

VISVESVARAYA TECHNOLOGICAL UNIVERSITY

BELGAUM – 590014



A Project Report on

**A REAL TIME APPLICATION TO IDENTIFY CHRONIC
ALCOHOLICS FROM ECG SIGNALS**

**Submitted in partial fulfilment of the requirement for the award of degree of
BACHELOR OF ENGINEERING
IN
ELECTRONICS AND COMMUNICATION**

By

Akarsh N Kolekar	[1PI13EC009]
Apoorv Vatsal	[1PI13EC017]
Rakshith Vishwanatha	[1PI13EC075]

Under the Guidance of:

Dr. B. Niranjana Krupa
Professor, Dept. of ECE,
PES University

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING



P.E.S. UNIVERSITY
(An Autonomous Institute under VTU, Belgaum)
BENGALURU - 560085

DECLARATION

We hereby declare that the project report entitled “**A REAL TIME APPLICATION TO IDENTIFY CHRONIC ALCOHOLICS FROM ECG SIGNALS**” is the bonafide record of the project carried out at **P.E.S. Institute of Technology** in partial fulfilment of the requirements for the award of degree **Bachelor of Engineering in Electronics and Communication Engineering** of **Visvesvaraya Technological University, Belgaum** during the academic year 2017. We further declare that the project report is not submitted to any other universities in fulfilment of the requirements for the award of any degree.

By

AKARSH N. KOLEKAR (1PI13EC009)

APOORV VATSAL (1PI13EC017)

RAKSHITH VISHWANATHA (1PI13EC075)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY

BELGAUM – 590014



PES UNIVERSITY

(An Autonomous Institute under VTU, Belgaum)

BENGALURU – 560085



CERTIFICATE

This is to certify that the project titled **A REAL TIME APPLICATION TO IDENTIFY CHRONIC ALCOHOLICS FROM ECG SIGNALS** is a bonafide work carried out by **Akarsh N. Kolekar, Apoorv Vatsal and Rakshith Vishwanatha** bearing University Seat Number **1PI13EC009, 1PI13EC017 and 1PI13EC075** respectively in partial fulfilment for the award of **Bachelor of Engineering in Electronics and Communication** from the **Visvesvaraya Technological University**, Belgaum during the academic year 2017. It is certified that all correction/suggestions indicated for internal assessment have been incorporated in the report deposited in the department library. The project report has been approved as it satisfies the academic requirements with respect to the project work prescribed for the said degree.

Guide:

Dr. B. Niranjana Krupa

Dept. of ECE.
PES University,
Bengaluru – 560085

Head of Department:

Dr.ChandarTS

Dept. of ECE
PES University,
Bengaluru – 560085

Principal :

Dr. K S Sridhar
PES University,
Bengaluru – 560085

External Viva:

Name of the Examiner Signature with Date

- 1.
- 2.

ACKNOWLEDGEMENT

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mention of people who made it possible, whose constant guidance and encouragement crown all the efforts with success.

Our most sincere and grateful acknowledgement to the P.E.S Institute of Technology for providing us with the opportunity to pursue our degree and thus helping us in shaping our career.

We would like to thank our project guide, **Dr. B. Niranjana Krupa**, Professor at the Department of Electronics and Communication Engineering for her continuous valuable guidance, advice and persistent encouragement throughout the project work.

We want to thank **Dr. T. S. Chandar**, Head of the Department Electronics and Communication, for his encouragement and support throughout the project work.

We are thankful to **Dr. Sridhar K. S.** , Principal of PES University, Bengaluru for his encouragement and supporting our endeavour.

We would also like to thank all the non-teaching staff and management of PES University, Bengaluru for their cooperation.

Last but not the least we wish to thank our family and friends for all their love support and encouragement.

ABSTRACT

Several medical studies reveal alcohol consumption has pronounced effects on the physiology of the consumer. These physiological changes can be seen in the heart rate variability (HRV) of the consumer. In this project the electrocardiogram (ECG) signal of a test subject is captured using an ECG sensor and noise present in the captured signal is filtered out using software techniques. The processed signals are then used to classify the subject as a chronic alcoholic or a normative person using machine learning algorithms on features extracted through HRV analysis.

ECG samples of chronically alcoholic subjects and normative subjects to train the classification system have been collected from a medical centre. To these signals once HRV analysis is performed, time domain, frequency domain, and non-linear features are extracted. The features extracted are fed to machine learning algorithms to enable the algorithms to classify subjects into alcoholic or normative classes. For this classification problem, Support Vector Machines (SVM) and Extreme Learning Machines (ELM) have been trained, and validated using k-fold cross validation.

Time domain, frequency domain and non-linear features are generally the types of features extracted from ECG signals using HRV analysis. Use of such features provided good accuracies for the classifiers however, to further improve the accuracy of the SVM and ELM models, a new set of features obtained from Autoregressive Modelling (using Exogenous Inputs) have also been used. A comparative study has been made between both the algorithms in the two cases where the usual time domain, frequency domain and non-linear features were used to train the classifiers, to the case when the autoregressive model coefficients were also included with the feature set.

One of the key ideas of the project was to develop a system that could capture the ECG signal of the test subject, perform pre-processing on the signal, extract features via HRV analysis and classify the subject then and there in real time. A Raspberry Pi was used to make the required portable standalone system.

Table of Contents

CHAPTER -1 INTRODUCTION	01
1.1 Introduction.....	01
1.2 Problem Statement	03
1.3 Objective	04
1.4 Proposed Methodology	04
 CHAPTER- 2 LITERATURE SURVEY	06
 CHAPTER- 3 METHODOLOGY	11
3.1 Introduction.....	11
3.2 Hardware	11
3.2.1 ECG Sensor Circuit Design	11
3.2.2 Heart Rate Monitor (AD8232)	17
3.2.3 Raspberry-Pi	19
3.2.4 Analog to Digital Converter (ADC)	20
3.2.5 Integration of Hardware	21
3.2.5.1 Setting Up Raspberry-Pi	21
3.2.5.2 Connecting Heart Rate Monitor to Raspberry-Pi.....	23
3.2.6 Communication Protocols	23
3.3. Software	25
3.3.1 Dataset Description	26
3.3.2 Pre-Processing	26
3.3.2.1 Infinite Impulse Response.....	27

3.3.2.2 Wavelet Transforms.....	29
3.3.3 Feature Extraction	37
3.3.3.1 Time Domain	37
3.3.3.2 Non-Linear	39
3.3.3.3 Frequency Domain	40
3.3.3.4 Auto-Regressive Modelling (with Exogenous Input).....	42
3.4 Classifiers	46
3.4.1 Support Vector Machine (SVM)	46
3.4.2 Extreme Learning Machine (ELM).....	52
3.4.3 Validation	56
3.4.3.1 Leave One out Validation	57
3.4.3.2 K-fold Validation	58
3.4.3.3 Confusion Matrices	58
3.5 Real Time application	59
3.5.1 Tkinter	60
3.5.2 Graphical User Interface	61
CHAPTER- 4 RESULTS AND DISCUSSION	63
4.1 Results of Pre-processing	63
4.2 Results of Feature extraction	64
4.3 Results of SVM	64
4.4 Results of ELM	65
4.5 Comparative Study	67
POINTS OF DISCUSSION	67

CONCLUSION AND FUTURE WORK	68
---	-----------

REFERENCES	69
-------------------------	-----------

APPENDIX.....	72
----------------------	-----------

List of Figures

Fig 2.1 Schematic Representation of ECG Waveform	07
Fig 2.2 Architecture of an Extreme Learning Machine	09
Fig 3.1 Traditional placement of ECG probes	12
Fig 3.2 Circuit Design-1	12
Fig 3.3 Circuit Design-2	14
Fig 3.4 Superposed Output – with Probe Connection to Limbs	14
Fig 3.5 50Hz Output without Probes Connected to Limbs	15
Fig 3.6 Circuit Design-3	16
Fig 3.7 Soldered Circuit	16
Fig 3.8 AD8232	17
Fig 3.9 Internal Pin Diagram of AD8232	18
Fig 3.10 Raspberry Pi 2 model B	19
Fig 3.11 MCP 3008 ADC	20
Fig 3.12 MCP 3008 interface to Raspberry Pi	23
Fig 3.13 Synchronous Data Bus	24
Fig 3.14 Sending and receiving data using SPI	24
Fig 3.15 Baseline Wandering and Power-line noise in ECG	27
Fig 3.16 PSD of a sample ECG signal with noise components	28
Fig 3.17 IIR Filtered Signal without Baseline Wandering	29
Fig 3.18 Diagrammatic Representation of Fourier Transform applied to a Signal	29
Fig 3.19 Diagrammatic Representation of Short Fourier Transform applied to a Signal	30
Fig 3.20 Sine wave and a Mother Wavelet	31
Fig 3.21 Wavelet Decomposition of a Signal	31
Fig 3.22 Wavelet decomposition into high and low frequencies	32
Fig 3.23 Wavelet Decomposition Tree	33
Fig 3.24 Mother wavelet	33

Fig 3.25 Wavelet Decomposition in different modes	34
Fig 3.26 Decomposition in Tree mode	35
Fig 3.27 Complete Wavelet Decomposition	35
Fig 3.28 Removal of Baseline Wandering	36
Fig 3.29 Poincare Plot	40
Fig 3.30 PSD of a sample from dataset used	41
Fig 3.31 MATLAB Toolbox to select order of ARX polynomial	44
Fig 3.32 ARX model structure selection	44
Fig 3.33 Coefficients of ARX model fit	45
Fig 3.34 Importance of regularization	50
Fig 3.35 Count of C and sigma used	52
Fig 3.36 Accuracy for a range of hidden neurons	56
Fig 3.37 Real time capture of ECG signal	60
Fig 3.38 GUI	61
Fig 3.39 ECG signal loading process is started	61
Fig 3.40 ECG signal loaded	62
Fig 3.41 Feature extraction completed	62
Fig 3.42 Classification completed	62
Fig4.1 Removal of Baseline Wandering and RR peak detection	63

List of Tables

Table 3.1 GPIO pins of Raspberry Pi	23
Table 3.2 Confusion Matrix	59
Table 4.1 Results of SVM for different feature sets	64
Table 4.2 Confusion matrix for SVM with ARX features	65
Table 4.3 Accuracies of ELM for different feature sets	66
Table 4.4 Accuracy of ELM for Leave One Out Validation with ARX order 5	66
Table 4.5 Confusion matrix for ELM with ARX features order 5	66
Table 4.6 Comparative results of SVM and ELM	67
Table 4.7 Comparative Sensitivity and Specificity of SVM and ELM	67