1 INTRODUCTION

xie2020

1.1 Xie, Li, Zhou, *et al.* [1]

1.1.1 Introduction

- cvd is the leading cause of death worldwide
- 30% of deaths and 130 million cases a year [1]
- ECG is good, non-invasive and real-time: heartbeat recognition, blood pressure detection, disease detection
- discovery of ECG [4]
- electronic analysis can give suggestions
- common ECG formats are 1-lead, 3-lead, 6-lead, 12-lead
- 12-lead is the standard and more detailed
- ECG is also future proof and becoming more readily available
- a doctor's reading of an ECG is heavily dependent on their experience, training, certs
- automatic analysis is becoming more and more common
- ECG features are unique information extracted that represent the state of the heart
- source [17] is a list of common feature classifiers
- instead of feature extraction and later classification, just using one neural network to do all the work is becoming more and more common
- ECD – time-varying signal with small amplitude
- the signal needs to be significantly de-noised for approaches to work
- normally though, signals are disturbed by baseline drift, electrode contact noise, power-line interference
- severe baseline wandering can lead to misdiagnosis
- methods of denoising
  - finding the QRS complex is usually hard because PLI and EMG mask it
  - digital filtering, wavelet transform, empirical mode decomposition [25]
  - digital filters are widely used for this, wavelet too [18,16,27]
  - src [29] is a really good method apparently
  - src [30] is also great
  - src [32] is favorable
  - src [33] is a different approach
  - Butterworth filter
- feature engineering
  - Fourier transform for investigating a signal in the frequency domain
  - FFT is useful and fast for feature extraction
  - QRS is the most striking, can be used for heart rate
  - FFT does not provide any information on the time of any of the components
  - short-time FT gives time and frequency information – we can either have good time

  and bad frequency or vice versa
  - the wavelet transform has a time scale resolution scheme that makes this simpler
  - wavelets are good for all frequencies because they are adaptive
  - their high resolution can give them the edge
  - there are many different options of wavelets that are good for different things
  - src [71] is myocardial infarction
  - DWT is a good computational tool to assess ECG changes
  - for statistical and morphological features
  - higher-order statistics have proven to be good at ECG analysis
- dimensionality reduction is important because while more feature mean more accuracy, they also increase the computational cost
- most data has correlated variables, meaning they can be ignored
- feature selection tries to select a subset of the original features and only select the best ones – options are filters, wrappers, and embedded
- filters are the most simple version, they simply remove the redundant data and then return the relevant data
- filters use algorithms to assign scores to individual features
- filters are fast and independent of the classification, but they may not be super good or precise
- feature extraction reduces the dimension of the information but does not throw out information, which makes it more efficient and precise
- this includes primary component analysis and other types of analysis
- some features of an ECG appear randomly, also entropy, energy, and fractal dimension cannot be easily spotted with the naked eye
- kernels can be used for locally linear embedding
- some machine learning decision making algorithms are k nearest neighbors KNN, support vector machine SVM
- KNN is pretty simple and divides points into multiple group using distance; data imbalance is hard to overcome and they are expensive for high-dimensional data
- SVM has good training ability on small data sets and it is a good all-rounder
- there is no standard about the construction of a NN for ECG analysis
- a general end-to-end model seems to be the best solution, removing the need for optimization at each and every step – feature extraction is shifted to the learning body, which is a nice solution
- a list of all the databases and what they are good at
- good list of applications of the whole thing

1.2 Plan

- use the Butterworth filter in the Julia DSP.jl package
- use FFT, SFFT, Wavelet for feature extraction
- find some simple type of filter to do feature selection

- classification could be done using the NearestNeighbors.jl package

1.3 Outline

1.3.1 Problem Statement

- ischemia and similar diseases are some of the most deadly and common diseases
- IHD – what is it? how can it be diagnosed (ECG)? how can it be treated(Stents)?
- what is the research problem that people are facing?
- the QRST–wave complex changes when ischemia is present, enabling its detection
- heat disease is a significant and deadly medical issue
- poorer countries like Kyrgyzstan are disproportionately affected because many of the newer and better methods cannot be afforded / implemented
- health expenditure in KG is low, the lower it is the worse these conditions are
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1.3.2 Rationale – Justification – Why

- when it comes to ischemic heart disease (IHD), rapid decision making is important – why
- ECG is one of the most widely used diagnostic tools – why
- reading an ECG is very difficult, which leads to different results among different physicians – relevance
- this could reduce the time it takes to diagnose IHD, which is crucial –
- detect changes during myocardial ischemia, some of those remain invisible to physicians
- promising method because other people are doing this
- what are the applications in practice?
- freely available ECGs on the internet – MIT-BIH, European ST-T database and the others

1.3.3 Goals and Objectives

- to develop software that analyzes 12–lead ECG to detect IHD – how will we do that?
- create a 12–lead ECG analysis tool to diagnose IHD
- mathematically model the changes in the ECG compared to at-rest and normal ECGs
- mathematical model and implementation that can speed up diagnosis (which is critical)
- get 100 digitized ECGs from healthy volunteers
- use FFT for analysis
- Fourier Transform, Fast Fourier Transform, Discrete Fourier Transform
- compare the different transforms for this specific problem

2 LITERATURE REVIEW

2.1 Outline

2.1.1 Current State of the Problem

- advances in IHD treatment (see research proposal)
- current methods for ECG modeling
- what is the progress in using FFT and DFT to model ECGs
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2.2 Important Points

2.2.1 background and purpose

- ischemia and similar diseases are some of the most deadly and common diseases
- when it comes to ischemic heart disease (IHD), rapid decision making is important
- ECG is one of the most widely used diagnostic tools
- reading an ECG is very difficult, which leads to different results among different physicians
- to develop software that analyzes 12–lead ECG to detect IHD
- this could reduce the time it takes to diagnose IHD, which is crucial
- detect changes during myocardial ischemia, some of those remain invisible to physicians

2.2.2 goals

- create a 12–lead ECG analysis tool to diagnose IHD
- we will mathematically model the changes of the ECG compared to at–rest, nominal ECGs

2.2.3 questions, problematic, rationale

- the ECG is the most widely used method to assess heart conditions
- the QRST–wave complex changes when ischemia is present, enabling its detection
- a mathematical model could make the analysis of ECGs easier for doctors and speed up their diagnosis
- the model needs to work well for this to be possible
- such a tool would remove some of the problems that normally exist (mentioned above)

2.2.4 background, literature review

- heart disease is a significant medical issue
- one of the most deadly ones
- middle income countries like KG are hit harder
- health expenditure in KG is also one of the lowest
- IHD is the main killing disease
- for most treatment methods, the longer the treatment is delayed, the lower the chances of survival become
- if the necessary infrastructure is nonexistent, treatment times cannot be reduced to acceptable levels
- basically, in Kyrgyzstan most modern and good methods do not work because of the missing infrastructure and economic limits
- computers can help to analyze an ECG, which makes diagnosis easier

2.2.5 methods

- get 100 digitized ECGs from healthy volunteers

- from this a good model of healthy and stressed ECGs should be created
- maybe use FFT for the analysis
- use a Maplesoft Signal Processing Tool for wave analysis

2.3 Advice from Imanaliev

1. Search for the recent advancements in published papers
2. Search for the advancements in software of the related problems
3. Study the Fourier Transform and Fast Fourier Transforms, and their representation on chosen software
4. Comparison of the different transforms for the related problem
5. Scan of the paper based verified cardiograms and digitalising
6. Comparison of the scanned graphs with the verified graphs
7. Adjustment of the software parameters
8. Error estimate
9. Analysis of the results with doctors
10. Real time method probation
11. Adjustment of the parameters
12. Thesis preparation and submission
13. Scientific Paper preparation and submission
14. Distribution of the results in media and analysis of references
15. Adjustment of the parameters

2.4 Content requirements

2.4.1 Introduction

- short, verbal problem statement
- rational relevance of the selected topic
- formulates goals and objectives of the project
- refer to some information
- maybe a brief description of the main results

2.4.2 Literature Review

- overview of the current state of the problem
- based on analysis of literary sources
- don’t summarize sources, just give the important information they contain
- don’t just call it ”Literature Review”, call it something like ”Mathematical models and methods of magnetotelluric monitoring”

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