International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.8, Issue.7, July 2020 E-ISSN: 2347-2693

Medbox: The Smart Pillbox

Sibin M.S.[1*], Elisha G. Pakalomattom[2], Haripriya S.[3], Denisious K.D.[4]

[1,2,3,4]Dept. of Computer Science and Engineering, Vijnan Institute of Science and Technology, Kerala, India

[*]*Corresponding Author: sibinms1998@gmail.com, Tel.: +91-9744857590*

DOI: https://doi.org/10.26438/ijcse/v8i7.5461 | Available online at: www.ijcseonline.org

Received: 13/July/2020, Accepted: 21/July/2020, Published: 31/July/2020

Abstract— This era created a change in life style of people and as a result more people are becoming vulnerable to diseases. Completion of medicine course is necessary to evict the disease completely from the body and here our aim is to design a system which can remind and monitor the medication schedule of patients. Medbox is a smart pill box which is an assistive system for patients to schedule their medication timings. It comes along with an android application in which user can customize the each cell in the Medbox. The app provides a provision for alerting the caretaker if the patient forgets to take the pill. The Medbox is designed with 21 cells. Assuming a person is taking medicine 3 times a day. During the medication time, the Medbox alert the user using the red light indicator, buzzer and alarm in the phone. The proper medication details of the patient can be monitored by the caretaker by using the app. There is a separate login portal for patient and caretaker. If the patient goes out without taking the Medbox then, the patients will be notified by an alert message. Medbox and phone is connected via Bluetooth. The Medbox and android application are connected via cloud.

Keywords—Medbox, Patient assistive system, Smart pillbox

I. INTRODUCTION

In this busy life, fast food, pollution, unhealthy habits are becoming part of our life style and more people are becoming vulnerable to diseases. So it‘s impossible to think of a day without medicines. People lack proper diet which also causes nutrition problems. They also need to take vitamin supplements to keep them healthy. Proper completion of medicine course is necessary to evict the disease completely from the body.

There can be a lot of individuals out there who need constant help – It can be the elderly people, family members, and the one who requires special care. Elders are more affected by the timing of taking a certain drug than others, in order to prevent any dysfunction or illness, timing is must. But in some cases ageing leads to poor eye sight and poor memory. What if the patient has a dementia like Alzheimer? Some people may forget to take the medicines at the correct time and can forget the medicines which they have to take.

In order to eliminate the factors of always needed observation like nurses or taking a risk of a missed dose, we had to find an easy, portable and efficient solution. Pill boxes already exist but most of them are either has limited use, doesn't fit for elder ages or even has a big size that makes it not suitable to take it with you anywhere.

In order to make a really useful smart pillbox it has to be easily integrated with the recent sweeping smart technologies. While at the same time it had be fit for the elders and their limited knowledge and experience to implement the ease of use. Size and portability was also an important factor that we had to keep in mind. For it to be called smart, its connected through a wireless network, which enables it to be connected to the internet for future applications and integration, also its distinguished by the wide range of the Wi-Fi instead of a Bluetooth or any other field communication, and erase the need for any wires or wired connection which enables portability in the first place.

Through that same network it is connected to the mobile phone, with it you can set the timing interval for the dose and also notifies you by many ways when the dose time comes. Also, we added a buzzer with a Light Emitting Diode (LED) to make a type of physical warning, so that it leaves you no choice but to remember the pill time and take it. When the pill time has been set, the pillbox will remind clients or patients to take pills utilizing sound and light. The warning of pills that must be taken will be shown by an android application which is held by the patient. Contrasted and the conventional pill box that requires clients or attendants to stack the crate each day or consistently. This model can aid in help elders to take their medication.

The rest of the paper is organized as follows, Section I contains the introduction of the importance and use of Medbox, Section II contains the related work carried out so far, Section III explains the methodology used in the proposed work, Section IV explains the results and discussion, Section V concludes the work with future work to be carried out.

II. RELATED WORK

The existing system is a box that has separate trays employed to put medicines. All the medicines are kept together in an open tray or in a single container. As a result, the medicines are exposed to moisture and thus may cause adverse effects. The trays have stickers on the top to identify whether that particular medicine inside the tray is for forenoon, afternoon or at night. Also they have to manually identify the medicines with the help of stickers to see whether it‗s for Monday, Tuesday and so on. Some of them can only store about 2 or 3 medicines. Some of them are large in size, so it‗s difficult to carry for people who are going long distance.

Pillboxes have alarm system are there in the market, different companies developed them with different functionalities. For example, GMS MED-E-LERT automatic pill dispenser [1], electronic dispenser, E-Pill's tamper proof automatic medication dispenser, etc. The pillbox available in market includes alarm system but lack in much other functionality.

Recently, pillbox was modified by many researches and new features are added. One of them is an assistive technology to open and close the pillbox automatically. Then, a smart pill box [2] proposed which uses infrared sensor and Arduino microcontroller, in this alarm notification is also sent on user's smart phone. Lastly, an intelligent pill box proposed in it is a single user platform and it connects the patient, doctors and pharmacies with each other.

Pill Dispenser with alarm via smart phone notification IOT [3] technology was used which generates reminder on a proposed time but there was no confirmation feedback. Enhancing Healthcare using m-care Box [4] uses alarm notification service but in that also there was no feedback notification and it was oriented for single user. A smart Pill Box with remind and Consumption confirmation function [5] camera were use in the compartment but it was costly as well as complex to put camera in every compartment. So far, there is no pillbox which gives proper feedback of whether the medicine is taken or not, to the user.

The existing system has no mechanisms to alert patients if they haven‗t taken medicines for the day or haven‗t they taken it while going outdoors. No one can cross check if a patient has taken any medicines, if so correctly. For elderly patients, they will have confusion regarding which medicine they have to take. So the existing system has no methods to notify which medicine they have to take. There is no proper mechanism for preventing the moisture that can react with the medicines. Hence, we are designing a pillbox which will give proper feedback of confirmation to the smart phone user using mobile application and also simpler in design, which have immunity against moisture.

III. METHODOLOGY

The main objective of this model is to solve the above-mentioned problems of the existing system by designing and creating a tool which will enable the owner to track every pill to ingest in an easy and simple way requiring no training or complex learning from their side in order to operate the device. This device will be an intelligent pill organizer. The Medbox can be linked via the cloud to a care taker, to aid in monitoring and reminding a patient to take his/her medications.

Nowadays, there has been an increasing awareness as the number of pills prescribed to elder people, are more in number. The system's alarm will help to alert patient and caretaker. Our system has a chargeable electric port with maximum battery backup and, has a compatible size and shape. It can notify patients and caretakers if the patient has missed to take the medicine. It actually helps elderly patients to identify the medicine and have it on correct course of time. It is tightly sealed to prevent exposure to moisture. The system has a buzzer and LED alert on its surface also, it is large enough to store medicines for a week. It has a medication monitoring system showing the analysis chart of the medicine intake. The modules used in methodology are 3D modeling, 3D printing of hardware mould, android application development using android studio and firebase, hardware module and these are discussed below:

3.1 3D Modeling

The software which is used for 3D modeling is Fusion 360. It's the first 3D CAD, CAM, and CAE tool of its kind, connecting your entire product development process into one cloud-based platform. The designs that we are created using the Fusion 360 software are the Medbox top compartment and bottom compartment, inner cell. The figures below describe the 3D model of the Medbox.

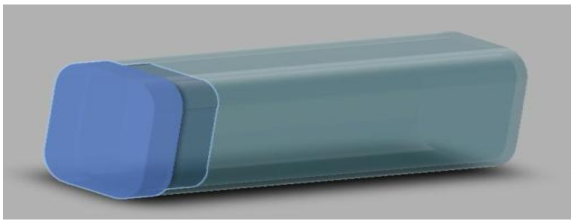

Fig. 1 The inner cell of Medbox

Fig. 2 Closed View of Medbox

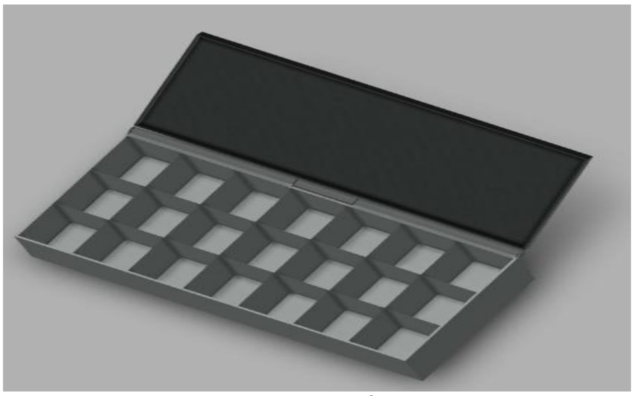

Fig. 3 Open View of Medbox

3.2 3D printing

3D printing, or additive manufacturing, is the construction of a three-dimensional object from a CAD model or a digital 3D model. 3D printable models may be created with a computer-aided design (CAD) package, via a 3D scanner, or by a plain digital camera and photogrammetric software. 3D printed models created with CAD result in relatively fewer errors than other methods. Errors in 3D printable models can be identified and corrected before printing.

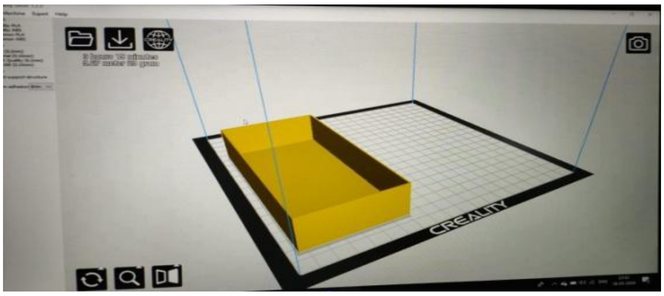

Fig. 4 3D Printing Stimulation of Bottom Compartment

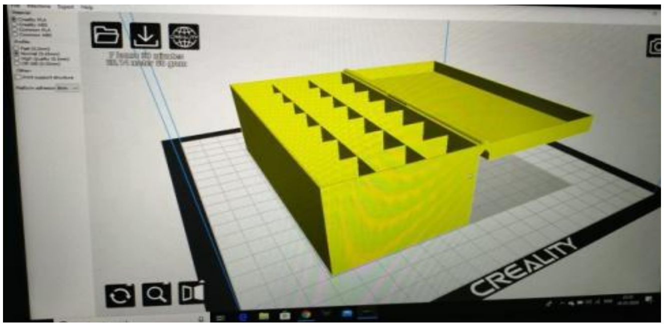

Fig. 5 3D Printing Simulation of Medbox

The manual modeling process of preparing geometric data for 3D computer graphics is similar to plastic arts such as sculpting. 3D scanning is a process of collecting digital data on the shape and appearance of a real object, creating a digital model based on it. CAD models can be saved in the stereo lithography file format (STL), a CAD file format for additive manufacturing that stores data based on triangulations of the surface of CAD models.

A step in the STL generation known as "repair" fixes such problems in the original model. Generally STLs that have been produced from a model obtained through 3D scanning often have more of these errors as 3D scanning is often achieved by point to point acquisition/mapping. 3D reconstruction often includes errors.

Once completed, the STL file needs to be processed by a piece of software called a "slicer," which converts the model into a series of thin layers and produces a G-code file containing instructions tailored to a specific type of 3D printer (FDM printers). This G-code file can then be printed with 3D printing client software (which loads the G-code, and uses it to instruct the 3D printer during the 3D printing process).

Printer resolution describes layer thickness and X–Y resolution in dots per inch (dpi) or micrometers (µm). Typical layer thickness is around 100 µm (250 DPI), although some machines can print layers as thin as 16 µm (1,600 DPI). X–Y resolution is comparable to that of laser printers. The particles (3D dots) are around 50 to 100 µm (510 to 250 DPI) in diameter. For that printer resolution, specifying a mesh resolution of 0.01–0.03 mm and a chord length ≤ 0.016 mm generate an optimal STL output file for a given model input file. Specifying higher resolution results in larger files without increase in print quality. Construction of a model with contemporary methods can take anywhere from several hours to several days, depending on the method used and the size and complexity of the model. Additive systems can typically reduce this time to a few hours, although it varies widely depending on the type of machine used and the size and number of models being produced simultaneously.

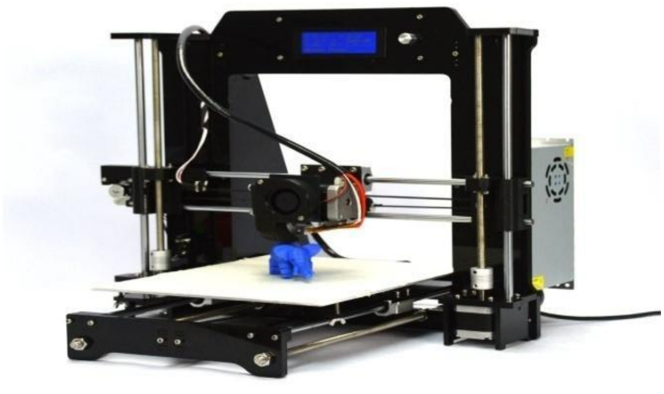

Fig. 6 3D Printing Machine

3.3 Android application development

Android Studio is the official integrated development environment for Google's Android operating system, built on JetBrains, IntelliJ, and IDEA software are designed specifically for Android development. In addition to android studio, firebase is used. Firebase's first product was the Firebase Real-time Database, an API that synchronizes application data across iOS, Android, and Web devices, and stores it on Firebase's cloud. The product assists software developers in building real-time, collaborative applications.

Software module is further classified into the patient and the caretaker module.

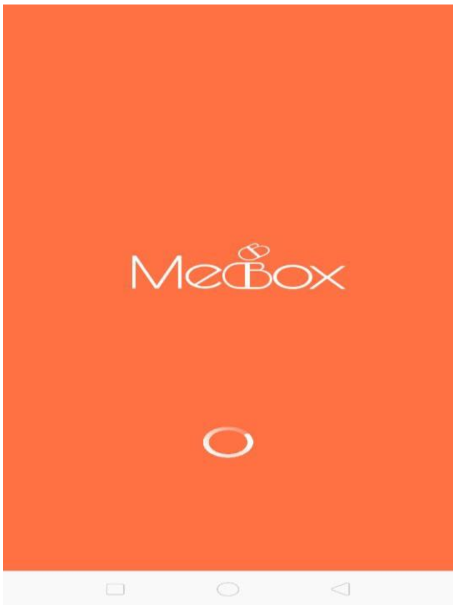
Fig. 7 Splash Screen of Medbox

Initial login or sign up form is shown after the splash screen. If the user is already have an account then he need to login to his own account otherwise he need to sign up for creating an account. This is a one-time signup or login facility which appears only one time during the very first login or signup. If the user forgot their email or password they can get sign in using the “forgot password” option.

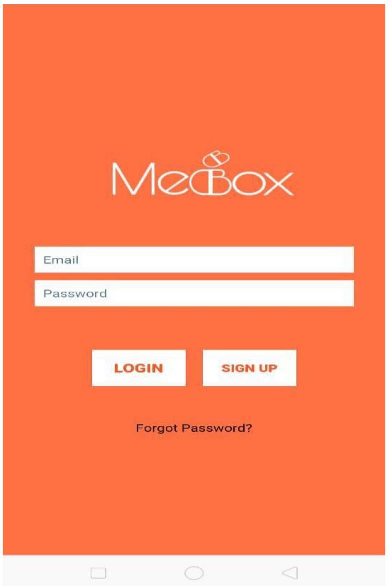

Fig. 8 Login or Signup Screen

Patient module has the following functionalities.

Sign Up -The details of the patients are collected and saved in this module. The basic details of the patient are collected like name, age, gender, date of birth, blood group and phone number. This is saved to our database.

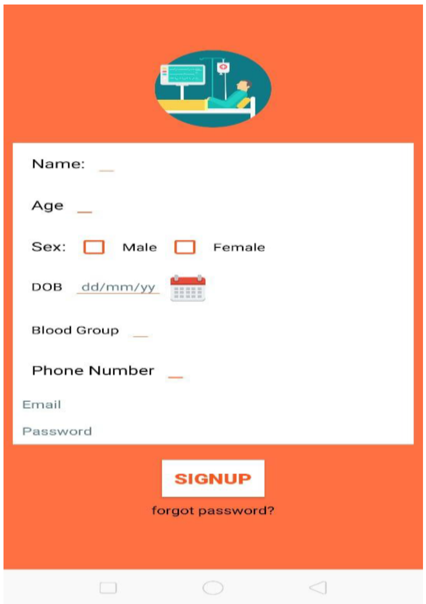

Fig. 9 Signup for patient

Authentication with the Medbox - Initially verification is done by a mobile number/mail Id and OTP is send to that number/mail. After the verification, the user can select either caretaker or patient. The modules functionality may change according to this.

Connecting to the Device -The hardware of Medbox device is paired with the application. This can be done using Bluetooth of the phone .They are paired using an ID. Once the connection is established we can control the Medbox using our application designed using android studio.

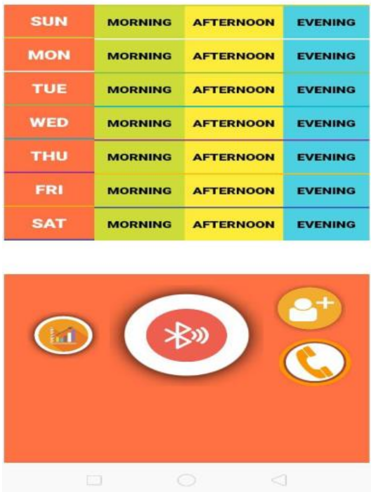

Fig. 10 Home Screen View of Patient

Customization of Medbox -Patient can customize the hardware using mobile application ones it is paired. There are 21 cells. That is designed in the form 7X3.The alert for each cell can be customized. Patient can set alarm time. There is a light indicator for each cell and it will glow to show which box she/he need to take out. There is a provision to add caretaker also. The caretaker also gets alert if the patient misses to take medicine.

Medicine intake history viewing -The Medical history chart can be viewed. With this we can see when a patient took the medicine. This date is stored in our database and this is represented in the form of a chart.

Care taker module consist the following;

Sign Up –The caretaker module has a signup platform through which he/she will be connected to the patient. The care taker has a patient id and this id is given to the login portal and the caretaker is connected to patient's application and Medbox

Connecting to the remote device -When a patient adds a person as a caretaker he can have access to the patient. He needs to sign in with the patient id.

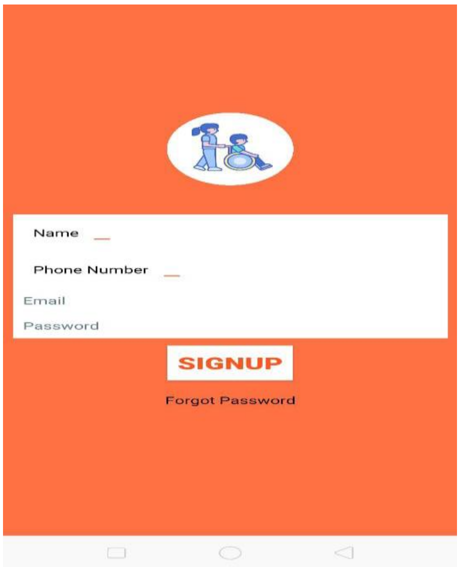

Fig. 11 Signup for Caretaker

Patient performance analysis -The Medical history chart can be viewed. With this we can see when a patient took the medicine. This date is stored in the database and this is represented in the form of a chart. The caretaker and the patient can analyze this chart.

Fig. 12 Home Screen View of Caretaker

3.4 Hardware module

Custom-Build Node Js Supportive Board -The ESP8266 NodeMCU has total 17 GPIO pins broken out to the pin headers on both sides of the development board. These pins can be assigned to all sorts of peripheral duties, including: ADC channel – A 10-bit ADC channel. NodeMCU is an open-source firmware and development kit that helps you to prototype or build IOT product. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The firmware uses the Lua scripting language. NodeMCU is an open source IOT platform. This ESP32 NodeMCU contains firmware that can run on ESP32 Wi-Fi SoC chips, and hardware based on ESP-32S modules. It is the Wi-Fi + Bluetooth hardware that can access through Wi-Fi and Bluetooth.

LED -Stands for "Light-Emitting Diode." An LED is an electronic device that emits light when an electrical current is passed through it. Early LEDs produced only red light, but modern LEDs can produce several different colours, including red, green, and blue (RGB) light. Recent advances in LED technology have made it possible for LEDs to produce white light as well. LEDs are commonly used for indicator lights (such as power on/off lights) on electronic devices.

Piezoelectric Module- A piezoelectric sensor is a device that uses the piezoelectric effect to measure changes in pressure, acceleration, temperature, strain, or force by converting them to an electrical charge. Piezoelectric sensors are versatile tools for the measurement of various processes. They are used for quality assurance, process control, and for research and development in many industries.

Micro Relay- Micro Relays are a smaller version of a standard relay. As the name would suggest, this micro relay is meant to fit into Mini ATM fuse boxes and save space. These micro relays feature an ISO 280 footprint, pin size and arrangement. In addition, select micro relays feature a built-in resistor for easy use. The resistor in the micro relay protects equipment and applications against high voltage spikes.

Lithium Battery -A battery is made up of an anode, cathode, separator, electrolyte, and two current collectors (positive and negative). The anode and cathode store the lithium. The electrolyte carries positively charged lithium ions from the anode to the cathode and vice versa through the separator. The movement of the lithium ions creates free electrons in the anode which creates a charge at the positive current collector.

BMS -A battery management system (BMS) is any electronic system that manages a rechargeable battery (cell or battery pack), such as by protecting the battery from operating outside its safe operating area monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and / or balancing it. A battery pack built together with a battery management system with an external communication data bus is a smart battery pack.

Buzzer -A buzzer or beeper is an audio signalling device which may be mechanical, electro mechanical or piezo-electric. Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.

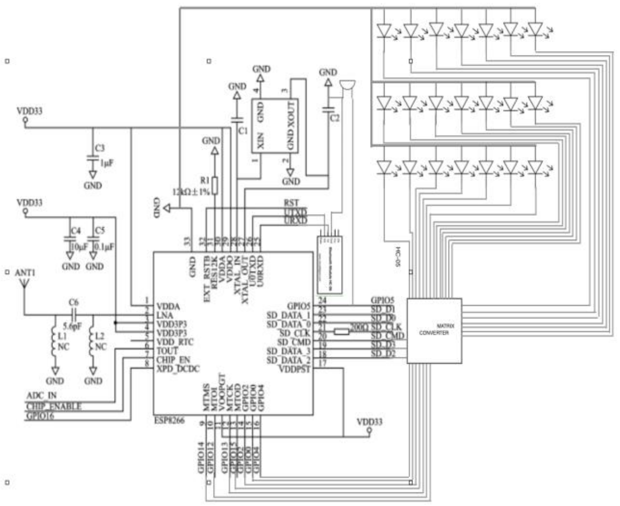

Fig. 13 Circuit Diagram of Medbox

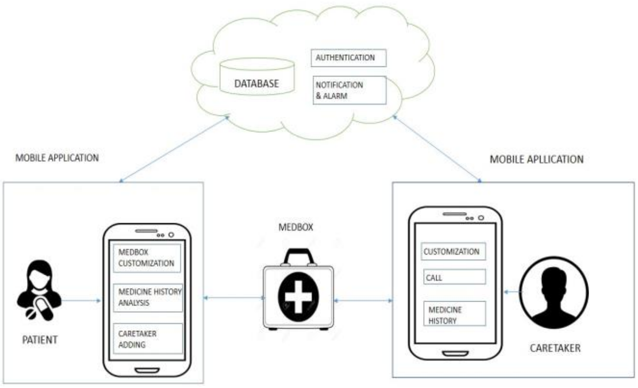

Fig.14 Developed System Architecture

IV. RESULTS AND DISCUSSION

For testing, one sample of this system was implemented as shown in figure 15. The developed system was tested over around fifty patients while taking into account different kinds and forms of pills weighting less than 500mg. As for the mobile application, it was tested on several platforms all running on android operating system. Various dosage and timing schedules were considered and the system was tested for each patient between several hours (at least 12hours) and some days (a maximum of seven days). A questionnaire has been filled by the users of this system concerning the satisfaction, the ease of use, the error percentage and the rating. Results show that about 85% were satisfied, 64% rated it as excellent and 23% as good. As for the failure rate, only 3% identified errors when using it. At the end, concerning the ease of use, more than 90% considered that this medicine box is simple when compared with other systems. One of the features which attracted the users is the battery life of the system. When the Medbox is fully charged it can stand up to two to three days. If we are mentioning the portability of the system, it was observed that people find the system as handy due to its ergonomic design.

We have analyzed the medication schedule of different patients and came to the conclusion that the daily usage of the system increased the accurate intake of medicines per week and this result is shown in the bar graph. Patients learned the functions of the system very fast comparing to the other existing system which bought a sudden hike in the usage of the Medbox. The system was tested for acceptance and the pie chart indicates that the alarm and notification mechanisms of the Medbox prompted the patients to take the medicines at the correct time; this conclusion was made by tracking the time of medicine intake by the patient. Caretakers found Medbox as an easy way to handle with the medication schedule of the patient. The system is checked for the weekly basis medication schedule and the proper working is ensured both in technical and mechanical terms.

Fig.15 Image of developed Medbox

Fig.16 Efficiency Analysis

V. CONCLUSION AND FUTURE SCOPE

Medbox is an effective solution for patients who always forget to take their medicines during their medication course. It‘s simple and effective notification mechanism makes it different from all other existing systems in the field of these pill reminders. As it provides 24X7 remote monitoring facilities, it is reliable and accurate. The developed system is suitable for all kinds of patients. It efficiently controls the time of patients to take medicine. Even the patient forgets to take the Medbox, the system itself reminds them. It also reduced the ratio that patient misses and delays taking medicine. Another feature is there is a provision which helps in locating the box whenever it is misplaced.

Although this system was well operating, several adjustments can be made in order to increase its use and ameliorate its behaviour. In the future, the application can be linked to medical stores or pharmacies of the hospital. If the pills are empty in the Medbox, it directly sends the "prescription" message to the concerned i.e. either to a chosen medical store or to a hospital pharmacy, in which they can help delivering the prescribed medicines at patients door step. Scanning of prescription to load the app can be done using image processing technology. Another useful feature would be the live streaming the pill-taking-action to someone else, so that the user‘s activity could be monitored by a family member or caretaker.

REFERENCES

[1] N.B. Othman, O.P. Ek, "*Pill Dispenser with Alarm Via Smart Phone Notification*" In Proceedings of 5th Global Conference on Consumer Electronics, **2017**.

[2] V. Shah, J. Shah, N. Singhal, H. Shah, P Uapdhyay, " *Smart Medicine Box* " In Proceedings of Imperial Journal of Interdisciplinary Research, **2016.**

[3] S. Shinde, T. Kadaskar, P. Patil, R. Barathe, "*A Smart Pill Box with Remind and Consumption Using IOT*" In Proceedings of International Research Journal of Engineering and Technology, **2017**.

[4] A. Bharadwaj, D. Yarravarapu, S.C.K. Reddy, T. Prudhvi, K.S.P. Sandeep, O.S.D. Reddy, "*Enhancing Healthcare using m-Care Box (Monitoring nonCompliance of Medication)"* In Proceedings of International Conference on Innovative Mechanisms for Industry Applications, **2017**.

[5] H.K. Wu, C.M. Wong, P.H. Liu, S.P. Peng, X.C Wang, C.H. Lin, K.H. Tu, "*A Smart Pill Box with Remind and Consumption Confirmation Functions*" In Proceedings of 4th Global Conference on Consumer Electronics, **2015**.

[6] E. Becker, V. Metsis, R. Arora, J. Vinjumur, Y. Xu, F. Makedon, *"Smartdrawer: Rfid-based smart medicine drawer for assistive environments"* In Proceedings of the 2nd International Conference on PErvasive Technologies Related to Assistive Environments, pp.**49**, **2009**.

[7] V.F.S. Fook, J.H. Tee, K.S Yap, A.A.P. Wai, J. Maniyeri, B. Jit, P.H. Lee, *"Smart mote-based medical system for monitoring and handling medication among persons with dementia",* In International Conference on Smart Homes and Health Telematics, pp.**54–62, 2007**

[8] N.B. Othman, O.P. Ek, "*Pill dispenser with alarm via smart phone notification"*, In Consumer Electronics 5th Global Conference, pp. **1–2, 2016.**

[9] Z. Pang, J. Tian, Q. Chen, *"Intelligent packaging and intelligent medicine box for medication management towards the internet-of-things"*, In Advanced Communication Technology 16th International Conference , pp.**352–360, 2014.**

[10] J.M. Parra, W. Valdez, A. Guevara, P. Cedillo, J. OrtizSegarra, *"Intelligent pillbox: Automatic and programmable assistive technology device*", In Biomedical Engineering **13**th IASTED International Conference, pp.**74–81, 2017.**

[11] A.S. Salgia, K. Ganesan, A. Raghunath, "Smart pill box", Indian Journal of Science and Technology, Vol. **8**, Issue.**2**, pp.**189–194, 2015.**

[12] G. Yang, L. Xie, M.M. antysalo, X. Zhou, Z. Pang, L.D. Xu, S.K. Walter, Q. Chen, L.R. 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**, Issue.**3**, pp.**2180– 2191, 2014**.

[13] Ali. A, "*Macroeconomic variables as common pervasive risk factors and the empirical content of the Arbitrage Pricing Theory*." Journal of Empirical finance, Vol. **5**, Issue. **3**, pp.**221–240.**

[14] H.-L. Tsai, C. Tseng, L. Wang and F.-S. Juang, "*Bidirectional smart pill box monitored through internet and receiving reminding message from remote relatives,*" in *IEEE International Conference on Consumer Electronics - Taiwan (ICCE-TW)*,Taipei, Taiwan, **2017.**

[15] B.-G. Lee, B.-L. Lee and C. Wan-Young, "*Mobile Healthcare for Automatic Driving Sleep-Onset Detection Using Wavelet-Based EEG and Respiration Signals*," *Sensors,* vol. **14**, no. **10**, pp.**17915-17936, 2014.**

[16] Gurpreet Kaur,Manreet Sohal,"*IOT Survey: The face changer in Healthcare Industy*", International Journel In Scientific Research In Network Security And Communication, Vol. **6**, Issue **2**,apr **2018**,pp. **34-39**

[17] Sanjay S Bhadoria, Hitesh Gupta, *" A Wearable Personal Healthcare And Emergency Information Based On Mobile Application*", International Journel Of Scientific Research In Computer And Engineering, Vol. **1**, Issue **4**, Aug **2013**

AUTHORS PROFILE

Mr.Sibin.M.S pursed Bachelor of Computer Science and Engineering from Vijnan Institute of Science and Technology, Kerala- India in 2020. During his academic year he had worked as part of IEDC (Innovation Entreprenuership Development Cell) as a Chief Technical Officer. And he had worked as a Campus ambassoder at Internshala and E-cell DTU. Also he devoted his time for an NGO called Indian Jeevakarunya Charitable Trust. He had done technicl training in Python, Java, Php and C.

Ms. Elisha G Pakalomattom pursued Bachelor of Computer Science and Engineering from Kerala, India in year 2020.She had participated in ICFOSS women hackathon and also as a delegate in International Model United Nations (IMUN) Conference. She had done internship in Python and Database and also handled a website for period of one year. Her area of interest includes Python, C, and Database.

Ms. Haripriya S is a B.Tech graduate in Computer Science and Engineering from Vijnan Institute of Science and Technology, Kerala- India in the year 2020. She was an elected member of the college student's council and has done internship at Keltron Controls. She has undergone training and internships in python, DBMS, java and has also participated in women hackathon conducted by ICFOSS.

Mr.Denisious.K.D pursed Bachelor of Computer Science and Engineering from Vijnan Institute of Science and Technology, Kerala- India in 2020. He had worked as a part of National Service Scheme.He had done training in Python and Data Analytics. He had done internship on Database Management System.