

# 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](https://doi.org/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 finding 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](https://doi.org/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](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
- 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 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](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](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](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](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](https://doi.org/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 arrhythmia 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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