Interactive Mobile Health Monitoring System

Varsha Wahane
Research Scholar,
Sant Gadge Baba Amravati University
Amravati

Dr.P.V. Ingole
Prof.Ram Meghe Institute of Technology and Research
Badnera- Amravati,
India

***Abstract*—Health monitoring system is an active application in pervasive and ubiquitous computing. It is an application of mobile computing technology for enhancing communication among health care workers, physicians and patients with a view to provide better health care system. Recent elevation in sensors, wireless communication and low-power integrated circuits has empowered the design of pocket size, light weight, low-cost, and interactive bio-sensor nodes. These nodes are seamlessly integrated for mobile health monitoring using wireless body area network which can sense, process and communicate one or more vital parameters.**

The proposed system, through mobile device can provide patient health parameters (such as temperature, heart rate and ECG) to medical server, care taker and to medical practitioner based on the biomedical and environmental data collected by deployed sensors. In this system, multiple physiological parameters are incorporated for monitoring as against one or two parameters in legacy system. In this paper hardware, software and implementation of system is discussed whereas the focus is on authentication, power consumption, accuracy in transmission of health parameters to medical server.

Keywords*—Biomedical sensors; Wireless body area network; mobile device and microcontroller

I. INTRODUCTION

The citizens aged 65 will almost double by 2030 and as they age, [24] various ailments in that age group prevail. Patients in this age group generally prefer to be at home rather than getting admitted to the hospital. If affordable healthcare services are provided for patients who prefer to stay at home and still being monitored due to an ailment through which they are undergoing, this will not only be beneficial to the patients but to the country as well, as it will decrease the load on health care systems. There are number of reasons for their decision, such as need for security, privacy and accessibility. So, it is the time to overcome the bodily limitations of hospitals and instead of bringing patients to the hospital extending patient monitoring facilities at home will benefit. The solution to this is the "Mobile Health Monitoring System".

The fundamental driving component for the mobile health monitoring system is "Pervasive Computing" [24] also known as pervasive health care. The Embedded systems and handhelds devices avail information access to anyone, anytime and anywhere. Number of citizens are participating in design, development and evaluating mobile technologies for customized health care. People are usually advised to visit their doctors periodically for repetitive medical check-ups for common health issues such as diabetes, irregular heartbeat, high blood pressure and obesity. A solution is proposed to provide a smarter and more personalized service to save time, cost and aspire personal health care.

The proposed Interactive Mobile Health Monitoring System indicates promise in terms of Telemedicine and Tele-home-care. It uses biometric sensors to monitor patient's health status in real time. The proposed system incorporates sensors for temperature detection, heart rate and ECG along with Wearable Body Area Network which sense and collect data from patients, mines the data and sends real time physiological data to Medical server, medical practitioner and also delivers comments to patients' mobile device for corrective action.

The framework of the paper is as follows: a short description of previous work in section 2, architecture of the system in section 3, Design and implementation of the proposed system in section 4, Characteristics of the system in section 5, Impact on society in section 6, System testing and Evaluation in section 7, Result in section 8, Conclusion and Future Scope in section 9.

II. PREVIOUS WORK

In 2007 [7] describes Open issues, challenges, requirements, network infrastructures for the number of pervasive health care applications. A dedicated research program [18] to design, develop and evaluate pervasive computer technologies to help citizens to participate in taking care of their personal health and also health professionals to treat patients in modern and smart way.

P. Szakacs-Simon, S.A. Moraru and L. Perniu [3] presents health monitoring system to detect and monitor abnormal heart rate and blood oxygen level to avoid emergency situations and keep updating patient about corrective measure. Whereas the proposed Interactive Mobile Health Monitoring System along with heart rate monitors temperature and an ECG signal also.

Dennis Joe Harmah, Kathirvelu D [4] Developed PC and Tablet based miniaturized ECG monitoring system for preliminary detection of heart disease. The system is implemented using programmable single chip microcontroller to indicate the heart condition by analysing bio signals. Health professionals are prompted with alerts if any cardiac abnormality is observed. Whereas the proposed system can transmit the same ECG signal to Medical Server as well as on Doctor's mobile along with real time heart rate and temperature of patient.

Dheerendra S. Gangwar [5] describes an exemplar model for keeping track of fitness and cardiovascular activity using various IEEE standards such as Body Area Network (IEEE 802.15.6), Cardiovascular Activity and Fitness Monitor (IEEE 11073-10441) and ZigBee (IEEE 802.15.4) which he tries to justify that this will lead to development of cost effective devices. Whereas the proposed implemented model shows that an ECG is transmitted wirelessly, precisely and cost effectively to Medical Server and to Doctor's Mobile.

III. Architecture of System

An Interactive Mobile Health Monitoring System is proposed to gather patient's physiological data (temperature, ECG, oxygen saturation and heart beats) through biosensors. The data is sensed by the sensor network and collected data is transmitted to a patient's cell phone, PDA or to PC which in turn is transmitted to Medical Server.

A. General Block Diagram of proposed system:

The proposed Block diagram mainly comprises of three main blocks:

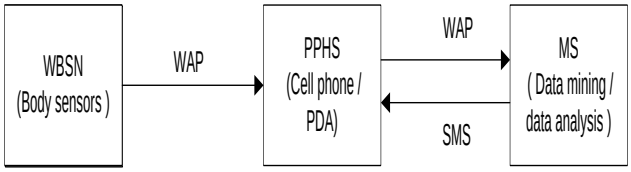

Fig. 1. Block Diagram of proposed system

1) WBSN (Wearable Body Sensor Network): It is a network of wearable biosensors on the patient's body. In the proposed system, the temperature sensor used is LM 35, heart rate sensor, CO2 sensor and ECG sensors AD624 which senses temperature, heart rate, environmental CO2 and ECG from patient's body, then these signals are processed by microcontroller ARM7 which acts as a central controller of WBSN and through Bluetooth send the processed data to PPHS (Patient's Personal Home Server).

2) PPHS (Patient's Personal Home Server): PPHS is nothing but an android mobile device employed to gather data from WBSN such as real time temperature, heart rate, and environmental CO2 and ECG data and then forward this data to the Medical Server (MS) using GPRS. PPHS can decide whether to forward this information to MS or not. Thus, PPHS initiates the service request which will be responded by MS.

3) MS (Medical Server): It accepts real time temperature, heart rate, and environmental CO2 and ECG data from PPHS. At periodic intervals or uninterruptedly doctor can investigate parameters and ECG signals. In addition, MS provide the log files to compare and verify the irregularities in the patient's health status at different time intervals, which in turn helps doctor to update patient with instant messages. But if some patient is at high jeopardy, it can notify the ambulatory service and arrange the medical assistance.

The heart of this proposal is the Medical Server (MS). The Proposed interactive mobile health monitoring system will monitor the temperature, oxygen saturation, heart beats and ECG. Why these parameters need to be monitored is described in detail with possible situations below:

Patient's vital parameters such as temperature, heart rate, etc. are continuously monitored in an intensive care unit. Generally, patients get well and return home from the hospital but even after discharge, they require attention to avoid return of disease or other contagious diseases which can be fatal. So, in many cases, patients are strongly recommended to be under observation and rest for some time. In these cases, an interactive mobile health monitoring system is very useful.

Patient's medical history can be observed by the doctor date wise, event wise etc. using the network of sensors and the Medical server.

PPHS can transmit all vital parameters continuously including ECG. Suppose a patient has returned home after cardiac surgery and is suffering from cardiac arrhythmia which leads to irregular variations in the heart signal that may occur once or twice a day. So, in this situation if PPHS is continuously transmitting the ECG data so variations in ECG signal is instantly noticed and alerts will be issued.

Hardware and software requirement:

The major components of hardware and software [25] are sensors, 32-bit ARM7 TDMI-S, LPC 2148 flash memory, android based handset, 802.15.1 Bluetooth, Eclipse, KEIL and VB.

IV. Design and Implementation of Proposed System

The proposed Interactive Mobile Health Monitoring System uses small wearable sensors such as temperature sensor, heart rate sensor, CO_2 sensor and ECG sensor for sensing critical physiological parameters. These signals are sensed by sensors and processed by ARM7. The processed data is transmitted to PPHS using Bluetooth and then to Medical Server via GPRS where parameter analysis and diagnosis are done by health professional. Further during analysis if some deviations are encountered, doctor can direct instant messages or advice as corrective measures to the patient.

The schematic representation of proposed system is as shown in figure.

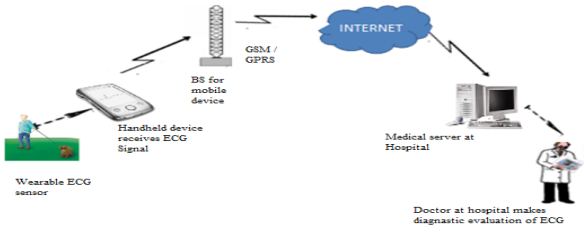

Fig. 2. Schematic representation of the proposed system

The patient's data is communicated to doctors or to hospital using the proposed system in following steps

Step1. Biological parameters are sensed and collected by sensors.

Step2. Collected data is processed by ARM7 controller.

Step3. Through Bluetooth processed data is communicated to Medical Server using GPRS through PPHS.

Step4. Medical Server analyse the collected data and provide feedback to the patient on his/her cell phone, PDA or PC regarding abnormalities of physical parameters.

B. Sensors used in the proposed system:

1) Temperature sensor:

LM35 a precision centigrade temperature sensor, is used to record the patient's body temperature. Output is directly proportional to Celsius temperature. It is a three terminal IC having input, output and ground pin. Its output voltage is linearly proportional to Celsius. The output of this sensor is connected to the P0.28 of ARM7.

2) Heart beat sensor:

It is observed that cardiac arrest is responsible for increasing number of deaths in the world; therefore, the heartbeat needs to be monitored constantly for the patients with cardiac ailment's history. As per WHO (World Health Organization) standard 60 to 135 is the normal heart beat range whereas heart beats above 145 or below 55 may be fatal. The heart beat is continuously sensed by sensor and if the heartbeat deviates from its standard range, it will take the intended action determined by the system to inform the doctors and to obtain the expert's advice in the prevailing circumstances.

Heart beat sensor LM358 IC and its basic principle and working:

The sensor with light detector and LED which needs to be super bright as the emitted light must pass through the finger and to be detected at another end. The principle used here is the opacity of finger changes as the blood flow in finger veins which in turn indicates variations in heart beats. These variations are detected in terms of electrical pulse, amplified to the required signal level. The output of heart beat sensor is connected to P 0.2 of ARM7 processor.

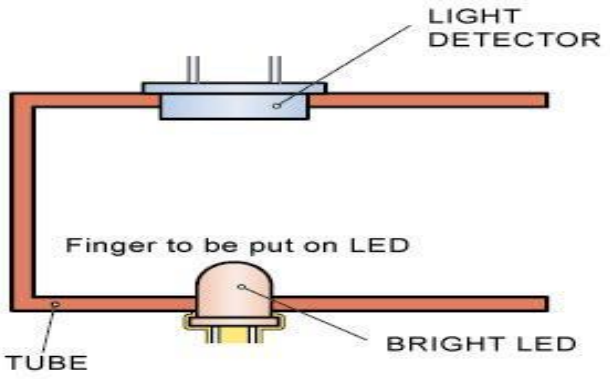

Fig. 3. Heart beat sensor

3) ECG (Electrocardiograph) sensor:

An ECG records the heart's rhythm and activity on a moving strip of paper or a line on a screen. In the medical tests the ECG deviation of actual verses normal patterns reflects heart condition.

ECG sensor:

For ECG sensor [25], a precision instrumentation amplifier an IC AD624 is used. It is high precision, low noise amplifier which is predominantly considered for use with low level transducer. Thus, it is ideally suitable for high resolution data acquisition system.

ECG sensor circuit:

ECG is the electrical potential [25] generated by heart appears throughout the body and on its surface. The potential difference is predetermined by placing electrodes on surface of body and measuring the voltage between them and then applied to the instrumentation amplifier as these voltages are very low level signals. After amplification, the output of the instrumentation amplifier is applied to the low pass filter. The output of the filter is connected to P0.29 of ARM7.

ECG measurement:

It uses 3 leads for ECG measurements. The most commonly used electrode placement scheme is

(a) Lead I: Right arm Left arm, (b) Lead II: Right arm left leg, (c) Lead III: Left arm Left leg

From ECG measurement, various features of the heart's depolarization can be calculated. Thus, ECG waveforms are referred to get pulse rate, QRS detection, P-wave and T-wave. Abnormalities in the wave pattern, helps health professional for diagnosis of cardiac problems.

V. Characteristics of System

1) Simple: The system architecture of Interactive Mobile Health Monitoring System is simple as only the biosensors need to be worn by the patient.

2) Cost: The proposed system is cost effective. WBSN requires some low-cost sensors and communication from WBSN to PPHS is also very cheap due to the use of low cost Bluetooth hardware.MS will incur some cost as it serves large number of patients. But still it is cost effective as numbers of patients are served by a single MS.

3) Security: Security is the main concern in our proposed system and without which the system is incomplete. It is provided by public key cryptography. As the patients' data is confidential and important, as well as large amount of data need to be transmitted at four different points in a system (such as WBSN, PPHS, MS and on doctor's mobile). So to protect the patient's data from security vulnerabilities the data is transmitted in encrypted form.

4) Flexible communication: The proposed system uses flexible communication protocol such as Bluetooth, internet, EDGE or GPRS. WBSN can communicate with PPHS (patient's mobile) using Bluetooth which in turn communicate with MS through internet/GPRS/EDGE. So, as the system is

supported by number of alternative ways of communication and this makes communication simple and flexible.

5) Capability to deliver the status of patient and predict spread of disease:

The proposed system delivers the status of patient and helps in predicting the spread of contagious disease in a particular locality.

VI. Impact on Society

Mobile health monitoring is not a new concept for developed countries. But, in developed countries Medical Servers are only for data storage whereas our system provides alerts and real time feedback to patients and doctors. For this development, all the existing central storage server can be replaced easily by our MS i.e. their central Medical Server's data needs to be migrated to our MS. Thus, the proposed system can aid physician and specialists for better treatment of patients as the whole medical data and treatment history is stored in MS. The system helps patient by providing continuous health monitoring facility anytime and anywhere**.**

VII. System Testing and Evaluation

The system evaluation is carried out through cognitive walkthrough and evaluation of measured data by comparing mean and standard deviation of proposed system against standard device.

A cognitive walkthrough strategy [28] which includes a group of evaluators to inspect a user interface through a set of tasks and assess its understand-ability and ease of learning. To evaluate our system, we have followed this strategy

1) Who is the user of the system? The patient of different age, literate, illiterate both males and females.

What health parameters and how they need to be analyse? They are analysed by verifying their transmission, data integrity and precision.

2) What is the correct action sequence for using this system at Medical Server side? First the process is explained to observer (doctor, nurse or care taker) and as the system's speciality is that patient's intervention is not required while he/she is under observation using the system. So a questionnaire is given to patient regarding usability and ease of handling the device with different ratings such as 5 has the highest value and 0 has lowest value.

A. Screenshots of Implementation

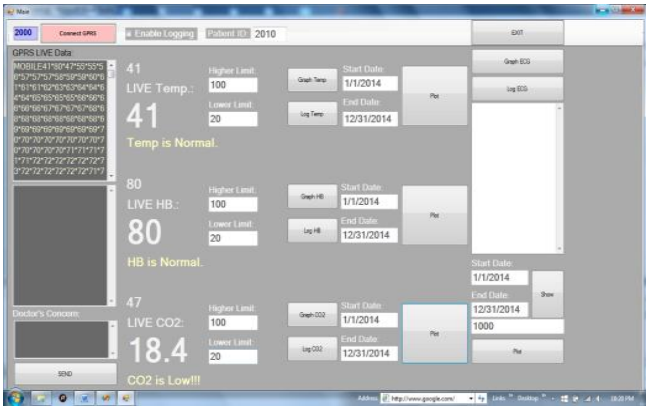

Fig. 4. GUI of Medical Server

Fig. 4 is main GUI of system at medical server side where care taker, medical practitioner can have observed the patient's real time data continuously.

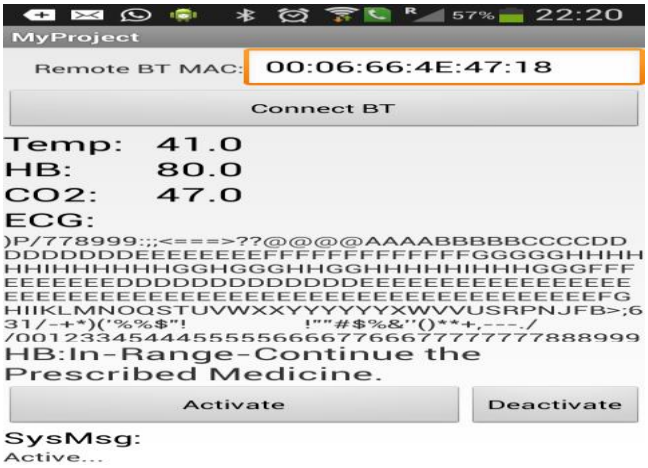

Fig. 5. Display at PPHS Patient Personal Home Server

Fig. 5 is display on patient's mobile phone where he can get the alerts or advice from medical practitioner.

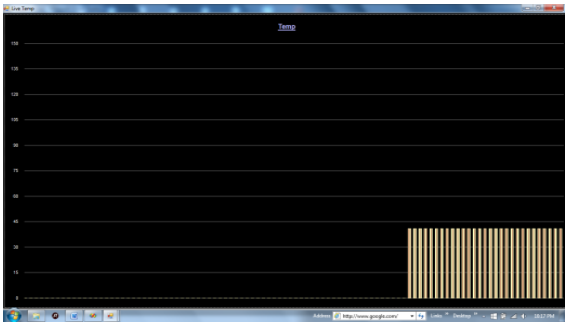

Fig. 6. Temperature Graph at MS

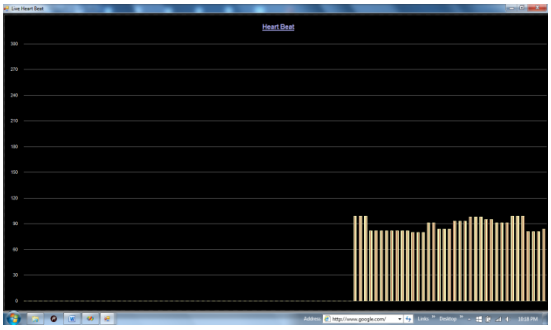

Fig. 7. Heart Beat Graph at MS

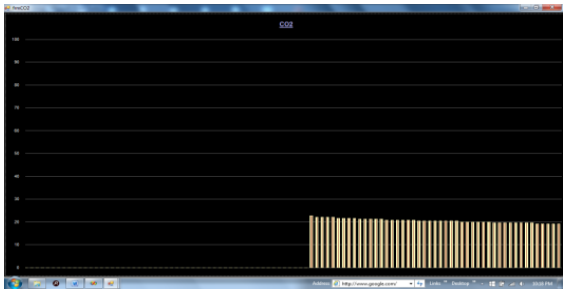

Fig. 8. CO2 Graph at Medical Server

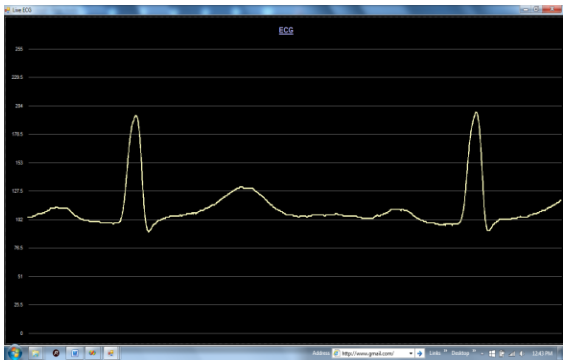

Fig. 9. ECG at Medical Server

Fig. 6, Fig. 7 and Fig. 8 is a graph of temperature, heart rate and carbon dioxide on X-axis with respect to time on Y-axis which is obtained on Medical Server side.

Fig. 10. ECG graph on Doctor's mobile

Fig. 10 is display on doctor's mobile which displays patient's parameters in critical range and real time ECG signal.

B. System Evaluation

System is evaluated by calculating the mean, variance, standard deviation and correlation for theoretical and practical values obtained by using standard device and our proposed system for various parameters such as temperature, heart rate and ECG pattern at various points such as Medical Server, PPHS and on Doctor's Mobile. Thus, precision and accuracy of system is examined by using following equations

$$\mu = \frac{\sum_{i=1}^{N} Xi}{N} = \frac{\sum X}{N} \quad (1)$$

$$\sigma^2 = \frac{\sum(X-\mu)^2}{N} \quad (2)$$

$$s = \sqrt{\frac{1}{N-1}} \sum_{i=1}^{N} (x_i - \bar{x})^2 \quad (3)$$

$$r_{xy} = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n\sum x_i^2 - (\sum x_i)^2}\sqrt{n\sum y_i^2 - (\sum y_i)^2}} \quad (4)$$

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2 \sum_{i=1}^{n}(x_i-\bar{x})^2}} \quad (5)$$

Where in equation (1), (2),(3),(4) &(5) μ is mean , $\sigma^2$is variance, s is the standard deviation and r_{xy} is a correlation

TABLE. I. STATISTICAL INFORMATION OF TEMPERATURE OF PATIENT USING STANDARD DEVICE AND THE PROPOSED DEVICE

Sr No	Patient Id	Patient Name	Temperature	
			TH	*PR*
1	2001	A	39.1	39.5
2	2002	B	40.5	41
3	2003	C	36.5	37
4	2004	D	37.5	38
5	2005	E	37.5	38
6	2006	F	37.5	38

TH: Theoretical Value measured by the standard device.

PR: Practical Value measured by the proposed system.

Table 1 shows the statistical information of temperature of patient recorded using the standard device and the system.

TABLE. II. AGGREGATED STATISTICAL INFORMATION OF TEMPERATURE OF PATIENT

Values		Min	Max	Range	Mean	Variance	SD	Correlation
Temp	TH	36.5	40.5	4	38.10	2.08	1.44	1.0043
	PR	37.0	41.0	4	38.58	2.04	1.43	

Table 2 shows the aggregated information of temperature of patient with range, mean and SD. The theoretical SD is 1.44 and practical is 1.43 with a difference of 0.01 and correlation is 1.0043 which is desirable as per precision point of view.

TABLE. III. STATISTICAL INFORMATION OF HEART RATE OF PATIENT USING THE STANDARD DEVICE AND OUR PROPOSED DEVICE AT PPHS AND MS

Sr No	Patient ID	Patient Name	Heart Rate		
			TH	*PRMS*	*PRPPHS*
1	2001	A	85	86	99
2	2002	B	78	80	80
3	2003	C	80	82	90
4	2004	D	91	93	99
5	2005	E	84	83	84
6	2006	F	80	82	93
Total			498	506	545
Average			83	84.33	90.83

TH: Theoretical Value measured by the standard device. PR MS: Practical Value measured by the proposed system at MS. PR PPHS: Practical Value measured by the proposed system at PPHS.

Table 3 shows the statistical information of Heart rate of patient using the standard device and the proposed system which shows the data collected at PPHS and MS.

TABLE. IV. AGGREGATED STATISTICAL DATA OF HEART BEAT USING THE STANDARD DEVICE AND THE PROPOSED SYSTEM AT MEDICAL SERVER

Values		Min	Max	Range	Mean	Variance	SD	Correlation
Heart rate	TH	78	91	13	83.00	22.40	4.733	0.967
	PR	80	93	13	84.33	21.86	4.676	

Table 4 gives aggregated statistical data of heart beat in terms of range, mean, variance, standard deviation and correlation, wherein theoretical heart beat is measured by using standard device and practical is by the proposed system. Thus Table 5 gives the SD difference of 0.054 and correlation in theoretical and practical readings of heart beat is 0.967 which is desirable.

TABLE. V. AGGREGATED STATISTICAL DATA OF HEART BEAT MEASURED AT MEDICAL SERVER AND AT PPHS

Values		Min	Max	Range	Mean	Variance	SD	Correlation
Heart rate	MS	80	93	13	84.33	21.8600	4.68	0.7548
	PPHS	80	99	19	90.83	60.5665	7.78	

Table 5 gives aggregated statistical data of heart beat on Medical Server and at PPHS, as the data is sensed by the sensors and through PPHS it is transmitted to MS and displayed there. So to check the data integrity at different point's precision is calculated in terms of range, mean variance, SD and correlation. Thus Table 5 shows the difference of 3.106 in SD and correlation is 0.7548 which is deviated from ideal value. This may be attributed to delay in transmission and data latency from PPHS to MS.

Advantages:

1) It is low power android based Health Monitoring system which monitors multiple parameters such as temperature, heart rate, CO2 and ECG.

2) This system can be applied to monitor the cardiovascular disease through wireless communication as the information provided is reliable and hence also can be used in critical condition to raise alarms and for initiating early first aid.

3) As the results are viewed on smart phone, all the parameters can be examined anytime-anywhere, this will improve the quality of medical treatment.

4) The alarm in the system will prompt the doctor about irregularities in patient's health status.

The advantages compact size, low power, user friendly, cost effective and being android based can revolutionize the patient health care.

VIII. RESULTS

The proposed system communicates the real time physiological parameters such as temperature, heart rate and ECG signals of the patient to medical practitioner either on PC or/and on his handheld device. If the temperature, heart rate goes either below or above the threshold, an alarm and a pop up message will be sent to patient to take corrective measures and if the doctor is also mobile these real-time parameters which are in critical range along with real time ECG signal will be sent on the doctor's handset. So, from each segment / interval of ECG waveform the medical professional can discover the different diseases like hyperkalaemia, ventricular tachycardia arrest, fibrillation, ischemia etc. Changes and various patterns that occur in ECG signal i.e. in PQRS waveforms are ST elevation, ST depression, T positivity, T negativity, tall peaked QT and long QT indicates various diseases. Thus, the system helps the medical practitioner in diagnosis of various heart diseases. Thus, system results are verified by comparing standard deviation and correlation between the values measured by the standard device and our proposed system. For temperature SD difference is 0.014 and correlation is 1.003 whereas for the heart rate SD difference is 0.054 and correlation is 0.967 which shows that the degree of agreement between them is highly desirable.

Thus, the proposed system effectively and precisely transmits patient's physiological parameters to Medical Server, on doctor's mobile and on the patient's mobile for taking corrective measures in order to avoid health risks.

IX. CONCLUSION AND FUTURE SCOPE

Interactive Mobile Health Monitoring System indicates promise in terms of applications in Tele-home-care and Telemedicine. Patients' health status can be monitored in real time by doctors using various biometric sensors even when the patient is residing at home. Also, hospitalized patients can

peacefully leave the hospital as they are monitored by health professionals even if they are outside the hospital.

Thus, the proposed system helps individuals as well as the whole society. It can help the patient by nursing his or her health and send alerts to take required actions against any upcoming health alarming conditions. The system can be used securely to diagnosis and monitor life threatening diseases such as cardiac arrest, dengue and asthma by measuring various physiological parameters such as temperature, heart rate and ECG.

Future Modifications:

Based on current developments, now only feedback can be provided to patient and patient needs to take action. Biosensors itself can't take necessary actions. With advancements in biosensors, a system can be think where the patients need not do any actions at all. The bio-sensors itself can take necessary actions e.g. a patient needed glucose does not need to take it manually rather the bio-sensors can push glucose to the patient's body depending on the feedback from MS.

REFERENCES

[1] Y. C. Su, H. Chen, C. L. Hung, and S. Y. Lee, "Wireless ECG detection system with low-power analog front-end circuit and bio-processing ZigBee firmware," in *Proc. IEEE Int. Symp.Ciircuits System,* pp.1216-1219, May 2010

[2] T. H. Tsai, J. H. Hong, L. H. Wang, and S. Y. Lee, "Low-Power Analog Integrated Circuits for Wireless ECG Acquisition Systems,"*IEEE Trans. Inf. Technol. Biomed., vol. 16, no. 5, pp.* 907-917, Sep. 2012.

[3] P Szakacs-Simon, S.A Moraru and L Perniu," Pulse –oximeter based monitoring system for people at risk."*13 th International Symposium on Computational Intelligence and Informatics CINTI* @2012 IEEE.

[4] Dennis Joe Harmah,D Kathivelu, " Design and Fabrication of Miniaturized ECG System with Bluetooth Connectivity," *International Conference on Information Communication and Embedded System ,@*2013 IEEE

[5] Dheerendra S Gangwar," Biomedical sensor network for cardiovascular Fitness and Activity Monitoring," *Point-of-Care Health Care Technologies(PHT) Bangalore, India,* 16-18 January,2013@IEEE

[6] Anliker.v.el.al.AMON: A Wearable Multiparameter Medical Monitoring and Alert System," *IEEE Transaction on Information Technology in Biomedicine,*Volume 8, Issue 4,pp415-427,Dec -2004

[7] U. Varshney Varshney."Pervasive Healthcare and Wireless Health Monitoring." *Journal on Mobile Networks and applications (Special Issue on Pervasive Healthcare), Springer,* 12(2-3):111-228, June 2007.

[8] Rodrigues. J .Goni, a andillaramendi. A real time classification of ECG on PDA, IEEE Transaction on Information Technology in Biomedicine, volume 9, Issue 1, pp23-34,March 2005

[9] Zhilin Zhang, Tzyy-Ping Jung, Scott Makeig, and Bhaskar D. Rao," Compressed Sensing of EEG for Wireless Telemonitoring With Low Energy Consumption and Inexpensive Hardware," *IEEE Transaction on Biomedical Engineering,* Vol.60, No.! January-2013

[10] Qi An, Yuki Ishikawa, Junki Nakagawa, Atsushi Kuroda, Hiroyuki Oka, Hiroshi Yamakawa, Atsushi Yamashita and Hajime Asama," Evaluation of Wearable Gyroscope and Accelerometer Sensor (PocketIMU2) during Walking and Sit-to-Stand Motions," The 21st *IEEE*

[11] *International Symposium on Robot and Human Interaction Communication, Paris, France* September9-13,2012

[12] Alar Kuusik, Sven Nõmm, Sergei Ovsjanski, Lii Orunurm, and Enar Reilent," Wearable system for patient motor condition assessment and training monitoring," *IEEE Point-of-Care Technologies(PHT) Bangalore, India,*16-18 January-2013

[13] Sang-Joong Jung, Risto Myllylä, and Wan-Young Chung,"Wireless Machine-to-Machine Healthcare Solution Using Android Mobile Devices in Global Networks,"*IEEE Sensors Journal,*Vol.13,No.5,May-2013

[14] May El Barachi1 and Omar Alfandi1," The Design and Implementation of a Wireless Healthcare Application for WSN- enabled IMS Environments," *3rd IEEE International Workshop on Consumer e-Health Platform,Services and Applications,*2013

[15] Sasan Bakhtiari, Thomas W. Elmer,Nicholas M. Cox, Nachappa Gopalsami, Appostolos C. Raptis, Shaolin Liao, Ilya Mikhelson, and Alan V. Sahakian, "Compact Millimeter-Wave Sensor for Remote Monitoring of Vital Signs"**,***IEEE Transactions on Instrumentation and Measurement,*Vol.61,No.3, March-2012

[16] Aravind Kailas" A Generic Conceptual Model Linking Wellness, Health Lifestyles, and User Assistance," *13th International Conference on e-Health Networking, Applications and Services,*978-1-61284-2/11@2011 IEEE

[17] Bruce Zamaere, Markus Hidell, and Peter Sj¨odin," CVPN: A multi-homed VPN Solution for Remote Patient Monitoring," *14th International Conference on e-Health Networking, Applications and Services(HealthCom)*@2012 IEEE

[18] Mandy Yang Tsinghua Xingzhou He Tsinghua Lei Gao, Li Zhao Tsinghua, "An Innovative System of Health Monitoring Using Mobile Phones," *14th International Conference on e-Health Networking, Applications and Services(HealthCom)*@2012 IEEE

[19] Christine Shuyu Xu1, Blake Anderson1, Jane Armer2, and Chi-Ren Shyu," Improving Disease Management through a Mobile Application for Lymphedema Patients," *14th International Conference on e-Health Networking, Applications and Services (Healthcom),*@2012 IEEE

[20] William Walker, A. L. Praveen Aroul, and Dinesh Bhatia," Mobile Health Monitoring Systems," *31st Annual International Conference of the IEEE EMBS Minneapolis, Minnesota, USA,978-1-4244-3296-7/09/$25.00* @September 2009IEEE

[21] Shih-Lun Chen, Ho-Yin Lee, Chiung-An Chen, Hong-Yi Huang and Ching-Hsing Luo, "Wireless Body Sensor Network with Adaptive Low power Design for Biometrics and Healthcare Applications,"*IEEE SYSTEMS JOURNAL,*Vol.3,No.4, December 2009

[22] Bulent Tavli & Kemal Bicakci & Ruken Zilan & Jose M. Barcelo-Ordinas, "A survey of visual sensor network platforms," *# Springer Science +Business Media,LLC* 2011

[23] Benoıˆt Latre´ , Bart Braem,Ingrid Moerman , Chris Blondia , Piet Demeester," A survey on wireless body area networks," *Published online: 11 November 2010_Springer Science+Business Media,LLC* @2010

[24] Orlando Pereira & João M. L. P. Caldeira & Joel J. P. C. Rodrigues," Body Sensor Network Mobile Solutions for Biofeedback Monitoring," *Published Onlinr: 16 November 2010, Springer Science+Business Media,LLC* 2010

[25] Rifat Shahriyar,Md. Faizal Bari,Gourab Kundu,Sheikh Iqbal Ahamed and Md. Mostafa Akbar,"Intelligent Mobile Health Monitoring System",*International Journal of Control and Automation,Vol.2,No.3,* September 2009.

[26] Varsha Wahane, Dr.P.V.Ingole,"An Android Based Wireless ECG Monitoring System for Cardiac Arrhythmia ", *IEEE NIH -2016 Special Topic Seminar on Healthcare Innovations in Point-of-Care Technoloies,IEEE,*-November-2016

[27] Varsha Wahane, Dr.P.V.Ingole,"Machine-to Machine Communication for Wireless Mobile Health Monitoring", *International Journal of Current Engineering and Technology,IJCET,Vol.5,No.3,*June 2015.

[28] Varsha Wahane, Dr.P.V. Ingole,"Role of BAN: Body Area Network in Wireless Health Monitoring". *International Conference on Advanced Computing and Communication Technology –ICACCT,* November 2012.

[29] M.F.John Rieman and D. Redmiles,"Usability evaluation with the cognitive walkthrough,"*CHI'95 Proceedings @ACM,1995*