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Touchless Heartbeat Detection using Machine Learning

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ABSTRACT: Heart Rate (HR) is one of the most important Physiological parameter and a vital indicator of people's physiological state and is therefore important to monitor. Monitoring of HR often involves high costs and complex application of sensors and sensor systems. Research progressing during last decade focuses more on noncontact based systems which are simple, low-cost and comfortable to use. Still most of the noncontact based systems are fit for lab environments in offline situation but needs to progress considerably before they can be applied in real time applications. This paper presents a real time HR monitoring method using a webcam.The heart rate is obtained through facial skin color variation caused by blood circulation. Three different signal processing methods such as Fast Fourier Transform (FFT) have been applied on the color channels in video recordings and the blood volume pulse (BVP) is extracted from the facial regions. HR is subsequently quantified and compared to corresponding reference measurements. The obtained results show that there is a high degrees of agreement between the proposed experiments and reference measurements.

KEYWORDS: FFT algorithm; blood volume pulse (BVP); Webcam; color variation

I. INTRODUCTION

The non-contact physiological parameters monitoring idea has come from the cardiovascular system of human body. The cardiovascular system permits blood to circulate in the body due to continuous blood pumping by heart. Our Heart pumps blood through the blood vessels of this system and for each heart beat blood circulation creates color variation in Facial skin. Therefore, it is possible to extract HR from the color variation of the facial skin. In 1995, the first noncontact health monitoring system was investigated by Costa et al. They used camera images in order to extract physiological parameters using color variation of the skin. But their approaches did not report quantitative results; they reported only a graph of heartbeats and also failed to show any correlation with reference ECG signals. After this first attempt further progress was moderate and in 2005 another novel method was introduced for the measurement of computer user's emotional state using the facial thermal.

Heart rate is a crucial factor for the diagnosis of heart diseases and one of the dominant parameters for cardiovascular diseases. Heart rate is defined as the rate at which heart contracts per minute. It is a vital physiological signal measured in the human body that reflects the physical and mental state. Heart rate variability is a measure of variations between each heartbeat that indicates the effects of stress on a person's body. With the rise of unhealthy eating habits and sedentary lifestyles across the world, mortality rates due to cardiovascular diseases (CVDs), stroke, septic shock, coronary heart diseases (CHDs) are rapidly increasing. Ischemic heart disease and stroke are the two major cardiovascular diseases responsible for 80% deaths in India . Therefore, the adaption of a healthy lifestyle with the regular examination of heart rate is essential to keep these diseases at bay.

Standard medical techniques to monitor heart rate are Electrocardiogram (ECG) and Pulse Oximeter sensors . These conventional methods provide accurate heart rate but the application of these devices can cause damage to elderly skin. Moreover, wearing these devices for long time duration can cause extreme discomfort to patients. Also, it cannot be used on neonates. Due to the complex hardware, usage of these machines at home can become complicated

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without any specialist's supervision. Therefore, interest is growing to measure heart rate without any contact between patients skin with the hardware so that it can be measured without any discomfort.

II. RELATED WORK

Photoplethysmography (PPG) is a technique that measures the changes in blood volume caused by scattering of light due to the flow of blood in the body parts. Because of its non-contact nature of sensing, PPG is currently gaining popularity. Face images captured by using the camera carries information about minute color changes in the skin caused due to the beating of heart, blinking of eyes and other physiological activities occurring in the body that generates pulse wave signals which cannot be seen by the naked eye. For computation of these crucial physiological signals from facial videos, researchers have designed approaches .

Experimental results validated that red channel was the most effective color channel, closely followed by blue channel. Lueangwattana C. et al employed PCA to the means of R, G, B channels. Simultaneously, the RGB color model was converted into HSI color model and the mean of hue channel was computed. Fast Fourier Transformation followed by the bandpass filter and z-score theorem was applied to PCA and hue channel for heart rate measurement This study focuses on an advanced technique of histogram equalization known as Brightness Preserving Bi-Histogram Equalization (BBHE). It is applied on facial videos to overcome brightness issues. Through its application, video's mean brightness can be successfully retained and its contrast can be enhanced in low or varying light conditions.

III. PROPOSED ALGORITHM

A. Face Detection :-

1. Converting the pixel intensity values into an Integral Image.
2. Haar features: They are different rectangular images, as presented in Figures.
3. The AdaBoost learning algorithm: it is used for selecting the best features out of the entireset.

The Cascades Filter: it discards the negative windows in order to focus the computational process on the positive ones as much aspossible.

B. The Selection of Region of Interest(ROI):-

The region of interest is an area of the image, selected on specific criteria, which is to be used during the computational process. In order to observe the skin color variation, the most suitable area is the forehead as it provides detailed changes encountered. The dimension of the rectangle placed on this area is in respect to the facial detection box, as its size changes depending on the distance between the subject and the webcam. The next step is calculating the median or the average of the pixels within the region of interest, for each frame.

C. Object Tracking:-

In order to identify the face of the subject, two options can be implemented:

1) Applying the face detection algorithm for each frame.

2) Applying the face detection algorithm for certain frames, between which only face tracking is implemented.

We used the second method, as it is considered faster. This is because when tracking an object detected in the previous frame, there are also given details about the appearance of the object

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D. **Measuring Heart Rate:-**

The FFT (Fast Fourier Transform) is applied to the window formed by the last 200 frames of the signal obtained at the previous point. Since normal heart rates are between 35 and 195 beats per minute, frequency filtering can be applied to correct false readings. The heart rate translates to a frequency between 0.5 Hz and 3 Hz. This frequency range is far away from the power line frequency, 50 Hz or 60 Hz, so there are very few chances of interference from there.

The continuous component on the other hand, will influence the spectrum, given how close the heart-rate is from 0 Hz. During the process, the sampling frequency will only take effect on the spectral density, as the algorithm will run on the web camera frequency.

First, the maximum is detected avoiding the 0 Hz component. To ensure the maximum indeed corresponds to a HR frequency, a ratio is calculated between the maximum and the median of the spectrum. We discovered that a ratio of 3:1 is a good discriminant for this case.

IV. ALGORITHM DIAGRAM'S

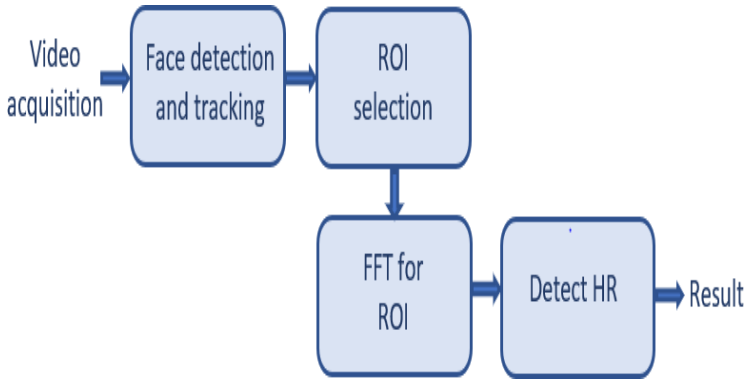

Fig. HR measuring algorithm diagram

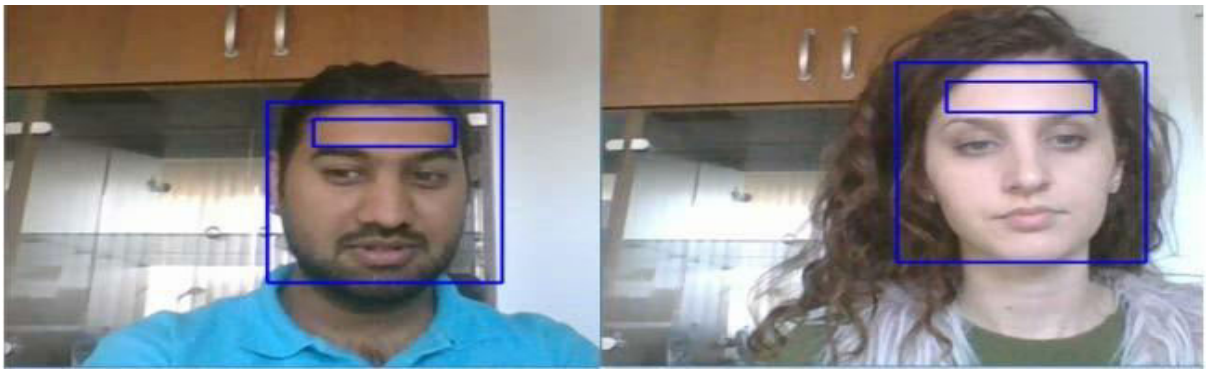

Fig. Running tests on different skin tones

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V. SIMULATION RESULTS

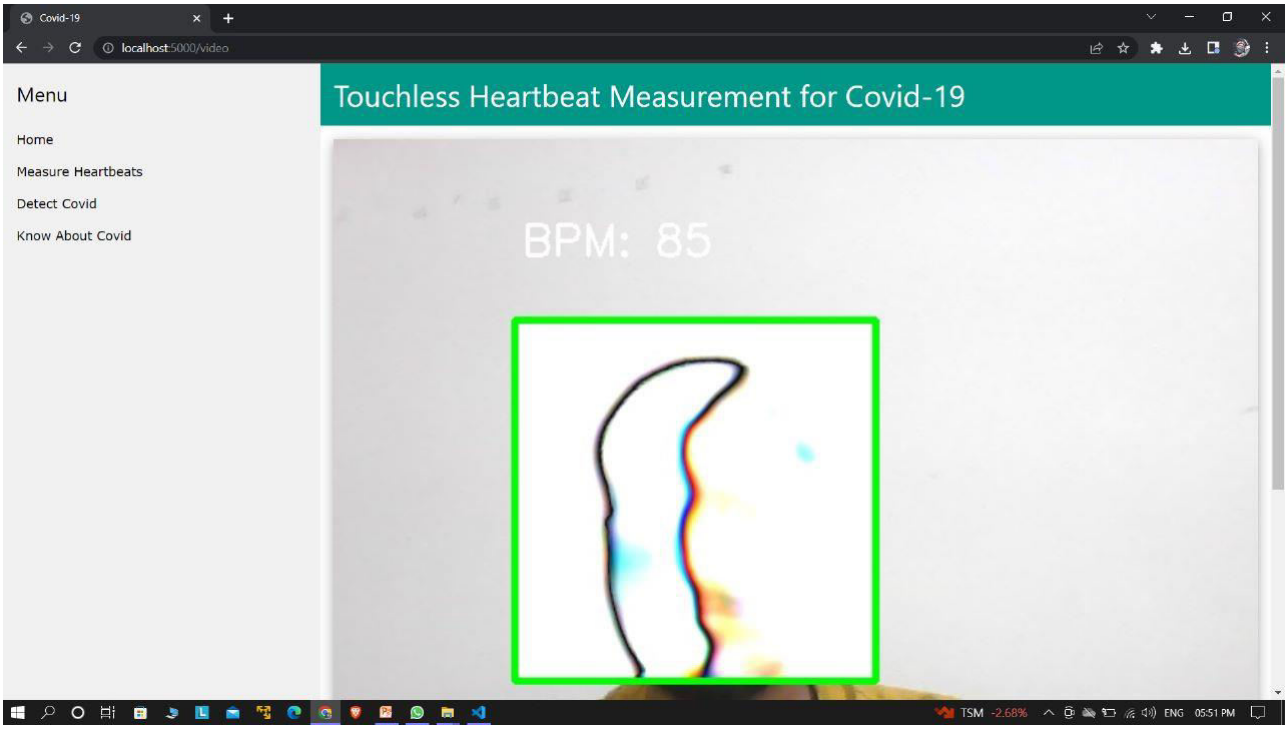

Fig. Final Output Result

VI. CONCLUSION AND FUTURE WORK

The non-contact physiological parameters monitoring idea has come from the cardiovascular system of human body. The cardiovascular system permits blood to circulate in the body due to continuous blood pumping by heart. Our Heart pumps blood through the blood vessels of this system and for each heart beat blood circulation creates color variation in Facial skin. Therefore, it is possible to extract HR from the color variation of the facial skin. In 1995, the first noncontact health monitoring system was investigated by Costa et al. They used camera images in order to extract physiological parameters using color variation of the skin. But their approaches did not report quantitative results; they reported only a graph of heartbeats and also failed to show any correlation with reference ECG signals. After this first attempt further progress was moderate and in 2005 another novel method was introduced for the measurement of computer user's emotional state using the facial thermal

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