A Health-IoT-based Smart Medicine Box

Abilesh K S
Electrical and Electronics Engineering
Kumaraguru College of Technology
Coimbatore
abilesh.20ee@kct.ac.in

Naveen V
Electrical and Electronics Engineering
Kumaraguru College of Technology
Coimbatore
naveen1.20ee@kct.ac.in

Pozhilan S
Electrical and Electronics Engineering
Kumaraguru College of Technology
Coimbatore
pozhilan.20ee@kct.ac.in

Shanmugaraja P
Electrical and Electronics Engineering
Kumaraguru College of Techlology
Coimbatore
shanmugaraja.20ee@kct.ac.in

Raffik R
Mechatronics Engineering
Kumaraguru College of Techlology
Coimbatore
raffik.r.mce@kct.ac.in

***Abstract*— The Internet of Things - IoT has made its footprint in each nook of fields. In this way, it has already been entered into the medical field. IoT enables home-centric based medical aid to the patient which is extremely reliable and easy to use. It creates a virtual hospital experience and assists the patient with regular medicine intake in case of any critical emergency, it notifies the doctor and their family members. Intelligent medicine packaging has reduced the risk of overdosage, under dosage, and any mis-intake of the medicine on time. Thus, a smart medicine box is created to implement all these features called iMedBox. It mainly performs three functions remaindering, monitoring, and warning. It uses current technologies to implement these features. A smart band will be fitted onto the patient's arm to continuously measure the body temperature, blood pressure, ECG, and heartbeats per minute. All this data will be sent to the iMedBox which analyzes this data to predict any abnormalities and display stats onto the LCD fitted onto the box. A periodic alarm will be made, and a smart medicine package will be used for efficient medicine intake. In case of any abnormalities, it alarms the doctor and family members. The box is made with uninterrupted connectivity without any signal loss and is user-friendly. Research on biosensors is increasing to improve their effectiveness and reduce their size to remote space complications and not create any disturbances to the user. The Graphical User Interface (GUI) of the box is made in mind that it can even be accessible to elderly patients.**

Keywords—IoT, health sector, medicine box, biosensors, MQTT

I. INTRODUCTION

The average age of human beings has been increasing due to advancements in medical technologies. Applying the concepts of IoT may improve the medical field to a great extent. IoT has revolutionized each field since the beginning of the 21st century. It has made the possibility of controlling sensors, actuators, and other devices anywhere in the world utilizing the development of wireless technologies in the network architecture. The concept of remote health in a comfortable place with the patient is very friendly and economical to implement. Routine medical check-ups and continuous health monitoring can now be made easier. This can drastically reduce hospital resources and medical expenditures. In the case of elderly people, this system will be of great use. Research shows that about 25% of the adult population does not take medicine at the prescribed time. This system will mainly serve three main purposes: 1) Continuous monitoring of the health of the patient using a biosensor fitted on the patient 2) Timely remainder for medicine intake at a particular time of the day 3) Warnings in case of improper medicine intake and emergencies based on the predictive analysis made on the health data from the biosensors [1]. These can be incorporated into our smart devices like smartphone, smartwatches, etc., for seamless connectivity and a friendly environment that open the door for new business opportunities. The advancements in the technologies like long-range communication, uninterrupted connectivity, and user-friendly nature have extended its opportunities in many fields. Health IoT systems could be implemented to monitor the health of the patient 24/7. Heath IoT platform has improved to make the biosensors wearable and predict the chronic disease at the earliest to improve the longevity of humankind. The prototype of this model is built in mind with reduced physical size, longer battery life, low-cost and rigid structure.

The smart medicine box works completely on the internet, and it is prone to malware attacks and data phishing. So, it has been well protected using a strong encryption method that the user and doctor need to verify their identity to access any information through the network. The auxiliary devices are well protected against data theft. All the collected information from the biosensor fitted onto the patient will be transferred safely through the network and stored at the data centres securely. Also, accessing information from those data centers needs verification. It needs support for long-term usage and does not malfunction at any cost and future proof of idea. It expands the contribution of IoT to the medical field. This system is perfectly tailored to each patient, and it can be personalized and unique for them based on their medical procedure. It acts as a bridge between the patient and the hospital. The patient's health data are stored at the data centres and are kept forever safe for future diagnosis and improved medical treatment. Engineering and technology improved humankind to a great extent. The ultimate motive of this prototype is to transform hospital-centric medical facilities into home-centric. These technologies enable the medical field to become smart by automating the workflow, and monitoring of equipment with high accuracy. Remote health monitoring helps in reducing frequent visits to the hospital using wearable biosensors.

II. ARCHITECTURE OF HEALTH IOT

A. Patient Level

First, as in Fig. 1. biosensors are fitted onto the patient with comfortable wearable modules. It senses the ECG (Electrocardiogram – Electric changes in the heart), Oxygen level (SpO2), and BPM (Beats Per Minute). All these data are sent to the health IoT cloud using a microcontroller and wireless communication modules [2]. Fig. 4., shows the module which will be fitted onto the patient for health data gathering. It contains a tiny MAX30102 biosensor which can

measure the blood oxygen level, BPM, and temperature of the body. An ESP 8266 is a low-powered microcontroller that collects these data from the sensor and sends it to the cloud platform. Various other sensors which can be implemented into the patient are blood glucose sensors, oxygen saturation sensors, and temperature sensors.

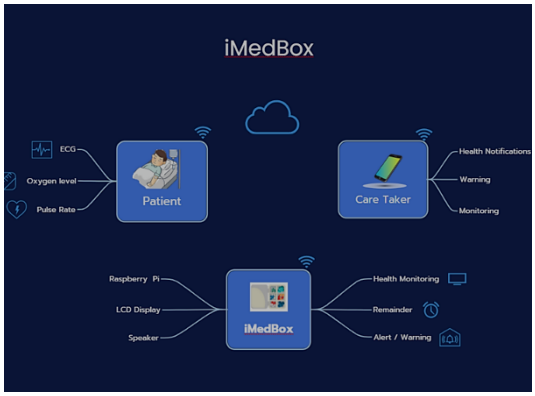

Fig. 1. Block diagram of the smart medbox at various levels

B. *Smart Medicine Box Module Level*

The Smart Medicine Box Module acts as a central device that coordinates the patient and the hospital. It collects the data from the IoT health cloud and displays it on the LCD on the lid of the box. In case of any health complications, it alerts the caretakers and remains a timely reminder for medicine intake. Fig. 3., shows the smart medicine box which contains smart compartments, an LCD, GSM modules, and buzzers. All these components are coordinated by ESP32, which is a low-power consuming microcontroller with high-end capabilities like Bluetooth and Wi-Fi. This acts as a medium of communication for the doctor and patient. It is made as a robust and rigid structure.

C. *Hospital Level*

All the health data will be stored at the data centres of the hospital and used for future use. Doctors can continuously monitor the patient's health and personalize the medical procedure for the improvement of their health [4]. Fig. 6., shows the data which will be collected from the patient which is continuously stored in the health-IoT cloud. Predictive analysis is made on these data to provide some insights. Here ThingSpeak is used as a health-IoT platform for collecting and storing these data.

III. FLOWCHART OF THE WORKFLOW

A. *Data Collection and Health Monitoring*

In the first step, as in Fig. 2. vital health data like BPM, Oxygen level, and Temperature of the patient are collected through the biosensors and stored in the health-IoT system. Doctors can continuously monitor the patient's health and take any important decisions based on the data [3]. All the collected data will be stored in the data centres for future reference. Based on the improvement in the health of the patient, a new prescription will be made and updated to the medicine box. Predictive analysis will be made to detect any disease at the early stage. This enables the transformation of hospital-centric to home-centric medicine applications.

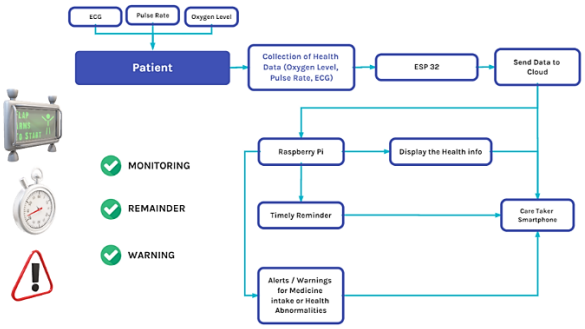

Fig. 2. Flowchart of proposed work

B. *Remainder for Medicine Intake*

A timely reminder for medicine intake will be done for proper medicine intake at regular intervals. An alarm and buzzer will be made for the patient. In case of failure of intake, a notification will be made to the caretaker. If continuous failure of medicine intake, a warning will be sent to the caretakers which will be helpful to take immediate action. Smart medicine package at the medicine box, only the compartments of the prescribed medicine will be made open, and it prevents the mis-intake of the medicine in case of elderly people [12]. To predict if the patient has taken only the recommended quantity of medicine, a weight sensor is used to find the weight of the medicine box before and after the medicine intake time. This helps predict any overdosage, under dosage, and untaken medicine. The medicine box is made in mind with a highly secure and perfect and rigid structure that suits most environmental conditions and surfaces.

C. *Warning for Emergency Conditions*

Data collected from the biosensors on the health IoT cloud will be made available for predictive analysis using machine learning models and predict any critical situations. Also, health data will be made for predictive analysis to detect the disease at the earliest. If found, a danger alarm will be made to the caretakers along with the type of complication that occurred and take emergency actions. In case of any internet interruptions in the internet connectivity, the warning will be sent through the GSM module [5]. It does not require any internet connectivity and sends the message through a simple 2G network. A dedicated software application will be made, and a user-friendly GUI (Graphical User Interface) is created for a seamless experience even for elderly people. This helps them to interact with the box easily.

IV. SYSTEM INTEGRATION AND PROTOTYPE DEMONSTRATION

A. *Components Used*

TABLE I. COMPONENTS USED

S. No.	Components Used
1.	ESP 8266
2.	MAX30102
3.	ESP 32
4.	16X2 LCD Display with I2C module
5.	Buzzer
6.	GSM 800L
7.	ThingSpeak

1) ESP 8266:

ESP 8266 32-bit, RISC processor. Is a low-power, battery-operatable microcontroller that acts as the heart of the system by monitoring and controlling all the peripherals connected to it. It has a built-in Wi-Fi module which makes it most suitable for our application.

2) MAX 30102:

MAX 30102 is a modern biosensor that has an integrated heart rate sensor and pulse oximeter. It can measure the heart rate (HR) and pulse oximetry (SpO_2) which can operate at a 3.3V voltage level. The sensor also consists of an on-chip temperature sensor to measure the body temperature. It works on the concept of photoplethysmogram, by measuring the amount of reflected light from the Red and IR LEDs and a photodetector. The data can be read only with the SCL and SDA lines from the sensor using its I2C compatibility.

3) ESP 32:

ESP 32 is a successor to ESP 8266 because of its dual-core processing, Wi-Fi, and Bluetooth capabilities. It is used as the main processing power due to its high processing power of up to 2.4GHz and storage [10]. ESP 32 has more analog and digital pins than ESP 8266 which makes it easier to connect more peripherals like LCD display, buzzer, and GSM module.

4) LCD display:

A 16X2 LCD display with an I2C module is used for easy visualization of the health data of the patient and the timely remainder of the medicine intake.

5) Buzzer:

In cases of medicine remainder and critical situations, a buzzer action will be made to alert the patient to take the required medication.

6) GSM 800L:

GSM 800L operates at a voltage range of 3.4 – 4.4V and requires more current for its operation. So it will be powered with an external Li-Po battery. It uses any 2G Micro sim for its operation of sending messages and voice call without the use of the internet.

7) ThingSpeak

ThingSpeak is a cloud-based IoT analytics platform from MATLAB used to analyze and visualize IoT data. Four independent channels have been created and visualized the health data of the patient.

B. Prototype Model

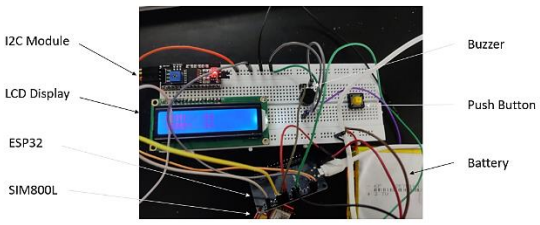

Fig. 3. Hardware module of a smart medicine box.

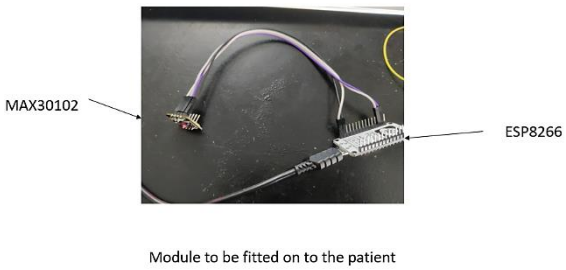

Fig. 4. Bio-sensor module fitted onto the patient.

A prototype for the idea is made with the components mentioned in above TABLE I. The first module is made with MAX3012, ESP8266, and a battery power source. It is made to operate wirelessly using MQTT and internet connectivity. So that the patient will be having a maximum degree of freedom of movement. The second module is the heart of medicine and acts as a central unit for controlling and processing all the data collected through the biosensor. It monitors the health, gives timely remainder for the medicine intake, and alerts the caretakers about any complications using predictive analysis.

C. Remote Prescription

A unique medicine prescription can be created every time for every person [9]. The biosensor fitted onto the patient will be continuously monitoring the vital health data of the patient and sending it to the database and the medbox continuously. The doctor can check the health of the patient remotely and change the prescription for the patient like increasing or decreasing the dosage level for the patient based on the sensor data. Thus, the doctor can have a complete diagnosis over the patient's e-prescriptions will be made. Also, the doctor verifies the medicine before dispensing it. The medbox operators are only based on the prescription given by the patient and open a particular compartment at a particular time of the day [6]. This prevents the mis-intake of medicine and ease of remote control over the medicine by the doctor. Every patient will be having a unique ID and the doctor can monitor and control the patients seamlessly. Medbox contains an LCD that shows the health data of the patient on the screen for the patient to feel themselves having the medical facilities available right in the world.

D. Medication Reminder

In Fig. 5., The medbox reminds the patient to take the medicine at a particular time of the day using the buzzer and speaker fitted in the box. Only the prescribed medicine containers will be open for the patient for a particular duration of time to avoid spills. A weight sensor fitted with the medbox calculates the weight of the box before and after the medicine intake and alarms or warns the doctor about any overdosage, dosage, and untaken medicine [7].

A mail or any app will remind the patient of medicine intake. Mail will be sent to the patient's caretakers or close relatives. Various wireless technologies are tested for better coverage without any interruption between the patient and the hospital. A GSM can also be used to send notifications in case of any remote locations without network coverage. All the information about the medicine intake will also be stored in a data server of the hospital for any future reference. A unique medicine compartment will be very useful for elderly patients who will forget to take the medicine at the proper time of the

day [8]. A well-designed Graphical User Interface (GUI) is developed for easy understanding of the medical prescription and health data coming through the biosensor which is fitted in contact with the patient's body.

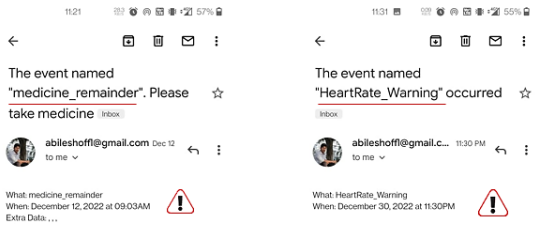

Fig. 5. Screenshot of a medication reminder and health warning sent to the caretaker and patient.

E. Programming and ThingSpeak

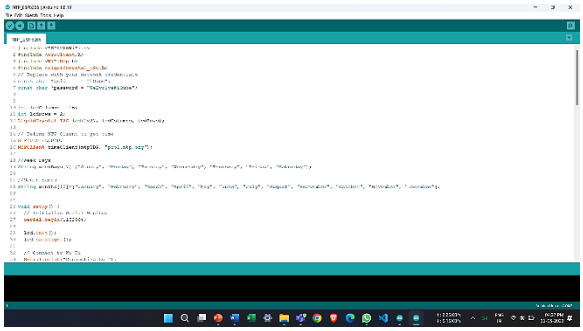

Fig. 6. Programming on Arduino IDE

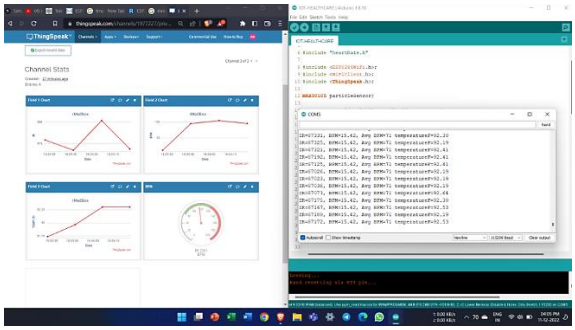

Fig. 7. Data collection on ThingSpeak

Fig. 6. & Fig. 7. Shows the technologies used and coding required to implement the concept of a smart medicine box. The Programming was done on Arduino IDE and the data from the biosensors are stored and visualized on the ThingSpeak IoT platform [7]. Various types of data visualization are used to display the data – Line graph and Gauge.

V. CONCLUSION

The rapid aging of humans is a major problem in the current century and challenging to the medical industry. Advancements are made to convert hospital-centric to home-centric medical facilities with optimized quality. Three major blocks of improvements which were done with this project were a smart medicine box, continuous monitoring of the health of the patient, and warning for any health abnormalities. Doctors can provide a personalized medical experience to the patient with these advancements in the medical industry with the help of IoT [11]. The vital signals are monitored continuously which could be used to predict any major health emergencies. More comfortable biosensors need to be made with the help of flexible silicon PCBs and a user-friendly GUI is needed to establish a strong impact on the health-IoT. Improvements in virtual healthcare are happening every day using remote healthcare tools, video consulting tools, and remote examination tools.

REFERENCES

[1] F. Wu, T. Wu, and M. R. Yuce, "Design and Implementation of a Wearable Sensor Network System for IoT-Connected Safety and Health Applications," 2019 IEEE 5th World Forum on Internet of Things (WF-IoT), Limerick, Ireland, 2019, pp. 87-90, doi: 10.1109/WF-IoT.2019.8767280.

[2] S. Ahamed, P. Bhatt, S. Sultanuddin, R. Walia, M. A. Haque and S. B. InayathAhamed, "An Intelligent IoT enabled Health Care Surveillance using Machine Learning," 2022 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI), Chennai, India, 2022, pp. 1-5, doi: 10.1109/ACCAI53970.2022.9752648.

[3] G. Yang et al., "A Health-IoT Platform Based on the Integration of Intelligent Packaging, Unobtrusive Bio-Sensor, and Intelligent Medicine Box," in IEEE Transactions on Industrial Informatics, vol. 10, no. 4, pp. 2180-2191, Nov. 2014, doi: 10.1109/TII.2014.2307795.

[4] T. Parbat, R. S. Benhal and H. Jain, "IoT Based Health Care Data Monitoring Using Machine Learning," 2022 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS), Erode, India, 2022, pp. 282-286, doi: 10.1109/ICSCDS53736.2022.9760770.

[5] S. Said, S. AlKork, T. Beyrouthy and M. F. Abdrabbo, "Wearable bio-sensors bracelet for drivers health emergency detection," 2017 2nd International Conference on Bio-engineering for Smart Technologies (BioSMART), Paris, France, 2017, pp. 1-4, doi: 10.1109/BIOSMART.2017.8095335.

[6] M. R. Yuce, "Recent wireless body sensors: Design and implementation," 2013 IEEE MTT-S International Microwave Workshop Series on RF and Wireless Technologies for Biomedical and Healthcare Applications (IMWS-BIO), Singapore, 2013, pp. 1-3, doi: 10.1109/IMWS-BIO.2013.6756254.

[7] O. Elijah, S. K. A. Rahim, M. J. Musa, Y. O. Salihu, M. J. Bello, and M. -Y. Sani, "Development of LoRa-Sigfox IoT Device for Long Distance Applications," 2022 IEEE Nigeria 4th International Conference on Disruptive Technologies for Sustainable Development (NIGERCON), Lagos, Nigeria, 2022, pp. 1-5, doi: 10.1109/NIGERCON54645.2022.9803173.

[8] J. Liu, Q. Wang, B. Wei, and Z. Li, "A fault early warning and health status rating method for ensuring safe operation of rotating equipment," 2019 6th International Conference on Information Science and Control Engineering (ICISCE), Shanghai, China, 2019, pp. 635-643, doi: 10.1109/ICISCE48695.2019.00132.

[9] 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.

[10] T. H. Orpa, A. Ahnaf, T. B. Ovi and M. I. Rizu, "An IoT Based Healthcare Solution With ESP32 Using Machine Learning Model," 2022 4th International Conference on Sustainable Technologies for Industry 4.0 (STI), Dhaka, Bangladesh, 2022, pp. 1-6, doi: 10.1109/STI56238.2022.10103231.

[11] M. Ogawa and T. Togawa, "The concept of the home health monitoring," Proceedings 5th International Workshop on Enterprise Networking and Computing in Healthcare Industry (HealthCom), Santa Monica, CA, USA, 2003, pp. 71-73, doi: 10.1109/HEALTH.2003.1218721.

[12] M. Elkahlout, M. M. Abu-Saqer, A. F. Aldaour, A. Issa and M. Debeljak, "IoT-Based Healthcare and Monitoring Systems for the Elderly: A Literature Survey Study," 2020 International Conference on Assistive and Rehabilitation Technologies (iCareTech), Gaza, Palestine, 2020, pp. 92-96, doi: 10.1109/iCareTech49914.2020.00025.