IoT Use Cases and Applications

G. Priya, M. Lawanya Shri, E. GangaDevi and Jyotir Moy Chatterjee

Abstract IoT in health care is wireless communication system of applications and devices which connects health providers and patients to detect, observe, track, and store medical information and statistics. In this chapter, various case studies of smart healthcare system have been discussed. A model which would monitor aspects of a human body such as his pulse rate and temperature are described. Smart IOT-enabled healthcare wearable device is used to aid paralyzed person for daily chores using machine learning to get better in understanding the patient gestures over time. Health monitoring system pill box and a pulse rate sensor is discussed for Alzheimer's patients. The system is based on Arduino-Uno microcontroller and uses accelerometer and pulse sensor to get data from the patient.

Keywords Internet of things · Healthcare system · Arduino-microcontroller · Machine learning

1 Introduction

The Internet of things plays an significant role in the healthcare industry. Healthcare industry is improved in terms of increasing efficiency, low costs, and having more focus on patients care. We have discussed a model which is helpful to the elderly people and the patient who need constant health inspection. His data can be accessed

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by his/her doctor, and immediate actions can then be taken. The data which are obtained from sensors are uploaded in the cloud, and they can be accessed by anyone. The data collected from sensor can be accessed from smartphone app which shows us the whole information of the user's body. In the next case study, the data that is transmitted over low power 433 MHz transmitter to local computer which further performs the data processing and store onto the cloud. Some hospitals and NGOs are coming forward to serve paralytic patients whose whole or partial body disabled by the paralysis attack. Those people are unable to deliver their requirements as they are unable to speak well nor do they deliver via sign language. In such scenario, the proposed structure helps disabled people in presenting a message on the LCD by simple gesture of any portion of his body. This system helps the patient to send message via GSM whatever he wants to send in SMS when there is no one to take care of him. In the third analysis, medicine dispenser is implemented. Generally, every person forgets to take their pill at once or more than once, but for patients who are on a multifaceted pill administration, not taking prescribed medicines at the right dosage and at the exact time can have main consequences, predominantly if they are elderly people. To our pillbox, we have attached a buzzer that will buzz every time a patient has to take a medicine. We have also included a pulse sensor which will detect the heart rate of the patient and indicate the agitation state of the patient. The results will be displayed using an LCD.

2 Pulse Rate Monitoring System

IOT is nothing but transforming or converting information of data from the physical world into the digital world for making it possible to analyze data to operate tasks [1]. Since our objective is based on health care, the proposed system should be able to manage huge volume of patient's medical data. The need for health care is growing nowadays to improvise admittance to health precaution, raise quality, and reduce cost. In IoT, devices collect and share data directly with others and the cloud is to assemble record and study new data streams quicker and more precisely.

The base for integrating all the things that are all the physical objects such as sensor-based networks is accomplished by using radio radio-frequency identification (RFID), NFC, and other wireless technologies [2]. The Internet-oriented vision provides connection between devices and Internet that described as smart objects. The data collected from sensors is analyzed and interpreted by semantic-oriented vision. When building a device related to health care, three main categories to be considered are tracking of objects, identification, and automatic sensing. The IoT adopts a notable part in a wide scope of public assurance applications, from overseeing chronic diseases toward one side to anticipating malady at the other side.

2.1 Clinical Care

The physical status of hospitalized patients needs continual observation by utilizing IoT-driven and noninvasive checking. This organization uses sensors to collect wide-ranging physical data and uses the cloud to store the data and then send the inspected data remotely to parent for helping investigation [3]. It exchanges the method toward having a comfort proficient stopped by common interims to plaid the patient's imperative symbols, rather than specifying a nonstop computerized sequence of data. At the same time, it improves the environment of care through steady attention and reducing the cost of care by providing the necessity for a parental figure to efficiently take part in data collecting and examination.

2.2 Remote Checking

There are persons universally all over the world whose well-being may suffer in light of the information that they don't have organized admittance to viable health checking [4]. These provisions can be used to safely understanding health information from a variety of sensors, apply difficult designs to separate the data, and then share it over remote availability with restorative professionals who can create suitable healthy proposals. Wearable healthcare systems contain pulse sensors, pulse oximetry sensors, respiratory rate sensors, blood pressure, and body temperature sensors.

Technologies that enable the IoT in health care possible are as follows:

1. Low-power operation,
2. Integrated precision—Analog capabilities, and
3. GUI.

We have built a framework that will plan a calendar which is properly planned for the entire worker in light of their heartbeat rate and the quantity of hours they spent working. The principle intention is the representative to client proportion which is a disturbing number. To counter this worry, this framework is going to be built. It includes fields such as defence, security, finance, banking, etc. Before we start, we have to ensure about the worker part we are thinking about. The high representative to client proportion pushes the worker past their well-being limits. These situations prompt individuals sitting and working for extended periods or extra timework [5]. It influences them socially by diminishing their available time. In this proposed method, we have built a heartbeat checker by using Arduino board, temperature sensor, pulse rate generator, and some wires (Fig. 1).

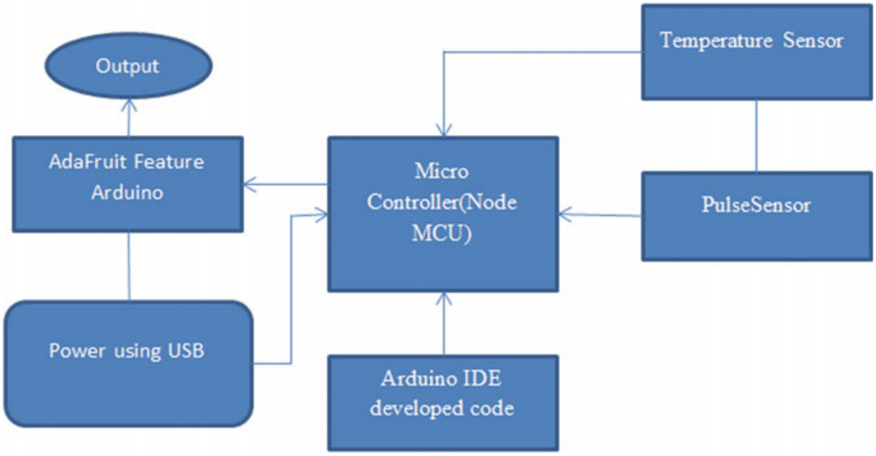
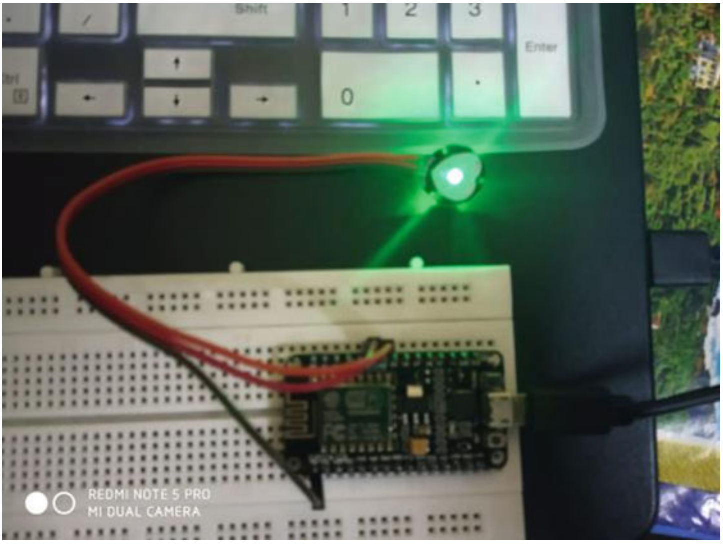


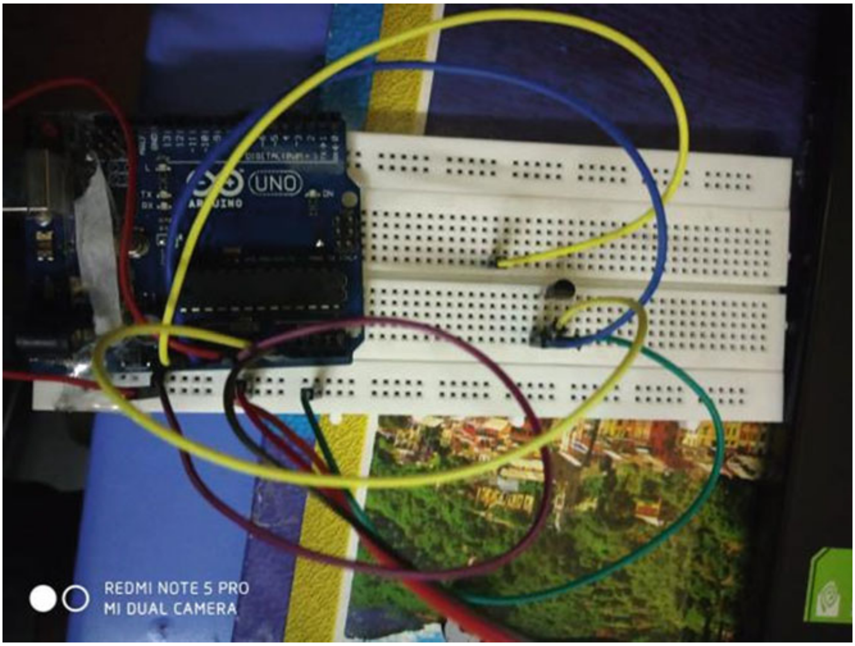
Fig. 1 Architecture of microcontroller

3 Hardware Components

Working With Node MCU:

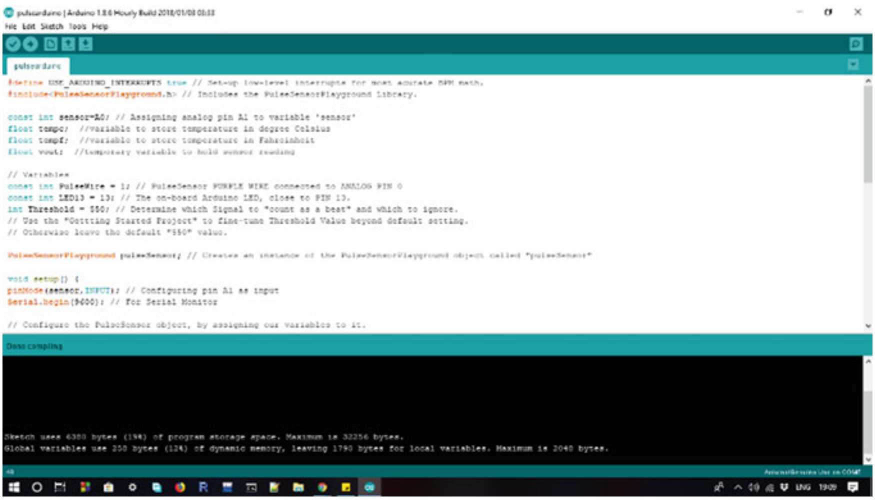


Trying with Arduino UNO:

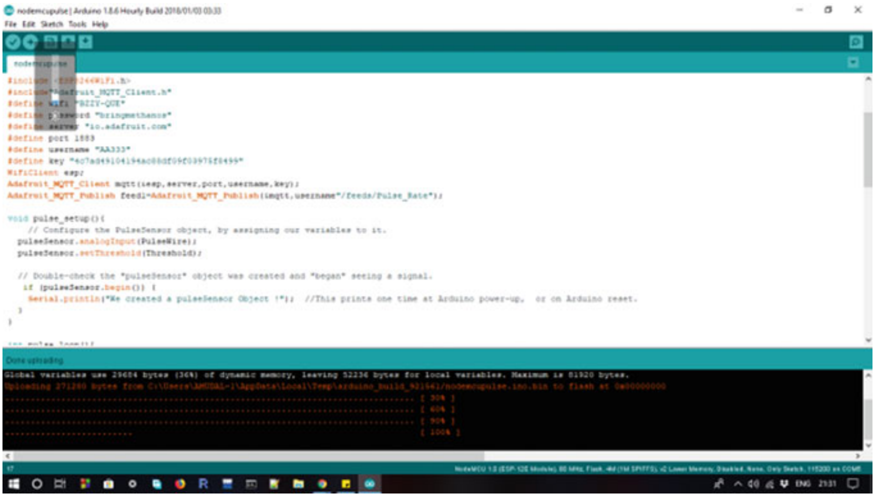


Output Screens

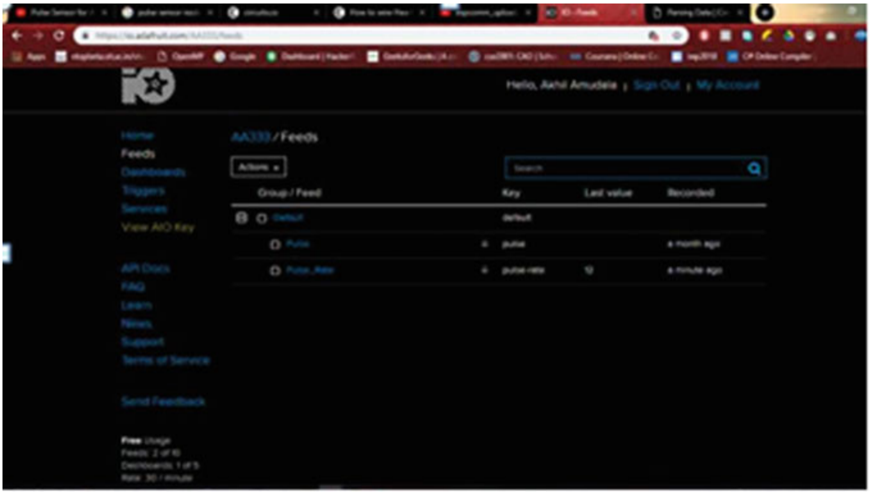
Verifying code:

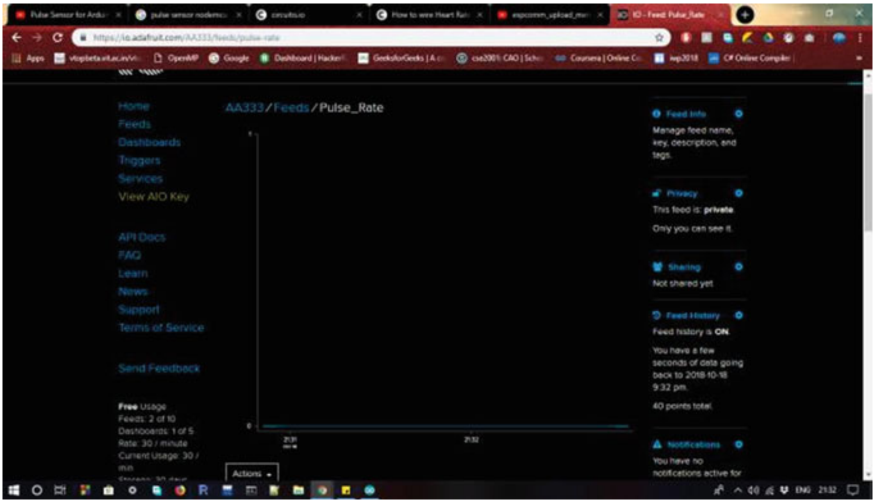


Uploading code to NodeMCU/Wi-Fi module Successfully:

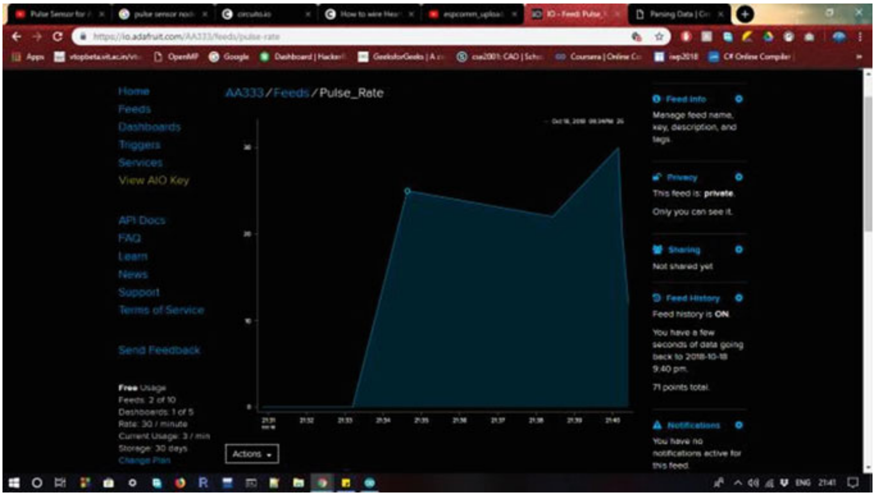


Open Source (AdaFruit compiling): Through Wi-Fi Module:

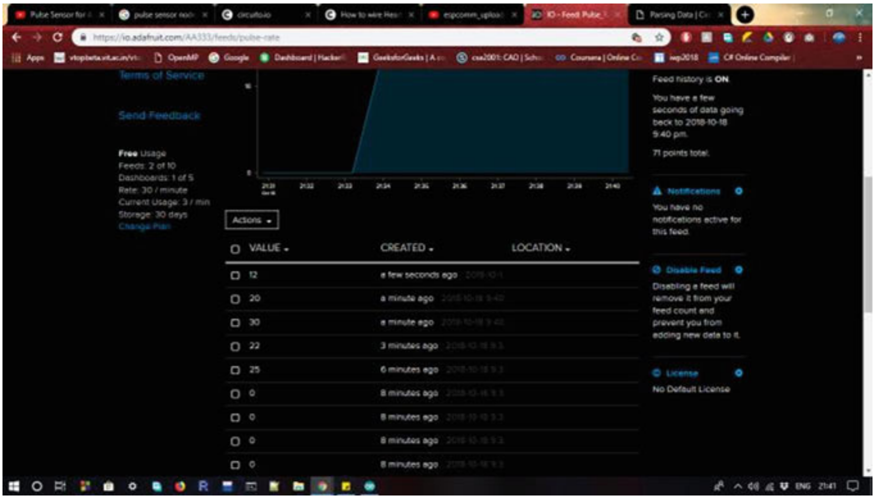




Analytics part:



Values:



NodeMCU uses a Wi-Fi module which is an advantage over Arduino since it makes easier for user to understand and process but still we can use better pulse sensors so that it would read input values so quickly and can work efficiently.

4 Smart Glove for Paralyzed Patients

In our body, if a muscle loses its function, it causes paralysis. This is due to the information which is sent our brain and muscle goes wrong. The sudden happening of paralysis can be partial or to a greatest extent. It can occur on one or both halves of our body. It can also take place in one region of our body, or it can be generalized [6]. This makes it difficult for the person with paralysis to perform daily tasks such as turning on lights, asking for help, etc. Another problem is that a paralyzed person is more prone to diseases related to the heart, since they restrict their daily movements and spend most of their time sitting or lying down. A solution proposed in this method is a smart device similar to a glove that the person can use and with simple gestures with the hands performs a variety of functions.

The glove will be a Arduino-based IOT device mounted with the accelerometer and a pulse beat sensor. The communication would be done through 433 MHz trans-receiver module. The transceiver is composed of a transmitter and a receiver in a one unit as a pair. It also suggested to wireless communication devices like handphones, two-way radios, cordless telephone sets, and mobile two-way radios [7]. An RF transmitter unit is a minute size PCB efficient to transfer radio wave and balance radio wave to carry bits of data. RF transmitter modules offer data to the transmitted phase, when it is worked with a microcontroller. These transmitters are used to control

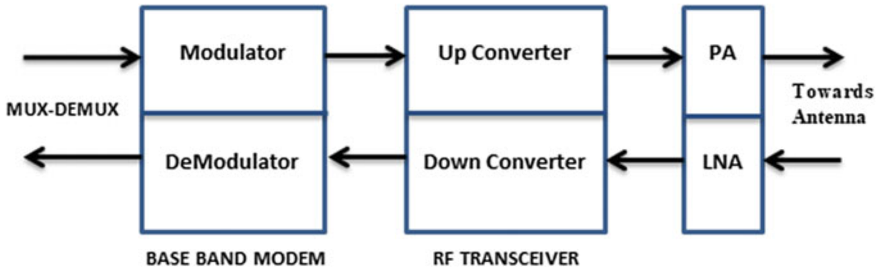


Fig. 2 Block diagram for trans-receiver module

the requirements to order the maximum acceptable transmitter power output, band edge, and the requirements of harmonics.

An RF receiver unit holds the modulated RF signal to demodulate them. There two different types of RF receiver modules are superregenerative receivers and super-heterodyne receivers. In general, superregenerative modules are very low-cost one. The projects which cost low will use a series of amplifiers to remove the data modulated by a carrier wave. The given modules vary and they are inaccurate due to their frequency operation with the voltage and temperature of the power supply [8]. The main advantage of heterodyne super receiver modules is a high efficiency compared to the superregenerative. They offer high stability and precision in a wide range of temperatures and voltages. This stability arises from a stable glass design which in turn leads to a relatively more expensive product (Fig. 2).

The equipped accelerometer is ADXL330 which uses a lot of less power and is a three-axis accelerometer. It continuously monitors the movement and sends the data over the Arduino for transmission. The heart pulse sensor is connected to Arduino as analog input. The main technique of working with the heartbeat sensor is photoplethysmograph [9]. With the help of this principle, the variation in the volume of blood in an organ is calculated by the changes in the intensity of the light which passes through that organ (Fig. 3).

The data sent over the transmission is a string enclosed within two parentheses, and extra bit of string is attached at the end. This is due to accommodate the loss last strings sent over transmission as the 433 MHz cannot support high speed, e.g., "[25,2,8,62]LOSS". On the receiver side, the string is parsed and if the data is highly corroded it is discarded. On the practical basis, the trans-receiver can support up to 3000 bits/s which is enough to send the sensor data. The recognized movement can be uploaded to cloud for further data analytics or be used to call specific functions from the receiving computer to perform operations which helps the paralyzed person [10].

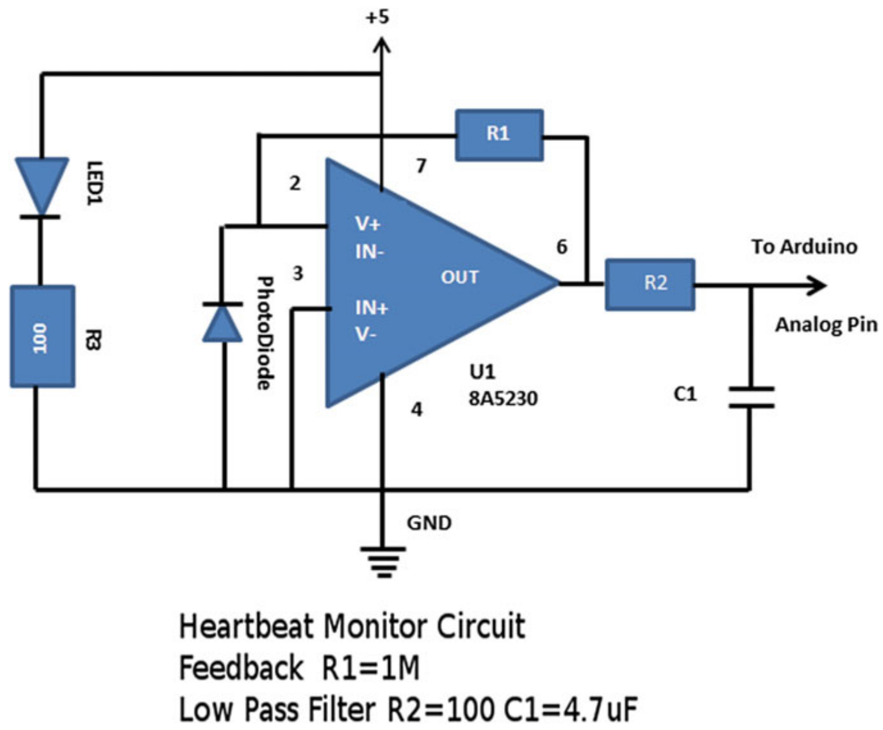


Fig. 3 Schematic of heartbeat sensor

4.1 Machine Learning on the Incoming Data

After the three-axis data and the heartbeat sensor data are received, the ML is performed to recognize the gesture. The model we use is K-nearest neighbor. A good classification algorithm which is simple and robust is KNN algorithm. And because of this, the algorithm can give highly good results. KNN algorithm can also be used for regression problems also. Instead of voting from the nearest, this methodology will be used for averages of nearest neighbors, which is the main difference here [11]. At first, the glove is trained over a gesture where the patient repeats a particular movement and all the data are recorded. This gives a specific pattern of values for each axis. After the training, the system is ready to perform whenever the movement is applied.

4.2 Data Analytics Over Collected Data

After sufficient data about patient is collected, we can perform data analytics to get hidden information such as what requirements he desire at a particular point of day. These data can be uploaded to cloud for further processing. Also, cloud will enable remote monitoring of the data through web or mobile app. Data was able to travel within the range of several feet which makes the 433 MHz trans-receiver perfect for home applications. It is better than other alternatives such as Bluetooth and Wi-Fi Shield as it is a low cost for small data transmission and is extremely power efficient. The range can be improved using an antenna.

However, for continuous large data transmission, other alternatives such as Bluetooth and 2.4 GHZ transmitter may be used. The machine learning model is efficient to recognize the simple gestures like horizontal/vertical waves [12]. However, for complex gesture, it was not accurate because the accelerometer was not sufficient. For this, we need gyroscope and bend sensors. But this would increase the cost of the plan.

5 Automatic Medicine Dispenser

With the development of Internet of things in various fields, we came up with its application in the healthcare domain. This is specifically designed for those on a complex and vulnerable medicine regime where missing even a single medicine becomes a huge risk in their life [13]. The medicine dispenser has also been proved to be useful where patients don't have a caretaker. It is affordable and easy to use. In our proposed method, we have programmed our medicine dispenser according to the regime of user [14]. An alarm has been set up to make the user to remember to take which medicine at what time. The sensor is attached to the medicine cap, whose opening denotes that the patient has taken his medicine and the signal is sent to the Arduino accordingly [15].

If the patient fails to take his medicine, a GSM module attached will send a message to the user that he hasn't taken his medicine. If he still ails to take the medicine, then the message will be sent to his doctor notifying this. The best part of our work is we can have multiple medicine reminders [16]. As a part of innovation, we will be storing his data in a database and uploading it to "ThinkCloud". From here, the user will be able to see how many times he took his medicine in a given month.

5.1 Smart Automatic Medication Dispenser

This was made for those who take medicine without help and aimed for avoiding the consumption of wrong medicine at the wrong time. The components needed for design of reminder to smart medication are raspberry pi zero W (core type-ARM1176JZF-S) interface with LCD16×4, buzzer, led, alarm module (DS3231), multiple pill container, and a stepper motor [17]. At the starting point, switch on the kit and the device will be asked to set the time for alarm and likewise set for the next alarm by allowing the pill into pillbox and close it. As the user sets the time for alarm, the sound is made by the buzzer and also makes the LED blink which is present in the pillbox separately. With the help of using raspberry pi zero W, the interfacing is very easy and simple. The software and the language used for programming are PyCharm and python, respectively.

5.2 Automated Drug Dispensing Systems

This chapter focuses on issues such as the continuous occurrence of errors, wastage of medication, and the inappropriate use of nursing time because of the multiple-dose drug distribution systems which were accepted throughout the world before the unit-of-use packages or unit-dose systems were introduced in early 1960s [18]. These systems replaced multidose systems in which nurses had the greater responsibility for the entire system of medication, which gathers the administering of hundreds of doses of medicine along with paperwork, inventory control, and dose preparation. On the other hand, unit-dose systems facilitate the nurses with separately packaged and labeled doses at eight or more hour intervals that are ready to administer according to the routine schedule determined by the nurse narrated by [19]. Building on this success, Johns Hopkins Hospital further introduced an automated feature into this existing unit-dose system by making the whole technique, from physician prescription entry to hourly dose administration, computer-assisted [20].

5.3 Construction of a Smart Medication Dispenser with High Degree of Scalability and Remote Manageability

This method proposes a smart medication dispenser which is of a high degree of remote manageability. The hardware architecture which aims for scalability is designed for a dispenser in order to gain an extensible hardware architecture and to focus for remote manageability, an agent program was also installed. The working of the dispenser is, when the real-time clock attains the predetermined medication time and the user tends to press the dispense button at that duration, the predetermined medication is dispensed from the medication dispensing tray (MDT) [21]. In the proposed dispenser, the medication allotted for each patient is maintained in an MDT. One smart medication dispenser consists of only one MDT. With respect to this aspect, the dispenser can be extended to add more and more MDTs which will support multiple users to use one dispenser. The final observation of implementation and verification proved that the proposed dispenser operated in a normal way and it performs the management operations from the medication monitoring server.

5.4 Design of Automatic Medication Dispenser

This paper importantly focused on providing medication to aged persons on time. This automatic medication dispenser is architectured especially for users who cannot afford professional supervision at all times. The population of adults and elders can benefit from this design of device as it neglects expensive in-home medical care. The major objective of this design was to keep the device simple and cost–benefit. It relieved the user of the error-prone tasks of doing wrong medicine at wrong time. The important parts of this medication dispenser were a microcontroller interfaced with a keypad, an LED for displaying, a controller, an alarm system, a multiple pill container, and a dispenser. The user is asked to press a button to get the pill and to reset the alarm button. The second alarm was installed to indicate the optimal availability of the pills stored in the container to intimate the user to refill the dispenser with the required quantity of pills. First, we will connect and complete the setup and the circuit. Real-time clock will be running and as soon as it reaches a current time, we'll code the Arduino to send the output to the LCD display and the buzzer. The LCD display will display the time slot of the medicine and buzzer will keep on buzzing.

6 Architecture

Now if the person or user takes the pills, i.e., by opening the lid, the IR sensor attached to the lid which will detect that the lid is opened and hence will send the output to Arduino which will stop the buzzer from buzzing, and this action performed will be sent into the log that the person has taken his medicine successfully. In case the person forgets to take the medicine (Lid is not opened), the buzzer will automatically get stopped after that time and will be put on for snooze. If a person once again misses the medicine, the output will be sent to GSM module which in turn will send a message to the person reminding him that he has missed a pill. And if once again the person misses the pill as a last chance, a message will be sent to family members or to the hospital. We will be uploading all the data about the patient whether he has taken his medicine or not in a database and will upload it to the cloud. At the end of the month, the patient will be able to analyze how many days did he/she consume is medicine (Fig. 4).

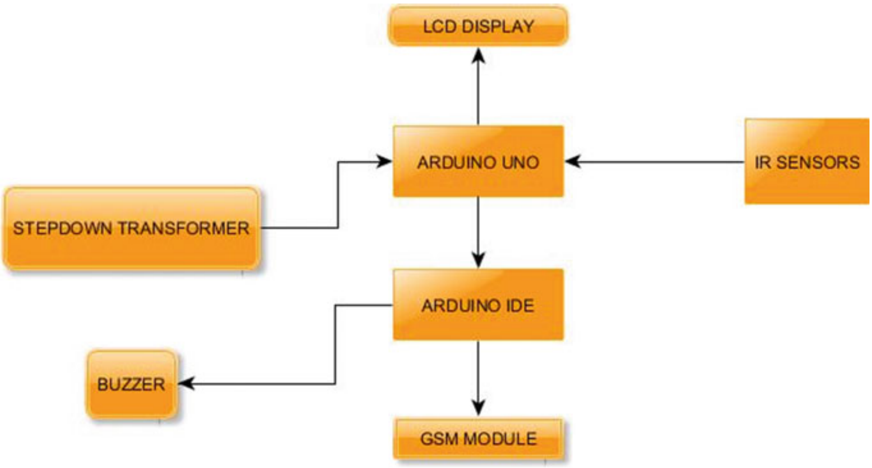


Fig. 4 Architecture

7 Conclusion

In the first case study to monitor the pulse rate, we can implement NodeMCU with a Wi-Fi module used in various workspaces like IT industries and can come up with various solutions so that we can use manpower correctly. The cloud or open source is also user-friendly to operate and shows direct graphical analysis which is an easier way to understand. In the next case study of smart glove for paralyzed patients, few attempts have been made to activate Smart Gloves as tools for hearing problems and speech disabilities. Most of these devices use any one of the following requirements: CMOS cameras, leaf switch-based gloves, copper plate-based gloves, and flex sensor-based gloves, with no innovation presented. In the same order, the different components of each device are common in most cases like microcontrollers, flex sensors, accelerometers, and communication modules. In the scientific literature, four gloves were found and they were compared by analyzing their advantages and disadvantages to make a comfort solution for the end users. The first glove which is developed has the capability to recognize gestures in order to translate them into speech or messages. In certain cases, the main disadvantage of this method is its bend sensors that have limited sensing capacity, which limits its usability. The second glove produced by has the ability to convert language into voice; nonetheless, it uses flex sensors which don't allow a high degree of sensitivity due that they can't bend more than 90°. It also uses sign language as its main tool which is not a universal language. A third glove which can interpret sign language using a wireless function and a screen to display its results has also been presented but it lacks the functionality to translate into voice. Finally, a glove that can translate sign language into audible language has also been designed but a has a limit capacity of storing just 30 gesture.

In the third case study, the proposed work enables the user in a significant way to maintain the health-related issues efficiently by taking medicines on due time. This device is a great relief in a time of competition where under the pressure of work and other liabilities one might forget to take his medicines on the prescribed timing. Making the health a lower priority, hence, the device is a greatly useful one in times like today.

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