Abstract

Electrocardiography (ECG) deals with recording of the electrical activity of heart muscles. Usual method of ECG recording is done using 12-Lead system. The paper deals with a new method of recording the electrical activity of heart from the neck region (carotid artery). The waveform obtained is known as Neck cardiogram (NCG). It uses a simple method of signal acquisition, using three surface electrodes and an amplifier. The work aims to prove the significance of NCG in diagnosis of certain diseases that may not be prominent in normal ECG. The acquired ECG and NCG of the patient is compared using Matlab software and LabVIEW environment. The analysis of the waveforms is done using Daubechies wavelet transform and Higuchi fractal dimension. The analysis was done on large group of subjects including thyroid patients, cardiac patients and healthy subjects. The results obtained suggested NCG can be used as a tool to diagnose certain abnormalities. NCG can be used to record heart's electrical activity for people with no upper limbs. This method of single lead system provides easier way of recording heart's activity compared to the chest electrodes used in 12-lead system.

Keywords: Daubechies Wavelet Transform, Higuchi’s Fractal Dimension, NCG, 12-lead system

1. Introduction

Neck cardiography (NCG) is the art of recording the electrical activity of the heart by measuring the potential picked up from the surface of the Neck region (Carotid artery). This is achieved by placing the electrodes at the surface of Neck of the person and recording the potentials generated between these electrodes. The acquisition method is simple as it uses only three electrodes which are placed at the regions of right carotid artery, left carotid artery (active nodes) and right leg (reference node). The acquired signal is amplified and subjected to analysis using a type of Discrete Wavelet Transform (DWT) known as Daubechies wavelet transform followed by a non-linear method of fractal dimension analysis known as Higuchi’s Fractal Dimension (HFD). This method of HFD is considered to be a suitable method to estimate the dimensional complexity of biological signal.

2. Project Description

2.1 Acquisition

The NCG of a person is obtained by placing electrodes on each side of the neck over the carotid artery region. The right leg is kept as reference.
A1 and A2 represents the two active nodes at left and right carotid, respectively.

- The ECG of the same person is acquired having the electrodes at right arm, left arm and reference at right leg (lead-I connection).
- The acquired signal is interfaced with DAQ (Data Acquisition) and fed into the computer. Further processing and analysis is done in LabVIEW environment.

2.2 Analysis
The input signal is initially processed with Daubechies wavelet transform function. The db function separates the input signal into its corresponding low frequency and high frequency components.

The high pass component alone is extracted and differentiated to enhance the singularities. The QRS complex of the enhanced signal is suppressed using a set of Matlab coding. The modified signal is given as input to Higuchi’s algorithm.

Higuchi is a form of fractal dimension method of non linear analysis which is most suitable method for analysing any non-stationary signals.

3. Data Collection
ECG and NCG were collected from several normal and abnormal subjects belonging to the age group ranging from 17-70. Some of the data collected from healthy, cardiac and thyroid subjects are tabulated in Table 1.

The ECG and NCG recorded from healthy subject found to have high similarity in their waveform characteristics compared to those recorded from an abnormal subject.

4. Data Analysis
4.1 Wavelet Transform
A wavelet is a mathematical function used to divide a given function or continuous-time signal into different scale components. A wavelet transform is the representation of a function by wavelets. It is classified into Discrete Wavelet Transform and Continuous Wavelet Transform.

4.2 Daubechies Wavelet Transform
The Daubechies wavelets are a family of orthogonal wavelets defining a discrete wavelet transform and characterized by a maximal number of vanishing moments for some given support. The names of the Daubechies family wavelets are written dbN, where N is the order. The db1 wavelet, as mentioned above, is the same as Haar wavelet.
4.3 Analysis using db1

The Daubechies transform when applied to the signal, it separates the High frequencies and Low frequencies and plot as the output waveform. The High frequencies plot of the input signal is sufficient for analyzing the waveform characteristics of the ECG and NCG of normal subjects and patients.

From the Figure 6, it can be seen that the high pass components of ECG and NCG from the normal subject do not show any variations in their waveform characteristics.

The waveforms shown in Figure 7 are the high pass components of the signals recorded from a thyroid patient. The encircled regions of the graphs clearly show variation between the components of ECG and NCG. This observation can be used for the diagnosis of thyroid abnormality.

Table 1. Data collected from various subjects

| SUBJECTS | AGE (Years) | SEX | CLINICAL UPDATES |
|----------|-------------|-----|------------------|
| 1        | 20          | F   | NORMAL           |
| 2        | 19          | M   | T-elevated       |
| 3        | 20          | F   | NORMAL           |
| 4        | 20          | M   | T-elevated       |
| 5        | 40          | F   | NORMAL           |
| 6        | 17          | M   | NORMAL           |
| 7        | 20          | F   | RR-int. large    |
| 8        | 50          | M   | NORMAL           |
| 9        | 20          | F   | Cold and Fever   |
| 10       | 41          | F   | T-depressed      |
| 11       | 20          | M   | Q-depressed      |
| 12       | 30          | F   | NORMAL           |
| 13       | 20          | F   | NORMAL           |
| 14       | 20          | M   | NORMAL           |
| 15       | 20          | F   | Tachycardia      |
| 16       | 50          | M   | CAG done         |
| 17       | 55          | M   | PTCA required    |
| 18       | 67          | F   | CAD-DVD, Diabetic|
| 19       | 63          | F   | CAG done         |
| 20       | 53          | M   | CAG done, Diabetic|
| 21       | 46          | F   | Hypothyroidism   |
| 22       | 22          | F   | Left side- Hypo  |
|           |             |     | Right side-Hyper |
| 23       | 46          | F   | Hyperthyroidism, Low BP |
| 24       | 55          | F   | Hyperthyroidism  |
| 25       | 45          | F   | Hypothyroidism   |
4.4 Signal Modification

In order to analyze the signals, the NCG of the subjects are modified. The signal is differentiated using Derivative VI block in LabVIEW environment.

The differentiated signal is given to Matlab script for the suppression of QRS complex and used for further analysis.

Figure 8 shows the waveforms obtained at each and every stage of the process. From the top 1) The input NCG signal. 2) Extracted high frequency component of the input. 3) The signal obtained after differentiating the previous stage output. 4) The waveform obtained after the suppression of QRS complex to enhance the other wave characteristics for further analysis.

4.5 Analysis using Higuchi’s Fractal Dimension Method

Fractal analysis is the modeling of data by fractals. It consists of methods to assign a fractal dimension and other fractal characteristics to a signal or object which may be sound, images or other data.

The Higuchi’s Fractal Dimension (HFD) is the best suited algorithm for non-linear analysis of a signal.

The signal after application of Daubechies wavelet transform and further modification as described above, is subjected to HFD analysis. The analysis for ECG and NCG waveforms were processed separately using Higuchi algorithm and the corresponding output values were noted.

5. Experimental Results

We implemented our proposed method on a large group of subjects. The processing was done using Matlab and LabVIEW software. The signal is decomposed into two bands; Low pass and High pass by using Daubechies order 1, (db1) mother wavelet. It is observed that the Thyroid patients have greater influence on T segment of the ECG waveform and is easily notable on the output of NCG High pass db1 wavelet filter. The db1 wavelet produced a stable value for both ECG and NCG for healthy persons and created a large difference for the diseased persons.

Higuchi’s algorithm calculates the Fractal Dimension (FD) directly from time series. This algorithm is simpler and faster than other classical measures derived from chaos theory. FD can be used to quantify the self-similarity of a signal. We utilized the ability of HFD to discriminate between NCG of the patients and compared it with the healthy individual.

From the tabulated values, Higuchi Fractal Dimension values are determined as follows:

The Higuchi Fractal Dimension values for normal subjects lie within the range 1.88 ± 0.05.

For thyroid patients the range of values found to lie between 1.22 and 1.35.

For cardiac subjects the range is 1.73 – 1.97.

The output values show clear difference between the healthy individuals and individuals having abnormality. Healthy individuals found to have higher HFD values than abnormal persons.

6. Conclusion

The work presented in this paper is novel in the way, we addressed the problem area of Neckcardiography (NCG). The NCG is intended to observe the influence of the disease on the ECG waveform, recorded from the neck. We focused on the thyroid and cardiac patients. In order to explore the significance of NCG, this work involved analysis by both graphical representation and numerical values. We applied Daubechies Wavelet Transform and computed Higuchi’s Fractal Dimension (HFD) for ECG and NCG.
signals, for normal and abnormal persons and observed the difference. The results explored the significance of NCG is diagnosing certain abnormalities.

7. References

1. Ahmadian A, Abolhasani MD, Mahmoodabadi SZ. ECG feature extraction using daubechies wavelets. Proc of 5th Inter Conf; 2005 Sep.
2. Niranjan U, Subramanyam RBV, Khanaa V. Developing a web recommendation system based on closed sequential patterns. Communications in Computer and Information Science. 2010; 101:171–9. ISSN: 1865-0929.
3. Fernandez A, Mediavilla A, Gomeza C, Abasolo D, Hornero R. Use of the Higuchi's fractal dimension for the analysis of MEG recordings from alzheimer's disease patients. Medical Engineering and Physics. 2009; 31:306–13.
4. Das S, Das MP, Das J. Fabrication of porous chitosan/silver nanocomposite film and its bactericidal efficacy against Multi-Drug Resistant (MDR) clinical isolates. Journal of Pharmacy Research. 2013; 6(1):11–5. ISSN: 0974-6943.
5. Azhim A, Yamaguchi H, Yamaguchi J, Yoshizaki K, Hirao Y, Kinouchi Y. Monitoring carotid blood flow and ECG for cardiovascular disease in elder subjects. Proc of the IEEE; Japan. 2005.
6. Jayalakshmi T, Krishnamoorthy P, Ramesh Kumar G, Sivamani P. Optimization of culture conditions for keratinase production in Streptomyces sp JRS19 for chick feather wastes degradation. Journal of Chemical and Pharmaceutical Research. 2011; 3(4):498–503. ISSN: 0975-7384.
7. Gopalakrishnan K, Prem Jeya Kumar M, Aanand SJ, Udayakumar R. Thermal properties of doped azopoly-ester and its application. Indian Journal of Science and Technology. 2013; 6(S6):4722–5. ISSN: 0974-6846.
8. Saritha C, Sukanya V, Murthy NY. ECG signal analysis using wavelet transforms. Bulg J Phys. 2008; 35:68–77.
9. Jebaraj S, Iniyan S. Renewable energy programmes in India. International Journal of Global Energy Issues. 2006; 26(4Mar):232–57. ISSN: 0954-7118.
10. Kimio T, Natarajan G, Hideki A, Taichi K, Nanao K. Higher involvement of subtelomere regions for chromosome rearrangements in leukemia and lymphoma and in irradiated leukemic cell line. Indian Journal of Science and Technology. 2012 Apr; 5(1):1801–11.
11. Cunningham CH. A laboratory guide in virology. 6th ed. Minnesota: Burgess Publication Company; 1973.
12. Sathishkumar E, Varatharajan M. Microbiology of Indian desert. Ecology and Vegetation of Indian desert. Sen DN, editor. India: Agro Botanical Publ; 1990. p. 83–105.
13. Varatharajan M, Rao BS, Anjaria KB, Unny VKP, Thyagarajan S. Radiotoxicity of sulfur-35. Proceedings of 10th NSRP; India. 1993. p. 257–8.
14. 2015 Jan 01. Available from: http://www.indjst.org/index.php/vision