DSAA Project

Heart Rate Detection from PPG

Team 45

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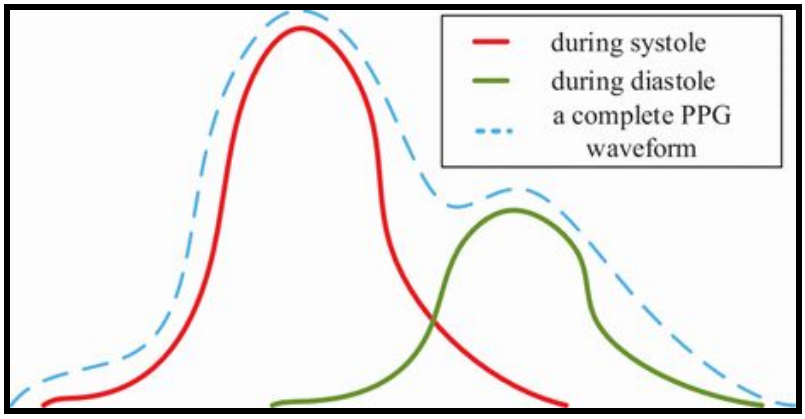
Introduction

- Photoplethysmography (PPG) is a simple optical technique used to detect volumetric changes in blood in peripheral circulation. It is a low cost and non-invasive method that makes measurements at the surface of the skin.
- Composition of PPG Signal Waveform
    - PPG signals comprise two waveforms , created during systole and diastole. For the first waveform, the increase in the blood flow volume causes a pressure change in the blood vessel.



Principle of PPG

- A pulse oximeter records a signal by illuminating the skin with an LED and measuring the intensity changes as the light reflects off the exercises during the wearer's skin, forming a PPG signal
- When light travels through biological tissues it is absorbed by bones, skin pigments and both venous and arterial blood.
- Since light is more strongly absorbed by blood than the surrounding tissues, the changes in blood flow can be detected by PPG sensors as changes in the intensity of light.
- The change in volume caused by the cardiac output is detected by illuminating the skin with a light emitting diode (LED) and then sensing the amount of light reflected to a photodiode.

- The voltage signal from PPG is proportional to the quantity of blood flowing through the blood vessels. Even small changes in blood volume can be detected using this method, though it cannot be used to quantify the amount of blood.
- Each cardiac output is seen as a peak in the PPG signal
- A PPG signal has several components including volumetric changes in arterial blood which is associated with cardiac activity, variations in venous blood volume which modulates the PPG signal, a DC component showing the tissues' optical property and subtle energy changes in the body.
- Some major factors affecting the recordings from the PPG are site of measurement and the contact force between the site and the sensor.
- Blood flow variations mostly occur in the arteries and not in the veins.

PPG vs ECG for Heart Rate Estimation

- A photoplethysmogram (PPG) and an electrocardiogram (ECG) are usually used to estimate the heartbeat rate. The PPG is measured from fingers or the wrist that is a distal part of a body, while the ECG is measured from some parts of the thorax. So the ECG can give better results for estimating the heartbeat over the PPG. However, the ECG cannot be used for wearable devices because of its complexity and inconvenience

- When it comes to key considerations like size, power consumption, accuracy, ease of integration and richness of data, ECG biosensors present a clear advantage over their PPG counterparts for heart rate monitoring.

- PPG sensors are capable only of measuring HR, and less reliably than with ECG biosensors.
- The key challenges with PPG technology are cancelling the effects of ambient light, accommodating different skin conditions and colors, and dealing with **physical motion artifacts**.
- **PPG can only be used on parts of the body that have a high concentration of blood vessels** (for example, it can be difficult to get a good PPG signal from the wrist).

Methodology

1. We are given two PPG signals, each has to be observed with in windows of 8 seconds with a 2 seconds overlap.
2. We use the sliding window short time fourier transform concept.
3. We remove the mean of each signals from themselves to decrease the DC value in FFT.
4. After doing the FFT on the windows of the individual PPG's, we use a bandpass filter to only allow signals with frequency which falls within the range of the average human heart beat, i.e., 0.5Hz to 3Hz.
5. Then we take an inverse fourier.
6. All the other noise signals fall outside of this region and thus are effectively removed from the signal.
7. We couldn't remove MAs because of time constraints.
8. After this we use this number of peaks obtained to calculate our estimated heart beat from the PPG signal.
9. To do this we take the common peaks observed in both the PPG channels.
10. This gives a rough value of number of peaks in an 8 second interval. From this HR can be easily calculated.

Error

We obtained a mean error of 9-20 BPM varying over different datasets.

What we could have implemented

There were some good resources available on internet like TROIKA and JOSS. Given more time we could have implemented this and obtained a better approximation.