The Analysis of Electrocardiogram signal processing showing nonlinear structure (abnormalities) of the heart using the Spectrum Analysis in SPSS

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Abstract: **Heart abnormality refers to the irregular electrical activity of the heart. Heart abnormality sometimes does not show any symptom and it is not sensible, and this may cause the heart to cease and stop functioning and thereby lead to sudden death. This paper attempts to develop a program that capable to detect the heart abnormality activity through the implementation of spectral analysis using SPSS. A dataset of heartbeat signals from electrocardiogram (ECG) from Heart-Statlog.arff will be used to test the network performance.**

I. INTRODUCTION

Heart Abnormality Activity

Heart abnormality activity means irregular heartbeat which is known as cardiac dysrhythmia or Arrhythmia. It refers to a condition where the heart electrical activity is not normal. The abnormality may be caused by the speed of the heartbeat which is slower or faster than normal condition. There are two conditions of the heartbeat that is faster or normal. If the heartbeat rate is faster which is estimated beyond 100 beats per minute, it is called tachycardia. If it is slower which estimated less than 60 beats per minute is, it is called bradycardia.

Among these conditions, there are two possibilities which predict whether the heartbeat is normal or abnormal. Arrhythmias do not necessity lead to death but some can cause a sudden or sometimes temporary, cessation of function of the heart (known as cardiac arrest).

Arrhythmias show several symptoms and may occur at any age. One of the symptoms is abnormal awareness of palpitations, which makes the patient uncomfortable.

Some arrhythmias do not show any symptom at all but may lead to deadly stroke. Not all arrhythmias are noticeable and sometimes can cause sudden death to patient due to heart stop functioning. In fact, arrhythmias are said to be the most common causes of death when patients reaching to a hospital. Back then when the early detection method was developed.

Signal Processing

Signal processing involves obtaining a representation of the signal based on a given model and then applying of some higher level transformation in order to put the signal into a more convenient form. The last step in the process is the extraction and utilization of the message information by either human or machines.

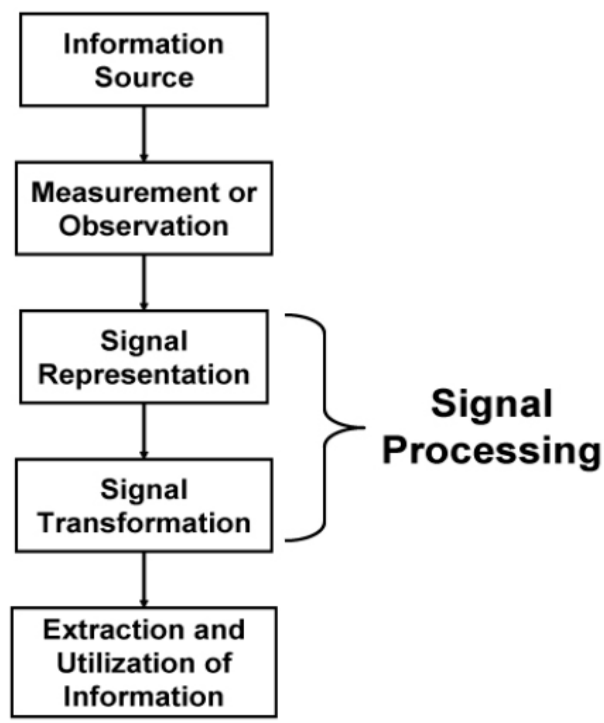

Figure 1: General view of information manipulation and processing (L. R. Rabiner 2009)

The Electrocardiogram (Ecg)

ECG can be defined as a non-invasive device that is used to monitor and measure the heart's electrical activity through the skin. A distinctive waveform is produced by the electrocardiogram which is in response to the electrical changes that happen inside the heart. This electrical changes can be used to monitor and detect problems such as in the hearts ionic environment, heart's conduction system defect, muscle fibers damage due to lack of blood supply and detecting several heart diseases. The electrical recharge and electrical discharge that happen in the heart can be expressed as depolarization and re-polarization respectively.

Electrocardiographic signals may be recorded on a long timescale (i.e., several days) for the purpose of identifying intermittently occurring disturbances in the heart rhythm. As a result, the produced ECG recording amounts to huge data sizes that quickly fill up available storage space.

The Electrocardiogram Analysis

Electrocardiography (ECG) analysis system was introduced in purpose to acquire initiatory information of the patient's heartbeat. The results acquired are then delivered to the hospital for further analysis. The ECG system uses two processing units to obtain the results. The first unit does signal acquisition process which is gotten from patients, while the second unit does noise filtering and filtered signal extraction processes. the signal extraction is used as the input parameter for the model to be able to detect the heart abnormality activity. Whilst the noise filtering is used for terminating noise that contaminates the ECG signal.

Common to all types of ECG analysis—whether it concerns resting ECG interpretation, stress testing, ambulatory monitoring, or intensive care monitoring—is a basic set of algorithms that condition the signal with respect to different types of noise and artifacts, detect heartbeats, extract basic ECG measurements of wave amplitudes and durations, and compress the data for efficient storage or transmission; the block diagram in Fig. 1 presents this set of signal processing algorithms.

Electrocardiography Ecg Block Diagram

The timing information produced by the QRS detector may be fed to the blocks for noise filtering and data compression (indicated by gray arrows) to improve their respective performance. The output of the upper branch is the conditioned ECG signal and related temporal information, including the occurrence time of each heartbeat and the onset and end of each wave.

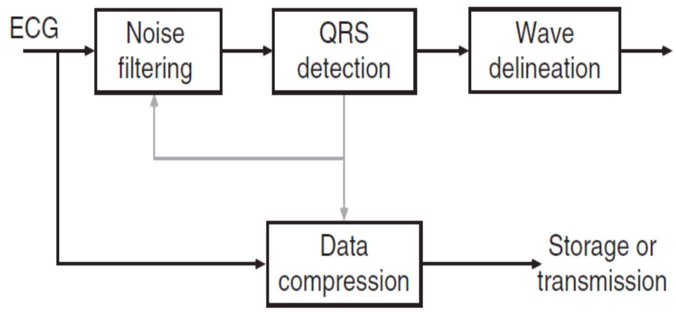

Fig.2 Algorithms for basic ECG signal Processing (LEIF SO ¨ RNMO 2018)

Spectral Analysis

Spectral analysis is applied in so many fields. It may be used to reveal *hidden periodicities* in the studied data in fields such as economics, meteorology, astronomy etc. It can be used in vibration monitoring to give information on the wear and other characteristics of mechanical parts under study using the spectral content of measured signals. In control systems, there is a resurging interest in spectral analysis methods as a means of characterizing the dynamical behavior of a given system, and ultimately synthesizing a controller for that system. In speech analysis, spectral models of voice signals are useful in better understanding the speech production process, and can also be used for both speech synthesis (or compression) and speech recognition. In medicine, the spectral analysis of various signals measured from a patient by a specialist, such as electrocardiogram (ECG) or electroencephalogram (EEG) signals can provide useful material for diagnosis. In seismology, the spectral analysis of the signals recorded prior to and during a seismic event gives useful information on the ground movement associated with such events and may help in predicting them. Seismic spectral estimation is also used to predict subsurface geologic structure in gas and oil exploration.

Experiment, Analysis and Result

Data set used: Heart-Statlog.arff
(http://tunedit.org/repo/UCI/heart-statlog.arff)

Model Summary

Table 1. The Model Fit

Fit Statistic	Mean	SE	Minimum	Maximum	Percentile						
					5	10	25	50	75	90	95
Stationary R-squared	.165	.200	-1.110E-015	.577	-1.110E-015	.002	.015	.075	.350	.548	.577
R-squared	.276	.349	.012	.988	.012	.013	.036	.081	.577	.952	.988
RMSE	7.998	15.170	.105	49.722	.105	.138	.354	.991	15.159	43.221	49.722
MAPE	38.886	37.958	2.449	120.675	2.449	2.916	6.012	35.256	64.135	113.365	120.675
MaxAPE	294.359	583.517	38.073	2043.719	38.073	45.050	86.975	98.885	203.414	1686.035	2043.719
MAE	5.742	11.314	.022	37.468	.022	.032	.252	.766	7.605	32.631	37.468
MaxAE	43.508	87.967	.870	286.223	.870	.872	.989	2.553	67.817	250.552	286.223
Normalized BIC	.878	3.894	-4.483	7.875	-4.483	-4.110	-2.058	.002	5.520	7.447	7.875

Table 2. The Model Statistics

Model	Number of Predictors	Model Fit statistics							Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	R-squared	RMSE	MAPE	MaxAPE	MaxAE	Normalized BIC	Statistics	DF	Sig.	
chest-Model_1	0	.433	.036	.933	35.256	255.298	2.553	-.118	22.327	17	.172	0
resting_blood_pressure-Model_2	1	.075	.075	17.215	10.193	38.073	67.817	5.733	14.737	18	.680	0
serum_cholestoral-Model_3	2	.081	.081	49.722	15.643	95.334	286.223	7.875	11.782	18	.858	0
fasting_blood_sugar-Model_4	1	.012	.012	.354	84.127	88.329	.883	-2.058	10.349	18	.920	0
maximum_heart_rate_achieved-Model_5	1	.577	.577	15.159	6.012	151.927	107.868	5.520	7.694	16	.957	0
exercise_induced_angina-Model_6	1	.047	.047	.462	64.135	86.975	.870	-1.460	23.186	16	.109	0
oldpeak-Model_7	0	.350	.202	1.023	120.675	2043.719	4.373	.066	22.003	17	.185	0
slope-Model_8	0	.021	.811	.267	4.782	203.414	2.034	-2.621	11.634	17	.822	0
number_of_major_vessels-Model_9	0	-1.110E-015	.988	.105	2.449	98.885	.989	-4.483	.690	18	1.000	0
resting_electrocardiographic_results-Model_10	1	.015	.015	.991	47.872	72.956	1.459	.002	14.030	18	.727	0
thal-Model_11	1	.207	.198	1.748	36.604	103.037	3.519	1.200	12.254	16	.726	0

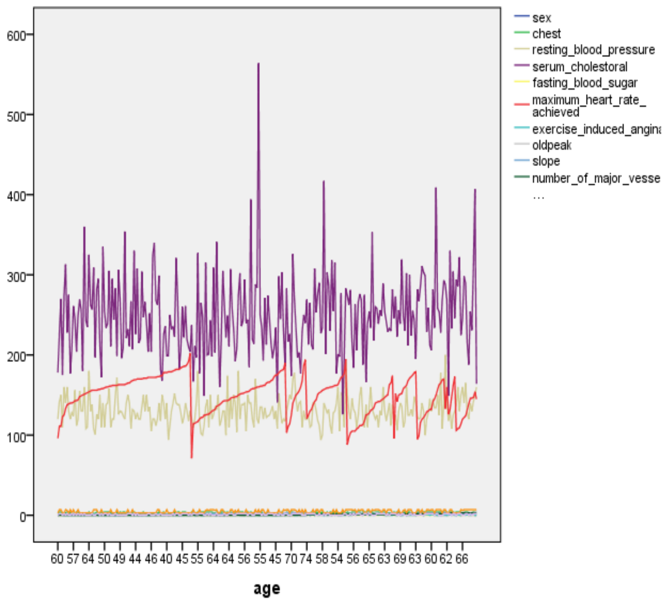

Fig 3a. The Spectral Analysis graph by Age

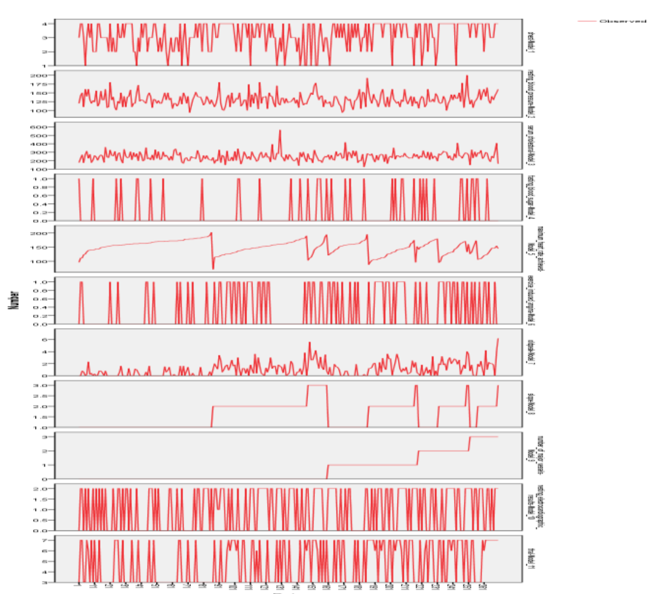

Fig 3b. Graph of the Spectral Analysis for all the attributes

Table 4: Model Description

Model Name		MOD_3
Analysis Type		Univariate and Bivariate
Independent Series		fasting_blood_sugar
Dependent Series	1	resting_blood_pressure
	2	maximum_heart_rate_achieved
	3	resting_electrocardiographic_results
	4	serum_cholestoral
Range of Values		Reduced by Centering at Zero

Periodogram Smoothing	Spectral Window		Tukey-Hanning
	Window Span		25
	Weight Value	W(-12)	5.404
		W(-11)	6.200
		W(-10)	7.003
		W(-9)	7.796
		W(-8)	8.563
		W(-7)	9.288
		W(-6)	9.954
		W(-5)	10.547
		W(-4)	11.053
		W(-3)	11.460
		W(-2)	11.757
		W(-1)	11.939
		W(0)	12.000
		W(1)	11.939
		W(2)	11.757
		W(3)	11.460
		W(4)	11.053
		W(5)	10.547
		W(6)	9.954
		W(7)	9.288
		W(8)	8.563
		W(9)	7.796
		W(10)	7.003
		W(11)	6.200
		W(12)	5.404
Applying the model specifications from MOD_3			

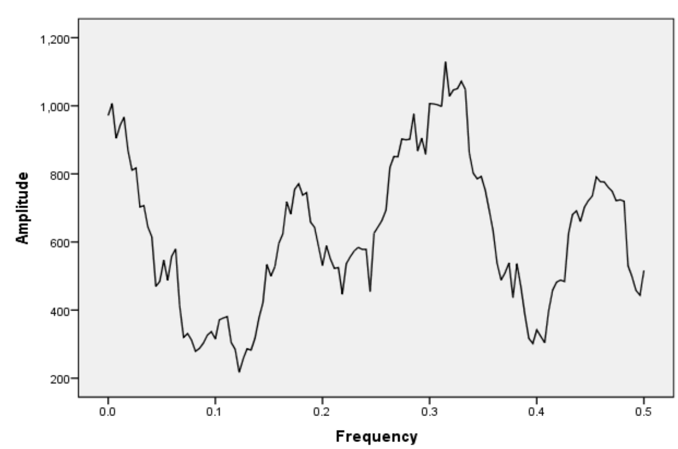

Fig. 4. The Cross Amplitude of Fasting blood Sugar and Rest Blood Pressure by Frequency

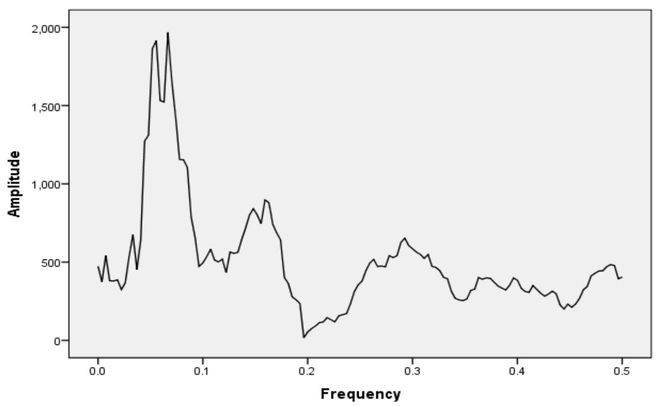

Fig. 5 : The Cross Amplitude of Fasting blood Sugar and Maximum Heart Rate achieve by Frequency

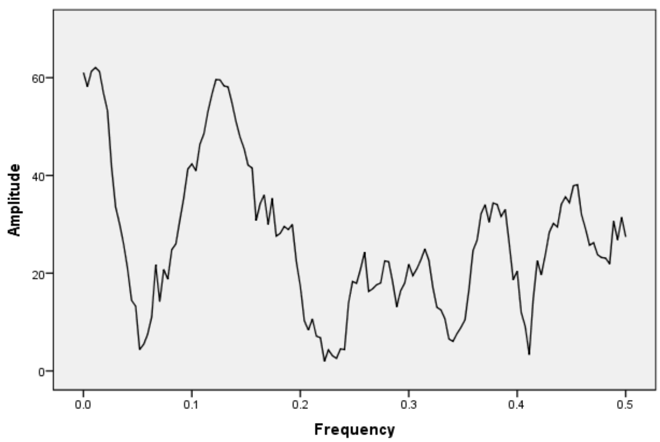

Fig. 6 : The Cross Amplitude of Fasting blood Sugar and Resting Electrocardiographic Result by Frequency

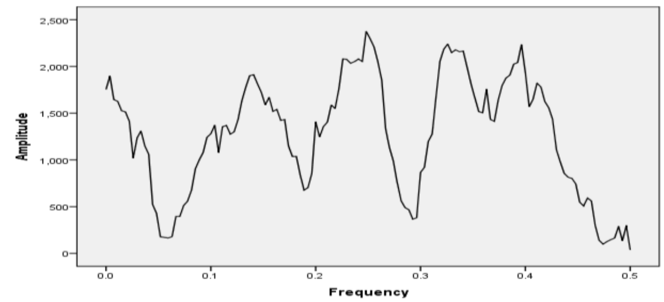

Fig. 7 : The Cross Amplitude of Fasting blood Sugar and Serum Cholesterol by Frequency.

II. CONCLUSION

This work describes ECG signal processing with an aim to Prediction Heart abnormalities. It is developed using spectral analysis technique. The system extracts hidden knowledge from a historical heart disease database. This is the most effective model to predict patients with heart disease. This model could answer complex queries, each with its own strength with respect to ease of model interpretation, access to detailed information and accuracy.

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