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Automatic Realtime Webcam based Heart Rate Monitoring System

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Abstract- In the current situation of COVID 19, a contactless method of measuring heart rate is essential. This project focuses on real-time heart rate detection using a simple webcam. It uses OpenCV for face detection, and then it isolates the forehead part. The heart rate is determined by measuring the average optical intensity in the forehead region. Here we have used face detection, filtering and peak detection in the FFT domain. A stable heartbeat can be isolated in about 15 seconds when there is good lighting and minimum noise. After the estimation of the user's heart rate, real-time phase variation associated with this frequency is also computed. Support for detection on more than one individual at a time in a single camera's image is also possible. Still, only the information from a single face is taken for analysis.

Keywords- Python, OpenCV, Deep Learning, Electro Cardio-Gram(ECG)

INTRODUCTION

In this modern era, continuous measurement of Heart Rate(HR) is essential. Heart Rate(HR) is an indicator of a person's overall fitness, stress level and many more. Electro Cardio-Gram(ECG) is used to measure heart rate in clinics where patients need to put on accessories that are not comfortable. Heart Rate can also be monitored with the help of a Pulse Oximeter, which needs to be worn in the fingertip. But it's not convenient for the long term, and the pressure can be uncomfortable.

And most importantly, all these can cause damage to the fragile skins of newly born babies and elders. SO a non-contact pulse detection can be very much beneficial. With the help of a simple webcam, a person can also measure the pulse without purchasing any other devices. It's a hot topic for driver safety, where using a webcam driver's Heart Rate can be detected. A computer camera or a webcam may

help see the changes in a person's Heart Rate and indicate changes in overall health condition.

In the last few years, several studies have been done on HR measurement using a webcam. This technique is known as photoplethysmography (PPG). It focuses on measuring variations in blood volume by detecting changes in light reflectance or transmission. In this case, a python code is used that catches the heart rate of an individual using a standard webcam or network IP camera. This application uses OpenCV to find the location of the user's face, then isolate the forehead region to collect necessary data. This is done by measuring average optical intensity in the forehead location, in the subimage's green channel alone (a better color mixing ratio may exist, but the blue channel tends to be very noisy). Physiological data can be estimated this way via a combination of photoplethysmology and the optical absorption characteristics of (oxy-) haemoglobin. With good lighting and minimal noise due to motion, a stable heartbeat should be isolated in about 15 seconds. Other physiological waveforms such as [Mayer waves] should also be visible in the raw data stream once the user's heart rate has been estimated, real-time phase.

Literature Survey

The following section reviews related work corresponding to the topic and the proposed method. Careful observation of related research papers clarifies that each method differs based on its architecture and not the flow, which is coherent with chronological improvements.

Previous survey papers on Pulse detector Using Webcam :

In this paper by KUAL-ZHENG, LEE, PANG-CHAN HUNG, AND LUOWEI TSAI, (Year of Publication: 2012)[1], a contactless heart-rate measurement method using an ambient light camera is proposed. And also, a skin colour classifier is used, through which time-domain frequency analysis has been done. It takes more time to determine the pulse rate.

In this paper by SAYIYAS NIGATU TIBA AND LI, (Year of Publication: 2013)[2], The method implements the Haar cascade classifier algorithm presented in OpenCV to detect a human face. It determines the graphical interface and is also image-based.

In this work by H. RAHMAN, MU. AHMED, S.BEGUM, P. FUNK, (Year of Publication: 2016)[3] heart rate is obtained through facial skin colour variation caused by blood and skin colour variation are determine mean HR.

In this paper by QI ZHANG, YIMIN ZHOU, GUOYUAN LIANG, SHUANG SONG, (Year of Publication : 2018)[4] The HR detection method is based on a facial tracking algorithm, i.e., the Kanade-Lucas-Tomasi, to transform the facial images into time-series signals. Indoor and outdoor shows different results.

In this paper by SAKTHI KUMAR ,ARUL PRAKASH, CONRAD S. TUCKER ,(Year of Publication : 2018)[5] a contactless heart-rate measurement using remote photo plethysmography methods that require a static, controlled environment for heart rate detection.

In this work by Amogh Gudi, Marian Bittner, Jan van Gemert 2, ,(Year of Publication : 2020)[6] HRV is a measure as fine fluctuations in the intervals between heart beats, rPPG uses a camera to estimate a person's heart rate and also uses a new multi-modal video dataset, VicarPPG 2.

This project aims to create a real time, non-contact heart rate monitoring program that utilizes a simple web camera to capture facial information. It uses Open CV for face detection and photo-plethysmography (rPPG) to estimate physiological data and also uses face detection, filtering and peak detection in FFT domain.

PROBLEM STATEMENT

Nowadays the usage of health monitoring systems are getting increased as diseases like cardiovascular disease is the most dangerous one. According to [14], heart disease is the number-one killer compared to all cancers combined. In this paper automatic cardiovascular pulse rate monitoring system using a webcam integrated with personal computers is described. Besides introducing a new application in image processing, this method believed to contribute a lot in monitoring the human heartbeat by measuring cardiovascular pulse rate at home.

Even if there are different methods (possibilities) to measure cardiac pulse, the golden and mostly used in hospitals and health care center is electrocardiogram (ECG) [15]. However, recording electric potential generated by the heart requires appropriate application of the electrodes, and it is too complicated and annoying in home conditions [9, 10].

Non-contact, long-term heart-rate monitoring systems are essential for home health care. Recent studies show that heart-rate can be measured by detecting blood volume pulse (BVP) in an individual's face with the help of Photo-plethysmography (PPG) [10]. This system is based on a novel theory introduced by (Ming-Zher Poh, Daniel J. McDuff, and Rosalind W. Picard) [7, 11]. It is a novel methodology for recovering the cardiac pulse rate from video recordings of the human face, which can be considered as a new application in digital image processing as shown in figure 1

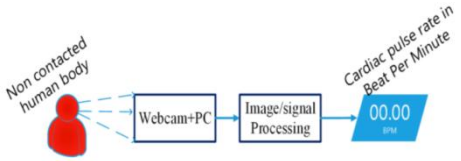

Figure 1. Principle of pulse rate monitoring system

The Heart Disease Health Center describes the normal range of a resting heart rate (after resting 10 minutes) in beats per minute, as shown in Table 1 below, according to age1 . In figure 1 we can see the principles of pulse rate monitoring system.

Even though there is a wide range pulse rate of normal beat, an unusually high or low heart rate may indicate underlying problem. It is highly recommended to call/see a doctor if any of the following symptoms getting to happen. An irregular or rapid heartbeat, (palpitations),Palpitations can be persistent or may come and go (episodic), Chest pain, Dizziness, Fainting, Lightheadedness, and Shortness of breath.

PROPOSED SOLUTION

OpenCV is used here in this application to locate the user's face and then forehead is isolated to calculate the heart-rate. Data is then collected from that area over time.This process is done in the forehead area, in the subimage's green channel alone (a better color mixing ratio may exist, but the blue channel tends to be very noisy), by measuring the average optical intensity. Physiological data can be estimated this way thanks to the optical absorption characteristics of (oxy-) haemoglobin

With good lighting and minimal noise due to motion, a stable heartbeat should be isolated in about 15 seconds. Other physiological waveforms (such as Mayer waves) should also be visible in the raw data stream.

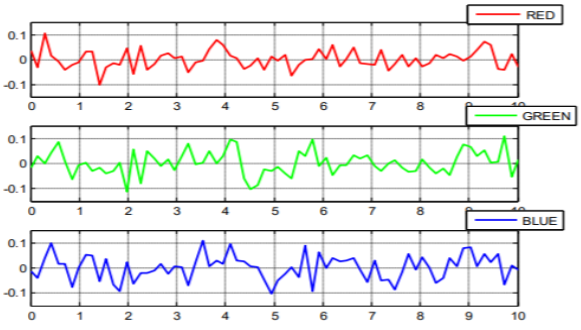

Figure 2: RGB traces

Once the user's heart rate has been estimated, real-time phase variation associated with this frequency is also computed. This allows for the heartbeat to be exaggerated in the post-process frame rendering, causing the highlighted forehead location to pulse in sync with the user's own heartbeat. In the above figure 2 we can see RGB traces.

The detection of multiple individuals in a single camera's frame can be possible, but at this moment only one person's face can be brought out for analysis. The figure 3 clearly describes the flowchart of our system.

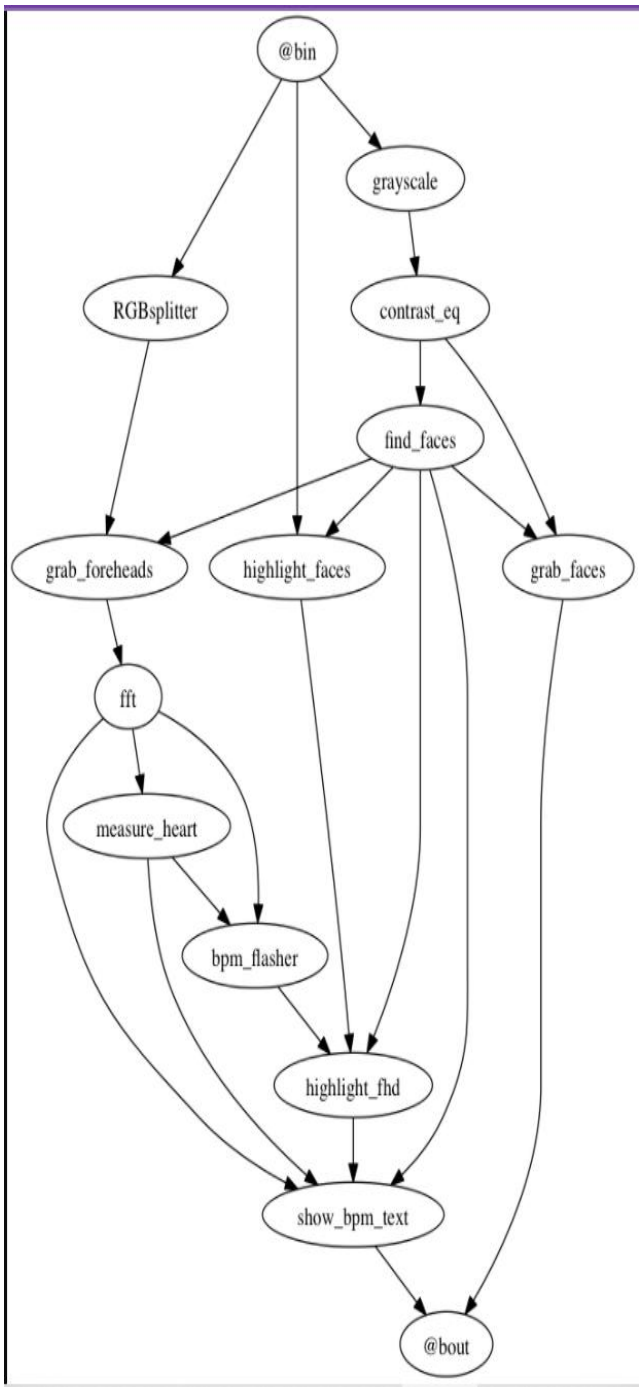

Figure 3: main flow chart

Requirements:

- Python v2.7 or v3.5+)
- OpenCV v2+
- Numpy, Scipy

Usage notes:

- When run, a window will open showing a stream from your computer's Webcam
- When a forehead location has been isolated, the user should press "S" on their keyboard to lock this location and remain as still as possible (the camera stream window must focus on the click to register). This freezes the acquisition location in place. This lock can be released by pressing "S" again.
- To view a stream of the measured data as it is gathered, press "D". To hide this display, press "D" again.
- The data display shows three data traces, from top to bottom:
    i. raw optical intensity
    ii. extracted heartbeat signal
    iii. Power spectral density, with local maxima indicating the heart rate (in beats per minute).
- A proper heartbeat can be isolated within 15-20 seconds With less head movement and adequate lighting. A count-down is illustrated in the frame.
- If a significant spike in optical intensity is measured in the data (due to noise or motion, sudden change in the lighting, etc.), the data collection process is reset and started over. The sensitivity of this feature can be tweaked by changing `data_spike_limit` on line 31 of get_pulse.py. Other mutable parameters of the analysis can be changed here as well. In the adjacent figure 4, we can see the spectra separated source signals.

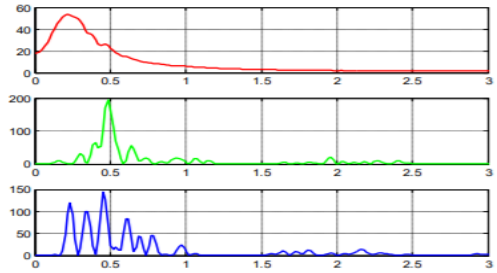

Figure 4: Spectra separated source signals

CONCLUSION

Every time an individual's heartbeats are called heart rate. Nowadays, it seems to be essential for everyone. The heart-rate measurement with the help of an ordinary webcam is more straightforward and has many applications. Like the device is used in analyzing problems like blood pressure and also used in the pulse oximeter.

In the present few months, these oximeters are being used in huge numbers for detecting if the oxygen level in the patient (suffering from COVID-19) is well maintained or is in a deficit situation. In the future, when this device will be available to almost everyone(due to the availability of a webcam to them), it will be easier for ordinary people to detect whether a person is suffering from fever(high heart rate) or some other disease. This can also be used as an alternative to oximeters.

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