ThingSpeak IoT - A Non-invasive Bio-Signal Measurement Approach for Advanced Health Care Monitoring Using Wearable Sensors

[1]Dr. A. Suresh, [2]Shalika R
[1]Professor & Head, [2]UG Scholar
[1,2]Department of Computer Science and Engineering, Nehru Institute of Engineering and Technology, Coimbatore
[1]prisu6esh@yahoo.com, [2] suraksha8@gmail.com

Abstract: The emerging trend in healthcare sector is to change the usual healthcare services and routine medical check-ups from hospital centric to home centric. By this way ,the total expenses spent on the healthcare can be reduced dramatically. It has become an important aspect in future for the healthcare sectors to advance and improve the practical health technologies and services using information and communication technology so that they can be applied in home environment. An intelligent home-based platform, the iHome Health-IoT, is proposed and implemented using ThingSpeak. The proposed platform uses IoT devices such as wearable sensors for improved accuracy and user experiences.

Index terms - Health-IoT, Information communication technology(ICT), Internet-of-Things(IoT), telemedicine.

1. Introduction

In order to track the physical status of the elderly and, in the meanwhile, to keep them healthy, the following two daily tasks are essential: 1) real-time monitoring and analysing vital signs to early-detect or predict life-threatening adverse events; and 2) checking whether they are following their prescribed treatment, including taking their prescribed medicine on time. However, with rapidly aging populations, these daily tasks have brought great pressure and challenges to global healthcare systems [1]. One review estimates that about 25% of the adult population do not adhere to their prescribed medication, which may lead to poor health outcomes and increased mortality [2]. Poor medication adherence is a major problem for both individuals and healthcare providers [2]. Technology improvements in healthcare facilities and services are highly desirable to meet the requirements of this giant group.

In the meantime, Internet-of-Things (IoT) has been recognized as a revolution in ICT since it started at the beginning of the 21st century [3], [4]. IoT technology provides the possibility to connect sensors, actuators, or other devices to the Internet and is conceived as an enabling technology to realize the vision of a global infrastructure of networked physical objects [5]. IoT extends the Internet into our everyday lives by wirelessly connecting various smart objects [6], and will bring significant changes in the way we live and interact with smart devices [7],[8].

Internet of Things (IoT) is mainly to connect the world through multiple devices. In healthcare system IoT is mainly used to access the information quickly. Internet of Things is mainly interconnected by more number of devices with the use of internet. In healthcare system, Internet of Things is mainly built to access the large scale of information. It defines that, grid of computers can deliver software and data. For detail, this technology can be most accomplished by multiple servers as retail businesses, whose needs can be strictly met by the cumulative usage. Here, the proposed medical service system provides the way to collect, integrates, and interoperates IoT data. In this case, an object will connect to the cloud through a (possibly wireless) Internet connection to upload or receive data. Objects to be connected are typically augmented with either sensors or actuators. A sensor is something that tells us about our environment. Think of a temperature sensor, or even the GPS receiver on your mobile phone. Actuators are something that you want to control. Things like thermostats, lights, pumps, and outlets. The IoT brings everything together and allows us to interact with our things and, even more interestingly, allows things to interact with other things. For the purpose of connecting an object to the IoT, we focus on the ThingSpeak API. ThingSpeak allows you to build applications around data collected by sensors. It offers near real-time data collection, data processing, and also simple visualizations for its users [9].

2. Background

The iMedBox is the central platform of the iHome Health-IoT system [1]. The inspiration for the iMedBox comes from the traditional in-home medicine container. The difference lies in the fact it is equipped with a high performance and open platform-based tablet PC and wireless transmission units, so the iMedBox is fully functional as a medication inspector, and a non-site examiner for daily monitoring [10]. An ultra-high frequency (UHF) RFID reader, a high frequency (HF) RFID reader, a Wi-Fi unit, a Zigbee receiver, and a tablet PC with extension ports are embedded into the lid. A high-resolution weight bridge sensor is integrated in the bottom of the iMedBox to track the weight variation of the medicine stored in the box, and based on which the dose of medication taken by the patient can be calculated. Wearable medical sensors (e.g., Bio-Patch), intelligent medicine packages, and the sensors/devices from third parties can be connected to the iMedBox via various wireless technologies. The iMedBox can serve as an in-home healthcare gateway to gather patients' physiological information and it can deliver a variety of services such as on-site analysis, health social network, telemedicine, emergency, and medication management services.

In healthcare system, delivering the information to the doctors, patients at the point of emergency will improve the quality of healthcare in emergency medical service [9]. At some time, health records of the patients and detail of the doctors are stored in different hospitals or stored in different location of the database, it is difficult to collect these records [11]. For that, ontology can be constructed to resolve these problems and to make correct decision at emergency period. In order to support the Ontology content accessing, a resource model was introduced to locate and get clinic data which are stored in heterogeneous hospital information systems.Clinic data of patient is defined as resource with unique URL address. Related clinic data of one patient is collected together to form a combinational resource, and could be accessed by physician if authority is assigned to the physician. The result shows that the clinic data of patients could be accessed more conveniently. In healthcare service, doctors, patients, physicians play a major role and they also involved in an entire servicing. Doctors need to access the patient record from anywhere by storing it in a distributed manner [12]. Patients also needs to know about the doctors availability and the equipment's status (busy/free). In order to help patient accessing doctors' availability status, a resource model is needed for this accessibility.

Data Acquisition is performed by multiple wearable sensors that measure physiological biomarkers, such as ECG, skin temperature, respiratory rate, EMG muscle activity, and gait (posture). The sensors connect to the network though an intermediate data aggregator or concentrator, which is typically a smart phone located in the vicinity of the patient. The Data Transmission components of the system are responsible for conveying recordings of the patient from the patient's house (or any remote location) to the data center of the Healthcare Organization (HCO) with assured security and privacy, ideally in near real-time. Typically, the sensory acquisition platform is equipped with a short range radio. Components of a remote patient monitoring system that is based on an IoT-Cloud architecture as Zigbee or low-power Bluetooth, which it uses to transfer sensor data to the concentrator [13]. Aggregated data is further relayed to a HCO for long term storage using Internet connectivity on the concentrator, typically via a smartphone's WiFi or cellular data connection. Sensors in the data acquisition part form an Internet of Things (IoT)-

based architecture as each individual sensor's data can be accessed through the Internet via the concentrator [14], [15]. Often a storage/processing device in vicinity of a mobile client, sometimes referred to as a cloudlet, is used to augment its storage/processing capability whenever the local mobile resources do not fulfil the application's requirements [16]. The cloudlet can be a local processing unit (such as a desktop computer) which is directly accessible by the concentrator through WiFi network. In addition to providing temporary storage prior to communication of data to the cloud, the cloudlet can also be used for running time critical tasks on the patient's aggregated data. Moreover, the cloudlet can be used to transmit the aggregated data to the cloud in case of limitations on the mobile device such as temporary lack of connectivity or energy. Cloud Processing has three distinct components: storage, analytics, and visualization. The system is designed for long term storage of patient's biomedical information as well assisting health professionals with diagnostic information. Cloud based medical data storage and the upfront challenges have been extensively addressed in the literature [17], [18]. Analytics that use the sensor data along with e-Health records that are becoming prevalent can help with diagnoses and prognoses for a number of health conditions and diseases. Additionally, Visualization is a key requirement for any such system because it is impractical to ask physicians to pore over the voluminous data or analyses from wearable sensors. Visualization methods that make the data and analyses accessible to them in a readily digestible format are essential if the wearable sensors are to impact clinical practice.

3. Methodology

Figure 1 illustrates the system architecture for a e-health monitoring system, whose major components we describe next:

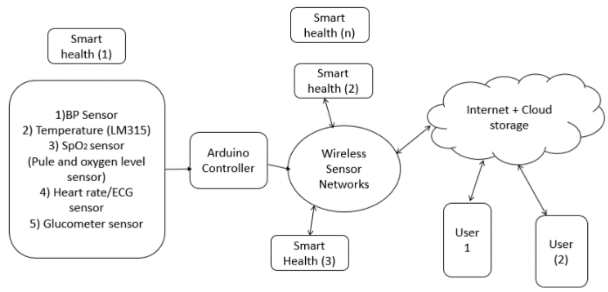

Figure 1: System Architecture of the Proposed System

Sensor interfacing is done by attaching the wearable band with various sensors like temperature sensor, heart rate sensor, BP sensor,spo2 sensor, glucometer sensors. These sensors are attached to the body so that the values of the vital signs are monitored and displayed through the LCD monitor. These values are send to the Arduino Nano controller.

Wi-fi Module Connectivity is done using ESP 8266. ESP8266 Wi-Fi module gives access to Wi-Fi or internet. It can communicate with any microcontroller and it is the most leading devices in the IOT platform. It is integrated with TCP/IP protocol. The ESP8266 will then communicate with the Arduino and will send the data to ThingSpeak. The ESP8266 will connect the network of your router that is provided in the code and will send the data of the sensor online.

Internet of Things Processing is done using ThingSpeak, which is an open source cloud service with proper security. The security is provided for each user with the SSID and a password. The user will also have an API key. With the help of Arduino IDE, it is able to connect the sensors to the ThingSpeak IoT. The sensors send the monitored value automatically to the IoT using the Arduino controllers

In Live Monitoring and Data Export the data transferred from the Arduino controller are send to the ThingSpeak.The API allows for very easy visualization of collected data through various forms.The various forms are graphical method, gauge method or based on the locations. The reports are visually appealing and is much easier when examining collected data compared to other API's.

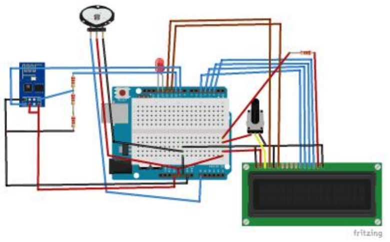

Figure 2: Setup of the Proposed System

4. ThingSpeak as a Healthcare Monitoring system

4.1. Sensor Interfacing

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ˚ Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1˚C in still air. The LM35 is rated to operate over a −55˚ to +150˚C temperature range.

LM35 is a precision IC temperature sensor with its output proportional to the temperature (in °C). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a thermistor (Figure 3).

The normal body temperature of a person varies depending on gender, recent activity, food and fluid consumption, time of day, and, in women, the stage of the menstrual cycle. Normal body temperature can range from 97.8 degrees F (or Fahrenheit, equivalent to 36.5 degrees C, or Celsius) to 99 degrees F (37.2 degrees C) for a healthy adult.

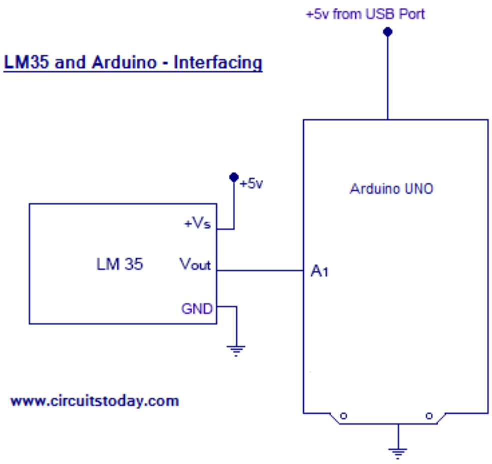

Figure 3: Temperature Sensor and Arduino Interfacing

Heart beat sensor is designed to give digital output of heat beat when a finger is placed on it. When the heart beat detector is working, the beat LED flashes in unison with each heartbeat. This digital output can be connected to microcontroller directly to measure the Beats Per Minute (BPM) rate. It works on the principle of light modulation by blood flow through finger at each pulse. For a human aged 18 or more year, a normal resting heart rate can be anything between 60 and 100 beats per minute. Usually the healthier or fitter you are, the lower your rate. A competitive athlete may have a resting heart rate as low as 40 beats per minute.

The Arduino Nano is a microcontroller board based on the ATmega328 (Figure 4). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Arduino Nano is used in the proposed system is because it has a great connectivity with the IoT.

The Arduino Nano can be programmed with the Arduino software. Select "Arduino Nano from the Tools > Board menu (according to the microcontroller on your board).

The ATmega328 on the Arduino Nano comes preboned with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).It can also bypass the boot loader and programs the microcontroller through the ICSP (In-Circuit Serial Programming) header.

The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer. A Software Serial library allows for serial communication on any of the Nano's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus.

Figure 4: Arduino Controller

A 16x2 LCD consists of two parallel plates between which the space is filled with liquid crystals (Figure 5). Once the voltage is applied, the back-plate transfer charge toward the front plate which is opaque and display the text on the screen. This LCD is used in this project to display information from a sensor value.

Figure 5: LCD Monitor

The data from the various sensors are obtained and send to the Arduino Nano controller. The program in the controller helps to display the obtained values in the LCD monitor. If the values exceed the normal level i.e. for the temperature if it is above 110^0C and for pulse rate if it is above 160 BPM, the buzzer connected to the Arduino beeps an alarm as indication. Using a GSM module it can be enhanced by sending an instant message that contain the values with proper time regarding the changes in the values to the Doctor

4.2 Wi-Fi Module Connectivity

Connect the ESP8266 with the Arduino. ESP8266 runs on 3.3V and if you give it 5V from the Arduino then it won't work properly and it may get damage. Connect the VCC and the CH_PD to the 3.3V pin of Arduino. The RX pin of ESP8266 works on 3.3V and it will not communicate with the Arduino when we connect it directly to the Arduino. So, we will have to make a voltage divider for which it will convert the 5V into 3.3V. This can be done by connecting three resistors in series . Connect the TX pin of the ESP8266 to the pin 9 of the Arduino and the RX pin of the ESP8266 to the pin 10 of Arduino through the resistors.

The data processed from Arduino Nano controller is sent to the cloud servers through this ESP 8266 which enables the uploading of data. The ESP 8266 uses TCP/IP protocols that helps in smooth uploading of data.

4.3 Internet of Things Processing

The details which are sent to the cloud servers from the ESP 8266 can be viewed in both public and private modes. We can monitor our data and control our system over the Internet, using the Channels and webpages provided by ThingSpeak. ThingSpeak Collects the data from the sensors, Analyze and Visualize the data and Acts by triggering a reaction. User needs to Create an Account on ThingSpeak.com, then Sign In and click on Get Started.

A unique API key is available for each user. The user has to login to use the cloud service using SSID and Password.

4.4 Live Monitoring and Data export

The data collected are simultaneously uploaded to the cloud servers (Figure 6). The data can be shown graphically with respect to time. The location is also shown. The data uploaded can be retrieved at any time using the data export facility. This shows the data in a table format with various values monitored using sensors with respect to time. The doctor can view the results immediately and prescribe the patient with proper medication.

Figure 6: Live Monitoring Using Thingspeak

5. Results and Discussions

In this project, health monitoring of a person is done using the values obtained from the sensors.

The temperature sensor senses the value based on the Thermistor. The values are plotted based on the temperature measured with respect to time and date.

If the graph shows a stable condition in which the value is around 30°C to 100°C. If the values is lower or higher than the normal values the graph shows a variation

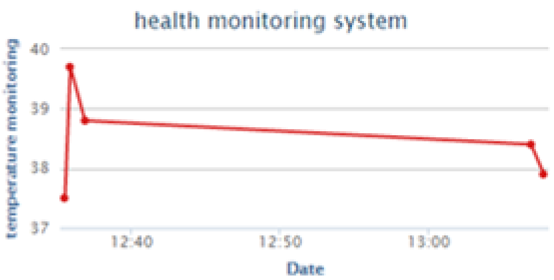

Figure 7: Temperature Sensor Reading

The pulse rate sensors measure the values based on the pressure of the blood flow. The normal range is about 60 BPM to 110 BPM. The variation in the beats per minute creates a change in the pulse rate.

From these values the doctor can take necessary steps and prescribe proper treatment. These values also helps the doctor to understand the present condition and status of the patient.

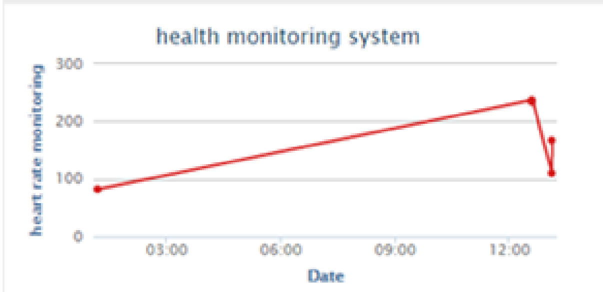

Figure 8: Heart Rate Sensor Reading

6. Conclusion and Future Enhancement

The proposed system helps to improve the healthcare sector by reducing the treatment expenditure. This system helps in improving the patient's health in a home environment itself. The level of security of IoT can be enhanced in future. In the proposed system, it is easy to retrieve the uploaded data. One of the major enhancement which can be done in future is to use low speed network for live updation.

References

[1] A Health-IoT Platform Based on the Integration of Intelligent Packaging, Unobtrusive Bio-Sensor, and Intelligent Medicine Box, IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS, VOL. 10, NO. 4, NOVEMBER 2014.

[2] B. Schuz et al., "Medication beliefs predict medication adherence in older adults with multiple illnesses," J. Psychosom. Res., vol. 70, no. 2, pp. 179–187, 2011.

[3] K. Ashton, (Jun. 2009). That 'Internet of Things' Thing, RFID J. [Online]. Available: http://www.rfidjournal.com/articles/view?4986.

[4] S.Li,L.Xu,andX.Wang,"Compressed sensing signal and data acquisition in wireless sensor networks and Internet of Things," IEEE Trans. Ind. Information, vol. 9, no. 4, pp. 2177–2186, Nov. 2013.

[5] E.Welbourneetal.,"Building the Internet of Things using RFID : The RFID ecosystem experience," IEEE Internet Computing., vol. 13, no. 3, pp. 48–55, Jun. 2009.

[6] G. Kortuem, F. Kawsar, D. Fitton, and V. Sundramoorthy, "Smart objects as building blocks for the Internet of things," IEEE Internet Computing., vol. 14, no. 1, pp. 44–51, Feb. 2010.

[7] S.Tozlu, M.Senel, W.Mao, and A. Keshavarzian, "Wi-Fi enabled sensors for internet of things : A practical approach," IEEECommun.Mag.,vol.50, no. 6, pp. 134–143, Jun. 2012.

[8] A. J. Jara, M. A. Zamora-Izquierdo, and A. F. Skarmeta, "Interconnection framework for mhealth and remote monitoring based on the Internet of Things,"IEEEJ.Sel.AreasCommun.,vol.31,no.9,pp. 47–65,Sep.2013.

[9] Ontology based Public Healthcare System in Internet of Things , Procedia Computer Science 50 (2015) 99 – 102.

[10] Z.Pang, Q.Chen, J.Tian, E.Dubrova, and L.Zheng, "Ecosystem analysis in the design ofo pen platform-based in-home healthcare terminals towards the internet-of-things," in Proc.15th Int.Conf. Adv. Commun.Technol.,2013, pp. 529–534.

[11] Boyi Xu, Li Da Xu, Senior Member, IEEE, Hongming Cai, Cheng Xie, Jingyuan Hu, and Fenglin Bu, "Ubiquitous Data Accessing Method in IoT-Based Information System for Emergency Medical Services, " IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS, VOL. 10, NO. 2, MAY 2014.

[12] X. D. Wu, M. Q. Ye, D. H. Hu, G. Q. Wu, X. G. Hu, and H. Wang, "Pervasive medical information management and services: Key techniques and challenges," Chin. J. Comput., vol. 35, no. 5, pp. 827–845, May 2012.

[13] Health Monitoring and Management Using Internet-of-Things (IoT) Sensing with Cloud-based Processing: Opportunities and Challenges, Moeen Hassanalieragh, 2015 IEEE International Conference.

[14] W. Zhao, C. Wang, and Y. Nakahira, "Medical application on internet of things," in IET Int. Conf. on Com. Tech. and Application (ICCTA 2011), Oct 2011, pp. 660–665.

[15] F. Hu, D. Xie, and S. Shen, "On the application of the internet of things in the field of medical and health care," in IEEE Int. Conf. on and IEEE Cyber, Physical and Social Computing Green Computing and Communications (GreenCom),(iThings/CPSCom), Aug 2013, pp. 2053– 2058.

[16] T. Soyata, R. Muraleedharan, C. Funai, M. Kwon, and W. Heinzelman, "Cloud-Vision: Real-Time face recognition using a Mobile-CloudletCloud acceleration architecture," in Proceedings of the 17th IEEE Symposium on Computers and Communications (IEEE ISCC 2012), Cappadocia, Turkey, Jul 2012, pp. 59–66.

[17] G. Nalinipriya and R. Aswin Kumar, "Extensive medical data storage with prominent symmetric algorithms on cloud-a protected framework," in IEEE Int. Conf. on Smart Structures and Systems (ICSSS), March 2013, pp. 171–177.

[18] A. F. M. Hani, I. V. Paputungan, M. F. Hassan, V. S. Asirvadam, and M. Daharus, "Development of private cloud storage for medical image research data," in Int.Conf. on Computer and Inf. Sciences (ICCOINS), June 2014, pp. 1–6.

[19] A.Suresh (2013), "An Efficient Conversion of Epigraphical Textual Image to User Readable Text", International Journal of Engineering Research & Technology (IJERT), ISSN 2278-0181,*Vol. 2, No.9, September 2013* pp. 1301-1304.

[20] A.Suresh (2016), "Sentiment Classification using Decision Tree Based Feature Selection", in International Journal of Control Theory and Applications, (IJCTA) ISSN: 0974-5572, *Vol. 09, No.36, December 2016*, pp.*419* – 425.