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Domotic House: Domotic

Casa Domótica: Domotic

LEDESMA-URIBE, Norma Alejandra*†, JUAREZ-SANTIAGO, Brenda, ACOSTA-ORTIZ, Jesús Ángel and CHÁVEZ-MATEO, Raúl

Universidad Tecnológica de San Juan del Río

ID 1st Author: *Norma Alejandra, Ledesma-Uribe* / **ORC ID**: 0000-0001-8422-2046, **Researcher ID Thomson**: S-4833-2018, **CVU CONAHCYT ID**: 673202

ID 1st Co-author: *Brenda, Juarez-Santiago* / **ORC ID**: 0000-0001-9071-9243, **CVU CONAHCYT ID**: 511613

ID 2nd Co-author: *Jesús Ángel, Acosta-Ortiz* / **ORC ID**: 0009-0004-7339-0545

ID 3rd Co-author: *Raúl, Chávez-Mateo* / **ORC ID**: 0009-0002-5285-2400

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Abstract

The main goal of this project is to develop a smart home that can be controlled through a mobile application built on Flutter, enabling cross-platform functionality. Various technologies were employed, including the AWS (Amazon Web Services) broker, with the MQTT protocol facilitating real-time communication between the Raspberry controller and the mobile device. The Raspberry PI 4 controller, along with multiple sensors and actuators, were utilized to enable interaction. To accomplish this project, it was necessary to use the SCRUM methodology, which allows identifying each stage of the product through a sprint. This work was carried out in 4 stages: In stage 1, called Requirements Analysis: the needs and objectives of the project were determined. A detailed analysis of the functionalities required in the software, the AI and the physical prototype was carried out. In stage 2. System design: the design of the home automation system and the AWS server were developed. The necessary hardware and software components were defined, as well as the system architecture and the integration with artificial intelligence was planned. In stage 3 Software development: the necessary software was developed to control all the components of the house and the implementation of the AWS server with MQTT. In the last stage: 4. Integration of hardware and software and AI: the integration tests of the home component of hardware, software and the integration and training of the AI with the life patterns of the inhabitants of the house were carried out

AI, domotics, IoT

Resumen

El objetivo principal de este proyecto es la realización de una casa domótica la cual se puede controlar a través de una aplicación móvil desarrollada en flutter para poder hacerla multiplataforma, además de esto se utilizaron diversas tecnologías, tal como el bróker de AWS (Amazon Web Services) y el protocolo MQTT para la comunicación en tiempo real entre el controlador Raspberry y el celular, el controlador Raspberry PI 4, y diversos sensores y actuadores con los cuales se puede interactuar. Para la realización de este proyecto fue necesario utilizar la metodología SCRUM, que permite identificar cada etapa del producto mediante sprint. Este trabajo se llevó a cabo en 4 etapas: En la etapa 1, llamada Análisis de requisitos: se determinaron las necesidades y objetivos del proyecto. Se realizó un análisis detallado de las funcionalidades requeridas en el software, la IA y el prototipo físico. En la etapa 2. Diseño del sistema: se elaboró el diseño del sistema de la casa domótica y del servidor AWS. Se definieron los componentes de hardware y software necesarios, así como la arquitectura del sistema y se planificó la integración con la inteligencia artificial. En la etapa 3 Desarrollo del software: se desarrolló el software necesario para el control de todos los componentes de la casa y la implementación del servidor AWS con MQTT. En la última etapa: 4. Integración de hardware y software e IA: se llevó a cabo las pruebas de integración de casa componente de hardware, software y la integración y entrenamiento de la IA con los patrones de vida de los habitantes de la casa.

IA, domótica, IoT

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* Correspondence to Author (e-mail: nledesma@utsjr.edu.mx)
† Researcher contributing as first author.

1. Introduction

Technology has advanced rapidly in recent years and home automation has become increasingly popular. A domotic home is a smart home, where lighting, heating, ventilation, security and entertainment systems are controlled remotely through mobile and other networked devices (Benites, 2021).

The creation of a domotic house aims to create a home that can be controlled from a remote access, i.e., from anywhere in the world, likewise, an artificial intelligence system will be implemented that can have facial recognition and can predict the hours of switching on the lights of the house.

The objective of the project is to facilitate the daily activities of the house, that is to say, through artificial intelligence, data will be obtained from the users that will be the training elements with the habits of each member. It also seeks to keep the house safe through the same artificial intelligence, which will control access and IoT devices.

Development

General information about the project

Problem

In the creation of this project, we seek to facilitate daily activities at home using IoT technologies, considering that more and more homes in Mexico have Internet connections (INEGI, 2022), increasing by 15% in two years prior to the pandemic where it is counted that 7 out of 10 households have Internet connection at home. On the other hand, artificial intelligence AI is available to the public and access to that interaction has allowed the coexistence of human beings at home and AI in their daily activities (Bryson, 2018).

Proposed solution.

Implement IoT technology to execute tasks remotely, with AI, using a mobile application that will allow its management. It will be sought that the application and the AI, have friendly interfaces for the ease of use of the end user.

2. Theoretical framework

a) Theoretical concepts

cv2 library

OpenCV is an open source computer vision library available for many programming languages. Among them is Python. Since the last version, OpenCV 3, this library allows to work with Python 3 (Marín, 2020).

Pandas libraries

Pandas is a library of the Python programming language, entirely dedicated to Data Science. Discover what this tool is for and why it is essential for Data Scientists. Created in 1991, Python is the most popular programming language for data analysis and Machine Learning (DataScientest, 2022).

NUMPY Library

NumPy is a Python library specialized in numerical computation and data analysis, especially for large volume of data. It incorporates a new class of objects called arrays that allows to represent collections of data of the same type in several dimensions, and very efficient functions for their manipulation. (Alberca, 2022)

MQTT protocol

MQTT is a standards-based messaging protocol, or set of rules, used for communication from one device to another. Smart sensors, wearable devices and other Internet of Things (IoT) devices generally have to transmit and receive data over a network with restricted resources and limited bandwidth. These IoT devices use MQTT for data transmission, as it is easy to implement and can communicate IoT data efficiently. MQTT supports messaging between devices to the cloud and the cloud to the device (Llamas, 2019).

AWS

Amazon Web Services (AWS) is the most adopted and comprehensive cloud in the world, offering more than 200 comprehensive data center services globally.

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Millions of customers, including the fastest growing startups, largest companies, and leading government agencies, are using AWS to reduce costs, increase their agility, and innovate faster. (Amazon Web Services, 2020)

3. Project Development

Application development in Flutter

In the code of the mobile application using the Flutter SDK (See Figure 1) with language in Dart the different screens were elaborated which correspond to each of the visible components of it, such as the Login screens, the main screen for the control of the house etc. The database was developed in MongoDB for the storage of the new registered users, as well as the connection to the AWS MQTT protocol.

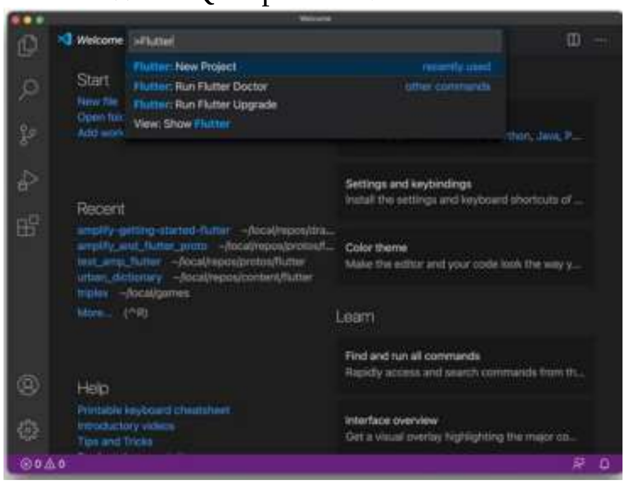

Figure 1 Project in Flutter
Own Elaboration

Libraries were used to allow portability on various devices and auto-adjust to them regardless of the type of screen available. In the user's home screen, the user has the option of logging in or registering as shown in Figure 2.

Creating the database in MongoDB Atlas

In MongoDB Atlas we have the collection in which the users and the components of the house are stored. The code for the connection to the MongoDB database that generates the link to make the connection to MongoDB Atlas was also developed, see Figure 3. The code that links to the AWS IoT core was also developed, in which the files and certifications that AWS provides when registering the application are stored.

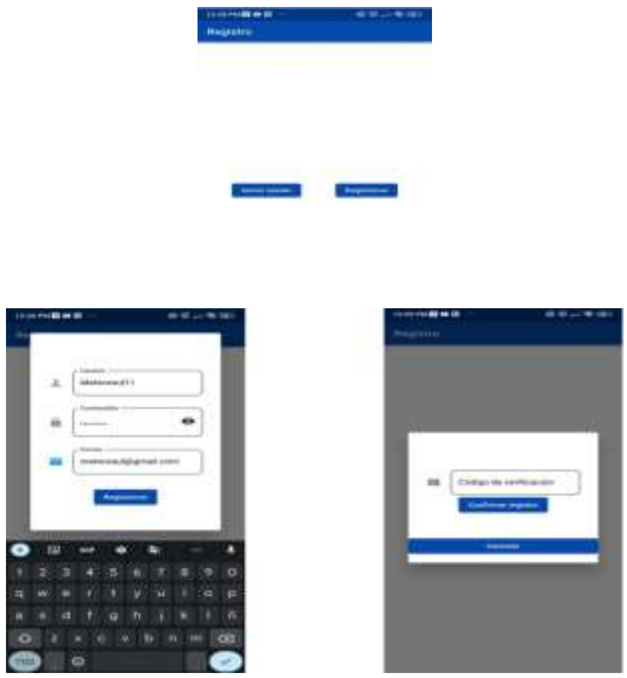

Figure 2 Mobile Application
Own Elaboration

Each time a new user is added to the application he/she will also be added to the page. See figures 3 and 4.

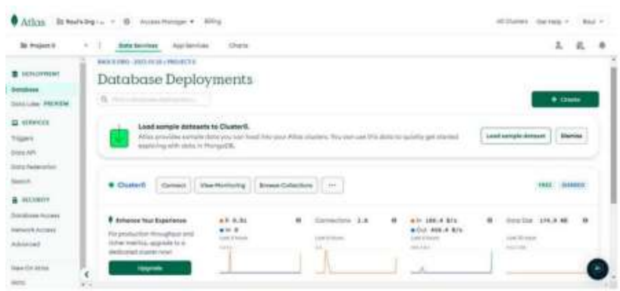

Figure 3 Database in MongoDB Atlas
Own Elaboration

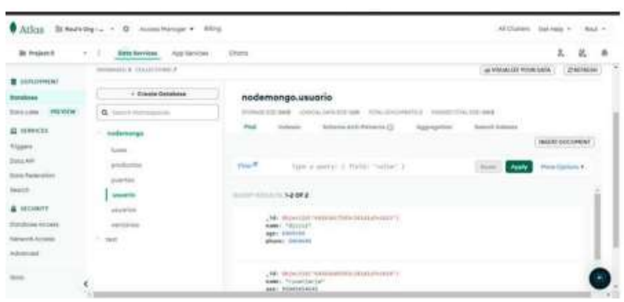

Figure 4 Registration in the database in MongoDB Atlas
Own Elaboration

Firebase implementation

A database was developed in Firebase that sends the mobile application and stores the status of each Switch to create a friendly environment between all the applications connected to the home, all this will be done in real time. See figure 5.

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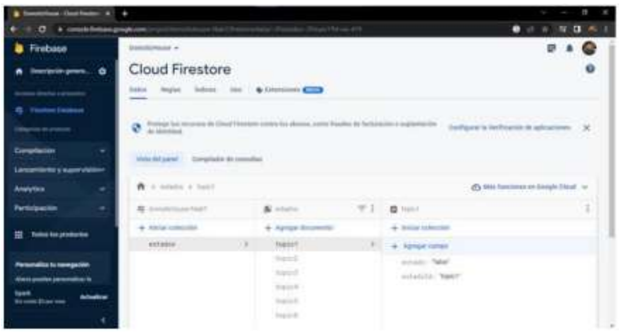

Figure 5 Firebase
Own Elaboration

– Implementation of Artificial Intelligence

As part of the innovation of the prototype, Artificial Intelligence was implemented, which is able to predict the time when the user is likely to turn on the lights.

Light	Hour	Time	On
1	2000	0	1
1	1050	0	0
1	1055	0	1
1	1050	0	1
1	1045	0	1
1	1049	0	0
1	1012	0	1
1	1021	0	1
1	1054	0	1
1	1051	0	1

Table 1 Data Repositor

Table 1 is a repository where the exact time at which the user turns on his lights is added and that the AI stores, reads and manages in order to predict the time at which the user will use his lights, for the moment only this item was trained. See figure 6.

Figure 6 Artificial Intelligence
Own Elaboration

– Communication between devices

Figure 7 shows the overall design of the prototype and the communications and updates to the databases and applications developed for this project.

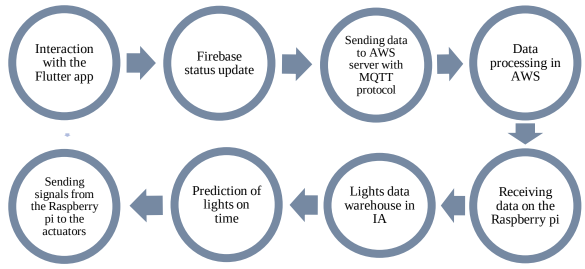

Figure 7 Prototype process diagram
Own Elaboration

To perform the communication between the devices as shown in Figure 8, the AWS service is the intermediary for communications between the mobile application and the server installed on the Raspberry PI. This in turn, communicates with the devices inside the house to control lighting, opening doors and windows, as well as monitoring and controlling the temperature.

As for the applications, the development in Flutter will have information flow with Firebase and MongoDB databases.

Figure 8 Communication diagram
Own Elaboration

Results

Physical prototype

a. Circuit

For the assembly of the circuit, see figure 9, there is a Raspberry Pi 4 board, 4 mini servomotors connected to 4 volts, there is also a channel of 4 transistors for the control and management of the lights, which, being analog, the corresponding converter was implemented. A 5-volt DTH11 humidity and temperature sensor is included in the circuit.

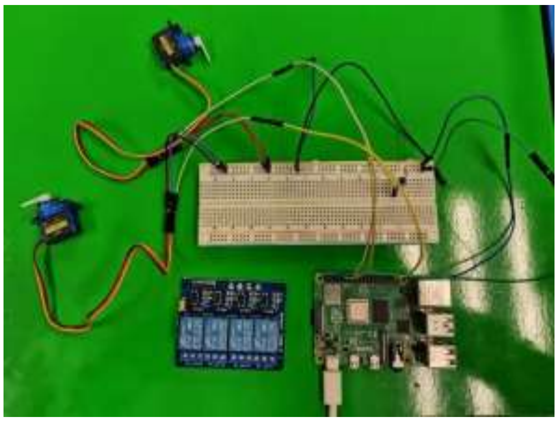

Figure 9 Circuit
Own Elaboration

b. Communication between the application and the devices

The mobile application was able to interact with all the elements of the house, both turning on and off the lights, opening and closing doors and windows and measuring the temperature inside the house, all thanks to AWS and the MQTT protocol. Figure 10 shows the updates with two mobile devices connected to different networks (each with its own internet provider).

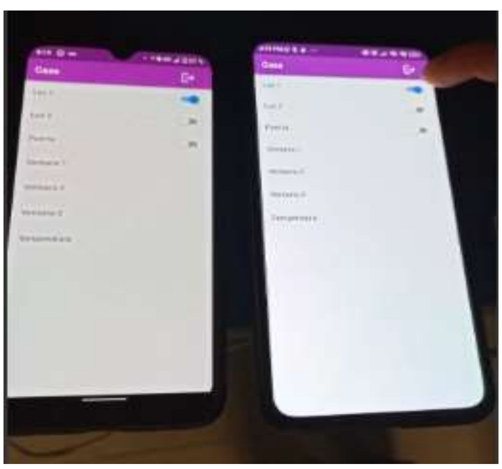

Figure 10 Real-time communication between apps
Own Elaboration

Figure 11 shows the prototype of the smart home, the connected devices, the app installed on the cell phone and the monitoring on the server screen installed on the laptop.

Figure 11 Control of the house with the app
Own Elaboration

Figure 12 shows the final result of the physical prototype.

Figure 12 House result
Own Elaboration

Figure 13 shows the results of the application as notifications sent to the user in real time by the application.

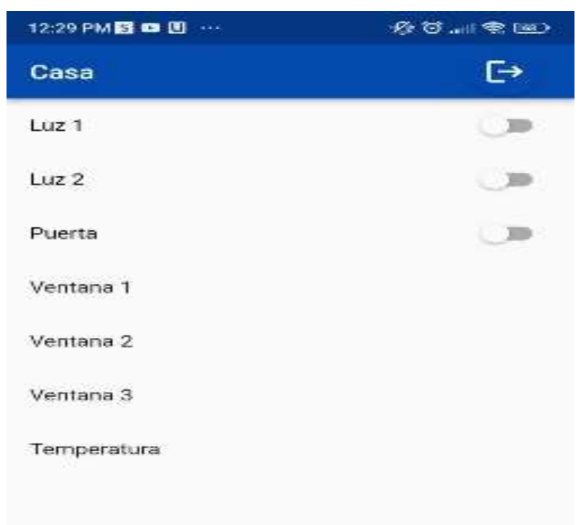

Figure 13 App result
Own Elaboration

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Conclusions

The development of this project allowed the integration of AI with IoT through a multiplatform environment, in which updates are displayed in real time to each of the devices connected to different networks, which allowed remotely from anywhere in the world to visualize or activate some of the devices of the prototype.

This proposal is oriented to the community and interest groups in the subject of AI and IoT, so that with this type of development they are able to identify and carry out a concrete idea of the integration of both technologies. It should be noted that programming languages do not necessarily have to be used in this prototype, there is a wide range of options for its development, what should be taken into account is the integration and compatibility with protocols such as MQTT and non-relational databases that are hosted in the cloud. AWS is a great option as a repository and communications management for initial or small projects, since they do not represent an initial cost for testing in academic or research projects.

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