Smart Sensing Based Photoplethysmography

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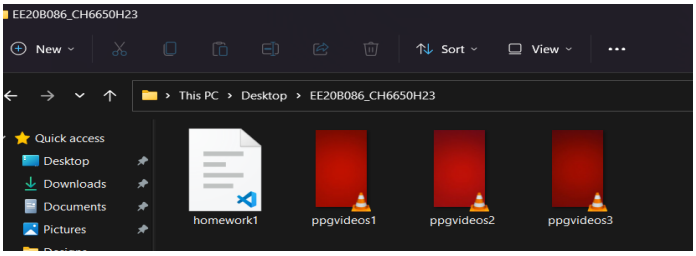
A. Data Collection :

The video data was collected using a smartphone (POCO X4) with 30 fps at 1080p resolution. The first video was captured by applying relatively constant pressure on camera with finger and flash light while in a relaxed state. Same procedure was followed after walking for 10 mins and exercising vigorously and two more videos were obtained. These were saved into the same directory as homework1.ipynb - project file



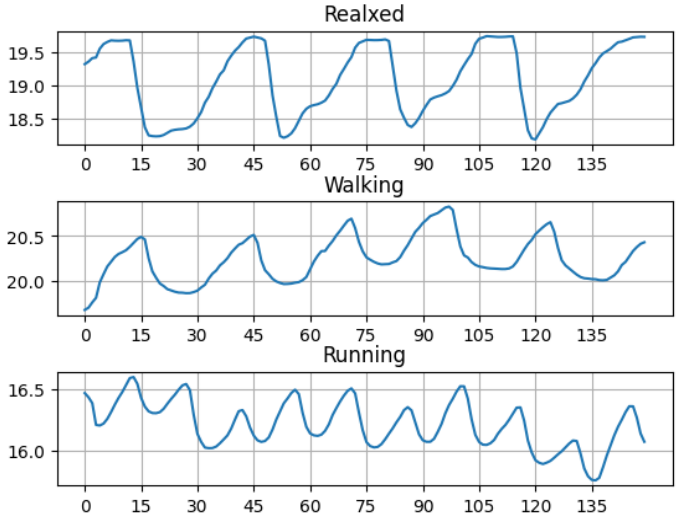
Later, the videos were read and frames were extracted using OpenCv. Also various other things like frame rate, total no. of frames, dimension of the video were found.

B. Sensing metric :

The sensing metric used was mean of b,g,r intensities for all pixels and then the result was normalized between 0-100

C. Temporal variation of intensity value :

A chunk of 5 secs of the video was chosen from each by selecting 150 continuous frames. Then their intensities were plotted across frame number (denoting time) for each case and the plot obtained was :

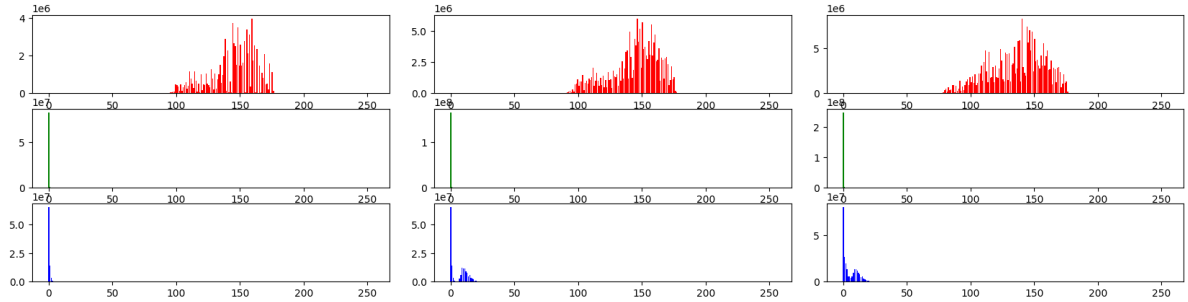


Heart rate calculated manually using number of peaks*(60/5) which gives,
Relaxed - 60 bpm
Walking - 72 bpm
Running - 126 bpm

D. Likelihood distributions :

20 frames close to maximum frame intensities and minimum frame intensities were collected (total 40 frames) for each case. The frequency occurrence of each intensity (bin) was obtained using np.histogram() for each frame.

Later the frequencies corresponding to same intensities (bins) were added across 40 frames to obtain a single combined histogram. Intensities were extracted separately as b,g,r and plotted in a subplot.

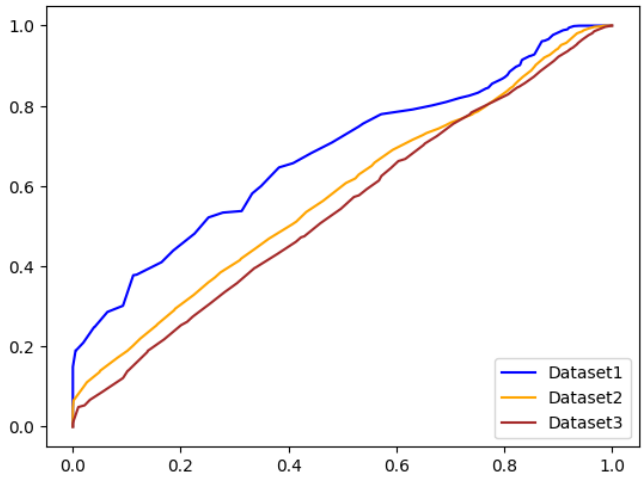


First set of data (Relaxed) shows more separation while the third dataset (Running) shows least separation with intensities closely packed.

E. Threshold Based Detection and ROC curve :

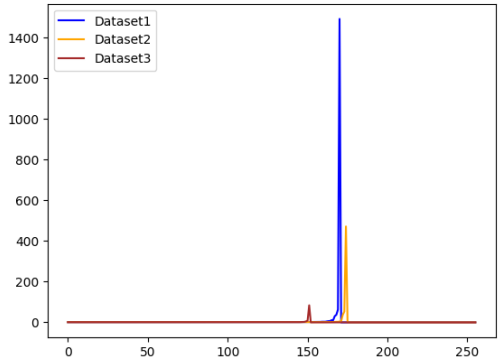
Now, 500 pixels were randomly chosen using np.random.randint for coordinates, from 40 frames (20 max intensity and 20 min intensity). From each of these 20k pixels red intensity was extracted, these were our detections. The threshold was then varied from 0-255 and corresponding no. of correct detections and false alarm was found.

If the intensity from a max frame is more than threshold it is correctly detected but, if the intensity from a mim frame is more than the threshold it is false alarm. Based on the no. of detections and false alarms Probability of detection (Pd) and Probability of false alarm (Pfa) were calculated for each threshold and then their variation - ROC curve was plotted. This process was done for all 3 cases.



F. Are "good" samples spatially correlated? :

To find the optimal threshold value gamma (Pd/Pfa) was calculated and plotted across varying threshold,



The Topt found for each dataset were :

Dataset 1 - 170
Dataset 2 - 174
Dataset 3 - 151

For the mentioned Topt above the good samples and bad samples are clustered together in different regions of the frame of the video. This is mostly due to the uneven pressure throughout.

- In the middle of the frame the pressure is maximum hence, intensity remains fairly stable causing it to be bad samples in some frames.
- In the outermost region pressure is least and thus the intensity does not vary much causing it to be bad samples in some frames .
- In the region between middle and outer the pressure applied is good enough to show variation in intensity giving us good samples.