Nhóm Khoa học dữ liệu Y sinh

Phân tích tín hiệu sinh học

Giảng viên:

- Lưu Gia Thiên
- Lê Ngọc Tài
- Nguyễn Mai Hoàng Long
- Nguyễn Bá Hoàng
- Lê Ngọc Khả Nhi

Từ tháng 1 năm 2021

Tentative plan

Stage 1: Basic concept and data wrangling

Stage 2: Digital biosignal processing

Stage 3: Machine learning

Nhóm Khoa học dữ liệu Y sinh

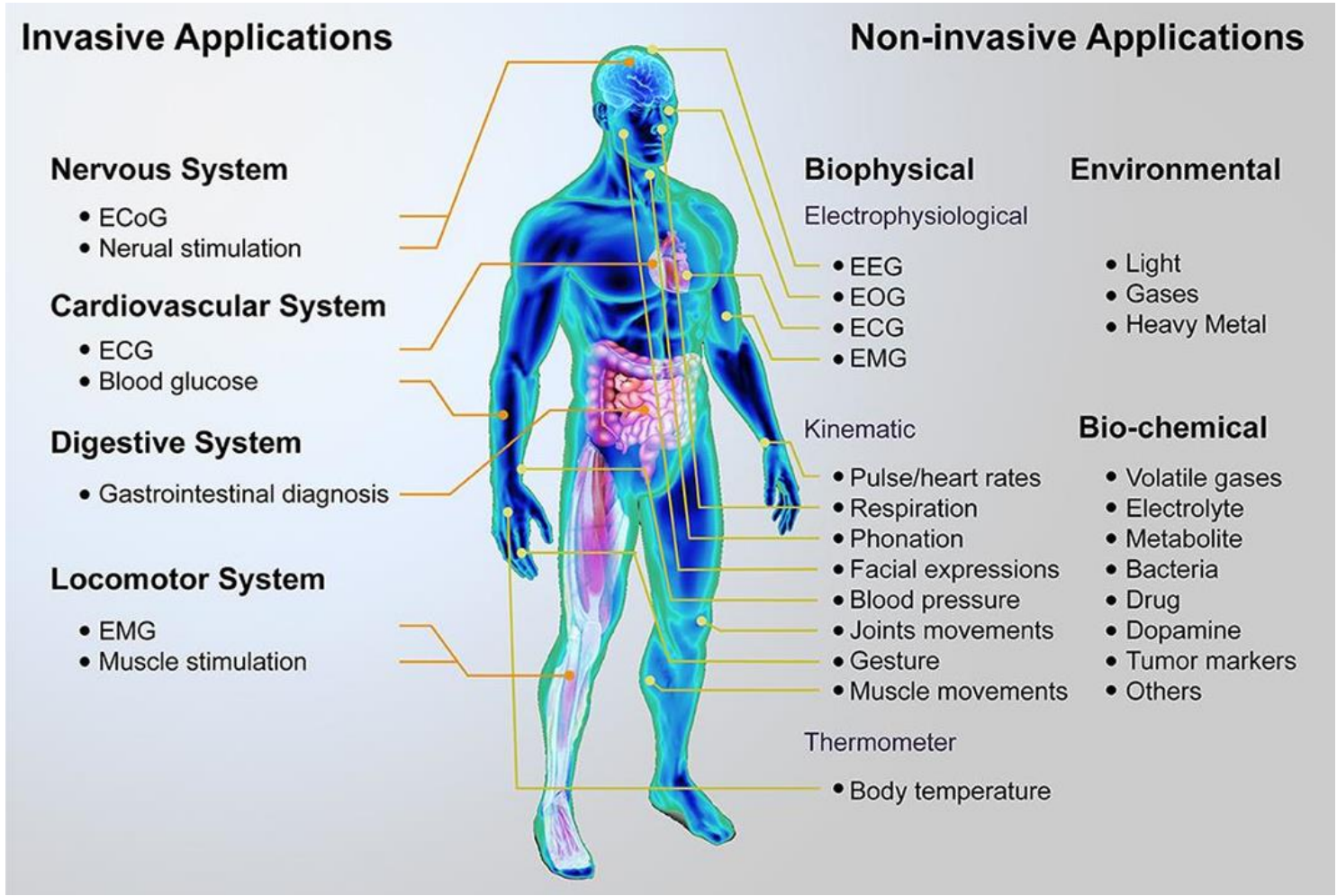
Dự án ‘Phân tích Tín hiệu sinh học’

Tín hiệu sinh lý tim mạch
Công nghệ và ứng dụng

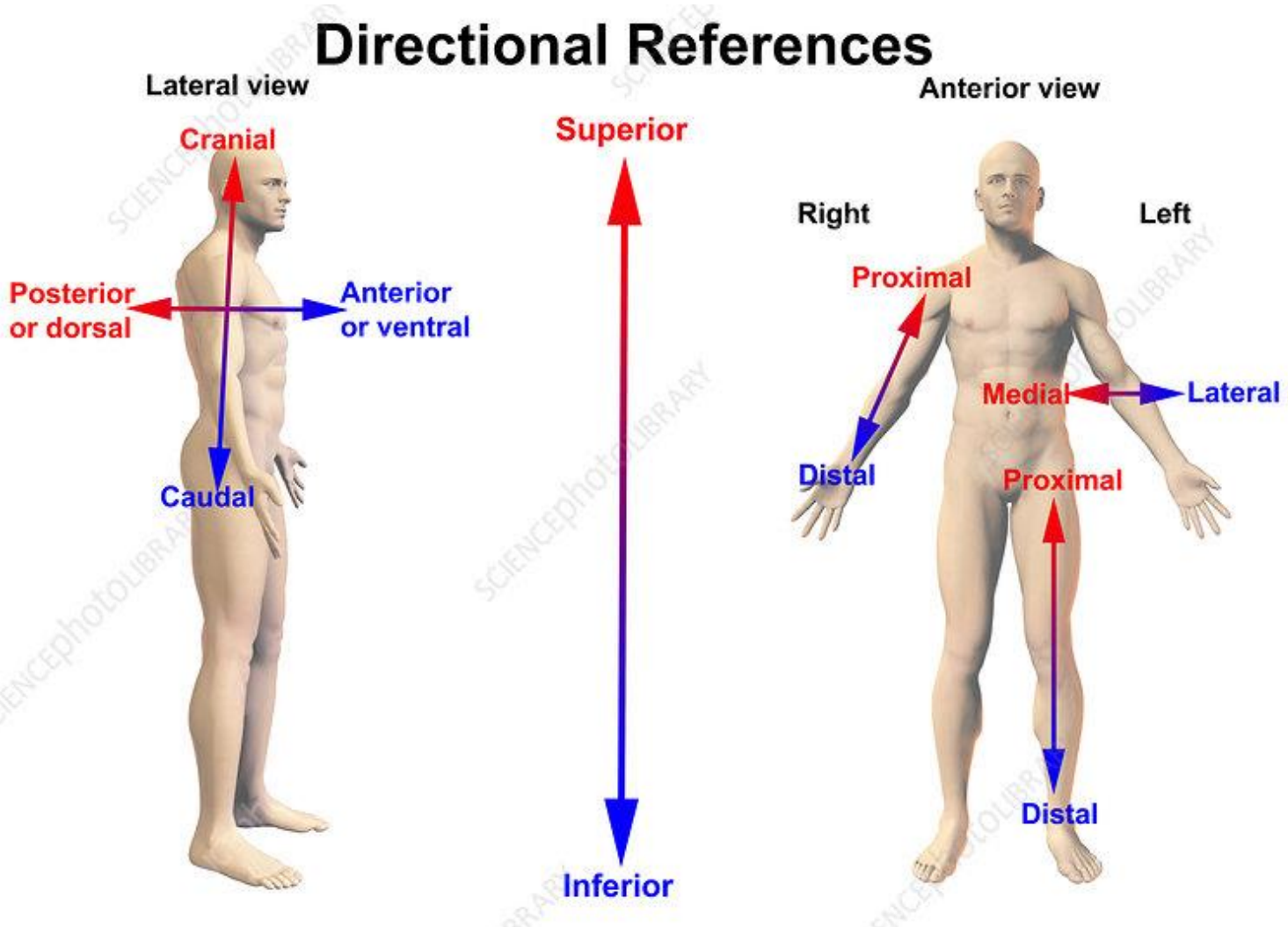
Tác giả

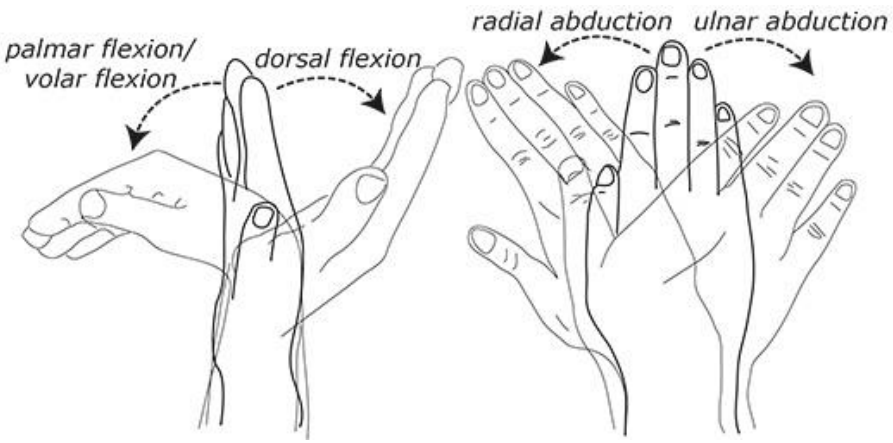
- Nguyễn Mai Hoàng Long
- Lê Ngọc Tài

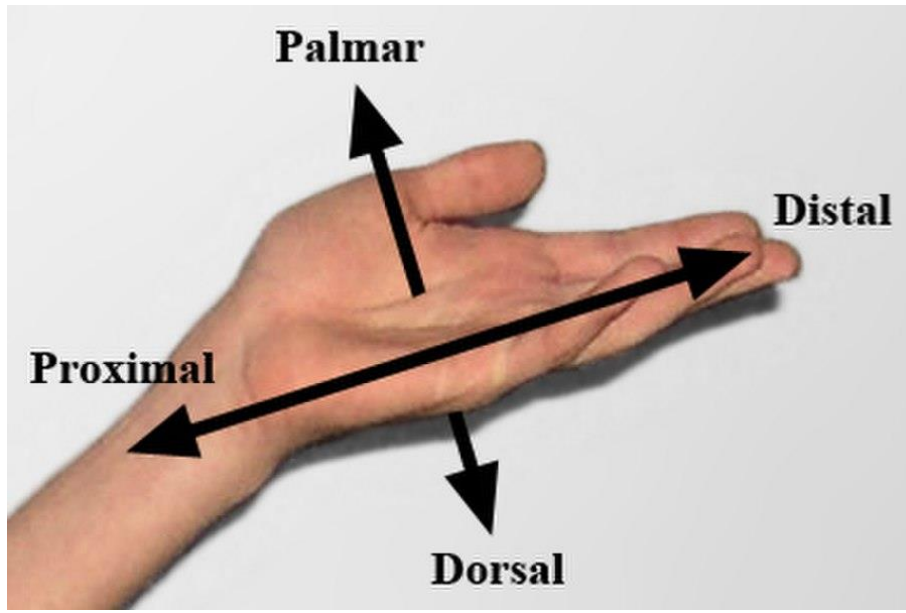
Genesis of Biosignal - Cardiology



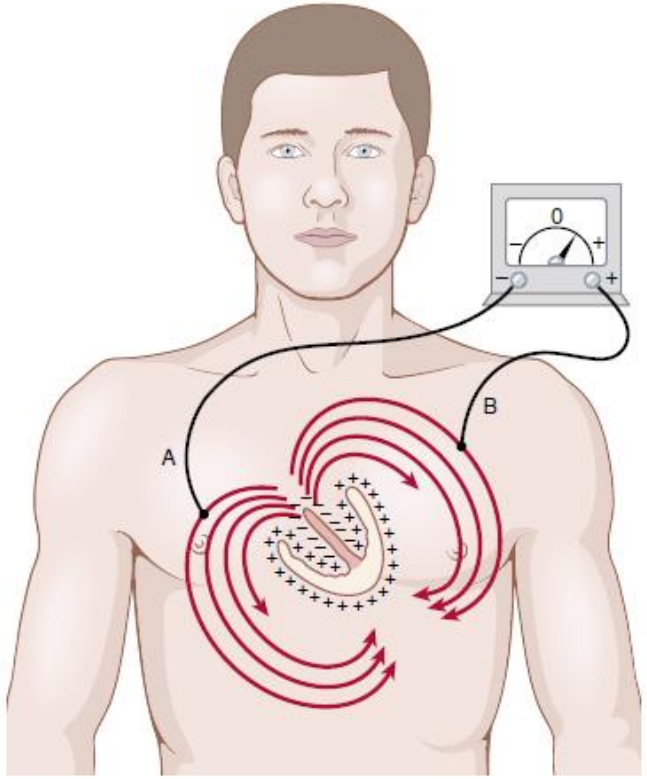
Definition of directional human

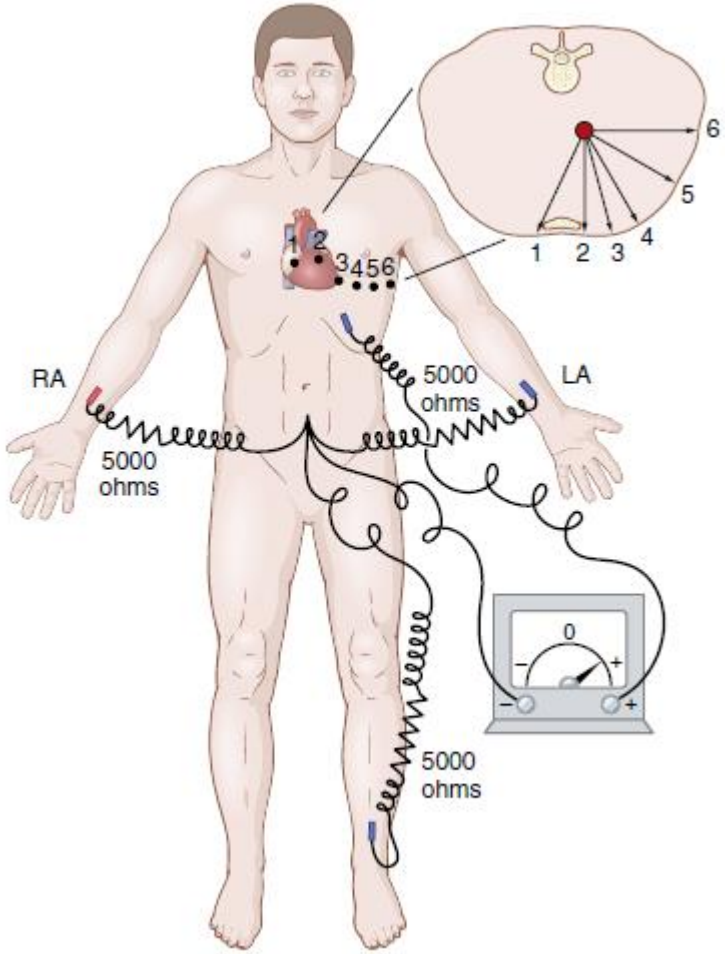


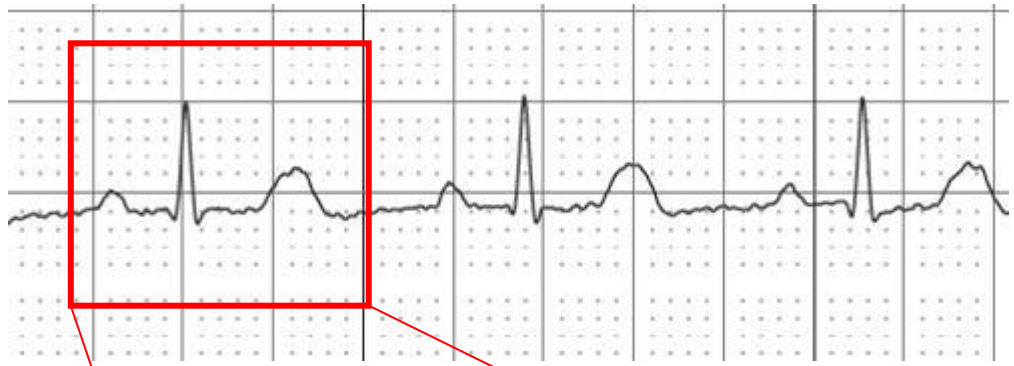


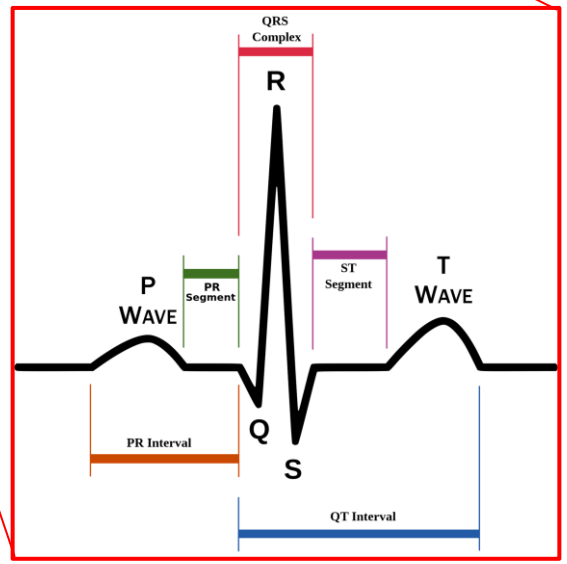


Electrocardiogram (ECG)

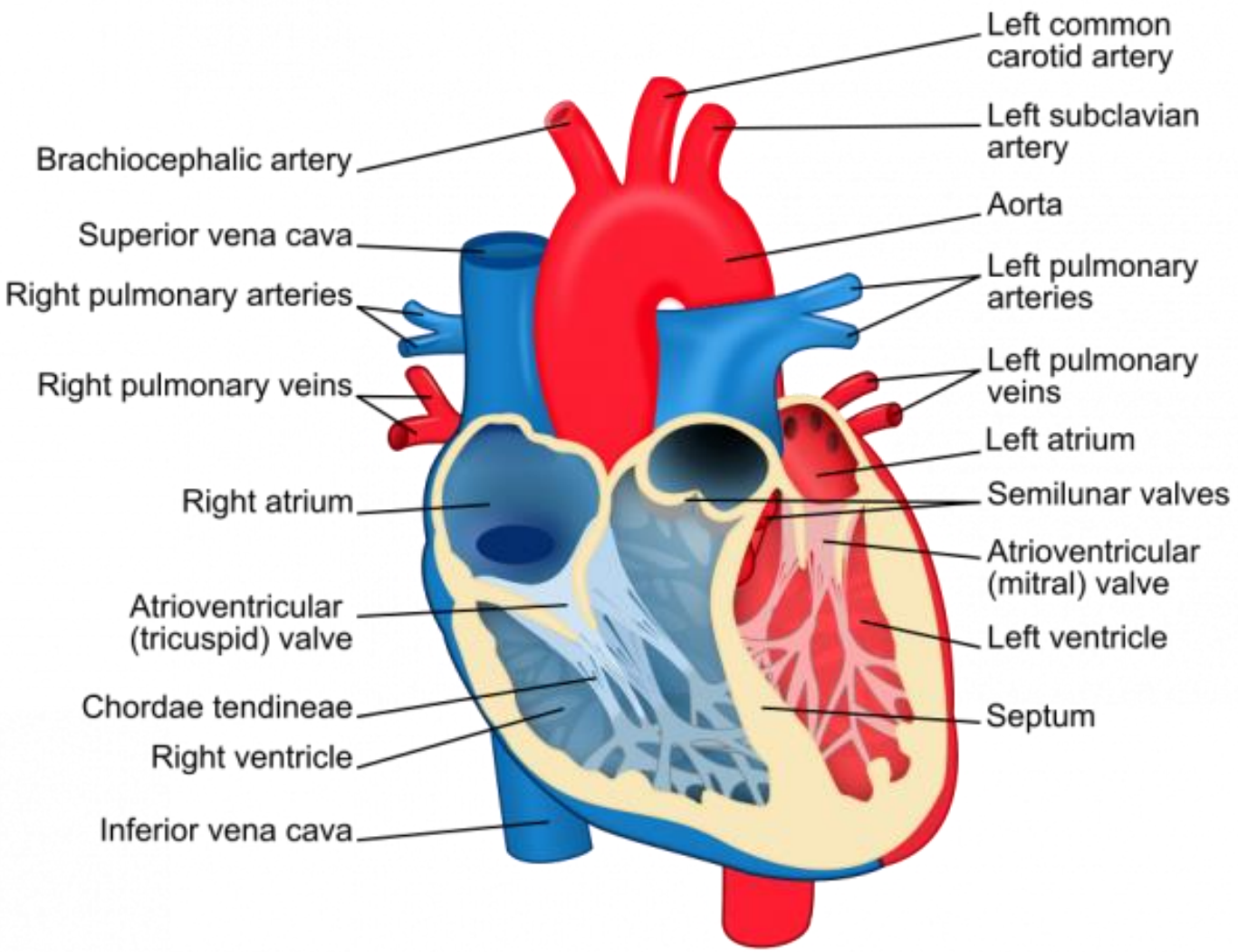




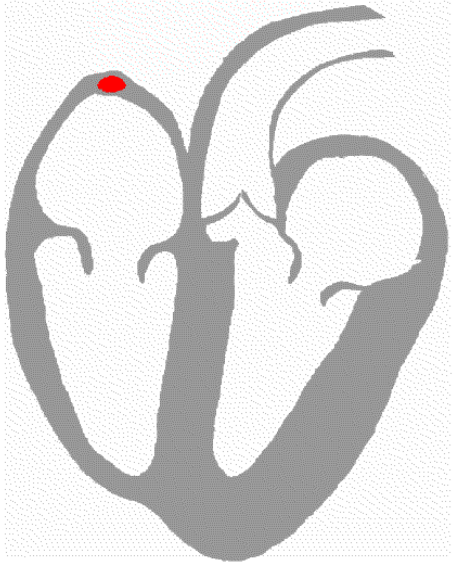


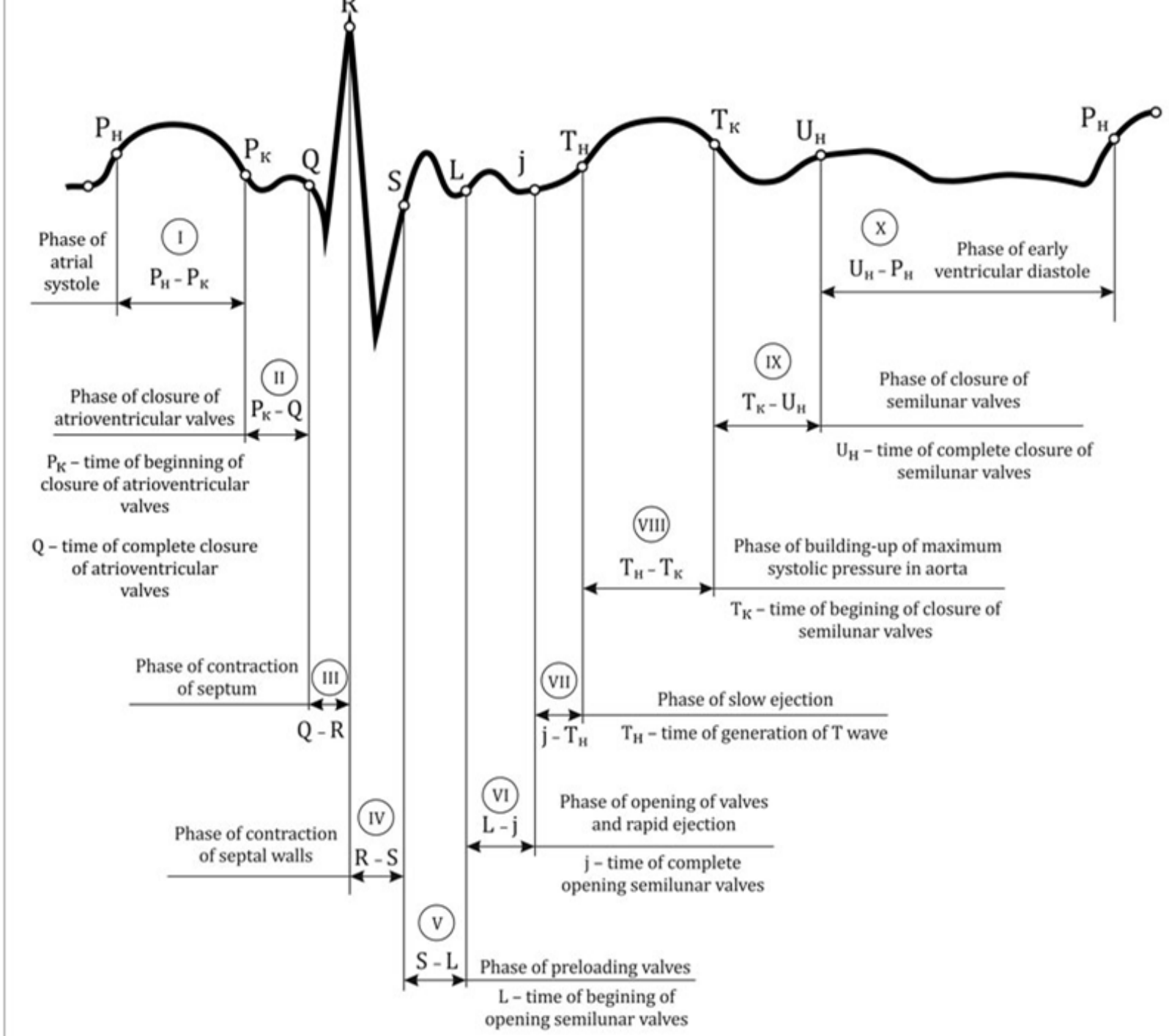


Heart Structure



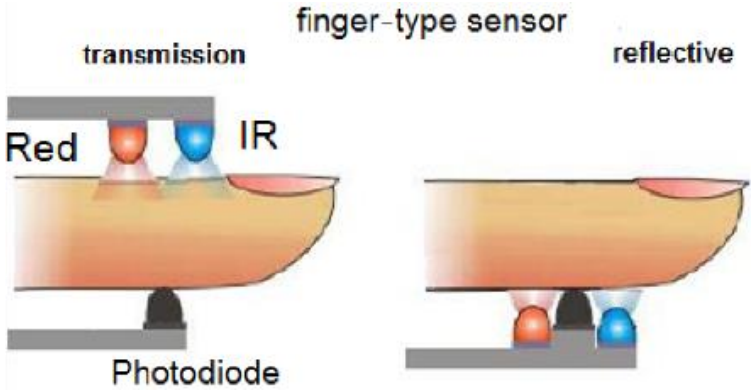
ECG Signal in Detail

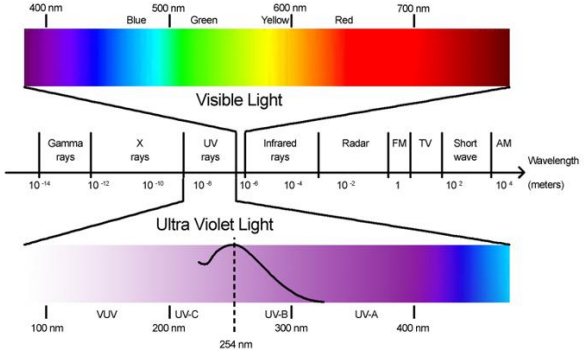


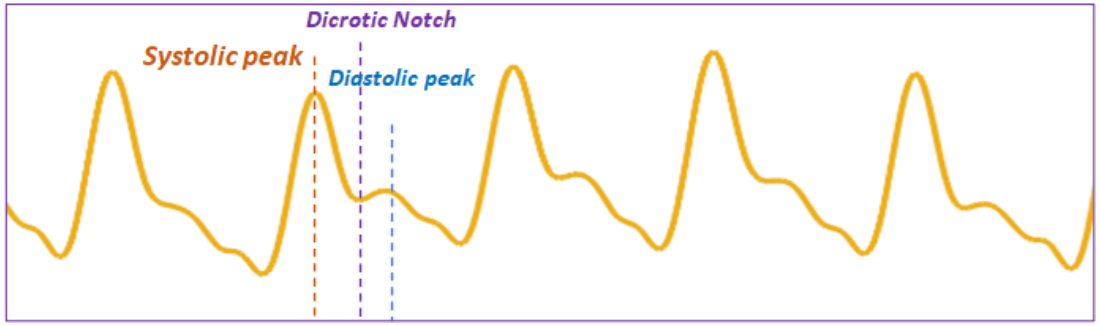


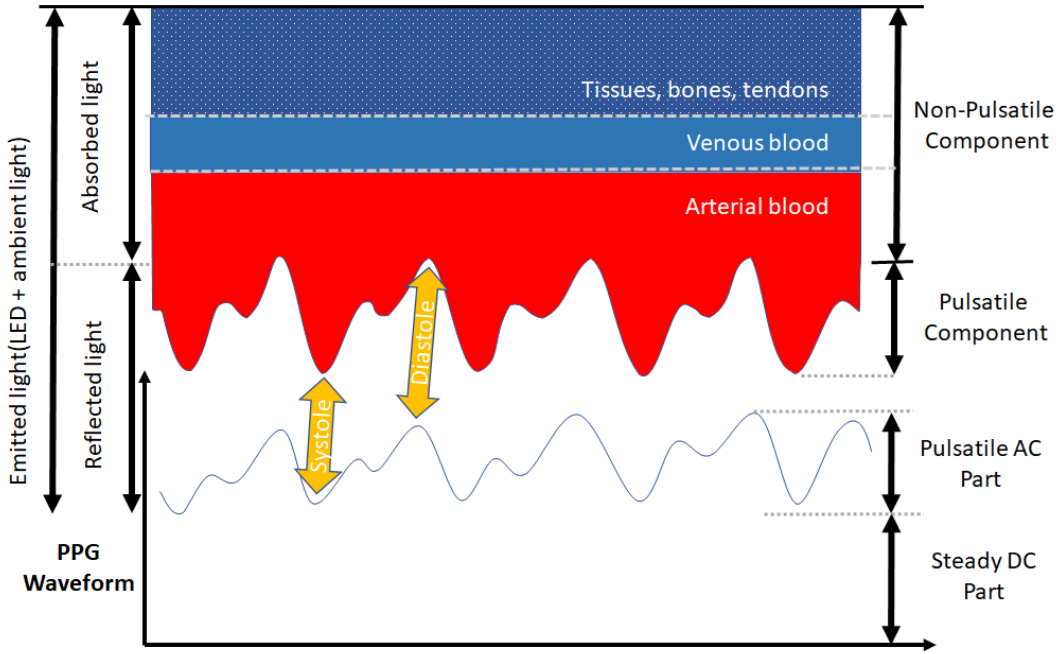
Photoplethysmography (PPG)

- PPG is an optical sensor with a LED and a PD.
- These are two types of PPG techniques:
  - Transmission PPG
  - Reflectance PPG
- Measured based on the variation of light intensity caused by blood flow in the vessels.
- The PPG waveform includes AC and DC parts
- Common sensor places are fingertips, wirst, forehead, earlobe, thigh, ankle etc.
- Applying to measure SpO2, HRV, BP etc.







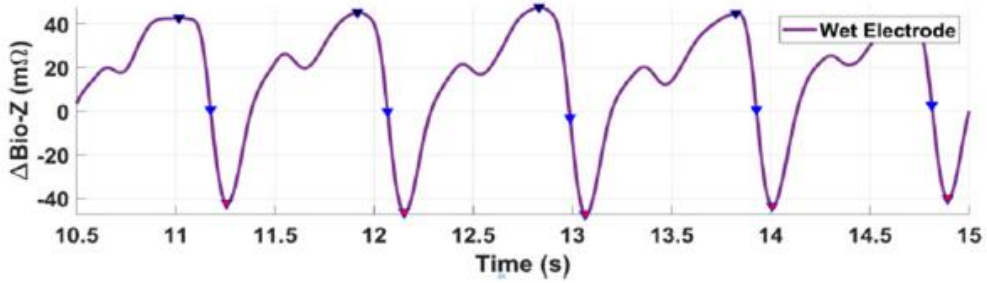


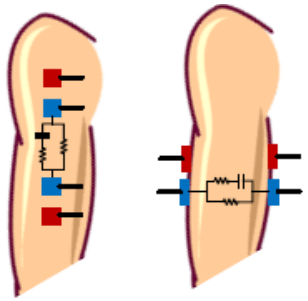
Impedance Plethysmography (IPG) or Bio-impedance (Bio-Z)

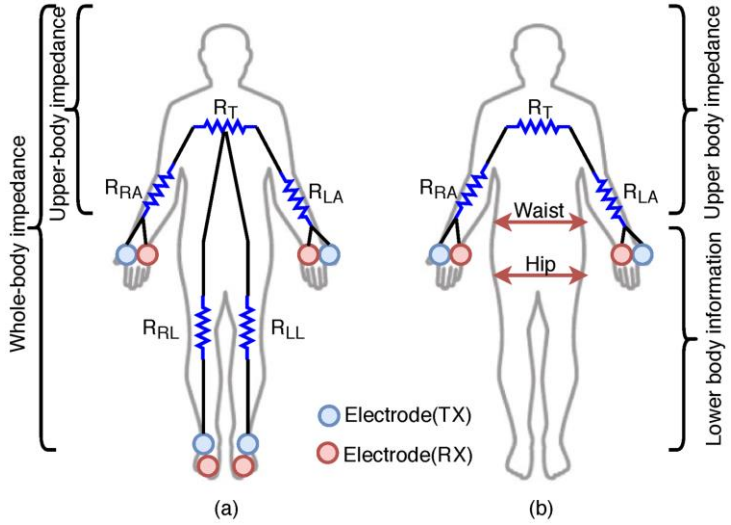
- Measured based tissue impedance between two V-electrodes (RX) while injecting high frequency current from two I-electrodes (TX).
- There are two types of IPG circuit
  - Bi-electrodes IPG
  - Terra-electrodes IPG (higher accuracy)
- Maximum current is obeyed IEC60601 standard

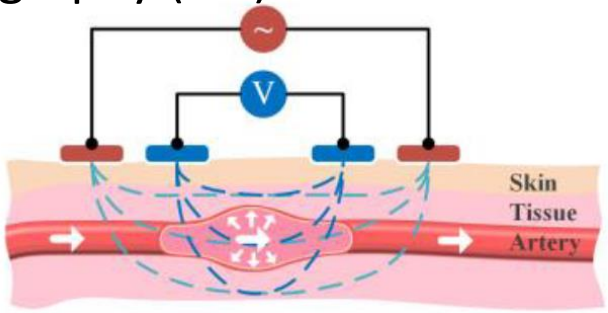
$$I_{AC_{MAX}} = \begin{cases} 10\mu Arms & (f \le 1\,Khz) \\ \dfrac{f}{1000Hz} \times 10\mu Arms & (f > 1\,Khz) \end{cases}$$

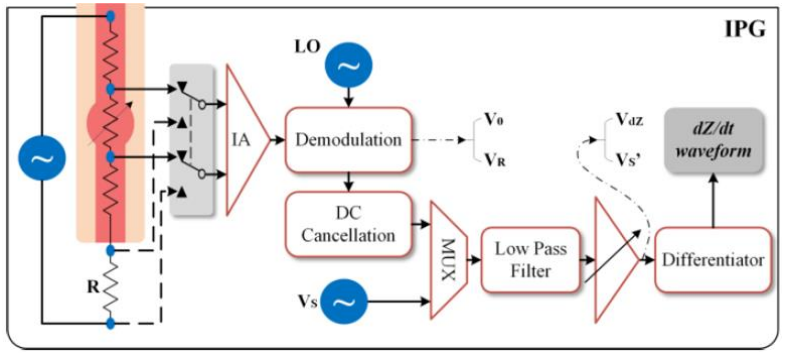
- Applying to measure HR, Bioelectrical Impedance analysis (BIA), Electrical Impedance Tomography (EIT)





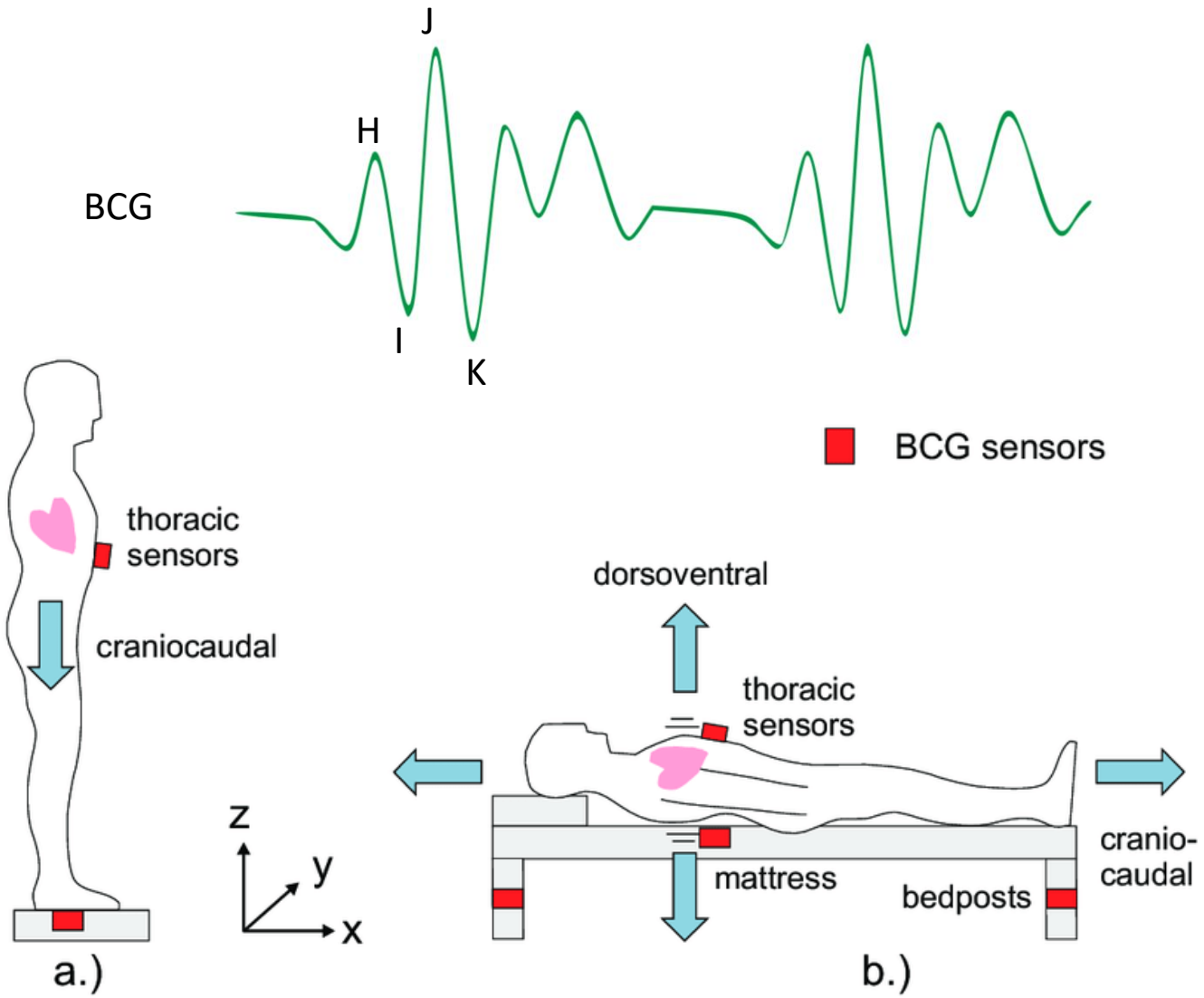






Ballistocardiogram (BCG)

- Motion imparted to the body from the motion of the blood and the heart during each cardiac cycle.
- These repeated motions happen due to the rapid acceleration of blood when it is ejected and transferred into other vessels of the body during periods of relaxation and contraction
- Measured at wrist, ear, feet or back (embedded sensor in bed/chair)



Source: https://ieeexplore.ieee.org/abstract/document/9268175

Phonocardiogram (PCG) - heart sound

- A diagnostic graphical method of recording sounds with the help of a specific equipment, namely phonocardiograph.
- Two dominant types of heart sounds (S1 and S2), corresponding to the beginning of the ventricular systole and the onset of the ventricular diastole
- Collected by an acoustic device (i.e., stethoscope) attached at the surface of the chest wall.

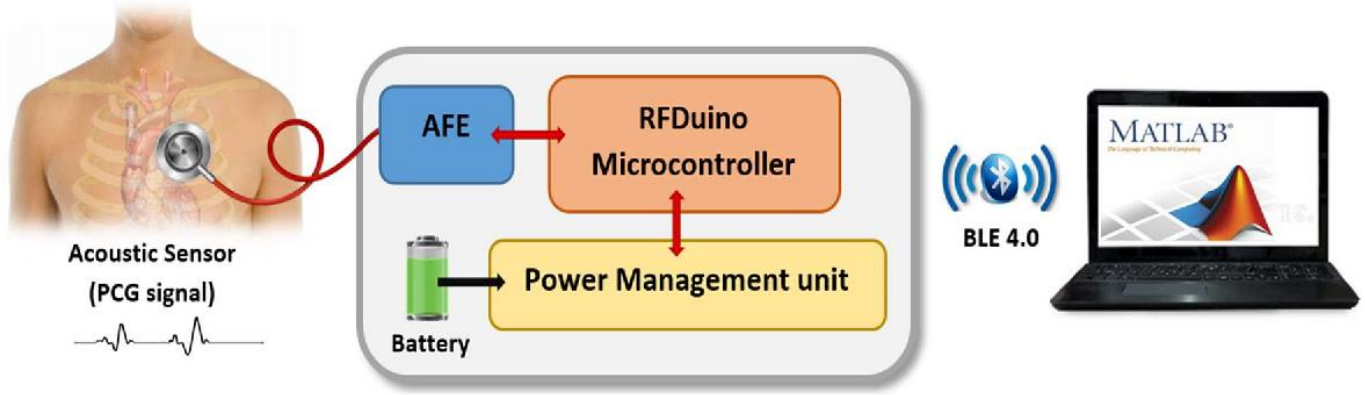
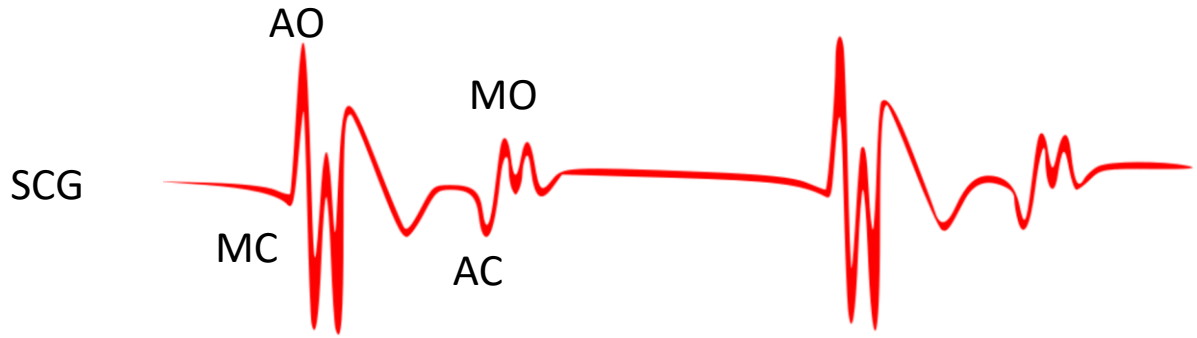


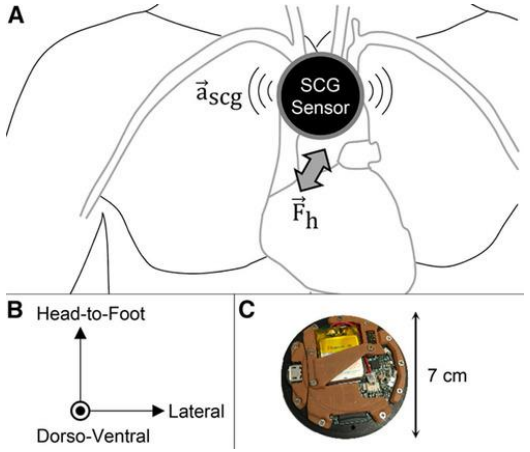
Figure 2. Overall system block diagram.

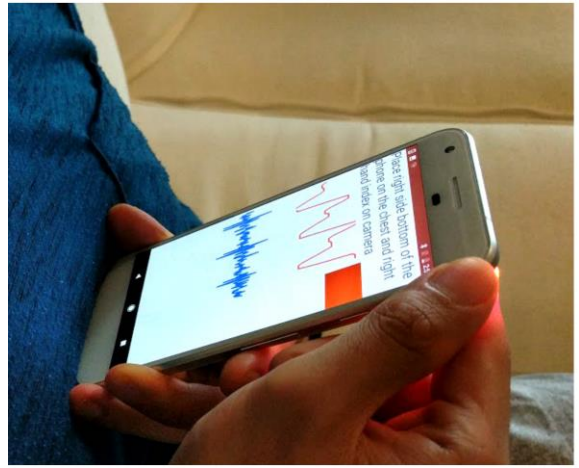
Source: https://ieeexplore.ieee.org/abstract/document/9268175

Seismocardiogram (SCG)

- Cardiac-induced mechanical vibrations on the chest surface, including frequencies below the human hearing threshold.
- Characterized by opening and closure of the aortic valve (AO and AC) and the opening and closure of the mitral valve (MO and MC).
- Measured by a lightweight low-noise accelerometers embedded inside portable or even wearable systems.
- Commonly placed sensor on the sternum or on its left lower border



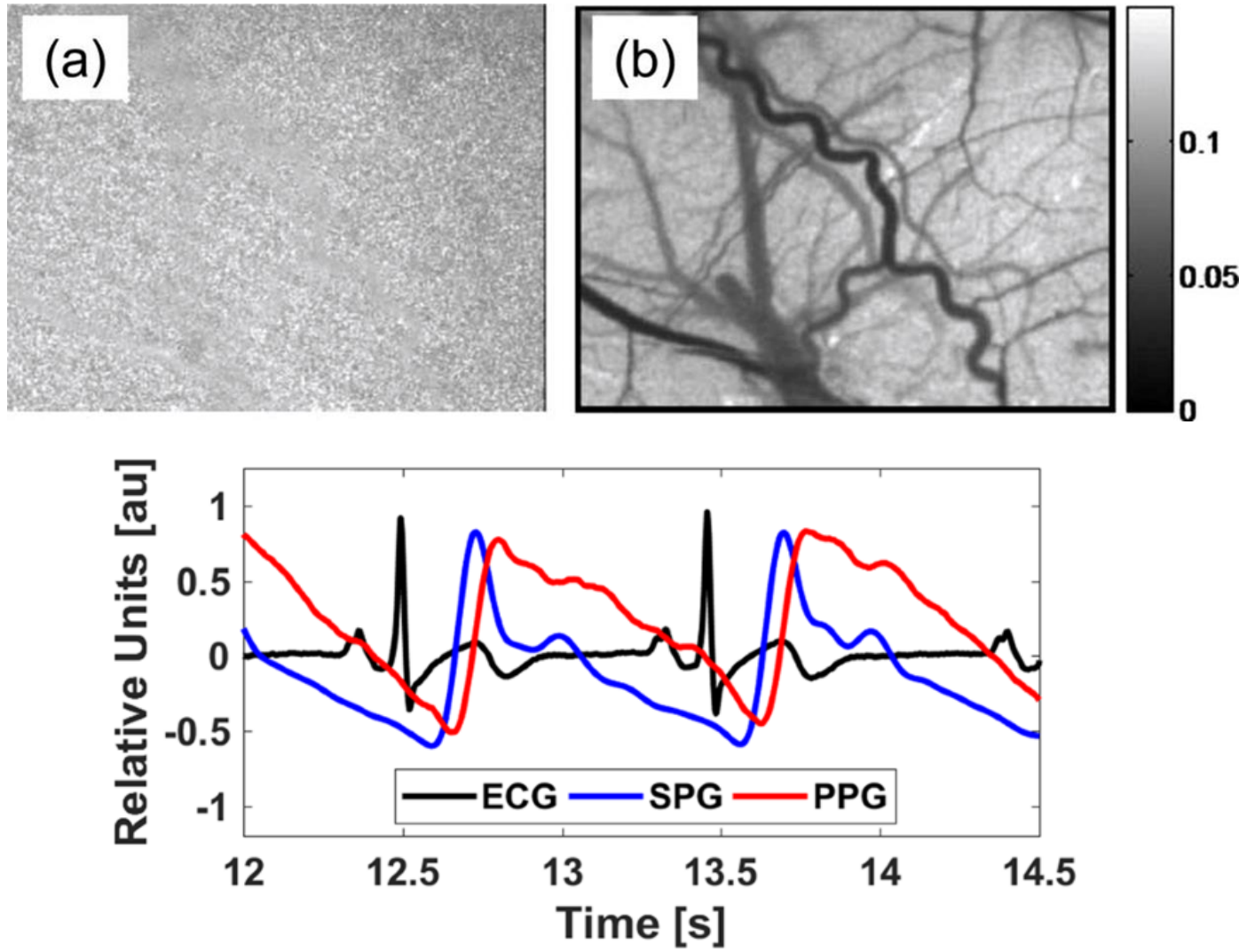




Source: https://ieeexplore.ieee.org/abstract/document/9268175

Speckleplethysmogram (SPG)

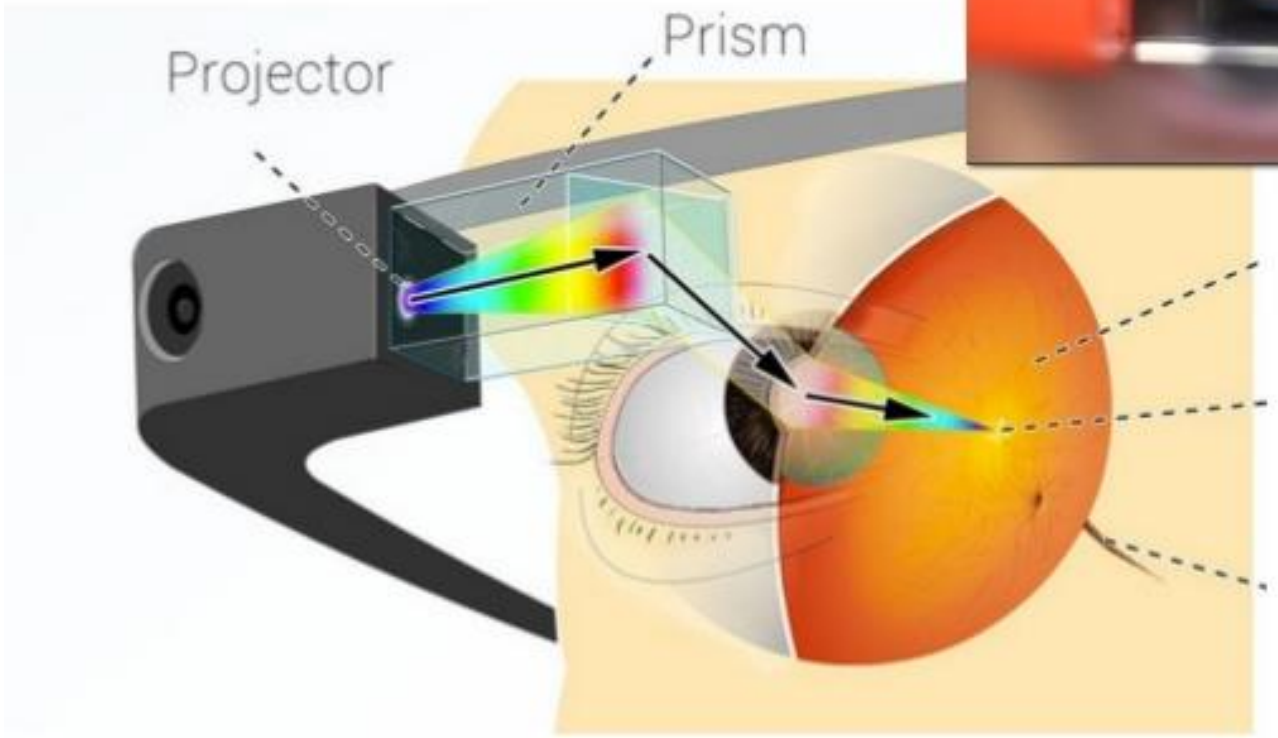
- An optical method based on laser speckle contrast imaging (LSCI) to monitor changes in blood flow.
- Amount of speckles detected in the image correlates to the volume of blood present at that time point, and the change over time forms the SPG waveform
- Measured at finger tip with a camera and laser source placing opposite direction.
- It provides improved SNR and robustness in the presence of motion artifact.



Source: https://ieeexplore.ieee.org/abstract/document/9268175

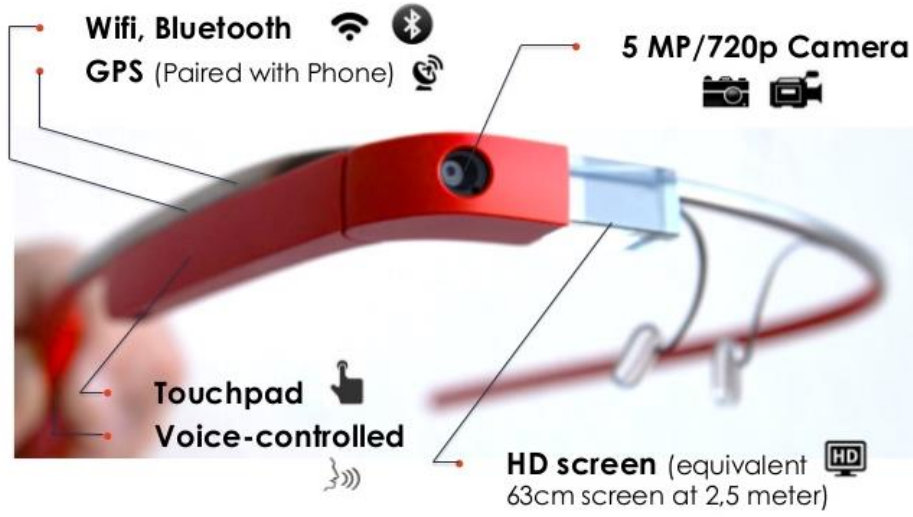
Medical and Wearable Devices

- Google Glass:
  - Prism Projection



+ Google Glass' ability to acquire images of a patient's retina

+ Voice command through microphone
+ Accelerometer, Gyroscope, Magnetometer
+ Ambient light sensor
+ Proximity sensor



Medical and Wearable Devices

- FDA-cleared, personal EKG monitor
- Detect Atrial Fibrillation, Bradycardia, Tachycardia or Normal heart rhythm
- Store your EKGs on your phone, and email your EKG to your doctor with the press of a button

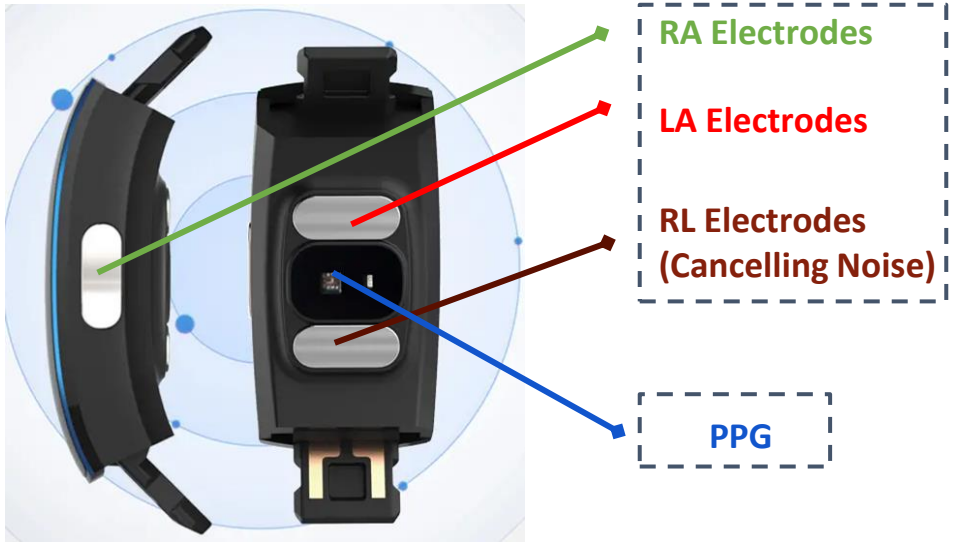
Source: [KardiaMobile EKG Monitor - Instant EKG on Your Phone | AliveCor – AliveCor, Inc.]

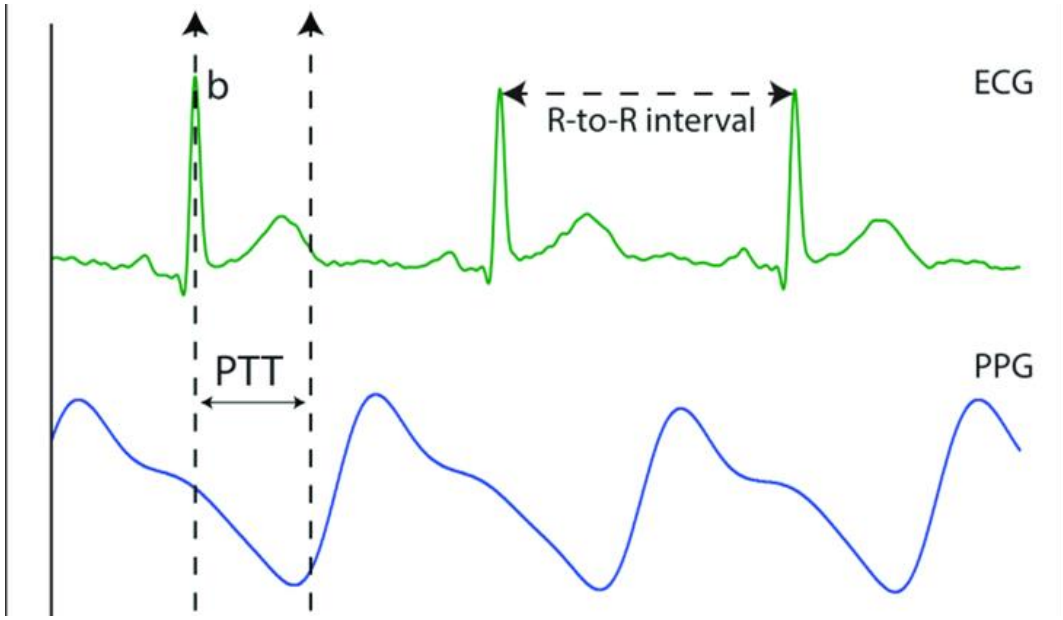
Medical and Wearable Devices

- Simultaneously measure PCG and ECG.
- Detect early-stage heart murmurs and AFib with Eko AI analysis algorithms.
- Removable earpieces support wireless auscultation.

Source: [DUO ECG + Digital Stethoscope - EKG Stethoscope | Eko (ekohealth.com)]

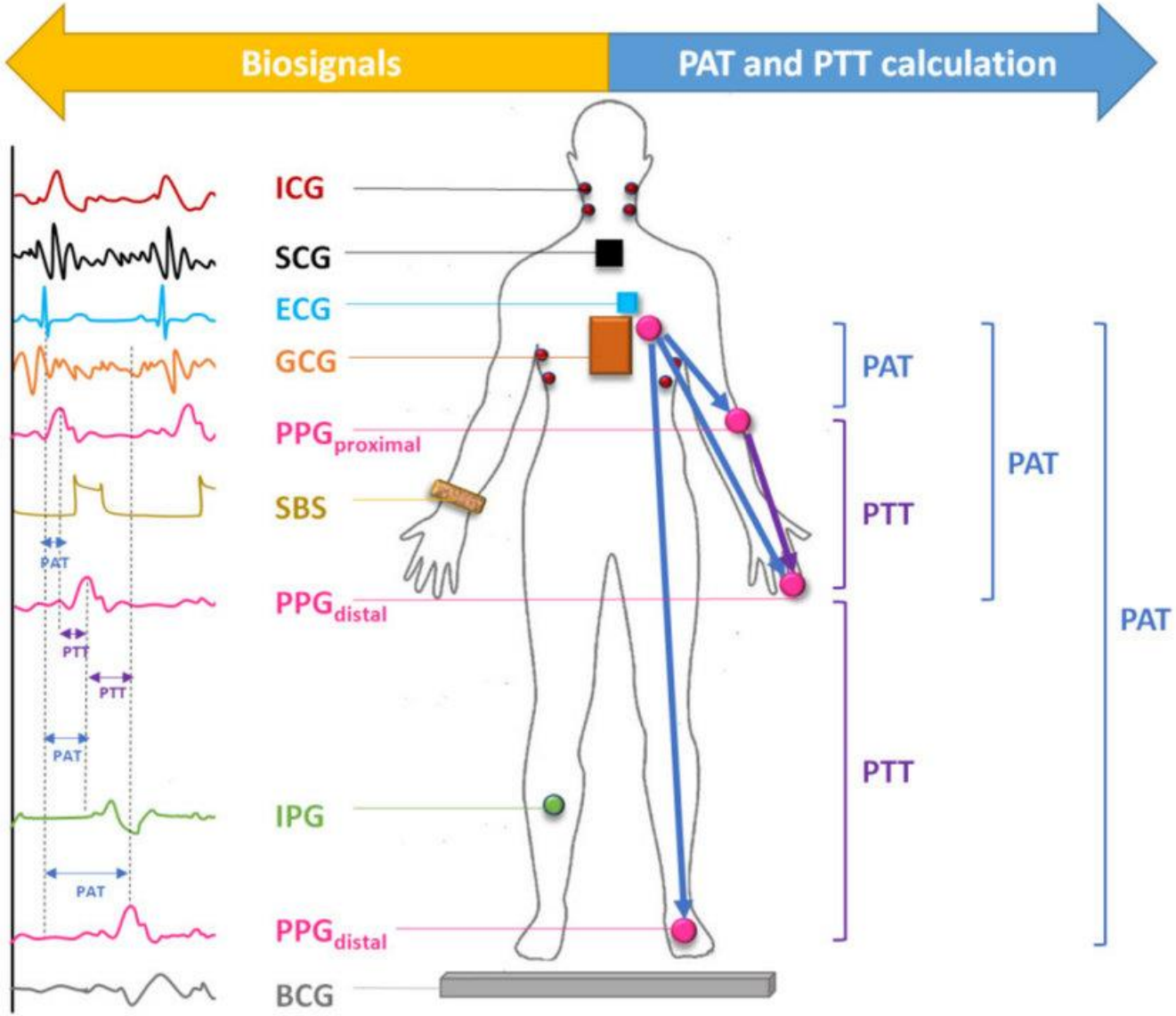
ECG + PPG for estimation Blood Pressure

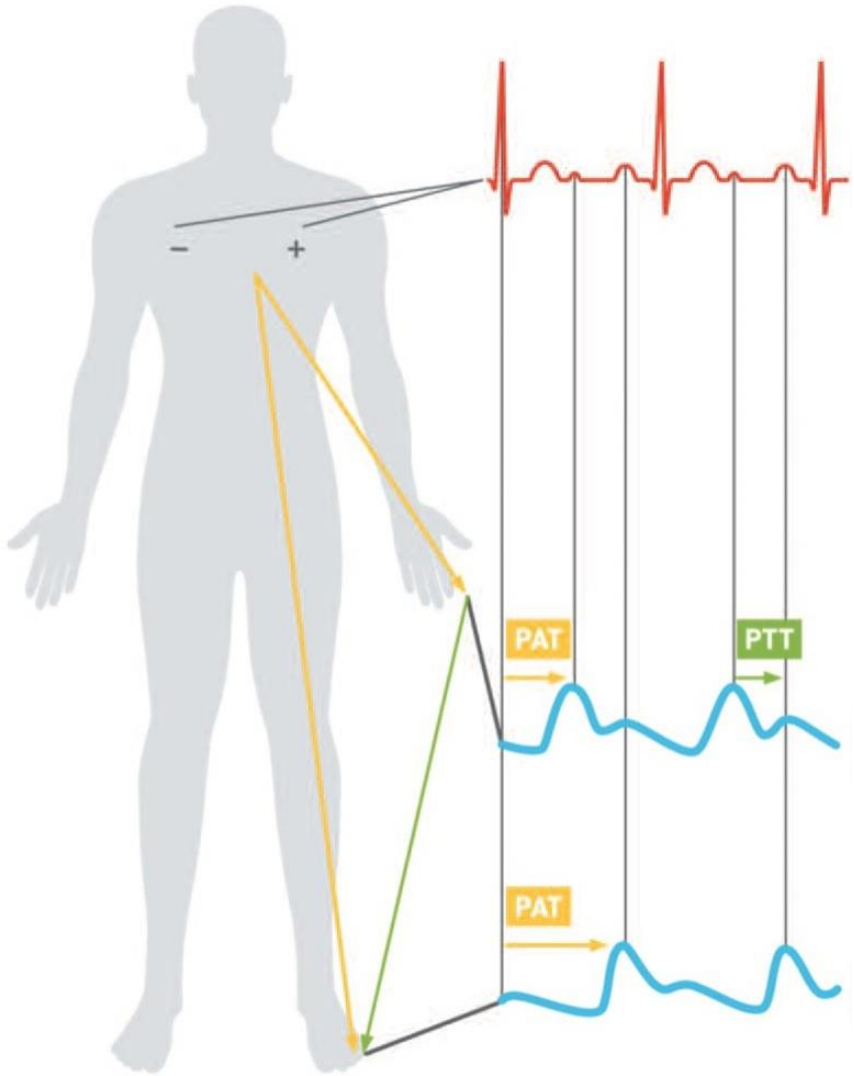




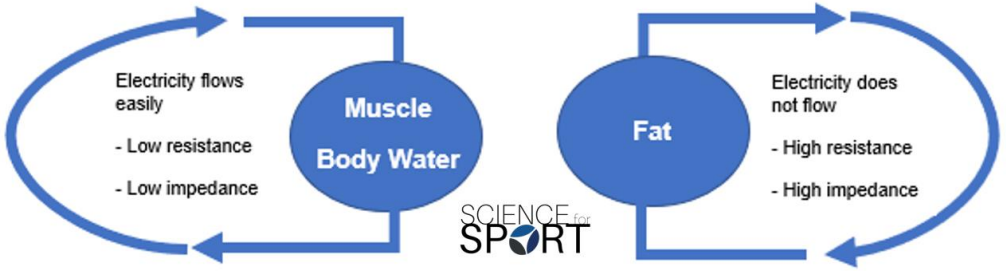
Stethoscope blood pressure

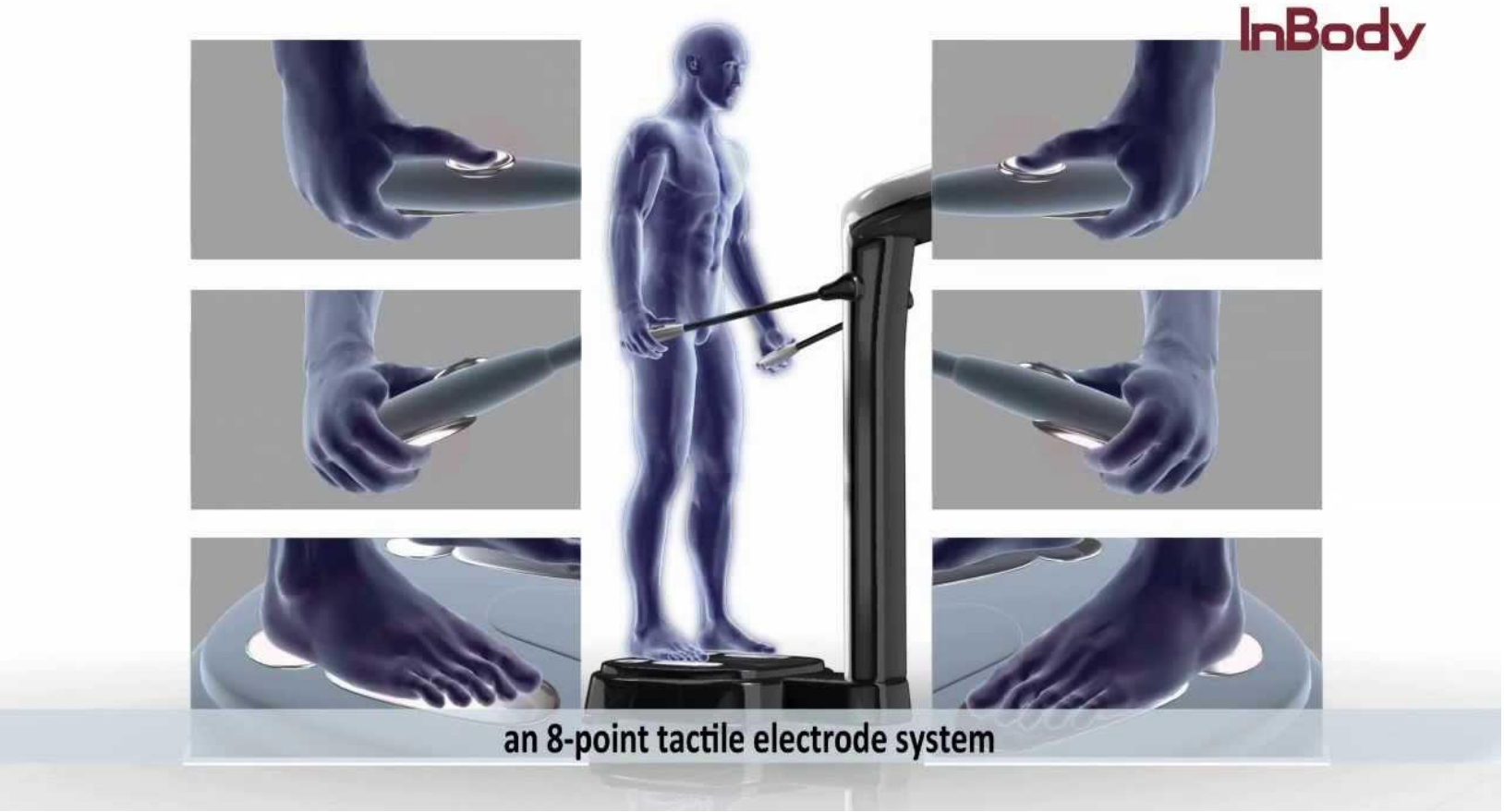
Pulse Arrival Time (PAT) vs. Pulse Transition Time (PTT)





InBody570

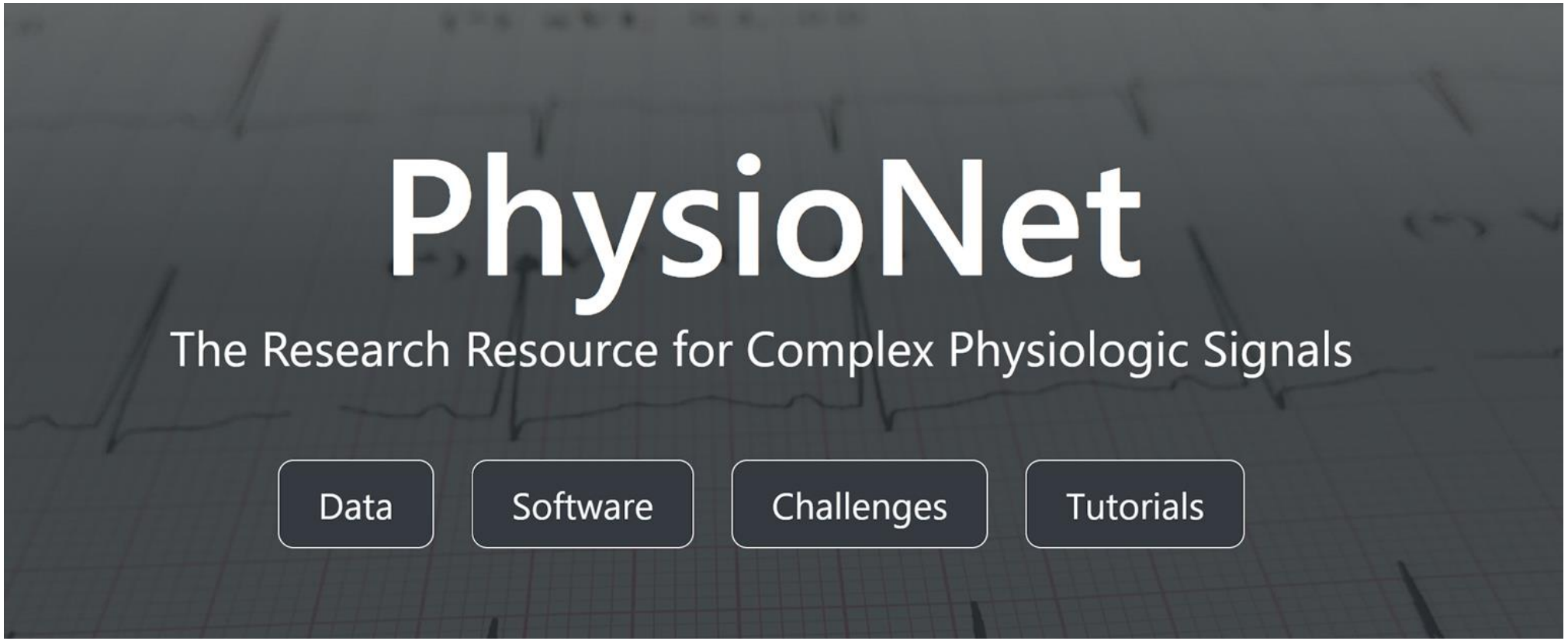




Source: [Bioelectrical Impedance Analysis Machine]

Next lesson

Topic: Import raw data collected from PhysioNet.




Merry Christmas
and
Happy New Year!