Thesis Literature Review

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Contents

Chapter 1

Good Sources

1.1 e

e

Summary

Well written paper

- signal processing and data analysis are widely used methods
- detecting cardiovascular abnormalities with an ECG is possible
- a fuzzy-based multi-objective algorithm using a fast fourier transform is used to extract rough features like PQRST amplitude
- then apply an algorithm to classify the abnormality
- ECG behavior depends on many different factors
- accuracy is achieved by taking into account these factors
- maintaining a database of previous results makes prediction better
- this provides 98.7% efficiency in abnormality detection
- accurate ECGs are necessary to classify cardiac abnormalities
- ECGs are noisy and thus an algorithm needs to de-noise the signal
- after noise removal, ECG signals must be extracted – FFT
- fuzzy–based scheme should classify how sick a patient is
- de-noising can be done using a wavelet transform
- contour wavelet transform CTW – Daubechies algorithm for de-nosing
- goal is to remove all noise
- discrete wavelet transform is not accurate enough, adaptive wavelet decomposition is proposed
- then FFT is used to extract the features
- ANN for classification
- FFT to discretize the signal
- radix–2 FFT, is the simplest way to evaluate the DFT
- heartbeat is calculated as the interval between two R peaks – heartbeat is the number of

R peaks in a particular minute
- RR interval can be useful for fining symptoms that include heart–rate variation
- QRS is the main thing that a heart's conditions is measured by
- QRS duration is the time interval between the two peak Q and S signals
- multi-objective genetic algorithm is exactly what it sounds like
- uses MIT–BIH arrhythmia database
- finds good results for their approach
- methods is more efficient than previous results
- IFR: analysing and modelling the sequence of heartbeats using advanced machine learning methods can be implemented to achieve better performance

1.2 b

b

Summary

Really well done and researched paper

- early revascularization (stenting basically) is essential for survival
- ECGs are widely used, but not all information contained in them can be extracted, even by well–trained physicians
- make a prediction model for urgent revascularization based on 12–lead ECG
- they collected 6 years of data for their study
- about 1% to 6% of patients with ACS have ”normal ECG”
- random splitting of the dataset
- an AI model that can learn time–dependent data in the right order
- 12–lead ECG data for 10 seconds at rest
- pretty efficient model for prediction
- IFR: validate the model using other datasets; no heed given to other biomarkers, drugs, age, sex, fitness; they suspect that the ECG contains important data, but they do not know where the data comes from

1.3 l

l

Summary

- 2D ventricular tissue model
- model Hyperkalemia (too much potassium), acidosis (lower conductivity)
- ischemia might leave traces that can be picked up using an ECG
- because ischemia is hard to properly study in the wild, having a model is very convenient
- they use the Luo–Rudy I cellular formulation for a 2D slice
- based on guinea–pig hearts
- equation of electrical activity of a stimulated cell
- the differential equations were solved using a combination of explicit (Euler) and implicit methods
- intracellular loss of potassium ions is the main alteration of electrical activity – hyperkalemia
- electrical parameters were altered to simulate these conditions
- good description of why they tweaked which parameters for simulation
- myocardium cell model: 2D
- cells are connected by gap junctions (low resistance ”bridges”)
- even a simple square–grid can be used to study complex phenomena
- simple impedance is enough to model the cell–to–cell interactions
- no–flux boundary conditions – no current is leaving the system at the edges
- it needs to be sufficiently big to have some area that is not affected by the disturbance at the boundaries
- you excite a layer of 5 cells, then let the model run

Chapter 2

Bad Sources

2.1 d

d

Summary

- using FFT to find abnormalities in ECGs
- ischemia or infarct can be seen in the ST–segment of the ECG
- ischemia can also cause low–amplitude notches and slurs in the ECG
- Holter monitors are ECGs over > 24h, you need programs to analyze that much data
- major problem is the feature extraction
- mentions a bunch of other peoples attempts at feature extraction
- FFT breaks down a signal into its sinusoidal components
- nothing that interesting

2.2 c

c

Summary

- digital signal filtering methods for ECGs
- remove 50Hz network and breathing muscle artifacts
- 3 heart rate detection algorithms
- main problems with ECGs are interfering 50Hz supply signals and muscle artifacts
- for real–time applications, these things should be very efficient
- heart rate is important and can be computed from ECGs among other things
- often, heart rate is detected by measuring the distance between QRS complexes
- neural networks, genetic algorithms, wavelet transforms, filter banks, adaptive threshold, signal spectral analysis, short–term autocorrelation can be used to find it
- the methods here are simpler and real–time suited
- Butterworth filter is used in professional ECG applications
- they remove all the noise from the signal first, using the described methods
- Butterworth filters are used to also detect the R peaks
- with the highlighted R peaks one can detect heart rate
- for heart rate detection, the autocorrelation method can be use because R peaks are quasi–periodical
- other methods find the difference between R peaks, by either using thresholds, or peak detector
- the three algorithms find completely different results

2.3 a

a

Summary

- arrhythmia detection algorithm for ECGs
- uses the morphology of different diseases to make the algorithm efficient
- ECG – electric activity of the heart, generally charted on paper
- ECG features can be extracted in the time domain or in the frequency domain
- morphological information can be time intervals, voltage extremes, duration, location
- Harr Wavelet Transform for ECG feature extraction
- MIT–BIH is used here again; forward–feed neural network
- ECG analysis is carried out using a digital audio processing chip
- they put a window on the QRS complex to only look at that
- PVC can simply be classified by using a threshold
- they implement stuff in MATLAB
- it works for implementation

2.4 Colli-Franzone *et al.* (1985)

Colli-Franzone, P. *et al.* A mathematical procedure for solving the inverse potential problem of electrocardiography. analysis of the time-space accuracy from in vitro experimental data. *Mathematical Biosciences* **77,** 353–396. ISSN: 0025-5564. http://www.sciencedirect.com/science/article/pii/0025556485901063 (1985)

Summary

- Cauchy problem for elliptic operator that's strongly ill posed
- solution is regularized
- electrocardiography potential problem: body surface potential from epicardial potential, also inverse problem
- epicardial data can be estimated using surface potential data
- estimates are good because they contain information not really available purely on the surface
- high errors are common with this procedure because: (1) simplification of body inhomogeneity, (2) reconstruction of data on static heart, (3) constant (over heart beat) smoothing parameter
- computed epicardial potential maps (CEPMs) still not clear
- not having the heart centered could improve accuracy for one side of the heart
- new experiment with a dog heart in a child-sized torso (roughly appropriate location)
- detailed analysis of potential estimates
- only errors should be noise in measurements, misaligned electrodes
- finite element matrix links surface to epicardial potential, fine 3D surface grid
- optimized for CEPM accuracy
- efficiency of choosing a time-dependent smoothing parameter
- applied inverse procedure to heart beat to reconstruct ECG
- for experiment description read the paper
- tank surface is Γ_1, epicardial frame surface is Γ_0, and Ω the volume bounded by Γ_0, Γ_1
- we have electrodes on the gammas and can approximate omega
- the electric cardiac potential $V(x,t)$ is the solution to

$$\Delta V(x,t) = V_{xx} + V_{yy} + V_{zz} = 0 \qquad \text{in}\, \Omega,$$
$$V(x,t) = u(x,t) \qquad \text{on}\, \Gamma_0,$$
$$\frac{\partial V(x,t)}{\partial n} = 0 \qquad \text{on}\, \Gamma_1$$

- $u(x,t)$ is the epicardial potential distribution at t, n is the normal vector to Γ_1 (from the insulating layer around the whole thing, nothing gets out)
- trace of V on Γ_1 is the thorax potential distribution, denoted by $z(x,t)$
- we have a linear operator A transforming u to z
- direct problem of electrocardiography is solving the above system of equations

- problem is discretized using finite-element methods

Chapter 3

Other

3.1 f

f

Summary

- propose a mathematical model of the ECG wave
- human body == cylindrical composite dielectric and conducting medium
- heart == harmonic bio–signal generator
- can use this model to predict experimental data
- ECG signal is due to heart beat and that is due to the signal of the S.A. node
- the electric field generated by this is then propagated to the surface through the dielectric medium that is the human body
- many different approaches to ECGs mentioned here, list here
- compression techniques to help with large amounts of data
- QRS complex evaluation in one paper
- the signal measured by an ECG electrode can be represented by Fourier harmonic components
- dense mathematical description of the model
- they test their model using an actual ECG – get the Fourier components from it
- all 12 ECG leads have about the same makeup of Fourier components
- they have to randomly assign some of the values to make the model fit
- this model is more accurate because it assumes a cylindrical body and not a sphere like the classical models
- good source list
- IFR: do rigorous experimentation to really test this model;

3.2 Unknown Presentation

Summary

- ischemic – lacking sufficient blood flow; generally because coronary arteries are obstructed
- infarction – cell death as result of ischemia
- heart failure is number 1 cause of death in the western world
- majority of that are infarctions
- on a cellular level, oxygen is not provided anymore, waste is not removed anymore
- this fucks with the heart on a cellular level
- reduced pH leads to reduced conductivity of the tissue
- necrotic tissue is basically non–conductive
- use a cell model (Luo–Rudy I) to model ischemia
- the voltage potential drops significantly if ischemia is present
- the upstroke is delayed and amplitude reduces
- the article uses a monodomain model of cardiac tissue (slide 15)
- model propagation on an 200x200 layer
- when ischemia is present, the wave is stunted and fucked up, parts of it might get stuck – leads to arrhytmia for example
- they may use their model to reconstruct ECGs based on the level of ischemia that they want
- they were able to reproduce qualitative characteristics using their model

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