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Smart Medbox Using IoT

Dr. Ramananda Mallya K[1], Gagandeep D Achar[2], Saadhan Ballal[3], Shreya[4], Yogeesh M[5]

Associate Professor, Dept. of Information Sc. & Engg, MITE, Moodbidri, Karnataka, India[1]

Student, Dept. of Information Sc. & Engg, MITE, Moodbidri, Karnataka, India[2-5]

Abstract: The proposed smart medical box is designed to address medication adherence challenges, particularly among the elderly. It consists of a companion phone application for initial setup and remote operation, allowing users to specify pills and schedule them at varying times throughout the day. An Arduino board/ESP 8266 controls the operations and connectivity functions of the box, which only unlocks for a short time in the specified slot. Notifications for missed or low-stock medication are sent to the app, and the system logs usage statistics. Implementation on a larger scale using IoT-based platforms can benefit institutions such as old-age homes and nursing homes, improving medication management, sanitation, and safety, and reducing drug overdependence. The proposed system offers a potential solution to medication mismanagement challenges by providing visual and auditory cues to reduce confusion and improve medication adherence. By using technology to regulate pill intake and generate medication adherence reports, the smart medical box has the potential to significantly enhance medication management for patients, especially the elderly, and improve overall healthcare outcomes. The records can be sent to the administrator who can further notify the participants.

Keywords: Smart Medical Box, Medication adherence, Companion phone application, Pill scheduling, Arduino, IoT-based, Healthcare outcomes.

I. INTRODUCTION

In our world's current climate, most humans can be considered barely healthy due to rampant pollution, unhealthy diets and lack of exercise. This has led to nearly everyone developing a reliance on some sort of medication. This eventually leads to imbalances in the body, causing the contraction of many diseases. While not life-threatening in most cases, a few diseases are dangerous and require long-term medication to be cured. Rarer still are the diseases that become a part of the human body, not being able to be cured [1]. The lifespan of humans is reduced because of such diseases and overcoming them requires timely medication, sometimes even in large doses [2]. The prescriptions given by healthcare specialists are crucial in such cases and must be followed to the letter. Any changes in the prescription must also be quickly adopted by the patient. Studies have shown that not adhering to the provided prescription is one of the major causes of the inefficacy of certain treatments.

Our project proposes a Smart Medbox which uses Arduino in tandem with an ESP8266 Wi-Fi module to manage the timely dispensing of medication. The box itself consists of many slots to store up to 8 different types of medication. The box is controlled via an Android application, wherein the medication and timings for a slot can be designated. When the specified time is reached, auditory and visual cues in the form of blinking LED lights and a buzzer are provided to alert the patient. Thus, the box ensures that proper medication adherence is followed. The 8-slot system of the box can be used to manage medication inventory. The box is powered by a wired cable that must be connected to a nearby power socket, thus foregoing portability.

II. OBJECTIVES

The primary objective of our project is to solve the problems mentioned prior by developing and designing a tool that will aid the user in managing their pill intake in an easy and simple way. The system is designed to be used without requiring any sort of advanced training or complex operation, requiring only knowledge of operating a standard smartphone.

III.ANALYSIS & REQUIRED SPECIFICATION

A. Purpose: Studies conducted by various reputed organizations across the world show that lack of proper medication adherence is the 6th leading cause of premature deaths. The majority of these cases involve patients with mental illnesses, leading to forgetfulness and inability to focus. This leads to common symptoms such as migraines and hypertension [4], which then increases the risk of lethal conditions such as heart disease and stroke [5]. On the other end of the spectrum, there are patients who try to take an overdose of medications or try unorthodox and archaic medications with mistaken

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assumptions on their effectiveness. Furthermore, some patients are simply unable to afford a caretaker, owing to financial constraints. Thus, we set out with a plan to develop a low-cost and simple utility, designed with the needs of the average patient in mind.

B. Scope: The proposed system provides its users a device to schedule medication and reminders so that elderly people can take medicine at the prescribed time. This system also helps for the purposes of monitoring and regulating the pills and tablets, and analysis of patient's medication adherence history to generate a report. This medical box system comes with phone application that facilitates scheduling of medicine intake and also remote operation of the medical box. Apart from the above-mentioned personal uses, the implementation of this system on a larger scale using IOT-based platforms can be a possible solution to the problems of medication mismanagement faced by old-age homes, nursing homes and other institutions due to various technical and/or personnel errors.

IV. FUNCTIONAL REQUIREMENTS

This subsection contains the requirements for the Smart Medbox system. The requirements have been collected after consulting with probable users and as per our own research. The project will be developed to satisfy all listed requirements and deliver the product expected by the users.

The requirements of the system include:

- The Smart Medbox system consists of two key components: The Medbox and the companion app.
- The application can be installed on an android smartphone, and will be able to connect to the Medbox when on a shared local network.
- The box will feature a 4x2 grid of pill slots, and will be of a stable construction of a combination of 3d printed components and a wooden exterior.
- The pill slots themselves are quite spacious, thus they can hold a large no. of pills and can fit the fingers of the average person.
- The pill slots will also have corresponding LEDs that light up to indicate the pill to be taken. Buzzers within the box will ring to notify the user.
- The top of the box will have a LCD screen that will also provide details about the current dose of medication.
- The lid of the box is equipped with ultrasonic sensors that track when the lid is opened. If the box is opened at the specified timeslot, it is logged and sent to the application.
- The Medbox is of a compact design, with all electronics enclosed within. The box is powered via a wired power plug.

V. NON-FUNCTIONAL REQUIREMENTS

A. Hardware Requirements:

Processor: Intel(R) Core (TM)i3-5005U CPU
Processor Speed:2.00 GHz
Memory:2.00 GB
Hard Disk: 40GB to 80 GB

B. Software Requirements:

Operating System: Windows 11
Front End: React Native
Back End: Node JS
IDE: Visual Studio Code
Database: SQL LITE

VI. METHODOLOGY

The system consists of two distinct parts: The box and the mobile application. The box houses the internal electronics, such as a NodeMCU ESP8266 wi-fi module, Arduino UNO R3 microcontroller, LCD display, sensors, buzzers and LEDs. The operation of the box is controlled via the mobile application, which is connected to the Wi-Fi module on a shared network. The operation of the box begins when data about a scheduled medication entered in the application is sent to the wi-fi module. Each instance of data consists of pill details, dosage, slot number, and the scheduled time. This data is stored internally in the Wi-Fi module, which has up to 4MB of free space for storage. A copy of the data is also sent to the Arduino board.

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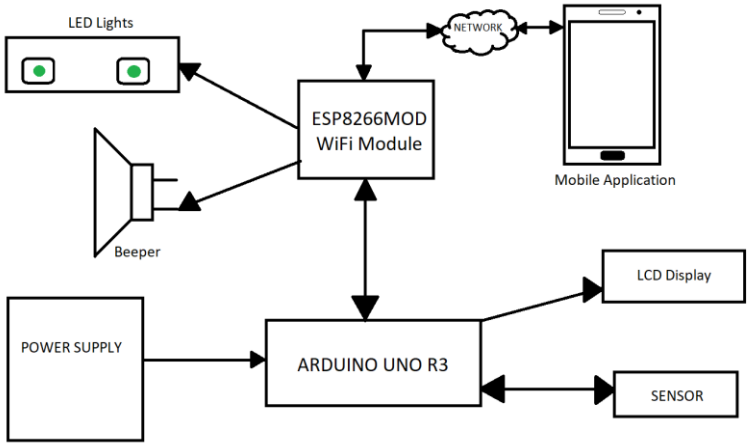
Once the ESP8266 is connected to the network, we initialize the NTP client and obtain the current time for the specified time zone. When the obtained time matches one of the scheduled times, the reminder functions of the system begin. The ESP8266 sends signals to the buzzer and the LED of the specified pill slot. Thus, the buzzer and the lit-up LED offer auditory and visual cues to alert the patient and indicate the pill to take. Furthermore, the Arduino board sends signals to the LCD display and also monitors the signals from the sensors within the box. The LCD display shows the name of the pill, the dosage of the pill, and the pill slot. The sensors monitor the state of the box lid. This state continues for up to a minute by default, but this limit can be changed. If the patient opens the lid of the box to take the specified pills within the time limit, the sensors signal the Arduino board that the pills have been taken. If the box is not opened, the Arduino board assumes that the pills have not been taken, and logs it into memory.

In the mobile application, users can create a schedule to be sent to the box. Operation begins when the user creates a new alarm within the app. The user then specifies the scheduled time, repeat condition and medicine details such as medicine name, slot number, and number of pills inserted. When the user saves the new alarm, the data is saved in the backend database (SQLite) and a copy of the data is sent to the wi-fi module. In this way, users can set up to 8 different pills at a time. When the specified time is reached, a notification on the users' phones reminds them of the medication. Also, as long as the phone is on the same network as the box, medication status and pill inventory details are sent to the application. Additionally, the app also allows users to monitor patients' pill intake and manage the details of any pre-existing pills.

VII. ARCHITECTURAL DESIGN

An architectural explanation is a formal description and illustration of a system, organized in a manner that supports reason in relation to the structure of the system which comprises system components, the externally detectable properties of individual components, the interaction among them, and provides a plan from which products can be procured, and systems developed, that will work mutually to implement the on the whole as a system.

Fig. 1 ARCHITECTURAL DESIGN FOR THE SYSTEM



The block diagram gives a simplified view of the major components and the connections to be implemented between them in the smart Medbox system. It is apparent that the ESP8266 Wi-Fi module and the Arduino UNO microcontroller form the core of the system.

FLOWCHART

A Data Flow Diagram (DFD) is a graphical illustration of the flow of data throughout an information system, modeling its procedural aspects. A DFD is often used as a beginning step to create an outline of the system, which can later be elaborated. DFDs can also be used for the visualization of data processing.

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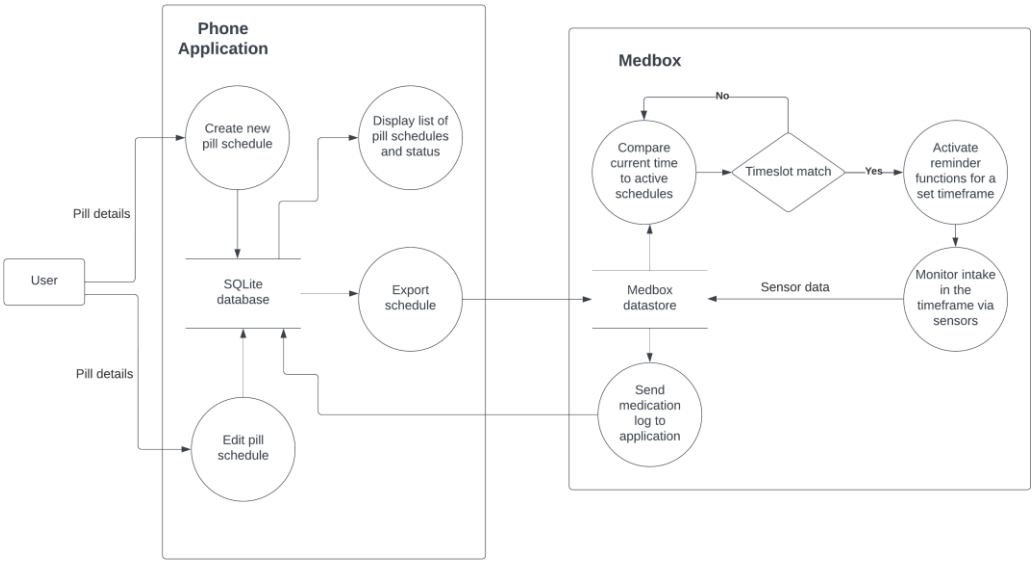

VIII. RESULT AND DESCRIPTION

Fig.1. Top-down view of the box

Fig.2. Isometric view of the box

Fig.1 and Fig.2 shows external views of the box. The slots, corresponding LEDs, and the LCD screen are visible. The box construction features a combination of 3d printed components and a plywood exterior.

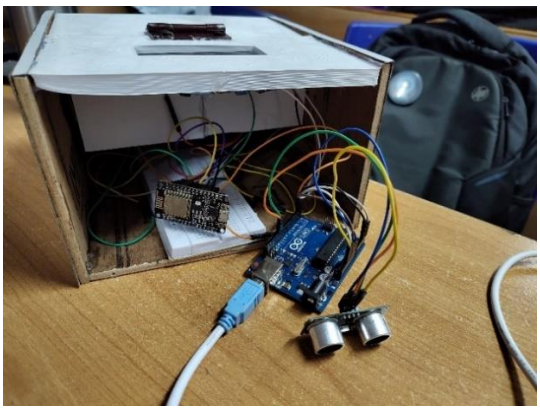

Fig.3. Internal electronics of the box

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Fig.3 shows the internal electronics of the box. The ESP8266 Wi-Fi module, the Arduino UNO microcontroller, ultrasonic sensor and the internal wiring of the box is visible.

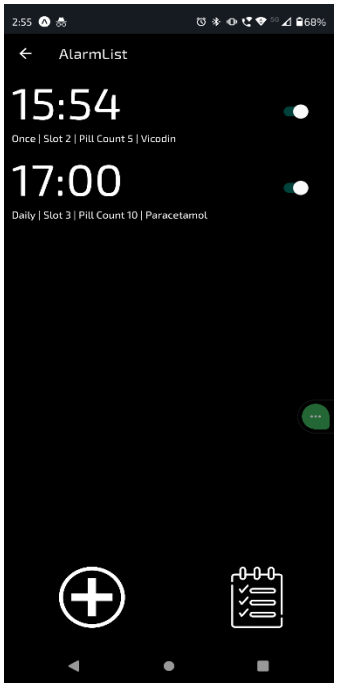

Fig.4. Screen displaying Alarm list

Fig.4 displays the home screen of the application. Added alarms are listed here, along with their status as active or inactive. The icons at the bottom of the screen allow for new alarms to be added and medication status to be viewed, respectively.

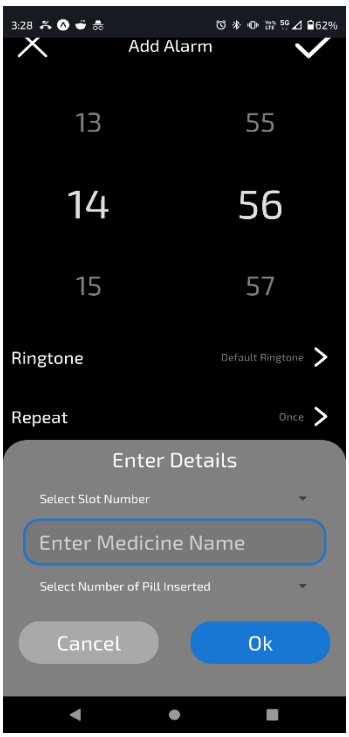

Fig.5. Screen for entering alarm details

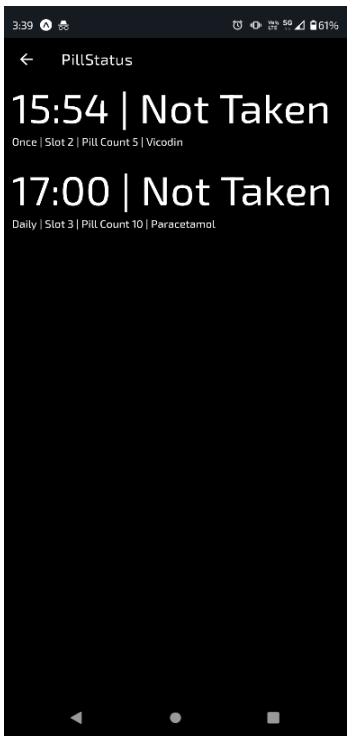

Fig.6. Screen displaying medication status

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Fig. 5 displays the screen for entering alarm time, repeat condition, slot number, medication name, and the number of pills. The alarm can then be saved or can be discarded. Fig.6 displays the status screen wherein the medication status and the pill count of each slot are displayed.

Advantages

- The Smart Medbox reminds patients to take their medication at the right time, without the need of a human caretaker to do so.
- The slot-based design of the pillbox allows patients to manage their intake of multiple types of pills with minimal confusion.
- The pillbox also tracks the count of the pills, allowing caretakers to refill them as necessary.
- Flexible timers and the inclusion of repeat conditions allows the pillbox to be operated for a long time on a single refill.
- The box itself is of a sturdy design and build, with a magnetically sealed lid, and operates on a wired power supply connected to a standard power outlet.
- The box features a cost-efficient construction, simple operation, and easy upkeep.

Applications

- The primary application of the box is to be used by elderly patients who find it too difficult to manage their medication on their own, or lack a caretaker to do it for them.
- The box can also be used by the working individual who might be too busy to manage their medication on a daily basis.
- The box can also be used to aid caretakers in their job, providing a system for managing the needs of each individual patient that they may have.
- The box can also be used by doctors to treat patients with chronic illnesses and mental disorders, to monitor effects of certain types of medication in clinical trials, and for remote treatment of patients.
- The box can also be used as a simple carrying case to keep medication organized while travelling.

IX. CONCLUSION & FUTURE ENHANCEMENT

The Smart Medbox System is simple to set up and operate and requires only minimal technical knowledge from the user. The companion mobile application features a UI that is both easy to use and accessible, and the box and the application are easy to connect together. The system is flexible enough to set up different medications at various times throughout the day, and is precise in issuing reminders. All these features deliver a system that provides a simple utility to aid anyone looking to ensure maximum effectiveness of treatment plans for themselves and their loved ones.

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