PPG (Photoplethysmography)

PPG (Photoplethysmography) is used to give the "blood volume pulse (BVP)" signal.

The PPG is mainly used to identify the heart rate of the person wearing the sensor.

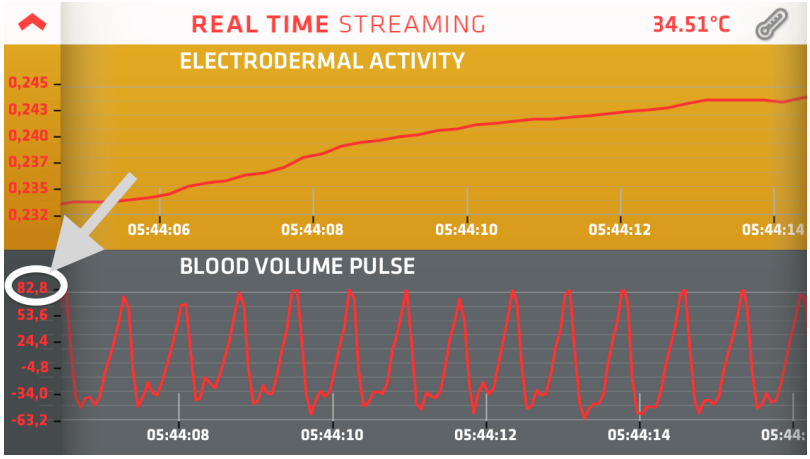
Heart rate is computed by detecting peaks (beats) from the PPG and computing the lengths of the intervals between adjacent beats. The inter-beat-interval (IBI) timing is used to estimate the instantaneous heart rate as well as to estimate average heart rate over multiple beats.

The main benefit of the Empatica's PPG is that it is more robust to motion than most other heart-rate sensors.

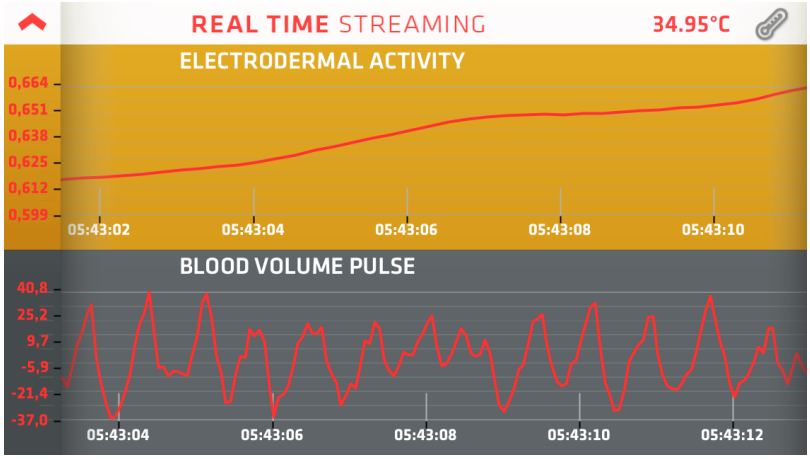
Empatica's PPG uses both green and red light. The green data contains the main information of the heart beats, while the red data contains information on the movements. By combing the two we are able to remove more motion artifacts that are not purely related to a global motion of the device but also to artifacts created by movements of tendons below the skin.

Keep the PPG data quality under control

The device must be worn reasonably snugly (but not uncomfortably tight) in order to be sure of getting good quality data. You can test the quality with the real-time application. The picture below tells you what a good PPG signal looks like.
Example of good PPG data



Example of PPG data that is not highest quality.



Know how the data are obtained to understand the strengths

Empatica provides two types of data: the PPG data and the IBI data. They are strictly related. The sequence below describes the processing chain that Empatica employs.

GREEN, RED -->[Algorithm 1] --> PPG--> [Algorithm 2]--> IBI

The artifact removal process in the photoplethysmography is a double step process that can be managed both by Algorithm 1 and 2.

- The Empatica software aims to detect "every" heart beat. This make it useless in conditions with huge movements, where the Empatica Algorithm 2 will simply discard a lot of heart beats; however, when it is highly valuable when it detects good beats because it will produce IBI's that can be used to measure heart rate variability. Heart rate variability is of huge interest in studies of stress and its impact on medical conditions.

How is IBI.csv obtained?

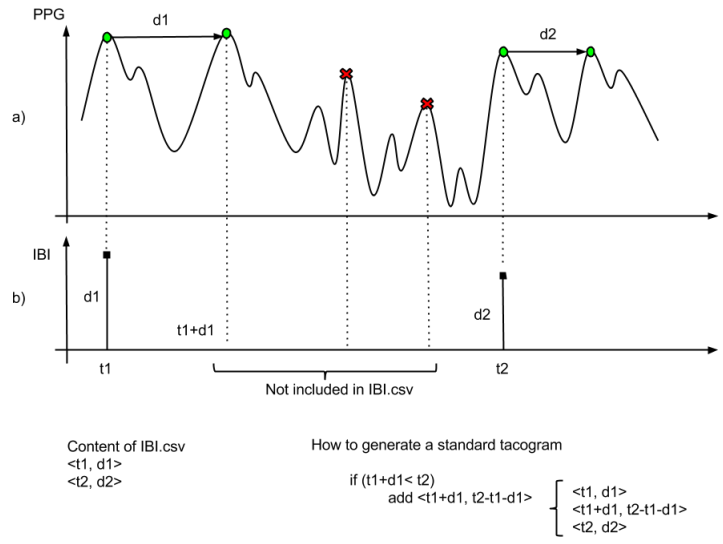
The IBI sequence provided by Empatica is obtained from an algorithm that already removes wrong peaks.

The picture below depicts a typical situation where the PPG data is corrupted by motion artefacts (graph a). The green points are the good heart beats, while the red x represent the wrong heart beats.

The wrong beats are not included in the IBI.csv and thus it may happen that two consecutive row in IBI.csv are not consistent with a standard tacogram. However the IBI.csv contains a timestamp indication since each row as the format : <time, distance>.

The graph b of the picture below indicates how each row is generated in the case of wrong heart beats. The latest two consecutive peaks at distance d1 are detected, and in t1 we add and IBI with value d1. In t2 other two consecutive beats are detected and thus we add a new ibi <t2, d2>. Since there have been a number of wrong heart beats, t2> t1+d1.

If you need to create a tacogram you could both use the time we provide or add a new row in the case t2> t1+d1 as explained in the picture



Reference: https://support.empatica.com/hc/en-us/articles/203621335-What-should-I-know-to-use-the-PPG-IBI-data-in-my-experiment-