Measurement of Vital Signs with Non-invasive and Wireless Sensing Technologies and Health Monitoring

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Abstract— **Medical treatment and health service is one of the basic needs for every human being. People tend to get services from physicians and clinics. Although medical service is supposed to be available and easily accessible, in the third world countries, it is rare and expensive to get this service easily everywhere and at any time. Mass people have also less idea about medical measurements. In particular in the third world countries medical practitioners are not available in remote areas. Hence, remote health and patient monitoring is important to provide the under privileged people easy health monitoring technologies and the freedom to be health-conscious. This research on remote health monitoring leads to development of technologies, which can be used by anyone for health check-up. The technologies researched here lead to making of useful devices and applications, which are very easy to use, less, expensive, and with the capability of monitoring health conditions remotely. This research includes remote health monitoring for technologies e.g. Spirometry, heart rate measurement, Body Mass Index measurement, and instant skin temperature measurement. We implemented these technologies using basic circuits and developed Android based application. The implemented hardware is interfaced wirelessly with an Android phone where the app provides the measured vital signals to the user. We evaluated our system by comparing the measured values with the values got from the standard medical devices and the results are found to be very close to accurate values.**

Index Terms—**vital sign, wireless sensor, spirometer, heart-rate monitor, body mass index calculator**

I. Introduction

The growth of health-related applications and the availability of mobile device drive the growth of mobile health monitoring. In 2010, only about 4,000 health-related applications available and now more than 20,000 health-related apps are available for mobile device. Revenues from remote patient monitoring services that use mobile networks will rise to 1.9 billion dollars globally by 2014, according to Juniper Researcher's recent report in 2011. Efforts are ongoing to explore how a broad range of technologies, and most recently mHealth technologies, can improve such health outcomes as well as generate cost savings within the health systems of low- and middle-income countries [1]. Technology integration with medical sector always has a great potential. Remote patient monitoring and health checking opens a new field of research. Mass awareness is needed for starting using these technologies. It is safe to imagine a world where the quality of life for people with chronic diseases is improved by real time monitoring of health parameters, medication, treatments, etc., through cognitive sensors network that should constantly self-adapt based on the dynamic context of the environment, individual stakeholders, and even more, compelling the interactions and relations between them [2].

Science and technology have advanced in many ways. Technology is being used as the strongest weapon for diagnosing and curing almost all of the difficult health problems. Still more people are falling for various diseases and health related problems. Unawareness and carelessness may be pointed out as the reasons and the answer to this question may come through several debates. But one thing is clear that with the development of modern technologies, people could not care less about health monitoring. As people are relying more on technologies, health monitoring should come in more handy, so that people could check up themselves as in regular basis [3].

The importance of smartphone and its usage is unavoidable these days and people are more and more getting used to this kind of technologies. Thus it is basic to use the smartphone as the main part of the technology [4]. People could easily measure heart rate, body or skin temperature, BMI ratio etc. and get suggestions based on the results. In this research, those technologies are incorporated into smart phones. The main target behind this research is to make the simple and easier monitoring tools for the under-privileged people of third world countries like Bangladesh. The basic software implementation requited for those monitoring is done here for Android based smartphones. The application is developed with connecting and implementing the necessary hardware devices to be used along with the application. These types of technologies are very easy to be used by the mass people. The experimental data is evaluated to check the accuracy and the outcome is very interesting. The monitoring results obtained by this

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application are quite close to accurate, validated by the state of the art health monitoring devices. The whole work was carried out based on the context of third world countries e.g. Bangladesh and it is realized that these type of researches are more than necessary since these areas are lagging behind in many respects. Any successful implementation that is easier and cheaper than those of related existing innovations, could be an important step towards the advancement of the under privileged countries. With improvements to this framework proposed here, this framework and application could be extended to monitor daily activities of human body, behavior and thus be used to predict human activity to provide health suggestions and to recognize human emotion to help providing better aids. The main contributions are summarized as follows:

- A low cast spirometer is designed and interfaced the with a smart phone,
- An android application and necessary interfaces are implemented to incorporate heart-rate monitoring, skin temperature monitoring with real experimental data accuracy in between 96 percent to 100 percent,
- BMI measurement and related suggestions providing with respect to standards, and
- A remote health monitoring system is proposed using this framework for the mass people of under privilege countries e.g. Bangladesh to help with the spread of mHealth and pervasive patient monitoring.

The rest of the paper is organized as follows: Section *A* focuses on the related works in the area of remote health monitoring, Section *B* explains the proposed system, Section *C* illustrates the methodologies of the proposed system, Section *D* explains the experimental evaluation of the proposed system, and finally in Section *E* we put our concluding remarks.

II. Related Works

Remote health and patient monitoring is a very important and much necessary research topic for invention and development [5]. Medical technologies have evolving very rapidly [6]. Thus various researches and implementations have been done and in progress in this field. Pervasive mHealth and e-Health systems are being developed from handheld devices to nearly invisible sensors [7]. Many pervasive [8] health and patient monitoring/sensing technologies have been developed [9], [10], [11], [12], [13], [14], [15], [16].

For example, Digital Stethoscope, which connects to mobile or laptop devices to capture and send sounds via iPhone, iPad, Android devices and Mac/PC. It can easily switch between listening to patients or playback recordings [12]. Pulse Oximeter monitors oxygen saturation in patient's blood through non-invasive wrist mounted remote sensor [13]. Glucometer is for determining the approximate concentration of glucose in the blood. A huge drop of blood, obtained by pricking the skin with a lancet, is placed on a disposable test strip that the meter reads and uses to calculate the blood glucose level. The meter then displays the glucose level [14]. ECG Sensor is routinely used to assess the electrical and muscular functions of the heart, which comes as in various wearable devices.

Heart Beat Rate and Oxygen Saturation in Blood Detection come as Smart Wrist Worn Device for Vital Signs and Motor Activity Monitoring. Smart Wheelchair/Walker is developed based on use of microwave Doppler radar sensors for Vital Signs and Daily Activity Monitoring [9]. Footwear-Based Wearable Sensors for Physical Activity Monitoring, also known as SmartShoe, which is capable of very accurate recognition of most common postures and activities while being minimally intrusive to the subject. SmartShoe relies on capturing information from patterns of heel acceleration and plantar pressure to differentiate weight-bearing and non-weight-bearing activities (such as for example, sitting and standing, walking/jogging and cycling) [10]. Smart Home Monitoring system for elderly people, the technology assisted home monitoring system integrated with sensing units and intelligent software identify daily activity pattern and irregular situation of elderly in real time [16]. Large-Area Sensor System Underneath the Floor for Ambient Assisted Living Applications known as SensFloor has a wide use. The SensFloor System enables a variety of different applications in the domain of Ambient Assisted Living (AAL) like fall detection, activity monitoring, energy savings, control of automatic doors, intrusion alarm and access control. Presence detection and self-test capabilities are additional features valuable in particular for security applications [17]. Some other technologies are- Continuous-Wave Photoacoustic-Based Sensor for the Detection of Aqueous Glucose, Non-invasive and Continuous Glycemia Sensing [18], Automatic Sensing of Speech Activity and Correlation with Mood Changes [19], and Universal Wireless Device for Biomedical Signals Recording [20].

Many research and development works have been done in this area as stated above. There are various innovative technologies implemented for health and patient monitoring. The research done in this paper mostly focuses upon developing low cost and pervasive health monitoring technologies especially for third world countries, for example, Bangladesh. Unlike other researches in health monitoring, this paper tries to implement technologies with locally available and low cost apparatus.

III. Proposed System

This research includes remote health monitoring technologies using Spirometry, heart rate monitoring, instant skin temperature measurement, and Body Mass Index measurement technologies. The research is conducted based on the usefulness, non-invasive characteristics, user-experience and low-cost devices to make it suitable for everyday use for all. Theoretical procedures have been done first on how to implement these types of technologies. Then the software and hardware implementations are done using smartphone based application for users. Then the data collection and experiments leads to the evaluation of the technologies as well as the implemented software and devices. Thus a complete smartphone based application is implemented with these technologies for health monitoring along with required hardware devices. The application is implemented in such a way that it can show results to the user and send data to the server, so that a user or a patient's condition could easily be monitored remotely. The architecture of such a system is shown in Fig. 1.

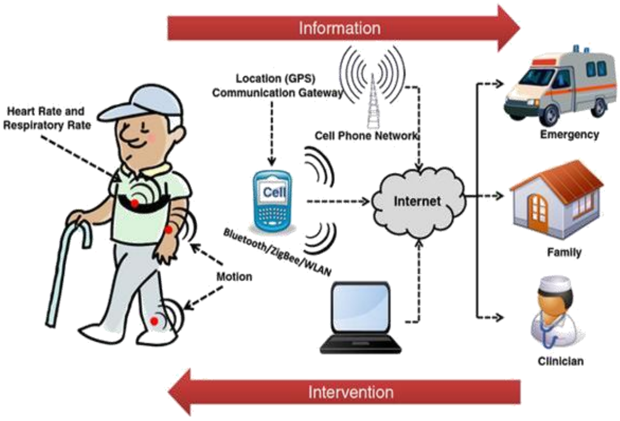

Figure 1. Remote health monitoring systems.

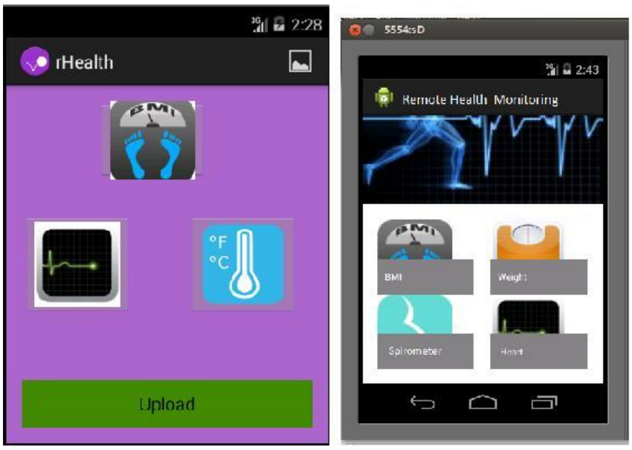

Figure 2. Our Android app interface.

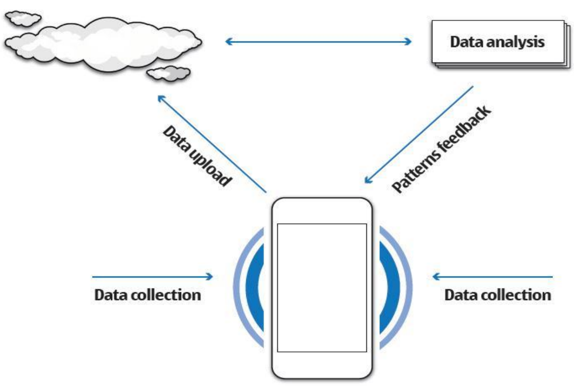

Figure 3. Data Analysis.

We have explained the detail description of the technologies that were proposed including introduction, system setup, circuit connection, both software and hardware implementation, data collection, experimental results and findings. A complete smartphone based app is developed for all these remote health-monitoring technologies (Fig. 2). Patient data will be uploaded to server via smartphone app to be monitored and analyzed. The data collection and analysis cycle is shown (Fig. 3). The data is collected from the sensor devices and uploaded to the cloud system where the data is analyzed. Finally the feedback is sent to the end user.

A. Spirometer

A spirometer (Fig. 4) is an apparatus for measuring the volume of air inspired and expired by the lungs. A spirometer measures ventilation, the movement of air into and out of the lungs. The Spirogram will identify two different types of abnormal ventilation patterns, obstructive and restrictive. There are various types of spirometers those use a number of different methods for measurement (pressure transducers, ultrasonic, water gauge). Spirometer is used for testing of lungs diseases e.g. asthma, bronchitis, emphysema [21].

Figure 4. Spirometer.

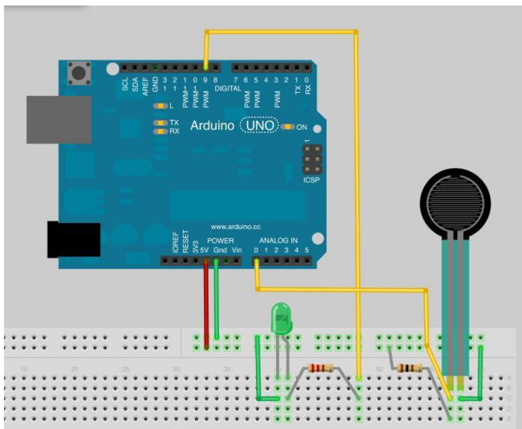

Figure 5. Pressure sensor circuit.

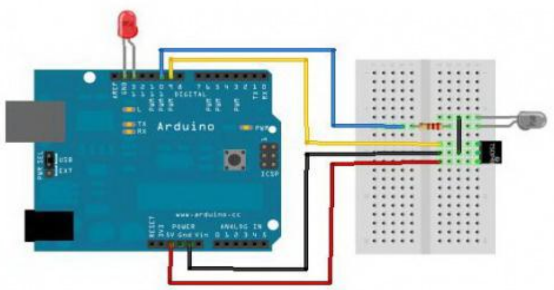

Figure 6. IR LED and receiver circuit.

System Setup: A low cost spirometer designed and connected to a smartphone via Arduino and HC-05 Bluetooth module to send data. The idea was to use pressure sensor of transducer (Fig. 5) inside the blowing pipe to get the volume [22] and IR LED and IR receiver sensors (Fig. 6) to get the rpm of the highly sensible fan inside the pipe [23]. We will incorporate the full implementation of spirometer in our future work.

Data Collection: The user needs to blow air several times through the air. Then the equations to determine the rpm of the fan are shown in Fig. 7.

- $U = \frac{\pi d_1 N}{60}$ $\quad d_1 = \text{diameter of fan}$
- $\tan\theta = \frac{v_{f1}}{v_{w1}}$ $\quad N = \text{rpm of fan}$
- $\tan\beta = \frac{v_{f1}}{v_{w1} - U}$ $\quad v_{f1} = \textit{flow velocity}$
- $\Phi = \pi d_1 b_1 v_{f1}$ $\quad v_{w1} = \textit{wheel velocity}$, $b_1 = \text{thickness of fan}$

Figure 7. Formulation to determine the rpm of the fan of the spirometer.

Skin Temperature Sensor.

Body temperature is one of the four main vital signs that must be monitored of a patient. Body temperature should be measured and recorded regularly with precision, consistency and diligence. Normal human body temperature depends upon the place in the body at which the measurement is made, the time of day, as well as the activity level of the person. General temperature under the tongue is near 36 degree Celsius or 98.2 Fahrenheit. The body temperature of a healthy person varies during the day by about 0.5 degree Celsius (0.9 Fahrenheit) with lower temperatures in the morning and higher temperatures in the late afternoon and evening, as the body's needs and activities change. Other circumstances also affect the body's temperature. The core body temperature of an individual tends to have the lowest value in the second half of the sleep cycle. The body temperature also changes when a person is hungry, sleepy, sick, or cold. Core body temperature is the operating temperature of an organism, specifically in deep structures of the body such as the liver, in comparison to temperatures of peripheral tissues [24].

The skin is the largest organ in the human body. It protects the body from the sun's rays. It also keeps body temperature normal (37 degree Celsius) [25]. Skin temperature depends on air temperature and time

spent in that environment. Such weather factors as wind chill and humidity cause changes in skin temperature. The normal temperature of skin is about 33 degree Celsius or 91 Fahrenheit. The flow of energy to and from the skin determines our sense of hot and cold. Heat flows from higher to lower temperature, so the human skin will not drop below that of surrounding air, regardless of wind. If a person was to be in a warm room and his skin temperature was cooler than the air, his skin temperature would rise. The opposite would happen in a cold room and warm skin temperature. The person's temperature would decrease. Humans fight air temperature by becoming warm or cold. When warm, they sweat. When cold, they get chills. And at the same time, different parts of the body can have different skin temperatures [26], [27].

System Setup: IR temperature sensor is used which passes voltage through Arduino analog pin and then voltage is converted to temperature (Fig. 8). Then using HC-05 Bluetooth module, this data is transferred to the connected phone and shows in the app.

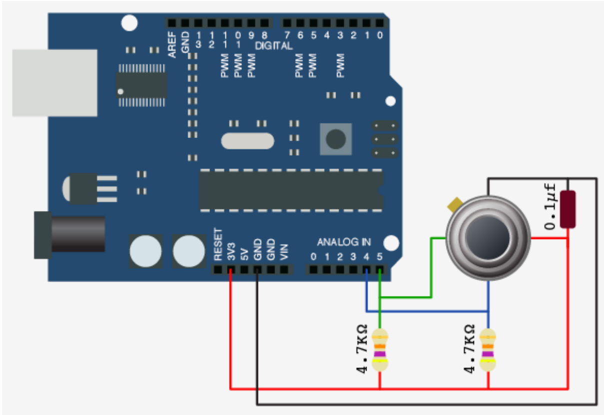

Figure 8. Skin temperature sensor circuit.

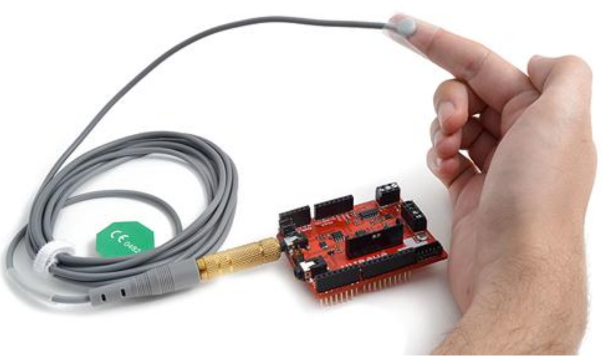

Figure 9. Skin temperature measurement.

Data Collection: To collect data, the user needs to place the skin almost on top of the IR temperature sensor without direct contact (Fig. 9). The equations to measure the temperature using the infrared temperature sensor are as below:

T = log(((10240000/RawADC) - 10000))
T = 1 / (0.001129148 + (0.000234125 + (0.0000000876741 * T * T)) * T)

T = T - 273.15 (Convert Kelvin to Celsius)

T= (T * 9.0)/ 5.0 + 32.0 (Celsius to Fahrenheit) where,
T = Temperature and

RawADC = Raw voltage read from sensor through Arduino analog port. Then the data collected through sensor is passed through Arduino and then to the smartphone via Bluetooth. Then the app shows the temperature at instant (Fig. 10).

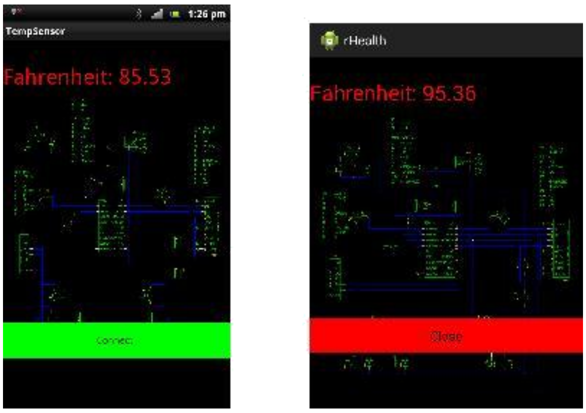

Figure 10. Skin Temperature UI.

B. *Heart Rate Monitor.*

Heart rate/pulse is the rate of heartbeats per second, which changes due to different physical activities. Placing fingertip upon camera of smartphone calculates pulse by image processing.

Implementation: The App uses the PreviewCallback mechanism to grab the latest image from the preview frame. It then processes the YUV420SP data and pulls out all the red pixel values. It uses data smoothing in an Integer array to figure out the average red pixel value in the image. Once it figures out the average it determines a heart beat when the average red pixel value in the latest image is greater than the smoothed average. The App will collect data in ten second chunks and add the beats per minute to another Integer array, which is used to smooth the beats per minute data.

Data Collection: All you have to do is open the rHealth App's Heart Rate Monitor option and then hold the tip of your index finger over the camera lens of your phone. The entire camera preview image should be red with a lighter area where the tip of your finger is touching. Do not press too hard or you will cut off circulation, which will result in an inaccurate reading (Fig. 11).

After a second or two, user should see the Android icon on the top of the screen start to flash red when it senses a heartbeat. After ten seconds it will compute your heart rate and update the number next to the Android icon. It will take between ten and thirty seconds to get an accurate heart rate.

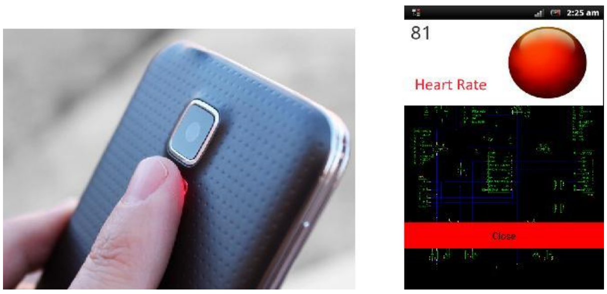

Figure 11. Heart rate measuring.

C. *BMI Calculator.*

BMI is Body Mass Index which is a proportion of height and square weight. BMI range tells whether a person should concern about food taken and weight controlling and mainte-nance. BMI range varies for children to adult person or men and women and in some special cases like pregnancy etc [28].

Data Collection: BMI calculator needs manual inputs of data for checking condition and then the app shows the results (Fig. 12). BMI output predicts the symptoms, which have the possibility to occur, and suggests how to maintain good BMI.

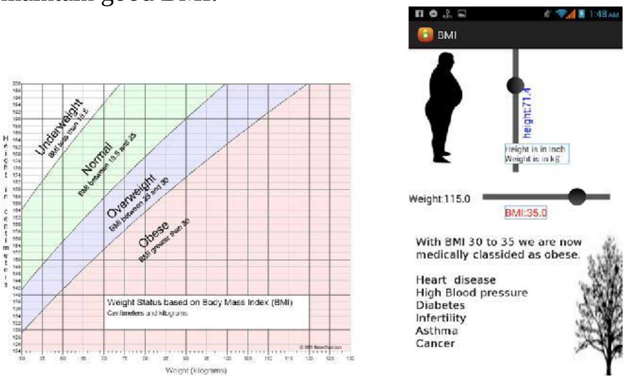

Figure 12. BMI calculation.

IV. EXPERIMENTS

The integrated smartphone based application is experimented with real-case measurement from different users. The application needs communicating to devices developed for measurement. Since the sensors/devices are talking to application running in android smartphone through wireless Bluetooth signals, it is very easy to collect data with this developed technology. We measured the BMI data, heart rates, and instant skin temperature by the mobile app and the associated circuitry. We also measure the heart rates and instant temperature using standard digital heart rate miter and digital thermo meter respectively. Finally we compare the two data sets one obtained from our devices and the other obtained from standard devices. We will incorporate the spirometer evaluation in our future work.

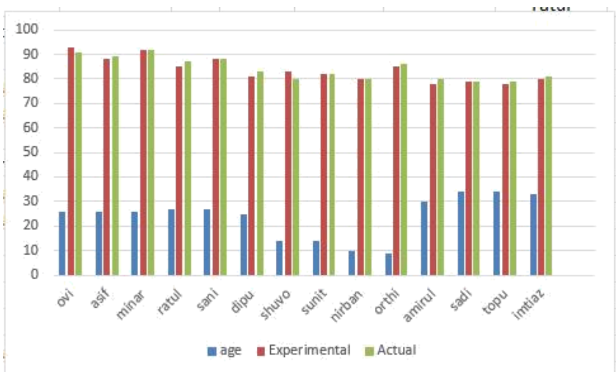

Figure 13. Evaluation of heart rate measurements.

A. *Heart Rate Monitor*

Heart rate measured by the application developed here proves to be 96 percent to 100 percent accurate with the actual data. Since our heart rate application is developed using the standard heart rate monitor PreviewCallback mechanism, the careful measurement by our application provides the accurate results in most of the measurements. A glimpse of the comparison between experimental and actual heart rate measurement is shown in Fig. 13. In this figure, each person has three bars presenting age, experimental, and actual values respectively. For example, when Ovi presses his index finger on the camera with flash of his smartphone's back while running our application to detect the heart rate, the application provides the experimental value of 93 after a 10 seconds press where the actual measured value is 91. The graph shows the data for fourteen persons and it is clearly that the experimental evaluation of the hear rates of these persons are very close to the actual heart rates.

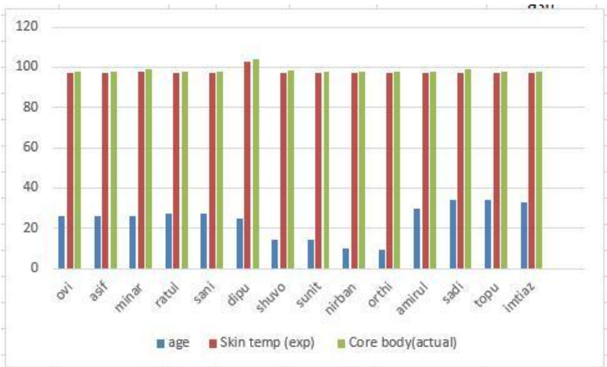

Figure 14. Evaluation of skin temperature measurements.

B. Instant Skin Temperature Measurement.

The instant skin temperature measurement device developed for this research gives surprisingly close to accurate results. It always gives skin temperature result 1 degree less than the actual core body temperature as presented in Fig. 14. For Instance, when Ovi measured his skin temperature by the sensor integrated with this application, it gave output of 97 degree Fahrenheit and then actual core body temperature was measured 98 degree Fahrenheit by the standard digital thermometer. The graph presents the data for fourteen persons and the experimental measurement is almost 90% accurate to actual measurement.

C. BMI Calculator.

For BMI calculation and suggestion, the standard BMI ratio measurement system is followed. This BMI ratio if calculated from the ratio of body weight and square of body height. The reference BMI indicator is checked against the BMI graph as presented in Fig. 12. If BMI ratio of a person is found less than 18.5, then that person is considered underweight; for normal weight, the BMI range falls in the range of 18.5 to 24.9; for overweight the BMI range falls in the range of 25 to 29.9 and for obesity the BMI range falls in the range of 30 or greater. The computed BMI indices of seventeen persons are shown for in Fig. 15. For a body height of 5.6 feet and weight of 63 kg, Ovi is given BMI ratio 22.3 by this application after providing inputs. Here, BMI can be calculated by the ratio of weight in pounds and the square of the height in feet/inches, or by weight in kilograms and the square of height in meters. For having 22.3 as his body mass index, Ovi falls in the normal weight category.

Name	height(feet)	weight-kg	BMI	Comment
ovi	5.6	63	22.3	Normal weight
asif	5.6	59	21	normal
minar	5.5	62	22.7	normal
ratul	5.11	70	21.5	normal
sani	4.11	80	35.6	over weight
dipu	4.2	65	40.3	Obesity
shuvo	5.5	54	19.2	Normal weight
sunit	4.3	40	23.8	Normal weight
nirban	4.1	45	29	Overweight
orthi	4.3	31	18.5	under weight
amirul	4.9	52	24.8	Normal weight
sadi	5.5	57	20.3	Normal weight
Jamil	5.6	90	32	Obesity
adnan	5.9	110	33.8	Obesity
topu	5.8	88	29.5	Overweight
imtiaz	5.2	75	21	normal
hasan	5.6	55	19.6	Normal weight

Figure 15. Evaluation of BMI measurements.

V. CONCLUSION

This paper presents an Android based application with rele-vant devices that incorporates spirometer, heart rate monitoring system, skin temperature measuring system, and BMI mea-surement and suggestion system. The application along with the developed devices i.e. the framework measures the vital signs with non invasive and wireless sensing technologies. The application and related measurement system are of very low cost and the system can be used to monitor patients remotely that can be helpful for the under privileged people of third world countries, e.g. Bangladesh. We have evaluated our system and verified the measure values of our system with the values obtained from standard medical devices and the the results are 96% to 100% accurate for heart rate monitoring system and 99% accurate for skin temperature measurement system.

While conducting this research, there were some limitations and obstacles regarding time, device, cost, sensors, availability, experience etc. For instance, the low cost spirometer needs sensible fan to accurately read data. Without the proper fan the hardware implementation got stuck at a point. And heart rate measurement can be updated with suitable information. Skin temperature sensor with hygrometer sensor can measure body climate under cloth. which can be used to recognize user activity and physical conditions [9]. Measuring skin and core body temperature alone is enough to suggest about many symptoms e.g. heat stroke [15]. The sensors could be also used to recognize human emotions. BMI for special cases can be implemented in future for pregnancy, weight tracker etc. It will analyze the BMI data of users and give predictions of their health conditions. Then the app will provide suggestions about how to maintain a good BMI range as well.

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REFERENCES

[1] [Online]. Available: M Health, Wikipedia. http://en.wikipedia.org/wiki/MHealth, 2016.

[2] Postolache, Gabriela, Pedro Silva Girão, and Octavian Postolache. "Requirements and Barriers to Pervasive Health Adoption." Pervasive and Mobile Sensing and Computing for Healthcare. Springer Berlin Heidelberg, 2013. 315-359.

[3] J. P. Black, et al. "Pervasive computing in health care: Smart spaces and enterprise information systems," in *Proc. MobiSys 2004 Workshop on Context Awareness*, 2004.

[4] S. Robert, "Utilizing social media, mobile devices and sensors for consumer health communication: A framework for categorizing emerging technologies and techniques," *Pervasive and Mobile Sensing and Computing for Healthcare*, Springer Berlin Heidelberg, 2013, pp. 233-249.

[5] F. Mircea and G. I. Mihalas, "EHR ecosystem," *Pervasive and Mobile Sensing and Computing for Healthcare*, Springer Berlin Heidelberg, 2013, pp. 251-268.

[6] S. Silvia, et al. "The potential of pervasive sensors and computing for positive technology: The interreality paradigm," *Pervasive and Mobile Sensing and Computing for Healthcare*, Springer Berlin Heidelberg, 2013, pp. 207-232.

[7] J. L. Ausín, et al. "From handheld devices to near-invisible sensors: The road to pervasive e-health," *Pervasive and Mobile Sensing and Computing for Healthcare*, Springer Berlin Heidelberg, 2013, pp. 135-156.

[8] M. Subhas and O. A. Postolache, eds. "Pervasive and mobile sensing and computing for healthcare: Technological and social issues," *Springer Science & Business Media*, vol. 2, 2012.

[9] Postolache, Octavian, P. S. Girão, and G. Postolache, "Pervasive sensing and m-health: Vital signs and daily activity monitoring," *Pervasive and Mobile Sensing and Computing for Healthcare*, Springer Berlin Heidelberg, 2013, pp. 1-49.

[10] E. Sazonov, "Footwear-based wearable sensors for physical activity monitoring," *Pervasive and Mobile Sensing and Computing for Healthcare*, Springer Berlin Heidelberg, 2013, pp. 89-110.

[11] W. Nilmini, "Pervasive computing and healthcare," *Pervasive Health Knowledge Management*, Springer New York, 2013, pp. 7-13.

[12] One digital stethoscope. [Online]. Available: http://www.thinklabs.com/one-digital-stethoscope, 2016.

[13] Pulse Oximetry. [Online]. Wikipedia. Available: https://en.wikipedia.org/wiki/Pulse-oximetry, 2016.

[14] Glucose meter. [Online]. Wikipedia. Available: https://en.wikipedia.org/wiki/Glucose-meter, 2016.

[15] S. Chika, "Wireless sensing system for healthcare monitoring physiological state and recognizing behavior in daily life," pervasive and mobile sensing and computing for healthcare, Springer Berlin Heidelberg, 2013. pp. 175-193.

[16] S. C. Mukhopadhyay, N. K. Suryadevara, and R. K. Rayudu, "Are technologies assisted homes safer for the elderly?" *Pervasive and Mobile Sensing and Computing for Healthcare*, Springer Berlin Heidelberg, 2013, pp. 51-68.

[17] C. Lauterbach, A. Steinhage, and A. Techmer, "A large-area sensor system underneath the floor for ambient assisted living applications," *Future-Shape GmbH*, Hoehenkirchen-Siegertsbrunn, Germany. 2013.

[18] C. Lauterbach, A. Steinhage, and A. Techmer, "A large-area sensor system underneath the floor for ambient assisted living applications," *Pervasive and Mobile Sensing and Computing for Healthcare*, Springer Berlin Heidelberg, 2013, pp. 69-87.

[19] M. Aleksandar, V. Osmani, and O. Mayora, "Automatic sensing of speech activity and correlation with mood changes," *Pervasive and Mobile Sensing and Computing for Healthcare*, Springer Berlin Heidelberg, 2013, pp. 195-205.

[20] D. Grzechca, D. Komorowski, and S. Pietraszek, "A universal wireless device for biomedical signals recording," *Pervasive and Mobile Sensing and Computing for Healthcare*, Springer Berlin Heidelberg, 2013, pp. 157-174.

[21] Spirometer. [Online]. Available: Wikipedia. http://en.wikipedia.org/wiki/Spirometer, 2016.

[22] Olesen, Bjarne W, "Thermal comfort," *Technical Review 2*, 1982, vol, pp. 3-37.

[23] Islam, M. Quamrul, and A. K. M. S. Islam, "Fluid mechanics Laboratory Practice," World University Service press, 1993, pp. 984-518.

[24] A. Farzana, "The physics factbook," *Temperature of a Healthy Human (Body Temperature)*, 2001.

[25] H. Yvon and E. F. J. Ring, "Human body temperature: Its measurement and regulation," *Springer Science & Business Media*, 2013.

[26] Infrared sensors for non-contact temperature measurement. (2016). [Online]. Available: http://www.micro-epsilon.com/temperature-sensors/index.html

[27] T. Colin, et al. "Conventional and novel body temperature measurement during rest and exercise induced hyperthermia," *Journal of Thermal Biology*, 2016.

[28] Garrouste-Orgeas, Maité, et al. "Body mass index," *Intensive Care Medicine*, vol. 30, no. 3, pp. 437-443, 2004.

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