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HEART RATE MONITORING SYSTEM USING IMAGE PROCESSING

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Abstract— The heart rate is one of the important physiological signals of a human body which varies according to our activities such as physical exercise and emotions. It is the number of heart beats in a minute and expressed as beats per minute (BPM). A normal resting heart rate for adults is about 60 to 100 BPM. The whole world realized the importance of non-contact health monitoring devices, during the time of Covid-19. Every patient has different health condition and even following the social distancing norms, it is inappropriate to use the same device to monitor the HR of every patient. So, to overcome all this issues, we came up with an idea of monitoring HR using a webcam and image processing. Using Python programming language, we tried building such a system from scratch which helped us to understand the field as well as its advantages and disadvantages compared to other biometric authentication methods.

I. Introduction

1.1 Background/context

A Heart rate can be a source of information related to the entire cardiovascular system. The diagnosis and assessment of the stress levels experienced by a person can be done by monitoring the Heart rate of a person. A image processing through video approach has been introduced by us which is contact-free method for measuring heart rate. The person whose heart rate is to be monitored requires to be relaxed and sit in front of the webcam.

1.2 Aim and Objective

Building such a system from scratch using the Python programming language helped achieve a better understanding of the field as well as its advantages and disadvantages compared to other biometric authentication methods. After some research, the decision to monitor the HR using an OpenCV library for Python was unavoidable due to not having a system that could reliably do both detection and recognition in the project's circumstances..

II. Theoretical Description

2.1 Theoretical description

The heart rate (HR) of a person represents the number of heart beats per minute. It is an essential physiological parameter, a source of information related to the entire cardiovascular system and has great importance in diagnosis or assessment of the stress levels experienced by the person.We present a new approach to contact-free methods for measuring heart rate using video processing. This technique requires the subject to be relaxed and to be placed near a webcam.

2.2 Resources required

Hardware Requirements: 1.Laptop / PC, 2.Webcam

Software Requirement: 1.Python v3.5+ , 2.OPENCV library, 3.NumPy library

III.ALGORITHM

The experiment was done in two phases: in the first phase the real time HR extraction was conducted . All the facial image frames were saved for offline testing. In the second phase, HR was extracted again in offline using the saved image sequences.

A.DATA COLLECTION: Data acquisition was done by 10 participants (all are male) of different ages (25 to 50 years) and skin colors. The experiments were carried out indoors and with a sufficient amount of ambient sunlight. The participants were informed the aim of the study and they seated at a table in front of a laptop computer at a distance of 0.5 m from the built-in webcam (HP HD webcam). During the experiment, participants were asked to keep still, breathe spontaneously, and face the webcam while their video was recorded for 1 minute. HR was extracted in real time and saved in an excel file. All facial image frames (24-bit RGB) during real time HR extraction were recorded sequentially at 30 frames per second (fps) with pixel resolution of 640 × 480 and saved in PNG (Portable Network Graphics) format in the laptop. Simultaneously, HR was also recorded using devices like pulse oximeter, fit band.

B. APPLIED ALGORITHMS: The algorithms such as FFT, ICA and PCA have been applied to extract HR in real time using only facial video. Then the average of the R, G and B signals was calculated for Fast Fourier Transform method. For the ICA method, the normalized raw traces were decomposed into three independent signals (R, G and B). The data collection was supposed to be performed in sitting position without any movement but during experiment there happened slight movements in test persons' hands and heads which caused slight motion defects. The small movements causes the

Motions artifact which is removed by ICA. It returns the independent components from the given signal randomly. Component with highest power spectrum peak is selected for further analysis. Similarly, PCA decomposes the raw traces to find the principal component. The vectors we get as a result are an uncorrelated orthogonal basis set. PCA algorithm is sensitive to the relative scaling of the original variables. At the last, the Fast Fourier Transform is applied on the selected source signal and the power spectrum is obtained. The pulse frequency was designated as the frequency that corresponded to the highest power of the spectrum within an operational frequency band.

C. FEATURE EXTRACTION : The three main independent signals are Green Signals, Red Signals, and blue signals which are produced from the red green and blue color of the pixel of the facial image.

i.Reading Image:

Frames: The fundamental part of any image or video is the image frame which incates the start and end of the video or image. The resolution of the video should remain constant during each image frame extraction.Therefore, a novel key frame video extraction algorithm has been used to maintain same resolution that can read image frames automatically one by one.

ii. Face Tracking:

Facial image is provided as an input of the proposed non-contact HR monitoring algorithm and hence it is very important to track face of the user.

iii. Region of Interest Selection :

The most essential part of this experiment is the RGB values of each pixel.Hence,there should be perfect Region of Interest for a detected face. Unwanted part of the face should be eliminated in order to avoid the error.. To identify the coordinates of the face in the first frame, a boosted cascade classifier was used. A box was drawn around the part of the face defined by the X and Y coordinates.. Only the ROI was then separated from the entire facial image.

iv. RGB Signals Extraction

R, G, B color values are the fundamental elements of R, G and B signals which were extracted from the facial cropped ROI image. Each pixel of the taken image has 3x1 matrix of color values which consists of Red (R), Green (G) and Blue (B) color of the image. Then the three desired signals Red, Green and Blue signals are produced in two phases. In the first phase the average R, G and B color values are calculated for each image frame and in the second phase the red, green and blue signals are calculated from the summation of all the averaged R, G and B color values indicated.

v. Signal Detrending:

De-trending is an important signal processing concept which is used to remove unwanted trend from the series. In our case, when environmental parameters changes such as temperature or external noise, the collected RGB signals will be drifting and noising. Therefore the signals need to be de-trended. The RGB signal has been detrended using the method based on smoothness priors approach with the smoothing parameter λ =10 and cutoff frequency = 0.059 Hz

vi. Filtering:

Before applying PCA, ICA and FFT the Red, Green and Blue signals formed from all red, green and blue image are filtered by Hamming window.

IV. SYSTEM DESIGN

4.1 Block wise design

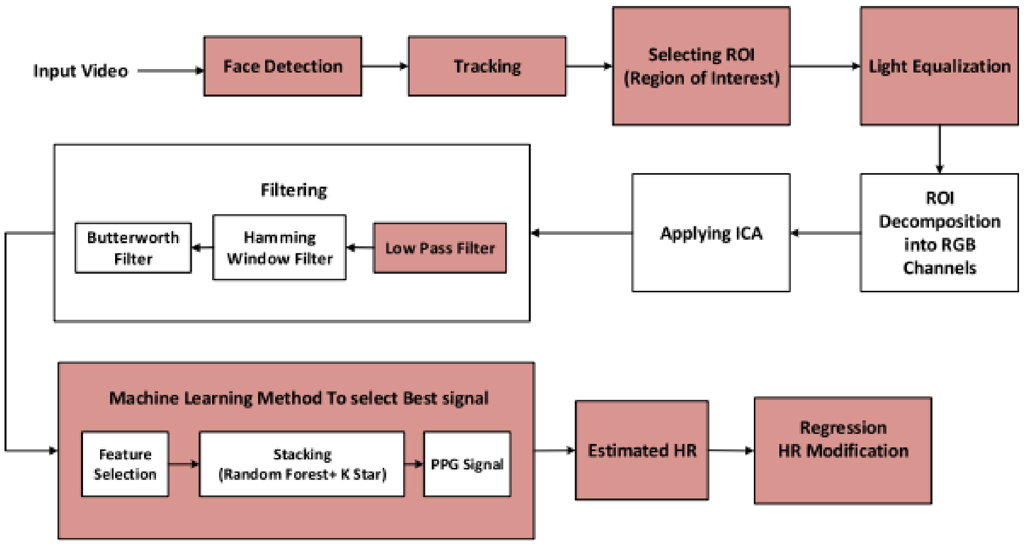
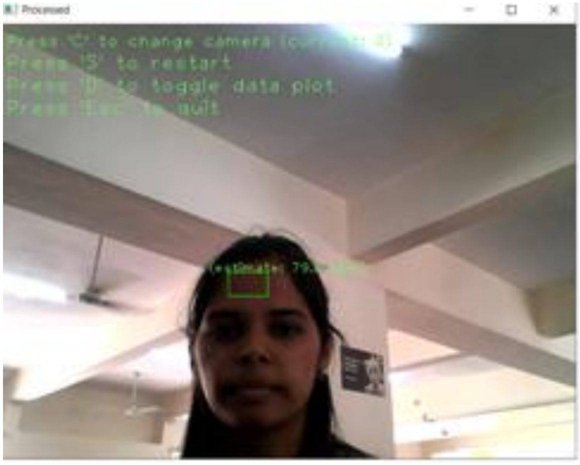


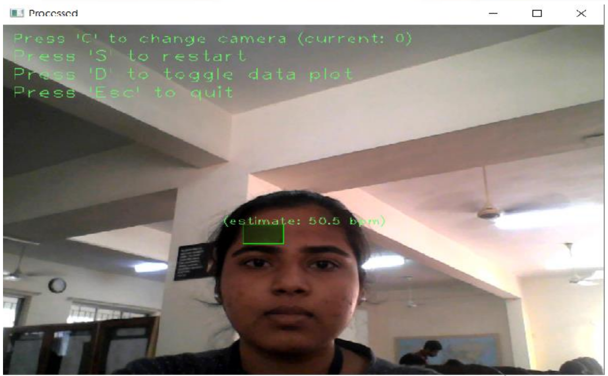
Fig 4.1 Block diagram

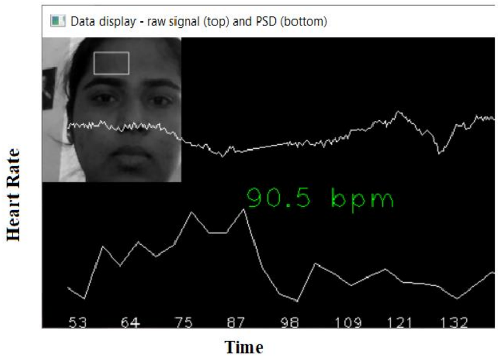
4.1.1 Face detection and tracking: We use a face detection method and a face tracker to find and track the face in a video recorded by a web camera.
4.1.2 Selecting Region of Interest: The region of interest like forehead region is selected from the image of entire face so as to carry out further processing on it.
4.1.3 Light Equalization: From the recorded video of face, light equalization is carried out to remove the light effects on the face so that image processing becomes easy and accurate.
4.1.4 Filtering: Various filtering techniques like low pass filter, hamming window filter and butterworth filter are applied to the raw signals extracted from the face video to extract them into ICA signals.
4.1.5 ML methods to find best signals: To identify the best signal to determine heart rate from , machine learning methods are used.
4.1.6 Regression HR modification: In this step, determined HR value is modified to get the most accurate value.

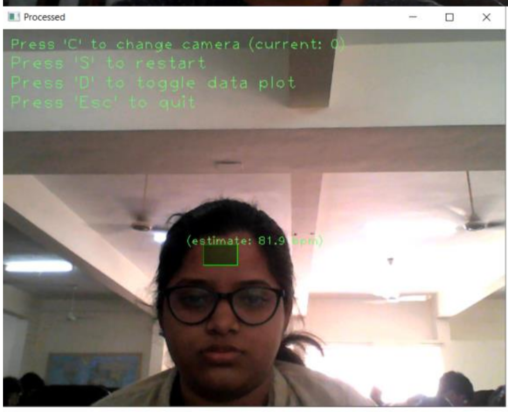
V. Implementation and Testing

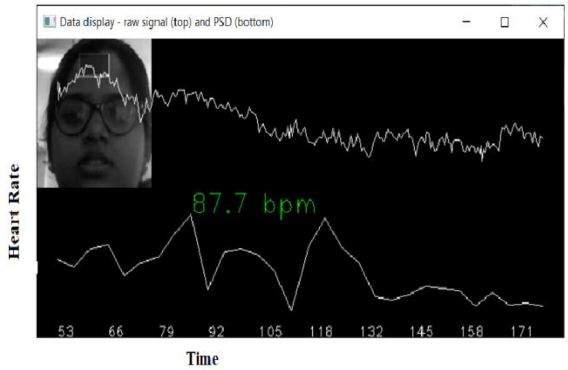
The system was tested on various people of different ages and the samples of their heart rate were collected.











VI. Result

Sr. No.	Name	System result(BPM)	Oximeter result(BPM)	Fitband result(BPM)
1.	Abhishek	80.7	75.6	71.8
2.	Aishwarya	68.9	75.9	73.5
3.	Divya	78.1	70	72.5
4.	Hitesh	65.7	71.2	72.5
5.	Hrishikesh	71.2	76.5	77.2
6.	Jaiswal Sir	92.9	82.6	82.4
7.	Kaif	67.5	75.2	74.8

VII. Conclusion

This summarize that a face detection system using python software has been done. We have referred many research papers, identified the different methodologies used to implement this project and also their merits and demerits. Also, we decided the methodology and algorithms which we should use to implement the proposed system to achieve the most accurate results.We have studied different algorithms including feature selection algorithm, namely PCA (Principal Component Analysis), Haar-cascade Algorithm, Independent Component Analysis (ICA) algorithm. And we have decided to use the Haar Cascade scheme to track the face across the video frames as the subject moves local binary pattern to recognize the face of the patient. From implementation point of view, we have designed a system which can measure the heart rate of the person sitting in front of the webcam. The system selects correct Region of Interest (ROI) i.e. forehead in our project. The results of the heart rate at that moment are shown on the screen just a minute after we take the reading. Also the graph of the heart rate for a minute is also shown.

VIII. Future Scope

Our project targets the medical professionals and patients . The main constraint we faced is distinguishing between identical twins. This situation is still a challenge to biometric systems especially facial recognition technology. According to Phillips and his co-researcher paper to get the best results of the algorithms your system employed, they should run under certain conditions for taken pictures (i.e… age, gender, expressions, studio environment ¦etc.) otherwise, the problem is still ongoing. For us, to solve this issue we suggest to record twins' parameters manually. As of now we have decided to monitor only the heart rate of the person. But in future, we can add few more parameter to this system such as Blood Pressure(BP) and Body Temperature. Also as the system already measures the heart rate it will be a bit easy to measure the stress as well. As the heart rate differs for different age, different medical history, we can take all this things consideration and can predict if the person diagnosed with any heart disease.

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