Health at Home System Design for Remote Patient Monitoring

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Abstract— This paper focuses on the design and development of the Health at Home (H@H) system for remote patient monitoring. The system is integrated with the windows PC for data acquisition. The implemented design contains Disease Detection Algorithm (DDA) for disease detection and metabolic parameter monitoring on health at home platform. Regular real-time monitoring in human beings is needed for early detection of abnormalities in metabolic parameters and prevention of disease occurrence. The general conditions of a person's body depend on many vital parameters which lead to consideration towards the system design. The system focuses on the monitoring of vital signs and work as early detection of disease. The proposed system consists of sensing devices and sensor processing using Arduino for remote monitoring of vital signs in human beings.

Keywords- *Sensing Devices,Wireless Sensor Network,H@H, Arduino, DDA,Real-Time Monitoring.*

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I. INTRODUCTION

Monitoring human health is of great interest to the prevention of diseases and controlling the abnormalities in patients. Medical and Pharmaceuticals industries are facing various problems related to increasing number of hospitalization. Sensing of vital signs of patients at home is of increasing importance to a healthy society and can help in reduction of hospital readmission rates. Manual and time consuming process of patient monitoring is still a common practice in many of the remote areas. This kind of approach is traditionally followed in many hospitals. The proposed system is a benefit to the health care sectors. Unlike the traditional method of individual parameter monitoring, our system is flexible to find disease using Disease Detection Algorithm (DDA) or to find abnormalities of health parameters early in its course. Due to increasing number of sudden deaths, it is necessary to provide continuous health monitoring services at home.

Figure 1.System architecture

The system aims at improving, prevention of disease as well as personalization and quality of care [1]. The device is equipped with sensors that can measure different vital signs, such as electrocardiogram (ECG), blood pressure, pulse oximetry, body position, etc. Once these signals are acquired, they can be processes on-board in order to extract information about the daily activities and the health states of the person. Significant changes have been made to the mobile sensor network area and its application in health monitoring. These signals from wireless sensor networks help to diagnose diseases related to alterations of the body metabolism. These diseases are hypertension, obesity, hyperthermia or diabetes etc. The system architecture as shown in Fig.1 consists of a laptop home gateway which collects all the sensors data from the patient's body, after data acquisition the medical data or changes in metabolic parameters are used by DDA for automated disease evaluation and conditions of individual parameter.

With the advent of low-power embedded systems and wireless networking, this proposed system have emerged new possibilities for distributed sensing applications. Recently, there is an increase in the development of in-situ sensing platforms in health sectors [2]. Care for patients in advanced intra-home clinical environment gives the patient a comfortable zone. Monitoring implies automated detection impending danger, life-threatening situations, or diagnostic organization by collection of data. At diverse situations also health monitoring is possible, whether it be at home or other environment as a part of the diagnostic procedure. To prevent a recovery from any minor event is very helpful, as medical assistance will be provided within time. Critical situations are to be managed successfully and cured. With the use of miniature circuits, microcontroller, frond-end amplification and wireless data transmission, this system can be deployed in digital health monitoring. During the last few decades wireless health monitoring systems has drawn considerable attention from research community. The unobtrusive and continuous monitoring in the home for the purpose of accessing early health changes is made by sensors embedded in the H@H environment [3]. Personal medical condition history is considered as one of the weakest links in the current healthcare

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systems [4]. The medical data of the patients need to be effectively and efficiently available that may allow patients or guardians to constantly monitor and control the personal health record [5].

The proposed system provides a wireless network consisting of spatially distributed autonomous individual sensor devices to monitor physical and metabolic conditions of human beings. Due to space curb, this paper constraints to discuss the parameter based disease detection using our embedded sensing platform. In this paper we consider the following things:

(a) We present the design of Multi-Parametric Health Monitoring System and implement DDA on the embedded platform.

(b)We propose an accurate and computationally efficient approach to disease detection using health monitoring systems.

II. PROPOSED METHODOLOGY

A. Harware Design

System consists of the array of sensors which is placed on the patient's body and is movable as per the patient's movement. Arduino Mega is used for processing and sending data through Bluetooth. The point-to-point communication makes the device secure in terms of data confidentiality. The system is manipulated by a programmable control board, which can communicate with the windows application through short-range wireless links such as Bluetooth.

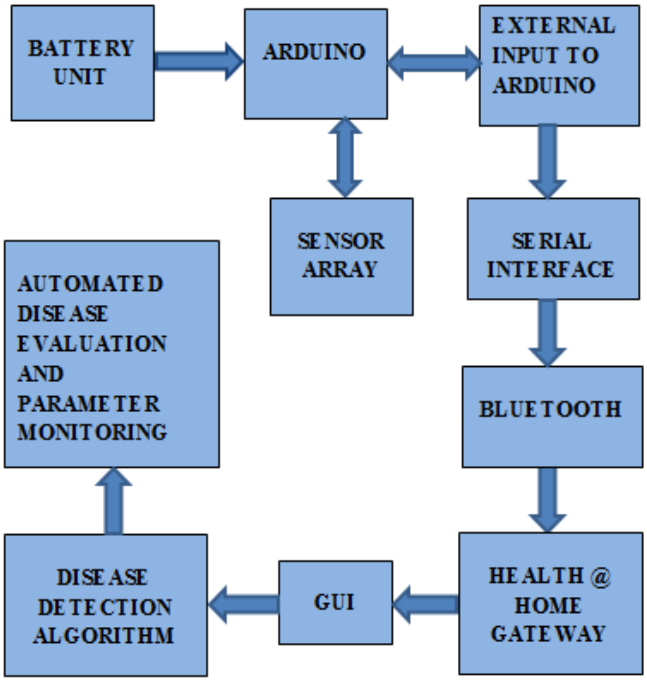

Figure 2.Block diagram of H@H Monitoring System

The block diagram of Health at Home monitoring system is shown in fig 2.The Arduino Mega 2560 development board is used for processing based on the ATmega 2560 platform. The Development board is a credit card sized board which plugs into your computer using a USB cable or can be powered with a AC-to- DC adapter or a battery to get started. Since our system is independent of direct connection to the monitor or desktop we are using a battery. Arduino is a capable electronic component that is used in many embedded projects. It contains everything needed to support a microcontroller. A serial interface between two digital systems is made that transmits data as a series of voltage pulses down a wire. Arduino and Bluetooth module are serially interfaced, encoding data bits by their temporal location. There are easy to use open source peripheral driver libraries. A flexible and high configurable platform for domestic vital signs acquisition and processing is developed within the health at home environment.

B. Software Design

The installed software in the remote computer receives the patient's metabolic data from the sensors and processes them to detect the anomalies. The Arduino Mega 2560 is programmed with the Arduino software which comes pre-burned with a bootloader, so that we can upload new code to it directly without use of any external hardware programmer. Also the GUI designed allows user to see the parametric conditions, disease name if detected and history of medical information and current vital signs in real-time.

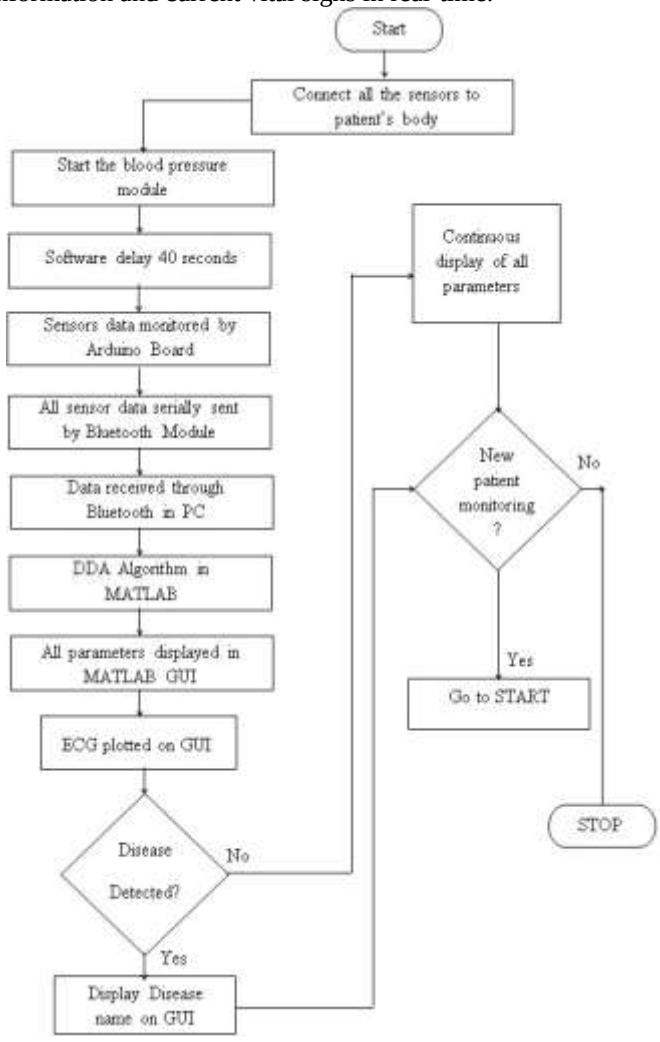

Figure 3.System flowchart

The system flowchart as seen in Fig.3 shows the graphical implementation of the flow of data in the system, and represents the work process of the system. Starting at an initial input, the instruction describes computation, execution, process, and well-defined successive states producing output and eventually terminating at final state. Also the development

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of DDA helps in prevention of any critical metabolic condition along with automated disease evaluation.

C. Embedded System Design

The metabolic parameters i.e. temperature, blood pressure, acceleration, stress, pulse oximetry, electrocardiogram, weight and blood glucose acts as input. Whereas the wirelessly controlling and displaying the monitored contents on the H@H gateway is part of processing and accordingly the resultant are acquired from the disease detection algorithm. The design is approximately 13cm long and 20 cm wide at base, and 3.5 cm high. It is an enclosed rectangular box structure. The complete circuit design is encased into a fiber body and placed over patient's waist using a Velcro belt or a strap. The system is designed in such a way that it is compact in size, light weight, handy and flexible for use. The Sensor interfacing of Multi-Parametric Health Monitoring System (MPHMS) is shown in fig.4 below.

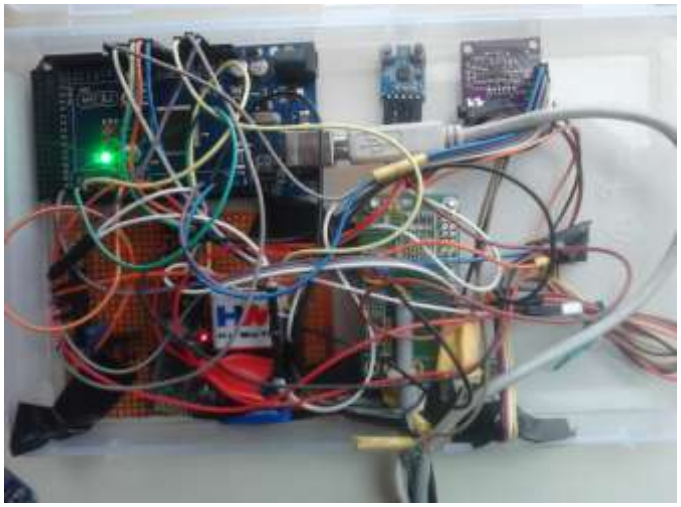

Figure 4.Sensor Interfacing of MPHMS

The fitness and activity heart rate monitoring is done by the fully integrated single-lead ECG front end .The three electrode configuration is emphasized for analyzing the heart condition of the concerned person . For this, the 'QRS' wave is located in the ECG signal from which the 'R' wave is manifested. After the first sample of R wave the Q wave is detected.

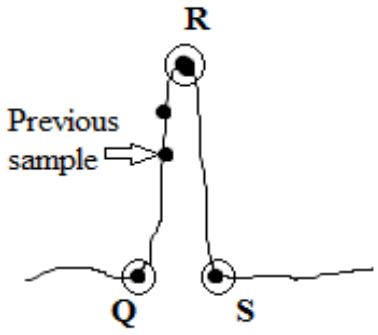

Figure 5.QRS Detection

The Q sample is detected by eliminating the previous sample of R minus the first sample of R, this process goes on till we obtain the subtracted as zero. As soon as the constant or null value of the Sample is obtained the Q wave is located.

Q Sample = (First sample of R peak) – (Previous sample of R) ……equation (1)

The equation (1) shows the detection of Q wave. Three electrodes from the ECG sensor are placed on the human body. The placement is such that one electrode is placed at left arm (LA); another is placed at right arm (RA) and third is placed at the right leg (RL). The embedded system design of Multi-Parametric Health Monitoring System is shown in fig.6 below.

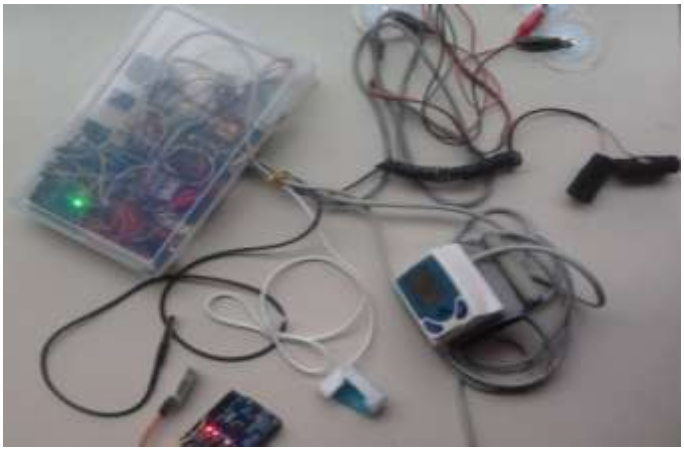

Figure 6. Embedded System Design of MPHMS

The galvanic Skin response sensor measures the skin conductance, which varies the moisture level of the skin. This is used as an indication of persons stress levels as the device measures electrical conductance between two points, indicating psychological or physiological arousal. The skin response time from sudden effect is 0.1 to 0.5 seconds. Similarly all the other sensor channels are implemented.

D. Disease Detection Algorithm

The algorithm depends on the parameter linkage data which compares the diseases and the metabolic parameters with each other [6]. The medical database has found that many of the diseases are related with the minimum set of parameters and each parameter affects the other directly or indirectly. Hence, change in a single physical or metabolic parameter may result in unhealthy status of the person. To prevent these flaws in health monitoring the disease detection algorithm may be very useful. This algorithm is capable of detecting diseases such as Hyperthermia, Type-I diabetes, Type-II diabetes, Dysautonomia. The parameters monitored are Temperature, SpO2, Weight, Stress, ECG, Glucose, Acceleration and Blood Pressure. If the sensed parametric data meets the threshold values for the particular disease then the disease is displayed at the GUI. Also the individual parameter conditions are monitored by the system. The traditional method of doctor intervention is replaced with the digital system for condition monitoring. This will also help in reduction of hospital readmission rate.

III. EXPERIMENTAL RESULTS

The Health Monitoring System evaluated the results through experiment done on the patients. The experimental results obtained on windows PC validate the feasibility of the

health at home monitoring system by evaluating the computation and effectiveness of each module with vital sign monitoring and disease detection. The results of all the sensors implemented in hardware of MPHMS extensively give the performance. The sensor application on human body is shown in figure 7.

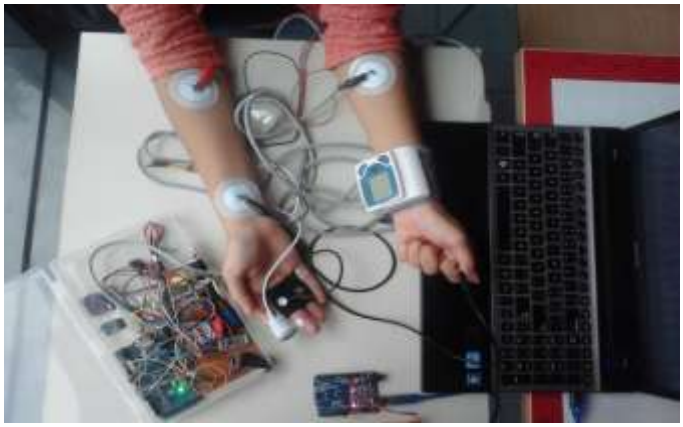

Figure 7.MPHMS Application

The graphical user interface shows the disease detection and real time patient monitoring. The results are as shown in figure 8 and 9 for type-I diabetes and Hyperthermia. Similarly other diseases are also detected.

Figure 8.Disease Detection for Type-I Diabetes

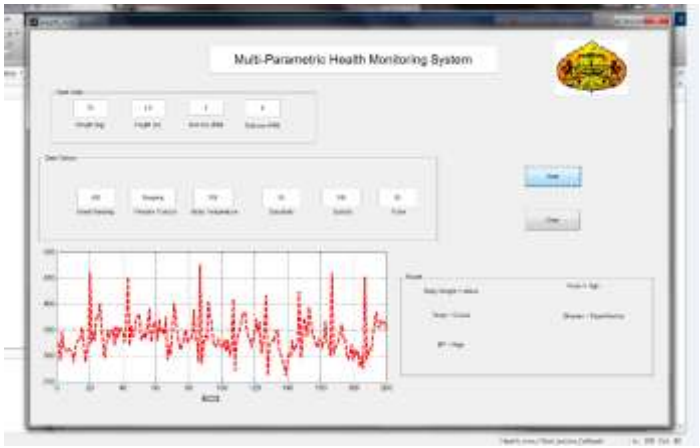

Figure 9.Disease Detection for Hyperthermia

CONCLUSION

This paper presents Health at Home System design for Multi-Parametric Health Monitoring.. The windows platform is integrated with the Arduino to acquire data of different sensors. The real-time metabolic parameter monitoring is done with the DDA algorithm efficiently. In future this can be extended for experiments on obese children and full migration to Android.

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REFERENCES

[1] Amna Abdullah, Asma Ismael, Aisha Rashid, Ali Abou-ElNour, and Mohammed Tarique. "Real Time Wireless Health Monitoring Application Using Mobile Devices" International Journal of Computer Networks & Communications (IJCNC) Vol.7, No.3, May 2015.

[2] Julie Barnett, Michelle Harricharan, Dave Fletcher, Becky Gilchrist, and Jane Coughlan "myPace: An Integrative Health Platform for Supporting Weight Loss and Maintenance Behaviors" IEEE Journal Of Biomedical And Health Informatics, Vol. 19, No. 1, January 2015.

[3] Marjorie Skubic1, (Senior Member, IEEE), Rainer Dane Guevara1,2,And Marilyn Rantz3, (Member, IEEE) "Automated Health Alerts Using In-Home Sensor Data For Embedded Health Assessment" Wireless Sensor And Health monitoring System, Volume 3,IEEE ,April 2015.

[4] Shih-Lun Chen, (Member, IEEE) , "A Power-Efficient Adaptive Fuzzy Resolution Control System For Wireless Body Sensor Networks" Volume 3,June 10, 2015.IEEE Access, Digital Object Identifier 10.1109/ACCESS.2015.2437897.

[5] Yeong-Tae Song, Sungchul Hong, Jinie Pak ,Dept. of Computer and Information Sciences Towson University, U.S.A. "Empowering patients Using Cloud Based Personal Health Record System" IEEE SNPD 2015 ,June 1-3 2015.

[6] Ms. Priyanka Bhoyar, Dr.S.S.Sonavane "Multi- Parametric Health Monitoring System" , International Journal of Advance Research in Computer Science and Software Engineering, Volume 4, Issue 12, December 2014 ,ISSN: 2277 128x

[7] Lei Clifton, David A. Clifton, Marco A. F. Pimentel, Peter J. Watkinson, And Lionel Tarassenko, " Predictive Monitoring Of Mobile Patients By Combining Clinical Observations With Data From Wearable Sensors " IEEE Journal Of Biomedical And Health Informatics, Vol. 18, No. 3, May 2014.

[8] Boudewijn Venema, Johannes Schiefer, Vladimir Blazek, Nikolai Blanik, And Steffen Leonhardt, "Evaluating Innovative In-Ear Pulse Oximetry For Unobtrusive Cardiovascular And Pulmonary Monitoring During Sleep", Wearable Sensors And Health Monitoring Systems, IEEE Volume 1, September 2013.

[9] Media Aminian and Hamid Reza Naji, "A Hospital Healthcare Monitoring System Using Wireless Sensor Networks" ,Volume 4 Issue 2,J Health Med Inform (JHMI) 2013.

[10] Lei Clifton, David A. Clifton, Marco A. F. Pimentel, Peter J. Watkinson, And Lionel Tarassenko, "Gaussian Processes For Personalized E-Health Monitoring With Wearable Sensors", IEEE Transactions On Biomedical Engineering, Vol. 60, No. 1, January 2013.

[11] Abderrahim Bourouis, Mohamed Feham And Abdelhamid, Bouchachia, "Ubiquitous Mobile Health Monitoring System For Elderly (UHMSE)", International Journal Of Computer Science & Information Technology (IJCSIT), Vol 3, No 3, June 2011.

[12] Orlando R. E. P., Caldeira, M. L. P. Lei S., and Rodrigues, J.P.C (2014), "An Efficient and Low Cost Windows Mobile BSN Monitoring System Based on TinyOS", Journal of Telecommunication Systems, Vol. 54, No. 1, pp. 1-9.