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Pulse Rate Gauging Using Opencv

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Abstract:

During the Covid-19 era, everyone grasped the significance of non-contact health monitoring technology. Despite adhering to social distance rules, it is unacceptable to use the same gadget to track each patient's HR because each patient has a unique health condition. We then came up with the notion of measuring Pulse rate using a webcam and image processing to resolve all these concerns.

We attempted to create such a system from scratch using the Python programming language, which helped us comprehend the area as well as its benefits and drawbacks in comparison to other biometric authentication techniques. After conducting research, we chose to utilize the OpenCV library for Python and Face API for face recognition because the project's requirements precluded us from utilizing a system that could consistently perform both detection and recognition. The human body's cardiovascular system inspired the concept of passive physiological parameter monitoring. Because of the circulatory system, the heart can continuously pump blood throughout the body. When our heart pumps blood through every blood artery in our body, the color of the skin on our faces varies with each heartbeat. Therefore, it is possible to determine the HR from the color fluctuation of facial skin.

Heartbeat, i.e., cardiac pulse measurement is one of the most frequent examinations performed in health care monitoring. Electrocardiography (ECG) and Photoplethysmography (PPG) are the procedures currently utilized in mainstream medicine to monitor heartbeats. Heart rate is the frequency of a heartbeat over a given period. Every person's heart rate is different depending on their circumstances, age, and time. Monitoring the variations in heart rate can be used to measure physiological characteristics, emotional arousal, and cardiac issues. The different heart rate measuring techniques are categorized as follows: (1) Contact 2) Non-contact. Contact approaches are the ones that are most frequently employed for heart rate extraction. This technique employs several sensors that come into direct contact with the human body. ECG sensors, pulse oximeter sensors, and other similar devices are some examples of contact-based heart rate monitoring systems.

Optical sensors are used in non-contact procedures, which do not involve placing anything on the human body. Non-contact technologies like laser, radar, and microwave doppler require highly precise sensors. Laser light and radar signals have certain detrimental effects on human health. One of the greatest methods is HR monitoring without any physical contact. Computer algorithms are used to process images and increase the accuracy of digital photos and movies. It is possible to use a considerably wider variety of algorithms to handle the incoming data without experiencing issues like signal distortion and noise accumulation. Evaluation is made simpler and more affordable by being able to determine Heart Rate variability from a simple recorded facial film.

With our strategy, we present a fresh way to solve all these issues. This innovative approach, which is based on automatic face tracking and blind source separation of color channels into separate independent components, can be used on color video recordings of the human face. We were able to achieve high accuracy and correlation even in the presence of movement artefacts and various lighting conditions when we compared the heart pulse rate derived from the color films captured by a very basic camera to a pulse oximeter and fitness band.

Keywords

PR	Pulse Rate
PPG	Photoplethysmography
ECG	Electrocardiogram

I. INTRODUCTION

The count of pulses per minute is termed as the pulse rate. The pulse rate can be relevant source of information throughout the human cardiovascular system. Diagnosis and assessment of a person's stress level can be predicted by monitoring the person's pulse rate. In traditional Pulse rate monitoring systems, the pulse rate was monitored by traditional contact based methods such as physical palpation, Electrocardiography, Pulse oximeter, Fitness band, etc. We have introduced an image processing approach to measure the pulse rate without contact. The person whose pulse rate is to be monitored should sit comfortably in front of the webcam. The system captures a facial video which then is processed according to individual frames and a Fast Fourier Transform is applied to the selected frequencies of the signal. Further the values from the signals are processed to get the pulse rate. The system was authenticated under various breathing conditions and different illumination levels in offline situations. We have come up with this idea as to provide a noncontact based pulse rate monitoring system.

II. LITERATURE SURVEY

Finding the heart rate is a critical step in medical monitoring and study. It offers important information about a person's cardiovascular health and can help with the diagnosis of certain heart-related diseases. Researchers have investigated using OpenCV, an open-source computer vision library, for heart rate detection thanks to improvements in computer vision and image processing methods. In this review of the literature, we evaluate numerous significant studies that have used OpenCV for heart rate detection, examining their methodology, constraints, and contributions.

In [1] the study presents a technique for calculating heart rate from face video captured by a typical camera. The authors used OpenCV to identify facial landmarks, track facial areas, and extract heart rate data using signal processing methods. The work has shown that it is possible to estimate non-contact heart rate from face video using OpenCV. For accurate heart rate detection, it underlined the significance of motion compensation and reliable signal processing techniques.

The electrocardiogram (ECG), one of the gold-standard techniques for measuring the heart pulse, currently requires patients to wear adhesive gel patches or chest straps that may irritate their skin and be uncomfortable. The spring-loaded clips on commercial pulse oximetry sensors that attach to the fingertips or earlobes can hurt if worn for an extended amount of time, which is another inconvenience for patients. A tantalising possibility that would improve the provision of primary healthcare is the capacity to remotely and non-contactly monitor a patient's physiological signs. For instance, Pavlidis and colleagues first proposed the idea of taking physiological measures on the face [13], which were later supported by the analysis of facial thermal images [14,15].

Recent research has investigated the use of photoplethysmography (PPG), a low-cost and non-invasive method of monitoring the cardiovascular pulse wave (also known as the blood volume pulse) through variations in transmitted or reflected light[16-20]. The cardiovascular system's heart rate, arterial blood oxygen saturation, blood pressure, cardiac output, and autonomic function can all be learned via this electro-optic approach [21]. However, new research [18, 20] has demonstrated that pulse measurements can be obtained using digital camcorders and cameras with regular ambient light as the illumination source. Traditionally, PPG has always been implemented using dedicated light sources (e.g., red and/or infra-red wavelengths).

The review of the literature demonstrates the considerable advancements made in heart rate detection with OpenCV. These studies highlight the significance of precise face detection, ROI tracking, and reliable signal processing methods and show the viability of non-contact heart rate estimation from video recordings. Although OpenCV offers a strong framework for heart rate recognition, problems with motion artefacts, changing lighting, and noise interference still exist. Future studies can concentrate on solving these problems and enhancing the precision and dependability of heart rate estimates using OpenCV.

III. PROPOSED METHODOLOGY

The idea is being implemented by taking a video input using a 24-bit camera. The input frames are processed according to the block diagram.

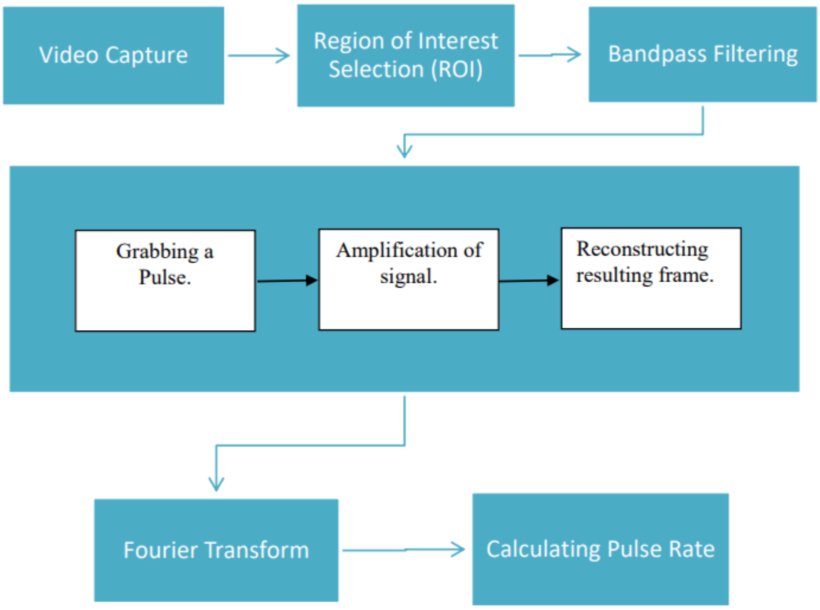

Fig. 1 – Block Diagram

Video Capture : The input video is captured through the webcam or an external camera device.

Region of Interest Selection (ROI) : A region of interest is selected from the captured video. This region frames will be further processed.

Bandpass Filter : Here a simple rectangular bandpass filter is applied. The frequencies within the range of "minFrequency" and "maxFrequency" are retained, while frequencies outside this range are set to zero in the Fourier domain. By applying this bandpass filter to the Fourier transform of the video frames, the code focuses on preserving the physiological signals within the specified frequency range and attenuating other frequency components.

Signal Processing : The signal processing involves grabbing a pulse from the signal, amplification of the signal and then reconstructing the frames.

Fourier Transform : The Fourier Transform is applied to the output signal after the signal processing which converts the frequency domain signal to time domain signal.

Pulse Calculation : The pulse rate is calculated by finding the dominant frequency in the filtered signal. The BPM (beats per minute) is derived from the dominant frequency, and it is stored in the bpmBuffer array. These outputs are then displayed accordingly.

IV. EQUATIONS

1. Gaussian Reduction

$$g_l(i,j) = \sum_{m=-2}^{2}\sum_{n=-2}^{2} w(m,n)\, g_{l-1}(2i+m, 2j+n)$$

l=levels , w(m, n)= window function (Gaussian)

2. Gaussian Expansion

$$g_{l,n}(i,j) = \sum_{p=-2}^{2}\sum_{q=-2}^{2} w(p,q)\, g_{l,n-1}\left(\frac{i-p}{2}, \frac{j-q}{2}\right)$$

l = levels, w(p, q) = window function(Gaussian)

V. CONCLUSION AND FUTURE SCOPE

We have outlined, put into practice, and assessed a unique methodology for calculating the heart rate from video recordings of the human face. We showed the methodology using a basic camera with natural light serving as the lighting source. To our knowledge, this is a cheap, automated, motion-tolerant approach for non-contact heart rate measurements. Furthermore, we have demonstrated how this method is easily scalable for the evaluation of people in front of a camera. Webcams are widely accessible and inexpensive, making them a promising technology for enhancing and expanding access to medical treatment. Although the recovery of the cardiac pulse rate was the only physiological parameter discussed in this study, the proposed technique has the potential to be used to estimate many other significant physiological parameters, including respiratory rate, heart rate variability, and arterial blood oxygen saturation. Future research will focus on developing a real-time, multi-parameter physiological assessment platform based on this technique.

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