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Functional analysis of computer system for home automation

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Abstract– What if there was an idea that could innovate society's whole concept of home automation? The aim of this project is to get closer to the nearby future we all begin to imagine, creating a fictional mobile application, based on home automation models of the future. The plan is to create an application that can go through different modules, each one of them with different implemented settings, that are able to control separate functions and parts of the house. All of these modules can also be separated for the user to use whichever ones are of interest. A module is a recollection of different functions that work together into one same category. These features would be able to control the light, music, blinds and even garage doors. The idea has come to life within this project, where a home automation mock-up application has been implemented.

Keywords– Software, home automation, application, home technology, home control.

Abstracte– I si hi hagués una idea que pogués innovar el concepte de domòtica que a dia d'avui coneix la societat? La idea d'aquest projecte és crear una aplicació mòbil fictícia que ens acosti als models domòtics del futur. Seguint aquesta línia, tenim previst crear una aplicació que pugui passar per diferents mòduls, amb unes configuracions específiques implementades, que siguin capaces de controlar funcions i parts separades de la casa. Els mòduls es poden tractar individualment, de manera que l'usuari pugui tenir l'opció de fer ús dels mòduls que li siguin de major interès. Un mòdul és un conjunt de funcions diferents que treballen juntes en una mateixa categoria. Aquestes funcions podrien controlar la llum, la música, les persianes i, fins i tot, les portes del garatge. Aquesta idea ha cobrat vida en aquest projecte, on s'ha generat una maqueta d'aplicació de domòtica.

Keywords– Software, domòtica, aplicació, tecnologia domèstica, control domèstic.

1 INTRODUCTION

THERE are plenty of different companies who, with smart technology, make new simpler products of everyday tools we use around the house: for example a doorbell, or a fridge. These companies focus on creating the best of their products with the technology available today. So what if there was a software where all of these technologies were combined into one, with the addition of new and exciting features that would innovate society's concept of home automation? This idea would be looking at a technology and software that sets the bar to a whole new level of what the public knows today as home automation. The idea of this project is to get closer

to the nearby future we all imagine, creating a fictional mobile application, based on home automation models of the future.

Taking into account the general thoughts stated above, the document will present the following structure: a first analysis of the project with specified objectives, the methodology used, a project risks evaluation and technology requirements, followed by the research found and all it entails. Ultimately, the design and testing of the applications design prototype, the conclusions, acknowledgements references, the annex and the bibliography.

2 PROJECT OVERVIEW

The goals for this project, are first of all, learning about all the different home technologies that already exist, as well as specific smart technology products. In addition, by studying what society needs, we will determine how that fits into home automation and making an ensuing approach to all

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the settings and modules we would be able to implement. Finally, we aim to develop a product prototype that controls and combines all of the above.

When evaluating the goals for the different parts of the project, there have to be clear targets to reach. The objectives that will get done throughout the lifespan of this project are the following:

- Completing a study on today's modern technology and what functions already exist; while evaluating what more can be done and which direction society's leading us to. Finally deciding, throughout this assessment, the modules, functions and technology that are going to be used and learned about throughout this final degree project.
- Gathering as much information on today's modern home innovation, smart technology, their gadgets and functions as possible.
- Creating a prototype of a design for the application on some of the modules it could control. It is important for the design of the application to feel modern and that is intuitive to users.

Methodology and Gantt Diagram

For this project, having a methodology to plan and track the progress of the project is essential. Through the Kanban methodology, a work plan was established. Questions like "What do I need to do by when?" was what helped organize and set project goals within the total time frame. Kanban [1] is a methodology that offers the possibility to visually see portrayed the project as a whole with the different milestones and time frames. Nevertheless, this methodology also has a digital board with three columns (To Do, In Progress, Done) which has been of vital importance along with the functionality of having tasks listed as story cards. On the other hand, a Gantt diagram of the final planification of the work done is attached in the Annex, Figure 11. The different sections and therefore milestones, were guided by the timings given throughout the project by the University. Each different Milestone is in a different colour to help represent each section. The Tasks that overlap in time, represent the possibility, or even necessity, of working on them simultaneously. Other tasks were dependent by final results of previous tasks and therefore have to be consequential.

Project Risks

Being aware of the risks involved in any situation is crucial. By taking into account all of the factors that are dependent for the project to succeed, and being conscious of all the factors that if changed, would affect the work done, has to be contemplated before hand. All of the risks that could negatively affect this project are found in Table 1.

Technical requirements

The Hardware/Software requirements are the following:

- Personal computer. Inter(R) Core (TM) i5-4460 CPU 3.2GHz with an installed RAM of 8,00GB.

Project Risks			
Risks	Definition	Impact	Contingency Plan
Not providing quality re-search.	Making sure all information is from reliable sources and there isn't any redundant information.	Medium	Check reliability of all web pages and extracting key points.
Not finishing tasks on-time.	Falling back on due-dates and winding up with a low quality project.	Critical	Follow-through on the planned tasks on Kanban.
Mediocre mock-up and prototype.	Making a prototype that does not meet the goals.	Medium	User testing through the process, as well as keeping the objectives in mind.
Providing a bad presentation.	Creating a poor presentation where the project isn't properly conveyed.	Low-Medium	Being satisfied with the project. Taking my tutors opinion into action. Practice presenting as many times as needed.

TABLE 1: PROJECT RISKS TABLE

- Diagrams.net for a Class Diagram as well as a Use Case Diagram.
- The Design program used for this project is Flutter-Flow Prototype Design program [2]. The first software considered was Proto.io [3] for its rapid and easy use. The final software chosen is FlutterFlow, the reason behind this decision is for its modern feel to the designs a client can create, as well as its rapid and easy use the first option also offers. The final decision maker is the fact that the design can be compiled, used and tested as a functional prototype, at the same time having the actual program's code.

Modules and functions

Based on a general idea of what a home automation software application contains, the modules that are being considered for the rest of the project, and therefore, for the application design are: House Maintenance, Comfort and Security. These modules have their specific functionalities shown on the following mind-map, and are going to be reflected on the prototype [Figure 1].

3 STATE OF THE ART

The main research expectation is to learn about all the different home technologies that already exist, as well as, specific smart technology products. In addition, by evaluating what society needs and how that fits into home automation

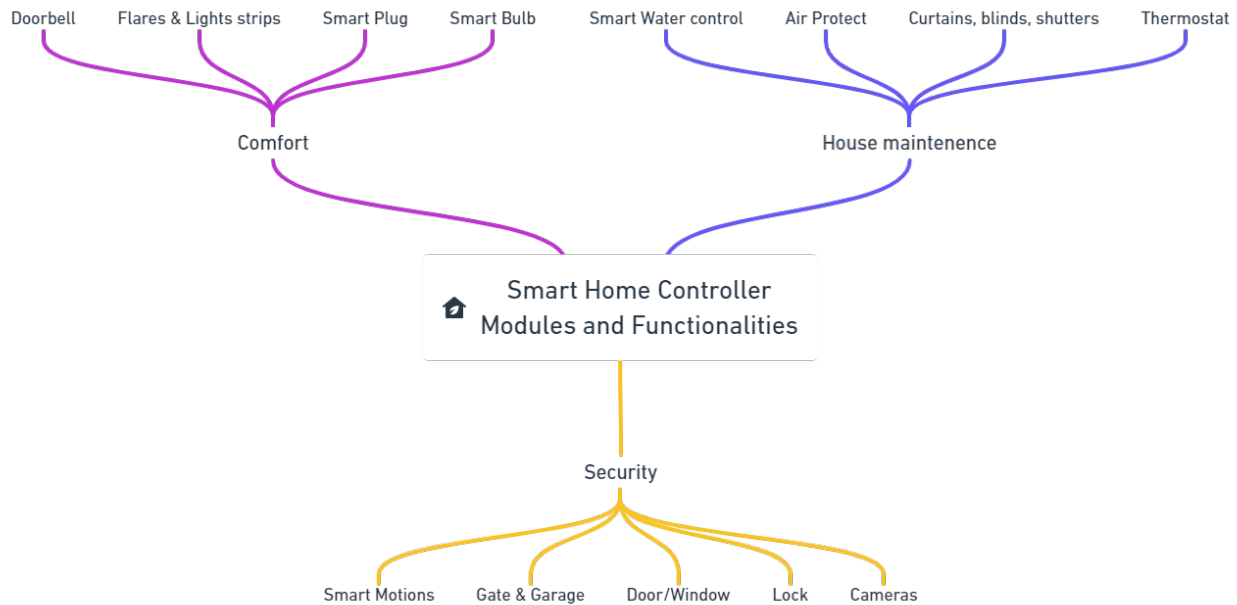


Fig. 1: Smart Home Controller Modules and Functions

and making an approach to all the settings and modules considered, a fictional software is going to be implemented. The idea is to only have one software that controls everything, and that is compatible with different gadgets, functions and technology. By gathering as much information on today's modern home innovation, smart technology, and their gadgets and functions, the hope is to be able to conclude the following statements:

- Find similarities between different companies, like the fact that they each have their own application, and that companies focus on their product, without thinking of their clients need to automate the whole house.
- Evaluating the reason behind the implementation of all of the above. If a company has taken the time and resources to create a certain gadget, function, or even lifestyle, there has to be a need and a cause for that.

The expectation is to find all of the statements above to be true, as well as the answer to the question: "Why hasn't any company created a full home automation package?", to be that it has not been any company's game plan yet; which ultimately gives this project value.

It is important to consider the presence of how this application, as well as, society are going to evolve. Every day new devices appear on the market that will have to be integrated into the software. Therefore, the application should have a device integration module.

Each appliance communicates with its own protocols. As devices become more complex, it will not only be about the connection between device and software, but about being connected to them and being able to activate them when needed. Further, the platform will need to be able to install new versions of software. The integration module will permit the addition of new devices, as they are invented. Likewise, the software will define standard communication processes and protocols for all device companies, so that

there is the possibility of each company wanting to develop their own APIs, and eventually having devices connect automatically.

In addition, it will be necessary to see if there is a standard protocol defined for home appliances and, if not, define a flexible, open protocol with interfaces to translate the proprietary protocols into standard intra-system communication; so that signals can be received and devices activated efficiently. The application will be able to connect the devices directly through physical wiring or indirectly through WiFi, Bluetooth or other wireless communication technologies.

At the same time, more sensors appear on the market. As they become commercially available they allow the generation of new devices, and consequently, the application, to have more information about what is happening in the house. Therefore, the application would gain knowledge which ultimately make the software more proactive. One of the main uses of this date, is the creation of a prediction model for the house to reach the point of being able to predict what is needed in every moment. It can not be forgotten that, the application's final objective, is to help the tenant of the home in every single possible action wanted. Sensors that provide system information, could allow some of these goals to be possible. Consequently, artificial intelligence can also be of help.

Artificial intelligence tools and methods, given by providers such as Google or Apple will help to fill information holes, for instance, the accumulation of house behavior information, which would guide home actions into the expected conduct. This conduct being, knowing when to set the washing machine on, which the days of the week, and with what special settings; it could even contemplate seasonal change. Allowing the application to have a "track record" that loads information into a history of BIG DATA, still learning and perfecting over time and with more data.

Companies Benchmark

By taking on this project, it was known that an important part of the work was going to be the research of what kind of software and technologies exist in the market. This information is essential to be able to create a software that properly conveys today's society.

Starting off with the biggest companies like Apple [5], Google [4] or Amazon [6]; not a lot of unknown information was found. Apple does have a Machine Learning [7] research, which is of interest when considering the future of the project and how this new developing technology can be beneficial. The most disappointing company out of the three previously mentioned, is Amazon. In comparison with other companies taken into account for the project, Amazon does not present the basic idea of smart living with Amazon as a whole. It is a company focused on the benefit of selling products, and that is exactly what is found. Individual products, such as, Amazon Alexa are just that, individual products.

Google Nest [8] dispenses of a strong presence in this area, specifically in machinery such as, indoor and outdoor cameras, doorbells, hubs and a Google Home platform. Apple Homekit on the other hand, has focused more on selling smart plug devices, smart light-bulbs, smart thermostats and device control technology, along with the home software, as well as, smart cameras and doorbells.

In addition, there are companies commonly known for selling domestic appliances, such as fridges or dishwashers, that have made their way into Internet Of Things (IoT). Bosch [9] and Samsung [10], are two perfect examples. These two companies have build smart living platforms [11] that pair with their new domestic appliances that have now integrated the world of IoT.

Other types of companies that are important to know about are the individual type of product ones. These companies such as, SmartLife [12] or ISmartGate [13], focus on creating a platform that can integrate individual smart devices into a home, or creating smart doors, gates, and blinds, in the case of ISmartGate.

In the following table [Table 2], there is a summary of what kind of products and functionalities exist in the market. *(Note: Not all companies researched on, are mentioned on the following table.)*

Extraction

There are plenty of companies that focus on covering the same need of led lighting and smart plugs, or smart thermostats and climate, even security; but none that rounds it all together.

What is interesting though, is that there is no need for a company that makes all different types of products, just the need for a software that is compatible with all of them, a software that can connect with Apple Home, Google Home [4], and all of their own particular case needs.

It is true that Apple Home [5] and Smart Life [12] are two applications that do integrate a lot of the functions that a smart house would require, and even give information about

appliances and companies that are compatible with them, but even so, there is a need for a second, third or even more applications, depending on the features. For instance, Smart Life[12] has an application where a user can create modules and settings, where ultimately they can control their smart house. The Smart Life application does not work without an integration of IFTTT[16], for each and every appliance. IFTTT integrates apps, devices, security systems, social media, and services with each other. A practical example is: Tweeting Instagram posts as native photos on Twitter. Contemplating all of this research and it's extractions, on the whole, there is a lot of competition between companies. Nevertheless, there is a place in the market for a software that can integrate all appliances, gadgets and functions of multiple companies, and can control a smart house, all through just one application.

4 DESIGN

This Design section introduces two different type of diagrams to help understand the functions and structure of the application, as well as the application's design.

4.1 Diagrams

To help design the structure of the application, two diagrams were created with different purposes. The Use Case diagram is created to describe the high-level functions and scope of a system. On the other hand, the Class diagram is used to model the objects that make up the system. These diagrams are found subsequently.

Use Case Diagram

In the following Use Case Diagram [Figure 2], a user can be connected, with six direct use cases. These main Use Cases, are the Profile, Home, Room and Procedures Controls, as well as the fundamental Login/Logout function, and the "add to Favourite" and "Pin Procedure" activities. Included or extended from these use cases, are second-hand tasks a user can do through the smart-phone application.

Class Diagram

In the following diagram[Figure 3], the different classes used for the design of the application are shown with their connections. Devices is a class that can be connected to each and every room of one same house. In each house, there can be multiple users, so that a whole family can access the smart automation system of their house.

4.2 Application screens

A prototype of the application has been designed with three main screens shown below.

The firsts two screenshots [Figure 4,5] are part of the same Home Page screen where a user will find the main functionalities of the application. This screen is the heart of the platform, as well as the access to the other two main screens that lead to all actions. This main screen has quick actions to procedures favoured and pinned by each user. That allows the user a quick response to a certain action that might be more common. On the first part of the screen [Figure

Companies Benchmark		
Company	Product	Benchmark
Apple	HomeKit	Apple's smart home platform, which is designed to let the user control various internet-connected home devices. Ranging from thermostats and plugs to window blinds, light bulbs. In addition, the software sets-up scenes, and automation's [5].
Google	Nest Doorbell	Functions such as: Front door view on remote. Interaction with whomever through talking and listening functionalities. Automatic response also available.
	Nest Cam	Functions such as: Notification and distinction of movements. Ability to select a certain area of interest. Look back three hours for free. Night vision that can activate light. Interaction with the camera. Weather resistant.
	Chromecast	Features: Single watchlist. When clicking on a tv show or a movie, it automatically opens up the correct entertainment platform. Streaming from an Android, iPhone, tablet or laptop to TV. Stream by voice command.
	Nest protect	Insights that separate regular smoke and carbon dioxide detectors from this one: Alerts phone at the start of getting signals. Ability to stop the alarm from your phone. Motion detection at night. Motion is detected when walking, a discrete light turns on and follows your steps so that the user does not find itself in the complete dark[4].
Bosch	Twinguard	Functionalities of the product: Smoke detector. Will send out an alarm to other detectors of the house for awareness. At the same time of detection, both inside and outside cameras are turned on and start sending information to your phone. When door/ window Contacts or Motion Detectors pick up signals, the siren of the Smoke Detector immediately raises the alarm and passes it onto all connected Smoke Detectors in your home. At the same time, an integrated lamp starts to flash red. Tracks Temperature, Air quality and humidity around the home.
	Door/ Window Contact	Reliably detects open doors and windows and informs users via smartphone. Raises the alarm as part of the alarm system in case of burglary. Notifies the networked radiator thermostats when windows are open so that the heating is switched off and no energy is wasted. (Function has a time span of 60 sec).
	Smart Motion	Intelligent and reliable motion detection with body heat, size and temperature detectors. Automatic light control (turn on by the motion of movement"). Pet immunity for pets up to 25kg.
	Smart Water	Alerts you acoustically, visually (turns on specific lamps with a certain color) and via the app in the event of a water leakage. Prevents possible material damage and provides your home with the best possible protection. (The alarm deactivates devices connected via plugs).
	Thermostat	Display of the current and desired room temperature as well as the relative humidity in the room. Highest heating comfort and efficiency by measuring the temperature at the room thermostat and not at the radiator. Control over electrical heating and their SmartPlug. Changing the desired room temperature directly on the device. Control of up to six radiator thermostats in one room.
	SmartPlug	Connects users conventional electrical devices into the Bosch Smart Home System. Switch electrical devices on and off while on the move via app or with the programmable timer. Increases the range of your Bosch Smart Home Controller. Informs when the washing machine cycle is finished. Users can set a certain temperature and when it is reached, the heater will stop[9].
Samsung	Home Packages	Check front door and entire home from your TV. Babysit from any room. Answer doorbell from the fridge. Check fridge from anywhere.
	Laundry Packages	Know laundry's done instantly. Do laundry from anywhere. Refresh different outfits at once.
	Appliances	Samsung has all type of Kitchen appliances, from the SmartFridge that connects the whole family with FamilyHub, to Dishwasher and Microwave. Appliances like Washer and Dryer sets, as well as, Vacuum machinery and Air Solutions.
	Smart Fridge	Inside view of fridge. Access to smart recipes. Meal Planner. Shopping List function. Share pictures, videos or drawings, leave handwritten notes, and sync calendars. Streams music apps, TV shows and has access to Facebook and Youtube. Front door control. Monitors multiple rooms. Voice and phone control. Nest thermostat control[10] [11].
Ismartgate	Gate and garage control	Detects Smartphones control over gate and garage functions. Works from anywhere in the world. Video Calls, Face Detection, Remote Access, Night Vision, Wi-Fi, Storage, Wired and Waterproof[13].
Gelighting	Direct Connect Smart Bulb	Create the perfect scene. Control with motion. Control by touch. Control from SmartPhone. Set your home to your schedule by putting in place certain actions. OFF/ON/Dim functions. Grouping with other bulbs[14].
Xioyan	Curtains, blinds, shutters	Pulls the curtains open at sunrise and shuts them at sunset. Scheduled. Voice and smartphone controls. Voice control. Shuts curtains when the user leaves the house, opens them when the user arrives. Instant stopping when encountering obstructions[15].

TABLE 2: COMPANIES BENCHMARK'S

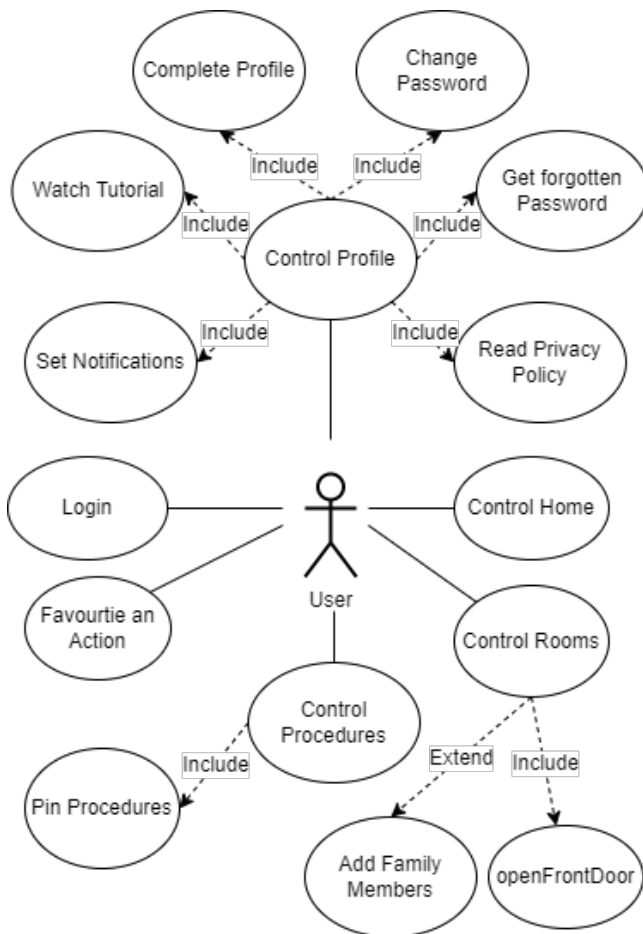


Fig. 2: Use Case Diagram

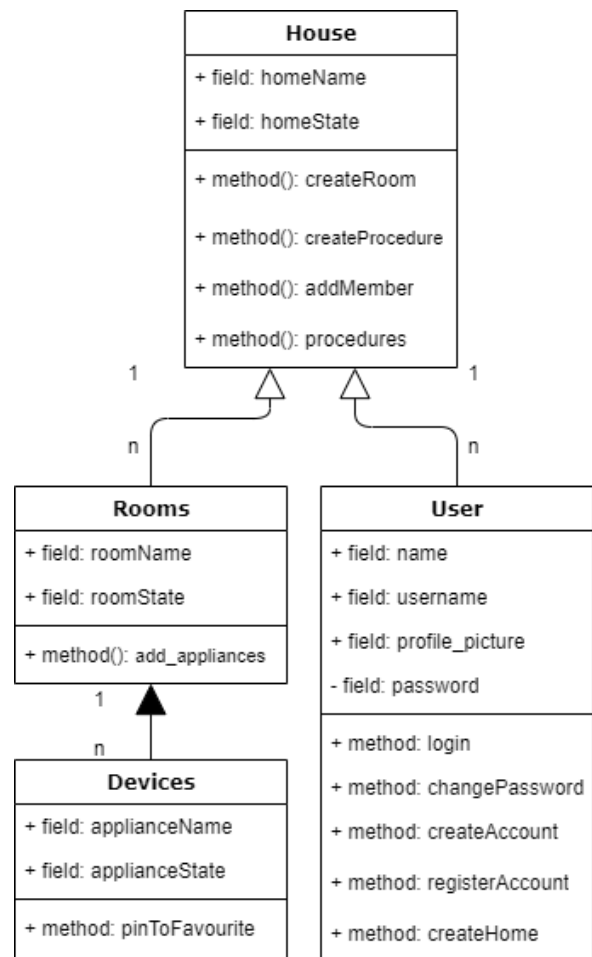


Fig. 3: Class Diagram

4], there is a big rectangle representing a digital key to a user's home. With the right device, the user no longer needs a physical key, and can control the main door on the go, through the application. The third screen-shot [Figure 6] is the Profile Control page, where a user has access to functionalities related to the user.

The fourth screen [Figure 7] shows the design and functions of the third main screen. From this point, the user will be able to control the house with functionalities, such as, creating a new room, adding devices to a certain room or even pinning planned procedures to the main Home Page Screen [Figures 4,5]. Figure 8 is an example of what an Accessory Page would look like; in this particular case, the lighting of the house is under control, and the user can easily play with the On-Off switch to turn on and off different appliances.

These last screens, represent the screens with the most important functionalities. The whole application is shown on a video linked on the [A.1] subsection of the Annex. The video starts off by showing the Login, Forgot Password, and Create Account screens. Once the user has entered the platform, the three main screens are shown as the base of the application, where the user would navigate through. In each different main screen, distinct functionalities are shown, keeping the same design pattern along.

5 TESTING

5.1 Design Testing

When the design was considered to be done, a prototype testing took place.

Fifteen different testers of different backgrounds and ages were selected to test out the application. At first they had a starting time to look and navigate to get a feel for the mock-up. No initial information was given to the tester except for the fact that it was a home automation application designed to control accessories build-up into houses. After this first contact with the interactive design, the testers were given three different use cases to achieve. The following graphic [Figure 9] shows the results of function understanding testing, after having the testers try and figure out three Functionality Use Cases.

In addition, a survey was passed, addressing the color scheme of the application, basic functionality layout, and the user-friendliness. A whole understanding of the design of the application and alternative comments took place. The global results are very positive in all of the previously commented sections, which authorizes this testing phase on a high note. The graphic below [Figure 10], manifests the general feeling of the colors chosen for the application.



Fig. 4: Home Page 1

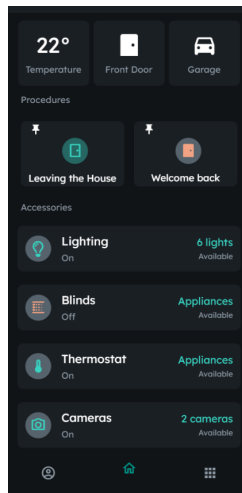


Fig. 5: Home Page 2

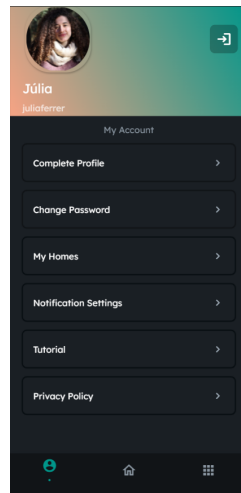


Fig. 6: Profile Page

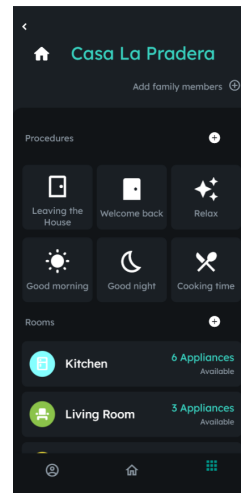


Fig. 7: Manage Home

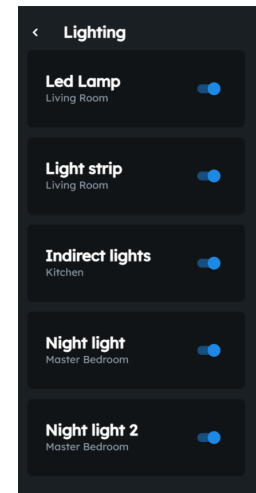


Fig. 8: Accessory Page

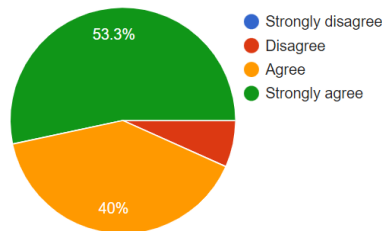


Fig. 9: Testing understanding of application functions

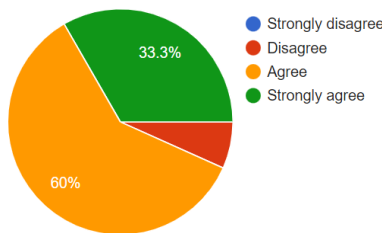


Fig. 10: Testing color scheme of the application

5.2 Use Case Testing

For this following section, all of the different use cases are individually tested with the product's interactive mock-up. These use cases were instructed to the testers in the following way: "Create a new room". All of the different testers were successful with the minimal amount of tries, and were found to be in more of the 90 percentile success score. This data concludes that the functionality layout is intuitive and easy to use.

6 CONCLUSIONS

6.1 Main Conclusions

Throughout this project, there have been a lot of eye opening and mind blowing gadgets and technologies that I have found, that can easily be integrated and connected to other devices. The world of home automation is big and constantly growing, which results in the need for a variety of products, ranging from individual company devices and smart setups to the software that controls each particular

implementation.

All in all, the outcomes that were hoped for in the State of the Art section of this paper, came out to be true. A reduced range of modules were selected to be implemented, focusing on the most basic functionalities, yet maintaining the idea of individuality of each user. Most of the value of the results obtained, is at the ability of each user to set a favourite and pinned actions to the home page, as well as the ability to create procedures containing multiple actions. For instance, a "Relax" procedure, where the user can ultimately engage a turning on music action, with a specific room temperature and a special lighting in a particular room of their home.

In the essence of the design part of the project, the design has properly portrayed all of the objectives set up at the beginning of the thesis. Through the first stage of product testing, I observed that indeed, the design is aesthetically pleasing, as well as intuitive. When testing different use cases, the testers were found to succeed in each different case and test. This information allows me to conclude that the functionalities are easy to use and are well-designed. This conclusion is supported with Figure 9 and Figure 10. When asking about the global feel of the application, taking into account the color scheme, the layout, and the thought behind every functionality, the extractions of the responses of the testers were that the application has a modern technology feel, which was a goal to begin with. The individual testing of the use cases are all completely satisfactory up to the point of expectation.

6.2 Review of the planification

Having a well structures planification proposal that works well in time with the project is critical. Having milestone dates and delivery of final project on a specific time, made the planification of the rest of tasks that had to be done for each milestone much easier. Had that not been the case, and for instance, only having one last end of project date, would have definitely made, not only the planning of different milestones, but having all of the work evenly spread and up-to-date, harder. All things considered, the project has suitably reached the placed objectives as well as the expectations and has produced a substantial final product.

6.3 Future work

Although there is a lot of potential in the application functionalities, a lot of brainstormed ideas are far-fetched for this thesis. For the purpose of this project, only the specified modules were considered and taken into account, with the ability to create and expand more modules. If this project were to continue, more specific functionalities would be added into the implementation. Ideas like a QR scan screen, where users can easily link new devices into the software. Another function would be adding specific options and filters when creating homes, rooms, or even procedures. Functions that would make the software even more personal would be to be able to choose and change the color scheme of the application. Energy saving is definitely a goal this technology wants to accomplish. Functionalities would start off with simple on and off light switches. Energy will be saved by, detecting the presence in a room and therefore turning on-off the lights, depending on whether someone is there. This functionality can also be applied to opening and closing blinds and curtains, relying on the time of day and keeping the room's temperature stable. Finally, a functionality that would certainly enter the main objectives of the project if it were to continue, would be allowing voice recognition to be able to control the software, as well as, the devices. In time a user could answer the doorbell, and interact with the house through their own voice. The idea of this project is not restrained to the application, as it has an incredible amount of potential to change society's lifestyle.

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ANNEX

A.1 Design

The link below has access to a Youtube video showing all of the different screens the application has to offer.

Press on this link to watch the video.

A.2 Gantt Diagram

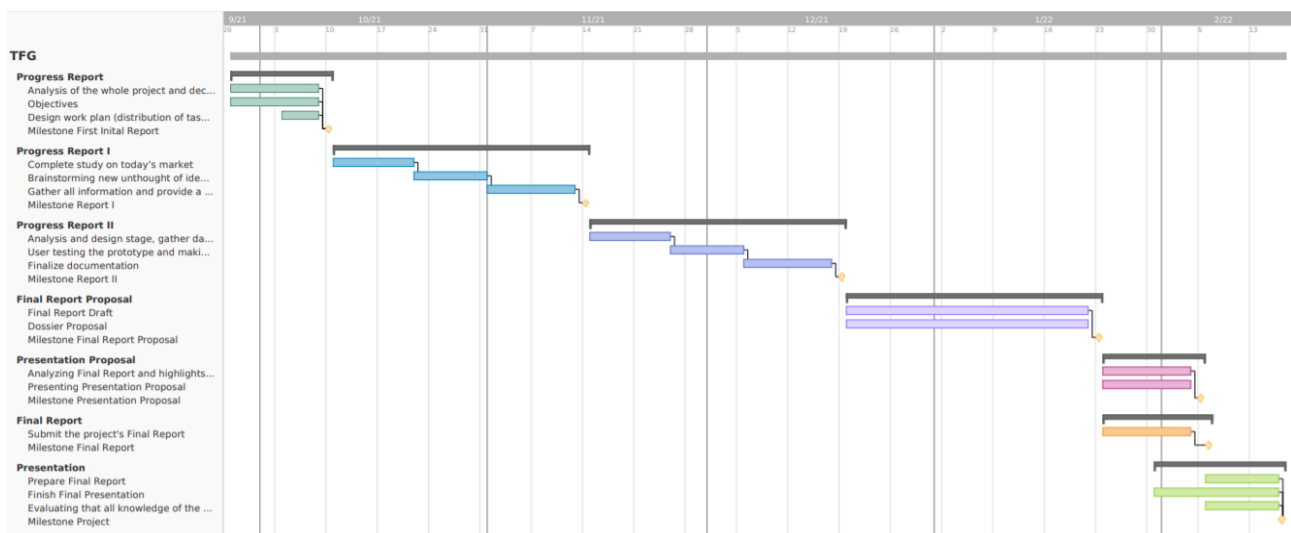


Fig. 11: Gantt Diagram