

Affordable Remote Monitoring of Health Status using Facial Image Processing



A.Gheitasi, M.M.Omari, A.Hashem, E.Al-Dfere, H.Al-Moussawi, K.Farhat

Abstract: This paper presents a real-time monitoring system with a novel approach to assess the human health status without the need for using a body sensor. The project mainly targets improving the quality of life for those living independently but still require close monitoring. Skin fluctuation of the human face is monitored real time with a high-speed camera to determine vital signs including the heart rate and blood pressure. A few image processing algorithms have been utilized to determine the image fluctuations and extract the related features and acquire vital signals. An algorithm assesses and evaluates the risks involved in irregular behaviors and takes follow up actions where required. The application has been implemented on two platforms and interfaced with a high-speed camera to evaluate the performance of the remote monitoring system in indoor situations.

Index Terms: Image processing, health signals, Remote monitoring, image acquisition, medical image processing

I. INTRODUCTION

Healthcare emergencies are a significant part of the lives of people in both developing and under-developed nations. One of the challenges in some of these emergencies come up for many patients in these nations is the delivery of medical treatment particularly if the patient is unresponsive and uncommunicative. Real time monitoring of the human health is becoming a major need considering the growing population of elderly population.[1] There is also a growing interest of security officials to monitor the level of stress of people in the public area to mitigate the risk of violent actions. Real time monitoring of heart signal and panic buttons have been utilized for unwell people with wired sensors and wireless facilities. Remote monitoring on the other hands provides more facilities for both patients and medical centers.

image processing methods provides even more flexibilities since they are not needing wearable sensors and the processing can be performed without causing any interception into the people's normal activities. These systems can be utilized for multiple people at the same time and check the health status of suspected people when needed. Heart rate is an important parameter to diagnose diseases and is an important indicator for human's physiological state. Earlier methods of heart rate measurement dependent upon some special electronic and optical sensors which require skin contact which is uncomfortable and inconvenient. Object recognition and tracking features are essential in computer vision system applications. Real-time face tracking is the process of identifying human faces and tracking the recognized faces. Then the face should be evaluated and pictured properly to capture vital signals. These vital signals then should be filtered and collected to determine these signals. [2].



Fig. 1. Real-time face detection

The method of remote monitoring of heart rate through cameras will have several potential applications. One of the advantages of monitoring heart rate is that patient could be monitored remotely. This paper study the remote monitoring of human health using Image processing technique. The purpose of this project is to design a system which can capture the images of the patient's face and examine the health through face recognition. The focus of this paper is limited to measuring hearth pulse and blood pressure and signal suspected events. Remote health monitoring has been reported in several papers in the past few days. These signals are mainly heart pulse, blood pressure and temperature. Several papers suggested analyzing heart rate monitoring using Webcam. They have implemented non-invasive heart rate system of different age groups using digital image processing. They estimated the heart rates from one's face by visualizing the flow of blood in the face.

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The method was by capturing a standard video of the subject, performed face tracking and then, filtering frames. The resultant was further amplified for clearer vision. [3] to [6].P. Zurek et al., established a new method for measuring blood pressure using a camera video and image processor. Four subjects were chosen for blood pressure measurement; blood pressure was measured with a cuff-based monitor system. After that video of the respective subject was processed frame by frame. An algorithm is applied to extract signal that was used to calculate shift in frames between two separate areas of the arm. Time shift analysis estimated blood pressure. [7]R. Kumar is developed a method to monitor patient's Heart Rate, Respiration Rate, Body temperature, and body movements using Raspberry Pi board and it acts as a server. Then it automatically sends data to the web server, and these parameters were monitored using web pages anywhere in the world using smart devices. [8]O.Nikisins, et al., proposed face recognition system based on the Raspberry Pi single-board computer. Face recognition system was consisting of face detection and face localization using wavelet transform. They described algorithms for face detection, localization, feature extraction, and recognition. [9]The above designs and developments are mainly utilized the webcams to capture images and then the recorded videos will be processed accordingly. In most cases are presented as an offline system with delays. it would be more appropriated if the signal processed in a real time manner and appropriate messages to be singled at the same time as with image acquisition or with a short delay.

II. DESIGN METHODOLOGY

This project is planning to develop a remote monitoring system for health signals by utilizing medical algorithms in real time for simple hardware configuration. A simple webcam with the resolution of 1080 pixels and the frame rate of 30 frames per seconds has been utilized. The output of this camera has been processed to determine health signals and evaluate the people's status accordingly. The methodology proposed is consist of various steps from the image capturing to the final output we get. We have detected the heart rate, blood pressure and temperature of a human by recognizing his/her face image captured using a webcam. We have proposed a simple processing pipeline given as below:

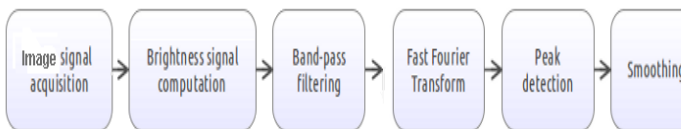


Fig. 2: Methodology of the vital signals acquisition

A. Video acquisition and signal processing

In this project, a Raspberry Pi minicomputer is used to process the webcam information and the vital signals. MATLAB Simulink has been utilized to read the video from the webcam and then perform image processing and the risk assessment. The process steps flow is shown in figure 3. The raw video signal will be clarified first with normal visual files. The human face will be extracted from the signal and the rest of

each frame is deleted to avoid noises. In order to determine heart rate and blood pressure, we need to sample a signal for which the most important parameter is bandwidth. The normal range of human heartbeat is 60 and 200 bpm. The signal used for processing is taken at a rate of 30 frames per second. The first stage of the process is to detect the face of the subject and remove the unwanted areas. Matlab face detection algorithm has been utilized to detect the face and element the rest of the video. In order to extract vital data, the brightness of the skin will be determined and tracked in each frame. Since the brightness itself is a function of the green, the red and the blue images, there are two possible approaches to process the information. The three matrixes of colors can be averaged to have a monochrome image that have all components of the single-color images or a single color may be chosen. The green power is noted to be the most useful as the color in this research and hence it is taken for the process of measurement and data acquisition. A square sample of target's face is chosen and sampled. Size of the sample varies depending on the distance of the object and quality of the video. Then a time series to be formed from the samples taken from the frames. Fast Fourier transform transfer the signal to the frequency domain. And a simple peak filter extracts the significant points out the signals. These points are easily corelated to the target's skin and determine related signals. These signals then compared with the data base required to determine the health condition of the person and generate the report and the required warnings if necessary.

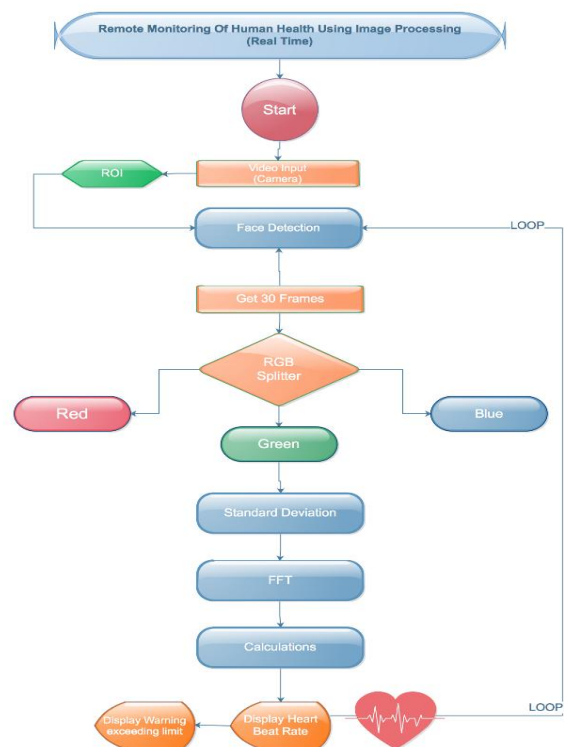


Fig. 3. image acquisition and processing flowchart

Then the value of the monochrome image in each frame is compared with the previous frames to extract raw signal that contains the health indices. The signal now is a two-dimension matrix containing the progression of frames in a period of three seconds. In order to produce a single vector that represents the brightness progression, the pixel's progression rate is averaged and hence each frame will be represented by one number at a point.

Figure 4 shows the implementation of the algorithm in Simulink using raspberry pi supported package toolbox.

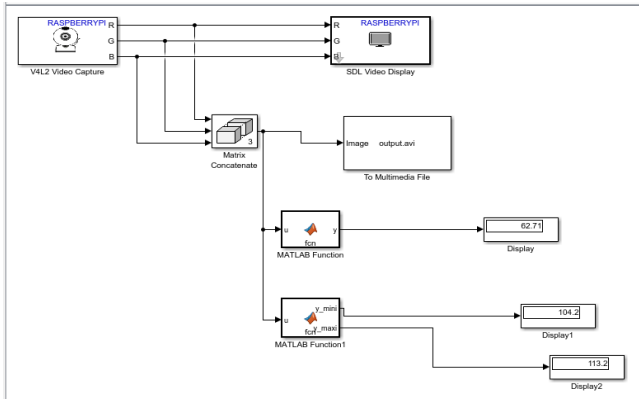


Fig.4. the matlab block diagram implemented for the raspberry pi to acquire image signals from the webcam

To translate the signal from time domain to frequency domain Short term frequency transform (STFT) has been utilized. STFT transform the signal which represents the magnitude and phase of the corresponding frequency in a fixed window of a time. STFT allows for FFT processing with a fixed samples and hence changes can be noticed from one to another sample.

$$STFT\{x[n]\}(m, \omega) = \sum_{-\infty}^{\infty} x[n]\omega[n - m]e^{-j\omega n} \quad (1)$$

III. RESULTS AND IMPLEMENTATION

The Amplitude of frequency in the range of interest with x-axis label as "Heart Rate" and y-axis label as "Amplitude" as shown in figure 4.

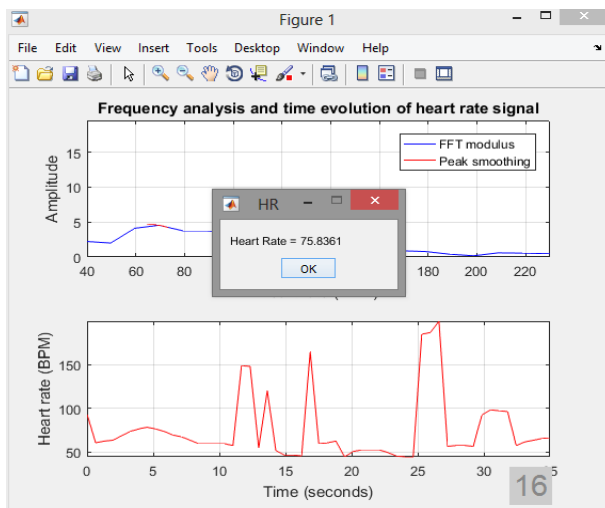


Fig. 5. The raw pulse signals

When the user pushes the Initialize button, the camera will turn on and records small clips. The clip only focuses on the face portion where selected by a MATLAB image acquisition toolbox. The green picture of frames then will be utilized to capture the vessels vibration. The signal then will be categorized to acquire the heart care and blood pressure considering their acceptable frequency ranges as explained in the previous section. Normal text files have been used to store the signals information. After detecting the green Channel, the program automatically finds the mean of the 90 frames (3 s) evaluate the rate and pressure and normalize the data accordingly. Then STFT is utilized to estimate frequency components of the derivative signal. After computing the frequency spectra, peaks are detected in the region of interest and all peaks are found using the find peaks function in MATLAB. STFT determines the frequency domains of the signals. These frequency components are including those related to the heart rate, blood pressure etc. a proper filtering the given signals determines the value a given vital signal. As discussed, we have taken the range of 30ppm to 200ppm as the acceptable range of heart rate signal. This results in a band pass of 0.5Hz to 3.3Hz. Since it is fairly a narrow frequency bandwidth, the heart signal can be acquired with a good accuracy. Comparing the heart rate obtained from the program and the heart rate from the mobile application which is very accurate which is shown in figure 5.

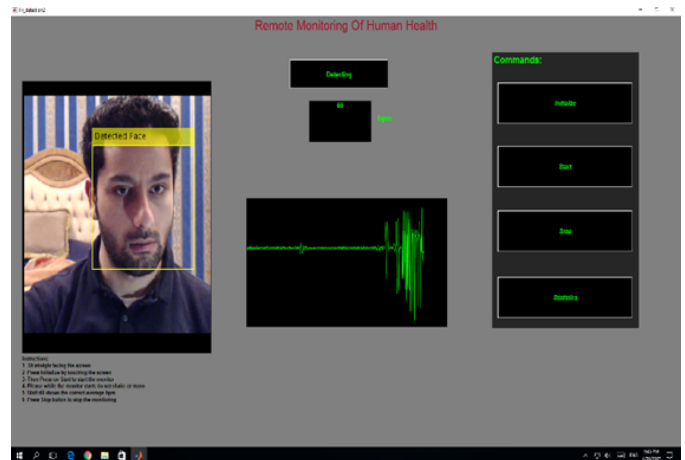


Fig. 6. MATLAB GUI for the heart rate monitoring system

We came up to a conclusion that the better lighting we are having around the patient we are getting much more accurate readings and that's due to the detection of each FPS in the patient's face. This plot shows the ECG signal over number of samples

Figure 7: Heart rate is detected up for 1.2 meters with an acceptable accuracy. The basic configuration which we have used for performing our research work or experiments comprises of the webcam, Raspberry Pi, and Matlab. This plot shows the ECG signal over number of samples

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Figure 1: Heart rate is detected up for 1.2 meters with an acceptable accuracy

The basic configuration which we have used for performing our research work or experiments comprises of the webcam, Raspberry Pi, and Matlab.

IV. CONCLUSION

This paper demonstrated the implementation of a simple data processing system using affordable hardware. MATLAB codes has been utilized and implemented into a Raspberry Pi. And a normal webcam is taken as the image acquisition devise. This project is taking advantage of current image processing methods to locate objects, acquire image signals and processing them. The main contribution of this paper however is having a real-time view of health parameters with a minimal delay.

This system is powerful, inexpensive, and flexible tools plus the robots play the vital role in patience health and security systems. It can be integrated with advanced cameras and processing systems to improve the diagnosis range and provide early warnings.

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