© 2018 IJSRSET | Volume 4 | Issue 9 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Estimation of Heart Rate from Face

Dr. Shubhangi D. C[1], Pooja C. Tallalli[2]

[1]Department of Studies in Computer Science and Engineering, Visvesvaraya Technological University Center for PG Studies, Kalaburagi, Karnataka, India

[2]Department of Studies in Computer Science and engineering,Visvesvaraya Technological University Center for PG Studies, Kalaburagi, Karnataka, India

ABSTRACT

Heart Rate, also known as pulse, is the number of times a person's heart beats per minute (bpm). There are several methods in which the human heart rate can be obtained without any contact to the body. This is specifically accurate if it could be prepared spending economical tools such as consumer-grade cameras. Various research and investigates have been achieved in current ages to aid consistently conclude the heart rate from video footage of a person. This paper also presents a real time HR monitoring method using a webcam of a laptop/computer. The heart rate is obtained through facial skin color variation caused by blood circulation. The approaches have taken an investigation method which comprises sequential filtering and occurrence spectrum investigation. Substitute approaches hired from further fields are also presented to find if they have distinction in remote heart rate recognition.

Keywords: Heart rate, Face, Photoplethysmography (PPG), Kanade Lucas Tomasi (KLT) Algorithm

I. INTRODUCTION

Throughout the years there have been numerous advanced strategies for noticing the natural procedures of the human body. These perceptions go from basic yet essential capacities like breathing to the mind boggling concoction firings of the sensory system. A standout among the most valuable of these measurements, with application in both therapeutic and individual zones, is heart rate.

Heart rate can be seen by a few techniques. Initially, it can be effectively estimated using pulse oximetry sensors that are attached to the fingertips or earlobes which can be inconvenient for patients and can cause pain if worn over a long period of time. It can also be identified further by estimating the electrical impulses produced by the heart through an entrenched strategy known as an electrocardiography (ECG).

These methodologies all require certain type of physical contact. There are instances, when physical contact is not possible. For example, in therapeutic practice, burn victims have skin which is excessively delicate, to assign probes essential for computing their vitals. One more problematic situation is when trying to track heart rate on practice equipment. There are uniform circumstances where it is finest that the subject is being supervised without their knowledge. This might arise when tracking people in a high security area looking for suspicious people exhibiting unusual anxiety.

Contact-free monitoring of the heart rate using videos of human faces is a user-friendly approach compared to conventional contact based ones. Photoplethysmography (PPG) is an optical measurement technique that can be used to detect blood volume changes in the micro vascular bed of tissue. Typically, PPG has always been implemented using dedicated light sources (e.g. red and/or infra-red wavelengths), but recent work [7, 8] has shown that pulse measurements can be acquired using digital camcorders/cameras with normal ambient light as the illumination source.

In this research, diverse approaches and examination procedures for remote heart rate approximation will be discovered. These approaches will depend entirely on 8-bit CMOS image or video frames sensors for information procurement. Every method will be practiced in superlative and concrete circumstances and, coupled with simple decision-makers, will be used as heart-rate estimators.

II. RELATED WORK

In 1995, the first noncontact health monitoring system was investigated by Costa et al. [1].They used camera images in order to extract physiological parameters using color variation of the skin. In 2005 another novel method was introduced for the measurement of user's emotional state using the facial thermal image using a thermal camera [2]. In 2006, Takano et al. shows that RR (Respiratory Rate), HR and BVP(Blood Volume Pulse) are possible to extract simultaneously using a camera [3]. They captured images of a part of the subject's skin and then the changes in the average image brightness of the region of interest (ROI) are measured for a short time. Later in 2007, Garbey et al. developed a contact-free measurement of cardiac pulse based on the analysis of thermal images using FFT algorithm [4]. Verkruysse et al. in [8] propose a method for remotely measuring the PPG signal using the face video. Poh et al. in [9] propose a low-cost method for extracting the PPG signal based on face video recorded from the webcam. They use the PPG signal for quantifying HR, RR and HRV (Heart Rate Variability).

This paper draws motivation from all such previous studies. We present an efficient novel approach for recording the PPG touchlessly using only the face video. Moreover, we use this PPG to estimate the HR. A face video of the subject is processed to extract the corresponding PPG signal. Time [5][6] and frequency domain parameters are obtained from this PPG signal. Finally, HR is estimated based on these extracted parameters.

III. METHODOLOGY

System architecture of the proposed approach is shown in Fig. 1

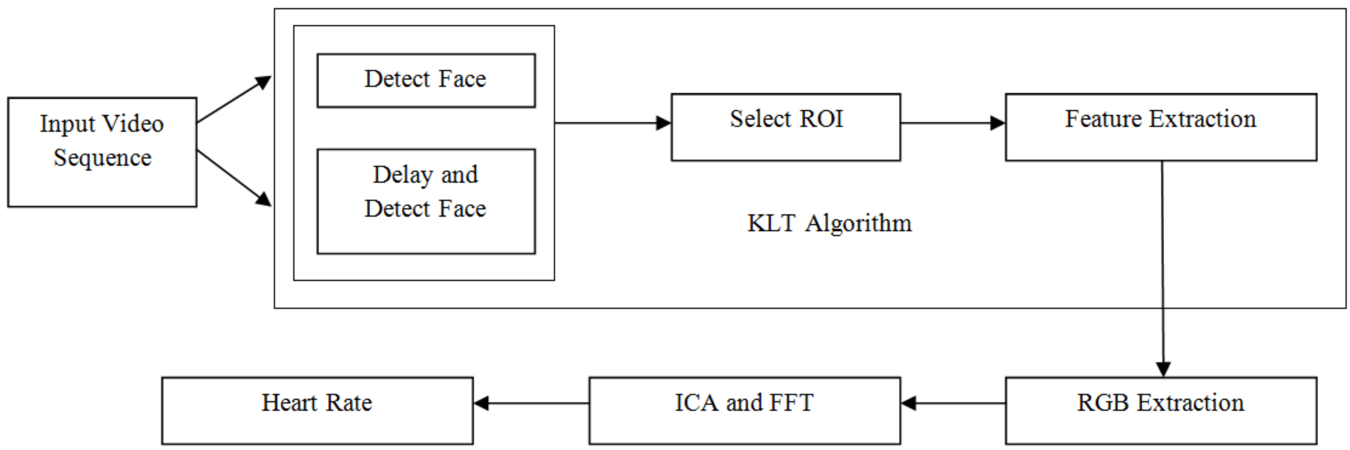


Fig 1: System Architecture of Heart Rate (HR) Estimation from Face

Video Collection

A face video of the person is recorded by the camera. All videos were recorded at 15 frames per second (fps), while the subject is asked to sit still. Face is onsidered as a ROI (Region of interest) and extract frame from video.

Face Tracking

Kanade-Lucas-Tomasi (KLT) algorithm is used here for tracking human faces continuously in a video frame. After extracting an image frame in real time, the automatic face detection function '*CascadeObjectDetector' is* applied.

KLT Algorithm:

```
% Create a cascade detector object.
faceDetector = vision.CascadeObjectDetector();
 % Read a video frame and run the face detector.
videoFileReader =
vision.VideoFileReader('tilted_face.avi');
videoFrame = step(videoFileReader);
bbox = step(faceDetector, videoFrame);
% Draw the returned bounding box around the
detected face.
videoFrame = insertShape(videoFrame, 'Rectangle',
bbox);
figure; imshow(videoFrame); title('Detected face');
```

Identify Facial Features To Track

The KLT algorithm tracks a set of feature points across the video frames. Once the detection locates the face, the next step identifies feature points that can be reliably tracked.

```
% Detect feature points in the face region.
points=
detectMinEigenFeatures(rgb2gray(videoFrame),
'ROI', bbox);

% Display the detected points.
figure, imshow(videoFrame), hold on, title('Detected
features');
plot(points);
```

Initialize a Tracker to Track the Points

With the feature points identified, you can now use the vision.PointTracker System object to track them. For each point in the previous frame, the point tracker attempts to find the corresponding point in the current frame. Then the estimateGeometricTransform function is used to estimate the translation, rotation, and scale between the old points and the new points. This transformation is applied to the bounding box around the face.

```
% Create a point tracker and enable the bidirectional
error constraint to
% make it more robust in the presence of noise and
clutter.
pointTracker =
vision.PointTracker('MaxBidirectionalError', 2);

% Initialize the tracker with the initial point locations
and the initial
% video frame.
points = points.Location;
initialize(pointTracker, points, videoFrame);
```

RGB Signals Extraction

R, G, B color values are the fundamental elements of R, G and B signals (together they are called RGB signals) which were extracted from the facial cropped RIO image. The ROI was then separated into the three RGB channels [Fig. 2(b)] and spatially averaged over all pixels in the ROI to yield a red, blue and green measurement point for each frame and form the raw traces 1 $x(t)$, 2 $x(t)$ and 3 $x(t)$ respectively [Fig. 2(c)].

We normalized the raw RGB traces as follows:

$$x'_i(t) = \frac{x_i(t)-\mu_i}{\sigma_i}$$

for each i = 1,2,3 where μ_i and σ_i are the mean and standard deviation of $x_i(t)$ respectively. The normalization transforms $x_i(t)$ to $x'_i(t)$ which is zero-mean and has unit variance.

Extraction of HR using Independent Component Analysis (ICA) and Fast Fourier transform (FFT)

The normalized raw traces are then decomposed into three independent source signals using ICA [Fig. 2(d)].The ICA model assumes that the observed signals y(t) are linear mixtures of the unknown sources x(t):

$$y(t) = Ax(t)$$

Where A is the mixing matrix which is also unknown.To estimate both A and x(t) assume that the components of vector x are statistically independent and nongaussian. After estimating A matrix its inverse W (demixing matrix) can be computed. Then the independent components can be obtained:

$$x(t) = Wy(t)$$

Finally, we applied the fast Fourier transform (FFT) on the selected source signal 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.

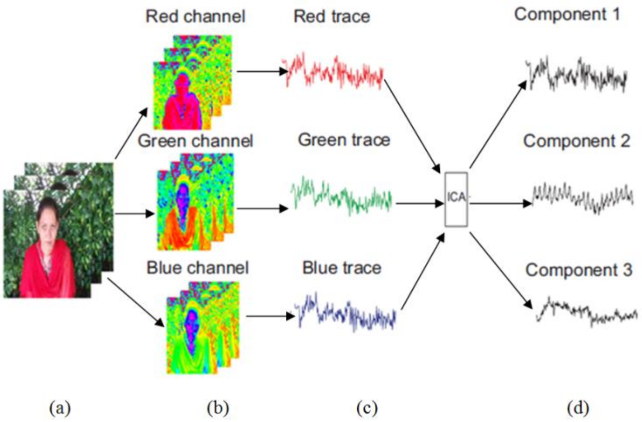
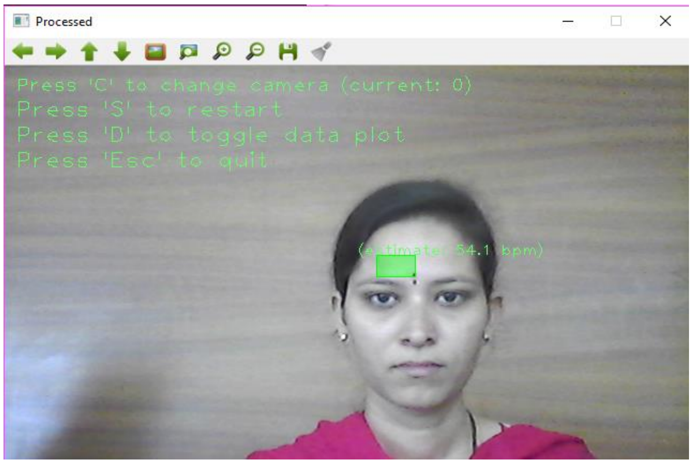


Fig 2: (a) The ROI is automatically detected using a face tracker. (b)The ROI is decomposed into The RGB channels and spatially averaged to obtain (c) the raw RGB traces.ICA is applied on the normalized RGB traces to recover (d) three independent source signals.

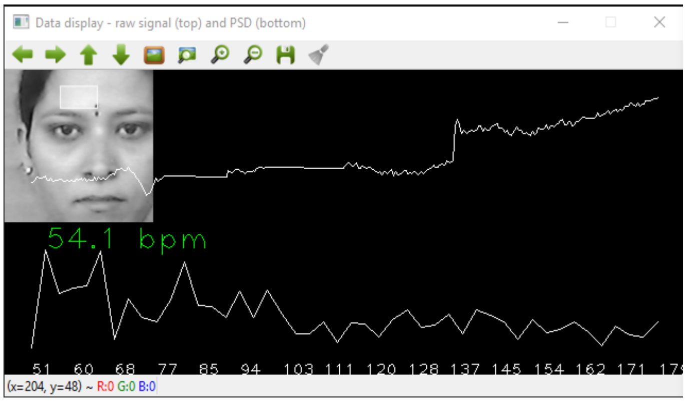
IV. RESULTS AND DISCUSSION

The proposed method has four main parts which are (i) video display and extract each image frame, (ii) face detection and facial image extraction, (iii) RGB signal extraction and (iv) Extraction of HR using ICA, FFT methods and displaying the results.

We observe three signals, red (R), green (G), and blue (B), in a recorded video sequence. The red signal may be effective for the HR measurement because the colour of the blood circulating through the veins appears red. Since the mean value of each signal within the ROI is used for HR measurement. It is expected that the larger the ROI is, the more reliable the measurement is. The results verify that the red signal is the most effective for the HR measurement, closely followed by the blue signal. The best spot for the HR measurement is the forehead, followed by the cheek.



(a)



(b)

Fig 3: Real Time HR monitoring GUI (a) and a data plot is shown in (b)

Age	Face	Finger Sensor
24	54.3	60
24	60	59
25	70.5	72
28	67	68
25	69	71

Table 1: Estimated HR values from Face and Finger sensor device

A real time HR estimation is shown in Fig 3 in which the heart rate is estimated as 66.2bpm.A Table 1 shows the heart rate values from the face and the pulse device and the graph is obtained in Fig 4.

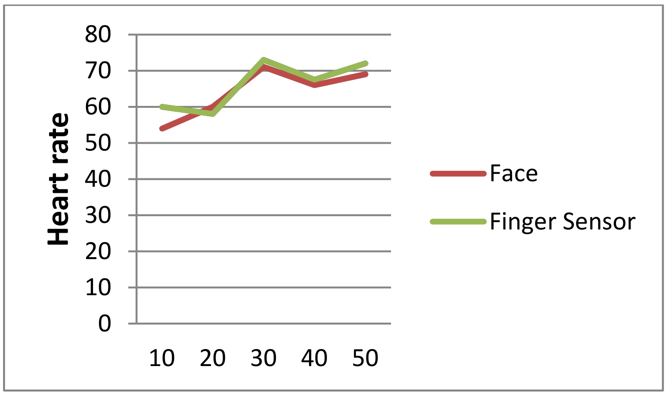


Fig 4: A graph showing HR values estimated by Face and Finger sensor

V. CONCLUSION

A real time noncontact based HR extraction method is described in this paper using facial video. The heart rate is obtained through facial skin color variation caused by blood circulation. In this videos are recorded via a webcam/camera, face detection algorithm is used to track the facial features. Lastly ICA and FFT are performed to estimate the Heart Rate. This non-contact HR estimation method is promising for medical care and others indoor applications due to widespread availability of camera specially webcams. In future, the proposed approach can be used for stress management and hypertension monitoring at home, office, school, college, and medical centers. Many other important physiological parameters such as, RR and arterial blood oxygen saturation can potentially be estimated using the proposed technique. Factors like different skin-tones, head movements and identifying multiple persons in a video can be considered in future.

VI. REFERENCES

1. G D. Costa, "Optical remote sensing of heartbeats," Optics Communications, vol. 117, pp. 395-398, 6/15/ 1995.
2. C Puri, J. Levine, L. Olson, I. Pavlidis, and J. Starren, "StressCam: Non-contact Measurement of Users-Emotional States through Thermal Imaging," presented at the Extended Abstracts Proceedings of the 2005 Conference on Human Factors in Computing Systems, CHI 2005, Portland, Oregon, USA, 2005.
3. C Takano and Y. Ohta, "Heart rate measurement based on a time-lapse image," Medical Engineering & Physics, vol. 29, pp. 853-857, 10// 2007.
4. M Garbey, S. Nanfei, A. Merla, and I. Pavlidis, "Contact-Free Measurement of Cardiac Pulse Based on the Analysis of Thermal Imagery," Biomedical Engineering, IEEE Transactions on, vol. 54, pp. 1418-1426, 2007.
5. Y Kurylyak, F. Lamonaca, and D. Grimaldi, "A neural network-based method for continuous blood pressure estimation from a ppg signal," in 2013 IEEE International Instrumentation and Measurement Technology Conference (I2MTC), May 2013, pp. 280-283.
6. A Visvanathan, A. Sinha, and A. Pal, "Estimation of blood pressure levels from reflective photoplethysmograph using smart phones," in Bioinformatics and Bioengineering (BIBE), 2013 IEEE 13th International Conference on, Nov 2013, pp. 1-5.
7. C. Takano, and Y. Ohta, "Heart rate measurement based on a time-lapse image," Med. Eng. Phys. **29**(8), 853–857 (2007).
8. W Verkruysse, L. O. Svaasand, and J. S. Nelson, "Remote plethysmographic imaging using ambient light." Opt. Express, vol. 16, no. 26, pp. 21 434-21 445, Dec 2008.
9. M Z. Poh, D. J. McDuff, and R. W. Picard, "Advancements in noncontact, multiparameter physiological measurements using a webcam," IEEE Transactions on Biomedical Engineering, vol. 58, no. 1, pp. 7-11, Jan 2011.
10. P. Viola and M. Jones, "Robust real-time face detection," in Computer Vision, 2001. ICCV 2001. Proceedings. Eighth IEEE International Conference on, 2001, pp. 747-747.
11. B. D. Lucas and T. Kanade, "An iterative image registration technique with an application to stereo vision," in Proceedings of the 7th International Joint Conference on Artificial Intelligence - Volume 2, ser. IJCAI-81. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc., 1981, pp. 674-679.