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Analysis of Heart Rate Monitoring Using a Webcam

Larissa Carvalho[1], Mr. H.G.Virani[2], Mr.Shajahan Kutty[3]

Student, Department of Electronics and Telecommunication, Goa College of Engineering, Ponda, India[1]

Associate Professor, Department of Electronics and Telecommunication, Goa College of Engineering, Ponda, India[2,3]

Abstract: In this project I have implemented a non invasive heart rate monitoring system, to monitor subjects of different age groups using Digital Image Processing. Using this method, it is possible to visualize the flow of blood as it fills the face. From this result, it is possible to extract the subject's heart rate. The main field of research is Image processing and computer Vision. Variations in videos that are difficult or impossible to see with the naked eye are revealed by taking a standard video of the subject as input, performing face tracking and applying pyramid decomposition, followed by filtering of the frames. The resulting signal is then amplified to reveal hidden information. We are thus able to visualize the flow of blood as it fills the face. This method is based on the Eulerian Video magnification algorithm presented at SIGGRAPH 2012.

Keywords: Heart Rate, Photoplethysmographic signal, Bradycardia, Tachycardia, Filtering

I. INTRODUCTION

Heart Beat originates in the form of spontaneous electrical activity of the primary pace maker cells of the Sino atrial node (SAN) .An efficient propagation of the electrical waveform initiated by this spontaneous electrical activity to the atria and via the cardiac conduction system, Bundle of His, Bundle branches, and Purkunje fibre network, to the rest of the heart brings about a highly co-ordinated rhythmic mechanical activity characterized by synchronized contractions and relaxations of different regions of the heart. The cardiac cycle repeats itself throughout the life of an organism with a high level of efficiency and determines the heart rate and rhythm.

The electric cycle recorded with an ECG begins with a P wave reflecting the atrial depolarization. The PR interval, the time taken for atrial depolarization to reach the AVN and beyond is well preserved in different mammals. The QRS complex represents the entry of the wave of excitation via the cardiac conduction cycle into the ventricles and depolarisation of ventricular Myocytes. Repolarization of the ventricles is reflected in the T wave which is often followed by the U wave

Heart Rate is an important parameter in diagnosing diseases and for the survival of mankind. The greater demand is put on one's body through physical exercises or through illness or mental stress. Therefore the Heart Rate is a parameter of high significance to medicine, physics, psychology and to many other fields

The Normal values for pulse rate depend on age and fitness level. A normal adult has a pulse rate of 72 per minute while that of an athlete maybe below 50 per minute.

Heart Rate describes how many times a heart beats per minute. By counting the number of R peaks per minute we can measure the heart rate of a person Cardiac pulse measurements play an important role in diagnosing heart diseases such as Tachycardia and Bradycardia.

Tachycardia is a heart rate that exceeds the normal range. In general, a resting heart rate over 100 beats per minute is accepted as tachycardia while Bradycardia is a heart rate that is less than the normal range ie. a resting heart rate under 50 beats per minute is accepted as Bradycardia. Thus by calculating the heart rate we are able to diagnose these diseases

II. LITERATURE REVIEW

At the beginning we need to perform the face detection algorithm which restricts the area of processing to only the facial region. Then we perform the colour magnification algorithm to detect the flow of blood as it fills the face.

The adaboost based face detector by Viola Jones [5] demonstrated that faces can be detected reliably in real time under partial occlusion, while Haar wavelets were used in [6] for representing faces and pedestrians. They proposed the use of haar like features that are used to encode the horizontal, vertical and diagonal intensity information of face images at different positions and scale. Given a sample image of 24 by 24 pixels, the exhaustive set of parameterized haar like features is very large. Contrary to most of the prior algorithms that uses one single strong classifier, they used an ensemble of weak classifiers where each one is constructed by thresholding of one haar like feature .the weak classifiers are selected and weighted using the adaboost algorithm [7]. As there are a large number of weak classifiers ,they presented a methods to rank these classifiers where each is constructed by thresholding of one haar like feature. The weak classifiers are selected and weighted using the adaboost algorithm [7] .As there are a large number of weak classifiers, they presented a method to rank these classifiers into several cascades using a set of optimization criteria. Within each stage, an ensemble of several weak classifiers is trained using the adaboost algorithm. The motivation behind the cascade of classifiers is that simple classifiers at early stage can filter out most negative

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examples efficiently and stronger classifiers at later stage are only required to deal with instances that look like faces. The final detector, a 38layer cascade of classifiers with 6060 haar feactures, demonstrated impressive real time performances with fairly high detection and low false positive rates. Several extentions to detect faces in multiple views with in plane ration have since been proposed.

In[3], they have used the independent component analysis to obtain the raw signals from the RGB components. In [8], they extracted the heart rate by video recordings of the finger tips which gave the cardiac pulse equivalent to that present in a photoplethysmographic signal. By performing peak detection on the pulsatile signal, the heart rate could be extracted. The most efficient of the above method was [1] where in the changes due to the blood flow through the face were recorded and compared with a Heart rate monitor.

III. EXPERIMENTAL SETUP

The test setup was designed in a way to minimize external environmental influences in order to extract the heart rate from the facial video. The subject was placed in front of a webcam(1.3MP, 24 bit RGB, 8 bit per channel), and colour videos were recorded for 25 sec at 30 frames per sec with a resolution of 640x480 pixels

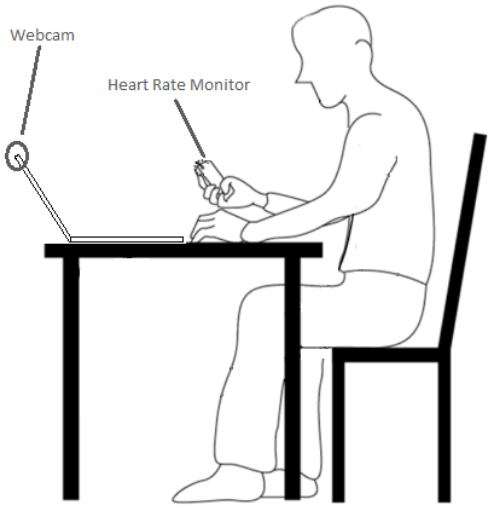

Figure 1: Experimental Setup

The subject was placed at a distance of 1 meter away from the webcam with bright light as the source of illumination. As the video was being recorded, the heart rate of the subject was noted down manually using a heart rate monitor for every 10 sec interval.

The pulse wave initiated by the heart beat travels through the whole arterial system and reaches the face causing short term volume changes in the blood. The intensity of the absorbed light depends on the volume. However this recorded video date has no clean RGB signals but has a mixture of illumination data along with noise and motion artefacts. The processing and analysis of the video data is done using MATLAB R2013a. Firstly, the ROI is selected using the face detection algorithm published by MATLAB.

IV. ALGORITHM

(1) Perform face detection on one frame of the video
(2) Decompose this frame into sub frames using the Gaussian pyramid decomposition algorithm. Thus the highest level of the pyramid has low pass information.
(3) Filter each level of the pyramid using a Band Pass Filter, with cut-off frequency given as [(hifreq*framerate/samplingrate)±1] .
(4) Magnify the intensities of the frequency band of interest by a magnification factor.
(5) Collapse the pyramid into a single frame.
(6) Repeat the above 5 steps for all the remaining frames of the video.

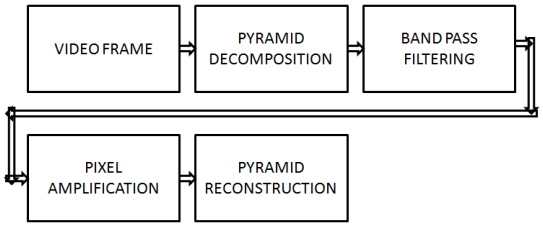

Figure 2: Block Diagram

V. RESULTS

The results were generated using MATLAB R2013a.The computation time per video was in the order of a few minutes. The Face Detection algorithm was implemented for 5 subjects belonging to different age groups. The Heart rate generated by the code was compared to that of the HRM and the results were obtained as shown in Table 1. Figure 3 shows the PPG signal corresponding to the red, component after reconstructing the pyramid

This algorithm has been implemented for 5 subjects belonging to different age groups. The results obtained by the heart rate monitor and that of the code is as shown in

Table 1.The Heart Rate was found using the formula HR=6 * Number of peaks in the 10 sec window.

TABLE I
RESULTS

Patient Age	HR Generated By Heart Rate Monitor	Calculated Heart Rate
2 Months	150	148
18 years	89	86
22 years	67	70
51 Years	65	66
58 Years	60	63

After reconstructing the pyramid, the graph of the average intensity of each frame versus time/frame number was

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plotted and a peak detection algorithm was used to note the position of the 'r' peaks. The figure 3 shows the graph for the 22 year old subject.

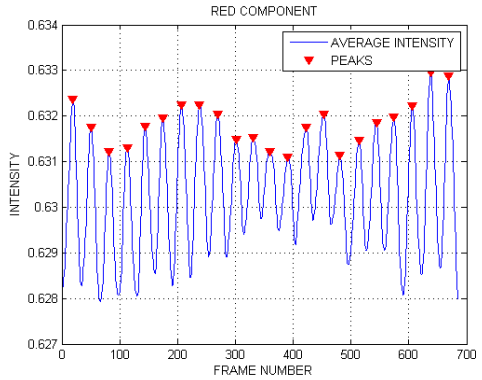

Figure 3: Intensity vs time waveform

The number of peaks was found in each 10 second window and thus the heart rate was calculated, and the result was compared to that found by the Heart Rate Monitor (HRM).

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