compared to Cardiac diseased subjects. Indicating that these subjects are more prone to cardiac arrests compared to Cardiac subjects. These observations are in agreement with the medical findings.

Even among Non cardiac subjects the Thyroid subjects indicate lowest values of Entropy, SE parameters. Indicating that these subjects are more prone to cardiac arrests compared to Depression subjects.

The higher values of Entropy, CD parameters for AF subjects compared to Healthy subjects indicate hyper active dynamics of the heart which is abnormal for Healthy subjects.

Amongst the entropy techniques the SampEn entropy techniques are found to be more efficient for detection, identification and monitoring of the Cardiac and Non cardiac diseased subjects compared to other entropy techniques. The CD techniques do not have adequate sensitivity and found not suitable for detection, identification and monitoring of the diseased subjects.

- Noncardiac diseased subjects (Thyroid and Depression) is having more risk compared to cardiac diseased subjects.
- It has been observed that Thyroid subjects are at more risk compared to Depression subjects
- Non linear measures are lowest for both Thyroid and Depression(non cardiac diseased subjects) compared cardiac diseased subjects

V. FUTURE WORK

The work presented in this paper may be advanced to carry out future work on the subject :To estimate HRV variation with varying degrees of Thyroidim and depression. Should find whether there exists a relation between Nonlinear parameters and the thyroid hormone reflected in lab testings , to see the possibility of using noninvasive thyroid test.

REFERENCES

[1] Bhat.A.N,Kalsotra L,Yograj .S" Autonomic reactivity with altered thyroid status",J.K.Sci,8,pp70-74,2007

[2] Vijaylakshmi, N.Vaney and S.V.Madhu,"Effect of Thyroxine therapy on autonomic status on hypothyroid patients",Indian J.Physiol Pharmacol,53(3):pp219-226,2009].

[3] Kernel Sayer,Huseyin Gulec,Mustafa Gokce,Ismail AK "Heart rate variability in depressed patients ",Bulletin Clinical Psychophamacology Vol 12,N:3,pp130-133,2002,

[4]U.RajendraAcharya,Pauljoseph.K,kannathalN,LimCM, SuriJS,"Heartrat

[5] V.C.Veera Reddy and Anuradha"Cardiac Arrhythmia classification using fuzzy classifiers"Journal of theoretical and applied information technology,pp352-359,2005

[6] Ziafuzhu.WeiHe and Hao Yang "Comparitive analysisof heart rate variability between morbid group based on Correlation Dimension" IEEE,2008, 978-4244-,pp2252-2255 ,2008,

[7] **Joan E Deffeyes,Regina T Harbourne,stacey L,Dejong, Anastasia Kyvelidou,Wayne A Stuberg and** Nicholas Sterigo**"** Use of information entropy measures of sitting postural sway to quantify developmental delay in infants" *Journal of NeuroEngineering and Rehabilitation* 2009,pp **6:**34

[8] CH.RenuMadhavi and A.G.Ananth " Analysis and Characterisation of Heart Rate Variability (HRV) Data of Different Sets of Subjects Using Nonlinear Measure (Approximate Entropy)" International Journal of Computer Theory and Engineering, Vol 2(4), pp 619-623, 2010

[9] CH.RenuMadhavi and A.G.Ananth " Estimation of Multiple scale Sample Entropy (MPE) of Heart RateVariability(HRV) of normal and CongestiveHeartFailure(CHF)cases by selecting 'm' and 'r' values" published in The Journal Of Material Science and Engineering" David Publishing, USA, volume 4 (34), No.9, ,pp 66-71, 2010

[10] CH.RenuMadhavi and A.G.Ananth."Quantification of Heart Rate Variability (HRV) data using Symbolic Entropy to Distinguish between Healthy and Disease subjects" International Journal of Computer Applications ,Vol 8(12), pp10-13, 2010

[11] CH.RenuMadhavi and A.G.Ananth"Noninvasive Detection of Thyroid Dysfunction using Bicoherence plot and Bicoherence metric of HRV data " International Journal of Multidisciplinary Research and Advances in Engineering (IJMRAE),Ascent Publications, vol 3,No1, ,pp81-90, 2011

[12] CH.RenuMadhavi and A.G.Ananth "Modified Multiple Scale/ Segment Entropy(MMPE) Analysis of Heart Rate Variability of NHH, CHF and AF subjects " International Journal Of Life Sciences" , David Publishing, USA.Volume 5, Number 8, pp593-597, 2011

[13] CH.RenuMadhavi and A.G.Ananth "Spectral Entropy Estimation of HRV Data of Thyroid & Healthy subjects",International Journal of Computer Applications ,Volume 30– No.1, pp39-41, 2011

[14] CH.RenuMadhavi and A.G.Ananth "A Review of Heart Rate Variability and It's Association with Diseases "International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307,Volume-2, Issue-3, July 05,pp86-90 , 2012.

[15] CH.RenuMadhavi and A,G.Ananth "Estimation Of ANS Status Of Healthy And Diseased Subjects Using Spectral Entropy" **International journal of** Biomedical Engineering **and Consumer Health Informatics**,Serial Publications(in the Press)

[16] CH.RenuMadhavi and A,G.Ananth "Areview of Heart Rate Variability and its association with diseases", **International journal of Soft computing and Engineering,(IJSCE),** Volume-2,Issue-3,July Volume-2,Issue-3, pp86-90, 2012.(all the References there in)

Mrs.CH.RenuMadhavi has done her M.Tech in Electronic Instrumentation From R.E.C Warangal in1993.Presently She is working as an Associate Professor in the Department of Instrumentation Technology,RVCE,Bangalore.She is persuing her PhD in HRV analysis using Nonlinear Techniches..

Dr.A.G.Ananth presently working as a Professor in Department of Telecommunications Engineering of RVCE, Bangalore. His areas of interest includes Digital Image processing, ,Biomedical signal processing, Fractals,Wireless networks etc.