



Magnification Of Wrist Video For Heart Rate Measurement

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Abstract--This paper deals with the implementation of non-invasive method of heart rate measurement by processing the subject's wrist video. There are small movements on the wrist where the radial artery is present under the skin layer. These movements are due to the blood flow variation which are proportional to heart rate. The invisible movements can be captured and made visible to naked eye through a technique called Eulerian Video Magnification. Spatial decomposition is applied followed by temporal processing and amplification to the input video sequence. Output video consists of visible changes of small amplitude motion variations. Heart rate can be extracted from this magnified video by considering region of interest on wrist around the radial artery. The heart rate value obtained is then compared with the reading of heart rate measuring device.

Keywords—Eulerian video magnification, spatial decomposition, temporal filtering.

I. INTRODUCTION

The heart rate is an important parameter in diagnosing medical conditions. There is significantly high demand for new methods of easy, unobtrusive, and personal health care and monitoring technology. It is desirable for an individual to obtain a low resting heart rate between 50 and 70 beats per minute (bpm) and an active heart rate between 100 and 150 bpm. Most of the current technologies require direct physical contact with the patient in order to achieve proper measurement. The physical contact consists of electrodes on Electrocardiogram (ECG) machines, or pressure sensors on major arteries such as a wrist band, watches, fingerclips, holder monitor, etc. as shown in Fig.1.



Fig.1 Present heart rate measurement techniques

The primary heart rate is measured from pulse signal by placing fingertips on the wrist by physicians [1]. This requires physical contact of the patient and the results may vary due to human errors. In traditional Chinese medicine pulse signal diagnosis has been used for thousands of years. Wrist pulse signals contain vital information of person's health and reflect the pathological changes [2]. Experiments demonstrated that the shape of the wrist pulse signals has high correlation with the characteristics of the blood flow [3, 4]. Computerised method for wrist pulse signal has three steps [5]. These steps include data collection, feature extraction and pattern classification. Many models and algorithms to extract and classify the feature parameters from the wrist pulse signals are proposed in previous work, such as Gaussian model, information fusion technology, and clustering technique. A modified Gaussian model is used to extract the features of given pulse signal called as modelling parameters [6]. Tightly correlated features need to be eliminated so a feature selection scheme is implemented. Then the Fuzzy C-Means classifier is used for pattern classification. A quantitative method is developed where haptic lens is used to find arterial pulse pressure parameters [7]. The 3D position and movement of underlying tissue during the application of a known force, same as that the physician feels through manual palpation can be captured in the form of images using haptic lens. A multiple criteria decision making framework is developed to cluster an unlabelled human pulse signal data set [8]. This is used to separate the suspected healthy and unhealthy clusters, can also be employed for unhealthy pulse signal detection.

Mathematical differentiation is used for the detection and location of partially overlapped peaks in a multi-component signal [9]. Wrist pulse can also be found

using a doppler ultrasound blood analyzer as applied in [10]. In this method wavelet transforms are used to extract the pulse signal features from the captured analyzer output. Then the support vector machine is used as classifier to validate the human wrist-pulse and provide useful information to diagnose viscera failures. Fingertips were replaced by piezoelectric film sensors for extraction of the wrist pulse signal [11]. It uses pulse obtained from sensor to check possible liver illness and heart disorder. The use of costly sensors may cause discomfort to patients and which can affect the accuracy of the measurement. These techniques are not convenient for self-monitoring. This paper presents a new technique which measures heart rate from patient's wrist video. The small movements on wrist skin present above the radial artery are invisible to naked eye. The recent technique of Eulerian Video Magnification can be used for extraction of invisible small motions from video input [12]. Motion magnification method is used where motions are made visible by extracting and amplifying them from the video input. The Eulerian magnified video output consists of small motion variation which are now made visible. The 2-Gaussian curve modelling method is applied to analyze the pulse signals obtained from Eulerian magnified wrist video [13].

II EULERIAN VIDEO MAGNIFICATION

The Eulerian Video Magnification of amplifying subtle changes in video stream was presented at SIGGRAGH2012 [12]. There are two main video based methods for the non-contact measuring at the present time. The first one is based on monitoring small movements of the body caused by reaction to the waves of blood pushed from the heart. The second one is based on small changes in skin color caused by the blood flow in tissues. The reflection capability of skin with capillaries supplied with blood differs from the reflection capability of a skin containing less blood. The blood volume is changing in correspondence with the heart rate. The goal is to develop an algorithm to detect these changes for pulse recognition which can be easily used by any individual. With the aid of Eulerian Video Magnification, we can determine a person's pulse simply from video of face or wrist. Fig.2 shows its block diagram. It reveals low amplitude variation in a given temporal frequency band of interest. Temporal processing is used to extract invisible signals or motions which need to be amplified. Here, in this case, bandpass filtering is done to extract the signal corresponding to the pulse. This allows us to amplify and visualize the pulse signal at location on wrist where there are small motions due to presence of radial artery.

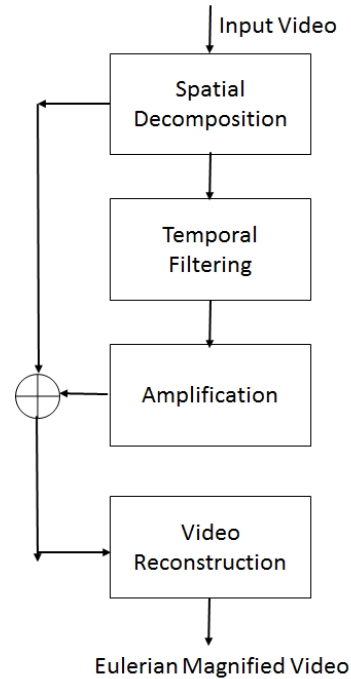


Fig.2 Eulerian video Magnification block diagram

III METHODOLOGY

Motion magnification is implemented using Eulerian technique to extract small amplitude motions on wrist. The block diagram of proposed project is shown in fig. 3. The subject's wrist video is recorded using laptop's webcam in the presence of bright light. The heart rate of the subject was noted down manually using a heart rate measuring device for every 20 sec interval while taking the wrist video. The block diagram is shown in fig. The different bands may have varying SNRs and to some of the bands the linear magnification cannot be applied. In order to minimize the artifacts, some bands are not magnified. The spatial filtering may be done by a laplacian filter to increase the signal to noise ratio. The size of the spatial filter should be properly estimated. Next stage is the temporal filtering. A band pass filter like butterworth is applied to acquire the required frequency band, by considering the time series corresponding to the value of each pixel. A wide band filter is designed to extract the invisible motion. The next step deals with selection of an amplification factor α . A large amplification factor is selected to make the motions visible. After amplification, it is added to the original signal and the pyramid is collapsed to reconstruct the output Eulerian magnified video. The motions are visible to the naked eye in magnified output video.

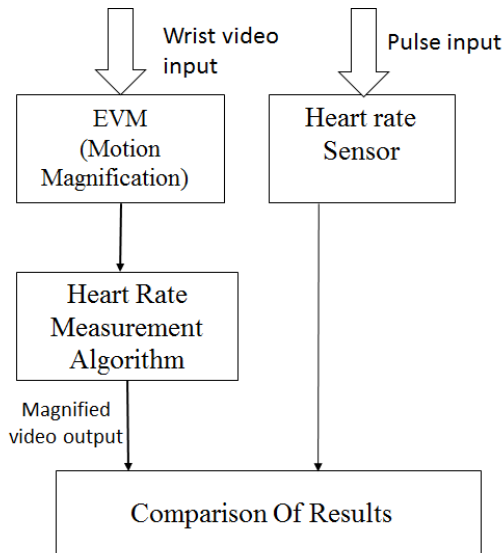


Fig.3 Block diagram for Heart Rate Measurement using wrist video

Heart rate extraction

In order to accurately from Eulerian magnified video several steps need to be implemented as shown in Fig 4. The first step in finding the heart rate is to extract the region of interest. The ROI is selected around point where the radial artery movements are visible in the magnified video. Average of pixel values in the selected ROI is calculated. The green channel has strong presence of heart rate signal. As haemoglobin absorbs green light better than red and blue light, this verifies that the signal is due to variations in the blood volume. Hence, we plot the only the green channel intensity values which approximately represents a sine wave. Now the aim is to find the frequency of this wave obtained. So we find the location of peaks and the distance between them. According to frame rate, calculate the distance in terms of time. The average of all the distances gives the time period T of the wave which in turn will give the frequency. This obtained heart rate value is then compared with reading of heart rate measuring device to find the accuracy.

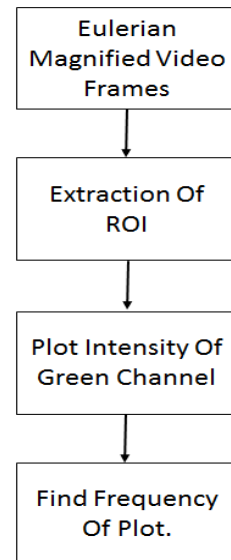


Fig.4 Flowchart for heart rate extraction from magnified video

IV RESULTS

The video of patient's wrist is captured using laptop webcam for about 30s. The video is then converted into frames for further processing as shown in fig.5.

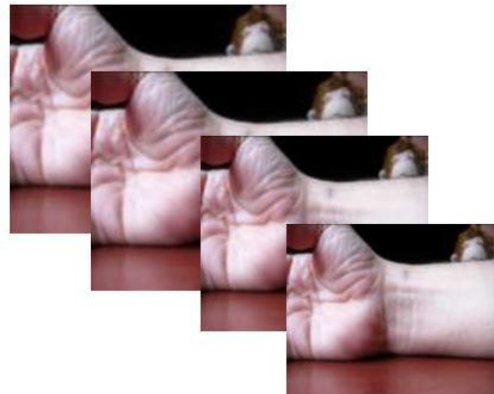


Fig.5 Input wrist video frames

Further processing can be done in RGB frame or they can be converted into NTSC format. Then the spatial decomposition of frames is performed. The gaussian and laplacian pyramid with level 4 for each frame is constructed. Gaussian pyramid corresponds to low pass filtering of frames with the help gaussian filtering mask [12]. The kernel of filter mask is show in fig. 6. Laplacian is constructed by taking difference of consecutive Gaussian levels. This corresponds to bandpass filtering in spatial domain.

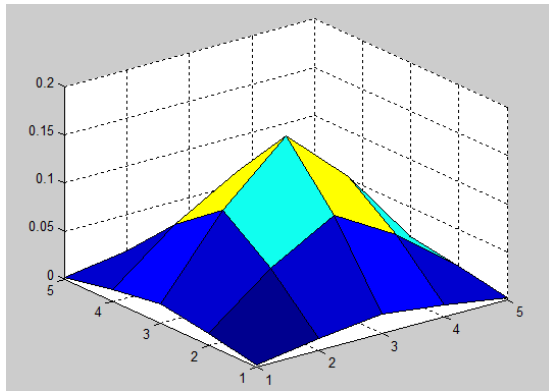


Fig.6 Surf plot of masking filter kernel.

The temporal processing is then performed to extract the pulse signal in temporal domain. Bandpass filtering is performed by using low order butterworth filter for 0.4 to 4Hz frequency range. Amplification is performed on only selected levels on pyramid with appropriate amplification factor. The next step is add the extracted signal back into the input frames. This is done adding the signal from each level to respective level of original input pyramid. Then the video is reconstructed by collapsing the pyramid levels. The output video frames are shown in fig.7.



Fig.7 Input wrist video frames

V. CONCLUSION AND FUTURE WORK

In Eulerian motion magnified video small amplitude motions are made visible. Thus the Eulerian technique can be used to extract and amplify changes in the video which otherwise invisible to naked eye. This can help to extract vital information of many natural and man-made phenomenon. The factors such as illumination, blurry background and unstable video due to camera shake limit the quality of output video. The heart rate will be calculated by selecting the region of interest around the location on wrist where radial artery is present. The obtained results will be compared with the results of actual heart rate measurement device to check for accuracy.

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