Analysis of Noncontact Heartbeat Detection

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***Abstract*--Heartbeat information is a crucial indicator in the clinical detection of life parameters. Current mainstream methods used for detecting heartbeats are contact detection technologies. Noncontact detection refers to using external energy to detect human physiological environment changes without contacting the human body.**

I. Introduction

Heartbeat information is a crucial indicator in the clinical detection of life parameters. Current mainstream methods used for detecting heartbeats are contact detection technologies, such as electrocardiography (ECG) [1] and photoplethysmography (PPG) [2]. Thus far, ECG has been a suitable indicator for evaluating physical health status. The major advantage of the contact detection methods is noninvasive measurements and complete waveforms, which can provide clinical references for physicians. However,measuring using ECG requires applying electrically conductive gel as a medium to attach conductive electrode pads onto the chest of the subject, rendering a low level of convenience for the user. The PPG refers to the signal of blood pressure changes sensed using optical sensing. The measurement method involves emitting lights on a selected skin area. The light enters the skin and is absorbed by blood, generating continual variations. The graph depicted according to the continual variation of light is the PPG. The advantage of PPG is that little electrical noise is produced. Although PPG requires measurement devices to be worn, it is more convenient for users, compared with ECG .

II. Experimental Equipment

The hardware part used in this study involved employing a video camera embedded in basic laptop computers for filming human faces. The video color was 24-bit RGB, at a 640 X 480 resolution and 30 frames per second (FPS). The software part involved using the LabVIEW platform, developed by National Instruments, combined with IMAQ Vision Function Palettes. The control group in the test used ECG devices. During experimental measurement, the participants wore the measurement device to facilitate comparison with the experimental data in this study. Fig.1 shows the state during measurement[3].

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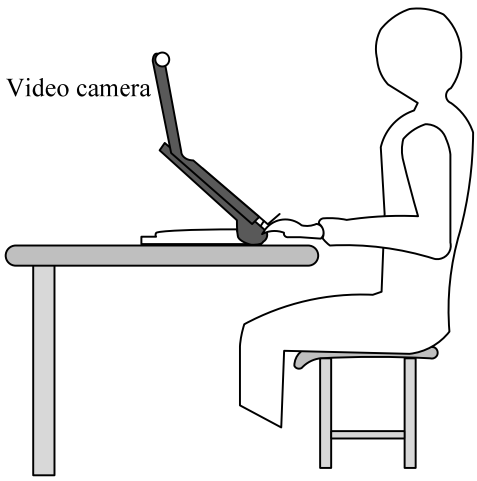

Fig.1. Measurement state diagram

III. Experimental Procedure

Fig.2 shows the Experimental Procedure. After the image was photographed, image preprocessing was conducted, including color channel separation, selection of region of interest (ROI), and calculation of color histogram means. The color histogram means of the three channels measured during image preprocessing were processed using ICA. The values of the three independent components were determined. Subsequently, fast Fourier analysis was used for determining the frequency spectrum of the color histogram means in the green channel and the data of three independent components. Within a frequency range between 0.75 and 4 Hz (heartbeat: 45–240 beats per minute; BPM), the strongest intensity in the frequency spectrum and the corresponding frequencies were determined. The highest independent component value among the frequency spectra of the three independent components was selected. Multiplying the frequency of the selected independent component by 60 determined the required heartbeat value (BPM). The frequency spectrum of the color histogram of the green channel directly converted the frequency at the maximal energy into heartbeat value (BPM). Finally, the two individual heartbeat values were compared with the heartbeat values measured using ECG devices.

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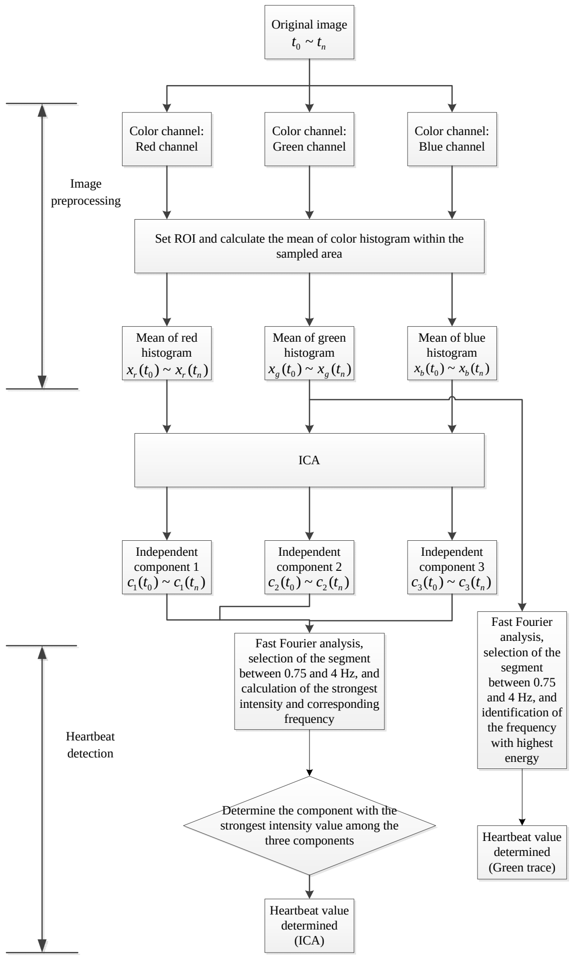

Fig.2. Experimental procedure

IV. Experimental Results

This experiment was conducted in an indoor space. During the experiment, each participant wore an ECG measurement device to facilitate a comparison with the data generated in this study.

TABLE I
DIFFERENTIAL VALUES AND DIFFERENTIAL VALUE STANDARD DEVIATIONS

Item / Time	Green Raw Trace V.S ECG Maximal Differential Value (BPM)	Green Raw Trace V.S ECG Differential Value Standard Deviation (BPM)	ICA V.S ECG Maximal Differentia l Value (BPM)	ICA V.S ECG Differential Value Standard Deviation (BPM)
20 s	7.21	2.82	5.35	1.53
10 s	28.52	8.82	5.85	1.56
5 s	38.31	11.87	52.98	15.35

Table I shows that when the measurement time was 5 s, the error was the largest. The error rates for 10 s and 20 s were within acceptable ranges.

V. Conclusion

This study proposes a set of image-based noncontact heartbeat measurement methods that involve using varying human face absorptions of light to detect heartbeats. By performing image processing and ICA, the hidden information in images were identified and concentrated. Subsequently, the frequency domain transformation and heartbeat estimation processes were used for achieving noncontact automatic measurement. By applying Cases and after a total of 80 iterations of measurements, using ECG measurement values as the indicators, a differential value percentage higher than 5% was identified as an error measurement [4]. The results are presented in Table II.

TABLE II
MEASUREMENT OF ERROR RATES

Item / Method	Number of items with a percentage of differential values higher than 5%	Error rate (%)
Green trace	33	41.25
ICA	18	22.5

Table II indicates that, regarding the measurement error rates, the ICA processing reduced error rates by 19%, improving the original values measured using green light variations only. In the cases of this study, the results clearly indicate that skin color and heartbeat rates do not affect measurements. Moreover, at a video camera sampling rate of 30 FPS, one iteration of heartbeat measurement can be completed in 10 s.

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