Heart Rate Measurement Using Face Detection in Video

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Abstract- *Estimating the pulse (HR) of individuals has different applications in telemedicine, Internet-of-Things (IoT), sports, security, and so on. Nonetheless, once in a while it is hard to utilize an exemplary strategy for estimating HR or the traditional technique does not scale. This paper displays an answer that takes a shot at live video streams and can gauge the HR of various individuals in the meantime. Face location joined with article following is utilized to create a lot of face square shapes, which are inspected in the later phases of the pipeline for shading varieties. The normal of the shading, in a district of intrigue (ROI) picked on the face, speaks to a flag which relates to the pulse Utilizing signal preparing, a pulse recurrence can be extricated from this flag. The technique is very exact and stable. With this calculation, four individuals' countenances were distinguished and their pulses were estimated in the meantime, and a mistake rate of 3-5% can be acquired for the HR. By using object following joined with face recognition, our strategy decreases the handling power required and permits better scaling.*

Keywords- heart rate; Internet-of-Things; face detection; object tracking.

I. INTRODUCTION

The pulse (HR) of an individual speaks to the quantity of heart thumps every moment. It is a basic physiological parameter, a wellspring of data identified with the whole cardiovascular framework and has extraordinary significance in finding or evaluation of the feelings of anxiety experienced by the individual. The pulse typical qualities vary contingent upon the age, therapeutic history or common physical movement [1]. For instance, individuals who are less physically dynamic are relied upon to have a higher pulse, as their heart muscle needs to work more diligently to keep up a consistent cardiovascular beat. It has been outstanding for a considerable length of time that any abnormal varieties of the heart beat must be mulled over for further examination and analysis[2].

As an outcome of society ending up more wellbeing cognizant, different ideas of remote wellbeing checking stages are created [3], [4]. Among others, these additionally incorporate managing old individuals or unending illnesses patients from private situations. Additionally, there are circumstances in which persistent pulse checking is required however skin contact is hazardous, and the patient feels awkward to be ceaselessly associated with a heartbeat estimating mechanical assembly. Also, any contact gadget is just ready to screen a solitary patient at any given moment, which does not help while requiring neither a quick nor a perpetual examination of individuals from a particular area – for instance an office or a metro station. 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.

The distance between the camera and the patient can vary between 1 and 3 meters, and the illumination conditions have to be constant during the process.

So as to gauge the pulse progressively, picture preparing will be performed utilizing OpenCV and executed in Python programming language. In contrast to other existing arrangements, it goes for at the same time estimating the beat for different individuals, utilizing object following related to confront identification. This streamlining will lessen the computational necessities and makes usage achievable on more kinds of gadgets.

The remaining paper has been divided in to three sections: Section II provides related work, and Section III presents our approach. Finally, the conclusion is dealt within Section V of the paper.

II. RELATEDWORK

As this non-contact strategy for estimating the beat can be effectively actualized in stages for wellbeing observing, there are a few investigations in regards to the estimation of the pulse utilizing picture handling.

In [5] the creators present a non-contact strategy for estimating HR. It is depicted as being useful for individuals experiencing diverse skin conditions. The beat discovery

calculation is executed while thinking about various ways for picking the locale of intrigue (ROI), which is then utilized for ascertaining the mean pixel esteems. Likewise, the technique is tried while the subject is moving and furthermore while experiencing signal aggravations. The mistakes experienced are very low: about 3.4 ± 0.6 beats every moment (bpm) in typical video and 2.0 ± 1.6 bpm when the subject is moving

Likewise, this [6] paper portrays a video-based pulse identification calculation which is actualized to decide the subject's physiological changes under the casual condition and keeping in mind that moving. The ROI chose is isolated into 3 sections and for every one of them, the pixels' mean qualities are determined. To get a reasonable flag, the Independent Component Analysis (ICA) is actualized, after which crest recognition is utilized to decide the pulse an incentive out of the video handled. As the creators notice, the calculation does not give "ongoing" results, yet the qualities got are of course when contrasted with other HR estimating strategies.

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Likewise, the paper [8] presents an alternate methodology for estimating HR, which comprises of utilizing both web and thermographic cameras. Every one of the estimations were taken amidst the day, and the main light source was the daylight. Likewise, the volunteers (the two people) stood 1 meter from the camera and did not move amid the analysis. The locale of intrigue was on the brow, a territory which appears to have a consistent temperature. For decreasing the multifaceted nature of the procedure, the ROI chose was littler, and the analysis results express that ICA and PCA have comparative precision while extricating the beat.

Also,the authors of this [9] patent describe the estimation of HR variability by video processing for obtaining a time-series signal. Data is then used to extract the PPG signal and to calculate a power spectral density function in order to detect frequency components needed for the HR measurement.

III. THEEXPERIMENTALMETHOD

Amid the pulses the blood is siphoned all through the body, causing skin shading varieties. These progressions can not be seen with the unaided eye but rather can be distinguished in a video stream. To execute the picture handling calculations, it is important to pick a district of intrigue, which is applicable in the feeling of having the capacity to see how the pixels in the chose region change their power. By averaging the force of the skin shading and extricating the frequencies that show up in the flag, a reasonable pinnacle will show up which speaks to the recurrence of the heart thumps. So as to achieve the venture, the pixels inside the chose area of intrigue are prepared in the Spyder advancement condition, utilizing OpenCV and Python.

A. Face Detection

Inthispaper,theprimaryfocusisnotthefacedetector.Because ofthat,wearenotgoingtochoosethebestcurrentmethodbutinstead,chooseonewhichisreadilyavailableanditisknowntohavebeenimplementedonconsumerhardwareandevenmobiledevices[10].

Face identification (FD) has been actualized utilizing Haar falls. It is a straightforward yet productive technique, which has been exhibited by Paul Viola and Michael Jones in their [11] paper. It depends on AI and is prepared on a set made of both positive pictures (photographs of countenances) and negative (pictures which don't contain any face). The Viola-Jones indicator has a few key-highlights, as pursues:

1) *Converting the pixel intensity values into an Integral Image.*
2) *Haar features:* They are different rectangular images, as presented in Fig.1.
3) *The Ada Boost learning algorithm:* it is used for selecting the best features out of the entire set.
4) *The Cascades Filter:* it discards the negative windows in order to focus the computational process on the positive ones as much as possible.

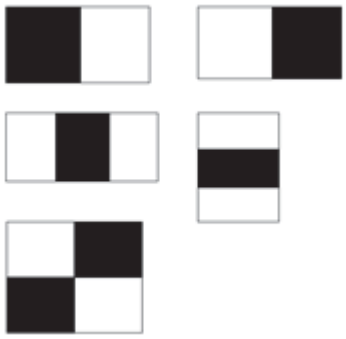

Fig. 1.HaarFeatures

B. The Selection of the Region of Interest(ROI)

The locale of intrigue is a territory of the picture, chose on explicit criteria, which is to be utilized amid the computational procedure. So as to watch the skin shading variety, the most appropriate region is the brow as it gives point by point changes experienced. The component of the square shape put on this region is in regard to the facial location box, as its size changes relying upon the separation between the subject and the webcam. The subsequent stage is ascertaining the middle or the normal of the pixels inside the area of enthusiasm, for each casing. The ROI determination is appeared in Fig. 2.

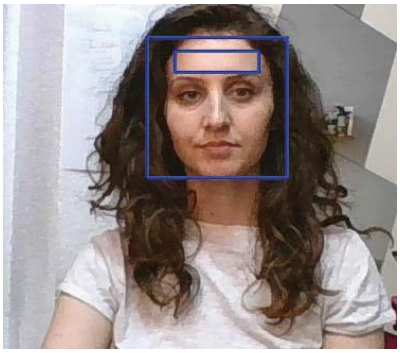

Fig.2.ROISelection

C. Object Tracking

Inordertoidentifythefaceofthesubject,twooptionscanb eimplemented:

1) Applying the face detection algorithm for each frame.

2) Applying the face detection algorithm for certain frames, between which only face tracking is implemented.

We used the second method, as it is considered faster. This is because when tracking an object detected in the previous frame, there are also given details about the appearance of the object[12].

According to this[13] study, the best tracking algorithms are Boosting and Multiple Instance Learning tracker(MIL). We chose to use MIL as when testing, its average processing time is about 9ms/ face while Boosting tracker needs about 15ms/face.

D. *Measuring the Heart Rate*

The FFT (Fast Fourier Transform) is applied to the window formed by the last 200 frames of the signal obtained at the previous point. Since normal heart rates are between 35 and 195 beats per minute, frequency filtering can be applied to correct false readings. The heart rate translates to a frequency between 0.5 Hz and 3 Hz. This frequency range is far away from the power line frequency, 50Hz or 60Hz, so there are very few chances of interference from there. The continuous component on the other hand, will influence the spectrum, given how close the heart rate is from 0 Hz. During the process, the sampling frequency will only take effect on the spectral density, as the algorithm will run on the web camera frequency.

First, the maximum is detected avoiding the 0 Hz component. To ensure the maximum indeed corresponds to a HR frequency, a ratio is calculated between the maximum and the median of the spectrum. We discovered that a ratio of 3:1 is a good discriminant for this case.

B. E. Method

The previous steps are combined to produce the final method. These can be seen as a series of blocks depicted in Fig.3. The first block does FD one very frame until a face or more are detected. After that frame, each face is tracked using a separate object tracker and FD is not used on each frame any more. Every 10 seconds , a new face detection n is applied for up to10 consecutive frames to verify if the object tracked is still a face or if new faces appeared in the frame.

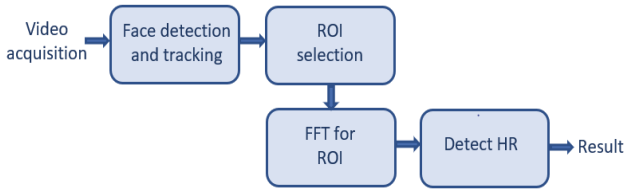

Fig. 3.TheHR measuring algorithm diagram

The faces detected by the previous block are passed to another block which selects a region of interest for each face, based on geometry, that corresponds to the fore head. If the fore head is covered, one of the cheeks is chosen. For each ROI an average is computed using a mean function. These will represent the samples that are processed by the next block, which does FFT in a moving window representing the last 200 frames. This value is chosen because the algorithm should detect frequencies between 0.5 Hz and 3 Hz , in steps of ~0.01Hz. The actual frequency is selected using the method described in section III.D.

C. F. Testing Environment

During development, tests were run on the following hardware:

v Processor: Intel(R) Core(TM) i5- 7200U, CPU @ 2.50GHz.

v RAM: 4.00GB.

v 720p HD webcam.

After calculating the mean value of the pixels from the ROI, we compared the results obtained for people having a visible difference of the skin tone, as presented in Table I . The tests have been run under the same conditions for each of the 20 persons involved. The subjects did not wear make-up and none of them suffered any form of skin condition.

TABLE I. EXPERIMENTAL DETAILS

	Features	
Subject	*Age*	*Skin tone*
Person1	23	Brownmedium
Person2	26	Brownmedium
Person3	23	Light

Fig.4 shows Person 2 and Person 3 while running the test:

Fig.4.Runningtests ondifferentskintones

In addition to this, HR tests were done later in parallel with two other heart rate monitor devices to ensure the accuracy of the measurement. Errors of ~3% were detected, but it is hard to calculate the real error rate, as the monitors exhibit intrinsic errors. The tests were done using different skin tones corresponding to persons of Europe an descent, and two persons originating from the Indian subcontinent. No significant differences were discovered in terms of HR accuracy. The devices used are:

1) *Ambiotex*: the smart shirt presented as having 99.1% accuracy[14].
2) *FitbitAltaHR*[15]: considered to be one of the best Fit bit products as it continuously measures HR[16].

Table II shows the intervals of the HR detected, and the errors encountered for each one of them. Each error has been calculated using the mean value of the Ambiotex HR results and the Fit bit Alta HR measurement.

TABLE II. HR TESTS ACCURACY

Interval number	ExperimentalResults	
	Interval[bpm]	*Error[%]*
1	55- 85	~5.1
2	85- 95	~4.3
3	95- 105	~3.8
4	105-115	~3.0
5	115-125	~2.7
6	125-135	~2.7
7	135-170	~2.5

IV. CONCLUSIONS

Heart rate monitoring is essential, as unusual changes related to the cardiovascular system help to obtain a diagnosis. Among all the pulse monitoring methods, the noncontactonesareconsideredtobecomethemostusefulindailylifeandIoTapplications.Theapproachwehavepresentedissolvingtheproblemofmultiplesubjectsheartratemonitoringandmakesamobileimplementationtobecomefeasible.Upto4peoplecanhavetheirHRmonitoredusingasinglewebcam,ashereonlyalowqualitylaptopcamerawasused.Thealgorithmalsohasareducedcomputationaltime,asitusesbothfacedetectionandobjecttracking.

Thisarticlerepresentsagoodproofofconceptforthismethod,buttherareareaswhichremainunexplored.Forthefuture,weproposetostudytheinfluenceofcameraqualitytothenumberoffacesthatcanbedetectedandtothemaximumdistancebetweenthecameraandthesubject.Also,weenvisiontoimplementtheHRmeasuringalgorithmondifferentplatforms,suchasAndroidandRaspberry Pi. This is in order to develop tracking of multiple persons and their HR, over multiple cameras.

V. ACKNOWLEDGMENT

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