Extracting Video Heart Rate in Very Low Lighting Conditions

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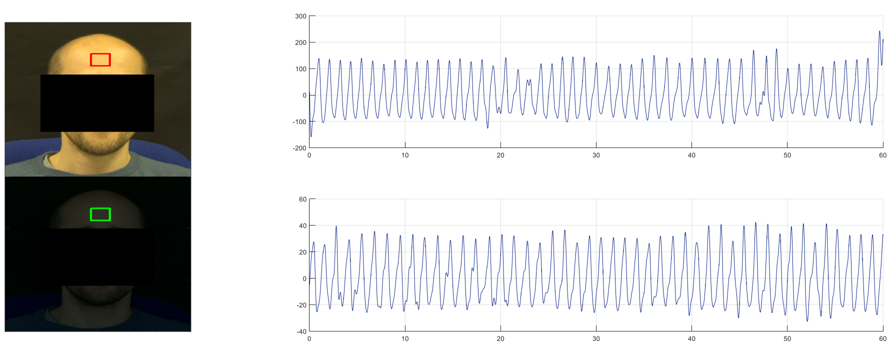
Introduction: Video monitoring of the photoplethysmogram (video-PPG) has attracted significant attention in recent years [1]. However, it is susceptible to three main confounders: motion artefacts, lighting levels (both low levels and dynamic variations) and skin pigmentation. Following on from a recent study where we varied lighting conditions by switching on and off additional light sources during a porcine study of desaturation [2], we sought to measure the video-PPG in very low lighting conditions. Here we report on early results which indicate that with high resolution imaging equipment, the video-PPG can be detected in very low lighting conditions, which may mean that it could be suitable for physiological monitoring (e.g. heart rate and respiratory rate) during sleep.

Method: Video was acquired with a Basler RGB scientific camera under two light intensities with the subject in a relatively still position: a 300 lx intensity corresponding to a reasonably low room lighting condition; and 20 lx corresponding to a dark room with the lights off and the blinds closed. The lux measurements were taken at the forehead of the subject using a lux meter. Images from the video stream in each lighting condition are shown in figure 1a. We extracted video from the Region-of-Interest (ROI) on the forehead as shown in the figure. The signals shown in figure 1b were obtained from the average of the green channel in the ROI after band-pass filtering the video-PPG between 0.7 and 3 Hz.

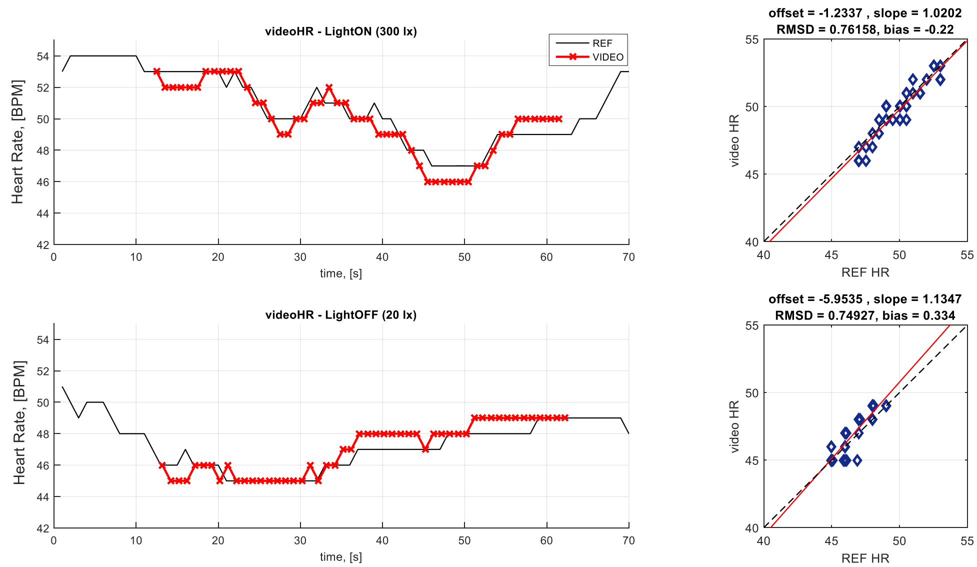


(a) (b)

Figure 1: a) De-identified image with the ROI used for video-PPG extraction (top: 300 lx, bottom: 20 lx). (b) Extracted video-PPG (band-pass filtering between 0.7 and 3 Hz) corresponding with the top and plots to the light levels.

Results:

The heart rates extracted from the two video-PPGs in figure 1b are shown in figure 2a with the corresponding reference heart rate from a Nellcor pulse oximeter (Medtronic, Boulder, CO) attached to the index finger of the subject. The corresponding scatter plots are shown in figure 2b. The root mean square difference (RMSD) between the extracted video heart rate (video-HR) and a reference pulse rate (ref-HR) for the 300 and 20 lx signals was calculated to be 0.76 and 0.74 bpm, respectively.



(a) (b)

Figure 2: (a) The extracted video-HR against the reference HR (b) scatter plots of the video-HR against the reference HR (top=300 lx, bottom=20 lx)

Conclusions:

Reports on video-based physiological monitoring studies are now prevalent in the literature as an increasing number of applications emerge. In a recent editorial in the journal Anesthesia and Analgesia [3], Thiele stated that such video based technologies 'may one day change our lives in ways we cannot imagine'. Our preliminary results demonstrate the determination of heart rate from the video-PPGs under very low lighting conditions. This indicates a potential use within darkened hospital environments without requiring external infrared light sources such as the monitoring of patients during sleep in wards with low level lighting.

References

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[3] R. H. Thiele, "The Anesthesiologist's Dream", Anesth. Analg., vol. 125, pp.724–725, 2017.