Heart rate estimation using Imaging Photoplethysmography

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Introduction

Standard measurements techniques for the heart rate (HR) require direct skin contact. Imaging Photoplethymography (IPPG) enables the detection of the HR in a remote and contactless manner [1]. Non-contact measurement methods could improve the care of patients with sensitive skin as well as neonatal patients [2]. IPPG uses Red-Green-Blue (RGB) video recordings of a skin area as an input. Improvements in video processing enable the analysis of the videos where subtle skin color changes are detected in form of different pixel intensities [3]. This study aims to create and test a workflow for the feasibility of HR estimation via IPPG video analysis of five facial regions of interest (ROIs).

Material and Methods

The RGB videos were recorded as part of a study at Odense University Hospital where the subjects were exposed to different environmental conditions. Here, 4-minute cut-outs in the beginning, middle and end of four recordings were analysed in such a way that values for heart beats per minute (bpm) were determined. Figure 1 shows the video processing steps in MATLAB. The arrangement of the ROIs is shown in Fig. 2.

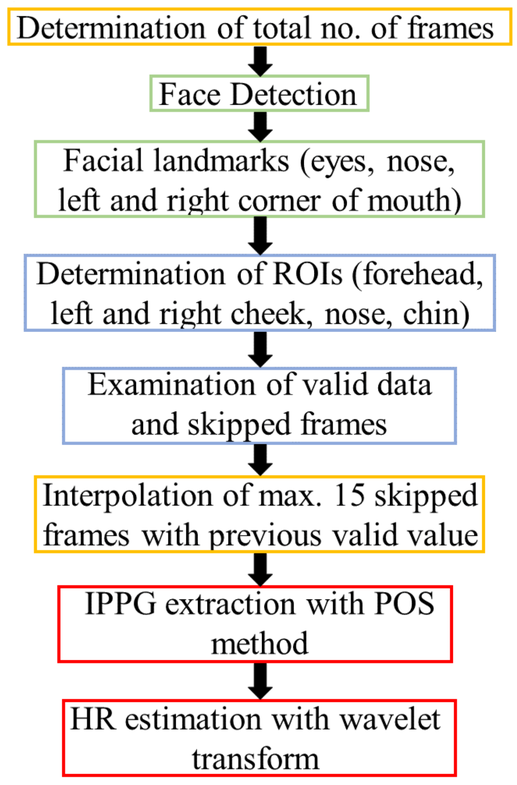

Figure 1: Flowchart for the video processing steps in MATLAB. Yellow boxes: Implemented in MATLAB code; green boxes: MATLAB toolbox „MTCNN Face Detection“; blue boxes: Manually done by evaluator; red boxes: MATLAB toolbox „Imaging-photoplethysmogram-extraction-pulse-rate-estimation“

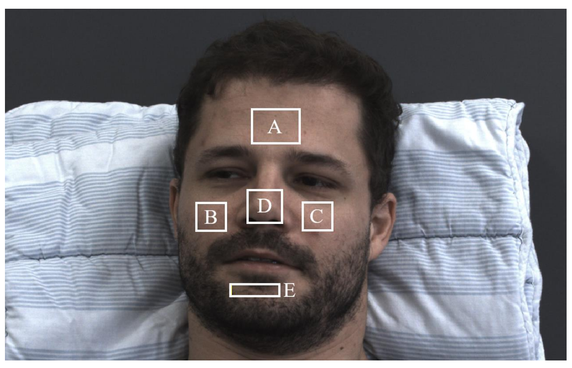

Figure 2: Positioning of the ROIs on a person‘s face.

Results and Discussion

The face detection and interpolation of the frames worked accurately for all video frames that fulfilled the specified conditions. The IPPG extraction with the MATLAB toolbox generated signals like the one in Fig. 3. The valid data after face detection as well as after IPPG extraction was high enough to calculate the HR values for all cut-outs. The HR values could be estimated from the IPPG signals. The results for the averaged HR values over all the ROIs and for every subject are shown in Table 1.

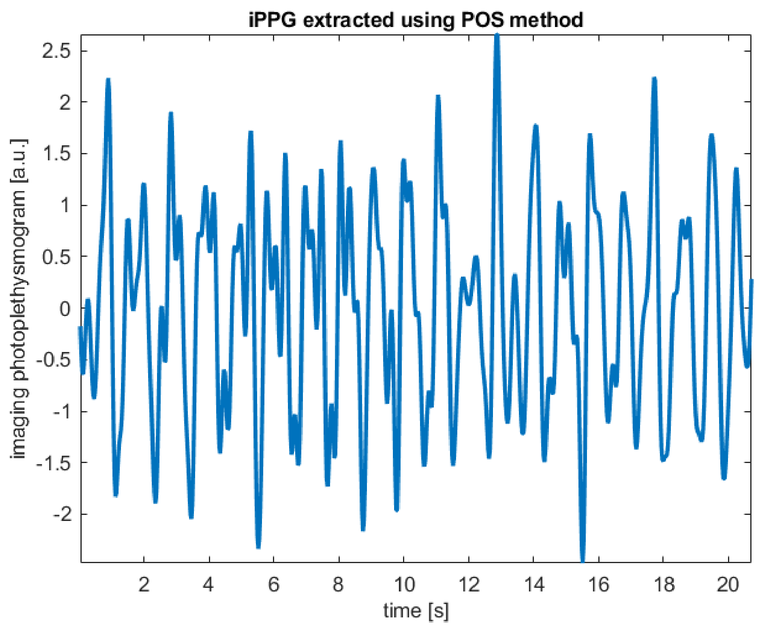

Figure 3: IPPG signal extracted with the toolbox over about 20 s.

The momentary values (between 72 and 90 bpm) were calculated for every time step whereas the estimated average values (between 62 and 81 bpm) were filtered with a moving average filter by the toolbox. All the values were in a suitable range for the human HR. However, it was noticeable that the estimated average HR values were always significantly lower than the momentary values. This could be explained with the averaging by the toolbox because outliers did not have such an influence here. Therefore the momentary values are expected to be more inaccurate.

Subject_cut-out	Momentary values	Estimated average
subject 1_01 cold	80 bpm	62 bpm
subject 1_02 cold	79 bpm	64 bpm
subject 1_03 cold	76 bpm	62 bpm
subject 2_01 warm	86 bpm	81 bpm
subject 2_02 warm	75 bpm	71 bpm
subject 2_03 warm	72 bpm	63 bpm
subject 3_01 cold	87 bpm	68 bpm
subject 3_02 cold	90 bpm	70 bpm
subject 3_03 cold	90 bpm	77 bpm
subject 3_01 warm	84 bpm	76 bpm
subject 3_02 warm	85 bpm	75 bpm
subject 3_03 warm	85 bpm	72 bpm

Table 1: Average values of the HR for each subject. Momentary values averaged for each step in time. The estimated average was averaged with a moving average filter from the toolbox before.

Conclusion

The analysis of the few sessions showed that the HR estimation from an IPPG signal was possible and generated values within a suitable range. A comparison with reference data (from hospital equipment) as well as the analysis of all the recordings in its whole length, remain part of future work to evaluate the quality of the achieved results.

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