Health-IOT Platform based Intelligent Medicine Box

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Abstract: In-home healthcare services based on the Internet-of-Things (IOT) have great business potential. In this project, the Health-IOT platform based Intelligent Medicine box is proposed and implemented. Owing to people's busy schedules and their forgetfulness or loss of memory due to age, many a times they miss their medication dosage meant to be taken at a specific time. Apart from the factor of forgetfulness, sometimes the patients (specifically in the case of elderly and blind people) are unable to read the names written on the medicine packets which may lead to intake of wrong medicines. These factors lead to medication non-adherence which may result in negative consequences for the patient. This is a critical problem for Medical Researchers as it hampers treatment success. This project proposes the design of an automated system which reminds people of their medication schedule and can also take the required medicine at a specific time. This project also provides mechanism to determine the condition of the elderly patients by sensing the one or more vital parameters using sensors such as heart beat sensor and temperature sensor. In the developed system, the time at which patient has taken medicine and the vital parameters readings of the patient measured through sensors can be monitored from the hospital management i.e., from clinical professionals by accessing the database of the patient in the hospital website.

Keywords: Health-IOT, Internet-of-Things(IOT), Intelligent Medicine box(iMedbox).

Introduction

NOWADAYS, global aging and the prevalence of chronic diseases have become a common concern. Many countries are undergoing hospital restructuring by reducing the number of hospital beds and increasing the proportion of home healthcare. A promising trend in healthcare is to move routine medical checks and other healthcare services from hospital (Hospital-Centric) to the home environment (Home-Centric). By doing so, first, the patients can get seamless healthcare at anytime in a comfortable home environment; second, society‟s financial burden could be greatly reduced by remote treatment; third, limited hospital resources can be released for people in need of emergency care. In-home healthcare and services can drastically reduce the total expenditure on medical care or treatment. 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 analyzing 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. Medication adherence is the degree to which a patient correctly follows the medical advice and Medication non-adherence is referred to negligence and delays in taking your medicines, not following your prescriptions or even neglecting medication. Medical Non-adherence also refers to altering medications and taking medications in combinations. Studies show that in developed countries, medical adherence is about 50%. The situation in developing countries is even worse.The problem of medication non-adherence is critical because of 1) Forgetfulness in the case of elders, 2) Inability to read and understand the prescription and the names on the medicines, and 3) Lack of resources and knowledge to utilize the various mobile based medication reminder applications. Medication non-adherence can have severe negative consequences for the patient. It may lead to adverse outcomes like health related problems, and even increased duration of treatment with higher cost. The available solutions can be divided into Software based and Hardware based methods. The majority of the software based solutions comprises of various medication reminder applications for several mobile based platforms which cannot be used by illiterate and elderly people. The device proposed in this project is a hardware based solutions. It is required to be fed in with the medication pills and their schedule by the doctor, the doctor‟s assistant or some literate family member (caretaker). The device then notifies the medicine to the patient at the required time.

Literature Survey

The use of tele health monitoring systems by skilled clinicians with critical care experience will reduce the hospitalization rate, save large amounts of money, provide more effective home health management for patients with diabetes, and improve the health care system in general by reducing the use of inpatient services [1].Decision-Support System (DSS) frameworks provide the mechanism with which clinical data from tele health devices is analyzed. This paper will also show the importance of DSS in tele health management systems for all patients with a chronic disease, not just those with diabetes [2].Tele health systems are a practical and cost-effective way of providing care to chronically ill patients by enhancing health care providers‟ ability to provide quality care in patients‟ homes and delay, or sometimes even eliminate, the need for expensive hospital admissions or traditional nursing home care [3]. Remote patient monitoring, which tracks and monitors patients, also offers more frequent contact between the patient and the primary care provider, provides early detection of potential problems, and allows real-time alerts, resulting in a proactive, affordable option for best-practice health care. [4]Home Tele monitoring for Chronic Disease Management: An Economic Assessment, analyzed the consumption of health care services by 95 patients with various chronic 5 month without technology. They find out there is a large reduction in number of hospitalizations, length of average hospital stay and, to a lesser extent, number of emergency room visits. Survey also found that the use of tele monitoring systems will save more than $1557 per patient as calculated on annualized basis, This represents a net gain of 41% as compared to traditional home care [5].

Problem Statement

In the present world, problem of medication non-adherence is critical because of 1) Forgetfulness in the case of elders, 2) Inability to read and understand the prescription and the names on the medicines, and 3) Lack of resources and knowledge to utilize the various mobile based medication reminder applications and also in the existing system the people have to waste a whole day to visit a hospital for monitoring their health and the person will not be able to check basic vital parameters when they are at home.

Existing system:

- Software based: Applications on mobile based platforms.

Limitations of existing system:

- Cannot identify which medicine to be taken.
- Cannot be used by those who cannot afford smart phones or are tech averse

Proposed System

iMedbox i.e. Intelligent Medicine box is proposed as a device-based solution to the mentioned problem faced by elders. It keeps your medicines as well as notifies the schedule to take them. It tackles the problem of forgetfulness and memory loss in elderly people and efforts have been made to make this device usable for the disabled people. Intelligent Medicine box is designed assuming no medical knowledge or literacy on the part of the patient. It assumes the presence of a Caretaker who could program the device using its simple interface for the use of the patient.

In the health monitoring system the patient can measure the vital parameters in the home environment and also get seamless healthcare at anytime in a comfortable home environment thus financial burden can be greatly reduced by remote treatment.

System Architecture

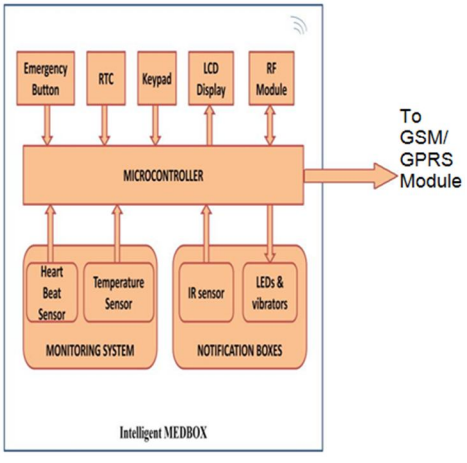

Figure 1: Block Diagram of Intelligent Medicine Box

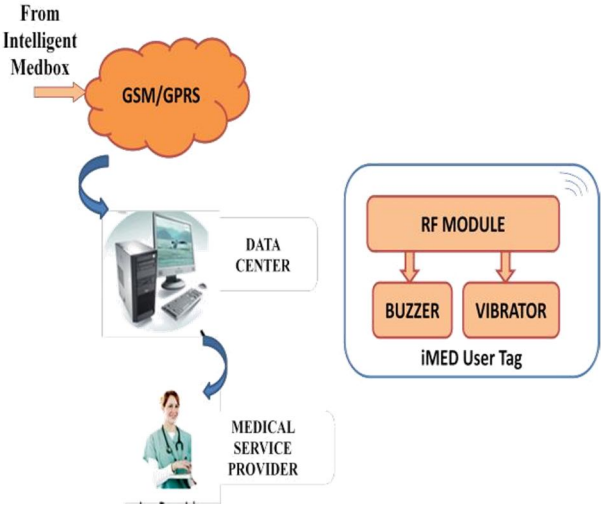

Figure 2: iMed User Tag

Proposed System Design

Proposed System is made up of two major components: iMED Box and iMED User-Tag. The box contains multiple small compartments in which only one particular medicine will be kept in each. The box has an LCD and a Keypad to interact with the user and has LED"s, vibrators and buzzers for notifications. It is connected via RF transmission to the User-Tag which is a small device to be kept by the patient at all times. The schedule of each medicine for the patient needs to be programmed into the iMed Box by the caretaker. It tracks the schedule, notifies the patient, and all the patient has to do is take the medicine kept in the box indicated by a light/vibrator. Apart from time of the medicine, it stores information like number of pills to be taken. A real time health monitoring system is a wearable device. This device will be wearied by the patient and parameters such as Temperature and Heart Beat will be measured and transmitted through wireless technology like GSM/GPRS at the time of taking medicines and the findings and the time at which medicines are taken are stored in database management of hospital and can be monitored from hospital management, i.e. by clinical professionals by accessing the data base of the patient records from hospital website.

The schedule of each medicine for the patient needs to be programmed into the MedAssist Box by the caretaker. It tracks the schedule, notifies the patient, and all the patient has to do is take the medicine kept in the box indicated by a light/vibrator. Apart from time of the medicine, it stores information like number of pills to be taken and for how many days the medicine is to be taken.

The Working is broken into parts:

Step 1: After getting the medicine prescriptions, the caretaker puts the medicines in compartments (one type in each) and sets the schedules for all the medicines using the on-device Keypad and LCD.

Step 2: After Step 1, all the required info is with the device. It keeps track with a real time clock. When the time comes to take a pill, it notifies the user.

Step 3 (Notification): It notifies the user by making a loud noise with a buzzer installed in the device and also uses RF Transmission to the "User Tag" with the user. The indicator light next to the compartment with the medicine scheduled to be taken will also turn on, and an attached vibrator is turned on (for the blind).

Step 4: After opening medicine box, patient will measure pulse rate and body temperature and the readings will be updated in the database along with time at which patient has taken medicine.

Implementation Details

Intelligent Medicine box(iMedbox) has one PIC 18F4520 Microcontroller Unit (MCU), one RF Module, Heart beat sensor, temperature sensor, RTC(Real time clock), GSM/GPRS modem, IR Sensor,16x4 LCD and one 4X4 Keypad as its major components. The MCU along with the Keypad make the major device (The Med Box) and RF Module make the "User-Tag" to be kept with the user for efficient notifications.

Hardware Implementation

Hardware Implementation is explained in two parts 1) The Med box and 2) User-Tag.

1. The Med box**:** A PIC 18F4520 microcontroller is the back end of this device. LCD and a 4X4 Keypad make up the User-Interface of the device. A buzzer and a main LED are placed on the Med Box both of which are triggered during the alarm time. Keypad controls are shown in Fig. 3. The Med Box has 4 compartments for 4 different types of medications. Each Compartment has one LED and one Vibrator which indicate the particular medication compartment during a particular alarm time. IR sensor is incorporated in each compartment as a sensor unit. This way, MCU can track whether user has opened the compartment during the alarm time or not. At the time of an alarm, The MCU sends the signal to the LEDs/Vibrators and also to RF module which transmits the signal to User-Tag. After opening medicine box, patient will measure pulse rate and body temperature and the readings will be updated in the database along with time at which patient has taken medicine.

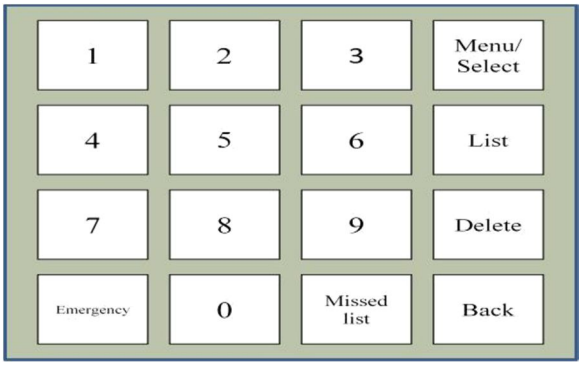

Figure 3: The Keypad layout

2. The User-Tag: The User-Tag has one transceiver RF module, one buzzer. The transmitter end of the RF module is attached with the Med box via MCU. The MCU triggers the transmitter at the time of an alarm which then sends a signal to the receiver end of the RF module which is attached with the User-Tag. The buzzer on the User-Tag turns on upon reception of this signal. This way, the patient can receive the notification even being far away from the iMedbox device.

Software Implementation

This section explains how the various functionalities of MedAssist are programmed.

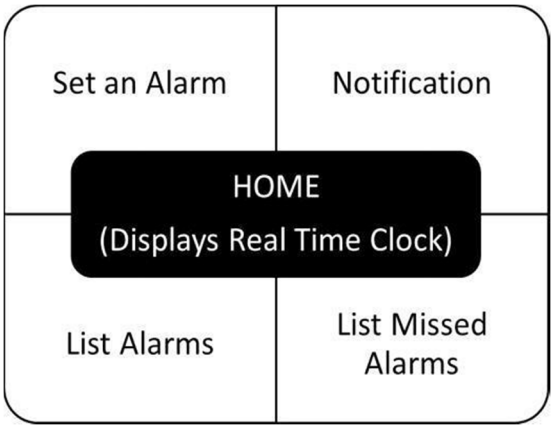

Figure 4: Functionalities of iMed box

The different modes of Software implementation are

Home: By default, the device is set in Home mode which shows Real Time Clock (RTC) on LCD screen and the microcontroller is in its Low Power Mode with interrupts enabled. In the event of an interrupt, it exits low power mode, executes the desired function, and goes back into low power mode. Notification of an alarm is an internal interrupt function and rest are external hardware interrupts caused due to pressing buttons on 4X4 Keypad or opening pill-boxes.

Set an alarm: Pressing one specific button on the Keypad triggers the interrupt corresponding to „Set an Alarm‟. The device wakes up from low power mode and calls „Set Alarm‟ function, executes it and goes back to Low power mode.

List Alarms: To view the list of alarms that are fed in the device, a button on the Keypad corresponding to “List Alarm()” can be pressed. It displays the list of alarms which can be navigated using buttons on the Keypad. User also has the option to delete any particular alarm using the Delete button.

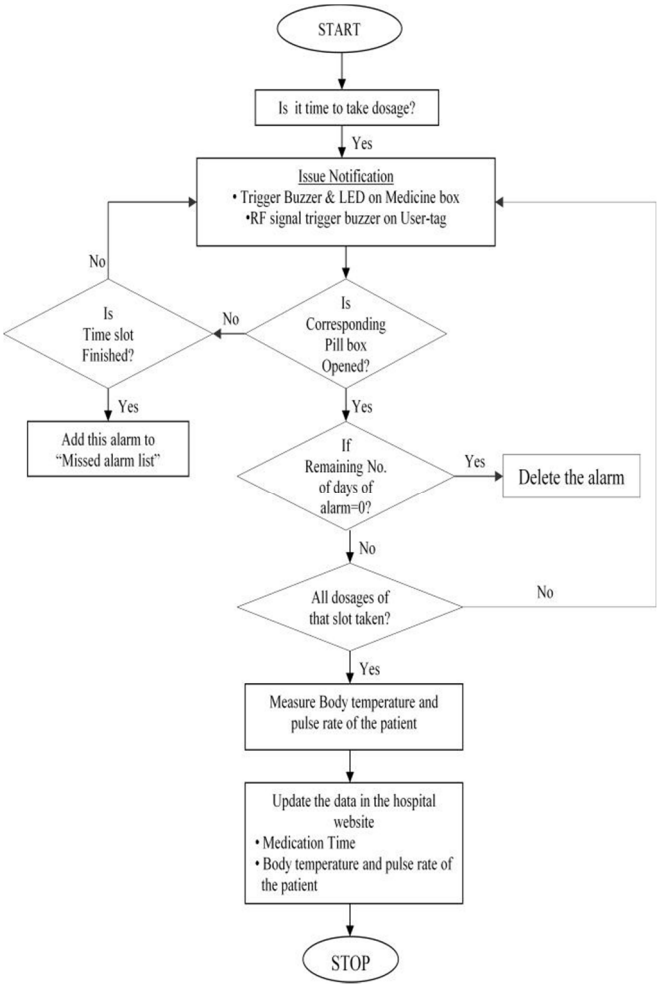

Figure 5: Flow chart of intelligent medicine box

When the time of an alarm matches with the Real time clock of MCU, Notifications interrupt is triggered. As the Notification interrupt is triggered, the Med Box buzzer is activated and the LED and Vibrator of the corresponding compartment along with the main LED turn on.

List Missed Alarms: When the user does not take the notified medication in the 1 hour time-slot, Med box assumes that there is no response from the user and adds that particular alarm to the „List of Missed Alarms". To view the „List of Missed Alarms", trigger the interrupt corresponding to "Stack Alarm ()". It displays the List of Missed Alarms which can be navigated using buttons on the Keypad. The Caretaker/Patient can use this to know about missed medications, contact their doctor to know how to proceed further. They can then delete that particular alarm from this list using the Delete button.

Result Analysis

The proposed project has been validated the effectiveness and advantages of the proposed methodology by doing software testing. Each module of the program was verified with various test cases. The device was programmed in such a way that it uses the available memory of PIC microcontroller efficiently.

The prototype was well designed to implement all the software modules and tested with all possible cases. All the basic functionalities mentioned in the proposed solution were successfully implemented in the prototype.

The iMedBox platform is built based on the integration of smart sensors with hospital database. The main focus in the implemented project is to regulate and optimize the accessibility of medical drugs and efficiently provide home-based healthcare services. The developed iMed box-IoT system connects the individual home environment with hospital, emergency centre and other medical facilities

A novel functionality in the proposed device is the Notification system: the indicators on the box and the User-tag. The User-tag uses wireless communication, thus making it possible for the user to sense the notification even when the patient is far away from the device.

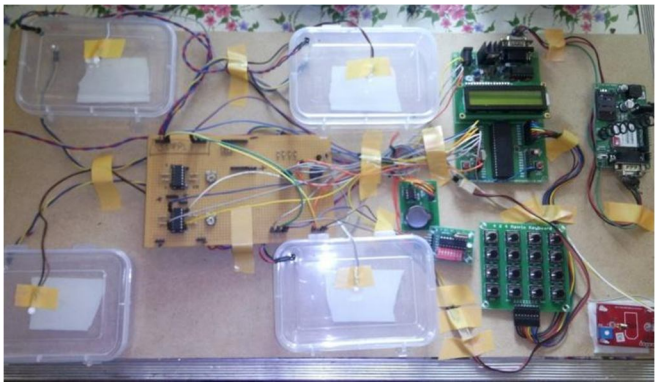

Figure 6: Prototype of Intelligent Medicine box

Figure 7: Emergency SMS sent to clinical professionals

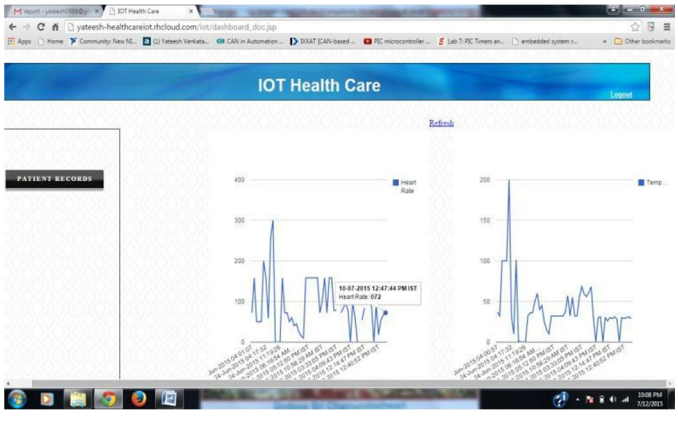

Figure 8: Heart rate & body temperature record of the patient in hospital website

The pills are to be kept within the medication box inside the medicine kit. When the patient feels uneasiness and if the patient presses emergency button, then emergency message will be sent to clinical professionals.

The device is completely user friendly as heart beat sensor and temperature sensor is interfaced with the intelligent medication box and the data from both the sensors will be updated in the hospital website.

Figure 9: Record of the patient Medicine taken time in the hospital website

Conclusion and Future Work

IOT now has been recognized as a revolution and is expected to be applied to many industrial sectors including healthcare. The iMedBox serves as a home healthcare station providing strong interoperability and IOT network connectivity. By connecting the iMedBox, Bio-Patch, and the back-end services through a wireless link, the iMedBox can deliver various services, including real-time bio-signal monitoring, local analysis and alarm, remote diagnosis and prescription, and medication noncompliance control. The Health-IOT iMedbox system combines the health social network, telemedicine and emergency and medication management services. It will speed up the transformation from Hospital-Centric medical treatment to Home-Centric healthcare, and finally bring about ubiquitous and personalized healthcare.

There are number of features that can be planned which increases the scope of Intelligent Medicine box project. I have planned to use a smaller RF module so as to make the User-Tag similar to a wrist-watch. Adding voice-based prompts such as „Take this medicine after lunch" and „Take this medicine before dinner" can increase the usability of the device as well and also e-prescription feature can be added to Intelligent Medicine box, where the changes in prescription by doctor will be automatically updated in the Intelligent Medicine box. Also, a mobile based app instead of RF user tag can be developed targeting urban crowd in the country. This app can also be used to track the intake of medicines by the patient.

References

[1] Geng Yang, Li Xie, Matti Mäntysalo, Xiaolin Zhou, Zhibo Pang, Li Da Xu, Sharon Kao-Walter, Qiang Chen, and Li-Rong Zheng, "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, 1551-3203 © 2014 IEEE

[2] S. Li, L. Xu, and X. Wang, "A continuous biomedical signal acquisition system based on compressed sensing in body sensor networks," IEEE Trans. Ind. Informat., vol. 9, no. 3, pp. 1764–1771, Aug. 2013

[3] Grad. Program in Bioeng., Seoul Nat. Univ.,Seoul, South Korea ;Gih Sung Chung ; Ko Keun Kim ; Kwang Suk Park "A Smart Health Monitoring Chair for Nonintrusive Measurement of Biological Signals ", Information Technology in Biomedicine, IEEE Transactions on (Volume:16 , Issue: 1), 1089-7771 © 2012 IEEE

[4] P. Castillejo, J.-F. Martinez, J. Rodriguez-Molina, and A. Cuerva, "Integration of wearable devices in a wireless sensor network for an E-health application," IEEE Wireless Commun., vol. 20, no. 4, pp. 38–49, Aug. 2013.

[5] Abdelghani Benharref, Mohamed Adel Serhani "Novel Cloud and SOA-Based Framework for E- Health Monitoring Using Wireless Biosensors", IEEE Journal Of Biomedical And Health Informatics, VoL. 18, No. 1, January 2014

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

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

[8] E. Welbourne et al., "Building the Internet of Things using RFID: The RFID ecosystem experience," IEEE Internet Comput., vol. 13, no. 3, pp. 48–55, Jun. 2009.