Ica Based Non Contact Heart Rate Measurement

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Abstract*: *In the time of robotization, a programmed and non invasive instrument is required for everyday wellbeing checking. Heart beat is one of the imperative physiological parameters has drawn consideration of specialists for its measurement .In this article a methodology for cardiovascular heartbeat measurement, using a ordinary webcam is proposed. In the presented approach, face region is detected and RGB traces are found for the face region. Independent component analysis is used for the linear source separation of signals and the FFT is applied on the selected traces to calculate power spectrum of the individual traces and heart rate is estimated based on the emotion based measurement.

Index Terms*: *ICA (Independent component analysis),RGB splitter ,ROI(Region of interest),FFT ,BPM(Beats Per Minute).

I. INTRODUCTION

Heart rate is one of the necessary parameters in most of the medical diagnosis techniques for many medical conditions. Earlier detection of heart rate is done by counting the heart rate either holding the person's hand or by attaching a machine having at a pulse rate sensor to person's body part over a vein. In past few years many systems have emerged that are able to extract heart rate by non-contact methods by examine the minute movements of facial features that happen due to blood flow in our head. These moments are so small that they cannot be observed by naked eye hence computer vision algorithms can be applied to detect and analyze these moments and from them we are able to find the heart rate. But this pulse rate is observed with errors ranging from 60% to 90%. To remove these errors, we have used an independent component analysis technique and the various source signals can be separated.

II. SURVEY

Many methods have been proposed already for heart rate measurement. Novel method for Heart rate measurement by bio impedance is one of the methods to find the heart rate.

Revised Manuscript Received on April 06, 2019.

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This system enclose a safe AC current into the patient through the soles of both feet and measures primary impedance which is related to body composition analysis Heart related impedance variations in the legs due to arterial blood circulation are observed below 50 milliohms..

To find the small variations in impedance, their system is implemented with fully differential AC input amplifier. The technique was demonstrated on volunteers whose bio impedance signal and ECG were simultaneously recorded. Robust heart rate measurement from video using selected random patches is also a another method for heart rate measurement PG(pulse generating) signal is used to extract from two raw point traces the green channel despite illumination variations .This would be useful in estimating heart rate variability. Automated Detection of Video-Based Estimation in Facial Expressions is based on the video detection and this research focuses on the basic emotions (anger, fear, surprise, disgust, sadness, and happiness).Heart Rate Extraction Based on Near-Infrared Camera is a method which is used for heart rate extraction based on an automatic facial tracking algorithm. Monitoring of the heart rate by pulse detection using HB(Heart Beat) sensor .The user needs to put his/her finger in the HB sensor for acquiring the input signals to provide the monitoring of heart rate as output.

In this paper heart rate is estimated from real time face videos by independent component analysis method and the experimentation is done for different human emotion like happy, sweat, normal, over emotion.

III. PROPOSED METHOD

The overall system consists of mainly three steps to generate the heart rate. The first step is to capture the facial images at a continuous rate n interval, while the second step is image analysis to detect face and facial features and from RGB components and third step is analysis of these components to generate the heart rate and applies regression on it to generate the actual rate. The whole system is implemented in python and some part is implemented in Opencv (3.0.0) library. Fig1 show the work flow of proposed methodology

A. FACIAL COMPONENT EXTRACTION AND RGB AVERAGE CALCULATION

A simple program using Open CV (3.0.0) library is used to capture images. and is used to obtain the coordinates of the person's face using algorithms as describes in

[1]. This analysis results into cropping of whole image into a small square image that contains the persons face only. There are 125 frames which are captured per second. [13].The face is detected, and we define a portion of 70% width and 85% the height of the image as the region of interest to extract facial components from the image. Here the complete RGB values of all the elements are collected to generate a raw trace. This raw data is then de-trended to remove any irregularities and to

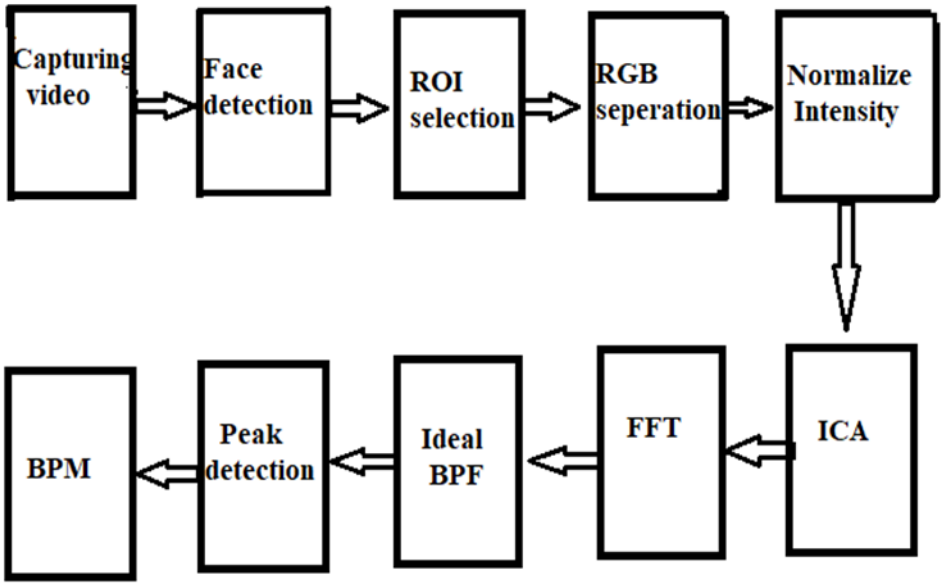

Fig :1 Work flow of proposed method for the measurement of BPM

obtain a stationary plot. Then the RGB trace obtained after de-trending and temporal filtering has normalized by the average factor and by the span value.[5] . In this work the span value is considered as 255).

A. REGION OF INTEREST EXTRACTION

The region of interest (ROI) is selected as a rectangle containing nearly 60% of the face region at the first frame of video recording .The first step in our approach is to recover the HRV(heart rate variability) signal from a facial recorded video and to decide the whether the ROI is based on the calculation of the facial coordinates. In this paper we have used Haar cascade classifier that generates a pre-trained classifier for the frontal face. A set of simple classifiers are used by the cascade, and these classifiers are used on all of the regions of interest sequentially. If all stages pass, this indicates that there is a face within the region; otherwise the region will be rejected. To find the ROI, we select the box centered 40% width and full height of the box.

The ROI taken from the first frame is used for all the frames to maintain its stability which minimize the motion artifacts.[1].

This algorithm draw a bounding box for the detected face, using the coordinates identified which decides the height and width. In the human face, the highest regions of blood flow are the forehead and the cheek regions, thus the regions which are most significant for heartbeat measurement.

The ROI is then separated into the three RGB channels and spatially averaged overall pixels in the ROI to yield a red, blue, and green measurement point for each frame and form the raw traces, respectively [11].

The raw RGB traces are normalized as follows:

$$x^2(t) = \frac{x_i(t) - \mu_i}{\sigma_i} \quad (1)$$

B. . INDEPENDENT COMPONENT ANALYSIS

ICA is a technique used for isolating independent signals from a set of vectors that consist of a linear combination of these signals. ICA is used to decompose three source signals like respiratory rate, systolic blood pressure, and diastolic blood pressure.

Since diastolic pressure has more number of independent components so it is added to obtain the necessary power spectrum plot [2].In this work the traces after normalization are then decomposed into three independent source signals using independent component analysis (ICA).

The principal attempt is to the improve the strategy for non-contact HRV estimation .The independent component analysis is used to measure the quantity of blood flow in the vein and compare it with the various heart cycles.

When taking a facial video, RGB (red, green and blue) sensors will capture a blend of the reflected signal along with other noise originating artifacts. Each color sensor will record a blend of the initial source signals with a little change in their weight as a result of the differences in the hemoglobin absorptive in the visible and near-infrared spectral range. In the detected signals from the RGB sensors are denoted as $y_1(t)$, $y_2(t)$, and $y_3(t)$ which represent the amplitudes of the saved signals at time t. Also, it supposes that $x_1(t)$,$x_2(t)$ and $x_3(t)$are the three fundamental source signals that have been linearly combined to generate y1(t), y2(t), and y3(t).

Hence, it describes a relationship between captured and source signals.

C. PEAK DETECTION

The fast Fourier transform (FFT) on the selected source signal is applied to obtain the power spectrum. The pulse

frequency was designated as the frequency that corresponded to the highest power of the spectrum within an operational frequency band.

There is enough computation efficiency in implementation of FFT. In this work, the operational range is set as 0.75–1Hz which is corresponding to 45–240 bpm in order to provide a wide range of heart rate measurements)[5]. The noise suppression is obtained with the help of a band pass filter. It suppress the noise and separate our heart beat signal corresponds to 50 bpm ~ 140 bpm, which is assigned as the cut-off frequency for the band-pass filter.The proposed algorithm includes the following steps:

- Track the face utilizing the Open Computer Vision library and a supported pretrained classifier.
- Decide Region of interest of about 60% of the width and full height of the facial box.
- Separate the RGB channels from the ROI.
- Take spatial average on RGB channels and. It is utilizing all pixels in the ROI to produce a red, green and blue discrete signs. These are individually used as the raw components. Each signal contains a solitary information point for every video outline.
- Detrend the raw components utilizing the methodology of with a cut-off recurrence of 0.89Hz.
- Standardize the detrended raw components utilizing condition, where μ_i and σ_i are the mean and standard deviation individually for i=1,2,3
- Apply ICA to separate the raw components into three autonomous source signals. The joint diagonalization of eigen matrices calculation is utilized in this progression.
- Perform ICA by applying Fast Fourier transform. From the peak identified on the power spectrum plot, heart rate is being calculated.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

The persons were made to sit in a sufficiently bright condition on a seat in the front of a HP workstation with Open CV (3.0.0) on Windows 10 stage with Intel Core i5 (fifth Gen) 2.2GHz Processor and 8G GB of Ram and 2 GB NVIDIA 950m Graphics Processor with a 1.3-megapixel inbuilt webcam as a picture catching gadget. The pictures were taken in 24bit-RGB position at 15 fps with goals of 640 × 480.In the proposed work, the heart rate is calculated under different types of human face emotions. The experiment is done by observing 5 persons with different body mass index in the dispensary and we noted the clinical reading by using the stethoscope under doctor surveillance for 60 seconds, by varying the facial expressions and performing various physical exercises. We observed that the persons under different circumstances have different heart rate.

The heart rate direct measurement for the various persons under different emotions is tabulated in TABLE [1]. Then the manual readings from our real time monitoring face video system for the same set of persons are tabulated in TABLE [2]. The average value of the persons having the different body mass index for the various emotions in clinic such as normal, sweat, happy, over emotion are 74bpm,79.8bpm,79.8bpm,88.6bpm respectively. The average values for the real time monitoring face videos for the persons having different body mass index are 73.6, 79.2, 76.6, 86.6 respectively. The mean difference is also tabulated for the two tabular columns TABLE[3].

TABLE 1 clinical reading from various emotions

Number of Persons	Normal (BPM)	Sweat (BPM)	Happy (BPM)	Over emotion (BPM)
1	74	68	73	85
2	62	78	65	79
3	80	90	81	90
4	76	84	78	95
5	78	79	80	94
Average	79. 4	79.8	79. 8	88.6

TABLE 2 webcam readings from various emotion

Numbr of persons	Normal (BPM)	Sweat (BPM)	Happy (BPM)	Over emotion (BPM)
Person 1	78	70	79	80
Person 2	69	83	67	81
Person 3	82	86	77	91
Person 4	72	80	81	92
Person 5	79	78	79	89
Average	73.8	79. 2	76 .6	88.6

TABLE 3 Mean difference

Number of persons	Normal (BPM)	Sweat (BPM)	Happy (BPM)	Over emotion (BPM)
Person 1	-4	-2	- 6	5
Person 2	-7	-5	-2	-3
Person 3	-2	4	4	-1
Person 4	4	4	-3	3
Person 5	-1	1	1	5

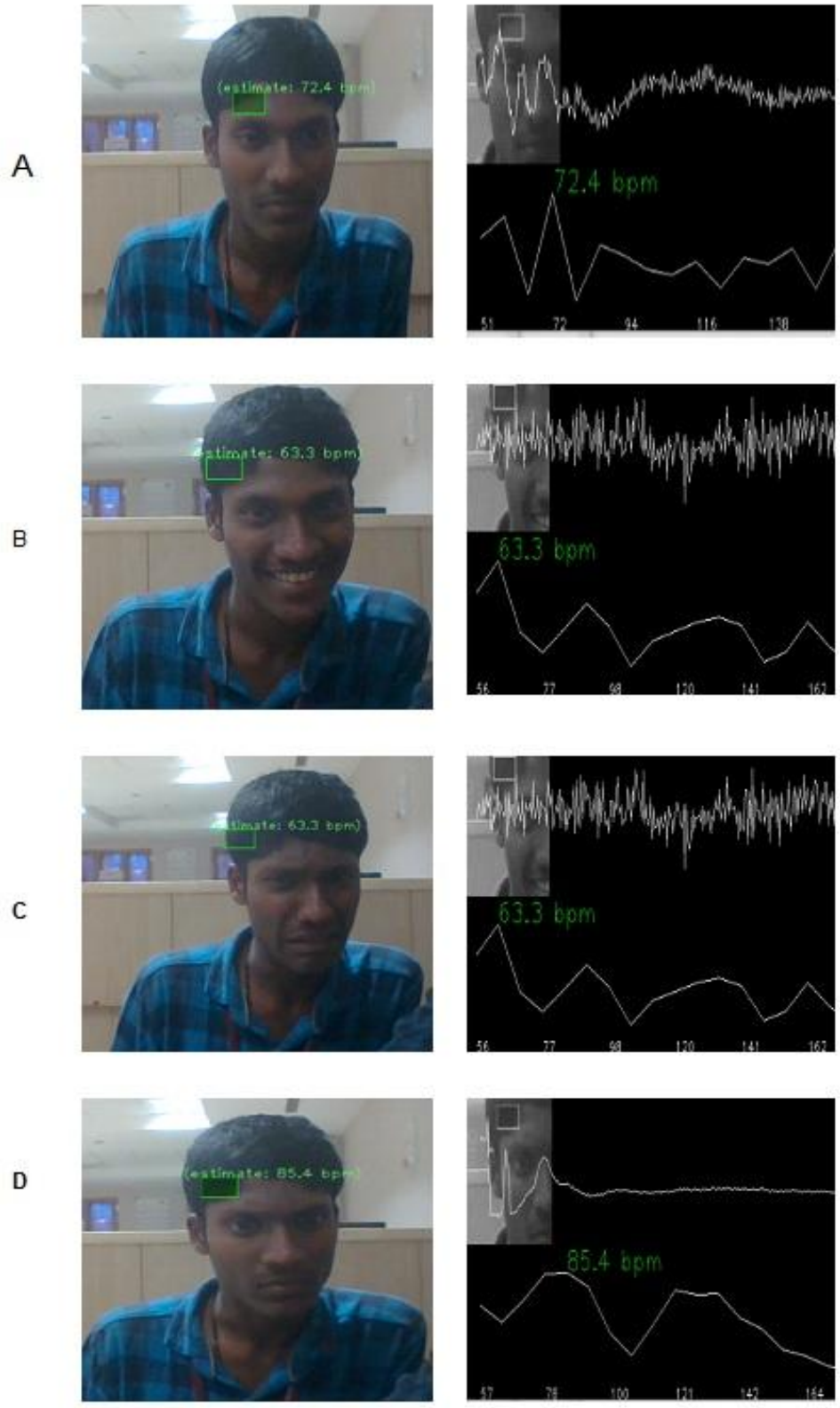

FIG 2 A-Normal face, B-smiling face, C-crying face, D-over emotion

I. CONCLUSION

In this paper, a heart rate measurement based on Independent component analysis is proposed. The experiment is done on real time videos for the persons having different body mass index and this methodology made it applicable to manage heart signs, particularly recordings and it plays a major role in remote diagnosis of any cardiac disorders. In this paper we have correlated the clinical as well as the manual readings and found the mean difference from it by varying the facial expressions with respect to the environment. Due to a low resolution camera we observed some mean deviation error, it can be rectified by using a high resolution camera.

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