Smart Medicine Dispenser (SMD)

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***Abstract*— This paper presents a Smart Medicine Dispenser (SMD) prototype. The main purpose of this system is to help the patients, primarily seniors, take their medications on time in an easy way without the possibility of missing pills, also reduce the risk of over or under dosing accidentally. Not taking medications correctly can have serious consequences such as delayed recovery, illness and even death. The smart medicine dispenser (SMD) could solve such problems by informing and alerting the patients to take the appropriate dose at the right time. Also, it provides direct communication between the patients and the caregivers as it will immediately notify the caregiver in case the patient missed his/her pill. In addition, SMD provides the user with a touch interface available as an application on their smartphone which will allow them to remotely manage and control pill schedules and usage data.**

Keywords*— *Smart Medicine; Dispenser; Android Application; PillBox; Microcontroller;

I. Introduction

Medication adherence is a growing concern throughout the healthcare industry with doctors, healthcare systems, and other stakeholders (insurance companies) since the elderly or senior patients' medication has a big issue of drugs misuse [1]. It is very likely for them to forget to take their pills on time. Especially, those who take multiple medications at the same time. Also, they might take wrong dosage accidentally which may lead to unfortunate consequences such as death [2]. This is a clear proof that it is a widespread problem and clearly related to adverse patient outcomes and higher healthcare costs.

In addition, a study has been done by group of professors (Grey, Mahoney, and Blough) at University of Washington about medication adherence in three home healthcare agencies on one hundred forty-seven older participants taking three or more medications, which resulted in 30.6% participants were under adherent and 18.4% participants were over adherent with at least one medication [3].

The main purpose of SMD system is to help the patients, primarily seniors, take their medications on time in an easy way without the possibility of missing pills. It can also reduce the risk of over or under dosing accidentally. The smart medicine dispenser (SMD) could solve such problems by informing and alerting the patients to take the appropriate dose at the right time.

In section II, we present some related works of the medications dispensers. The methodology of the Smart Medicine Dispenser (SMD) is described in section III. Some results obtained from SMD are presented in section IV followed by a conclusion in section V.

II. Related Works

There are several types of pill dispensers available in the market that have been produced by different companies consisting of built-in alarm to notify the users without having online database to save the users and pills, or having remote access functionality.

To state a few:

- An electronic pill dispenser realized using pic microcontroller with keyboard and an LCD that lets the user schedule his/her pills manually on a plate. It dispenses the pills and generates an audio alarm to alert the patient. Also, an SMS is sent to the caregiver phone number in case the pill wasn't taken [4].

- A pill dispenser was created using a combination of infrared sensors and Arduino microcontroller with alarm system to help the patients take their pills at the correct time. The alarm system was implemented using a popup notification on smartphone [5].

- Another pill dispenser that is created using Arduino microcontroller that dispenses only one pill at a time to prevent overdose. Then it notifies the user via SMS that the pill is ready to be taken. Also it was connected to an android application that is used by the caretaker to edit the dates and times of the pills to be dispensed [6].

The proposed SMD system takes the idea of automated dispenser to the next level as it has some functionalities that are not included in any other automated dispensers. An account is provided for each patient and no one else can access it except the patient and the caregiver if the credentials were provided to him/her. Also, some statistics are provided about the pills taken with their alarms and the already existing ones. Online database of the users, pills and their alarms is also a great feature that helped in the design of the project. The alarms can be edited and created using an android application remotely through smartphones.

III. Smart Medicine Dispenser Methodology

This section describes the methodology of the proposed prototype system. The explanations consist of the SMD design and its external peripherals. In this paper, we built an Android application that is responsible of controlling the whole system.

It's the primary way of interacting with the system, the application stores its data on the cloud and performs synchronization upon login. To dispense the pills, the phone will automatically connect to the Arduino via Bluetooth and starts sending commands indicating which container and Stepper Motor should be rotated as shown in Figure 1.

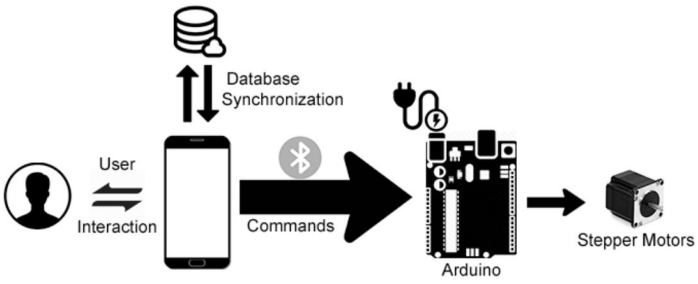

Fig. 1. Design Breakdown

A. *Android Application Overview*

The whole system relies on the android application to provide the user interface, control the medicine dispenser and manage user schedule and usage data.

When the application starts it shows a login screen where the user is authenticated as shown in Figure 2.

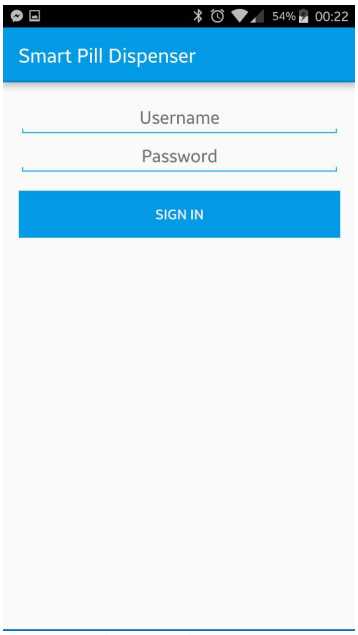

Fig. 2. Login Screen

After the user login, the application will show an overview of the pills to be taken on the same day and on the next day in another Tab, it will also provide a History Tab that shows when old pills were taken as shown in Figures 3, 4 and 5.

To add a new pill alarm the user should press on the Plus icon and then the pill's name and time he should also specify on what days the alarm should be repeated. The user should also choose in what container (from the connected Pillbox) the pill is placed. The Add Alarm view is shown in Figure 6.

Fig. 3. History Tab

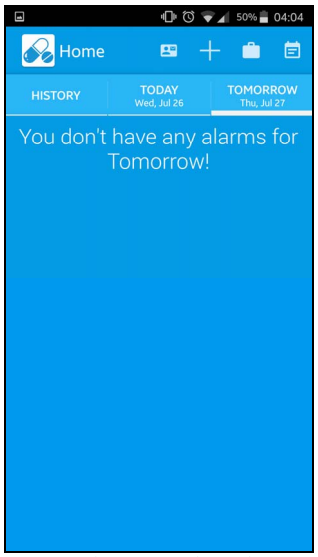

Fig. 4. Next day Tab

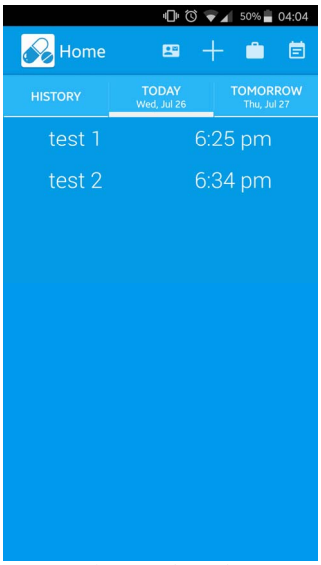

Fig. 5. Today Tab

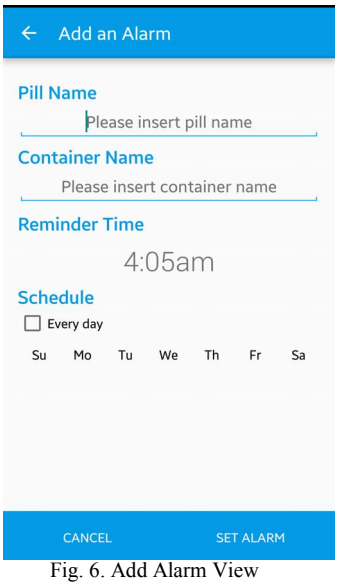

Fig. 6. Add Alarm View

The application also provides an overview of existing pills with their respective remaining number of pills as shown in Figure 7. The User can select a pill timer to change it or delete it. Or if he/she sees that the remaining pill supply is low he/she can click on the refill button the increase the remaining pills back to 8

Included in the application is a settings tab where the user can enter his/her Caretaker's phone number and add new username and password as shown in Figure 8.

When it is time to take the pill, an alarm sound will start and will not stop till the user selects an option of these 3 as shown in Figure 9:

- Take the pill now: which will then dispense the pill in its respective container, and decrease the number of pills remaining
- Snooze the pill for 10 minutes;

- Or Select to not take the pill, where the application will then alert the number, saved in the settings, that the patient skipped his/her pill via SMS.

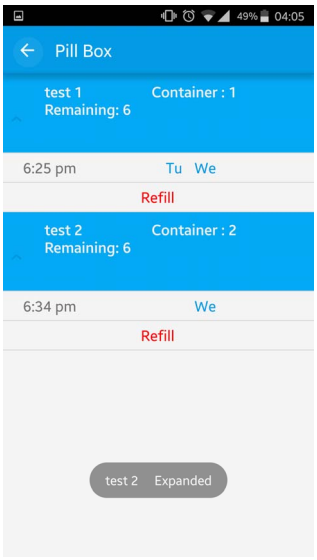

Fig. 7. PillBox Overview

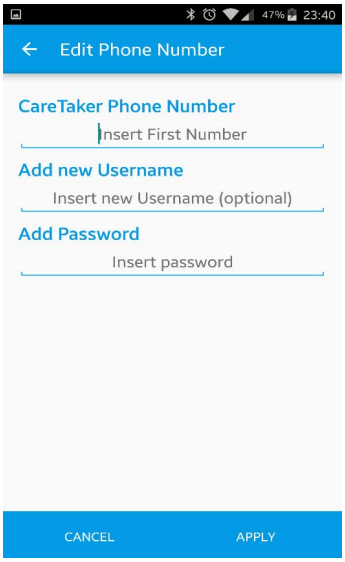

Fig. 8. Settings Tab

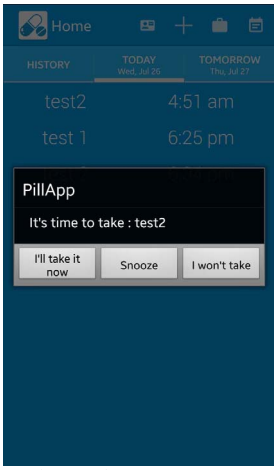

Fig. 9. Alarm Popup

B. *Database Management*

The pill alarms and usage data are stored first locally using SQLite Database. The local database is then synced with an online MySQL Database, hosted on the 000webhost.com servers for free, whenever the user enters the application or changes something in the schedule using PHP and JSON as a way to communicate and transfer data between databases.

C. *Hardware Design*

Figure 10 shows the SMD modular as prototype, with expandable container units. Each container is controlled separately with its own LED and can keep up to 7 servings (a serving can consist of multiple pills of the same type). Servo motors are used to rotate the cylinders; the motors are controlled by an Arduino Uno R3, using PWM signals that make the servo rotate for a bit then stop, and are connected as shown in Figure 11. When the user wants to take his pills, his smartphone will connect to the Arduino via Bluetooth, and sends it which container should be rotated.

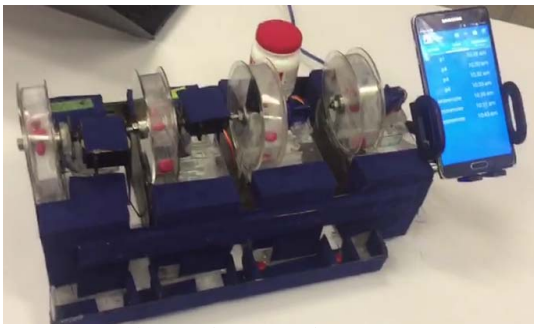

Fig. 10. Dispenser Unit Prototype

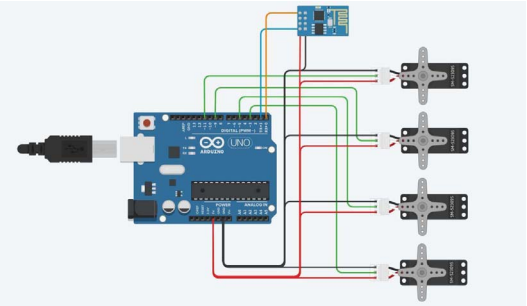

Figure 11. Arduino Connections

The Arduino will then verify if the command is valid by checking if the command string starts with a “c”, the character that comes after the “c” is the container number which will be used to trigger the desired container as shown in Figure 12.

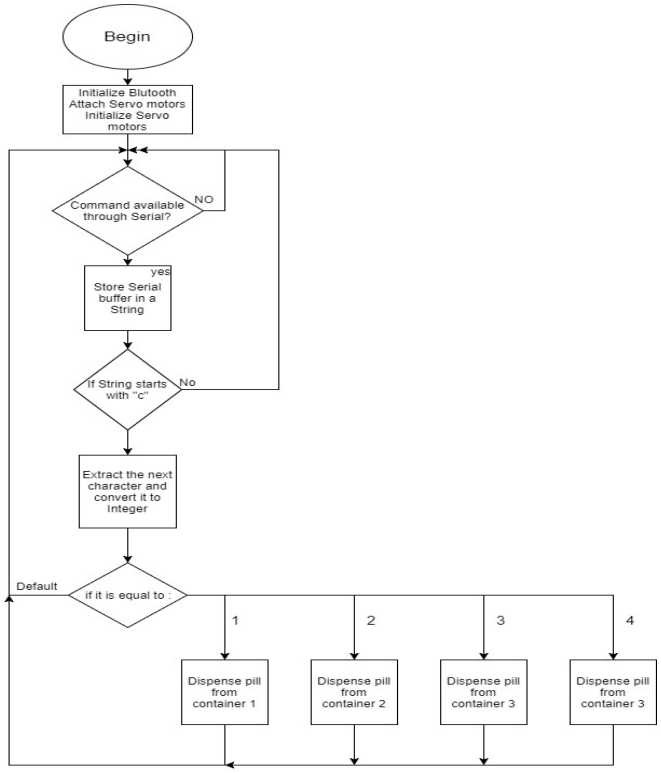

Fig. 12. Arduino Code Flowchart

IV. Results

The application was tested multiple times, and demonstrated little to no functionality breaking bugs. The application is very lightweight and has a very low internet data usage since the local database syncs with the online database only when a change happens or when logging in. The database generated by our tests was captured form our cloud host and shown in figure 13, 14, 15 and 16. Figure 17 shows the text message received by the Caretaker in-case a pill was not taken.

id	pillName	container	remaining
1	testremote	1	5
2	test2	2	8
3	p1	3	8
4	p4	4	6

Fig. 13. Existing Pills

id	pillName	day_of_week	hour	minute
1	testremote	3	18	44
2	test2	3	16	58
3	p1	4	10	28
4	p4	4	10	30
5	p4	4	10	32
6	p4	4	10	33
7	testremote	4	10	36
8	testremote	4	10	37
9	testremote	4	10	43

Fig. 14. All Alarm times

id	pill_id	alarm_id
1	1	1
2	2	2
3	3	3
4	4	4
5	4	5
6	4	6
7	1	7
8	1	8
9	1	9

id	pillName	date	hour	minute
62	p4	Aug 2, 2017	10	32
63	p4	Aug 2, 2017	10	33
64	testremote	Aug 2, 2017	10	36
65	testremote	Aug 2, 2017	10	37
66	testremote	Aug 2, 2017	10	43

Fig. 15. Dispensed Pills Date and time

Fig. 16. Pill and Alarm Linking Table

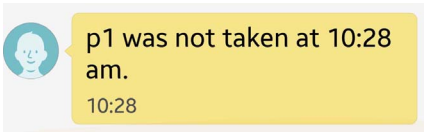

Fig. 17. Received SMS Alert

Hardware testing showed that the dispensing mechanism remained fully accurate after a full container rotation, which is more than enough since the user will have to refill the containers and hence recalibrate them.

V. Conclusion

This paper summarized the major points about our SMD. Elderly patients, especially ones with chronic and periodic medicine, will benefit the most for the SMD, since it will greatly increase their medicine adherence which will insure a better treatment effectiveness or even save their lives. Insurance companies will surely benefit from the SMD since it will help their costumers to live in a healthier lifestyle away from life threating accidents caused by forgetting to take their medicines on time or with the right dosage, and in case of skipped pill, the Caretaker will get alerted almost instantly via SMS.

Finally, the user interface which is the same on all the devices including the machine is intuitive, clear and easy to use, even for elderly patients. The design allows the user to add more containers or more pills per serving.

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