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Heart Rate Detection System

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Abstract - *A non-contact method of measuring heart rate could be advantageous for sensitive inhabitants, and the ability to calculate pulse using a phone camera or a simple webcam could be useful in telemedicine. In this paper a method for detecting heart rate using a camera is demonstrated which is also known as Photoplethysmography Imaging. The RGB color of the human face is obtained using pulse related signals from using a high quality camera under proper light conditions. Readings have been recorded under different conditions of humans and compared with other technologies.*

***Keywords* – Photoplethysmography, ECG, Butter BandPass Filter, Signal and Image Processing Techniques, Heart Rate Detection.**

I. INTRODUCTION

In today's world there are many ways in which heart rate are measured such as manually, by using smart bands, by using chest traps, etc. ECG is also used to measure the heart rate, which is the best in providing accuracy but all these methods involve the machine to contact the skin. There are electrodes used in these methods which cause harm to the skin if it is in contact with the skin for a longer time. Monitoring HR i.e Heart Rate is used to state the physiological aspect of the person and hence is very essential to monitor. Heart Rate is measured at a very high cost nowadays and involves usage of many sensors. In the last decade there have been researches focusing more on cost efficient,effective to use and easy to use non contact based applications. Thus we have proposed a system which does not have any contact with the skin and is very much easy to use and flexible for the users.

In our project the HR can be monitored using a webcam which is present on a laptop or a camera attached to a computer in real time. The heart rate is monitored by focusing on the color variation in facial skin caused due to circulation of blood in various regions of the face.

II. METHODOLOGY

A. Measurement Principle

Whenever light hits a floor it is either absorbed, transmitted, or reflected. In PPGI technology, image acquisition systems are used to detect light components reflected from upper tissue layers. Instead of using single photodiodes, other technology of detector arrays can be adopted, CCD cameras being a good example. Fig. 1 shows the reflected light portion in upper layers. The absorption capacity of hemoglobin is much more in perfused tissue than the inner tissues which leads to significant absorption of light. As the blood content changes, optical attenuation of the skin is observed[6]. The blue-colored layer, slowly fluctuating part (~0.25 Hz) adds up to 10% of the entire signal containing details about venous blood volume changes. Changes in thoracic pressure that are respiration-dependent affects the blood from veins returning to heart. Thus, signal components can be used to acquire respiratory parameters. The arterial blood volume changes corresponding to the rapidly fluctuating part (~1 Hz) constitutes only 0.1% of the total signal. Measurement of the human heart rhythms is done with these signals [6].

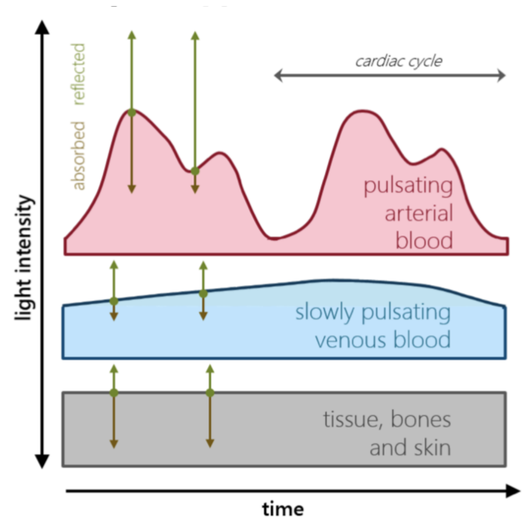

Fig. 1. Components of Reflected light portion in upper human tissue layers

B. System properties

Proposed systems can be distributed in 4 fundamental parts, providing various solutions:

- Definition of focused region.
- A plan of action to illuminate the focused region.
- A camera system as an optical detector

1) Region of interest (ROI)

Every blood rich skin region is suitable for measurement and acquisition of biosignals. An area which is freely accessible like a human's face should be chosen for unobtrusive and continuous measurements of the focused region. Also, there is a direct proportion between the signal-to-noise ratio (SNR) and degree of perfusion of the area. The cheek and forehead regions are best suited in terms of degree of perfusion and area size[8].

2) Illumination strategy

On the basis of the type and boundaries of the application a decision between an active and passive approach can be made. For this system, a passive approach is preferable where ambient light is used which suffices the need of extraction of pulse signals.

3) Image detection

Acquisition of vital sign parameters is best possible with cameras having low cost providing images with good quality [9]. Low-cost-cameras are a good choice for applications related to determining pulse and respiratory rates but not beyond that. For this system web camera inbuilt in the desktop/laptop is used for image detection.

To isolate essential signs from image frames from the people various types of algorithms have to be advanced:

- Image processing algorithms to detect the ROI
- Signal processing algorithms to acquire vital signs

The very first step is processing the image captured. As a person might not be stable initially, frames are captured for the first 15 seconds. Each captured frame is being processed for a particular region (i.e cheeks) in this system using shape predictor landmarks.

To isolate the pulse signal from the raw signal, signal processing algorithms are used. To filter the signal butter bandpass filter is implemented. In order to reduce the impact of noise technique of Independent Component Analysis (ICA) for PPGI, using RGB channels is recommended. The filtered signal has to be analyzed in time or frequency domain so as to determine the human's pulse rate. The filtered signal here is analysed in the frequency domain.

III. METHODS

A. System Concept

Following conceptual decisions are made for the PPGI system detecting Heart Rate.

- Cheeks as ROI
- System with ambient light illumination
- Image acquisition with low-cost-cameras

B. Algorithms

All the data processing methods that are being developed in the algorithm are described in this part. Before the adoption of this method, all the image and signal processing methods were developed in Matlab affecting various parameters such as signal quality and runtime. Methods with finer results are briefly shown in section (III.B.2). The developed algorithm comprises of these methods, which are visualized in the flowchart shown(Fig.2)

1) Online Algorithm

When the system starts, initialization of Graphical User Interface and camera takes place(Fig. 4). The face detection module is activated as soon as GUI is initialized. On the UI the user chooses to start the process. Meanwhile, it makes himself stable and during that time images are being captured using OpenCv library. On the UI the person's face is being marked with red points with the help of python dlib library. A shape predictor landmark is used for marking different facial features.

Cheeks are chosen as the Region of Interest. Out of the RGB channels captured from different frames of cheeks only red channels are chosen[10]. A gaussian pyramid is built of different frames so that the region of interest does not get unidentified, even the sharp edges can be detected through this technique. A sufficient amount of data is being collected from the frames captured for 15 seconds. This data is passed on to the signal processing module.

Signals captured are filtered in a particular range of frequency using butter bandpass filters. An appropriate PPG signal is extracted after the execution of this module.

2) Methods for vital sign extraction

For peak detection, maxima of all the signals are localized (see III.B.2). Based on the peak-to-peak distances current pulse being one of the vital signs is calculated and visualized in the GUI. A butter bandpass filter is used for the same and a PPG graph is plotted and visualized on the user interface.

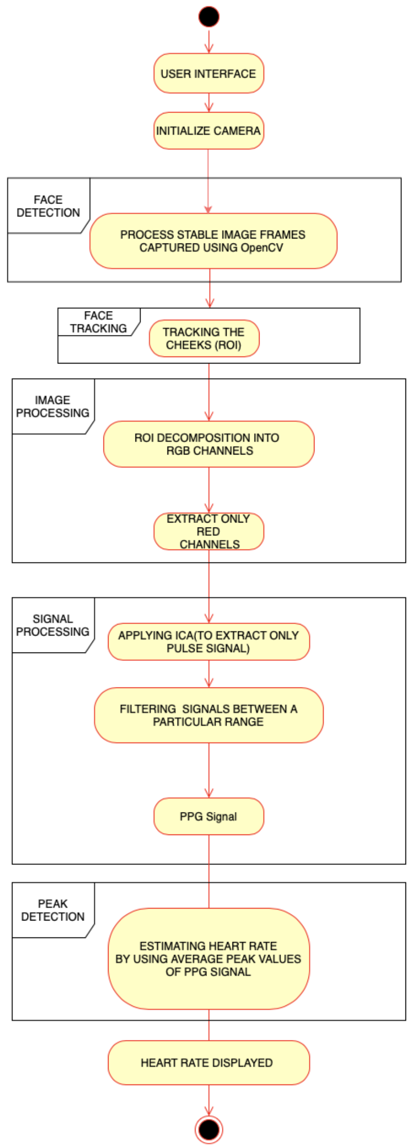

Fig. 2.Online Algorithm Flowchart

IV. EVALUATION AND RESULTS

A. Study Description and Measurement Setup

System was tested under a closed room with good ambient light and without any kind of disturbance. Readings were taken under this condition with candidates of all range of age.

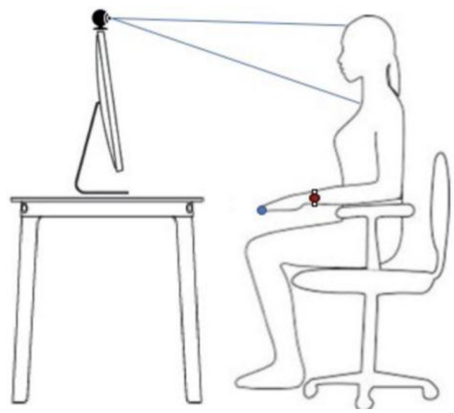

Fig 3. Experimental Setup

Subjects were suggested to sit in a relaxed position. In order to have optimum results in detecting peaks with minimum errors this kind of arrangement was adopted. The readings of two females and a male were taken from fitness bands and ECG also, which was taken as a reference.

B. Results

Following image is the GUI of our system. A person's image is taken from the leftmost window. There is a start button below the window which you can click when you are ready for the process. Frames are captured and ROI is detected in the right topmost window during the process and simultaneously two graphs are being plotted and heart rate readings are shown. Once the heart rate becomes stable the process stops.

Fig 4. Graphic User Interface (GUI) to visualize heart rate

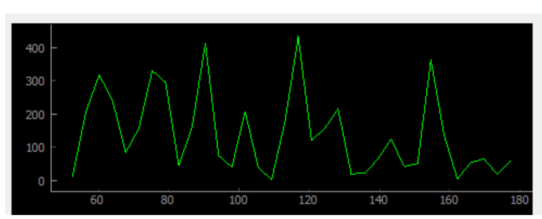

Fig 5.

The above graph extracts the photoplethysmography signal from the frames captured during the live video.

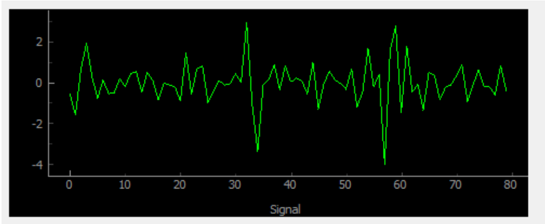

Fig 6.

The above graph calculates the meaning of the above graph and displays the heart rate of the person.

C. Discussion on Accuracy

In comparison with the other methods of heart rate detection, our system shows ~5-10 bpm deviation from the actual heart rate measured from the reference instrument i.e ECG machine.

V. CONCLUSION AND FUTURE SCOPE

A real time noncontact based Heart Rate detection method using facial images is an easy to implement, low cost and comfortable alternative for other non contact solutions for real time applications. Idea of extracting heart rate from facial skin color variations due to cardiac pulse is suitable as it can be opted just by using a simple webcam in an indoor environment with constant ambient light. Our system is feasible and easy to use as well as it is a contactless solution for detecting heart rate so there will be no harm to skin. As we have seen that the accuracy of the system is quite good in comparison to some other PPGI technologies, it can be adopted by anyone and anywhere. The only requirement is having a computer with a webcam and a good internet for better results. For future work an android application can be built from which the user can check their heart beat from anywhere they want. Another thing that can be done is analyze and predict the heart rate according to the age of the person whether the heart rate is healthy or not.

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