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Future Computing and Informatics Journal 3 (2018) 443–456
http://www.journals.elsevier.com/future-computing-and-informatics-journal/

Smart drugs:Improving healthcare using Smart Pill Box for Medicine Reminder and Monitoring System

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Received 23 February 2018; revised 9 September 2018; accepted 20 November 2018
Available online 29 November 2018

Abstract

Many medical errors are due to the fact that people in charge of patient or elder's medication have to deal with sorting huge amounts of pills each day. This paper consists on the conception, design and creation of a pillbox prototype intended to solve this deficiency in the medical area as it has the ability of sorting out the pills by itself as well as many other advanced features, with this device being intended to be used by hospitals or retirement homes. This medication pill box is focused on patients who frequently take medications or vitamin supplements, or attendants who deal with the more seasoned or patients. Our smart pill box is programmable that enables medical caretakers or clients to determine the pill amount and timing to take pills, and the service times for every day. Our shrewd pills box contains nine separate sub-boxes. In this manner, medical caretakers or clients can set data for nine distinct pills. At the point 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 should 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. Our shrewd pill box would essentially discharge medical attendants or clients' weight on much of the time preloading pills for patients or clients and overlook the measurements which must be taken.

Keywords: Smart Pill box; IoT; Health Care; Medicine Reminder

1. Introduction

There can be a lot of individuals out there who need constant help – may it be our elderly people, family members, the ones who have special needs. Elders are more affected by the timing of taking a certain drug than others, in order to prevent any dysfunction or illness timing is a must [1,2].

But as with aging comes 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 [3,4].

In order to make a really useful smart pillbox it had 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 fact that we had to keep in mind [5–7].

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

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Peer review under responsibility of Faculty of Computers and Information Technology, Future University in Egypt.

https://doi.org/10.1016/j.fcij.2018.11.008

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 its connected to the mobile phone, which 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 LED to make a type of physical warning, so that it leaves you no choice but to remember the pill time and take it [8,9].

The aim of this study is to build a Smart Pill Box for Medicine Reminder and Monitoring System. 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 should 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 described as follows: In Section 2 describe the problem statement; Section 3 presents the basic concept of elders problems; section 4 presents the main objective of the research; section 5 presents previous work. Section 6 presents the proposed smart reminder system model; Section 7 presents the research design; Section 8 presents the proposed framework for smart pill box; Section 9 presents the implementation of the proposed model; section 10 presents the experimental results of proposed model. Finally shows the conclusion of this paper.

2. Problem statement

As pills have taken such an important role in everyday life there has been the past years an increase in the number of medical neglect cases related to incorrect medication given to patients, such as the case of the nurse who gave a patient a paralytic instead of an antacid that was prescribed by the doctor, causing the patient's death [10]. After seeing so many of these cases it is evidently crucial that the correct pill is taken by the correct person at the correct time, otherwise taking an incorrect one or not taking one at all may expose the patient to several dangerous situations, ranging from mild health issues up to death [11].

Other cases of wrong pills being ingested by patients are caused by patients themselves, especially at an old age. As people grow old the human body tends to malfunction and the number of pills the average person has to take when certain age is reached greatly increases, were, according to a 2008 study published in the Journal of the American Medical Association, more than 40 percent of Americans age 65 and older take five medications a day [12]. Usually they are a wide range of different pills an elderly has to take at different times. Keeping track of taking the right pill at the right moment each day can become a challenging experience for the elderly, as it is not as easy as it could be for a younger person. This fact is easily explained when we understand that many of the abilities such as sight, memory or logical capabilities tend to decrease in a proportional way to age once human beings have entered old age, making it difficult for them to remember which pill to take at the correct time, remembering to take them or confusing one pill with another as the person may not be able to distinguish one from another thanks to their decreased sight as well as the similarity in the pills forms and colors. This problem will most surely be a cause for concern for the people surrounding the pill-taker, as not taking a pill at the correct time can cause severe problems (such as organ rejection in a patient with organ transplant or heart attack in patients suffering from grave heart conditions) [13,14].

On the other hand several problems related to the high amount of pills nowadays are prescribed to patients are found in hospitals or in retirement homes. In these places on of the main jobs is to give out to its patient the correct pills. Managing, sorting and giving out the pills to each one of the patients can sometimes have a high chance of error, with a patient or resident receiving one or more incorrect pills.

Finally there are situation where taking an incorrect amount of pills is a matter of the patient's inexperience and/or ignorance. No matter the cause, it has been proven that there is a significant risk of people ending up swallowing the incorrect medication or dose.

3. Elders problems

A. Alzheimer

Alzheimer's is the most widely recognized type of dementia, a general term for memory misfortune and other intellectual capacities sufficiently genuine to meddle with day by day life. Alzheimer's illness represents 60 to 80 percent of dementia cases. Alzheimer's isn't an ordinary piece of maturing. The best-known hazard factor is expanding age, and the dominant part of individuals with Alzheimer's are 65 and more seasoned. In any case, Alzheimer's isn't only an illness of seniority. Around 200,000 Americans younger than 65 have more youth-full beginning Alzheimer's infection (otherwise called early-beginning Alzheimer's) [15].

B. Missed dose

The build ‘missed dose’ is integral to numerous appraisals of medication adherence. Nonetheless, few examinations have explored how patients or clinicians conceptualize missed dosages or the degree of the concordance or harshness amongst clinicians and patients. Generally speaking, patients revealed a stricter meaning of missed measurements than did clin-icians. Fifty-five percent of patients suspected that a pill-taking postponement of 6 h past the endorsed dosing time constituted a missed measurement, by correlation, just a single doctor concurred with this evaluation. More than 33% of patients believed that the best possible reaction to a missed dosage is skipped it through and through, yet just around 12% of clinicians concurred [16].

4. Objectives

The main objective of this model will be to solve the above-mentioned problems by designing and create 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 dispenser.

The pill dispenser will be designed to prevent errors in hospitals and retirement homes where many pills have to be given daily to each one of the patients, each patient owning a device will not only drastically reduce the chances of errors occurring but also well optimize and speed up work for the caretakers/nurses by allowing the device to take care of pill management for them and freeing the time slot usually dedicated to that.

This device is intended to log the pill name, number of pills and hours at which each pill is actually taken versus the time it should have been taken. Nowadays there has been an increasing awareness as the number of pills prescribed to elder people, stating that so many pills may have negative effects on the patient's health. The pillbox's logs will help gather data concerning this matter.

There is a need to ensure the device is wirelessly connected so device management (defining the hours when a particular pill must be taken, number of pills in each compartment, etc…) as well as possibility of emitting warnings to the owner's relatives or nurses if needed (such as the patient not taking pills).

In essence, the device will have to be a wireless electronic apparatus, having special attention to make it very precise as an error could prove fatal.

5. Related work

In Ref. [17], a pill box based on a MCS-51 micro-controller was proposed; that pill box can send out medicine using a stepper motor at a scheduled time, but there was no provision to record the time when the patient actually took the medicine. Apart from the abovementioned disadvantages, the other disadvantages of these previous systems are as follows:

- The family members or patients need to fill the medicine in the pill box manually; this is an additional responsibility for family members of the elderly, or even the patients.
- Manually filling the medicine in the pill box may cause the medicine to dampen easily.

In Ref. [18], an intelligent pill box (IPB) was proposed. The IPB is based on the medicine bag system, and the IPB sends a medicine bag out of the box at the appropriate time. If the patient does not take the medicine bag away, the IPB would notify the caregivers via Skype. The IPB system improves the interactivity between patient and caregivers, but it works well only if an internet connection is available.

In Ref. [19], an electronic pillbox called MedTracker was proposed; in the MedTracker, the time at which each lid was opened or closed is recorded, and transmitted to PC via a Bluetooth link. However, the MedTracker does not provide any remind or confirm functions.

In Ref. [20], developed a medication safety and to avoid confusion in taking tablet among the elderly, this paper proposed a smart pillbox with remind and confirm functions. The proposed pill box can reduce family member's responsibility towards ensuring the correct and timely consumption of medicines. Because the proposed pillbox containing an alert sound to the user for a particular time and real-time clock gives continuous time as an output.

In Ref. [2] proposed Multidisciplinary approaches to achieving efficient and trustworthy eHealth monitoring systems (2014), The technological merging between IOT, wireless body area network and cloud computing have vital contribution in e health care which improve the quality of medical care, basically patient centric monitoring play a role in e health care services which involve medical data collection, aggregation, data transmission and data analysis here entire monitoring lifecycle and essential services component have discus as well as design challenges in designing the quality and patient centric monitoring scheme along with potential solution.

In Ref. [21] proposed the intelligent pill box—Design and implementation (2014), the implementation of pill box has proposed by keeping the problems of old age people in mind to provide full medication safety. The pill box will remind the patient about timing by doing this drug abusing can be controlled.

In [106] proposed A Self-powering Wireless Environment Monitoring System Using Soil Energy. The monitoring system can uses the self-powering wireless environment with the help of renewable energy which can be beneficial in remote places where the power problem in wide manner, in this the system have demonstrated which will uses soil energy with carbon, zink electrodes.

In Ref. [22] proposed embedded platform for Web-based monitoring and control of a smart home, Present the low cost embedded platform for web based monitoring and controlling and the platform consist of distributed sensing and control network and.

For more information about smart healthcare using IoT will be found in Refs. [20,23–31].

6. Smart medicine reminder

Medicine hasn't always been the precise science which we know nowadays, in fact, throughout history the vast majority of maladies and afflictions would have resulted in probable death. Fortunately medicine has experienced a great development in the last century, resulting in an increased life expectancy and the possibility to cure a great quantity of diseases and health disorders.

Pills are one of the pillars of medicine, being used as direct treatments of some sort of illness as to assuring some medical condition remains stable.

Our smart medicine reminder system is designed for, but not restricted to, helping old people in taking care of themselves in taking their medications at the correct time and in the correct amount. It has been observed that people in general neglect their health and give preference to other things than taking their medicines. This is also the reason they forget to

take their prescriptions on time. Many health maintenance organizations, health practitioners and medical researchers have realized that increased use of patient reminders can significantly increase the treatment of chronic illness and delivery of medical services to the patients who need it.

However, many patients and especially old people, do not take their medicines in the correct quantity. They either take overdose of medicines thinking it will help them heal faster, or they fear the doctor has prescribed a larger quantity than required and take under dosage of medicines. The former leads to several unsuccessful health implications while the latter delays the treatment of the patient and in some cases, allows the illness to spread further requiring further treatment.

Furthermore, some patients are so occupied with their day-to-day activities that they just forget to take their medications. This is particularly true for old patients who have to take more than one medicine at more than one time in a day. Setting alarm clocks is a tedious task which patients are too lazy to set again and again. If asked about what time people have to take their medicines, many forget to answer the correct times or remember whether they have already taken the medicine in the day already. Elderly people specially face this problem because of their degrading memory and in severe cases, forget that they have already taken their prescription and retake the same medicine 2 or 3 times in the same duration. This may not be harmful for lighter medicines, but for some strong and concentrated medicines, it can have further harmful effects to the body. This is exactly where our medicine reminder system can help. Our system takes up the prescription details from the user such as the duration of the prescription, the names of the medicines, the times they are to be taken and the amount of each medicine which is to be taken. After all this data has been entered, our system will remind the user at the prescribed time of which medicine is to be taken in form of a mobile notification and a physical reminder. The patients can leave taking medicines to just our app. whenever the time for the medicine is up, they will be notified and they only have to take their prescriptions during that time, and no other time. If implemented properly, this will drastically decrease overdose of medicines due to forgetfulness and the patients will also be reminded to take their medicines.

7. Research design

The purpose of the proposed model is to reach the same or even better results as many brands in the field, reach maximum quality with the lowest cost possible, together with the aid of our target which is to alert the patient and his caregivers with the regular doses he has to take. We should be looking for reaching to the patient to his phone as this the most suitable and dependable utility he has, also the same can be done with the family, relatives or even the nurse.

At the end we want to reach a few simple objectives which are:

- Take the periodic time and store it for every pill. Alarm the user in many ways through the device itself or the mobile app.
- In case of any missed dose, it notifies the patient's relatives.

7.1. Conceptual design

Pillbox will work under two different working modes: Normal mode, and Management mode.

7.1.1. Normal mode

Normal mode is intended to be the default working mode when the seniors are using it. During this mode the pillbox remains in standby till a pill/dose has to be taken by the user.

Once a pill is due the pillbox will emit acoustic and visual notifications via the internal speaker and the LEDs. The notifications will last for a short amount of time which will be defined later (around 10 s) and then emit a bleep each 10 s. The LEDs will remain lit up till the senior interacts with the device and takes the pill. User will have to press the button and then the pillbox will automatically dispense the pill, shutting off all the visual and acoustic notifications once the button is pressed and the pill dispensed.

If an amount of time (to be defined in later design stages) passes without the user pressing the button the pillbox will emit a wireless notification which will alert the nurse/caregiver in charge that there is a pill pending to be taken by the user of that particular pillbox.

7.1.2. Management mode

Management mode will be engaged when the pillbox is being managed by the management the mobile application. Connection will be done wirelessly.

Management program may:

- Reprogram the pillbox with the new pill schedule.
- Activate the refilling sequence, for which each of the compartments of the pillbox will become accessible while the program will indicate which pill type corresponds in each compartment so that the caregiver/nurse replenishes it.
- Run the test function throughout which the nurse/caregiver will check the correct operation of the pillbox.

Once the device enters management mode the charging LED will blink twice at the start to indicate the pillbox has established correctly the connection with the managing program.

7.2. Conceptual design

Sketches for various different models were made. A total of 5 different models were finally created.

After discarding the majority of them for obvious flaws only two sketches were taken into account as a possible starting point to start designing the first prototype of the pillbox, model A and model B (See Fig. 1).

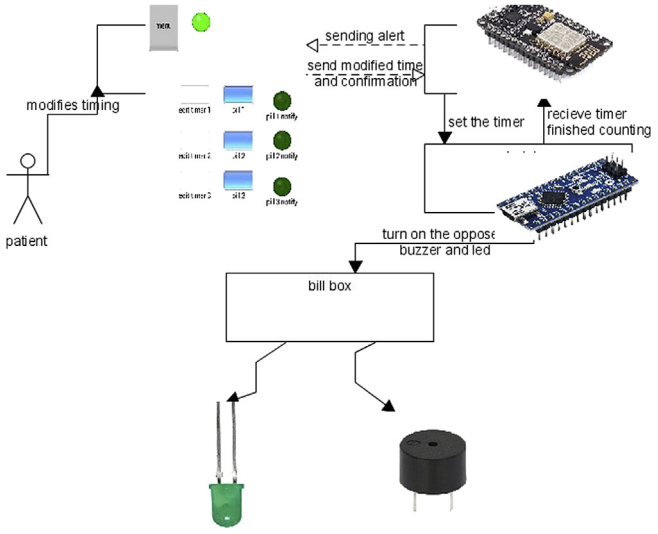

Fig. 1. Implementation of the proposed System.

7.2.1. Model A

Model A consists on a rectangular box design in which there are nine pill compartments (labelled A to I), Led which indicate different working modes and notifications are located of the pillbox, front beside the box. Refilling will be made by Refill zipper with the pill compartments at a time and when the pillbox had to dispense a pill, the mentioned pill will fall into the tray found at the lower center in the front side of the pillbox.

7.2.2. Model B

Model B consists on a circulator with a hole in the lowest part from where it is intended for the pills to be dispensed at the indicated time. On the lower section of the tube a big button to be used by the senior users will be located and beside it the different notification LEDs as well as a smaller switch to be used by the nurse/caregiver in charge for different advanced options such as management, refilling the pillbox, etc.…

Finally became clear that the model which would continue onto the next production phase will be model B. This decision was made when an unexpected concept problem arose when studying each one of the models in further detail, which method was needed to make it possible for the pillbox to give only one pill and no more to the patients without using advanced technology which could make the both the production and the final price of the pillbox greatly rise. A purely mechanical mechanism using only plastic 3d printed parts was devised which could only be implemented in a Square shape and not in a circulator.

7.3. Flowchart

The flowchart represent the logic of the pillbox when operating. Fig. 2 shows the flowchart for implantation the smart pill box.

7.4. Block diagram

A simple block diagram was created to use as a template when designing the different parts (both physical and software) of the pillbox, this diagram can be seen in Fig. 3.

Arduino board will be the “brain” of the pillbox, managing each one of the different areas and will be powered directly with the adapter (charger 12 V). The notification block will be in charge of emitting sound and light signals for the patient to know a pill has to be taken and wireless signals to the caregivers. In a separate block the pill compartments and the pill dispensing mechanism will be also managed apart by the Arduino. Finally an external charger will be in command of charge the battery directly through the Arduino.

A. Materials

1) *Arduino NANO* (Fig. 4): The Arduino Nano is a little, total, and breadboard-accommodating board in view of the ATmega328P.

It has pretty much a similar usefulness of the Arduino Duemi lanove however in an alternate bundle. It needs DC just a control jack and works with a Mini-B USB link rather a standard one. The Arduino Nano is open-source.

The Arduino Nano can be controlled by means of the USB association, 6–20V unregulated outer power supply 30), or 5V directed outside power supply (pin 27). The source is naturally chosen to the most astounding v source. The ATmega328P on the Arduino Nano comes with a bootloader that enables you to transfer new code it without the utilization of an outside equipment software engineer. It conveys utilizing the first STK500 convention. You can likewise sidestep the bootloader and program the controller through the ICSP (In-Circuit Serial header utilizing Arduino ISP or comparable.

2) *ESP 8266 NodeMCU 12E Dev.kit:* NodeMCU is a phase for IoT which is an open source organize, that furthermore, fuses firmware which continues running on the ESP8266 Wi Fi SoC from Espressif Systems and gear which relies upon the ESP-12 module. So we here imply the dev. the unit itself not the firmware that continues running on it. In the disdain of the way that the chip uses Lua scripting vernacular, yet we imagined that it was more solace to use the Arduino centre for the chip with a particular true objective to programming it through the Arduino condition.

The Arduino core is delivered by some inventive ESP8266 fans which can be found on the GitHub name under the of” Arduino core for ESP8266 WiFi chip”, which can have presented in the Arduino IDE through the board executive or on the other hand various diverse ways [6]. The core is a course of action of programming libraries and parts required by the Arduino IDE to amass an Arduino C/C++ source crush down to the objective MCU's machine lingo, which is the ESP8266 chip on our case.

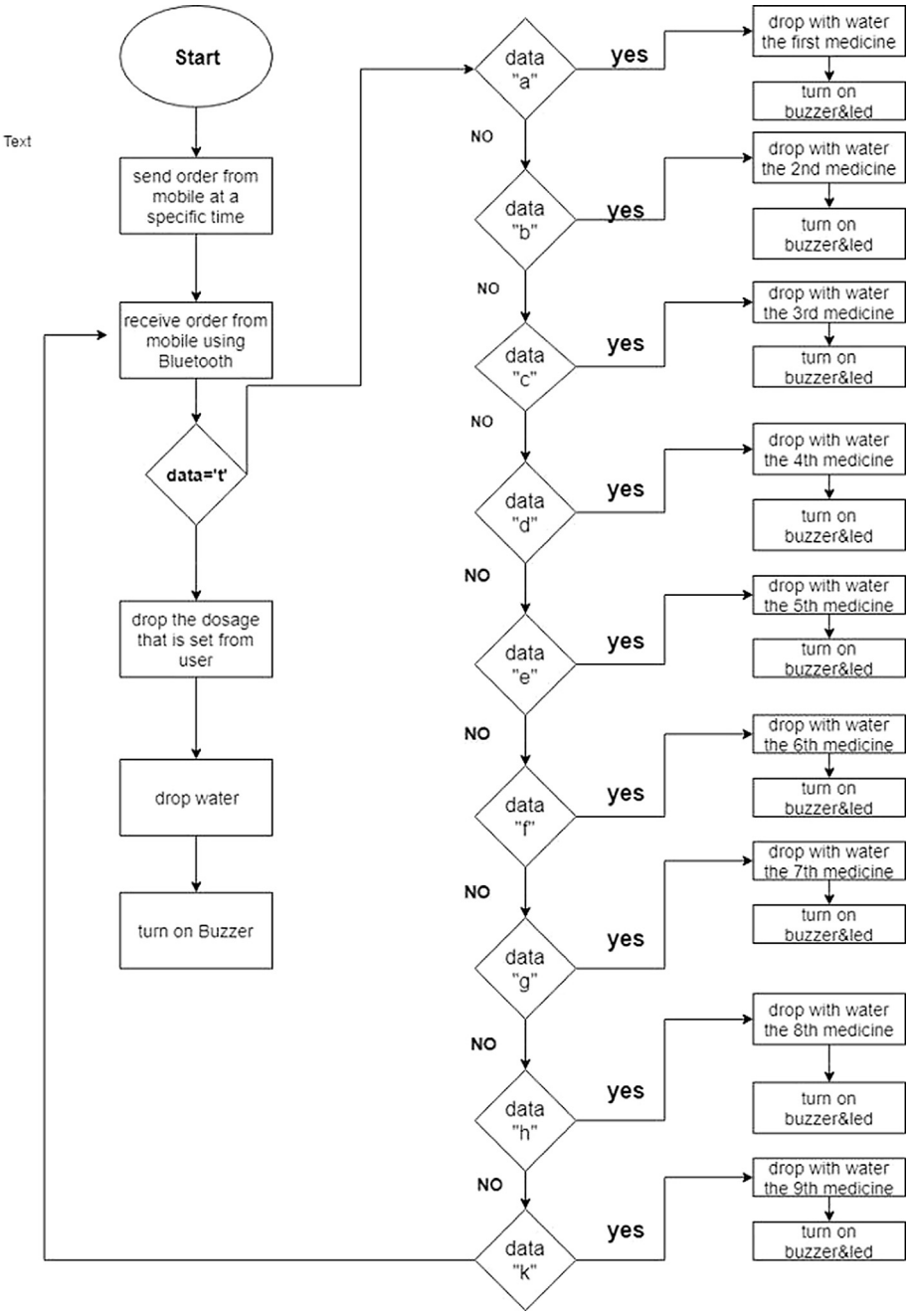

Fig. 2. Flow Chart for of the proposed System.

3) *buzzer:* Piezoelectric signals, or piezo ringers, as they are at times called, were developed by Japanese makers and fitted into a wide cluster of items amid the 1970s−1980s. This headway primarily came to fruition on account of helpful endeavours. In 1951, they set up the Barium Titanate Appli-cation Research Committee, which enabled the organizations and achieves a few piezoelectric developments and creations. Piezoelectric materials are either normally accessible or syn-thetic. Piezoceramic is class of synthetic material, which postures piezoelectric impact and is broadly used to make a plate, the core of piezo bell. At the point when subjected to an exchanging electric field they extend or pack, as per the recurrence of the flag in this way creating sound.

4) *RoboRemo App:* A simple form of the interface as per your task requires: include catches, sliders, LEDs, and so on. Utilize accelerometer sensor for controlling the guiding of a RC auto, or for tilting an automaton. Utilize plots to show constant information from sensors. You can interface the Arduino board straightforwardly utilizing OTG link (if your gadget bolsters OTG), or you can utilize a remote module and associate with Bluetooth or WIFI. WIFI TCP client, TCP server and UDP, Mobile Internet TCP client, TCP server and UDP.

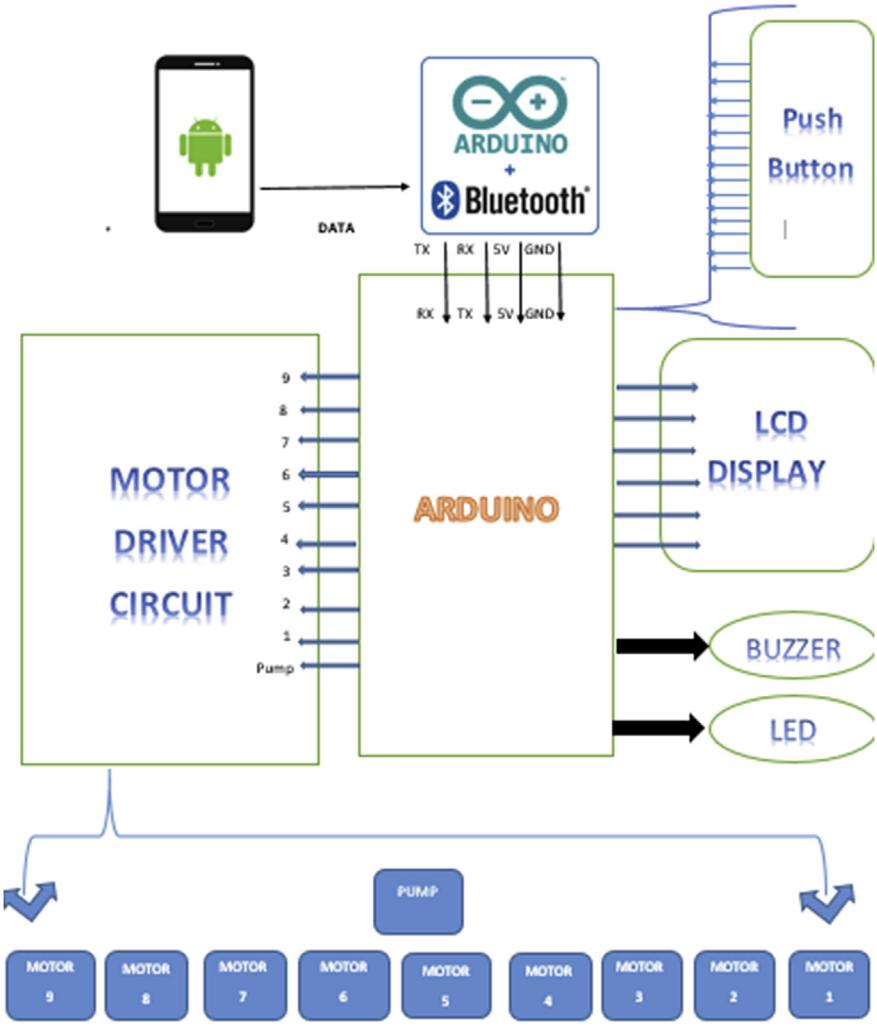

Fig. 3. Block Diagram for of the proposed System.

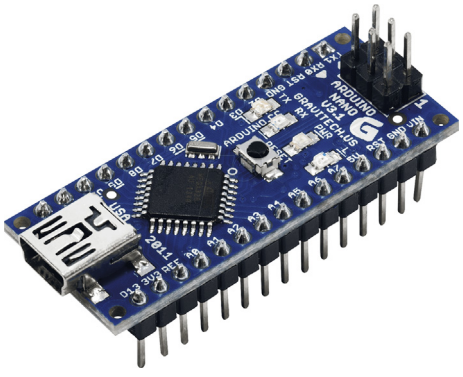

Fig. 4. Arduino nano.

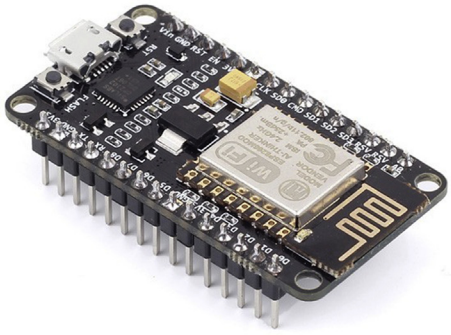

Fig. 5. ESP 8266 NodeMCU 12E.

8. Proposed framework

The framework of this project is divided into two sub-categories, the first is the ESP package which is consisted of all the classes, sub classes and objects needed for the WiFi to establish a server and become ready to connect. The second one is intended for the Arduino NANO, which is the classes set up in the software in order to run the serial ports used for communication, the figure below shows the two packages server and shuts the association. The wifi module is the essence of all; it empowers us to control the system part of the device.

B. Arduino

1) *SoftwareSerial:* As from its name it's the class which enables us from defining any two digital pins as a

Fig. 6. A buzzer.

transmitter and a receiver. We had to use that in the debugging and testing stage, it was more efficient to use more than one serial communication as long as the baud rate is low. We first use the method begin () then define the baud rate in order to run the UART serial communication on the specified pins. It enabled us from monitoring the whole system through the serial monitor, also seeing how fast the transmission goes defined the stability and the capability of the system. Checking the serial transmission was through the method available (), the method read () and write () were for transmitting and receiving to and from the ESP device.

2) *Timer One:* Timer One is the class used for controlling the internal timer of the Arduino, in order to set the periodical timing for each dose we had to count the smallest scale of time which is in seconds. We first has to initialize the timer through initialize () method for the unit to be counted, or more convenient, how frequent would be the timer initiating an interrupt for processing the ISR (Interrupt Service Routine). Then attach an interrupt to it through the attachInterrupt () method, which defines the ISR that has to be executed. Then the timerisr () contains the command that has to be executed, which is initially controlling four separate counters (See Figs. 5 and 6).

8.1. Pillbox design

Different modules have to be defined as stated in section "Block diagram" in the conceptual design. In order to start the final design of the pillbox it is mandatory to locate each one of the modules in a specific area. These modules will be the pill refilling mechanism, the pill dispensing mechanism and the electronic module, where most of the circuitry will be located such as the Arduino, switches, etc … Also the location of the pill tray where each one of the pills will exit the pillbox must be noted in the diagram.

Fig. 7 represents a minimalist cross-section of the pillbox locating the modules inside the pillbox's body.

8.1.1. Pill refilling module design

This module will be in charge of allowing the person in charge of refilling the mechanism to refill adequately the pillbox with a minimal chance for errors in the process.

The opening will be located in the top surface of the pillbox. Refilling will be done with help of the pillbox's management software. The person in charge will be prompted to insert a specific pill type in the pillbox and press a button in application when that action has been completed and the compartment for that pill has been fully replenished. Once the user hits the button in application the program will ask to refill another pill type and press a buttons and the action will be repeated until all of the pill compartments have been refilled.

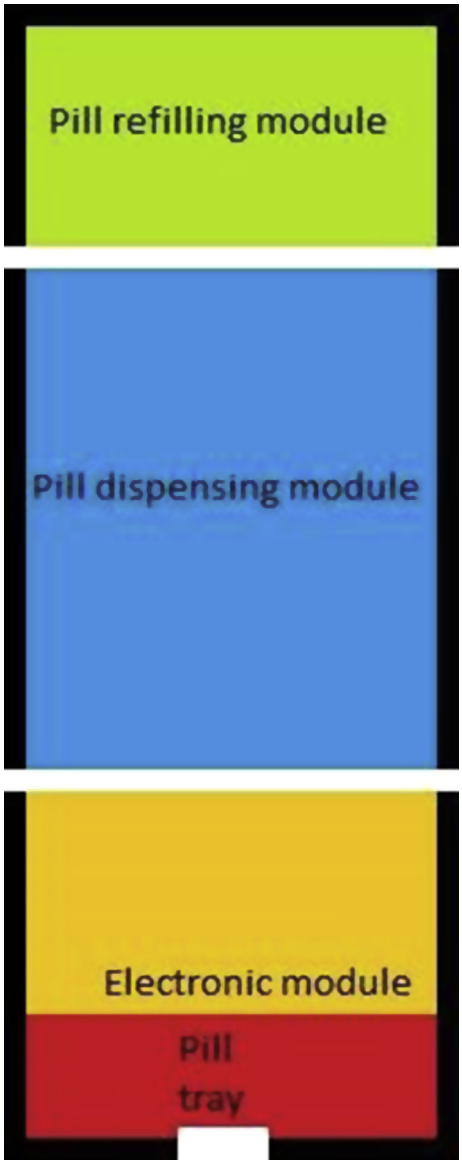

Fig. 7. Pillbox's module scheme.

Pill storage will consist on a Zippers where all the different compartments will be contained in the form of hollow pillars, which will be the ones holding the pills in them. In order for the pills to access each pill compartment a servo installed below the lid which will be holding the Zippers will align via a command sent by the computer each one of the compartments with the entry hole, making the pills fall directly to the selected compartment. Once the compartment in use is filled the servo will rotate the tube as to align the next compartment with the entry hole (See Fig. 8).

8.1.2. Pill dispensing mechanism design

This module will take action each time a pill needs to be dispensed as it will be the module in charge of making the pill fall in the pill tray at the moment the Adriano sends the signal.

Module will need to be capable of selecting the correct compartment from the different compartments of the pill storage and it is vital it only gets one pill from the compartment, as getting more than one pill could prove fatal.

The mechanism for the pill dispensing module will use two Arduino-controlled servos, one of them located under the lid and attached to the pill storage cylinder (same servo as the one used in the pill refilling mechanism) and another one which will control an intermediate piece Mechanism consists in three different stages: default stage, pill load stage and pill release stage. After the pill release stage the system will reset to the default stage. The system goes through the three stages each time a pill has to be dispensed to the user.

Parts involved in the dispensing mechanism.

Parts have been labelled 1 to 4 in the following diagrams for an easier comprehension:

- Part 1 – Pill storage.
- Part 2 – Pill hatch.
- Part 3 – Pill chamber.

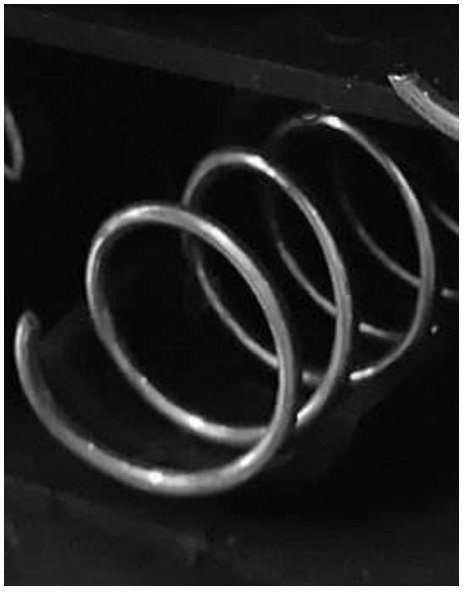

Fig. 8. A view of the Pill storage.

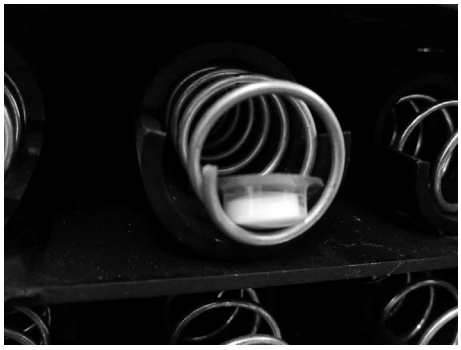

Fig. 9. A view of the Pill chamber.

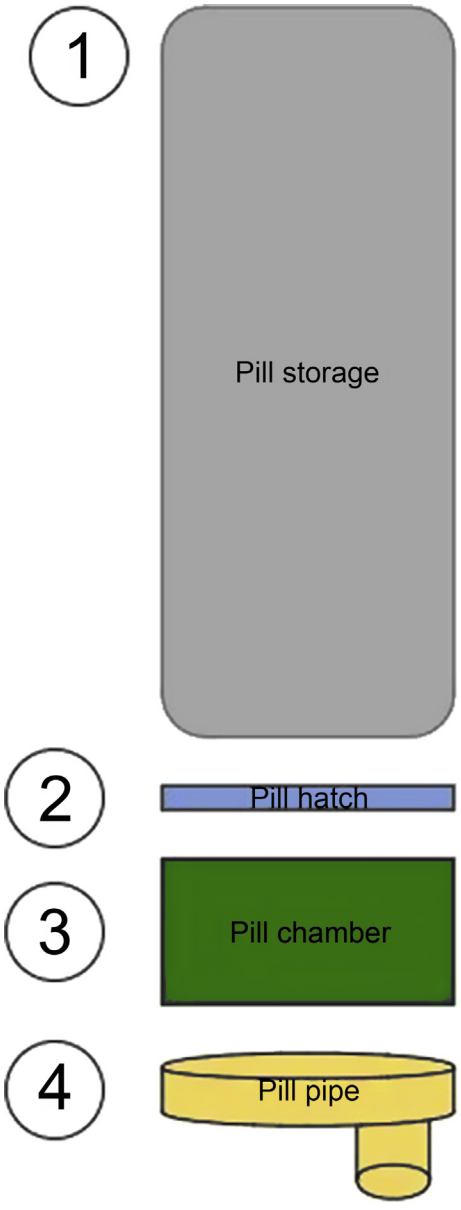

Fig. 10. Pillbox refilling mechanism.

• Part 4 – Pill pipe.

Part 1 Pill storage

This part consists on a cylinder with hollow tunnels which cover the total length of the tube distributed radially along the tube. On the center of the part there is a circular hole where different cables for circuits will pass when the pillbox is assembled. This compartments will be the ones storing the pills until they need to be dispensed. Each compartment will hold only pills of the same type, consequently there can be as many pill types as usable compartments minus one.

Part 3 Pill chamber

The pill chamber consists on a cylinder with a circular hole at the center and another passage beside the hole. This passage is wide enough to hold a pill in an upright vertical position. The height also is the same as the model pill which will be used in this pillbox, therefore this part can only hold one pill standing in an upright position in its storage space (the storage space will be the side passage of the part, which will be also addressed as the pill chamber from now on). Part may be viewed in Fig. 9.

8.1.3. Pill box stage overview

The four parts will be presented in a minimalist way as seen in Fig. 10. During this explanation the location of the different passages will be marked in red in each of the parts (these passages will be the ones the pill has to traverse to get to the exit), as can be seen in Fig. 11.

Stage 1 default stage

This stage is the stage where the pillbox is by default when no pill needs dispensing, the starting position from where the pill dispensing mechanism starts.

The pill compartments in the pill storage (part 1) are positioned so that they are not aligned with the opening of the

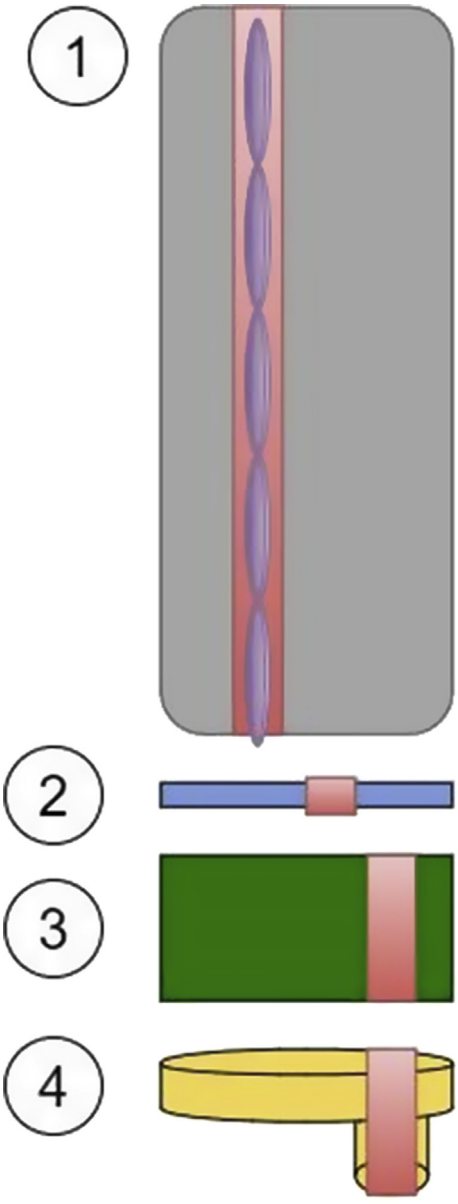

Fig. 11. Pillbox refilling (pills in the cross-section).

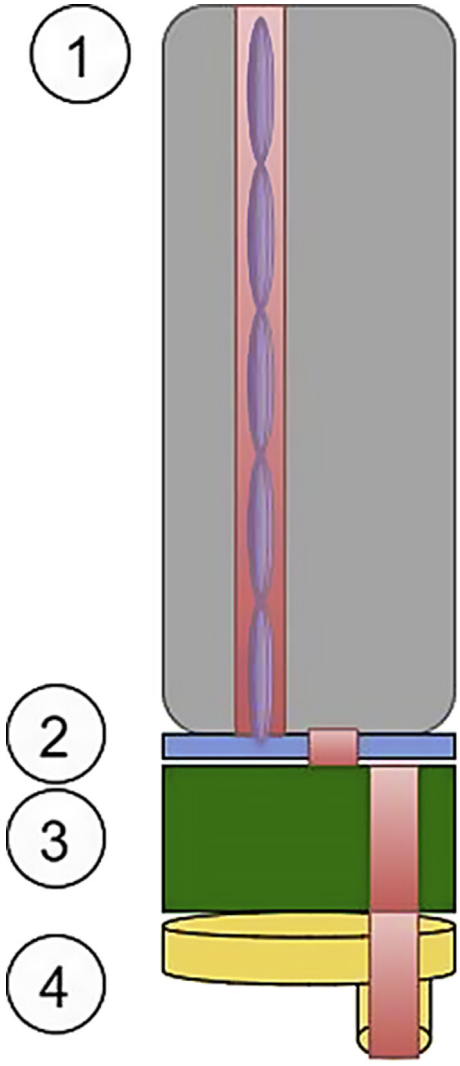

Fig. 12. Pillbox position of inner parts at default stage.

pill hatch (part 2), therefore preventing any pills to exit the pill storage.

Pill chamber (part 3) has the chamber aligned with the pill pipe (part 4), meaning it is not aligned with the opening in the pill hatch (part 2). Parts position in this stage is shown in Fig. 12.

Stage 2 pill load stage

In the pill loading stage both the pill storage (part 1) and the pill chamber (part 3) align with the pill hatch (part 2). It has to be noted that as the pill chamber (part 3) is aligned with the hatch then it is not aligned with the pipe in the pill pipe part (part 4). This means the chamber is closed in its lower part (preventing any pills from falling below) and open in its upper part, which connects directly to the pill storage through the pill hatch. This causes a pill to fall from the pill compartment to the pill chamber, but, as there is only space for a pill in the pill chamber, the pill itself will prevent any more pills to fall into the pill chamber. The position of the different parts is shown in Fig. 13.

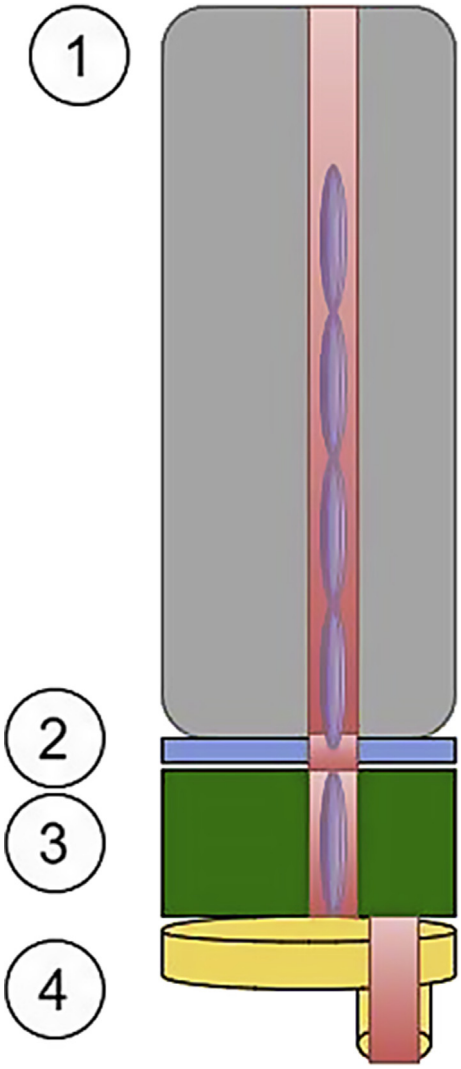

Fig. 13. Pillbox position of inner parts at pill loading stage.

Stage 3 pill release stage

When the pillbox reaches this stage the pill chamber (part 3) will move aligning itself with the pill pipe and therefore letting the pill stored in the chamber fall through the pipe, this position is shown in Fig. 14. Pill storage (part 1) then rotates, aligning the empty compartment of the pill storage with the hatch opening, preventing any other compartments to be aligned over the hatch. Final position is then shown in Fig. 15.

8.2. Parts overview

The pillbox consists on a total of 9 plastic 3D-printed parts which conform both the outer body as the inner mechanisms of the pillbox. The plans for the different parts will be shown here in a reduced scale. The actual full-size plans with

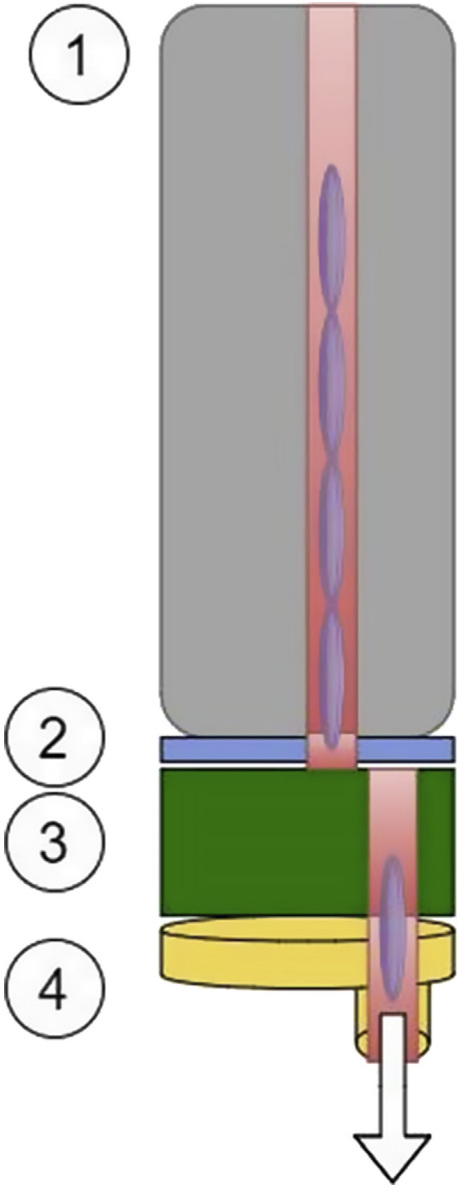

Fig. 14. Pillbox position of inner parts at the first Step of the pill release stage.

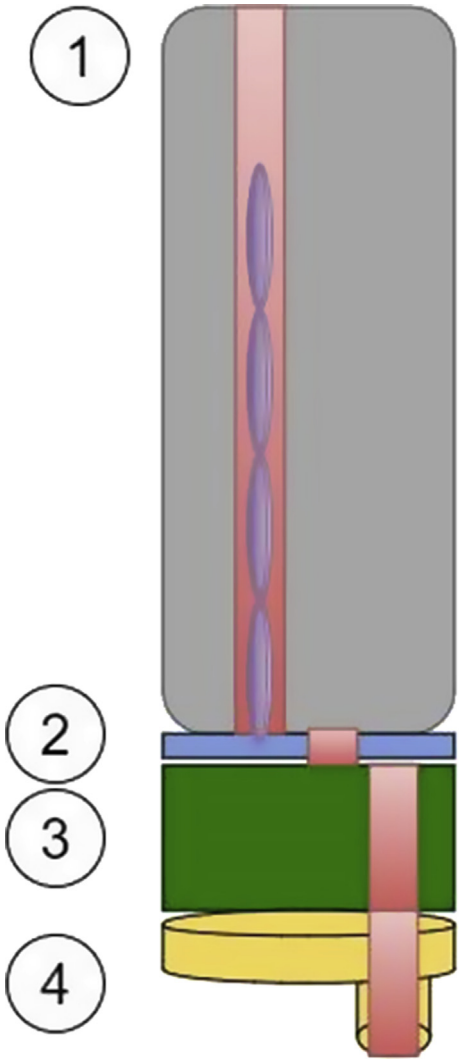

Fig. 15. Pillbox position of inner parts at the last step of the pill release stage.

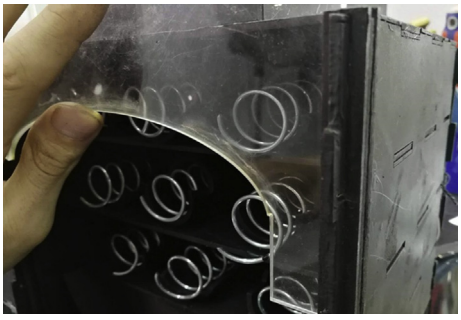

Fig. 16. Scaled plan for the lid part.

measurements of each one of the parts will be appended in the annex. Final hardware is then shown in Figs. 16 and 17.

9. Implementation

A mobile application is developed to full control on smart pillbox remotely using android application. At first when we open it we will see this.

Fig. 17. Scaled plan for the pill chamber part.

Fig. 18. Main screen of mobile application.

Then after connection between mobile application and smart pill box, we click on the middle button “MEDICINES “to write the medicines that the patient take.

After that we go to the last button “SET ALARM” to set alarm on the time we need There are a lot of tunes and if we forget to set the alarm and clicked go out the device gives us warning message like that.

10. Results

A. Steps To Run The System

- Power On The Device.
- Connect with the phone to the ESP AP
- Open the mobile App through Roboremo.
- Modify the timing of each pill and enter it in it's opposed space.
- Wait for every time of the pill, notification is poped.

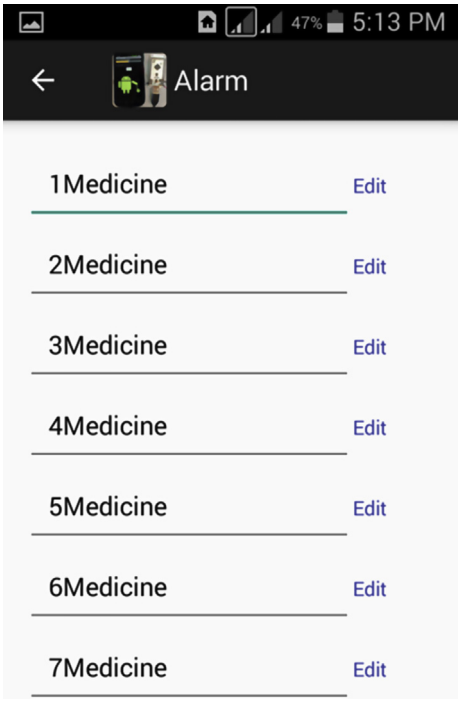

Fig. 19. Set configuration for medicine.

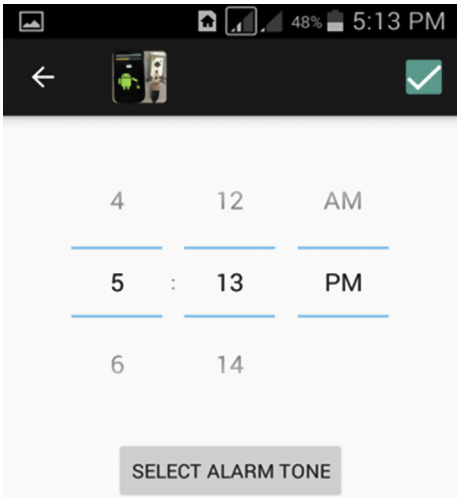

Fig. 20. Setting alarm for medicine.

B. Testing

First, we tested the ESP connection to the remote app, it was successful as we communicate with the app using certain string patterns or codes. Also tested the monitoring through the serial monitor in order to check that there is no delay in the transmission or any lost characters, the same testing method was applied to test the connection between the ESP and the Arduino NANO, the results showed the delay only was for a 100 ms. That small delay didn't affect the timing of the doses in any way noticeable, the graphs below and the interface shown below assures that (See Figs. 18–22).

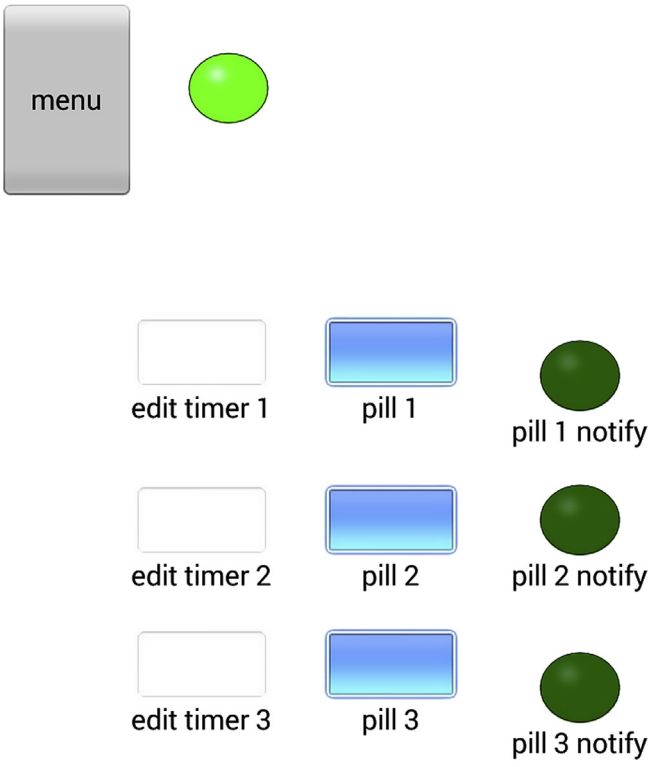

Fig. 21. The user interface.

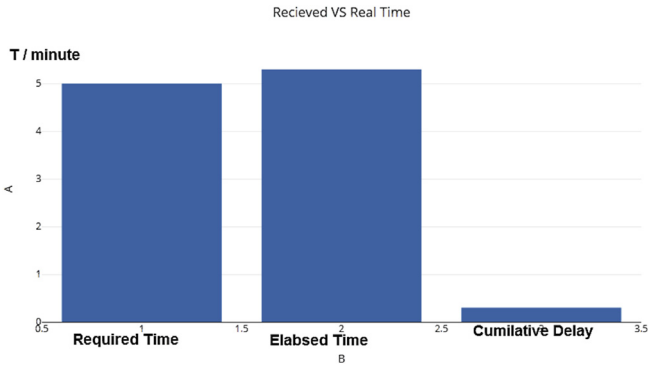

Fig. 22. Required VS elapsed time.

11. Conclusion

A canny pillbox is proposed and actualized this paper. It illuminates the elders to take medication. It productively controls the season of senior citizens to take medication. It additionally diminishes the proportion that patient misses and defers taking medication. The remote user interface joins with the RoboRemo software programming so that the parental figures can help the patient. Which adds more functionality by applying more usability through networking locally or using the internet if it is available. The outline design is too appropriate for the medication bundles. Later on, we trust that the vitality sparing and compact can be considered. In this way, missing and deferring taking solution can be totally eliminated.

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