Mobile Programming Applied in the Dissemination of Climatic Data: Remote Sensors for Monitoring the Weather of the 3 Climatic Floors of The Province of Bolívar

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The general objective of the technological project was to disseminate climate information from the province of Bolívar through a mobile application, which aims to be an informative App that shares data in real time. For its development, a prototype methodology was used whose purpose was to early feedback, resulting in substantial improvements to the design and functionality of the software. Additionally, the prototype methodology promotes agility and flexibility in the development process, which makes it easier to adapt to changing needs. The software developed was called RSR-MET APP, which bases its operation on the GRINTEC.ORG website, which shares climate data through remote sensors in the province of Bolívar and its graphs can also be viewed. The App has the same functions. than the website, but presents the information in a more appropriate way, the development of this resulted in a mobile application that correctly meets all functional requirements. In conclusion, the application allows sharing climate information, and this contributes to technological development, as well as contributing to the benefit of the inhabitants of the Bolívar province who will have access to climate data in real time.

Keywords: Remote sensors, APP, Climate data, Real-time information.

Introduction

Over time, there has been a great change in mobile technology, technological tools that make people's lives easier with more efficient ways to view information or perform tasks, these are better known as mobile applications. The State University of Bolívar, through the project "Remote sensors for the monitoring of the weather of the 3 climatic floors of the province of Bolívar period 2022-2024, first stage", created the RSR-MET website, which monitors the meteorological data of the remote sensors through graphs that share the information collected.

However, on a mobile phone the website cannot be displayed correctly, compared to the mobile technology that is currently used, the reason for this is that the website is not responsive in the section where it shares the data of the sensors, which does not allow the information to be displayed completely on the screen of the cell phone making it difficult to use, so it has been seen the need to access the RSR-MET website through a mobile application, created from the functions performed by the RSR-MET website, since it was not created for the purpose of using it as a mobile application, the graphics used to share the data from the remote sensors are too small to see them in full and that does not allow to see the clear information, Similarly, the problem with the statistical data of the remote sensors on the RSR-MET website is that it does not have any backup to be able to visualize data after the date on which the website is entered.

In this sense, (Denis et al., 2021), in their article "Potentialities of smartphones for biological research. Part 1: Integrated Sensors", an article written for the University of Havana and published in the Journal of the National Botanical Garden in 2021, tells us about the capacity of smartphones and mobile applications today and their uses in different areas of research and concludes that mobile applications can be summarized in different uses such as their large geographical scope, exponential growth in efficiency, shorter response time, accurate and high-quality data, reduced human error, increased data security, adaptability between cellular models and a huge number of usable integrated sensors. (pp. 77-91)

The use of mobile sensors connected to smartphones is still considered to be at an early stage of development and, excluding some that are frequently used and from which great advantages are obtained, we are many years away from exploiting their full potential. In the doctoral thesis "Applications of wearable sensors and smartphones in personal well-being: Quantification of physical activity and control of mindfulness practice" work carried out for the University of Uruguay in 2018, several issues of mobile development for applications that control integrated sensors are explained.

According to (Monteiro et al., 2018), the use of smartphones and other similar devices has spread rapidly in recent years around the world. Throughout the development of this doctoral thesis, the effectiveness of devices as study tools in improving the quality of life of end users has been proven. Specifically, we have validated these sensors in the monitoring of physical activity and in sitting meditation. In both cases, the sensors have provided valuable information that leads to favorable results. (p. 1)

From these studies, it has been possible to develop new methods and devices with more specific purposes for the control of physical activity through the use of integrated sensors. In

the research article that refers to the master's work of the University of Valladolid in 2019. "Use of smartphones to carry out laboratory practices outside the educational center" the benefit of sensors for the remote control of laboratory practices using a mobile device was analyzed.

According to Samuel Fraile Lobato (2020), when we think of a smartphone, we imagine a device that allows us to make phone calls, send messages, connect to the internet and use countless applications, all through a touch screen. And to put it another way, it's a pretty accurate definition. However, we rarely ask ourselves how these devices work the way they do. And it is achieved with the large number of sensors they have and that are used to control the different functions that the phone executes. (p. 15)

It explains the most basic models, those that are included in most commercial models, On the other hand, it talks about the most common sensors for the realization of the proposed objectives. According to (Rochina, 2022) they state that: the development of software for different areas and specifically in commerce has allowed small, medium and large companies to grow and access other markets, something very difficult to achieve through the traditional way and that is currently easy with the implementation of e-commerce systems. The main objective of this project is the implementation of a web application for the commercialization of products of the FUNORSAL foundation of the Salinas parish, in order to promote the growth and publicity of the community store that offers the product El Salinerito, in addition to providing a solution to the problems of electronic payments and sales reports of the business.

According to (Hat, 2020) mentions that: Agile methodologies do not refer precisely to a set of instructions on what to do during software development. It's a way of thinking about collaboration and workflow, defining a set of values that guide our decisions about what we do and how we do it. There are some agile frameworks such as Scrum, Kanban, or extreme programming.

Android Lollipop is the fifth discontinued major version of the Android mobile operating system developed by Google and the twelfth discontinued version of Android, covering versions 5.0 and 5.1.1. Unveiled on June 25, 2014 at Google I/O 2014, it was made available via official over-the-air (OTA) updates on November 12, 2014, for select devices running Google-serviced Android distributions such as Nexus and Google Play edition devices. (W. contributors, 2023). Its source code was available on November 3, 2014. It's the fifth major update and twelfth version of Android.

Finally, most people use their cell phones several times a day to perform different activities, interacting whenever they need to from anywhere with internet access. The implementation of a mobile application is necessary to improve access to the RSR-MET website, this will be in charge of monitoring the weather and will generate a backup of the data collected by the RSR-MET website through remote sensors, in this way the management of statistical data can be viewed from anywhere just by accessing the application, It will also have all the information on the RSR-MET website regarding the project.

People from the cantons where the weather sensors are located and people who visit Bolívar province will benefit from the information presented through the mobile application, as they

will have real-time data on the weather and also a weather forecast.

METHODOLOGY

According to (Bunge, 2019) methodology is defined as a set of methods and techniques that are systematically used to achieve robust results. If we talk about a software development methodology, we can say that it is an environment in which the development of a software product is planned, structured and controlled to ensure that it meets its objective. In the development of the RSR-MET mobile application, the methodology of software development by prototypes was used, which was used as conceptual support in all stages of the construction of the product and the preparation of the project documentation in an appropriate way. In addition, the prototyping methodology is related to continuous improvement, and considering that the RSR-MET mobile application must have changed throughout the development process, this is the methodology that best suits the project, as it has an iterative approach that will allow designing, implementing, measuring and adjusting to a plan.

According to the nature of the research, a survey on facts was used, which helped to define how necessary the mobile app is and was applied to a group of inhabitants of the province of Bolívar, including tourists who visit the cantons where the remote sensors are located, observation sheets were also used as a means to keep an orderly record of the most important data of the research. In this way, we had a record that helped to evaluate the progress of the results obtained.

RESULTS AND DISCUSSION

During the development of the mobile application, the requirements and variables were defined in several of the stages of the life cycle of the software product, the prototype methodology allowed to add several requirements as they were needed in the new versions and deliveries. In addition, the tools for the design and testing were defined, which for the execution of the project was Android Studio. A fundamental advantage of the prototype methodology in the implementation of the RSR-MET mobile application was that the prototype was designed according to the developer's ideas and this fit perfectly with the RSR-MET website since it already has an interface designed with functions and information that was perfectly adapted to the mobile application through the prototypes that were built. All the prototypes of the RSR-MET mobile application were tested and the results and lessons learned were analyzed to obtain a better version in each delivery until obtaining a functional final product that meets all the characteristics described in the client's requirements.

First phase: the planning of the project, in the first phase the user stories (use cases) were defined, which indicate the functionalities of each software user, the re-read planning or release plan was also elaborated in which the dates for each deliverable were indicated, in addition, the iterations within the project were planned, Finally, the meetings with the client were planned.

Second phase: design, in the second phase the system interfaces were designed, the glossary of terms was developed, possible risks were managed, the scope of the system functions to avoid delays, and the refactoring of the functions code was planned to optimize its operation.

Third phase: coding, as its name indicates, in this phase began with the programming of the software, implementation of the maintainers of the users, the functionalities of the system, the elaboration of the database and everything that corresponds to the development of the software.

Fourth phase: testing, is the last phase of the methodology, in this phase the system was tested before it was put into execution, to avoid any type of error that could harm or put the data at risk.

As for the scope of the product, the mobile system "RSR-MET" provides an online information platform for monitoring the weather status of the 3 climatic floors of the Province of Bolívar period 2022-2024: Real-time information, Information search and Report generation. From a product perspective, the RSR-MET-APP application is designed to work on mobile devices with Android operating system, this application allows the user to visualize the repositories of climate data in a fast, efficient and real-time way.

In addition, the mobile system: provides general information about the website; allows you to view weather information; allows you to visualize information from remote sensors; and, sending messages.

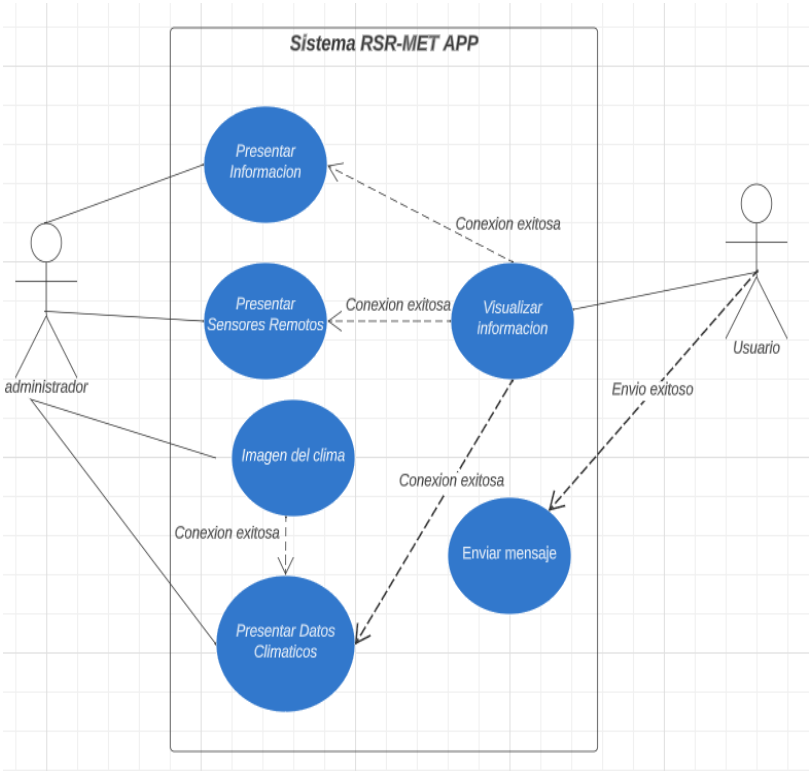


Figure 1 General Use Case Diagram

Prepared by: authors

The general restrictions of the App: to be used it requires internet access and a mobile device with the Android platform.

Functional Requirements

Tabla 1. Functional Requirement 01 Visualize APP Information

Identification of the requirement:	RF01
Request Name:	View APP information
Actors	User
Characteristics:	The RSR-MET application must allow the display of the information taken from the website in a responsive manner.
Description of the requirement:	Users will be shown a screen with a menu to access the app's information.
Non-functional requirement:	• RNF01 • RNF02 • RNF03
Preconditions	• Have the app installed • Be connected to the internet
Requirement Priority: Low	

Tabla 2. Functional Requirement 02 Visualize Remote Sensing

Identification of the requirement:	RF02
Request Name:	Visualize Remote Sensing
Actors	User
Characteristics:	The RSR-MET application shall allow the display of the information from the different remote sensors in a readable manner.
Description of the requirement:	Users will be shown a screen with a menu to access information from each of the sensors.
Non-functional requirement:	• RNF01 • RNF02 • RNF03
Preconditions	• Have the app installed • Be connected to the internet
Priority of the requirement: High	

Tabla 3. Functional Requirement 03 Visualize Climate Data

Identification of the requirement:	RF03
Request Name:	Visualize climate data
Actors	User
Characteristics:	The RSR-MET application shall allow the display of climate information in graphs and readable text.
Description of the requirement:	Users will be shown a screen with a menu to access and navigate the information from each of the sensors.
Non-functional requirement:	• RNF01 • RNF02 • RNF03
Preconditions	• Have the app installed • Be connected to the internet
Priority of the requirement: High	

Tabla 4. Functional Requirement 04 Send Message

Identification of the requirement:	RF04
Request Name:	Send Message
Actors	User
Characteristics:	The RSR-MET application should allow you to send a message, in case more information is required.
Description of the requirement:	Users will be shown a screen with a form so they can send the message.
Non-functional requirement:	• RNF01 • RNF02 • RNF03
Preconditions	• Have the app installed • Be connected to the internet
Requirement Priority: Low	

Non-functional requirements

Tabla 5. Non-Functional Requirement 01 Functionality

Identification of the requirement:	RNF01
Priority:	Loud
Request Name:	Functionality
Description of the requirement:	The application will allow you to enter and exit it correctly, and visualize the information taken from the sensors in a legible way.

Tabla 6. Non-Functional Requirement 02 Usability

Identification of the requirement:	RNF02
Priority:	Loud
Request Name:	Usability
Description of the requirement:	The app will be easy to use, work responsively to adjust to the mobile device and allow users to understand and navigate the information presented.

Tabla 7. Non-functional requirement 03 Availability

Identification of the requirement:	RNF02
Priority:	Loud
Request Name:	Availability
Description of the requirement:	Once installed, the app will be available 24/7.

Tabla 8. Non-Functional Requirement 04 Security

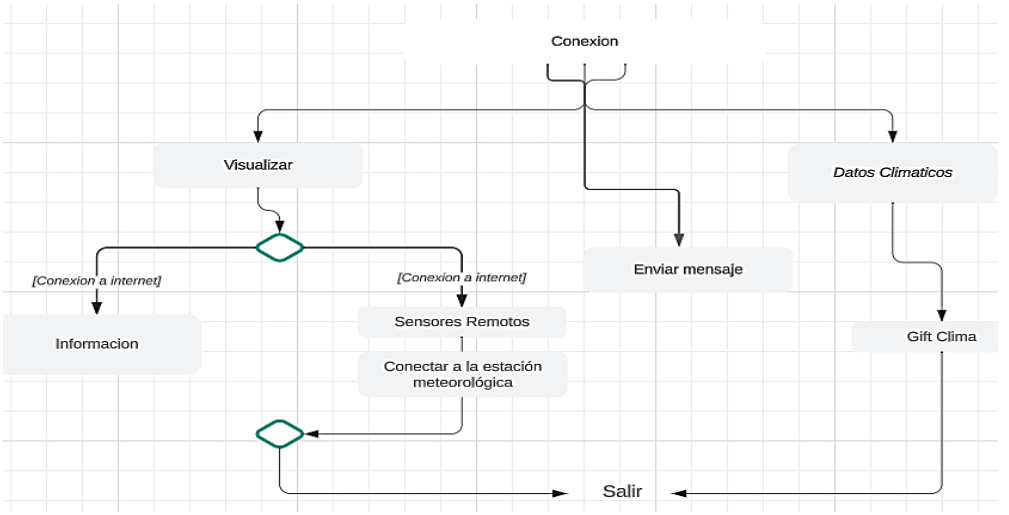
Identification of the requirement:	RNF04
Priority:	Loud
Request Name:	Safety
Description of the requirement:	The app has the need to access the internet without sharing personal data.

As a common requirement of the graphical interface, the design is intuitive so that the user can quickly identify the components and parts of the application. It has been designed using different layouts, composed of buttons, text boxes, labels, among others. It also has colors that are pleasing to the eye so that the user can browse for several hours in the App without any problem. In addition, it is compatible with the most common browsers (Google Chrome, Firefox, Microsoft Edge).

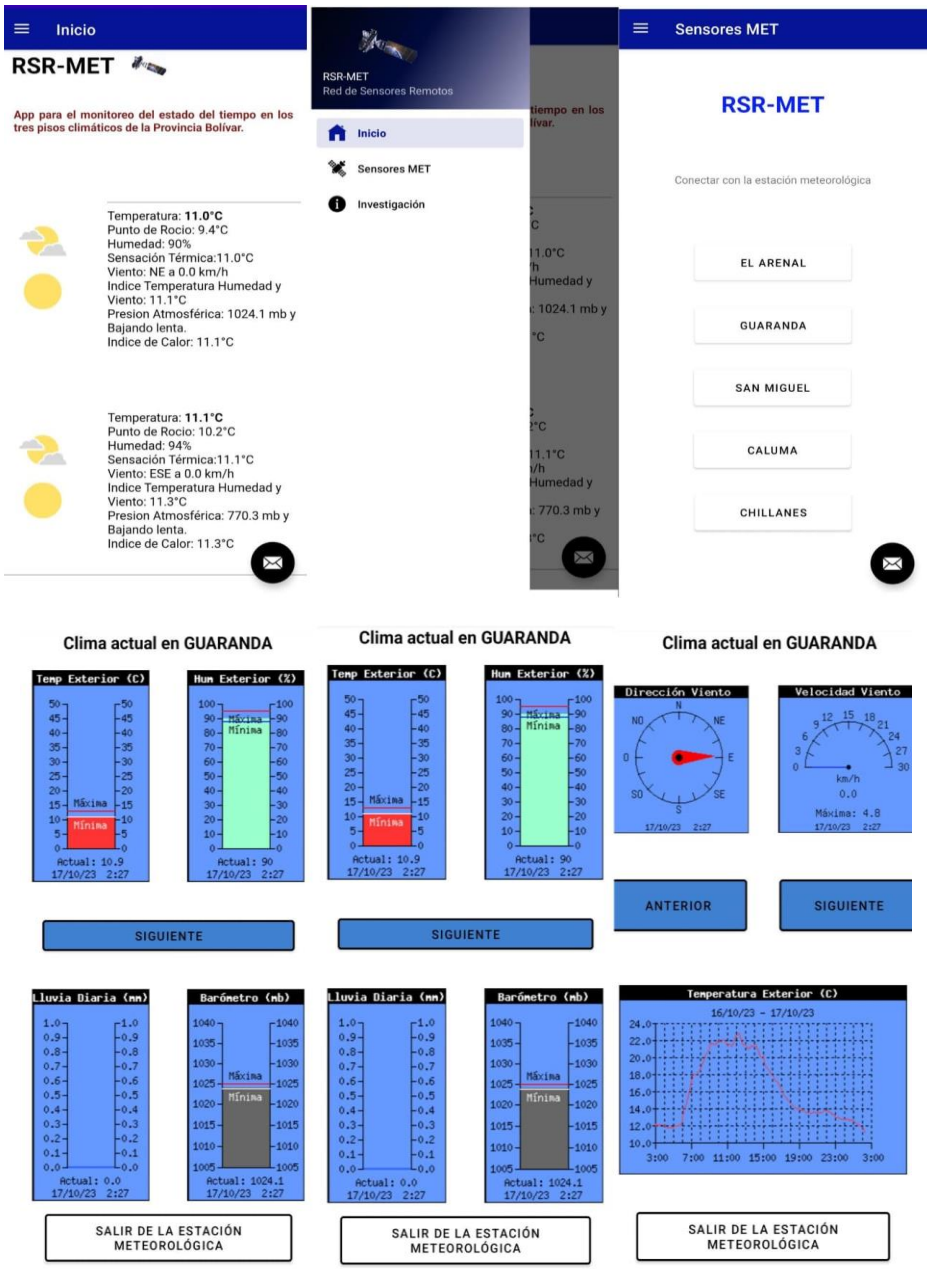
On the other hand, the RSR-MET-APP interface can be viewed on mobile devices such as Smartphones and Tablets, which must have the following minimum characteristics: hardware, network card, 1GHz processor, 1Gb RAM, GPS sensor and 2Gb storage. As far as the software is concerned, the following is required: Operating System: Android 4.4 (API level 19 – kit kat) or higher, Google play services and GPS configuration in high precision, all this will allow the correct functioning of the App.

The RSR-MET-APP has a model-view-controller (MVC) software architecture, as it allows you to keep your code organized, modular, and easy to maintain. The MVC pattern clearly separates the business logic (model), the presentation (view) and the control (controller), making it easier to update and improve specific parts of the application without affecting other areas, making it easier to maintain and scalable.

Figure 2 Navigation Pattern



Regarding the design of the interface, the choice of the dark blue color for the app turned out to be a wise decision for several reasons: First of all, dark blue connotes trust and professionalism, which reinforces the credibility of our app among users. Additionally, this shade of blue is known to convey a sense of tranquility, creating a more relaxed and enjoyable user experience. Also, dark blue works well in terms of text readability and contrast, ensuring that information and content are easy to perceive. In short, the choice of dark blue has contributed to an attractive, reliable, and functional appearance of our app, improving user satisfaction and usability. Additionally, typography is suitable for sharing information in a clear and concise manner.


Inicio
RSR-MET
App para el monitoreo del estado del tiempo en los tres pisos climáticos de la Provincia Bolívar.
Temperatura: 11.0°C
Punto de Rocio: 9.4°C
Humedad: 90%
Sensación Térmica:11.0°C
Viento: NE a 0.0 km/h
Indice Temperatura Humedad y Viento: 11.1°C
Presion Atmosférica: 1024.1 mb y Bajando lenta.
Indice de Calor: 11.1°C
Temperatura: 11.1°C
Punto de Rocio: 10.2°C
Humedad: 94%
Sensación Térmica:11.1°C
Viento: ESE a 0.0 km/h
Indice Temperatura Humedad y Viento: 11.3°C
Presion Atmosférica: 770.3 mb y Bajando lenta.
Indice de Calor: 11.3°C
RSR-MET
Red de Sensores Remotos
Inicio
Sensores MET
Investigación
Sensores MET
RSR-MET
Conectar con la estación meteorológica
EL ARENAL
GUARANDA
SAN MIGUEL
CALUMA
CHILLANES
Clima actual en GUARANDA
Temp Exterior (C)
Hum Exterior (%)
Máxima
Mínima
Actual: 10.9
17/10/23 2:27
Actual: 90
17/10/23 2:27
SIGUIENTE
Clima actual en GUARANDA
Temp Exterior (C)
Hum Exterior (%)
Actual: 10.9
17/10/23 2:27
Actual: 90
17/10/23 2:27
SIGUIENTE
Clima actual en GUARANDA
Dirección Viento
Velocidad Viento
km/h
0.0
Máxima: 4.8
17/10/23 2:27
ANTERIOR
SIGUIENTE
Lluvia Diaria (mm)
Barómetro (mb)
Actual: 0.0
17/10/23 2:27
Actual: 1024.1
17/10/23 2:27
SALIR DE LA ESTACIÓN METEOROLÓGICA
Lluvia Diaria (mm)
Barómetro (mb)
Actual: 0.0
17/10/23 2:27
Actual: 1024.1
17/10/23 2:27
SALIR DE LA ESTACIÓN METEOROLÓGICA
Temperatura Exterior (C)
16/10/23 - 17/10/23
3:00 7:00 11:00 15:00 19:00 23:00 3:00
SALIR DE LA ESTACIÓN METEOROLÓGICA

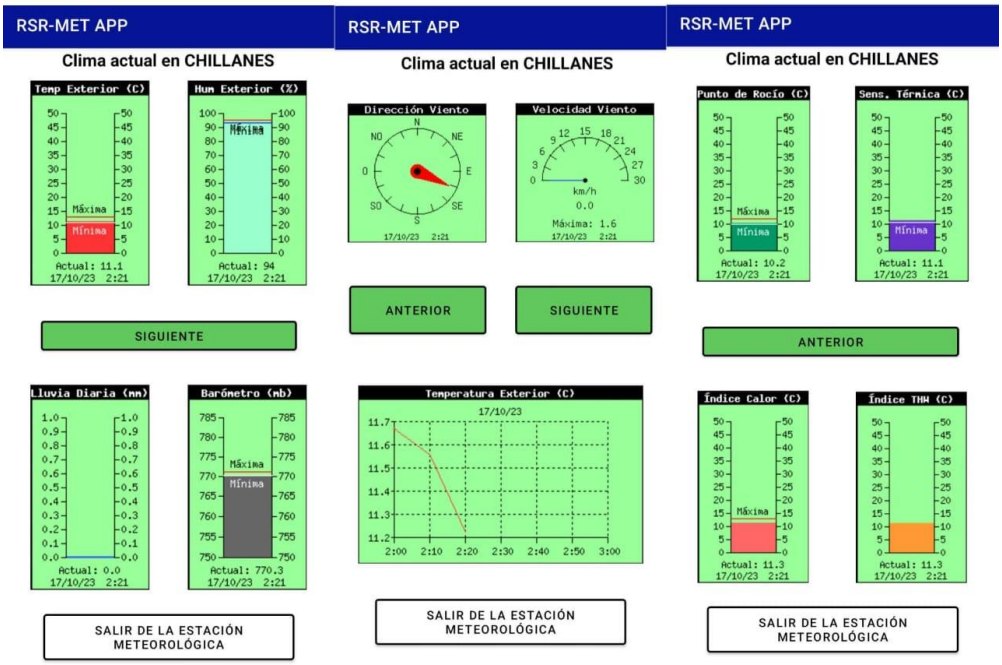


Figure 3 Remote Sensor Interface

In programming, good development practices were employed along with software engineering to detail an algorithm that aligns with the solution to: lack of early warnings; planning outdoor activities; travel planning; optimization of agricultural resources; energy saving; public safety and environmental awareness. As well as the different tests of the software were carried out to verify and validate its correct operation. In summary, a weather forecasting app could improve the daily lives of residents and visitors to the province of Bolívar by addressing challenges related to climate uncertainty and providing tools to make more informed and safer decisions.

On the other hand, the mobile application performed the same tasks as on the RSR-MET website, such as: entering the different remote sensors of the province of Bolívar, monitoring the weather in its different locations which are Guaranda, El Arenal, San Miguel, Caluma and Chillanes all in the Province of Bolívar, this served to be able to compare them and forecast the weather in the different cantons; Also, it displays all the theoretical information that the website contains with a similar interface.

The development of the application is of great help to the cantons of the province of Bolívar, since it does not have any type of mobile application that presents monitored data of the weather in the 3 climatic floors in real time and that is of benefit to the inhabitants of this province. Likewise, the application is feasible because it has been developed for mobile devices that have the Android platform, which today is at the forefront of mobile technologies, is growing by leaps and bounds in the market and is becoming the one chosen by the vast majority of users.

CONCLUSIONS

The creation of a mobile application to share climate data in the province of Bolívar was successfully addressed, taking advantage of the development capabilities provided by Android Studio. Throughout the software lifecycle, the technical and design aspects have been explored in depth, focusing on ease of use, data accuracy, and efficiency in the transmission of information.

Through the collection of information, emphasis was placed on applying the best practices of mobile application design and development. The resulting app not only meets users' needs in terms of access to weather information, but also demonstrates the usefulness of mobile technology in providing data.

Finally, the application complies with the standards established in the technical and design manuals, the operational performances meet the needs of the users. Testing of the software was conducted to gather feedback and continuously improve the user experience throughout the development cycle. Ultimately, it proves that the Android operating system is efficient for the creation of useful and effective applications that can have a positive impact on the province of Bolívar.

RECOMMENDATIONS

Prioritizing the design and ease of use of the mobile application is essential for the success of the app and above all for the user experience to be favorable, the app must be intuitive, easy to navigate and visually appealing. Check if the mobile app will work effectively on a wide range of devices with different screen sizes and technical specifications. In future updates or maintenance of the application, it is suggested to implement a module that can store weather information in the form of a history.

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