Biomedical Signal

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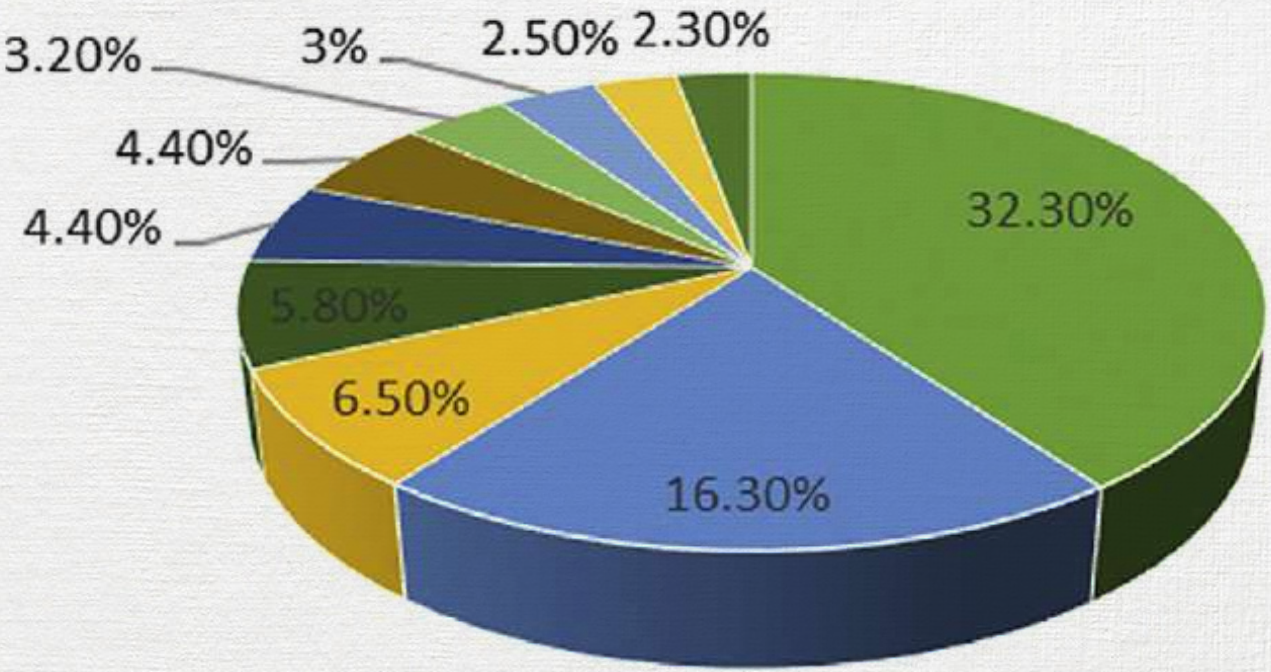
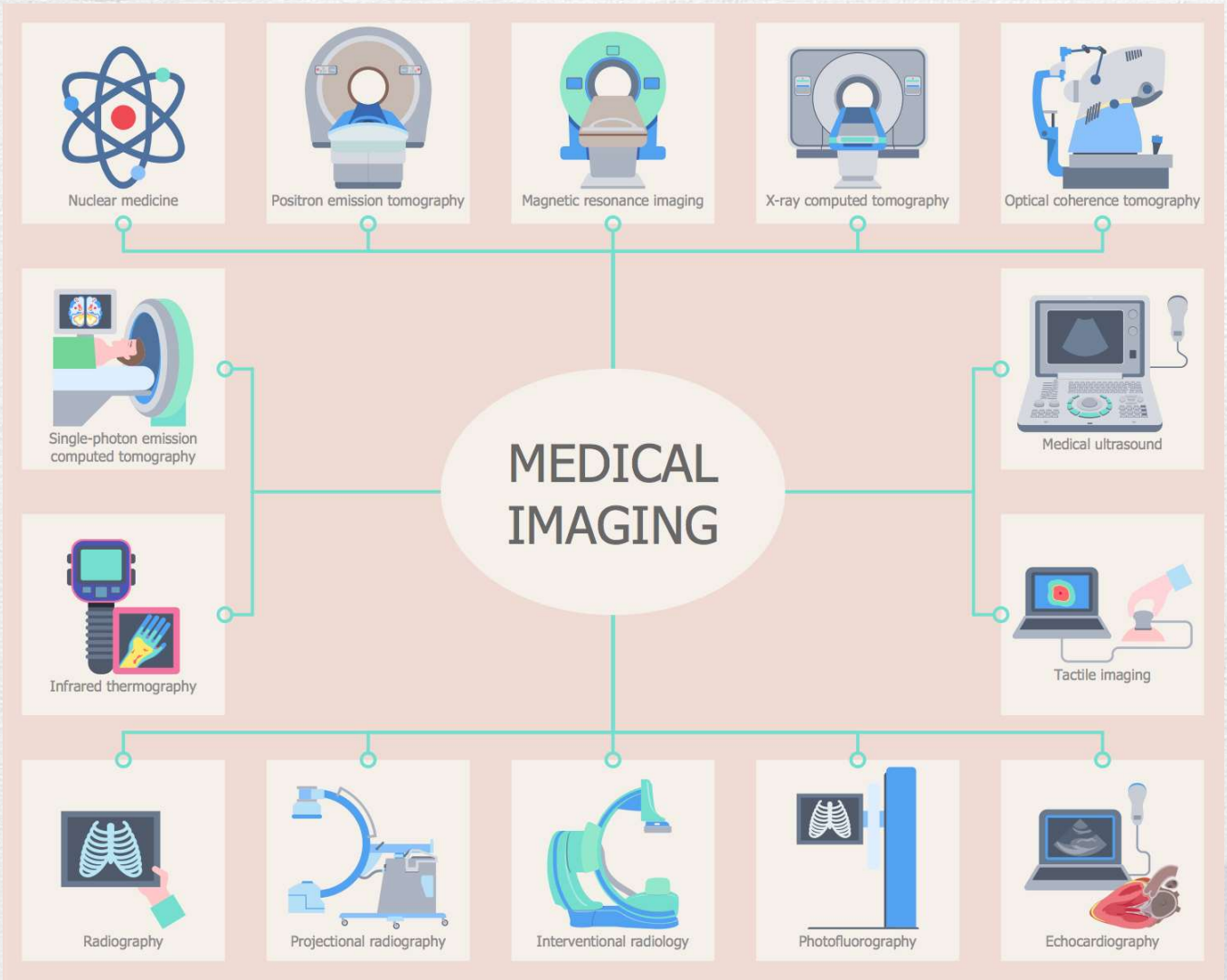
Overview

Introduction



Introduction



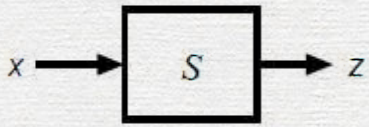
Signal

- A signal: a function of independent variables
  - Time, distance, position, temperature, pressure, etc
- Carries information
- Generated naturally
  - Can also be generated artificially
- A function of one, two, or N dimensions (1D, 2D or 3D).

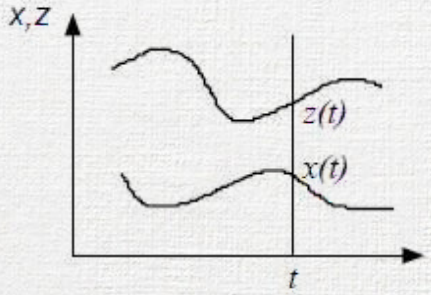
Analog and Digital signals

- Representing the numerical value of quantities
  - Analog: values from a continuous (infinite) set
  - Digital: values from a finite number of discrete values

Fundamental of signals



(a)



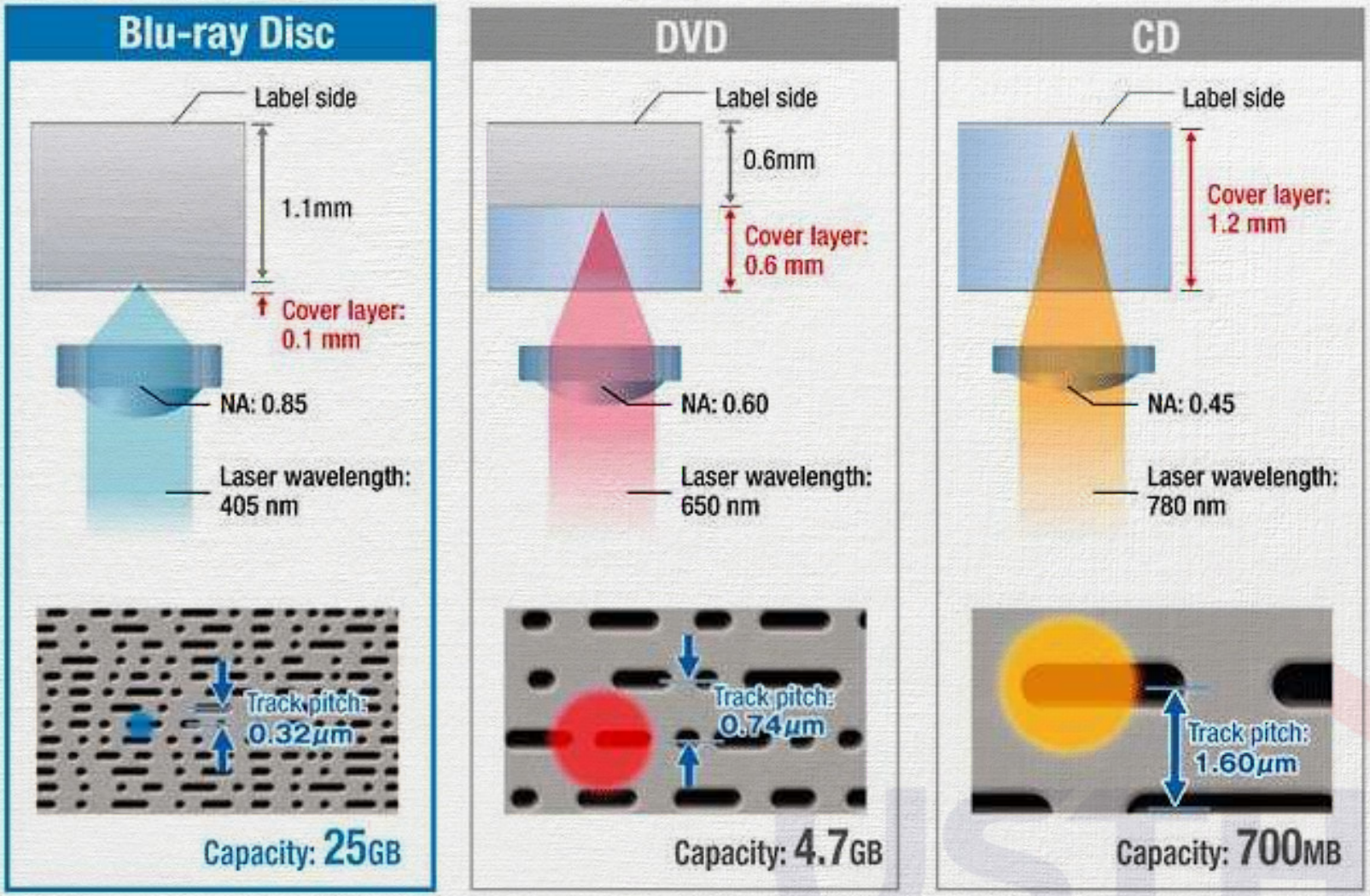
(b)

(c)

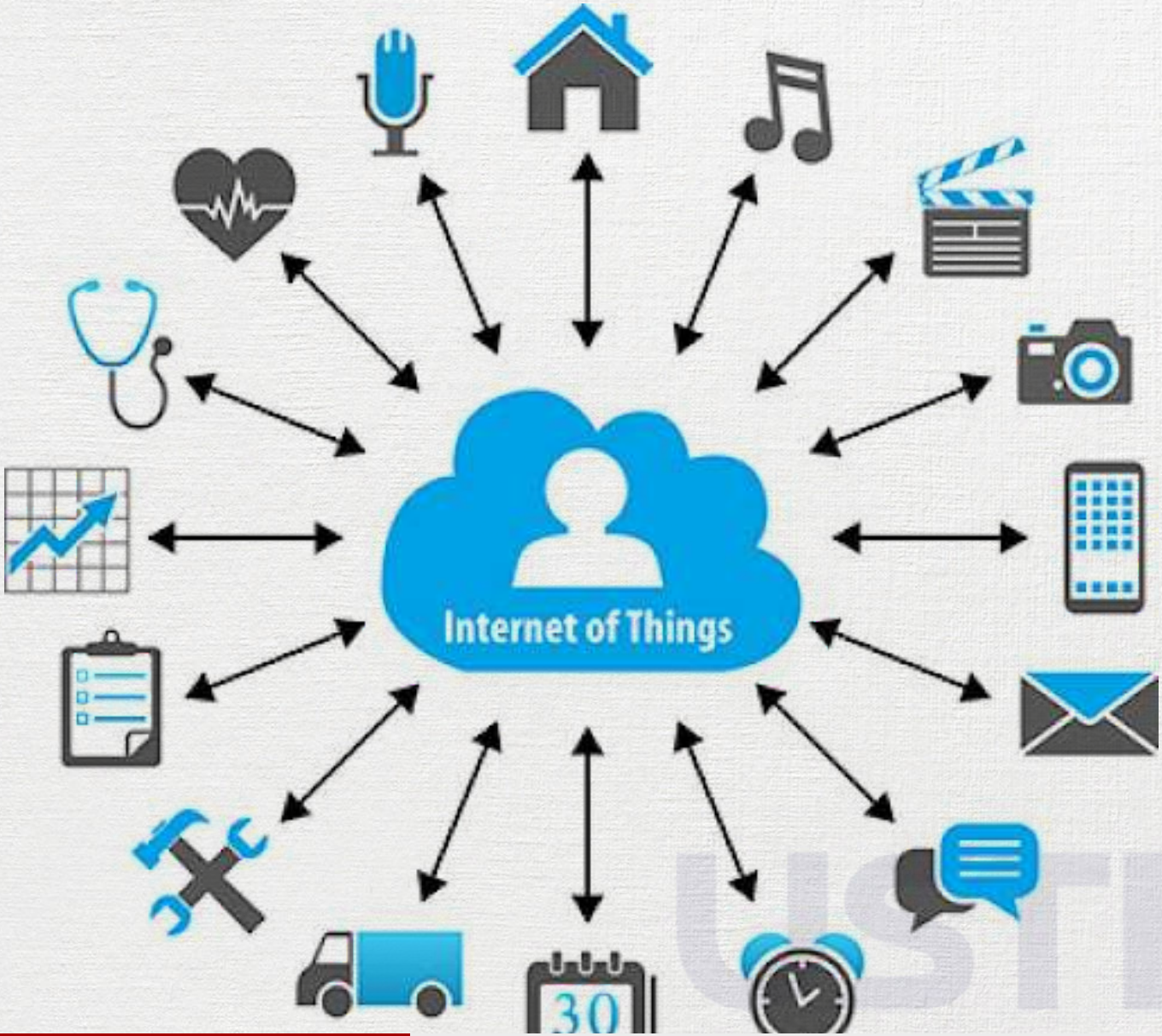
t	0	1	2	3	4	5	6	7
$x(t)$	2	3	2	5	4	5	3	3
$z(t)$	5	4	7	7	6	6	2	4

(d)

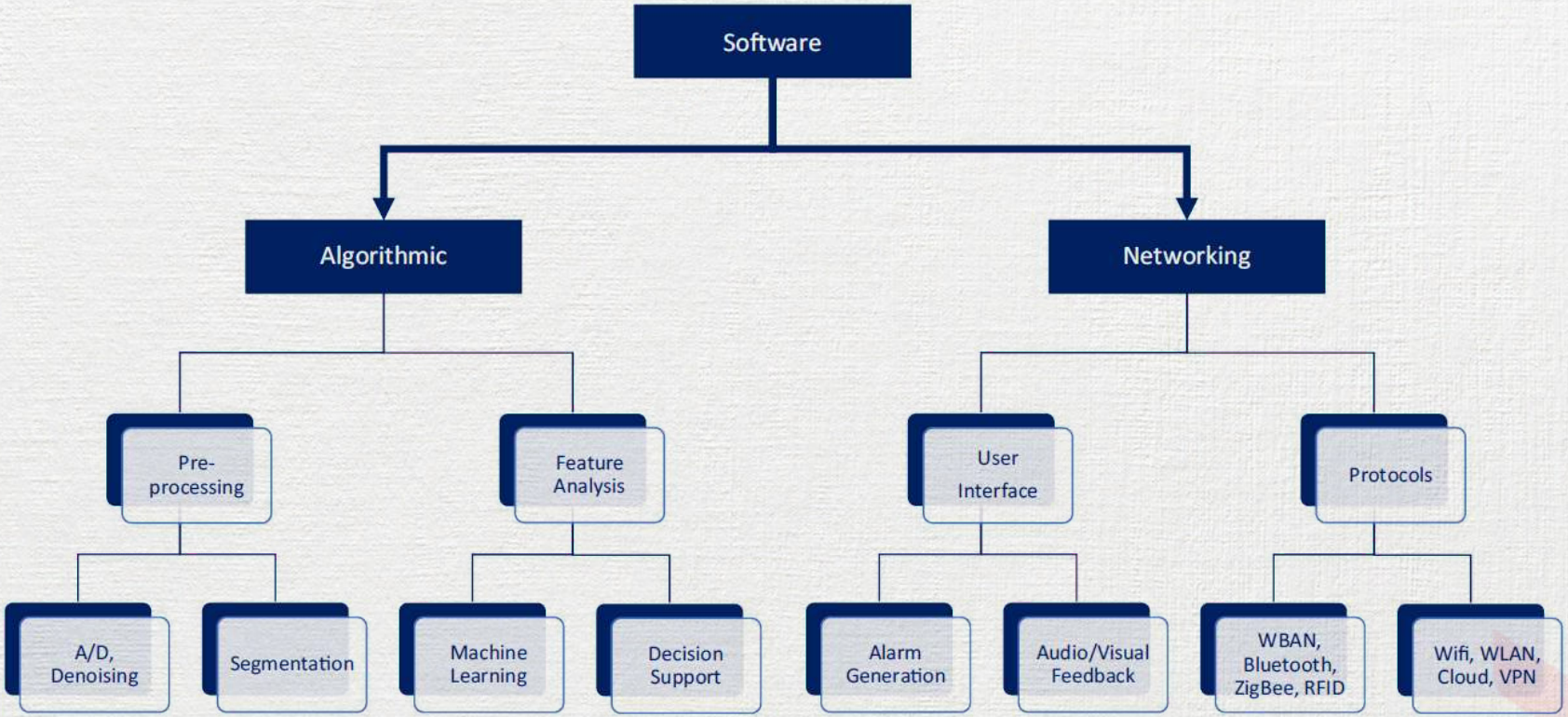
Fundamental of signals



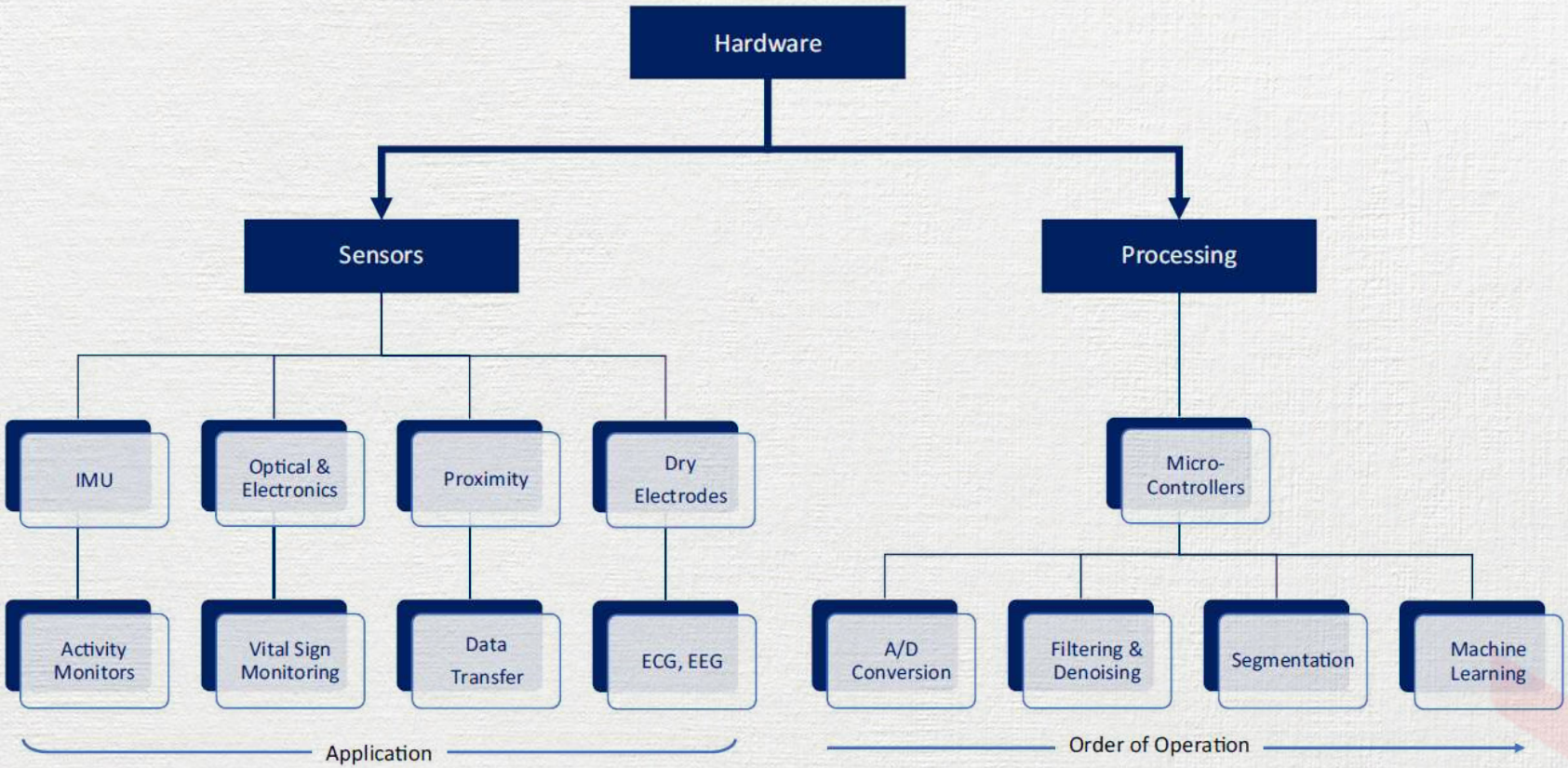
IoMT



IoMT Software

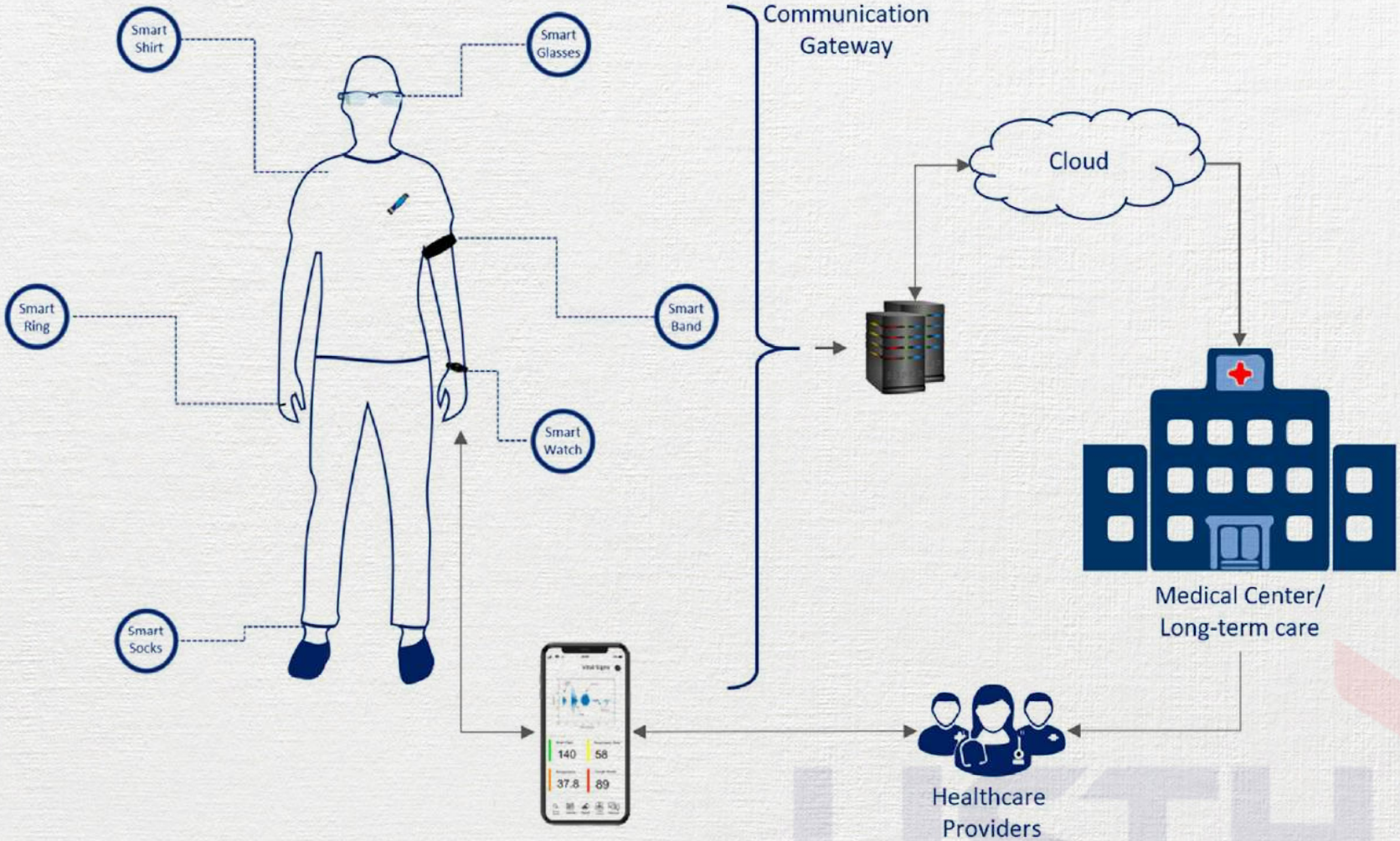


IoMT Hardware



Biomedical signals

Biomedical signals



Biomedical signals

- The human body is made up of different systems
  - the nervous system,
  - the cardiovascular system,
  - the respiratory system...

Biomedical signals

- The different physiological signals in the human body
- Cause diseases and lead to pathological processes.
- The nature of these physiological signals can be in the form of
  - physical
  - electrical
  - or biochemical signals

Biomedical Signals

Biomedical signals

- Bioelectrical signals correspond to physiological and anatomical aspects of the human body
- Detection
  - Electronics sensors
  - Optical sensors
  - Mechanical sensors

placed on the surface of the body.

Biomedical signals

- Amplitude modulation and frequency modulation components
- 4N:
  - Nonstationarity
  - Nonlinearity
  - Non-Gaussian
  - Near-sparse
- 4V
  - Velocity
  - Variety
  - Veracity
  - Volume

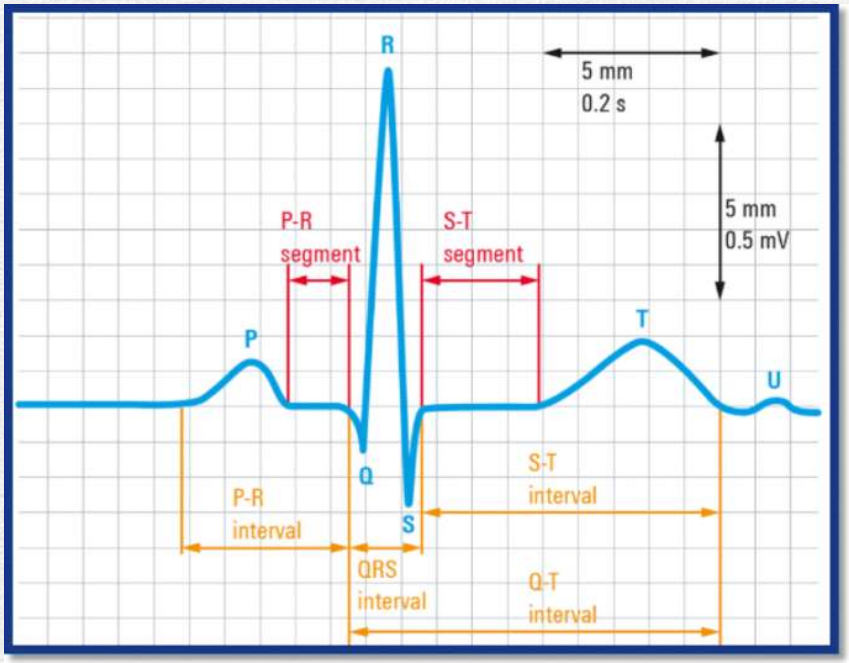
Examples

From	Metrics
Heart	Electrocardiogram (ECG)
Brain	Electroencephalogram (EEG)
Muscle	Electromyogram (EMG)
Blood oxygen level	Oxygen Saturation (SpO2)

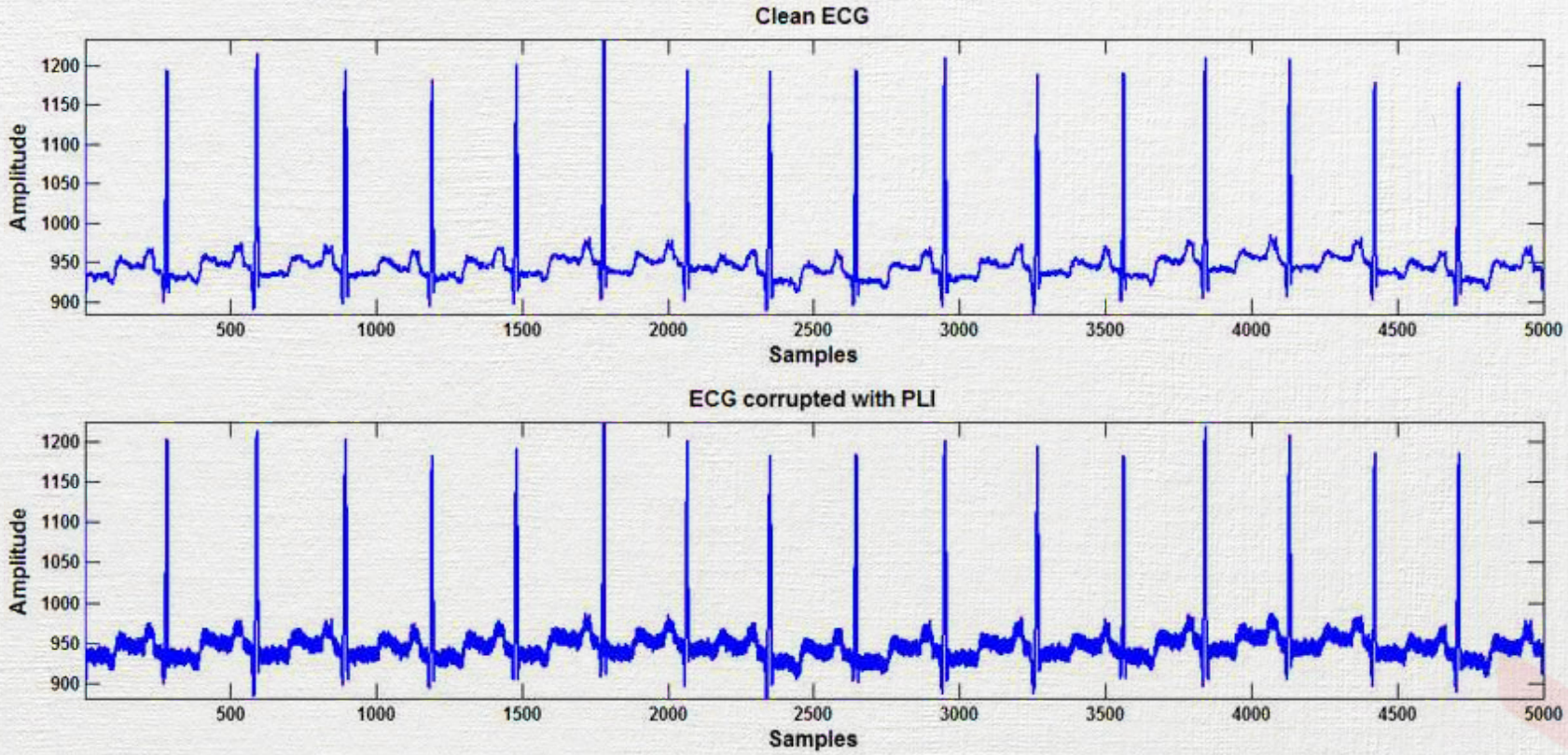
Acquisition

Electrocardiogram (ECG)

- Electrical recording of cardiac activity especially heart rhythms
- Normal values
  - P wave: 80 ms
  - QRS complex: 80 – 100 ms • T wave: 160 ms
  - PR interval: 120 – 200 ms
  - PR segment: 50 – 120 ms
  - ST segment: 80 – 120 ms
  - RR interval: 0.6 – 1.2 s



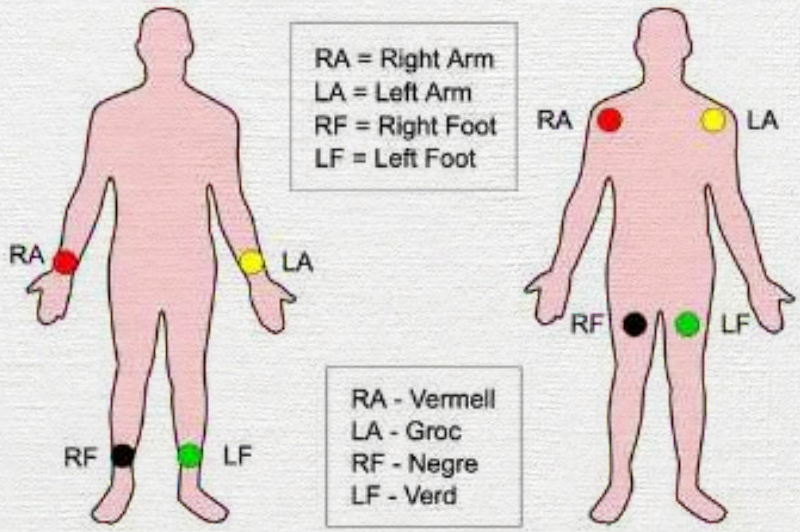
Electrocardiogram (ECG)

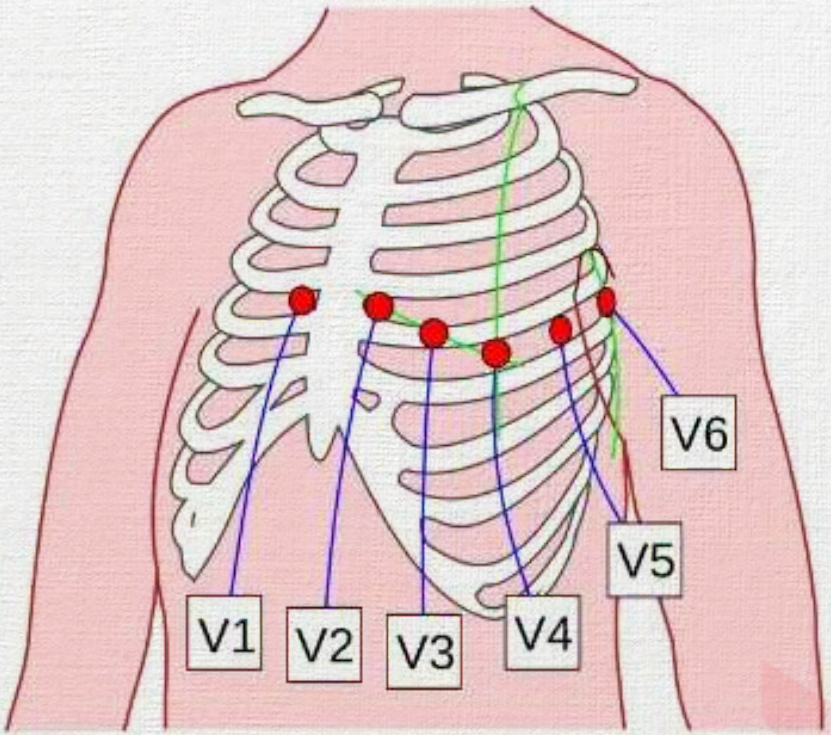


Electrocardiogram (ECG)

- Measuring ECG under different conditions
  - resting state ECG (comfortable position),
  - stress ECG (person is exercising),
  - ambulatory ECG (patient's ECG is recorded continuously for days or weeks).

Electrocardiogram (ECG)





Electrocardiogram (ECG)

Electrocardiogram (ECG)

ECGs are typically used:

- Detecting arrhythmias (heart beats faster or slower)
- Detecting myocardial infraction or heart attacks especially
  - Heart blood supply restricted
  - Cardiomyopathy
- Coronary artery disease
  - Fatty substances restricting the flow of blood in arteries.
- Seizures
- Medical monitoring when some kind of anesthesia is involved.

Electroencephalogram (EEG)

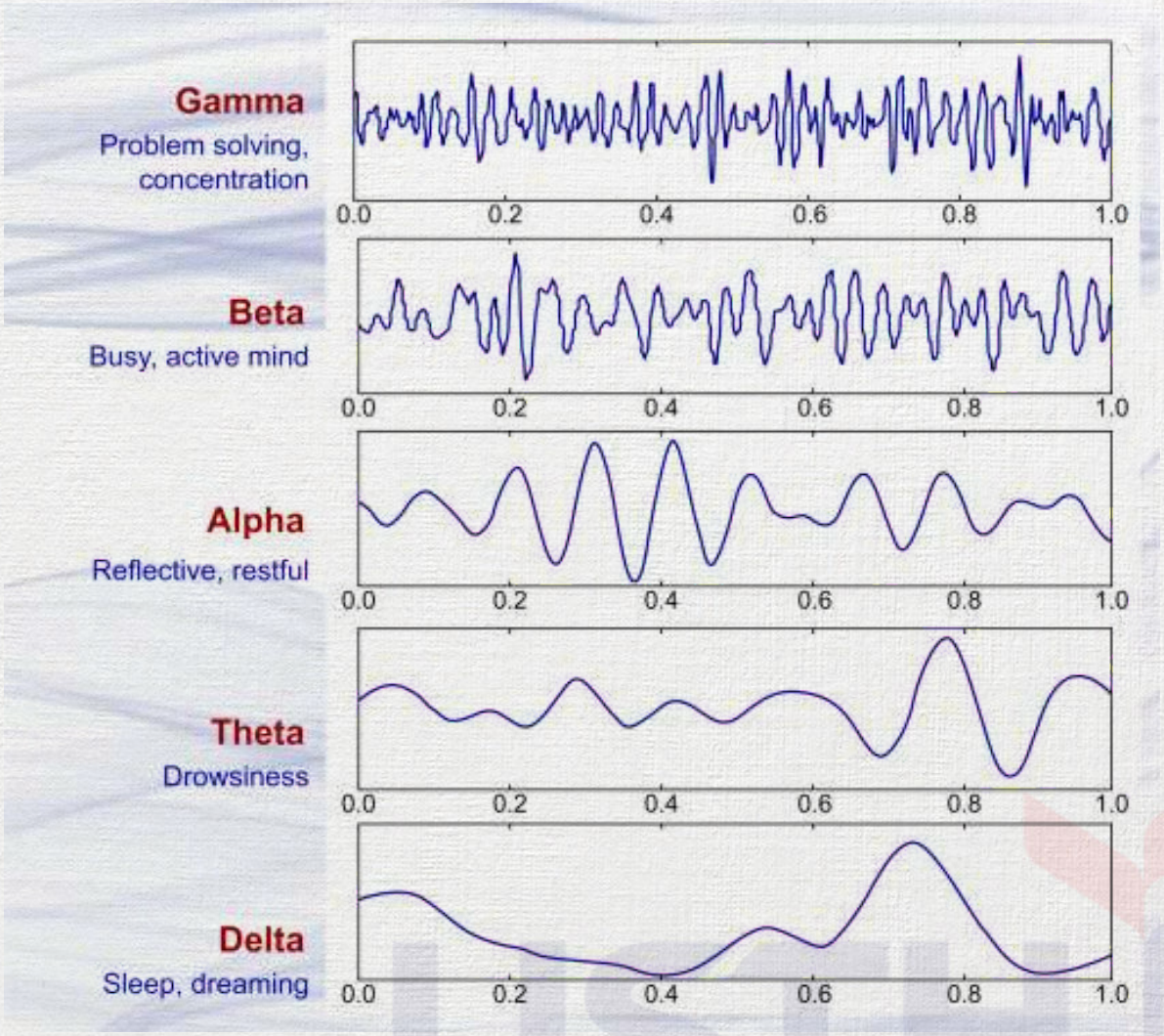
- Graphical representation of electrical activity of the brain captured from the scalp using few electrodes.
- Reflects the cortical electrical activity

Electroencephalogram (EEG)

- Detecting
  - seizures
  - brain trauma
  - brain tumor
  - head injury
  - sleep disorders
  - other neurodegenerative diseases
- The most popular EEG electrodes topography is called as 10 - 20 EEG system

Electroencephalogram (EEG)

- Bands based on the frequency



Electrocardiogram (ECG)

Frequency band	Frequency	Brain states
Gamma (γ)	35 Hz	Concentration
Beta (β)	12-35 Hz	Anxiety dominant, active, relaxed
Alpha (α)	8-12 Hz	Very relaxed, passive attention
Theta (θ)	4-8 Hz	Deeply relaxed, inward focused
Delta (δ)	0.5-4 Hz	Sleep

Electrocardiogram (ECG)

- Applications
  - Seizure, Alzheimer's, and epilepsy detection
  - Brain activity analysis
  - Neuroentertainment such as VR
  - Sleep analysis and study
  - Cognitive training: brain aging, mindfulness, focus, etc.
  - EEG biometrics for security
  - Anxiety disorders
  - Attention deficit hyperactivity disorder study

Practice!

Practical work 1

- ECG Heartbeat Categorization
  - Download dataset from Kaggle
  - Explore dataset
  - Build ONE machine learning/deep learning model to perform classification
  - Compare results with the original paper

Practical work 1

- Write a report (in LaTeX)
  - Name it « Report.1.tex »
  - Describe the dataset *in detail* that you have downloaded
  - Explain how you implement the model
  - Try experimenting with different hyperparameter values
- Push the report and your code (Notebook and .py script) to your forked repository