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Article

Smart Phil Dispenser - SPD

Dispensador de Pastillas Inteligente - DPI

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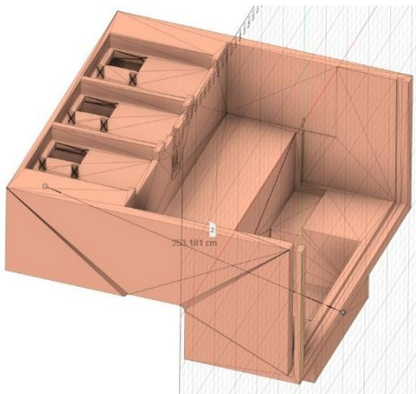
Abstract

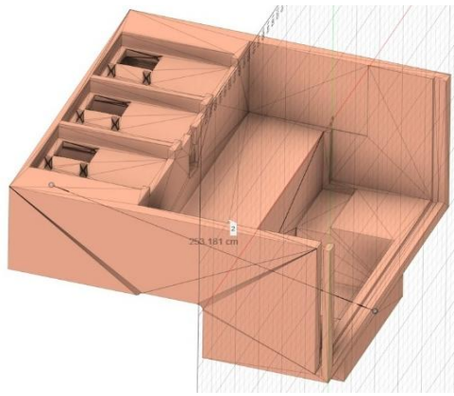
This article presents the development of a Smart Pill Dispenser called Phil by a team from the Technological University of San Juan del Rio called IoT Connection. Following the Scrum methodology, a prototype was designed to medication schedule, ensuring accurate and timely administration. Functional tests demonstrated the device's effectiveness and realism. This innovative approach to healthcare offers a practical and safe solution for medical care, promoting better daily management focused on well-being and health. To this end, a mobile application and a website were developed, and database and the MQTT protocol were implemented to communicate with our physical prototype.



Automatic, Innovation, Health

Resumen

Este artículo presenta el desarrollo de un Dispensador de Pastillas Inteligente llamado Phil por parte de un equipo de la universidad Tecnológica de San Juan del Río llamado IoT Connection. Siguiendo la metodología Scrum, se diseñó un prototipo para programar la medicación, garantizando una administración precisa y oportuna. Las pruebas funcionales demostraron la eficacia y el realismo del dispositivo. Este innovador enfoque en la atención medica ofrece una solucion practica y segura para la atención médica, promoviendo una mejor gestión diaria centrada en el bienestar y la salud por lo cual se desarrolló una aplicación móvil y una página web así como se implementó una base de datos y el protocolo MQTT para tener comunicación con nuestro prototipo fisico.



Automatic, Innovation, Health

Area: Dissemination and universal access to science

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Introduction

The Smart Phil dispenser represents an innovative solution that integrates advanced technology with the need to improve adherence to medical treatments. This device was created to facilitate daily medication management, ensuring that patients take their medications on time and with the correct dosage, without requiring constant intervention from a caregiver.

Its main objective is to offer a reliable, safe, and easy-to-use tool, specially designed for people who must follow a strict medication regimen. This includes those suffering from chronic illnesses, prolonged treatments or conditions that require continuous monitoring of medication use.

One of the dispenser's most notable features is its ability to organize medications into individual compartments, which can be programmed to release pills at specific times, according to medical indications. This automation reduces the risk of human error, improves treatment effectiveness, eliminating the need to remember exact schedules or does.

The device automatically dispenses the correct medication at the right time, providing the user with peace of mind and confidence in their treatment. It also incorporates a secure locking mechanism that prevents unauthorized access or accidental consumption, a feature especially useful in homes with elderly people, children, or patients with cognitive impairment.

Smart Phil also features visual, audible and mobile notification reminders that alert the user when it's time to take their dose. These reminders are fully customizable, adapting to each user's needs and preferences, improving their experience and commitment to medication.

Unlike traditional pillboxes, Smart Phil integrates into the smart device ecosystem [IoT], allowing synchronization with mobile applications or medical platforms to keep a digital record of treatment adherence. This way, family members, caregivers, or healthcare professionals can monitor patient adherence in real time, receive alerts in case of omission, and access detailed reports on their progress. In addition to its individual benefits, the project seeks to reduce healthcare costs associated with medications errors and improve patient's quality of life through the responsible use of technology.

With this initiative support tool, but also represents a step toward the digitalization of healthcare combining technological innovation with human well-being.

Problematic

In the healthcare field, one of the greatest challenges is proper medication management, especially for older adults who must follow long-term treatments.

Factors such as forgetfulness, confusion about schedules, or lack of supervision lead to medication-taking errors, which can lead to medical complications and reduce treatment effectiveness.

Given this situation, we identified the need for an automated technological solution that facilitates medication control, ensures the correct dosage and schedule, and provides users with security, autonomy, and confidence in their daily treatment.

Therefore, we decided to develop a pill dispenser to improve health adherence among older adults.

Justification

The Smart Phil project is justified by its ability to automate the medication administration process, allowing the user to receive the correct dose at the right time, without relying on memory or the constant assistance of a caregiver, This automation not only increases the accuracy and safety of treatment, but also promotes patient independence and confidence, improving their physical and emotional well-being.

Furthermore, the dispenser offers added value in the medical and family setting, as it allows medication intake times to be recorded, generates personalized alerts, and provides remote access to caregivers or healthcare professionals thus facilitating continuous monitoring of therapeutic adherence. This contributes to strengthening the relationship between patient and healthcare system, favoring risk prevention and the early detection of irregularities.

Furthermore, from a technical perspective, it promotes the use of automation, IoT connectivity, and user-centered design as key tools for innovation in the healthcare sector.

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In conclusion, Smart Phil not only represents a technological advance, but also a tool with a social and healthcare impact, aimed at reducing medication errors, increasing patient safety, and strengthening personal autonomy. Its implementation directly contributes to the goal of achieving more efficient, humane, and sustainable healthcare.

Methodology

The Scrum methodology is a widely used agile framework for the management and development of technology projects, aimed at improving collaboration, adaptability, and the continuous delivery of functional results. In the Smart Phil project, this methodology allowed the team's work to be efficiently organized, promoting constant communication and continuous improvement at each stage of the smart phil dispenser's development.

Scrum is structured in short work cycles called sprints, which have a defined duration [usually one to four weeks]. Each sprint begins with planning, in which the team establishes clear and achievable objectives, defines priority tasks, and assigns specific responsibilities to each member. At the end of each sprint, a review of results and feedback are provided, allowing for errors to be detected, improvements to be implemented, and the project's course to be adjusted flexibly and quickly. The use of Scrum at Smart Phil allowed for a clear view of progress, fostering team autonomy and accountability, and ensuring that each partial delivery added tangible value to the project. Thanks to this methodology, a process focused on the user's real needs was achieved, thus ensuring a functional and high-quality result.

Development

We made the sketch of our prototype ourselves, which is the Smart Pillbox, we designed it in SolidWorks and sent it to be 3D printed.

Box 1

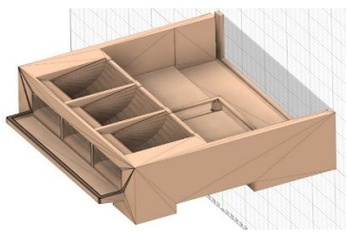

Figure 1
Dispenser model

Our sketch of how our dispenser would be made was created based on what each of us had in mind about how we wanted it to look, which was presented to the collaborative team beforehand to determine if the prototype was suitable for what we wanted.

Box 2

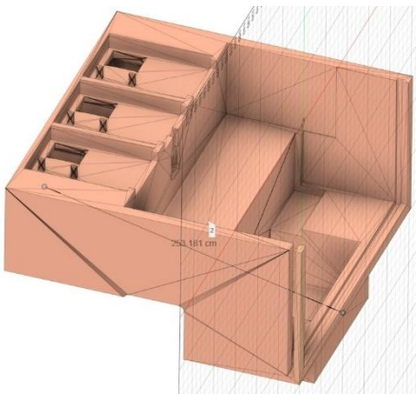

Figure 2
Top of the dispenser

Before starting our project, we made a diagram where we listed all the technologies to be used so we could clearly define what would be needed to carry out the project, since making this diagram made certain points easier for us.

Box 3

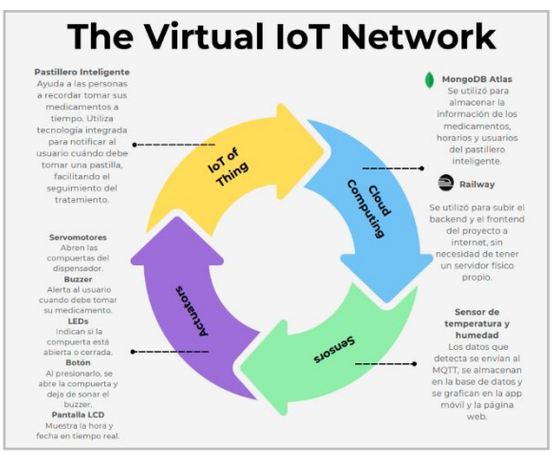

Figure 3
Technology diagram

Similarly, when we knew what was going to be stored in the database, a model was created to define how our database was structured.

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Box 4

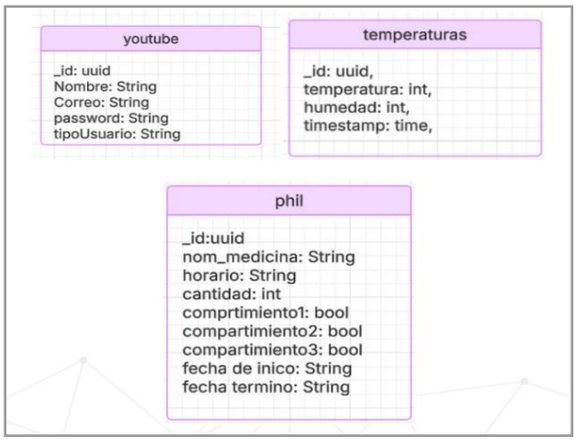

Figure 4

Database composition each table is a collection

Similarly, Mongo Atlas interfaces were created to store data from our website and mobile app.

Our Mongo Atlas interfaces have a collection called test, another called test.youtube, and another called test.temperature, each of which stores data from the website and mobile app.

Here is our test.youtube where there is an Id, Name, Email and password.

Box 5

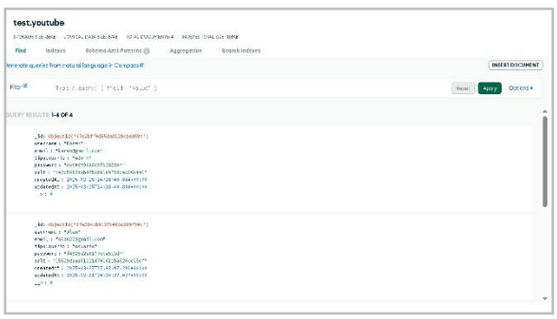

Figure 5

Mongo atlas interface TEST.YOUTUBE

Here is the test.temperature where the Id, Temperature, Humidity and Timestamp are saved.

Box 6

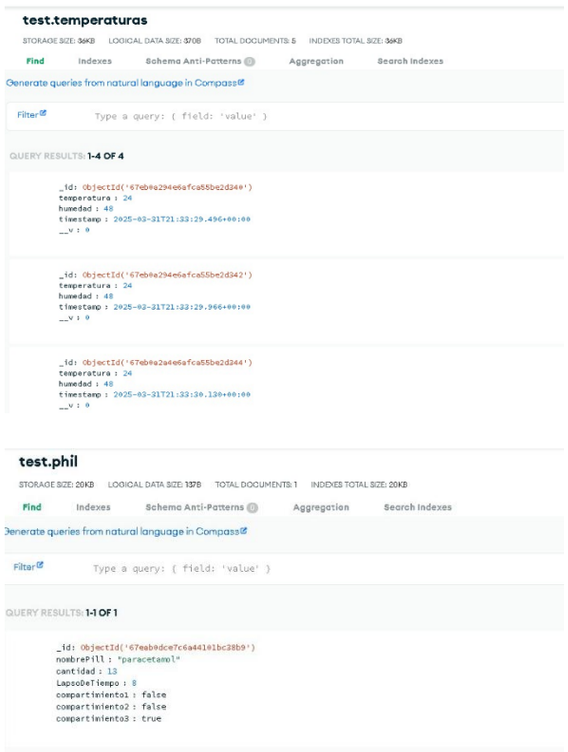

Figure 6

Mongo atlas interface Test.Temperature and Test Phil

We also have test.phil which shows Id, Name, Quantity and Time period.

On our website and mobile app, there's a section that shows us the temperature of the medications in our dispenser. We did this because sometimes medications need to be at a certain temperature.

Below, l'll show a screenshot showing the temperature of the medications on our website.

Box 7

Figure 7

Temperature History (Web Page)

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Similarly, the mobile application was programmed to be able to display our graph.

Box 8

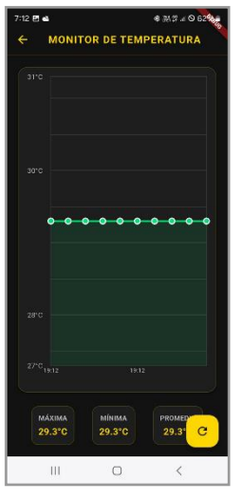

Figure 8
Temperature History (Mobile App)

Box 9

Figure 9
Login (Mobile App)

Here's our login page, which you can use if you already have a Username and Password.

Here's a section where you can register if the user doesn't have an account and can create one in this section.

Box 10

Figure 10
Account registration for login (Mobile App)

Here we see registered users, medications, reports, patients, user management, and settings in our application. This is the main screen that appears when you log in and where the administrator can make changes to medications and users.

Results

After implementing and testing the pill dispenser, the result was a functional device that fulfilled its purpose of alerting and dispensing pills at the scheduled time.

The audible and visual alerts were successful, and the user servomotor-operated opening mechanism operated accurately.

The timer programming remained stable, allowing the system to operate error-free.

As general conclusions, it is highlighted that the project demonstrated the feasibility of applying IoT technologies to solve everyday problems and improve user's quality of life.

Opportunities for improvement were identified, such as the integration of an app for remote management.

The project represented an enriching experience that combined programming, electronics, and design knowledge.

The results obtained in our mobile application included Login, Administration User, Management, Registration [if they do not have an account], and graphics.

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Box 11

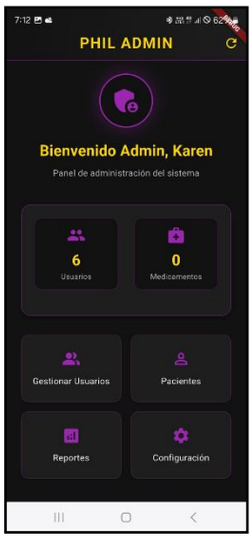

Figure 11

Administrator screen (Mobile App

Our app also features a user management system that lists users who have logged in and those who are registered

Box 12

Figure 12

User management (Mobile App)

Website

On our website, you can also find several sections:
Home Page
Patient Management
Patient List
Temperature History
My Medications

The first section's four websites contain three sections: medications, charts and the compartments of our dispenser.

Box 13

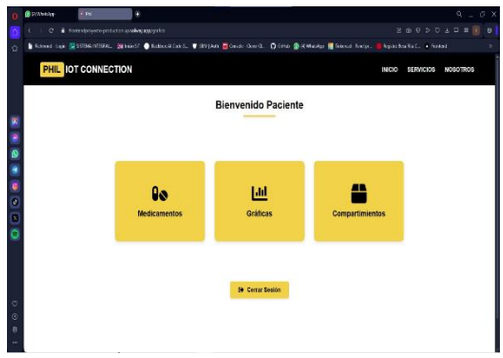

Figure 13

Patient welcome screen (Website)

As the next section we have a patient management in which there are 3 sections in which the first is for patients, the second for patient management and another one which is the reports.

Box 14

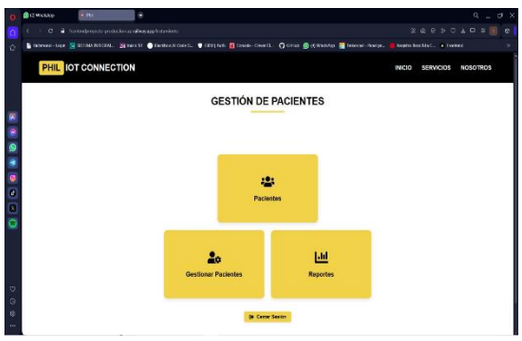

Figure 14

Patient management (Website)

In another section of the page, there is a list of discharged patients, which is the person who will take the medication.

We enter the type of pill, the treatment to be administered, the date and time it should be taken, the dose to be taken, and finally the compartment through which that type of pill will be dispensed.

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Box 15

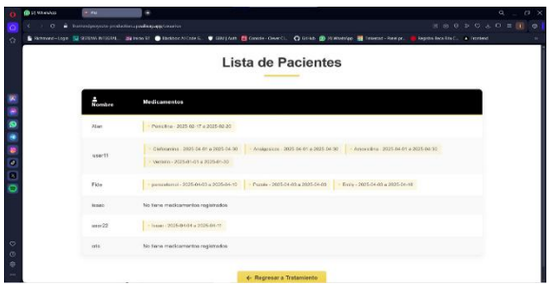

Figure 15

List of patients with details (Website)

Another section on our website is My Medications, which has three sections indicating the prototype's three compartments, as well as the dosage and time the pill will be released from the assigned compartment.

Box 16

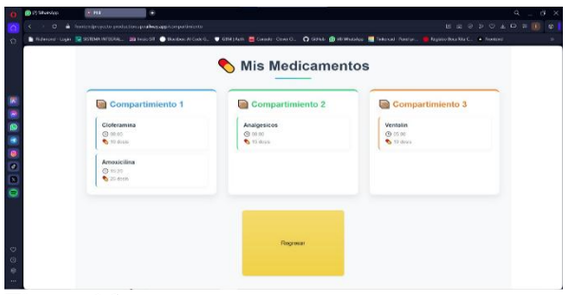

Figure 16

My Medications (Website)

Base de datos

The database created to store all the data generated by both the mobile app and the website also includes a function to create a temperature graph for the tablets.

Box 17

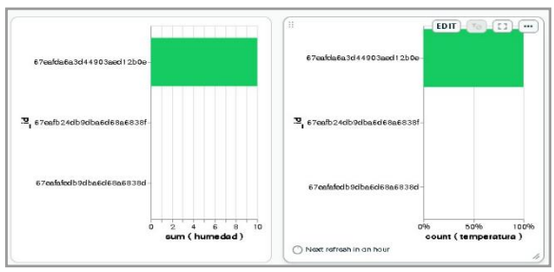

Figure 17

Graph in database (Database)

Our project implemented the MQTT protocol, a lightweight messaging protocol designed for machine-to-machine communication. This allows us to communicate between our dispenser and our project's website and mobile app.

The dispenser publishes a message in the dispenser/status topic indicating that a pill has been dispensed or if there was an error.

The web/mobile app we have for our project will receive the notification instantly and update the user's status.

Our MQTT protocol showed us that when sending a message, it responds correctly. This step involves entering the time the pill will be dispensed, as well as the compartment.

Box 18

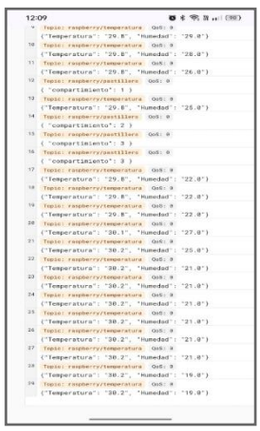

Figure 18

MQTT message sending protocol

Our results regarding our prototype were what we expected, and it resulted in something satisfactory since during testing everything turned out as we had planned in several Scrum meetings.

Box 19

Figure 19

3D Prototype

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Our prototype contains several components, one of them is an LCD screen that shows us the time and date, this helps us to check what time our medication is due, we also have two LEDs that indicate when the compartment is going to open and when it indicates that it will close, as well as we have a buzzer that we use as an alarm that tells us when our pill is due and lastly and most importantly we have a button whose function is that when pressed the alarm is deactivated and the compartment is opened through which the pill that corresponds to us will come out, in this case we have 3 different compartments.

Box 20

Figure 20

Prototype with everything implemented

During the assembly process of our prototype, a Raspberry Pi was used to control everything integrated into the prototype, from the operation of the button to the LEDs.

Two fans were also installed on our Raspberry Pi. When everything was connected, the Raspberry Pi temperature rose, causing it to shut down and taking several minutes to restart. So, when it was time to implement everything, it lasted a little longer with the fans.

Box 21

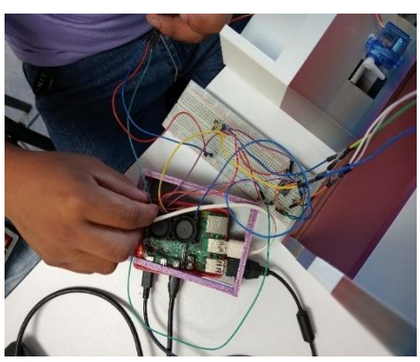

Figure 21

Wiring on the Raspberry

User Tutorial

Step 1: Go to our website

Step 2: Search the website under "My Medications". Enter the name of the medication and which compartment the pill will be in.

Box 22

Figure 22

My medications screen

Step 3: Send a message using our MQTT protocol.

Box 23

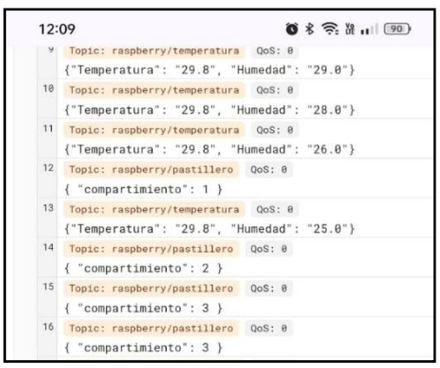

Figure 23

MQTT

Step 4: Verify that the LED and buzzer light up so you can press the button and receive the pill. Tables and adequate sources.

Box 24

Figure 24

LED and buzzer on so they can give me the pill

Step 5: Press the button to open the compartment where the pill will come out.

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Box 25

Figure 25

Button

Step 7: Check where the pill will come out of the compartments that are available in the prototype.

Box 26

Figure 26

Prototype compartments

And this is how you can use our prototype quickly and safely for your senior health care.

Conclusions

The development of a smart Pill dispenser with integration into web and mobile applications was an exciting and multidisciplinary challenge.

Through a combination of hardware engineering, software development, and user experience design, we were able to create a comprehensive system that facilitates medication management, allowing users to configure and monitor their medication easily and efficiently.

The collaboration of the eight-member team, with clearly defined roles, was key to the project's success. The collaborative work between backend and fronted developers, designers, hardware engineers, and testestr allowed for a comprehensive approach to the technical and functional aspects. Through an agile approach, the research, development, and testing phases were completed in reasonable timeframe components.

The use of technologies such as MongoDB Atlas, Node.js, Flutter and Visual Studio, along with integration with a physical prototype using microcontrollers, provided a robust and scalable solution. Furthermore, the implementation of push notifications and the ability to access the system are both seamless and accessible.

In terms of results, the system meets the proposed objectives, providing a Smart Pill dispenser that not only reminds users when to take their medication but also offers historical usage reports.

However, as with any technology project, there is room for improvements. Future updates may include integration with other health devices or the addition of advanced features such as medication pattern analysis.

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Basic

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