A Real Time Application to Identify Alcoholics from ECG Signals

by

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1. Introduction

Technology has advanced in various fields at rapid rates, however in an area that concerns the common wellbeing of humans, technology has remained dormant. Identifying accurately if a person is intoxicated is utmost important to keep public harm and nuisance at bay. The most common device used, the breathalyser has drawbacks that we aim to rectify. The common drawbacks of a breathalyser are:

i) Contamination of SiO_2 sensor requires frequent recalibration and replacement
ii) Breathalysers being a medium for propagation of contagious diseases
iii) Interfering components (like acetone) being higher in the breath of dieters and diabetics make them more prone to being detected falsely
iv) Infrared sensors detect the absorbance of the compound as a function of the wavelength of the beam when the infrared beam is passed through the sample breath chamber. The chamber is prone to environmental pollutants and aerosols leading to errors.

These disadvantages mentioned above are addressed with the use of infallible computers and well trained machine learning algorithms.

HRV (Heart rate variability) obtained from ECGs is a useful biomarker and is used extensively in our paradigm to extract features. The features extracted are then used to train the system to classify patients as chronic alcoholic or otherwise. This may be useful in discriminating individuals based on their habits while preventing other external environmental conditions from altering or corrupts the readings.

2. Problem Statement

To develop a prototype to read ECG signals, extract features to perform HRV analysis, and classify the person under test as an alcoholic (person under the influence of alcohol) or otherwise.

3. Objectives

(a) To study the recently developed ECG sensor and improve it
(b) Identify an effective method to extract and analyze Heart Rate Variability (HRV) features from the raw ECG sensor data to accurately classify results for Alcoholic and Normative data.
(c) Implement algorithms on a Raspberry-Pi 2 to perform real time feature extraction and classification.

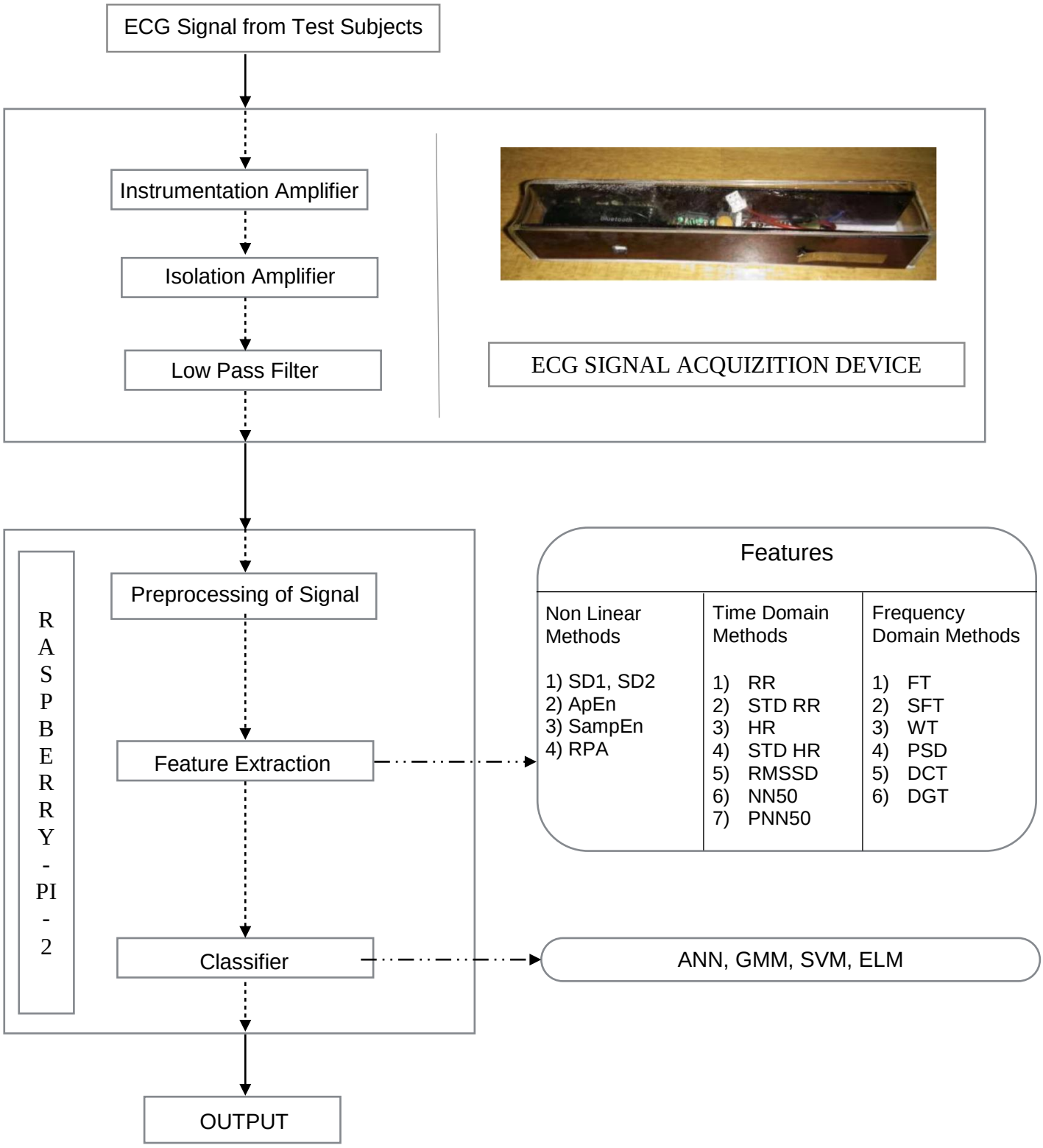

Figure-1: System Block Diagram

4. Methodology

i. First, we will start with studying the advantages and disadvantages of HRV (Heart Rate Variability) analysis over other markers for cardiovascular health.

ii. Familiarization with the form and structure of the ECG signals, and understanding distortions (artifacts) that can occur in the signal will be our next step. Two common artifacts seen in ECG signals are the wandering baseline and fuzzy (60 Hz) distortions caused due to probe movement, uneven conductive gel, muscle movement, etc.

iii. Then, we would want to survey available devices for measuring and recording ECG signals and study what improvements can be made for the device previously developed to record ECG signals. An instrumentation amplifier already exists in the sensor circuit, and we would like to add an isolation amplifier which allows measurement of small signals in the presence of high common mode voltage while providing electrical isolation. This is done in order to properly isolate the patient from the power source. The device presently connects to a phone via bluetooth and the data is then routed to a server from the phone. We would like to interface the sensor directly with the Raspberry Pi 2 and do all the processing on it, making the overall system more compact.

iv. Parallel to working on the sensor hardware, once we understand the ECG waveforms, we will start working with the training data set to decide the feature extraction techniques and classifiers that could be implemented. We plan to survey tools like KubiosHRV to understand time domain and frequency domain feature extraction for HRV analysis. The training data set has been obtained from Autonomic Lab, Department of Neurophysiology, NIMHANS and consists of 30 samples of alcoholic and normative subjects.

v. To this data, preprocessing will be performed to remove artifacts, and then we plan to use time domain, frequency domain, and/or non-linear methods for feature extraction from the ECG signals. On extracting the desired features, ANN, SVM, GMM and ELM are classifiers that we wish to train to our dataset.

vi. Accuracy of the classifiers will be checked using leave-p-out cross validation and k-fold cross validation, and classifiers providing highest consistent average accuracy in these validation methods will be selected.

vii. Based on the algorithms that we finalize on, we would need to choose the controller board on which we would like to implement the feature extraction and classification algorithms. Our target device is the Raspberry Pi 2 currently, as it has a 900 MHz quad-core CPU that is necessary for machine learning applications.

viii. Training of the classifiers to obtain weights will be done on MATLAB and the trained parameters would then be used on the Raspberry Pi 2.

ix. Finally, the sensor will be interfaced with the Raspberry Pi 2, be uploaded with trained parameters be ready to take classify real time ECG data.

5. Components of the Block Diagram (Figure-1)

The system consists of the following main components. The description and role of each of them is as follows:

A. ECG data acquisition device — Used to acquire real time ECG data from the patient. This device can further be broken down into the

- Instrumentation amplifier: used to amplify the weak signals obtained at the electrodes
- Isolation amplifier: used to ensure isolation of a patient from power supply leakage current
- Low pass filter: to remove unwanted frequency components

B. Raspberry Pi 2 — Used to run all the code for the classification algorithms

- Preprocessing: Includes procedures like normalization and removal of artifacts
- Feature Extraction: Apply time domain transforms, frequency domain transforms, and/or non-linear techniques to obtain features
- Classifiers: Use the features obtained and a classification algorithm to classify the input data into its respective class

6. **Software and Hardware Requirements**

(i) Software:
- (a) MATLAB
- (b) Python Libraries
- (c) MultiSim

(ii) Hardware:
- (a) Raspberry Pi 2 - processing board to implement the classifier
- (b) ECG Sensor

7. **Expected outcome:**

By the end of the project we should have an end to end working model of the system proposed. Real time ECG graphs will be obtained, features from the graph will be extracted, and classification of test subject as alcoholic or normative will be performed.

8. **Literature Survey**

[1] In the "A Precise Drunk Driving Detection Using Weighted Kernel Based on Electrocardiogram" paper the authors collected ECGs from 50 volunteers. They applied pre-processing for noise suppression and signal segregation into a number of samples, where each sample represented the heart activity for one heartbeat. To identify characteristics of an alcoholic, features such as Pmax, Pd, means and variances of P, R, S waves and R-R intervals are extracted. The paper used SVM as a classifier and 10-fold cross validation.

[2] The paper “Effects of Alcohol on the Electrocardiogram” took electrocardiograms of 1,000 chronic alcoholic patients and analyzed them to find evidence that excessive consumption of alcohol may produce changes in the electrocardiogram. The predominant abnormalities that were observed by the authors were sinus tachycardia and nonspecific T-wave changes.

[3] The paper by “The Electrocardiogram of alcoholic cardiomyopathy” Evans, William is one of the first few studies that emphasized the need to study the relation between not the just alcohol consumption and the liver but also consider the effect of alcohol consumption on the heart. Various changes were seen in the ECG of alcoholic patients like the dimple T wave, spinous T wave, cloven T waves, etc. This study clearly establishes the fact that alcohol consumption leads to variation in heart beat.

[4] The "Supervised machine learning: A review of classification techniques." gives a comprehensive view of various supervised machine learning classification techniques and provides interesting domains where machine learning can be applied.

9. **References**

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