



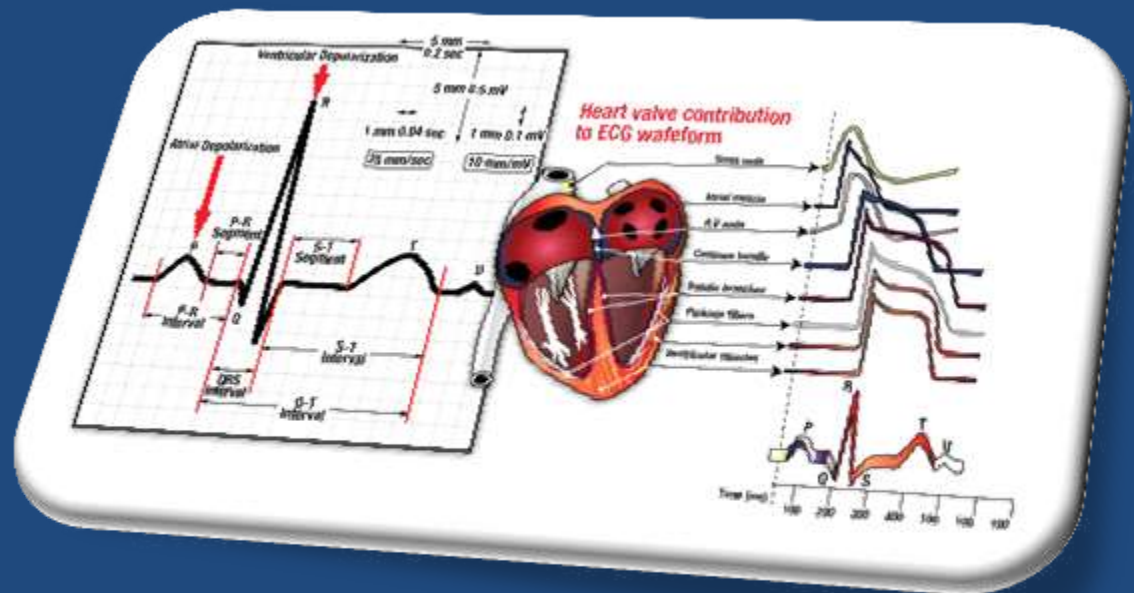
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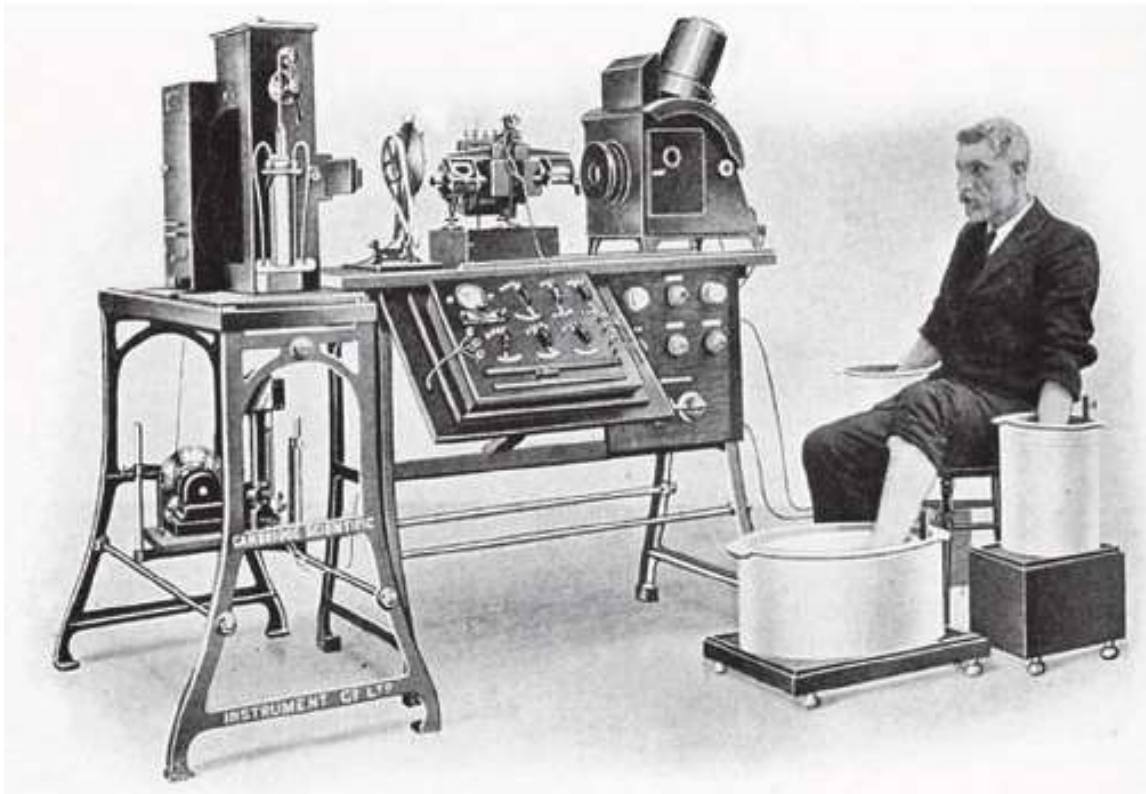


Computer Engineering Department

A Discussion on
ECG Signal Processing
By
Ahmed Salah Hameed



History of ECG



“Photograph of a complete electrocardiography showing the way in which the electrodes are attached to the patient. In this case the hands and one of the feet being immersed in jars of salt solution” [*Learn ECG in a Day - Sajjan, M*]

- It required 5 people to operate it.
- weighed around 600 lb.



Einthoven, born in Indonesia in 1860

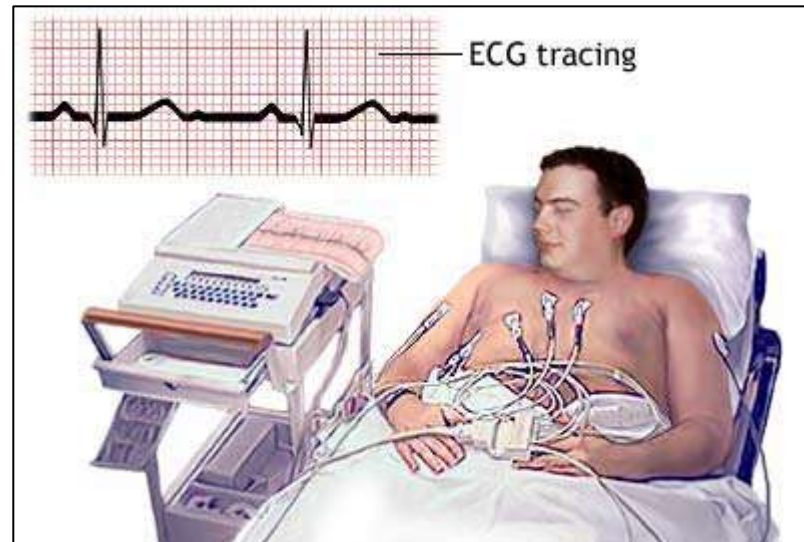


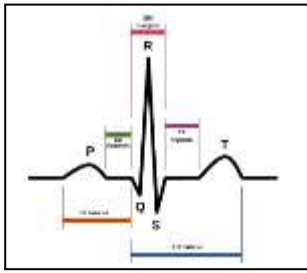
ECG Overview

- **What is ECG**
- **How ECG is generated**
- **Recording ECG**
- **Benefits of ECG**

Electrocardiogram (ECG) or (EKG) is a diagnosis tool that reported the electrical activity of heart recorded by skin electrode.

ECG is the electrical activity of the heart





- Heart Cardiac cells are negatively charged.
- Losing this negativity is called depolarization which is the fundamental electrical activity of the heart [2] .

ECG Overview

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Depolarization propagates from cell to cell producing a **wave**

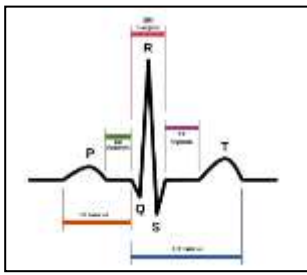
This **wave** is transmitted to the entire heart producing a **current**

This **current** can be detected using **skin electrodes**

Skin Electrodes are put on the surface of the body

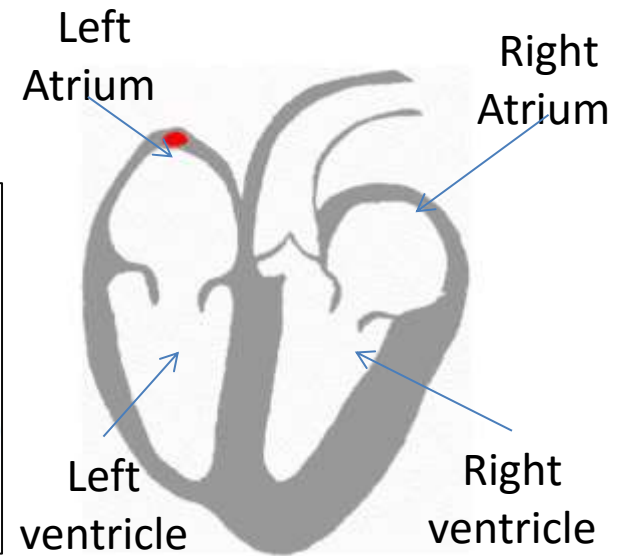
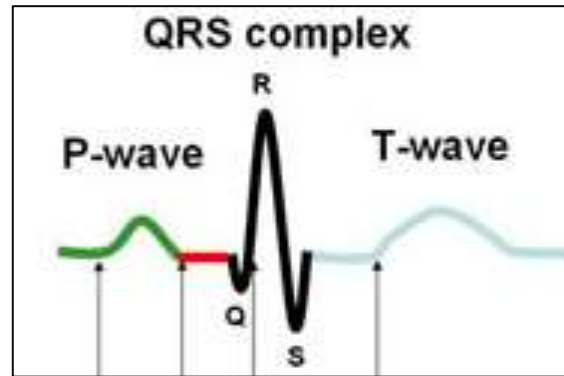
The result is a periodic signal called **ECG**





ECG Overview

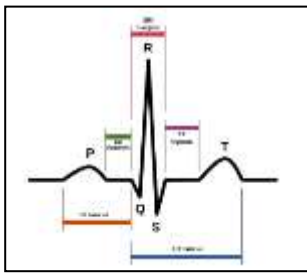
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P-wave : is produced by muscle contraction of atria.

QRS-wave : marks the ending of atria contraction and the beginning of ventricular contraction

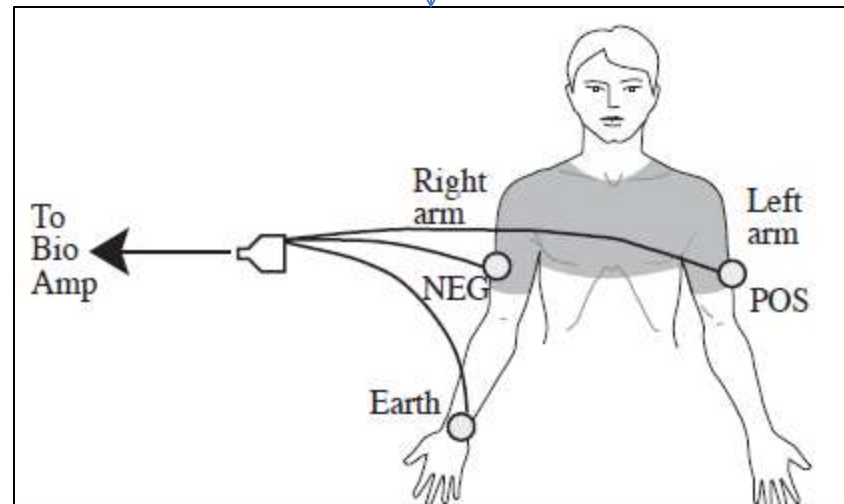
T-wave : marks the ending of ventricular contraction.



ECG Overview

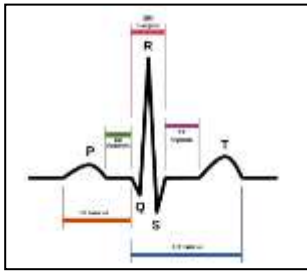
- What is ECG
- How ECG is generated
- **Recording ECG**
- Benefits of ECG

Special electrodes are put on the surface of the body



After amplifying the recorded signal , the obtained ECG signal is contaminated with different noises that must be cleared to get the best ECG .





ECG Overview

- What is ECG
- How ECG is generated
- Recording ECG
- **Benefits of ECG**

Any ECG gives two kinds of information

First

the duration of the electrical wave crossing the heart

Second

the amount of electrical activity through heart muscle

decides whether the electrical activity is normal or slow or irregular

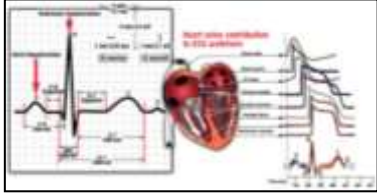
enables to find whether the parts of the heart are strong or overworked.



For example

a narrow and high QRS-wave indicates a physically strong heart

Processing ECG



Processing techniques

Noise Cancellation

Further Analysis

Noise

Examples

Input
ECG

Filtering

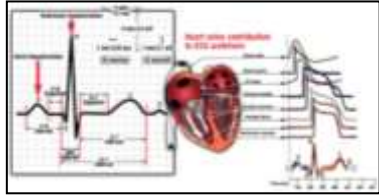
- Bandpass filter
- Adaptive Filtering

Further Analysis

- Differentiation
- Squaring
- Windowing
- Statistical Variance
- SVM
- Wavelet

Detect
heart
diseases

Processing ECG



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Examples

Filter is an electronic device that passes and blocks certain frequencies. In most system, noise is suppressed.

The most common types of noises that occur during the collection of ECG are

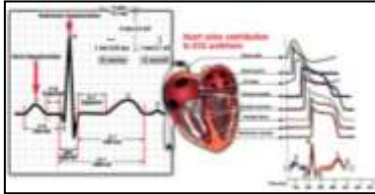
Power line Interface

60 HZ and its multiples

Electrode Contact

noise
less than 0.5Hz

Processing ECG



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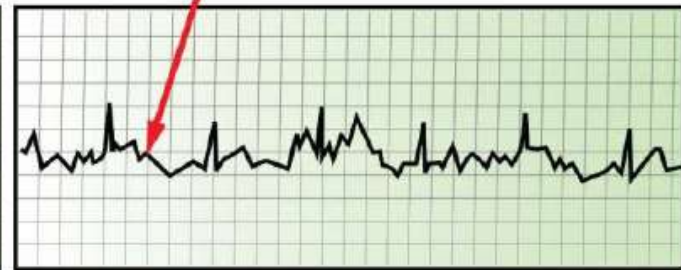
Examples

50/60 Hz pick-up



Alternating Current (AC) Interference

Baseline dc instability



Irregular Baseline

Muscle shaking



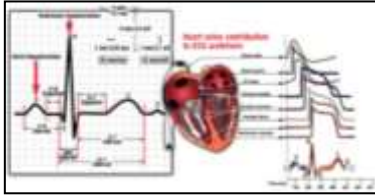
Somatic Tremor

Baseline or dc drift



Wandering Baseline

Processing ECG



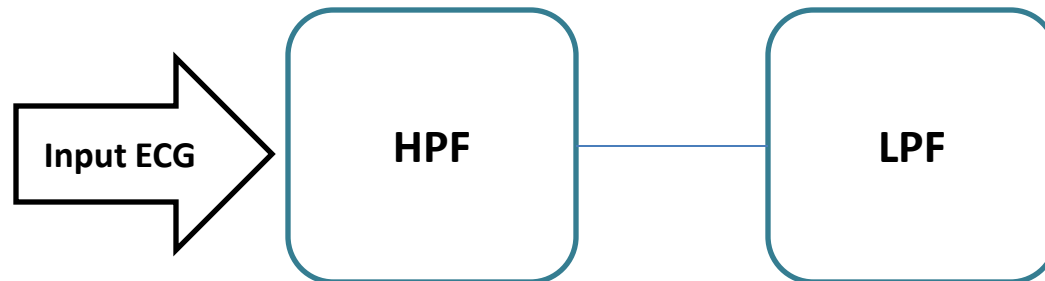
Processing techniques

Noise Cancellation

Further Analysis

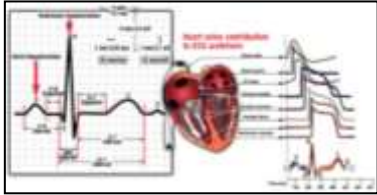
Noise Examples

- **Bandpass filter** : Cascading a high pass and low pass filters the low and high frequency signal will be canceled.



- Once the clear ECG signal is obtained, further analysis is applied depending on the application.

Processing ECG



Processing techniques

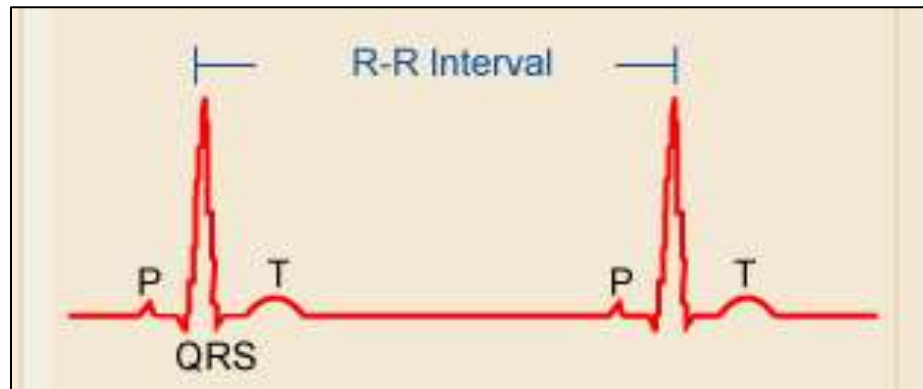
Noise Cancellation

Further Analysis

Noise

Examples

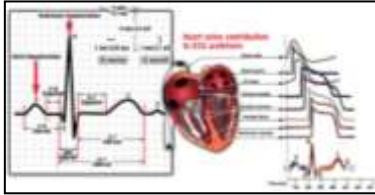
- To calculate the heart beat, passing the filtered ECG through the differentiator will help to determine the maximum picks by detecting the slope.
- R-R interval can then be calculated as shown in the diagram



- The given formula will then calculate the Heart Beat.

$$HR = \frac{60000}{R - R} \text{ (bpm)}$$

Processing ECG



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Examples

In this case two signals are required

Primary signal
which
has two components

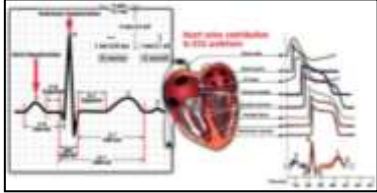
Reference Input
which is the
common noises

Clean ECG (S) + Noise signal (n_0)

Estimated Noise signal (Y)

The adaptive filters essentially minimizes the error between a primary input, which is the noisy ECG, and a reference input, which is either noise that is correlated in some way with the noise in the primary input or a signal that is correlated only with ECG in the primary input.

Processing ECG



Processing techniques

Noise Cancellation

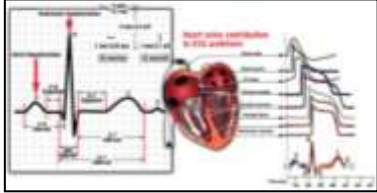
Further Analysis

Noise

Examples

- ❖ Wavelet transforms are used in detecting irregularities in QRS section accurately.
- ❖ Wavelet Energy based Diagnostic Distortion (WEDD) for distortion measurement.
- ❖ Heart Rate Variability (HRV) to measure regulated emotional responding.

Processing ECG



Processing techniques

Noise Cancellation

Further Analysis

Noise

Examples

ECG Database

MIT-BIH Arrhythmias database(PhysioNet)

The MIT/BIH arrhythmia database [6]

AAMI Standard

MIT-BIH heartbeat types are combined according to Association for the Advancement of

Medical Instrumentation (AAMI) recommendation [7].

Thank you

References

- [1] L. Wang, “The ECG Signal Processing by ADSP-21062 Digital Signal Processor”, Thesis submitted to the College of Engineering and Mineral Resources at West Virginia University, 2005 .
- [2] C. Saritha, V. Sukanya & Y. Narasimha Murthy, ECG Signal Analysis Using Wavelet Transforms, February 2008 .
- [3] <http://www.adinstruments.com/>, “Electrocardiogram and Heart Sounds”, An Introduction to the recording and analysis of electrocardiograms, and the sounds of the heart.
- [4] Md. Zia Ur Rahman, R.A.Shaik & D V R. K. Reddy, “Noise Cancellation in ECG Signals using Computationally Simplified Adaptive Filtering Techniques: Application to Biotelemetry” ,
- [5] S. Z. Islam¹, S. Z. Islam², R. Jidin³ & M. A. M. Ali⁴, “Performance Study of Adaptive Filtering Algorithms for Noise Cancellation of ECG Signal”,
- [6] MIT-BIH Database distribution, www.physionet.org/physiobank/database/mitdb/
- [7] American National Standard for Ambulatory Electrocardiographs, publication ANSI/AAMI EC38-1994, Association for the Advancement of Medical Instrumentation, 1994.