TOUCHLESS HEART RATE DETECTION USING IMAGE PROCESSING: REAL TIME APPLICATION

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ABSTRACT

Heart rate is the number of heartbeats per minute which is the number of contractions of the ventricles (the lower chambers of the heart). For some human beings it might also be too excessive (tachycardia) or too low (bradycardia) which can cause clinical problems. In the current pandemic situation estimating or monitoring heart rate of a subject with the help of instruments can be risky as it involves physical contact and also one has to visit the clinic which might not be possible all the time. Research focused on non-contact based systems has increased over the past years. Existing systems include those which require contact, some having restrictions on skin tone, and others often involve high costs and complex application of sensors. This paper focuses on real time monitoring of Heart rate of multiple people simultaneously. It is obtained through a real time video using a webcam of laptop/computer. As blood circulation causes facial skin variation, therefore facial video is considered. Signal processing methods such as Fast Fourier Transform have been applied on the region extracted after applying colour magnification channels in video recordings. Application also sends a notification via a text message to the specified contact number if the Heart rate is below or above a given range. This algorithm is easy to implement, low cost and simple for real time application. Testing included trials to calculate heart rate of multiple people simultaneously. Once such a trial involved detection of faces of four people and their Heart rate calculation at the same time. Measured value of Heart rate in comparison with the ideal method was within justifiable range. Further, work can be done on environmental conditions which can be very useful in many real time applications.

Keywords *— Heart Rate, Fast Fourier Transform, Colour magnification, Image processing, Guassian pyramid.*

INTRODUCTION:

As of late, human beings are struggling from coronary heart associated diseases. According to the World Health Organization over 17.9 million people die from Cardiovascular diseases. Of these deaths, 80% are due to coronary heart diseases, for examplecoronary heart attack. So, our system describes how to develop and design heart monitoring systems. Heart continuously pumps blood around the physique and for each heart beat, blood circulation takes place which results in a colour version in facial pores and skin that is no longer seen with the aid of the bare eye. Therefore, it is viable to extract heart from colour change of skin through live video. To plan such a system, Image processing which is an application of Artificial Intelligence that gives gadgets the capability to routinely examine and enhance from experience without being explicitly programmed is being used. This website will act as a medium for the subject which can be monitored virtually through an android app.

MOTIVATION

In a situation like COVID-19, it is very necessary to maintain social distance and it has become very difficult with the old traditional method of measuring heart rate. So to reduce the physical contact, we proposed a touchless system which eases the process of heart rate monitoring. To reduce the complication and risk related to heart, this system provides a platform for doctors to examine the subject continuously from any location whenever needed and the emergency treatment will be provided within that time.So we have decided to ease the method through the use of a non contact method to observe coronary heart rate.

RELATED WORK

Minal Patil et. al. [1] in 2019 the proposed device will be connected to the wi-fi module which will send the statistics of rate of heartbeat continuously on the cloud server. So when a person is required to see his pulse rate history or records then it can be retrieved from the cloud serve along with his temperature. Along with heart rate monitoring it also notify the temperature of a person.

Face detection (FD) has been carried out with the use of Haar cascades. It is based on machine learning and is educated on a set made of both positive images (photos of faces) and negative images (pictures that don't include any face). This method was proposed by Carmen Nadrag et. al. [2] in 2018. Apart from Heart rate, various different physiological parameters related to health status can also be measured. But it's a complicated task to find the real error rate in heartbeat pulse as video display windows show intrinsic errors, so here 3 percent of the error rate was detected.

Jifeng Huang et. al. [3] in 2018 proposed a device that makes use of LiPPG the algorithm, which extracts the PPG signal with the heat rate robustly, uses color pattern to symbolize the PPG signal, enabling the extraction of the PPG signal under low illuminance and a multiscale variable weight Savitzky-Golay combination (MVSGC) model, to extract the signal from noise or trend.

Joel Hernandez et. al. [4] in 2018 concluded a heart rate monitoring system that uses the angular rate data from a single axis of a MEMS gyroscope to detect heartbeats. With a mean absolute error (MAE) and standard deviation of the absolute error (SDAE), when our tests are compared with a reference ECG signal, we exhibit that our machine is accurate enough to track HR changes. It is not regarded as a reliable way due to its much less accuracy in coronary heart rate detection.

J Johan Bathile et. al. [5] in 2018, proposed an approach that was once evaluated on a novel method that extracts the PPG using face video from a self-collected dataset of 45 subjects. Dataset is divided into 9 parts (5 subjects per part) such that every section is used as the test data once when the last remaining 8 components are used as the training data. Apart from Heart rate, Blood pressure additionally is estimated. This strategy can have multiple additions like stress management and hypertension monitoring at home, office, school, college, meditation, and clinical facilities in the future.

Monika Jain et. al. [6] in 2017 proposed a light-based sensor can be used to detect variations in coronary heart rate; this is accomplished via the usage of a Photoplethysmography (PPG) sensor. The sensor consists of a LED with a photodetector and isin a position to notice the variations in blood quantity of blood flow in the physique and directly correlates to heart rate. The strategy to construct the sensor proposed right here is of very low price and additionally detects heart arrhythmia means an irregular heartbeat.

Using Haar cascades Face detection (FD) has been implemented. It is primarily based on machine learning and is trained on a set made of both positive images (photos of faces) and negative images (pictures that don't contain any face). Apart from Heart rate, many different other physiological parameters associated with health status can also be measured. This method was proposed by Quing Zhu et. al. [7].

M. A. Hassan et. al. [8] in 2017 proposed a methodology that is Ballistocardiography used for video-based heart rate detection. It measures coronary heartbeat rate by estimating the movement generated through the pumping of blood, from the heart at every cardiac cycle. This methodology overcomes the challenges of the realistic environment. However, the distance of the subject from the camera(i.e. 0.8m) appeared to be an issue. Therefore, the potential of the motion tracking algorithm to trackthe microscopic reduces because ROI measurement is decreased to certain pixels and due to which the accuracy of the heartbeatrate estimation was decreased.

Rahul Kumar Singh et. al. [9] in 2016 proposed a simple and reliable actual-time heart rate monitoring system for automaticdrivers. The developed machine employs the principle of non-contact convenience on the Steering Wheel. This used a simple analog conditioning unit to give real-time HR monitoring. However, it used to be specially designed for drivers, and additionally, the subject needs to hold the steering wheel through an insulator.

A brief explanation of the concepts that can be used for the implementation of the proposed system is given by Hamidur Rahman et. al. [10]. They have used MATLAB for designing a GUI to monitor Heart rate in real time. Also explained calculating Heart rate from a recorded video by extracting image frames. Different signal processing methods like Fast Fourier Transform (FFT), Independent Component Analysis (ICA) and Principal Component Analysis (PCA) have been applied in video recordings and the blood volume pulse (BVP) is extracted from the facial regions.

Table 3.1 summarizes highlights and observations of the related work discussed above.

TABLE 3.1
LITERATURE REVIEW

Ref. No.	Highlights	Observations
[1]	Connects to the wi-fi module which will send therate of heartbeat continuously on the cloud server.Pulse rate history can be retrieved along with his temperature. It also informs the temperature of a person.	Approach is based on physical contact with help of hardware devices.
[2]	Face detection(FD) has been implemented usingHaar cascades for heart rate monitoring. Several other physiological parameters related to health status can also be measured.	Errors of 3 percent were detected, hard to calculate the real error rate.
[3]	Works well under low or very illuminate conditions.	Unable to give accurate results under dark environments.
[4]	Implemented as an embedded system using low-costmicrocontrollers. The use of a single axis of the gyroscope reduces the power consumption and increases battery life.	Not considered as a reliable way due to its lessaccuracy in heart rate detection.
[5]	Uses Photoplethysmography (PPG) sensor, which is able to detect the variations in blood volume or bloodflow in the body and directly correlates to heart rate. Sensors proposed here are of very low cost and also detects heart arrhythmia.	Uses low cost hardware and MI band, which isworn at the wrist so it is based on physical contact.
[6]	Extracts the PPG using face video from a self-collected dataset of 45 subjects. Heart Rate, Blood pressure can also be estimated. Used for stress management and hypertension.	Challenging to extract PPG from the face video with a darker skin tone. Approach is testedover a very small database that mostly had young and healthy volunteers.
[7]	Fitness exercise video with optical flow algorithm and motion information frequency can be improved. Used in applications for smart health and sports medicine.	The face images were roughly aligned using theface tracker.
[8]	Measures heartbeat rate by estimating the motiongenerated by pumping of blood, from the heart ateach cardiac cycle. Overcomes challenges of the realistic environment.	Distance of the subject from the camera (i.e. 0.8m) appeared to be an issue. Therefore, the ability of motion tracking algorithms reduces.Accuracy of the heartbeat rate estimation wasdecreased .
[9]	Designed for drivers where decrease in heart rate canbe easily used to detect driver fatigue and also alert the driver.	Specifically designed for drivers and also the subject needs to hold the steering wheel throughan insulator.

	The system can also be designed to send the data to a central server.	
[10]	Extraction of Heart rate using three signal processingmethods ICA, PCA, FFT methods and display continuous Stress assessment. Statistical parameters for 10 test persons are being presented. Statistical analysis has been done for theevaluation using 2 statistical parameters RSQ (R-squared) and CORREL (Correlation Coefficient).	Subjects need to be in ambient light for better visibility of video. First approx. for 5 min video is recorded through a webcam and then in an offline mode heart rate is estimated. Values extracted are stored in the excel file.

Based on the observations mentioned in TABLE, the proposed system is discussed in the next section. From all related researches it is observed that to monitor physiological parameters, many non-contact machines are designed and monitoring isbeing done in offline mode and most of them are good for the lab environment. This paper presents a non-contact method of monitoring heart rate in real time for an unlimited amount of time using a webcam which covers some of the flaws of previous work.

The rest of the paper is organised as follows: chapter 4 describes methods of real time heart rate monitoring. Finally, chapter 5 talks about the applications of this system and chapter 6 summarizes the work.

PROPOSED SYSTEM

The proposed system presents the heart rate monitoring system without any physical contact. The system detects the face of the subject via the digicam and performs image processing based totally on frames and calculates the coronary heart rate . Theaim behind this system is to avoid physical contact and grant an emergency remedy to the situation to limit the hazard and additionally alert will set off via textual conten**t** message to admin.

The proposed system consists of different steps : (A) Face Detection , (B) Defining Parameter , (C) Image pyramid , and (D) Heart Rate Estimation.

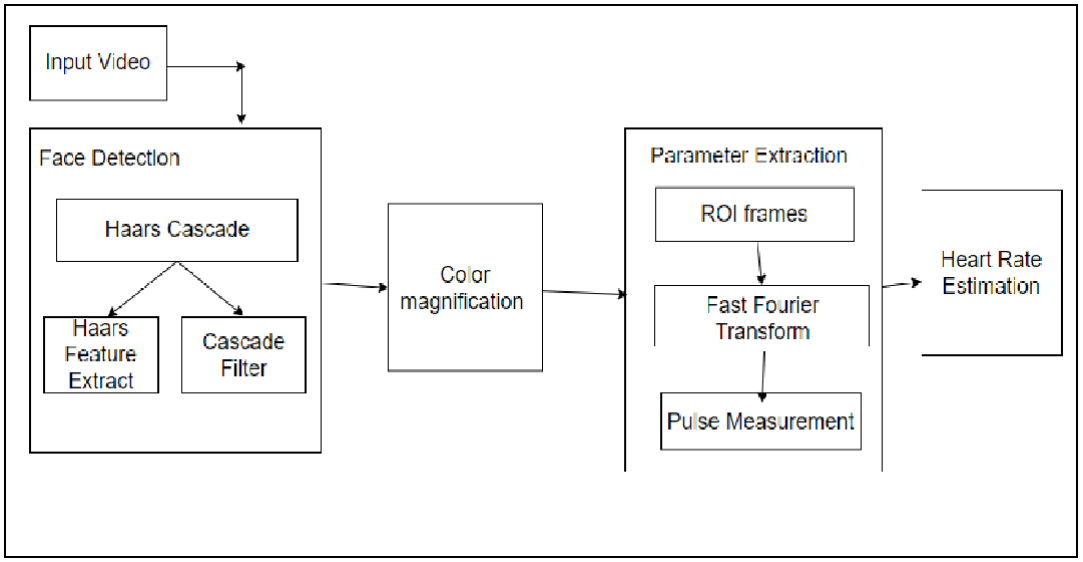

Fig 1: System Architecture

1.1 Face Detection

The preliminary stage of the system is to detect the subject which needs to be steady in front of the web camera .The live video streaming must continuously progress so that face can be detected or it can also detect the absence of subject . The most important part is to detect the single subject through the camera so that we will be using a haar cascade [2] classifier which is aneffective object detection way and helps to locate the subject in the live video. Face detection is refined further by extracting theforehead area [2] specially for better accuracy. Instead of making use of all the 7000 elements on a window, crew the points intodistinct ranges of classifiers and observe one-by-one. (Normally the first few tiers will comprise very much less variety of features). If a window is not applicable at the first stage, remove it. If it passes, observe the next stage of facets and proceed the process. The window which passes all degrees is a face region.

1.2 Defining Parameter

The different parameters need to be set to increase the accuracy of the system. The required parameter are discussed below:

A. Web Camera parameter :

Different parameters are defined based on requirements like number of VideoframeRate, Video channel count and some video capturing parameter. This parameter changes according to the user.

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B. Color Magnification Parameters:

There are a number of frames captured which need to store for accurate magnification of exact colours. So for that buffer size and buffer index are needed to set it initially some threshold values like minimum and maximum frequency for defining the range for frequency rate .

C. Heart Rate Calculation Parameters:

We need to set some limit for beats per sec to use a specific count of frame frequency to achieve the accuracy.

1.3 Image Pyramid

This stage is to extract the feature from the face color variant. These images can be studied deeper using the image pyramid. There are two types of image pyramid. They are (A) Gaussian Pyramids (B) Laplacian Pyramids. Here we used a gaussian pyramid which consists of multi scale copies of image and used as a low pass filter for image blurring. In the gaussian pyramid, the image resolution reduces level by level to discover the smallest magnifying image. It comprises down sampling of image, scale search and extract the major characteristics. The gaussian pyramid rectifies the color changes happening in images and enlarges it level by level. After extracting features the level again reconstructs into its original size and displays the continuous streaming.

1.4 Heart Rate Estimation

The gaussian pyramid gives refined image in the smallest pixel and on that image the color magnification algorithm is utilized to locate the variant in color alternate in veins for precise body inside video for getting the change in parameter, the bandpass filter is used and grab that pulses the amplify it. For finding the frequency, Fourier transform [10] is used and calculate the mean average of frequency and for best result we take 15 as a video frame rate. The resultant value of frequency we get is in hertz. As per the requirement to calculate heart beat per second we need some mathematical equation to convert hertz into beats per sec.

After getting the frequencies we need to reconstruct the frames. The heart rate can be calculated as HeartRate = 60*f_h bpm where the frequency is calculated using number of peaks per time. The result based on the frame rate to be chosen for calculating the

frequency. When the first 15 image frames are read, the actual time Heart rate extraction begins and after that each value is introduced to the firebase and the approach presents a new Heart Rate.

CONCLUSION

The proposed system is based on real time, touchless heart rate monitoring which utilizes the camera to detect subjects' face.The main aspect to come up with such a system which reduces the time delay in treatment and also increases the flexibility of the monitoring the subject from far distance. The purpose of the live monitoring system is to help the admin to observe the subjects heart rate from anywhere through an android app. The key threshold range of value was given to the model so that if the heart rate varies beyond the range the notification will send to the registered number so that required action needed is to be taken immediately. In this way, the system proposed is user friendly, robust and effective to measure heart rate without any physical contact.

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