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Video based Heart Rate Measurement from Human Faces

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Abstract: This paper presents a method for measuring the heart rate (HR) of a human face and does not require any costly medical equipment. The video sequences are captured with a camera attached to Smart phones. In this paper, we have attempted to measure the HRs of a group of people using red, green and blue signals in the video sequence. In addition, we have repeated the experiment on various parts of the human body. The results reveal that the forehead and checks are more suitable for the measurement purpose.

Keywords: Heart Rate, Video Sequences, Camera, Colors.

I. INTRODUCTION

In general, the heart rate (HR) is measured using contact based device, for example electrocardiogram (ECG).The heart rate measurement may be time consuming, uncomfortable and inconvenient for patient. Recently, the HR measurement using a video sequence from a smart phone camera has becoming a popular research topic. Significant advantage of it is that the HR of a patient can be monitored remotely by a medical doctor. Another advantage is that it does not require any expensive device, but requires only a smart phone. In this paper, we investigate the feasibility of the HR measurement using Red (R), Green (G), and Blue (B) signals from colour video sequences. Moreover, we perform the HR measurement on various spots of the human body. The forehead and checks may be a suitable spot for the purpose.

II. EXPERIMENTS

A. Set Up

In the experiment, we use the smart phone camera for capturing video sequences. Note that the camera is equipped with the auto-focus function. The resolution of the video frame is the VGA, namely, 640 by 480 pixels with the frame rate 30fps (frames per second) .The AMCAP is used as its video compression rate is not too high. We realize that it is difficult to measure the heart rate (HR) on highly compressed video sequences. The experiments were conducted indoors and with a varying amount of sunlight as the only source of illumination. We record 20 seconds of video sequences on one human subject who are asked to sit still on a chair in front of the camera for 20 seconds. The recorded video sequence are analysed with MATLAB.

B. Algorithm

Fig. 1 describes the flow of the experiment. A video sequence of a human subject is first recorded for 20 seconds. We next select the region of interest (ROI) manually on the first frame of the video sequence. We select five spots on the human face for comparing the feasibility of measuring the heart rate (HR). Within the ROI, the mean intensities of the red, green, blue signals are computed. Fig. 2 shows the plots of those four signals for 20 seconds. The discrete Fourier transform (DFT) is applied to the three signals to extract a spectrum, we set the range for observation from 40 to 120 BPM (beats per minute) as that covers the HR of the human in a normal state. We observe the Fourier transform only between 13^{th} to 40^{th} spectrums. In fact, the indexes are 14 to 41 in MATLAB as it counts the zero-frequency as 1. We are supposed to have a prominent spectrum that corresponds to the HR. We then evaluate the reliability of the spectrum using z-scores described below.

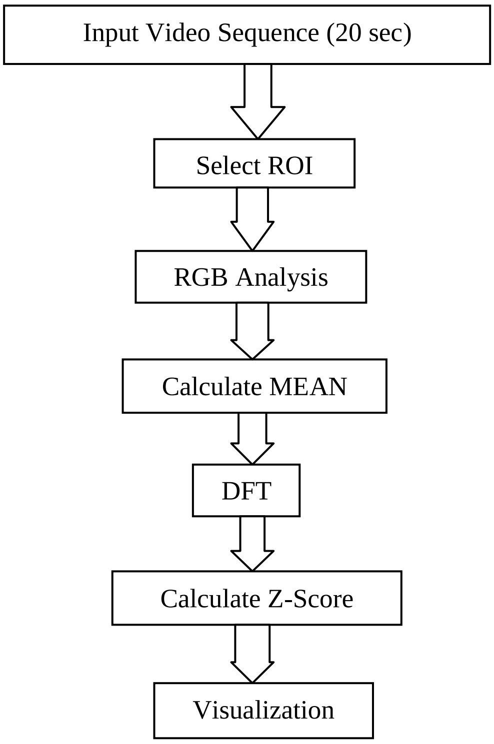

Fig. 1: Flow chart of the heart rate measurement.

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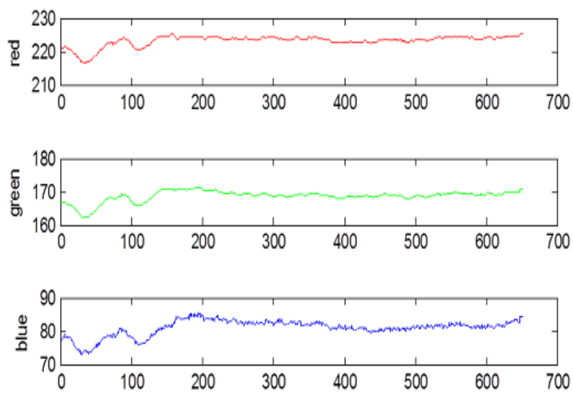
The theorem of Z-score is applied to standardize the data. The z-score or standard score is a difference of an observation data and the standard deviations over the mean. If the data is above the mean, the standard score will present in positive value and in negative value vice versa. The more value of z-score means the more different in value of the datum and mean. The higher the z-score can be calculated as the equation (1).

$$z = \frac{(x - \mu)}{\sigma} \quad (1)$$

Where
Z = z-score,
x = observed data,
μ = mean of data in the observed range,
σ = variance of data in the observed range.

III. RESULT AND DISCUSSION

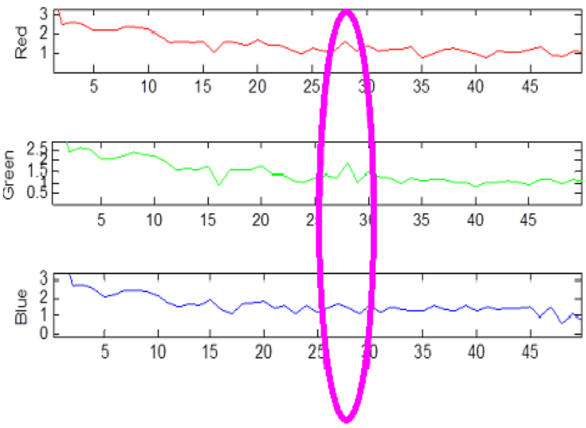
We observe three signals, red (R), green (G), and blue (B), in a recorded video sequence. Fig. 2 shows the three signals in a video sequence recorded for 20 seconds. The mean value of each signal within a region-of-interest (ROI) is used for the plotting. The discrete Fourier transform (DFT) is then applied to those three signals. Fig 3 shows the Fourier spectrums of the three signals up to the Nyquist frequency. There are high spectrums at the 28^{th} frequency in the oval superimposed on the plots. This corresponds to 28-1 cycles per 20 seconds, which means, 27 times 60/20, 81 BPM. It is important to note that the spectrums from the R and B signals are more prominent than those from G signals.



Frame indexes

Fig. 1: Plots of red, green and blue signals in a video sequence recorded

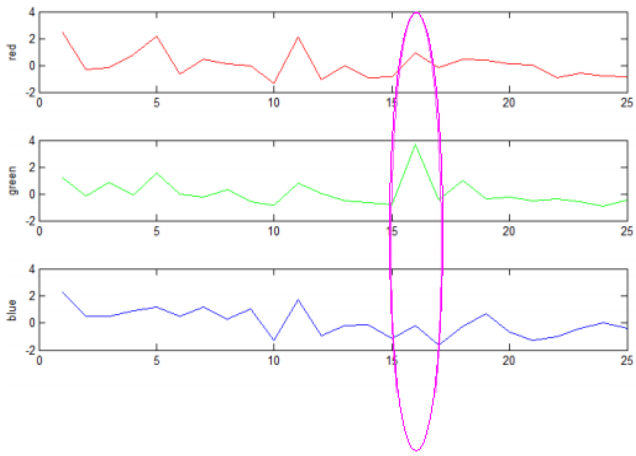
For quantitative evaluations, we crop the Fourier spectrum from the 14^{th} to the 41^{st} spectrums. This corresponds to 40 to 120 BPM that covers the human heart rate in a normal state. We then evaluate the degree of prominence of each spectrum using the z-score. Fig.3 shows the z-scores of the spectrum from the 14^{th} to 41^{st} spectrums. The indexes are shifted by 1, because the plot cannot start at zero index. The highest peak at the 16^{th} frequency in the oval superimposed on the plots, corresponding to the 14^{th} + (16-1) = 29 cycles per 20 seconds, which means, 29 times 60/20, 87 BPM.



Frequencies up to the Nyquist

Fig. 2: Fourier spectrums of the red, green and blue signals

The z-scores reveal the following two points: 1. the red and blue are more suitable for the heart rate (HR) measurement than the green signals. 2. The forehead and cheeks are more suitable for the HR measurement than the nose and tongue.



Frame indexes

Fig. 3: The z-score of the spectrum from the 14^{th} to the 41^{st} spectrums.

The red signal may be effective for the HR measurement because the colour of the blood circulating through the veins appears red. The good spots for the HR measurement are found to be the forehead and cheeks. This may be due to the fact that the areas of these facial parts are large and it is easy to set up the large region-of-interest (ROI) for the HR measurement. Since the mean value of each signal within the ROI is used for HR measurement. It is expected that the larger the ROI is, the more reliable the measurement is. The results verify that the red signal is the most effective for the HR measurement, closely followed by the blue signal. The best spot for the HR measurement is the forehead, followed by the cheek. The results indicate that the HR measurement can be performed on a human subject in a regular posture, without requesting him/her to raise his/her hand or stick his/her tongue.

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IV. CONCLUSION

This paper has presented a comparative study on the heart rate (HR) measurement of a human subject using a video sequence. We have tested the feasibility of the task using red (R), green (G), blue (B) channels in the video sequence computed from the RGB signals. Experimental results show that the red is the most effective signals, closely followed by the blue signal. We also have compared the performance of the HR measurement on various spots of the human body. The results reveal that the forehead is the most suitable spot for the HR measuring purpose, followed by the cheeks. Moreover, it is low-cost method for non-contact heart rate measurement that is automated and motion tolerant. There are two extra findings from the experiment: 1. The size of the screen for measuring the HR may be crucial. The larger the screen of smart phone is, the more reliable the measurement is. 2. The quality of the video sequence may matter. If the sequence is greatly compressed, it is difficult to measure the HR. As future work, we plan to continue the comparative study on more human participant.

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