Elektronica Core Selection Task

ECG Analysis and Arrhythmia Detection

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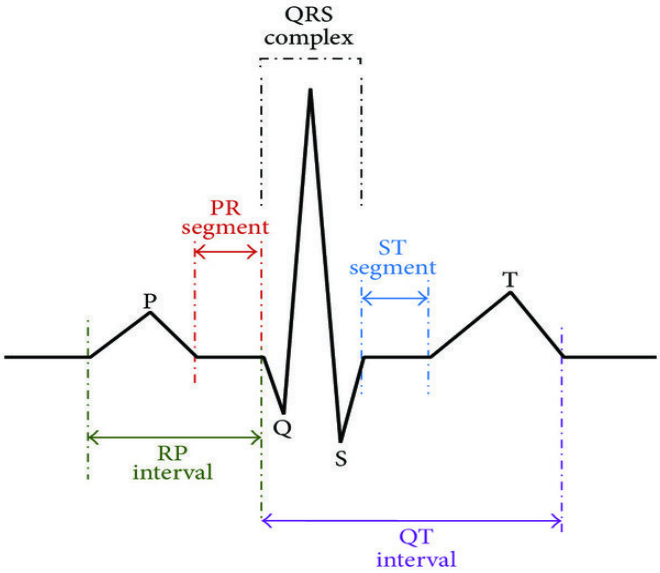
Link of Google Collab File:
https://colab.research.google.com/drive/1nSm_XYMLY75r9r9J6m6D0I8KnFQjSfSd

Resources leveraged

Dataset of cardiac Arrhythmia:https://www.kaggle.com/datasets/erhmrai/ecg-image-data

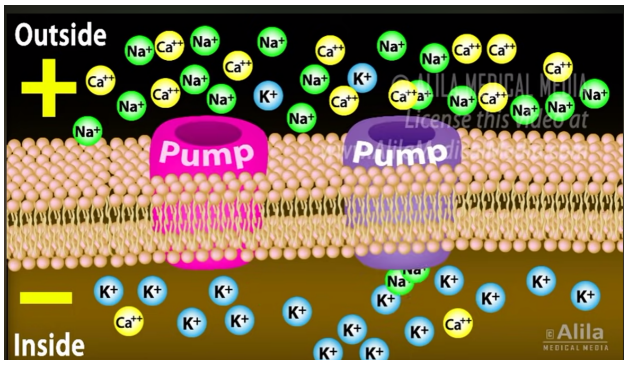
Understanding the ECG diagram



Polarization and Depolarization of the Pacemaker cells

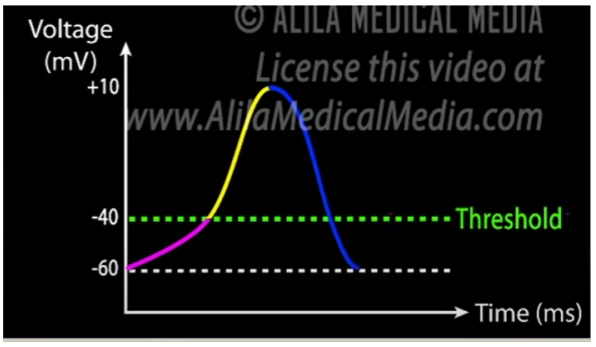
The resting membrane potential is negative inside the cell.

The depolarization of the cell occurs through the entry of Na and Ca via the gates. Similarly the polarization occurs when K+ ions leave the cell.

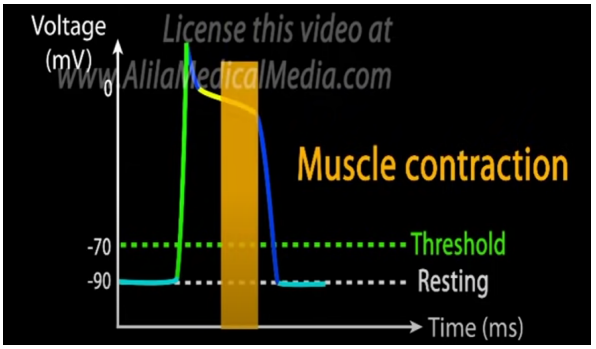


Whether the gate is open or not is dependent upon the relative concentration of ions in the cells and the extracellular matrix .

The recurring polarization of the heart cells gives rise to the following Potential.

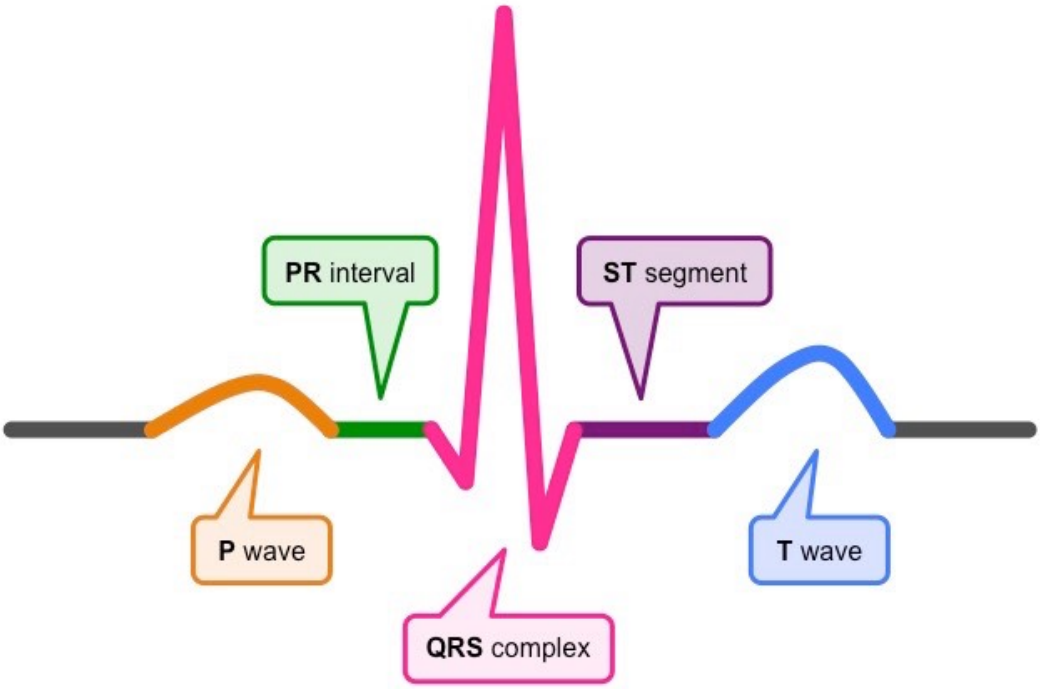


Similarly when the impulse travels to the cardiac myocytes the waveform will change in accordance with the conc.
Sensitivity of the gates of the cardiac myocytes.



The polarization and depolarization of the segments of the heart gives rise to the ECG wave.

Understanding the segments of ECG Wave



The P wave represents the depolarization of the atria, which corresponds to the contraction of the atria to pump blood into the ventricles.

PR interval :The PR segment represents the time from the start of the P wave until the start of the QRS complex. It reflects the time the electrical impulse takes to travel from the SA node to the AV node,

QRS complex: The QRS complex corresponds to the depolarization of the ventricles, which leads to the contraction of the heart that pumps blood to the aorta and the pulmonary artery

T wave: The T wave represents the repolarization or relaxation of the ventricles.

Arrhythmia and its Types

Arrhythmia , refers to an abnormal heart rhythm. This can occur when the electrical impulses that coordinate your heart's beats aren't working properly. This results in irregular heart beat.

Arrhythmias can be categorized as

- N(Normal Beat)
- S(Supraventricular ectopic beat)
- V (Ventricular ectopic beat)
- F (Fusion beat)
- Q (Unknown beat)

Classification of Arrhythmias

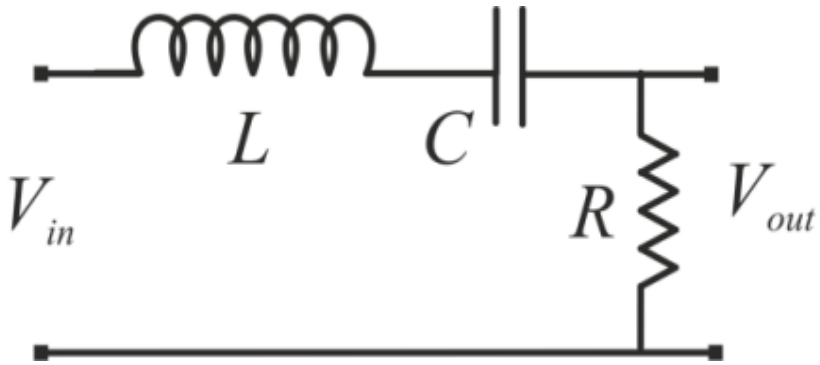
The approach taken to classify the Arrhythmias is via a 3 layered neural network.. Signal Processing techniques like filtering, feature extraction are used by the neural network in its hidden layer to find the class of the image

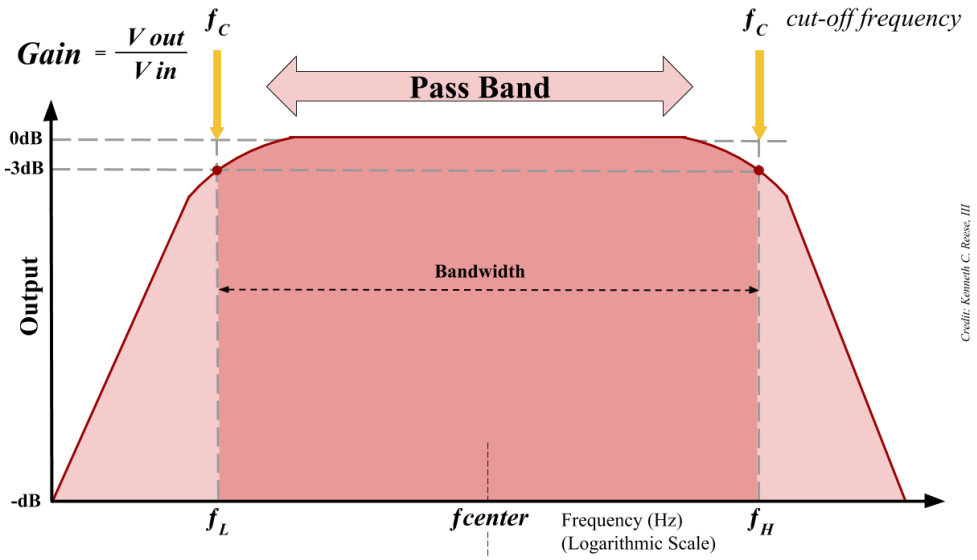
Filtering:

If the the data_set of ECG images has significant noise then a frequency based filter or a bandpass filter can be applied that allows frequency in the ECG frequency to pass

Baseline wander can be removed using a high pass filter.

A bandpass filter is a simple RLC circuit.
The output potential will allow only certain frequency to pass due to the frequency dependance of the impedance of C and L components





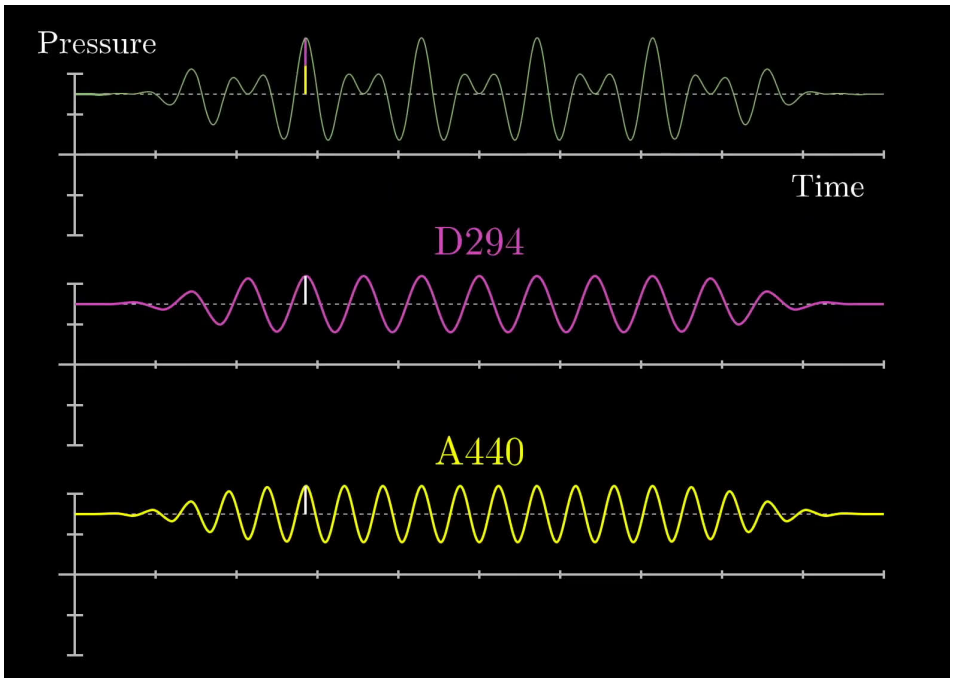
Feature Extraction

Fourier Transform:Any periodic continuous function like an ECG wave can be broken down into set of sine waves of different frequencies

time dependant function like ECG will turn into a frequency dependant function on application

$$F(\omega) = \int f(t) \exp(-i\omega t)\, dt, \text{ for all real } t$$

The magnitude of the function $F(\omega)$ gives value of ω in the original signal



The Fourier transform can break down the final function of pressure into its constituting parts D291 and A440.Similarly an inverse fourier transform will transform the frequency Function of the waveform into the original function with respect to time

This is very useful in detecting certain arrhythmia like atrial fibrillation that are more prominently detected in the frequency domain than in the time domain

Atrial fibrillation in the frequency domain, consists of a distinct, high-frequency component.