Thesis Literature Review

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Chapter 1

Good Sources

1.1 B. V. P Prasad and Parthasarathy (2018)

B. V. P Prasad and Velusamy Parthasarathy. "Detection and classification of cardiovascular abnormalities using FFT based multi-objective genetic algorithm". In: *Biotechnology & Biotechnological Equipment* 32.1 (2018). Retrieved from https://www.tandfonline.com/doi/full/10.1080/13102818.2017.1389303#, pp. 183–193. DOI: 10.1080/13102818.2017.1389303

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 Goto et al. (2019)

Shinichi Goto et al. "Artificial intelligence to predict needs for urgent revascularization from 12-leads electrocardiography in emergency patients". In: *PLoS ONE* 1.14 (2019). https://doi.org/10.1371/journal.pone.0210103. DOI: 10.1371/journal.pone.0210103

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 Cimponeriu, Starmer, and Bezerianos (2001)

A Cimponeriu, Frank Starmer, and Anastasios Bezerianos. "A theoretical analysis of acute ischemia and infarction using ECG reconstruction on a 2-D model of myocardium". In: *IEEE transactions on bio-medical engineering* 48 (Feb. 2001). Retrieved from https://www.researchgate.net/publication/12095490_A_theoretical_analysis_of_acute_ischemia_and_infarction_using_ECG_reconstruction_on_a_2-D_model_of_myocardium, pp. 41–54. DOI: 10.1109/10.900247

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
- II. Methods

Chapter 2

Bad Sources

2.1 A. K. M Fazlul Haque et al. (2009)

A. K. M Fazlul Haque et al. "Automatic Feature Extraction of ECG Signal Using Fast Fourier Transform". In: (2009). Retrieved from https://www.researchgate.net/publication/295813369_Automatic_Feature_Extraction_of_ECG_Signal_Using_Fast_Fourier_Transform

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 Parak and Havlik (2011)

Jakub Parak and Jan Havlik. "ECG SIGNAL PROCESSING AND HEART RATE FREQUENCY DETECTION METHODS". in: (2011). Retrieved from https://www.researchgate.net/publication/266281892_ECG_Signal_Processing_and_Heart_Rate_Frequency_Detection_Methods

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 Dr. Rahul Kher and Shivang Gohel (2016)

Dr. Rahul Kher and Shivang Gohel. "ABNORMALITY CLASSIFICATION OF ECG SIGNAL USING DSP PROCESSOR". in: (2016). Retrieved from https://www.researchgate.net/publication/299441676_Abnormality_classification_of_ECG_signal_using_DSP_processor

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

Chapter 3

Other

3.1 Bera, Chakraborty, and Ray (2005)

S.C. Bera, B. Chakraborty, and J.K. Ray. "A mathematical model for analysis of ECG waves in a normal subject". In: *Measurement* 38 (2005). Retrieved from https://www.researchgate.net/publication/223280187_A_mathematical_model_for_analysis_of_ECG_waves_in_a_normal_subject, pp. 53–60. DOI: 10.1016/j.measurement.2005.01.003

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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