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IoT BASED REMOTE PLETHYSMOGRAPHIC IMAGING WITH THERMAL READING

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***Abstract*—Vital signs are measurements of the body's most basic functions and are useful in detecting or monitoring medical problems. Pulse Rate is a strong indicator of overall health and fitness. This paper presents how non-contact Pulse Rate is measured remotely (>1m) using ambient light and a simple consumer level digital camera in movie mode. Plethysmographic signals (plethysmography-variations in the blood flow volume with every heartbeat) are extracted from human faces by observing the color variations using Image processing techniques. On the other hand, human body temperature using a digital temperature sensor is measured. Temperature values along with pulse rate values are displayed on the LCD. The values can be accessed remotely via the cloud. The results show that ambient light photo-plethysmography may be useful for medical purposes and real time remote sensing of vital signs for triage or sports purposes.**

Keywords*—plethysmographic signals, pulse rate, thermal reading, vital signs, image processing, internet of things

BACKGROUND WORK

There are various papers published related to measuring plethysmographic signals. In the paper that has been published earlier like [1] T. Pursche ,J. Krajewski and Reinhard Moeller, “Video-based Heart Rate Measurement From Human Faces”, 2012 IEEE International Conference on Consumer Electronics(ICCE) ,the main focus was on measuring the pulse rate from facial videos that were previously stored. Here, the image processing techniques were implemented using the MATLAB software. In the paper [4] “Real Time Heart Rate Monitoring from Facial RGB Color Video using Webcam”, The 29th Annual Workshop of the Swedish Artificial Intelligence Society, 2016 byHamidur Rahman,Mobyen Uddin Ahmed,Shahina Begum,Peter Funk, the pulse rate is measured through colour changes from facial video in real time using a simple web camera. As in the paper [1], most of the papers implement image processing using MATLAB. With the introduction of PYTHON, a powerful programming language which is an open source and could run on cross platform, OPENCV with PYTHON is used to apply the image processing techniques in this paper. All these papers concentrated only on measuring pulse rate more efficiently. In this paper, the human body temperature is also measured along with pulse rate so that the basic vital signs data of the user are available. Furthermore, to make these values accessible remotely thus facilitating telemedicine and integrating healthcare systems, the pulse rate and temperature measurement is integrated with internet of things. And so, the pulse rate is measured in real time and pulse rate values and thermal values are accessed by the cloud.

INTRODUCTION

The pulse rate is a measurement of the heart rate, or the number of times the heart beats per minute. As the heart pushes blood through the arteries, the arteries expand and contract with the flow of the blood. Taking a pulse not only measures the heart rate, but also can indicate heart rhythm and strength of the pulse. The normal pulse for healthy adult’s ranges from 60 to 100 beats per minute. The pulse rate may fluctuate and increase with exercise, illness, injury, and emotions. Females of age 12 and older, in general, tend to have faster heart rates than males do. Athletes, such as runners, who do a lot of cardiovascular conditioning, may have heart rates near 40 beats per minute and experience no problems. The word plethysmography comes from a Greek word ‘plethysmos’ meaning increase and ‘graph’ meaning write. Plethysmography is the measure of variations in the blood flow volume in each and every part of the human body. The blood flow volume changes are in accordance with the heartbeat. For every beat, the heart pumps blood out of it to every part of the body. The blood flows through every organ and reach all the way to the skin through the tissues. So, there

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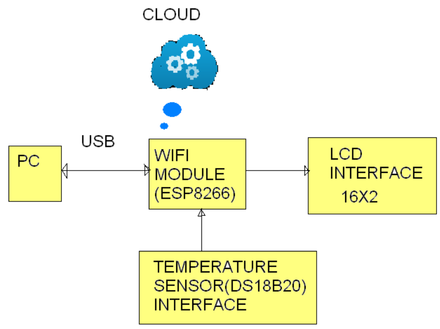
are color variations in the skin that is noticed when the blood flows i.e. when the volume of the blood changes. These color changes are identified keenly from which the plethysmographic signals are generated. Tracking of these blood volume changes in an efficient way gives us the pulserate. Traditional ways of measuring pulse rate are using stethoscopeor usingECG. Stethoscope are sometimes inaccurate and they only show the approximate values whereas ECG is costly and has a difficult set up. There are situations where the person is unable to move (like elderly or person with severe body pain) and his/her body pulse needs to get checked up immediately. By using the below mentioned method, one can easily measure their vital signs in real time. In such cases this paper helps thereby measuring pulse rate in real time and sharing it via the cloud.This paper focuses on Non-contact measurement of pulse rate. Measuring pulse rate through plethysmographic signals give us an accurate value of pulse rate in the real time. Another vital sign measurement which the body temperature is measured using a digital temperature sensor which is easy to use and accurate too. Plethysmographic signals are generated using image processing techniques. Here real time video processing is implemented. PYTHON is an open source programming language which has efficient and powerful libraries. It can also be run on cross platforms. Here Python and OpenCV is used to generate the plethysmographic signals from a real time facial video. From the signal, pulse rate is measured. Human body temperature is measured using a digital temperature sensor. The temperature and the pulse rate values are displayed on a LCD. The reference papers were focused on measuring pulse rate from facial video. Here we measure the pulse rate in real time and also extend it to IoT where the pulse rate measured is being shared instantly. The parameters that are measured are shared in the cloud using a WIFI module. Using the Arduino IDE, the data are uploaded to the WIFI Module. The Node MCU supports WIFI module. The uploaded data are sent to cloud. Hence, they are made accessible from anywhere. Though there are many papers relating to pulse rate measurement from facial videos, here in this paper, measurement of pulse rate along with human body temperature is performed to assist medicinal practitioners to measure vital signs with ease thus saving time and cost. In order to provide remote healthcare monitoring the values are integrated with IOT. The doctors from any part of the world can track their patient's pulse rate and body temperature who is at home.



PULSE RATE MEASUREMENT

A. Accessing the Camera

First, the web camera of laptop or any personal computers are used to capture the faces in order to extract the plethysmographic signals. The initial step is to access the front camera and open the camera window. The camera must start capturing a real time video and store 50 frames of the video as images in a buffer and refresh the buffer with the next set of frames continuously.

B. Face Detection

Once the camera window is open, the second step, that is, the face of the person in front of the camera must be detected. In image processing, in order to detect the faces, Viola Jones Algorithm is used. The Viola Jones algorithm is extremely robust, has a very high detection rate, is fast enough to be implemented in real-time for practical applications involving frame rate of 2/sec used for face detection. The OpenCV provides with various library files to facilitate face detection using Viola Jones Algorithm. A rectangle box is drawn around the face, from the x and y coordinates obtained after detecting the face.

C. ROI Isolation

The third step of the process, is to isolate the region of interest. Plethysmographic signals can be extracted from any region of the face. Generally, the forehead or the cheeks or the lower face regions are concentrated. Here the region of interest (ROI) is the forehead region. This is because, the pulse rate variations are more evident and the surface of the forehead is even thus avoiding unnecessary reflections. The forehead region is by calculating the distance from the edges of the rectangle drawn around the face. Once the ROI is found, a rectangular box is drawn to isolate the forehead region.

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D. Signal Extraction

The fourth step is to extract the plethysmographic signal. Data is collected from the forehead region over time to estimate the user's pulse rate. This is done by measuring the variations in colour of the tissues resulting due to the pulse rate, over a period of time, with the help of OpenCV. Any colour is usually composed of three main components, red, green and blue (RGB) signals. Each pixel on the region of interest has R, G, B values. However, here data is collected by averaging the optical intensity in the green channel alone, as the other tends to be either inaccurate or prone to noises. The frequencies of green colour in each and every frame is extracted by applying Fourier transforms on the coloured images from the buffered frames. Thus, the plethysmographic signal is obtained.

E. Finding the Pulse Rate

Next, the green colour wavelength variations are tracked. The number of peaks in the frequency domain over the frames are noted, and also the time taken is also noted. From these values, pulse rate is calculated. Thus,

Pulse Rate= 60*(no of peaks/time) bpm.

Initially it takes around 5 to 10 seconds to calculate the pulse rate and then the values obtained starts syncing with the user's pulse rate.

HARDWARE INTERFACING

Laptop is connected to a WIFI module using an USB so that the pulse rate values can be accessed via the Internet. On the other side, body temperature measurement using a digital temperature sensor is also done and that value is sent to the WIFI module. The pulse rate and the body temperature values are displayed on the LCD. Once the WIFI module receives the pulse rate and temperature values instantly it sends it to the cloud server and the values can be accessed in real time.

INTERNET OF THINGS

Once the pulse rate and the body temperature are measured we must share the data across the internet. For this we use the concept of the Internet of Things where we collect and share the data across the globe for various purposes. Three steps to IoT are Create, Connect and Visualize. Our first step is to create a server with a unique account. Our next step is to connect our data to the server for which we use the ARDUINO programming language. The final step is to visualize the real time data acquisition.

IMPLEMENTATION

When the entire set up is ready we start measuring the parameters in real time. The web camera detects the face and starts processing and the pulse rate values are measured instantly. On the other hand, body temperature is measured with the DS18B20. These two data are displayed on the LCD. These data in a required JSON format is communicated via the Arduino code. The data gets shared in the cloud instantly when the measurements are made at the real time. These data can be protected using a key. An URL is provided to the authenticated person who can access the data from anywhere.

RESULTS

Once the face is detected, the forehead region is locked and the pulse rate in bpm (Beats Per Minute) is calculated and displayed. The below images show how the output is obtained. The pulse rate displayed on the screen as shown below is in sync with the pulse rate of the heartbeat. Thus, the users can get their pulse rate instantaneously and continuously. The value displayed keeps changing for every second as it calculates values based on the previous data available. The pulse rate calculated is compared with other pulse rate monitors used, and the values vary more or less the values displayed by the comparative devices used.
The efficiency of the system is almost similar to the paper [1] Remote Heart Rate Measurement from Face Videos Under Realistic Situations. The measurement of pulse rate must be made under ambient light conditions and the user must be within a range of 5m. The values are distorted under ill illuminated conditions. The temperature measurement is done using a digital thermometer and the values are accurate. Both these values are displayed on a LCD so that users can see these vital signs values. With the help of Internet of Things, these vital signs can be viewed on any phones or laptops by accessing the particular URL. This facility provided by IOT helps to access the measured values remotely, thus helping people to access the values from anywhere at any time. The values are uploaded every few seconds, providing real time monitoring of vital signs even from a distant. With proper connection to the internet, the values are accessible, in a more user-friendly manner.

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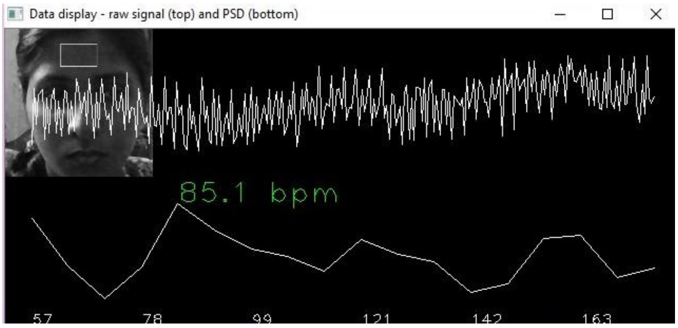
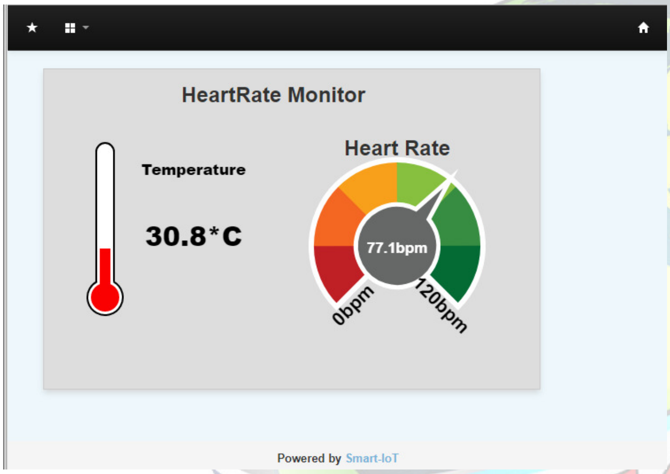


The pulse rate in beats per minute is displayed continuously in real time.



The pulse rate and body temperature are sent to the cloud via WIFI module and displayed in the URL specified website.

CONCLUSION

The reference papers which were focused only on data measurement, guided us to extend to IoT implementation where the data are being shared which makes it more accessible. It is found that the pulse rate that is measured from detecting forehead region is more accurate than other facial regions. When all the papers related to plethysmographic signals and its measurement from facial video focused on improving their efficiency and making them more reliable even under different circumstances, this paper focuses on making the values measured more accessible and more user friendly. The pulse rate measurement was the sole focused value in all the referenced papers, and this paper extends to measuring the vital signs. As technology has evolved and everything is connected virtually, uploading the pulse rate and body temperature values to the cloud helps people to access them easily, quickly and time effectively. The system proposed by this paper can be integrated with the hospitals system to monitor patients' vital signs. This system can be more commonly used to monitor retired people's vitals by their closed ones, giving people a sense of relief. Human vital signs measurement in real time finds many applications for medical purposes.

FUTURE WORK

This paper uses the web camera available on laptops to measure plethysmographic signals. This can be extended to all types of camera, like the cameras on our phones or any other Ip external cameras. The described work can be incorporated with user-interface applications to make the measurement of vital signs more user friendly. The entire hardware interface can be made more compact and lightweight, so that they can be used as a wearable device. This can be extended to measure respiration rates and blood pressure so that all of the vital signs are measured. Facial expressions can also be detected from facial videos and the data can be stored and analyzed to improve the performance.

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