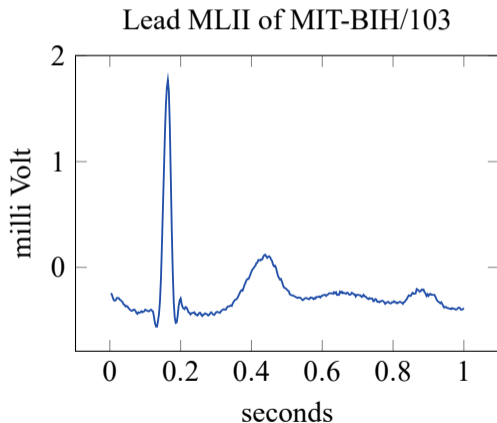# What is an ECG?

Figure 1: ECG of one heartbeat

- electrocardiogram (ECG or EKG) records the heart's electrical activity

- contains up to 12 simultaneous measurements – the leads [moody1992a]
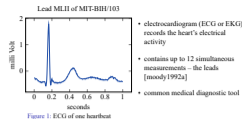
- common medical diagnostic tool

MSAX for ECG Analysis
└─Introduction
  └─ECG Basics
    └─What is an ECG?

2021-04-30

Figure 1: ECG of one heartbeat

- muscle contractions caused by electric pulses
- electric pulse can be measured on the skin
- the measuring things are called electrodes
- electrodes form leads (need 2 to measure anything)
- they have specific positions and names
- 12 leads is the modern standard
- most types of heart disease can be detected
- diagnosis and analysis is performed by trained cardiologists
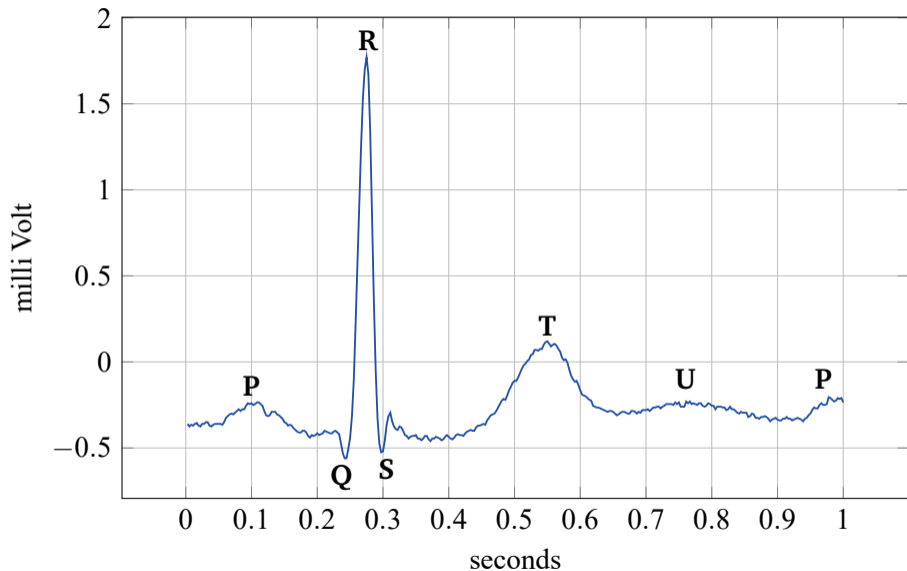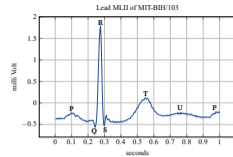- datasets available online; contain 2 or more leads (the most significant ones)

Figure 2: Annotated ECG of one heartbeat

Figure 2: Annotated ECG of one heartbeat

- P: short repolarization
- Q: repolarization before heartbeat
- R: big contraction that actually pumps blood
- S: section after heartbeat
- T: big repolarization; this is where ischaemia is
- U: not always present
- P: short repolarization

ECGs as Time Series

Definition

A discrete multivariate time series is a sequence of values

$$\{\mathbf{x}[t]\}_{t\in\{1,\ldots,T\}}$$

where

- $\mathbf{x}[t] = (x_1[t], \ldots, x_n[t])$ — set of values at moment t,
- t — discrete moment in time,
- T — number of sets of values,
- n — number of values at moment t.

$\Rightarrow$ ECGs are discrete multivariate time series [anacleto2020]

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⇒ ECGs are discrete multivariate time series [anacleto2020]

- multivariate: measure more than 1 lead per time point
- discrete: set sample frequency in the machines
- discrete: because measured at discrete moments in time
- time series: they are data measured at equal time intervals
- n measurements per point in time (i.e. leads)
- $n = 1$ is univariate, $n > 1$ is multivariate

Automated ECG Analysis

- ECGs represent large amounts of data, thorough analysis is required

- 5 stages: (1) signal acquisition, filtering; (2) data transformation, processing; (3) waveform recognition; (4) feature extraction; (5) classification[kligfieldpaul2007]

- some methods include FFT, DWT, ANN, kNN, filters

- balance between accuracy and complexity needed

SAX and MSAX

- Symbolic Aggregate Approximation (SAX) creates a simplified, symbolic representation [lin2003]

- is guaranteed to behave like the original data

- works on univariate time series, has been used on ECGs[zhang2019]

- Multivariate SAX (MSAX)[anacleto2020] expands SAX to multivariate time series

$\rightarrow$ using MSAX on ECGs should increase the accuracy of discord detection compared to SAX