Advances in Photopletysöography Signal Analysis for Biomedical Application

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Summary in 3 lines of what's distinctive about this paper : Presentation of the main heart variable, their utility and interdependancy. Presents the PPG sensor and the two main modes + signal acquisition

- HRV : analysis of a patient physio + cardi conditions
- **PPG = . Photoplethysmography** : optical technique applied in the monitoring of the HRV
- Most used method to measure HRV : ECG
- HRV analysis (cranial heart rate variability) : used to evaluate cardiovascular autonomic nervous system
- Neural control : related
- **HRV : Heart rate Variability**
- Partial Thromboplastin Time : blood test that measures the **time** it takes your blood to clot
- Diastole : or relaxation phase, the blood flows to the auricles, causing pressure to decrease in the blood vessels
- Systole : r contraction phase, the blood is pumped out of the ventricles and distributed throughout the body, causing pressure to increase in the blood vessels
- PTT: Pulse Transit Time = PPT is defined as the time the pulse propagates from the heart to a peripheral locale and has been proposed as a potential substitute of the calculation of the arterial pressure (AP)
- The PTT may be promptly derived from the electrocardiogram (ECG) or photoplethysmogram (PPG)
- PTT value is inversely proportional to the blood pressure (BP)

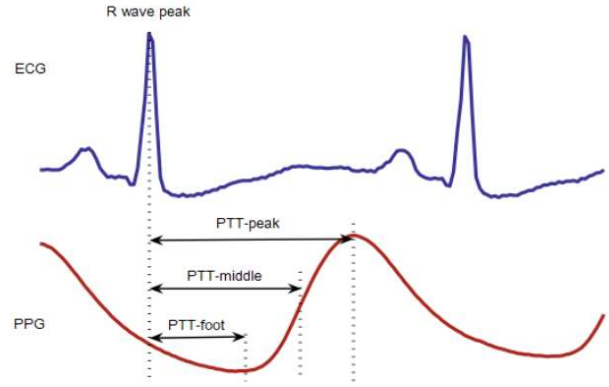


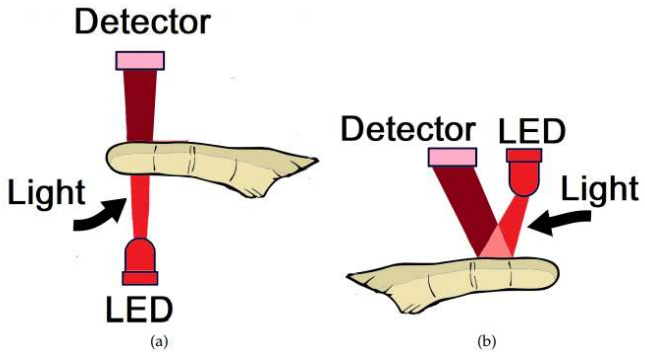
Figure 4. Different measurement points of PTT [45].

- PAT : Pulse Arrival Time
- PWV : Pusle Wave Velocity

Variable	Link to other variable	Information given	Formula
PTT : Pulse Transit Time	time taken for the arterial pulse pressure wave travel from aortic valve to periphery	Investigqtion of diseases related to sleep index of **arterial stiffness** and **cardiac output** and it has been used to **estimate BP indirectly**	
PWC : Pulse Wave Velocity	elasticity of the blood cells and the arterial pressure values elasticity coefficient, the thickness of the arterial wall, the end-diastolic diameter of the vessel lumen and the blood density	Relevant information about the heart rate as well as the good functionning of the heart	$PWV = \frac{\Delta D}{\Delta T}$ D: Distance between heartbeats T:time between heartbeat
PRV : Pulse Rate Variability		blood oxygenation and the ventilatory rate	. The calculation of the PRV is related to the PTT, that is, the beat-to-beat alterations in the pulse wave velocity PRV as an alternative solution to HRV

PPG Sensor

- Measure the amount of IR absorbed by blood
- Pressure changes in blood cells through the cardiac cycle -> Volume changes



a. TRANSMISSION MODE
b. REFLECTION MODE

TRANSMISSION MODE
With a PPG sensor in transmission mode, the LED light passes through absorbent substances, such as the skin pigmentation, bone and arterial and venous blood, and is then received by the detector and quantified by filters and converters

REFLECTION MODE
PPG sensor in reflection mode reflects the LED light on the skin, which is received by the detector, and quantified in a similar fashion through the use of filters and converters

This mode is applied mainly in the body parts too thick to allow the transmission of light (for example, wrist and forehead). Therefore, the PPG sensors can assume varied shapes, for example, a band, a wristwatch, or a patch. Additionally, some PPG sensors already make use of wearable technology, monitoring the heart rate in real time

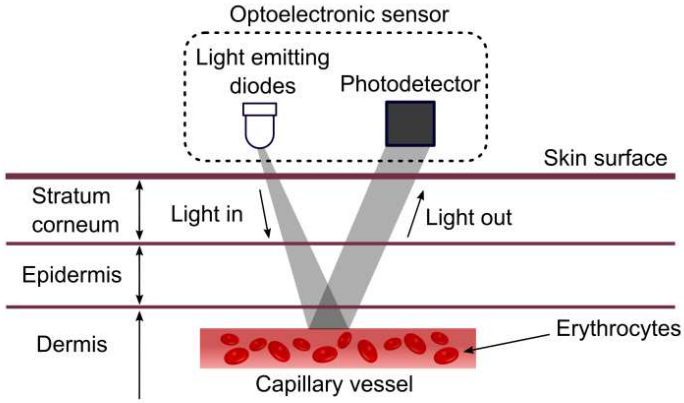
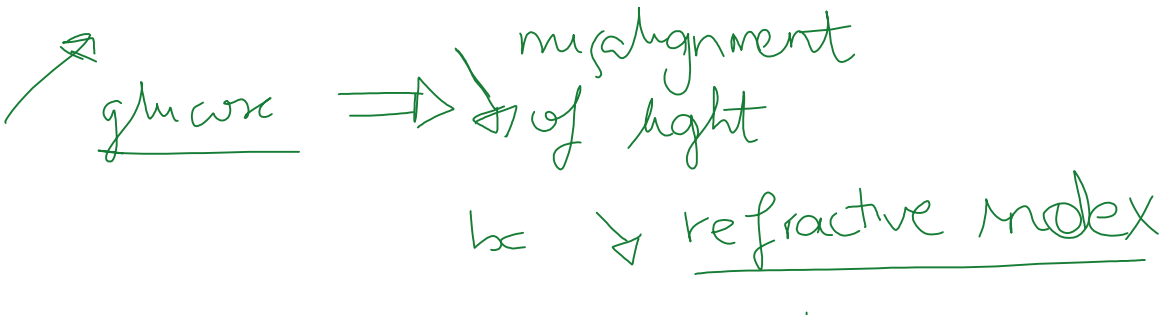


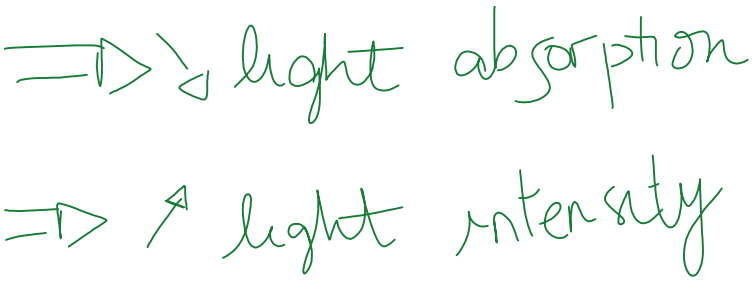
Figure 6. Working principle of PPG sensors [19].

PPG signal :
- DC offset : constant absorption of light passing through the tissue
- AC component : generated by heartbeat affecting blood volume when light transverse arteries

Sites to measure the pulse : fingers and toes [63–65], forehead [66], wrist [67] and ear [62,68], since all of them have a rich arterial source and are relatively easy to attach a senso

Physics principle :
Light scattering by glucose in blood.





Why the wave is personal ?

- skin ton
- thickness of the fat layer
- rigidity of the radial artery

have huge intervention in the morphology and amplitude of the plethysmographic wave

The Beer–Lambert law relates the intensity of the emitted to the incident light, in function of light absorption by the medium, the concentration of the solution, and the path the light travels. The higher is the luminosity emitted by the photo-emitter (LED), the higher is the amount of light transmitted through the medium as well as the amount of light reflected

Signal Processing

- Linear methods
    - Time domain
    - Frequency

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