RESEARCH ARTICLE

The Smart Medical Mirror – A Review

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ABSTRACT: People with their busy schedules tend to ignore the importance of health. To encourage people to keep track of their health and to overcome the difficulty of making regular visits to the hospital the Medical Mirror is proposed. The Medical Mirror is a novel interactive interface that tracks and displays a user's heart rate, height, weight, body temperature, blood pressure and sugar levels in real time. It is an approach to make ordinary people to have access and control over their own physiological data so as to play a vital role in the management of their health. However, current techniques for physiological data monitoring, require users to strap on bulky sensors, chest straps or sticky electrodes. This discourages regular use because the sensors can be uncomfortable or encumbering. This work proposes a new mirror interface for real-time, contact-free measurements of pulse rate without sensors. These techniques also involve the use of separate equipment in the measurement of each health parameters of human body. Medical Mirror integrates all the measuring facilities at one place with a compatible user interface providing a convenient means for people to track their health condition. It records the measured data and will be displayed in the form of charts. The application will understand the input given by the user and accordingly it provides feedback for the further health improvement. Users can have the experience of remote health monitoring by looking into the Medical Mirror. The Medical Mirror fits seamlessly into the ambient home environment, blending the data collection process into the course of daily lifestyle. Medical mirror will ease the user interface. Digital medical devices promise to transform the future of medicine because of their ability to produce exquisitely detailed individual physiological database. When people start accessing this technique they can easily monitor their physiological condition by referring their data.

KEYWORDS: Raspberry Pi unit, Rectifiers, Relays, Voltage regulators, Sensors, Transformers, Webcam Module, Load Cell, Signal Processing.

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1. INTRODUCTION

Regular and non-invasive assessments of cardiovascular function are important in surveillance for cardiovascular catastrophes and treatment therapies of chronic diseases. Resting heart rate, one of the simplest cardiovascular parameters, has been identified as an independent risk factor (comparable with smoking, dyslipidemia or hypertension) for cardiovascular disease. Currently, the gold standard techniques for measurement of the cardiac pulse such as the electrocardiogram (ECG) require patients to wear adhesive gel patches or chest straps that can cause skin irritation and discomfort. Commercial pulse oximetry sensors that attach to the fingertips or earlobes are also inconvenient for patients and the spring-loaded clips can cause pain if worn over a long period of time.

The ability to monitor a patient's physiological signals by a remote, non-contact means is a tantalizing prospect that would enhance the delivery of primary healthcare. For example, the idea of performing physiological measurements on the face was first postulated by Pavlidis and associates and later demonstrated through analysis of facial thermal videos. Although non-contact methods may not be able to provide details concerning cardiac electrical conduction that ECG offers, these methods can now enable long-term monitoring of other physiological signals such as heart rate or respiratory rate by acquiring them continuously in an unobtrusive and comfortable manner. Beyond that, such a technology would also minimize the amount of cabling and clutter associated with neonatal ICU monitoring, long-term epilepsy monitoring, burn or trauma patient monitoring, sleep studies, and other cases where a continuous measure of heart-rate is important.

Medical Mirror is a novel interactive interface that tracks and displays a user's heart rate in real time without the need for external sensors. Currently, collection of physiological information requires users to strap on bulky sensors, chest straps, or sticky electrodes.

The Medical Mirror allows contact - free measurements of physiological information using a basic imaging device. When a user looks into the mirror, an image sensor detects and tracks the location of his or her face over time.

By combining techniques in computer vision and advanced signal processing, the user's heart rate is then computed from the optical signal reflected off the face.

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The user's heart rate is displayed on the mirror, allowing visualization of both the user's physical appearance and physiological state. Digital medical devices promise to transform the future of medicine because of their ability to produce exquisitely detailed individual physiological data. As ordinary people start to have access and control over their own physiological data, they can play a more active role in the management of their health. This revolution must take place in our everyday lives, not just in the doctor's office or research lab. Users can have the experience of remote health monitoring by simply looking into the Medical Mirror. Non-contact, Automated Cardiac Pulse Measurements Using Video Imaging and Blind Source Separation was reported. A novel methodology for non-contact, automated, and motion- tolerant cardiac pulse measurements from video images based on blind source separation [1,2].

The Medical Mirror is a novel interactive interface that tracks and displays a user's heart rate in real time without the need for external sensors. The current techniques for physiological monitoring typically require users to strap on bulky sensors, chest straps or sticky electrodes. They propose a new mirror interface for real-time, contact-free measurements of heart rate without the need for external sensors. Users can have the experience of remote health monitoring by simply looking into the Medical Mirror [3].

The paper explains a novel method to measure human cardiac pulse at a distance. It is based on the information contained in the thermal signal emitted from major superficial vessels. To compute the frequency of modulation (pulse), we extract a line-based region along the vessel. Then, we apply fast Fourier transform (FFT) to individual points along this line of interest to capitalize on the pulse's thermal propagation effect. Finally, we use an adaptive estimation function on the average FFT outcome to quantify the pulse. This signal is acquired through a highly sensitive thermal imaging system [4,5].

Remote measurements of the cardiac pulse can provide comfortable physiological assessment without electrodes. This novel approach can be applied to color video recordings of the human face and is based on automatic face tracking along with blind source separation of the color channels into independent components. Using Bland-Altman and correlation analysis, we compared the cardiac pulse rate extracted from videos recorded by a basic webcam to an FDA-approved finger blood volume pulse (BVP) sensor and achieved high accuracy and correlation even in the presence of movement artifacts [6,7].

Photo plethysmography (PPG) is an electro-optic technique to measure the pulse wave of blood vessels. In this paper, the new motion artifact reduction method was proposed under the constraint of dual-wavelength measurement. We combined independent component analysis (ICA) and a signal enhancement pre-processor to separate the PPG signal from the motion artifact-contaminated measured signals. Experiments with synthetic and real data were performed to demonstrate the efficacy of the proposed algorithm.

Firstly, we describe our approach and apply it to compute heart rate measurements from video images of the human face recorded using a simple webcam. Secondly, we demonstrate how this method can tolerate motion artifacts and validate the accuracy of this approach with a FDA-approved finger blood volume pulse (BVP) measurement device. Thirdly, we show how this method can be easily extended for simultaneous heart rate measurements of multiple persons [8-10].

2. METHODOLOGY

The maintenance of health and fitness helps a person to be in the general state of health and well-being. It provides ability to perform physical actions without being tired or restless. However, the maintenance of health and fitness requires regular physical exercise with balanced diet. Due to the busy schedule these days, people tend to ignore their health and diet which results in health issues such as increase or decrease in blood glucose level, blood pressure and weight.

To overcome this ignorance and difficulties of making regular visits to the hospital we are designing a mirror which fits seamlessly into the home environment to monitor their health easily.

- The main objective of Medical Mirror is to build a device which measures the most commonly measured body parameters such as Height, Weight, Pulse-rate, Body Temperature, Blood Glucose Level and Blood Pressure.
- To design a device which will be easy to use and have a compatible user interface to display the measured parameters on the mirror itself.
- A user friendly mobile application that can record the reports of every visit. The report can be accessed whenever required.

To encourage people to keep track of their vital signs on a daily basis, we designed the Medical Mirror to provide a natural user interface. We utilized an LCD monitor with a webcam to provide an interactive display. A glass is fitted onto the frame which will acts as a reflective surface for the users in normal lighting conditions. The monitor and webcam are connected to a processor running the analysis software in real-time as shown in Fig 1. The Medical Mirror fits seamlessly into the ambient home environment, blending the data collection process into the course of our daily routines. For example, one can envision collecting health data when using the mirror for shaving, brushing teeth etc. This interface is intended to provide a convenient means for people to track their daily health with minimal effort.

3. BLOCK DIAGRAM

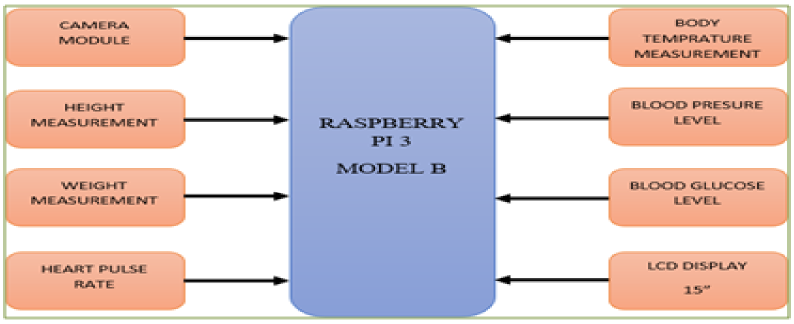

Fig 1: Block Diagram of Proposed Work "THE SMART MEDICAL MIRROR"

At the back of the mirror glass, the half portion is covered by the LCD screen and the rest half is silvered such that it appears as a mirror to the user on the front end. Whenever input is given to the LCD it displays through the glass making the information visible to the user on the front end.

3.1. Pulse Rate Measurement

Our medical mirror detects heart rate by a special algorithm using PiCamera. By combining techniques in computer vision and advanced signal processing, a person's heart rate can be computed from the optical signal reflected off the face with an error of less than three beats per minute. An overview of the general steps in our approach to measuring a user's heart rate is illustrated in Fig 2. First, an automated face tracker detects the largest face within the video feed from the PiCamera and localizes the measurement region of interest (ROI) for each video frame. The ROI is then separated into the three RGB channels and spatial averaged over all pixels to yield a red, blue and green measurement point for each frame and form the raw RGB signals. Next, the raw RGB signals are decomposed into three independent components using independent component analysis.

The power spectrum of the component containing the strongest blood volume pulse signal is then computed. Finally, the user's heart rate is quantified as the Frequency that corresponds to the highest power of the spectrum within an operational frequency band (45-240 bpm). When looking into the mirror, the user will see a box appear around his/her face and a timer will be displayed on the top corner of the box. Users will be asked to stay relatively as the timer counts down. After 15 seconds, the user's heart rate will be displayed on the mirror, allowing simultaneous visualization of his/her physical appearance and physiological state. The heart rate measurement will be updated continuously until the user looks away as shown in Fig 3.

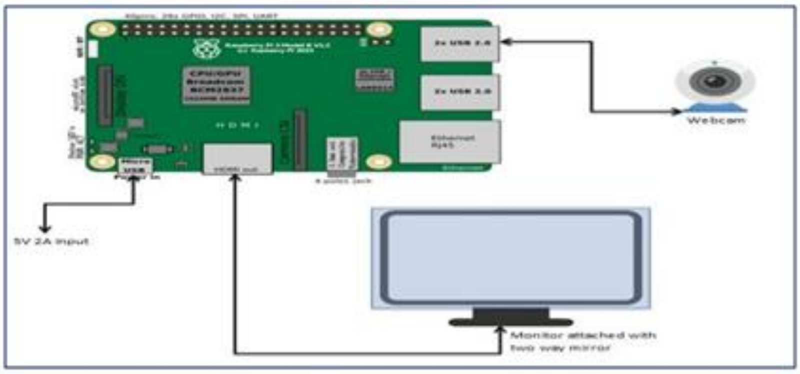

Fig 2: Interfacing of Raspberry Pi with Webcam and Mirror

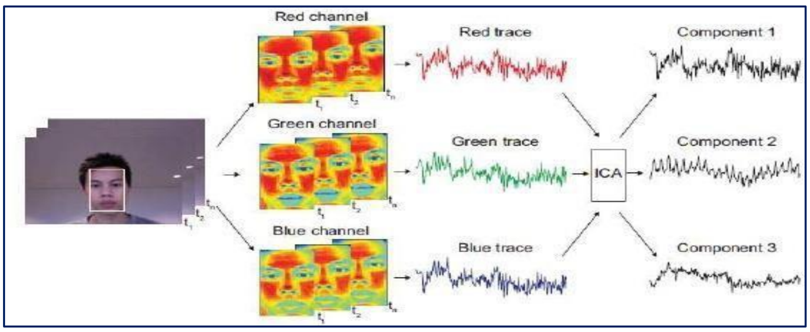

Fig 3: Pulse Rate Measurement

3.2. Height Measurement

To measure the height of a person an ultrasonic distance sensor is fixed on the ceiling below which the user stands (in front of the mirror). An Ultrasonic sensor measures the distance between the user's head and ceiling. This distance is cancelled from a predefined measurement between the ceiling and the floor (by the processor), giving the height of the user. As well as the place where the person stands a weight measuring sensor is placed beneath, which gives the weight of the person.

3.4. Body Temperature measurement

Body Temperature is measured using a Humiture Sensor Module. The module will be hanging beside the mirror and the person standing in front will have to hold the module for few seconds and the Humiture Sensor Module will detect the temperature and its output is given to the Raspberry Pi.

3.5. Blood Glucose Level measurement

A self-designed glucometer is placed on the frame of the mirror. A user has to place the strip containing the blood sample inside the glucometer to read his/her blood glucose level.

The data from all the sensors is sent to the processor Raspberry Pi to read, manipulate and display the required result on the mirror. This result will also be shown in our mobile application. The mobile application stores a year long data and allows the user to compare his/her progress by displaying in form of graphs and charts. We are building the mobile application using MIT app inventor tool. This app will be capable of identifying the user's interest of measurement and accordingly it will display the suggestions that a user can follow to improve his health. One can consult a physician directly from the app to seek his/her advice.

4. RESULTS AND DISCUSSION

A case study conducted on the proposed model is discussed in the following section. Fig 4 shows the person under test. The parameters like, height, weight, temperature and pulse rate etc obtained through the model are tabulated as in Table 1and 2.

The following electronic circuitries and sensors chosen are interface with the controller for the appropriate measurement and display.

4.5. Pulse Rate Measurement

The Fig 5 represents the heart rate monitoring circuit consists of Raspberry Pi and a webcam. The webcam is connected to the Raspberry Pi via USB port and the Raspberry Pi is in turn connected to the monitor through HDMI port. When looking into the mirror, the user will see a box appear around his/her face, after 15 seconds, the user's heart rate will be displayed on the mirror, allowing simultaneous visualization of his/her physical appearance and physiological state. The heart rate measurement will be updated continuously until the user looks away.

4.6. Height Measurement

Here is an Ultrasonic sensor used to measure the height of a person as shown in the Fig 6. Ultrasonic sensor is connected to the Raspberry Pi which measures the distance between the user's head and ceiling. This distance is cancelled from a predefined measurement between the ceiling and the floor (by the processor), giving the height of the user and the same will be displayed on the mirror.

4.7. Weight Measurement

Human body weight is measured using an ultrasonic sensor. Fig 7 shows the connection diagram of the weight measuring tool using load cells and HX711 IC module. Each load cell is capable of measuring 50 kilograms and four such load cells are used where maximum of 200 kilograms can be measured. The HX711 IC is a load amplifier which amplifies the output current obtained by the load cell and this setup is interfaced to the raspberry pi and the output weight is obtained.

4.8. Body Temperature Measurement

Temperature is measured using a Humiture Sensor Module. The sensor is connected to the Raspberry Pi and then made to hang at the side of the mirror and the person standing in front will have to hold the module for few seconds and the Humiture Sensor Module will detect the temperature and its output is given to the Raspberry Pi. This output is displayed on the mirror.

Fig 4: Person under the test using Medical Mirror

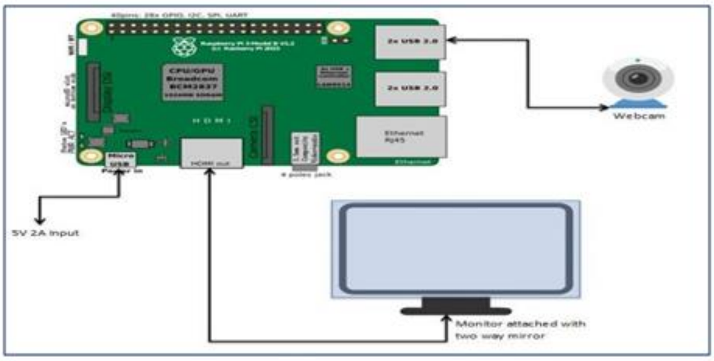

Fig 5: Pulse Rate Monitoring Circuit

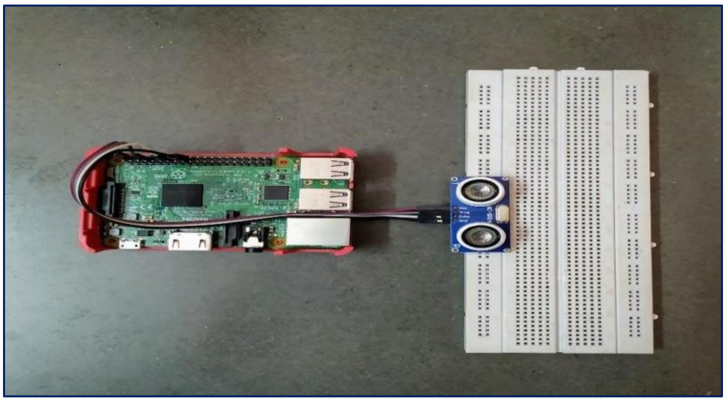

Fig 6: Height Measuring Circuit

Fig 7: Weight Measuring Circuit

Table 1: Results for Weight Measurement

Candidate	Weight (in kg)	Voltage (in V)		Current (in A)	
		SCK	DT	SCK	DT
Anjumkousar	51	3.70	3.87	0.027	0.043
Darshana	52	3.74	3.88	0.027	0.043
Manasi	81	3.50	3.57	0.022	0.025
Altaf	65	3.69	3.74	0.025	0.038

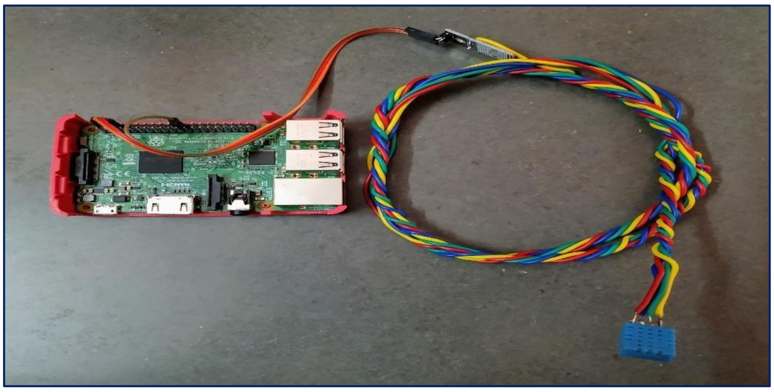

Fig 8: Body Temperature Measuring Circuit

*Results of actual measured parameters are tabulated in table shown below, which could indicate the conversion of voltage/current in to temperature.

Table 2: Results for Body Temperature Measurement

Candidate	Temperature (in F)	Voltage (in V)	Current (in A)
Anjumkousar	95.6	4.92	0.044
Darshana	92.5	4.85	0.041
Manasi	94.5	4.92	0.043
Altaf	96.3	4.96	0.043

5. ADVANTAGES AND APPLICATIONS

Advantages

i. The Medical Mirror fits seamlessly into the ambient home environment.
ii. Blending the data collection process into the course of our daily routines.
iii. The interface is intended to provide a convenient means for people to track their daily health with minimal effort.
iv. It is low cost compared with other methods.
v. An advanced approach to user's health monitoring depends upon the state of the art technology.

Applications

i. It can be used as a domestic tool.
ii. It can be placed in hospitals, clinics etc.
iii. It can be used in military camps.

6. CONCLUSION

A novel methodology for recovering the cardiac pulse rate from video recordings of the human face and implementation using a simple webcam with ambient daylight providing illumination is proposed. This is the demonstration of non contact heart rate measurements that is automated and motion-tolerant. This work also demonstrate how this approach is easily scalable for simultaneous assessment of multiple people in front of a camera. Given the low cost and widespread availability of webcams, this technology is promising for extending and improving access to medical care.

This proposed work illustrates an innovative approach to pervasive health monitoring based on state of the art technology. The Medical Mirror fits seamlessly into the ambient home environment, blending the data collection process into the course of current scenario. For example, one can envision collecting health data when using the mirror for shaving, brushing teeth etc. This interface is intended to provide a convenient means for people to track their health condition with nominal effort. Future scope of proposed work will be non-contact measurement of Blood Pressure which can be done in the same way as pulse rate is calculated.

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