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Non Contact Heart Rate Monitoring using Facial Video

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Abstract: ***Heart rate (HR) is a direct measure of heart's function. Conventional measurement based on contact-based measurement may cause discomfort to patients, especially in the case of long-term monitoring. This paper proposes a non-contact method of measuring heart rate using facial video of the patient. The variation of light intensity from the skin from each heart beat is used to estimate HR. A standard RGB camera is used to record the video. The Region of Interest (ROI) is obtained using face detection and tracking algorithms. A mean is taken across the frame yielding three values per frame. The Photo Plethysmo Graphy(PPG) signal is isolated using Independent Component Analysis (ICA). The signals are further filtered to reduce out of band noise and improve accuracy. The Fast Fourier Transform (FFT) is used to convert the signal to frequency domain and the peak is identified, whose frequency will correspond to the HR. This method of measuring HR has several advantages over conventional methods. HR measurement during exercise, prisons where contact-based methods cannot be employed, and long-term HR measurement in hospitals are some applications where the proposed method will be highly advantageous. The method also reduces the amount of hardware needed for HR measurement; HR can be measured even using smartphones.***

Keywords: ***Independent Component Analysis (ICA), Photo Plethysmo Graphy (PPG), Fast Fourier Transform (FFT).***

I.INTRODUCTION

Heart Rate (HR) is the number of contractions of the heart, measured as beats per minute (bpm). The heart rate depends on the needs of the body. It is low during sleep, and can be high during exercise, illness, ingestion of drugs. The resting heart rate is 60 – 100 bpm. Conditions with a heart rate above 100 bpm are called tachycardia and heart rate below 60 bpm are called bradycardia. The irregular beating of the heart is referred to as arrythmia. Abnormal heart rates are often symptoms of diseases.

The heart rate is an important parameter in evaluating the cardiac health of the patient. Regular monitoring and recording of heart rate can help in diagnosing a wide range of health problems. The heart rate can be measured manually by compressing the artery with the finger and sensing the pulse.

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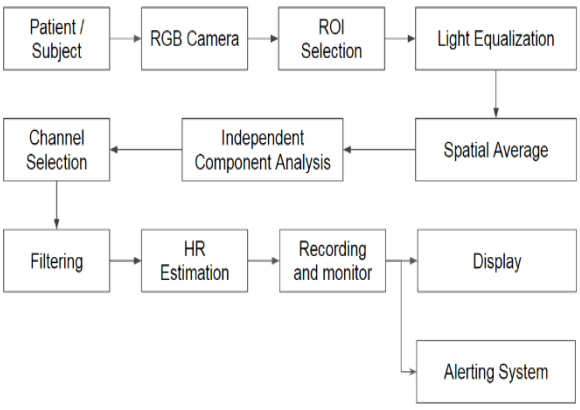
The high blood flow in the thumb may interfere with measurement, and is not used. The radial arteries are usually used for measurements, but in critical conditions, the carotid arteries may be used.

The electrocardiograph (ECG) is a well-established precise method for measuring the heart rate. The ECG records the electrical activity of the heart, and the pattern directly corresponds to the heart function. Continuous ECG monitoring is done, especially of patients under critical conditions. The R-to-R wave interval in the ECG pattern may be measured to estimate the heart rate. Some other alternatives for measurement are pulse oximetry and seismocardiography.

Contactless techniques to measure the heart rate have several advantages compared to the conventional methods. They can allow the movement of the patient, also, skin irritations due to the contact sensor during long-term monitoring can be avoided. Several non-contact methods to measure heart rate have been explored. Some of these methods rely on the different light absorption properties of the skin and blood. When a blood pulse flows through the artery, the colour of the skin changes. These color variations can be recorded using camera, which can then be processed to estimate the heart rate.

II.METHOD

We propose estimating HR from recorded facial video using a standard RGB camera, based on an algorithm using Independent Component Analysis (ICA) for separating the PPG source from the rest of the noise recorded. The HR is estimated after smoothing, normalizing, and filtering the signal output after the ICA.



A. Identifying the Region-of-Interest

The face of the subject is our ROI, it is detected and tracked from the video recorded using a camera. The video is recorded at 640x480 at 30 fps.

The ROI should be as large as possible so that sufficient data can be selected for further analysis. Accurate face-detection and tracking is important for reliable collection of the PPG signal, otherwise there will be excessive noise present in the collected information which would make HR estimation difficult.

B. Source seperation using ICA

The Independent Component Analysis (ICA) is a blind source separation technique. It is a linear transformation between the input and output signals such that the dependence between the signals is minimum. Efficient computer algorithms exist, which would provide the ICA in polynomial time. The PPG signal may be distributed randomly about the three recorded channels. ICA is used for isolating the PPG signal onto a single channel.

C. Filtering

Each frame is decomposed into RGB channels and a spatial mean is taken yielding 3 values per frame (one value for each channel). These signals are detrended so that cyclic variations are more exposed, and further normalized. ICA is then done over the signals. It is difficult to estimate HR immediately after ICA, so additional filtering is applied for noise reduction. The output of the ICA module is first low-pass-filtered with cutoff of 5Hz. This cutoff is selected based on the frequency range of typical HR signals giving us a maximum of 300 bpm that can be measured. This is followed by a narrow-band filter with dynamic cutoff frequencies based on current estimate of the heart rate. This eliminates noise in the same frequency band as that of the PPG signal and significantly improves the signal-to-noise ratio.

D. Channel Selection

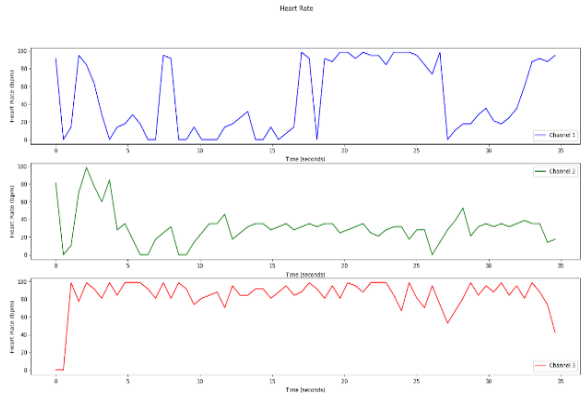
The heart rate can be estimated by finding the maxima in the spectrum of the signal. The ICA being given 3 signals produces 3 independent signals as its output. The signal that maximally represents the PPG signal can be heuristically assumed to be the second as done by Pohet. al. The channel may also be selected using machine learning as done by Ghanadian, Ghodratigohar and Osman.

E. HR Adjustment

An offset exists between the calculated HR and the ground truth; this offset can be reduced by using linear regression. This increases the output accuracy thereby decreasing the RMSE.

III.RESULTS

Face video from a subject was recorded and analyzed. The following graph is a plot of the heart rate estimated by the algorithm versus time across the three channels. The video was recorded at 480p at 30 fps for 35 seconds.



The PPG signal is isolated into the third channel output by ICA, shows the heart rate of the subject.

IV.CONCLUSION

This paper proposes a non-contact method to monitor the heart rate using a video of the patient's face based on Independent Component Analysis. A standard RGB camera is sufficient for recording the video. Such a method of measuring heart rate is advantageous, especially for long-term monitoring and for moving subjects as contact sensors are not needed.

V.FUTURE WORK

Reduce the required computational power of the proposed method, enabling it to run in real-time on low power devices like smartphones. This would enable easy heart rate monitoring just using a smartphone without any special equipment.

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