FACULTAD DE INGENIERÍA Y CIENCIAS APLICADAS
UNIVERSIDAD CENTRAL DEL ECUADOR

INGENIO
2024, VOL 7(2), JUNIO-DICIEMBRE, PP. 4-17

REVISTA INGENIO

Implementation of a Educational System Using IoT and RaspBerry PI

Implementación de un Sistema Meteorológico Educativo Usando IoT y Rasperry PI

Santillán Holger[1,2] [1] Universidad Politécnica Salesiana, Grupo GISTEL, Guayaquil - Ecuador, hsantillan@ups.edu.ec ,
[2] Universidad de las Palmas de Gran Canaria, Palmas de Gran Canaria - España, holger.santillan101@alu.ulpgc.es

Romero Kevin[1] [1] Universidad Politécnica Salesiana, Grupo GISTEL, Guayaquil - Ecuador, kromeroa1@est.ups.edu.ec

Huayamave María José [1] [1] Universidad Politécnica Salesiana, Grupo GISTEL, Guayaquil - Ecuador, mhuayamavec@est.ups.edu.ec

Wong Peregrina[2] [2] Universidad de las Palmas de Gran Canaria, Palmas de Gran Canaria - España, peregrina.wong101@alu.ulpgc.es

ARTICLE HISTORY
Received: 12/09/2023
Received after review: 15/10/2023
Accepted: 25/11/2023
Published: 15/06/2024

PALABRAS CLAVE
Sistema meteorológico, Asistente del hogar, Raspberry Pi, IoT.

RESUMEN
El documento subsiguiente presenta un examen e investigación sobre un sistema meteorológico utilizando tecnología IoT y Raspberry Pi. El objetivo principal es ilustrar una de las numerosas aplicaciones de las tecnologías emergentes. Se establece una red WLAN compacta para enlazar el servidor de la estación meteorológica con un controlador de automatización del hogar a través de un dispositivo Raspberry Pi. Esto permite la incorporación del Internet de las Cosas en el sistema previsto y la recopilación de datos de varios sensores dentro de la estación meteorológica. Además, estos datos se comparan con los obtenidos por otros sistemas en línea durante un período específico, confirmando la eficiencia de los sensores con una tasa de precisión del 97.66% y la exactitud de los datos recopilados. Esto crea un precedente para futuras investigaciones en los ámbitos de la automatización del hogar y las telecomunicaciones.

KEY WORDS
Meteorological system, Home assistant, Raspberry Pi, IoT.

ABSTRACT
The subsequent document presents an examination and inquiry into a weather system utilizing IoT technology and Raspberry Pi. The primary aim is to illustrate one of the numerous applications of emerging technologies. A compact WLAN network is established to link the server of the weather station to a home automation controller through a Raspberry Pi device. This enables the incorporation of the Internet of Things into the envisioned system and the gathering of data from various sensors within the weather station. Furthermore, these data are compared with those obtained by other online systems over a specific timeframe, affirming the sensors' efficiency with a precision rate of 97.66% and the accuracy of the collected data. This creates a precedent for future research in the realms of home automation and telecommunications.

1. INTRODUCTION

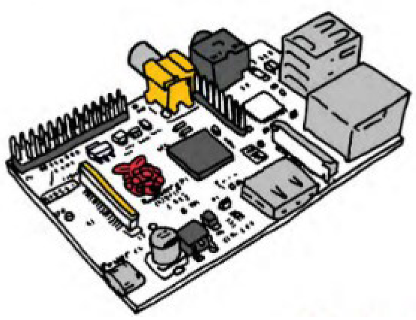
Over time, the study of meteorology has gained increased importance due to the various climate changes being experienced today, which are largely attributed to human negligence. Therefore, it is crucial to examine each factor encompassing this discipline, such as atmospheric pollution, wind speed, precipitation, temperature, ultraviolet (UV) radiation index, and humidity, among others, as these elements impact various outdoor activities [1], [2]. Consequently, the use of weather systems or stations becomes essential for collecting and recording data, aiming to assess areas where these climate changes have the greatest impact and thus prevent risks associated with natural disasters, both in the analyzed regions and in people's health [2]. The purpose of this project is to analyze the functioning

https://doi.org/10.29166/ingenio.v7i2.5265

pISSN 2588-0829
eISSN 2697-3243
vicedecanat.fing@uce.edu.ec

of a weather station and describe its corresponding implementation. The mentioned equipment will be implemented in an autonomous manner and will be connected to the Internet using technology that is widely used in companies and households in this era. Through the use of the Internet of Things (IoT) and a Raspberry Pi device, a connection will be established to monitor the records on a server, allowing the operator or client to perform necessary analyses in case studies. From this point onward, this section should be included in the Materials and Methods section. The Raspberry Pi is a type of computer that is much smaller than conventional ones and is used in various programming projects, robotic prototypes, and weather stations. This computer has a considerably lower cost compared to other devices, making it the preferred option for student projects [3]. It is important to note that this hardware device is essentially a compact computer, as shown in Figure 1.

Figure 1.
Graphical representation of Raspberry Pi.



This computer is of the ARM (Advanced RISC Machine) type, where the architecture is RISC (Reduced Instruction Set Computer), meaning that the instructions are reduced and simple, allowing for faster processing. It has a GPU (graphics processing unit) and RAM (Random Access Memory) all within a single chip, making it known as a System on a Chip (SoC). Its information is stored on an SD (Secure Digital) card; however, it needs to be connected to an external power source of 5V as it does not have integrated power. The board has several ports that provide accessibility to various devices and also provides both wired and wireless internet access through its ports and components [3], [4], [5], [6], [7].

Currently, ARM processors are considered one of the best options due to their lower power consumption [4]. The aforementioned ARM architecture is based on a set of 32-bit instructions, which allows for processing a reduced number of instructions but with high performance [8]. It is important to note that, although this device may appear to have lower performance compared to traditional computers, it is used in exploration robots and space probes [9].

Since the system is designed to operate on a local network, where the operating system (OS) installed on the Raspberry Pi retrieves information from the sensors, a router is used to configure a subnet and access the assistant. The Raspberry Pi is connected to the router via an Ethernet cable.

A router, also known as a gateway, is a device that allows for the interconnection of networks with different IP address prefixes (Internet Protocol) [22]. Its function is to determine the best route for each data packet to reach the network and the destination device. It is commonly used to connect to the Internet as it connects our home, office, or any network to our service provider's network [23]. It is important to mention that it operates at the network layer of the OSI model and can be thought of as a general-purpose personal computer [22].

An IP address (Internet Protocol) consists of a series of binary values (1 and 0) resulting in 32 bits. For ease of use, the values are separated by periods and converted to decimal format. For example, 192.168.0.1 [24], [25], [26]. Internet protocols originated in the early 1980s and were initially adopted by ARPANET in 1983. While they were initially used for military purposes, their usage expanded across all domains over the years [24].

A LAN (Local Area Network) and WLAN are utilized. A LAN is a network of interconnected computers within a limited space such as a building or office. The length of the network varies depending on the type of physical connection used. Within the LAN, there are computers with resources capable of organizing the connection between other devices and providing network security. These computers are known as servers [27], [28]. WLAN stands for Wireless Local Area Network, which allows for wireless connectivity without the need for cables. Computers communicate with each other by sending and receiving radio or infrared waves, eliminating the need for a physical medium [32], [33].

Regarding the mention of a network cable, it is important to note that a CAT 5e cable and RJ45 connectors are used to establish the physical connection between the Raspberry Pi, the router, and the computer, creating a small LAN network. To ensure proper connectivity between devices from different layers, a direct cable is created following either the EIA/TIA 568A or EIA/TIA 568B standard on both ends of the cable [29] [30].

2.METHOD

A weather station is a device that features a microcontroller responsible for monitoring the system's operation. It is equipped with sensors that gather data on various phenomena such as wind speed, solar radiation, temperature, rainfall, and levels of ultraviolet radiation (UV). These measurements of variables have had a significant impact, as the information captured by the sensors is crucial for understanding climate changes [1].

Figure 2.
Meteorological Station

It is also possible to obtain data from the indoor environment of a room, hall, or laboratory. In this case, values of humidity, pressure, and temperature can be obtained. Figure 2 shows a graphical representation of a weather station with its respective sensors [10]. Similar to any equipment that requires hardware to acquire and perform actions, one of the important components within weather stations is the Datalogger. This section is responsible for collecting information from the weather sensors [1]. Weather stations collect all the data obtained from the sensors and store it in a server for subsequent study and analysis. The elements present in weather stations, which were used in the station built for our project, are as follows [11].

Wind has three main characteristics: direction, speed, and type, whether it's gusts or intermittent bursts. Vein vanes and anemometers are used to measure the surface changes caused by variations in wind speed and direction. For measurements at greater heights, pilot balloons and radiosondes are employed, as wind speed increases with altitude [12], [13].
An anemometer is a sensor used to measure wind speed. The average value of the data obtained over a 10-minute interval is taken since wind gusts can affect measurement precision. Therefore, the average value within the mentioned interval is the most suitable measure. If the anemometer is located on the ground, the measurement corresponds to the wind speed in the surrounding environment. However, if the station is positioned on a moving object, the measured wind speed is the relationship between the ambient wind and the wind generated by the moving object [14]. This instrument consists of 3 or 4 cups mounted one above the other, enabling the detection of wind speed [15].
A wind vane is used to measure wind direction. It is a rotating instrument equipped with an analog sensor and a resistor that helps obtain a different voltage value for each wind direction indicated [16].
Temperature is a variable that has a linear relationship with altitude. In other words, at higher altitudes, the temperature decreases, with a variation of 6.5 °C per 1000 meters. The Kelvin unit is used for temperature, although the Celsius or centigrade scale is widely employed as well. In the Kelvin scale, the absolute zero corresponds to the lowest temperature, while the highest value is 273.16 K. In the Celsius scale, the zero value represents the freezing point of water, and the boiling point is 100 °C [12], [17], [18].
Equations (1) and (2) are used for temperature conversion:

$$T[°K] = T[°C] + 273,16 \qquad (1)$$

$$T[°F] = T[°C] + 32 \qquad (2)$$

Where:
T: temperature
°C: degrees Celsius
°F: degrees Fahrenheit
°K: degrees Kelvin
The equations (3) and (4) for maximum and minimum temperature, respectively, are:

$$\overline{t_1} = \frac{\Sigma t_1}{n} \qquad (3)$$

$$\overline{t_2} = \frac{\Sigma t_2}{n} \qquad (4)$$

Where:

t_1: The average of the maximum temperature within a range of days.

t_2: The average of the minimum temperature within a range of days.

Σt_1: Sum of all maximum temperatures during each month in the nth season.

Σt_2: Sum of all minimum temperatures during each month in the nth season.

n= Number of months with recorded information in the nth station.

Atmospheric pressure is determined based on the force exerted by the air in a specific area from the Earth's surface to the uppermost part of the atmosphere. As a result, when we are in an elevated area, the pressure is lower due to the reduced amount of force exerted from that distance to the atmospheric boundary. [19] This relationship is defined by equation (5).

$$P = \frac{F}{A} \qquad (5)$$

Where:
P: Pressure. (N/m)
F: Force. (N)
A: Area (m^2)

The barometer is an instrument used to measure atmospheric pressure. There are different types of barometers, such as mercury barometers and those that measure pressure in a closed environment. However, in automatic weather stations, the barometer is presented as a sensor directly connected to a microcontroller [16] [20]. Precipitation refers to the amount of rain that accumulates in a specific area during a certain period of time. The rain gauge is a device used to measure the amount of rainfall within a particular time interval. This measurement is expressed in millimeters (mm), indicating the height of the rain in millimeters that falls on a square meter of surface area. This relationship is described by equation (6) [20].

$$1\,mm = \frac{L}{m^2} \qquad (6)$$

Where:
L: unit of volume (L)
m: unit of measurement (m^2)

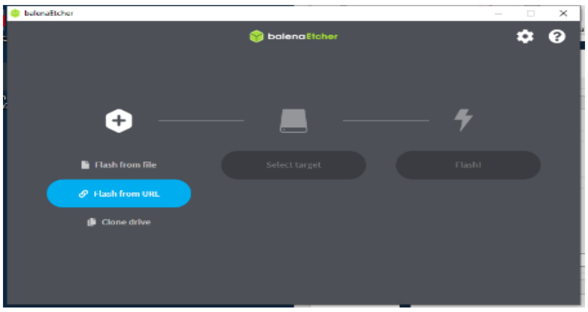
The rain sensor used in automatic weather stations employs a system that generates pulses each time the container fills up and water falls. The ultraviolet (UV) radiation spectrum spans wavelengths ranging from 100 nm to 400 nm. Within the different categories of UV radiation, we find types A (315 nm to 400 nm), B (280 nm to 315 nm), and C (100 nm to 280 nm). In meteorological stations, UV-B radiation is commonly measured. The UV sensor is responsible for measuring the relationship between the analog signal generated by the sensor and the amount of UV light detected [16], [17], [18], [19], [20], [21].

2.1 Experiment

The Balena Etcher software was used to perform the installation of the operating system on the SD card that is inserted into the Raspberry device. Figure 3 displays the main interface of the program, which contains various sections for configuring the card using different methods. In the specific case of this project, the installation is carried out through the URL: "https://www.home-assistant.io/installation/raspberrypi/".

Figure 3.

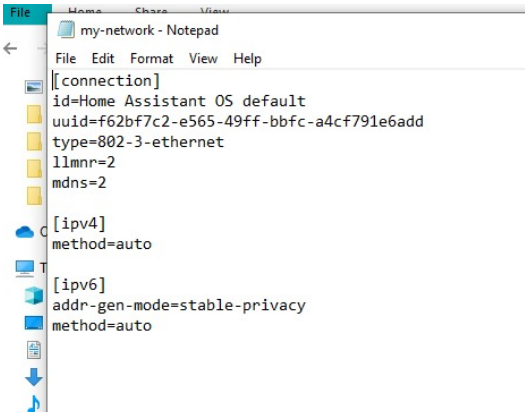
Formatting the memory card of the Raspberry Pi device



After installing the operating system on the hardware, the network connection method is configured, which depends on the components of the device and the mode of operation.

In this project, a wired network connection is used in the RJ45 port of the device, and it is programmed whether to use a DHCP-assigned IP address or a static IP address. An IP address file is created using the Python programming language or directly from a text editor, as shown in Figure 4, and it is saved without any extension.

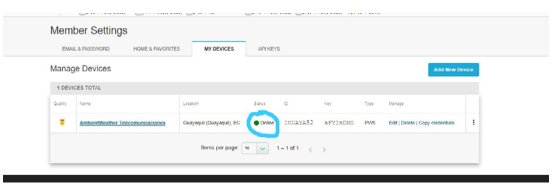
Figure 4.
Code for creating an address file.



If the network configuration is DHCP, connect the device to the power source. Optionally, you can connect a screen to verify the assigned address. Otherwise, enter the following URL directly into a computer's web browser: "http://homeassistant.local:8123". Alternatively, replace "homeassistant" with the IP address.

Monitoring devices, depending on the model, have a default server where data is stored. This server generates an "API KEY," which is a key used to retrieve data from a server in an application or another webpage. It serves as an identifier to authenticate a client and grant access to a specific service [34]. Access the following URL: "https://www.wunderground.com/", register, and fill in the necessary fields. Then, verify that the device is "Online" in the "My Device" section, as shown in figure 5.

Figure 5.
Connecting the equipment to the WunderGround server



In the home assistant server, access data to the system is recorded in order to perform the necessary configurations and programming to retrieve information from the server of the data-generating device. It is crucial to integrate two essential add-ons for programming data storage variables, as shown in Figure 6 (Appendix Figure 6). It is important to note that communication files between the Wunderground server and Home Assistant are used, which can be obtained from the following URL: "https://github.com/", as shown in Figure 7(Appendix Figure 7).

Access the file editors and make modifications to the commands in order to create variables for storing sensor data and displaying them later on. The file that needs to be modified is called "conFiguretion.yaml", in which the "API KEY" obtained from the WunderGround server should also be registered. Save all the modified data and restart the device using the restart button in the home assistant window. It is important to note that, similar to the conFiguretion of IP addresses shown in Figure 4, Python is also the programming language used.

To install the weather station, place and align the flat shaft on the axis of the weather vane, ensuring that it matches the flat side of the piece, and then push down onto the axis. Tighten the securing screw using a flat-head screwdriver, making sure that the vane can rotate freely [31]. It may be necessary to remove the securing screw before sliding the paddle onto the axis, as shown in Figure 8 (Appendix Figure 8).

The axis of the weather vane will not rotate as freely as the wind cups due to its design. This damping prevents the vane from turning with the slightest breeze, resulting in inconsistent wind direction measurements. The added resistance allows the vane to change direction with wind speeds of 2 to 3 mph, providing more accurate tracking of the wind direction [10]. For calculating server efficiency using data, equation (7) is considered.

$$V = \left(1 - \frac{Vmax - Vmin}{Vmax}\right)(100\%) \qquad (7)$$

Where:

V: It is the value of the sensor efficiency.

Vmax: It is the highest data value among the sensors in comparison.

Vmin: It is the lowest data value among the sensors in comparison.

3. RESULTS

After configuring all the windows, data visualizations, and function settings, the registered values from each sensor of the meteorological monitoring unit can be displayed graphically. These data are presented in the main window of the home assistant, as shown in figure 9 (Appendix Figure 9). In this window, the main sections such as ambient temperature, humidity, pressure, among others, can be viewed.

By analyzing the data stored in the variables used to generate the graphs, it can be concluded, based on the graphical representation of the data collected by the internal temperature sensor, that the temperature remained constant from January 24th until the last sample taken on February 8th, 2023. These results are shown in figures 10, 11, and 12 (Appendix Figure 10,11, and 12).

Likewise, it is programmed to display and graph the trend of pressure and humidity values, as can be seen in figures 13 to 16, respectively (Appendix Figure 13 to 16).

Upon analyzing figures 13 and 15, it can be observed that humidity and pressure vary on different dates. This variation is attributed to the seasonal changes during the testing period of the project, as these dates correspond to the rainy season.

The windows of the home assistant also contain widgets or sections that display the current value of a data obtained from the equipment's sensors, such as temperature, humidity, ultraviolet (UV) radiation index, and solar radiation, as shown in figures 17, 18, 19, and 20, respectively (Appendix Figure 17,18,19, and 20).

Since the home assistant has variables that store data from the Wunderground server, where all the information is initially stored, it has the ability to predict future scenarios related to the weather. These predictions are shown in figures 21 and 22 (Appendix Figure 21 and 22), which display sunset and sunrise times, as well as moon phases as indicated in figure 22, indicating a waning moon on the specified dates.

Figure 23 (Appendix Figure 23) displays the predictions of temperature and humidity changes throughout the week.

In conclusion, the table in Figure 24 (Appendix Figure 24) displays the real-time values of all sensors present in the monitoring equipment, along with their respective indicators.

Samples were taken from the various sensors of temperature, humidity, pressure, UV index, and heat index of the weather station shown in Table 1. These will be used for tests presented during this work.

Table 1.

Measured values of the different sensors

EFICIENCIA TIEMPO REAL			
SENSORES	TELECOMUNICACIONES	GOOGLE	TOTAL
TEMPERATURA	33	31	93,94%
HUMEDAD	57	58	98,28%
INDICE UV	3	2	66,67%
SENSACIÓN TERMICA	33,53	34	98,62%
PRESIÓN	1007,11	1005	99,79%

3.1 Efficiency of the results

Taking into account Google's digital platform, a comparison is made between the data generated by the device in the home assistant and the data stored on Google's server. By using equation (7), the values of Vmax and Vmin are replaced with the results provided by each sensor, enabling the calculation of the efficiency to be analyzed as shown in equations (8), (9), (10), and (11).

$$T[\%] = \left(1 - \frac{Tmax - Tmin}{Tmax}\right)(100\%)$$
$$T[\%] = \left(1 - \frac{33°C - 31°C}{33°C}\right)(100\%) \quad (8)$$
$$T[\%] = 93{,}94\%$$

Calculation of temperature sensor efficiency [%] is considered in equation 8: The value of T[%] represents the percentage efficiency of the sensor compared to the data used, as shown in Figures 25 and 26 (Appendix Figure 25 and 26). In this case, the sensor presents an efficiency of 93.94%, which indicates that it is technically reliable. This sensor is generating measurements in relation to the established reference values.

To calculate the efficiency of the humidity sensor [%], equation (9) is used as a reference. This equation allows for a comparison between the data generated by the sensor and the established reference values. By substituting the measured humidity and reference humidity values into equation (9), a percentage is obtained that indicates the sensor's efficiency. For example, if the result is 90%, it means that the sensor is operating with 90% efficiency, indicating precise and reliable humidity measurement. This efficiency calculation enables us to evaluate the quality and performance of the sensor in relation to the established standards.

$$H[\%] = \left(1 - \frac{Hmax - Hmin}{Hmax}\right)(100\%) \quad (9)$$

$$H[\%] = \left(1 - \frac{58\% - 57\%}{58\%}\right)(100\%)$$

$$H[\%] = 98{,}27\%$$

centage of efficiency that the sensor has in comparison to the data used for comparison, considering the values shown in Figure 27 and 28 (Appendix Figure 27 and 28). This indicates that the sensor has an efficiency of 98.27%, which is technically reliable. A high efficiency percentage suggests that the sensor is accurately capturing and measuring humidity data, providing reliable and consistent results. This level of efficiency demonstrates the sensor's ability to perform effectively and meet the required standards.

To calculate the efficiency of the UV sensor [%], equation 10 is utilized as a basis. This equation enables the comparison of the sensor's generated data with established reference values. By substituting the measured UV intensity and the reference UV intensity into equation 10, a percentage is obtained, indicating the sensor's efficiency.

$$IUV[\%] = \left(1 - \frac{IUVmax - IUVmin}{IUVmax}\right)(100\%) \quad (10)$$

$$IUV[\%] = \left(1 - \frac{3 - 2}{3}\right)(100\%)$$

$$IUV[\%] = 66{,}67\%$$

percentage of efficiency that the UV sensor has in comparison to the data used for comparison, considering the values marked by the system and Google. In this case, the sensor Appendixs an efficiency of 66.27%, which is technically not considered reliable. However, it is important to note that this lower efficiency is due to the evaluation of data using integer values. If decimal values were considered, the efficiency would be close to 100%. Despite the slightly lower efficiency, it's crucial to recognize that the sensor's performance is still valuable and provides meaningful insights, albeit with a small margin for improvement.

To calculate the efficiency of the thermal sensor [%], equation 11 is taken into consideration. This equation allows for the assessment of the sensor's efficiency by comparing the measured thermal value with the reference values. By applying the values of the measured temperature and the reference temperature in equation 11, a percentage is derived, indicating the sensor's efficiency.

$$FL[\%] = \left(1 - \frac{FLmax - FLmin}{FLmax}\right)(100\%) \quad (11)$$

$$FL[\%] = \left(1 - \frac{34 - 33{,}53}{34}\right)(100\%)$$

$$FL[\%] = 98{,}62\%$$

The FL[%] value represents the percentage of efficiency of the sensor when comparing the data used for comparison with the values shown in Figures 29 and 30 (Appendix Figure 29 and 30). This value indicates that the sensor has an efficiency of 98.62%, making it technically reliable. A high efficiency level means that the sensor accurately captures and measures thermal values, providing dependable results. This high level of efficiency demonstrates the sensor's ability to function effectively and meet the required standards, instilling confidence in its reliability and precision. The data from Figures 29 and 30 support the sensor's efficiency, indicating that it can consistently and reliably provide accurate measurements in diverse environments.

To improve the efficiency calculation of the pressure sensor [%], equation 12 is taken into consideration. This equation allows for the comparison of the sensor's data with the reference values. By applying the measured pressure and the reference pressure values to equation 12, a percentage is obtained, indicating the sensor's efficiency.

$$P[\%] = \left(1 - \frac{Pmax - Pmin}{Pmax}\right)(100\%) \quad (12)$$

$$P[\%] = \left(1 - \frac{1007{,}11 - 1005}{1007{,}11}\right)(100\%)$$

$$P[\%] = 99{,}79\%$$

percentage ... r has when compared to the data used for comparison, considering the values shown in Figures 31 and 32 (Appendix Figure 31 and 32). This indicates that the sensor has an efficiency of 99.79%, which is technically reliable. A high efficiency percentage suggests that the sensor is accurately capturing and measuring pressure data, providing trustworthy results. This high level of efficiency demonstrates the sensor's capability to operate effectively and meet the required standards, instilling confidence in its reliability and accuracy. The data presented in Figures 31 and 32 strongly support the efficiency of the sensor, indicating its ability to consistently provide precise and dependable pressure measurements in various scenarios.

3.2 Discussion

Based on the information previously discussed, new measurements were taken using various sensors, including temperature, humidity, pressure, UV index, and thermal sensation. These data were compared with those obtained from online sources to calculate the equipment's efficiency. The general equation (7) was applied to each sensor, and the results are presented in Table 2. Additionally, the reference values obtained from Table 1 were used to evaluate the efficiency of each sensor compared to the data from online sources.

The comparison of the collected data with the web data provides a comprehensive assessment of the sensors' efficiency. It allows us to determine how accurate and reliable the results obtained by each sensor are in comparison to the measurements taken from online sources. The calculated efficiency values for each sensor provide valuable information about their performance and quality in relation to established standards. This evaluation is essential to ensure reliable and accurate measurements in various contexts and to support the optimal functionality of the equipment.

Table 2.

Data compared to display efficiency per day.

Data for Days					
	Temperature		Humidity		
	Google	Proyect	Google	Proyect	
07-ene-23	28	29,5	0,73	0,63	
08-ene-23	28	29,5	0,87	0,73	
09-ene-23	28	29,5	0,9	0,63	
10-ene-23	28	29,5	0,9	0,63	
11-ene-23	23	24,7	0,4	0,91	
12-ene-23	24	24,7	0,29	0,91	
13-ene-23	28,5	28,7	0,18	0,68	
14-ene-23	28	27,7	0,72	0,74	
15-ene-23	27	23,9	0,33	0,97	
16-ene-23	27,5	27,7	0,32	0,77	
17-ene-23	27,5	27,2	0,4	0,72	
18-ene-23	27,5	27,8	0,34	0,73	
19-ene-23	27,5	26	0,78	0,87	Total average by sensors.
20-ene-23	27,5	27,6	0,84	0,73	
	27,14	27,43	57%	76%	
	98,96%		75,12%		87%
	98,96%		75,12%		87%
Reference	https://www.msn.com/es-xl/el-tiempo/pronosticomensual/in-Guayaquil, Guayas?loc=eyistjoiR3VheWFxdWisliwicil6ikd1YXJhcyislmMiQUFY3VhZG9yliwia5/6lkVDliwiZyI6ImVzLXhsliwieCI6li030S44OTI2MDEWMT-MxODM21 WiesI6tOYLjI0MDYzOTkyNTAWMzA1MTgifQ%30%3D&weadegreetype=C&ocid=winpitask-bar&cvid=07725421 Be844f23a2bcc3dd67c06aab				

Table 3.

Efficiency values by sensors.

EFICIENCIA TIEMPO REAL			
SENSORES	TELECOMUNICACIONES	GOOGLE	TOTAL
TEMPERATURA	33	31	93,94%
HUMEDAD	57	58	98,28%
INDICE UV	3	2	66,67%
SENSACIÓN TERMICA	33,53	34	98,62%
PRESIÓN	1007,11	1005	99,79%

I ... s that show the efficiency of each sensor in different measurements. It is important to highlight that the UV index sensor presents the lowest efficiency, reaching a precision of 67%. This discrepancy is due to the fact that the data is recorded in integer values instead of decimals, which limits the precision of the measurement.

On the other hand, the temperature, humidity, and thermal sensation sensors achieved highly accurate results. The temperature sensor reached an efficiency percentage of 93.94%, indicating an acceptable measurement within the measurement process. Likewise, the humidity sensor showed an efficiency of 98.28%, providing a highly precise value for this measurement. In addition, the thermal sensation sensor achieved an efficiency of 98.62%, also demonstrating a very precise measurement. These results support the reliability and capability of the sensors to accurately capture and measure data related to temperature, humidity, and thermal sensation.

The efficiency values per sensors provide a quantitative evaluation of the quality and performance of the equipment used in the meteorological system. These results demonstrate the sensitivity of each sensor and its ability to accurately capture and measure relevant climate data. Furthermore, the high efficiency percentages obtained, such as 93.94% for the temperature sensor, 98.28% for the humidity sensor, and 98.62% for the thermal sensation sensor, support the credibility of the implemented meteorological system.

These efficiency values validate the approach adopted in using technologies such as IoT and Raspberry Pi in the design of an educational meteorological system. The successful implementation of this system demonstrates its feasibility and capability to provide precise and reliable measurements in an educational setting. These results support the utility and effectiveness of combining technology and education in teaching meteorological concepts, fostering enhanced learning and understanding among students. Moreover, the utilization of this system provides a unique opportunity to actively engage students in hands-on collection and analysis of meteorological data, fostering their interest and active participation in the study of weather.

4. CONCLUSIONS

Based on the efficiency data obtained, it can be concluded that the weather station is in optimal conditions to provide accurate data from the various measurement sensors. Furthermore, by using Home Assistant as a home automation controller, alerts can be generated when the temperature is high or the UV index is elevated, helping to prevent users from going outside without adequate protection. The combination of Home Assistant with weather stations is not only applicable in residential settings but also has uses in scientific research, as in the present case. Thanks to the reliability of the data provided by the installed station, this research can serve as a foundation for future experiments in the field of IoT and other branches of telecommunications.

Despite the changes occurring worldwide, the field of meteorology has experienced significant advancements. Learning from past human errors, meteorology has evolved with the aid of technological progress, enabling remote monitoring in specific areas.

Technological advancements have played a fundamental role in enhancing the precision and efficiency of meteorological monitoring systems. In the past, human errors were a frequent cause of inaccuracies in weather forecasts and measurements. However, with the development of new technologies, sophisticated systems have been implemented, allowing for more precise and reliable monitoring.

These technological advancements have facilitated real-time data collection and transmission of meteorological information through communication networks. It is now possible to remotely and instantaneously monitor weather conditions in specific areas, providing scientists and meteorology experts with a more comprehensive and up-to-date understanding of climate patterns.

This approach of remote monitoring in specific sectors has enabled a greater comprehension of meteorological phenomena and their impact on different regions. Furthermore, it has contributed to the development of more accurate prediction models and the design of early warning systems that help mitigate the adverse effects of weather.

The implemented project has demonstrated an efficiency of over 90% compared to the data provided by Google servers. These data were crucial for making comparisons and demonstrating the effectiveness of the project.

As mentioned in the equipment configuration sections, both the Raspberry Pi and the monitoring device, it is crucial that access is performed within the same network or subnet generated from the router. This requirement ensures a stable and reliable connection between the devices, ensuring optimal project performance.

By following this specific network configuration, communication is optimized, and potential connectivity issues that could affect the efficiency and accuracy of the collected data are avoided. It is essential to ensure that all devices involved are properly configured within the same network to guarantee the success and reliability of the project.

Furthermore, when configuring the Raspberry Pi, it is important to assign a static IP address to the device. This will allow accessing the home assistant interface using the same IP address from which the device is operating.

By assigning a static IP address, it ensures that the Raspberry Pi always has the same network address, which facilitates consistent connectivity and access to the home assistant. This is particularly useful when accessing the system from external devices or through a remote network.

Assigning a static IP address ensures that there are no address conflicts and simplifies the management of the Raspberry Pi within the network. Additionally,

it enables more convenient and reliable access to the home assistant, as the interface can always be accessed using the preconfigured IP address.
It is essential to install the meteorological monitoring equipment in an elevated location or in a position without obstructions that could interfere with the accurate reception of data by the sensors. The UV index and humidity are clear examples of this, as the collected information can be affected by the location of the monitoring unit.

Elevating the equipment ensures that the sensors are exposed to optimal environmental conditions, avoiding obstructions that could distort the data. For instance, in the case of the UV index, the presence of trees, buildings, or other nearby structures can create shadows or block direct solar radiation, which affects the accuracy of the measurements. Similarly, the location of the humidity sensor is crucial, as different areas can have variations in air humidity due to local factors such as vegetation or nearby bodies of water. Therefore, it is essential to carefully select the installation site for the meteorological monitoring equipment, considering factors such as height and the absence of obstructions that could affect the quality and precision of the collected data. This ensures that the obtained results are representative and reliable, allowing for accurate and effective meteorological analysis.
Finally, it is important to emphasize that when using the home assistant, we are not only automating the weather station but also our entire home. The home assistant provides us with the ability to control lights, doors, power distribution, and other functions, which can also make our home vulnerable. Therefore, it is necessary to take appropriate security measures to prevent possible intrusions into our network, such as cyberattacks.
Having a network connection and an automated system in our home requires extra caution to protect our privacy and security. It is essential to implement robust security measures, such as strong passwords, regular firmware and software updates, and proper firewall and network protection settings.
Furthermore, it is recommended to use trusted devices and stay informed about the latest threats and security solutions in the field of home automation. By taking these precautions, we can enjoy the comforts and benefits offered by the home assistant without compromising the security of our home and network.

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Appendix

Figure 6.

Home Assistant add-ons

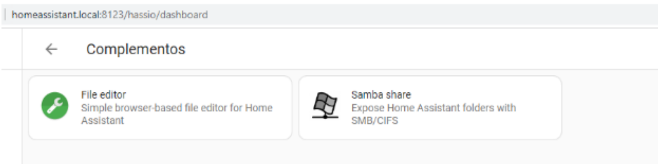

Figure 7.

GitHub page for downloading add-ons and files for Raspberry Pi.

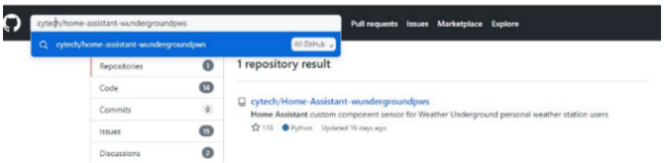

Figure 8.

weather station

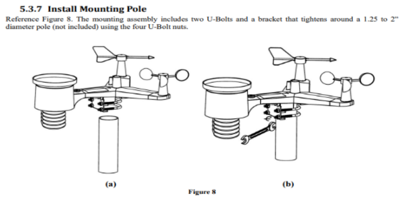

Figure 9.

Home Assistant Sensor Values Window

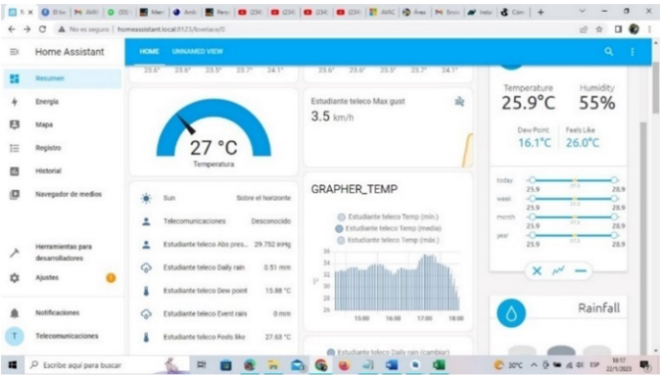

Figure 10.

Temperature graph

Figure 11.

Temperature graph by hours throughout the day.

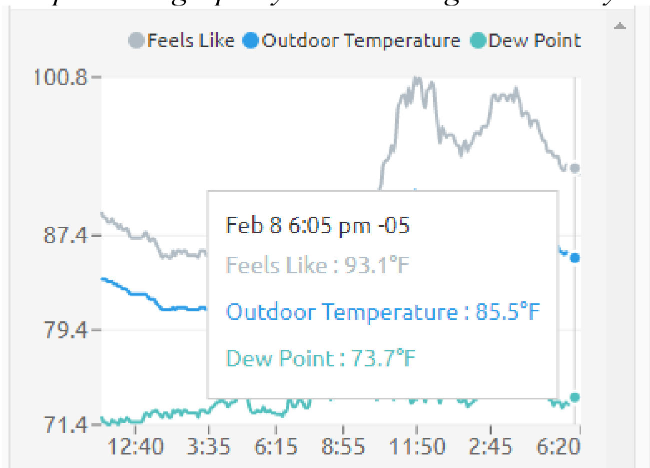

Figure 12.

Average temperature graph

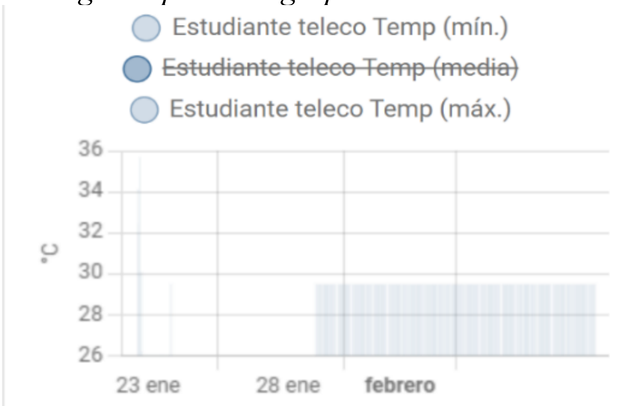

Figure 13.

Pressure graph

Figure 14.

Pressure graph by hours throughout the day.

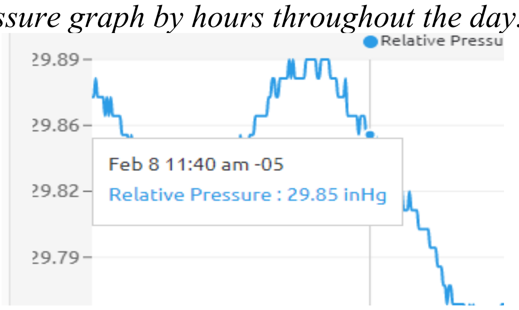

Figure 15.
Graph of humidity percentage changes by dates.

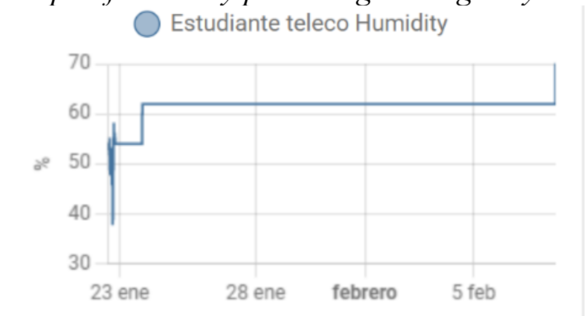

Figure 16.
Graph of humidity by hours throughout the day.

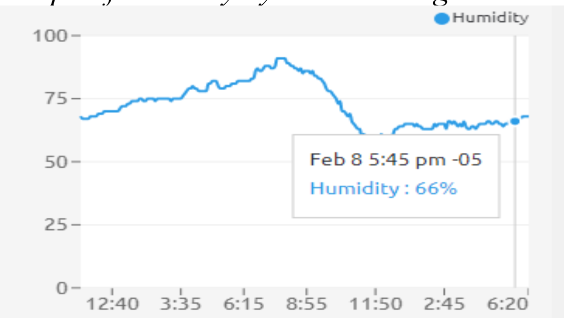

Figure 17.
Current real-time temperature value.

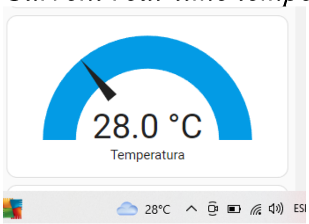

Figure 18.
Current real-time humidity value.

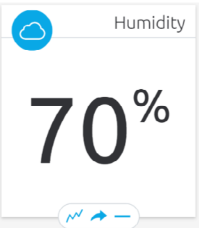

Figure 19.
Hourly UV index value throughout the day.

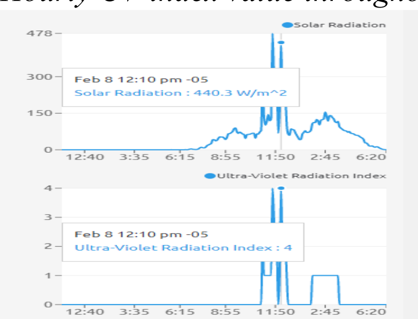

Figure 20.
Solar radiation per hour throughout the day.

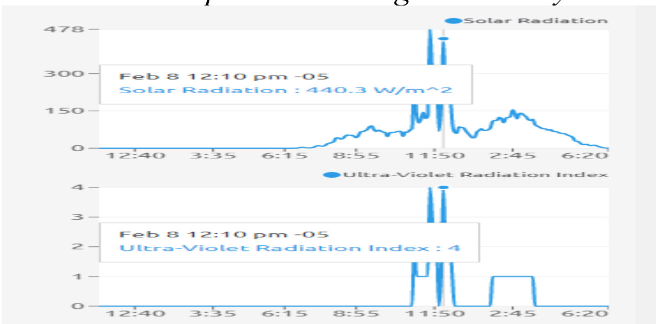

Figure 21.
Sunset and sunrise prediction

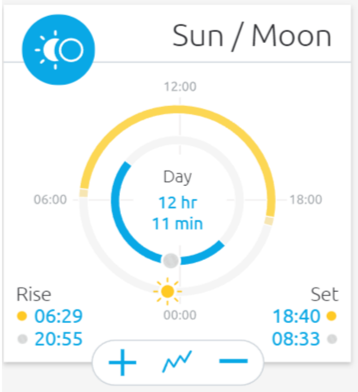

Figure 22.
Moonrise and moonset prediction

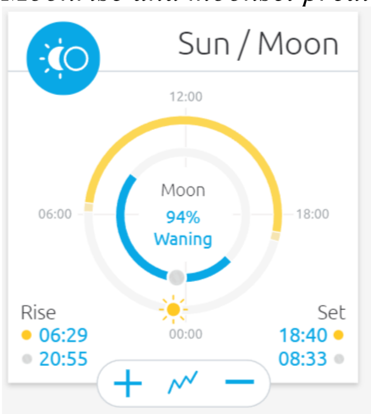

Figure 23.
Temperature and humidity prediction.

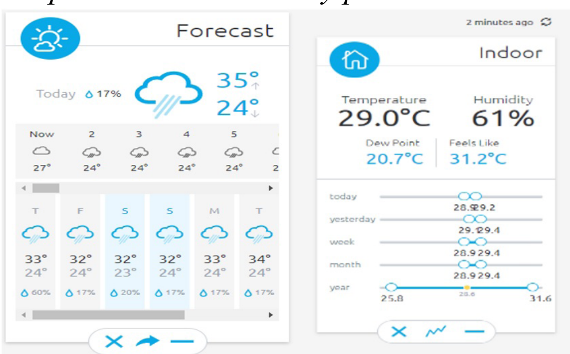

Figure 24.
Real-time data obtained.

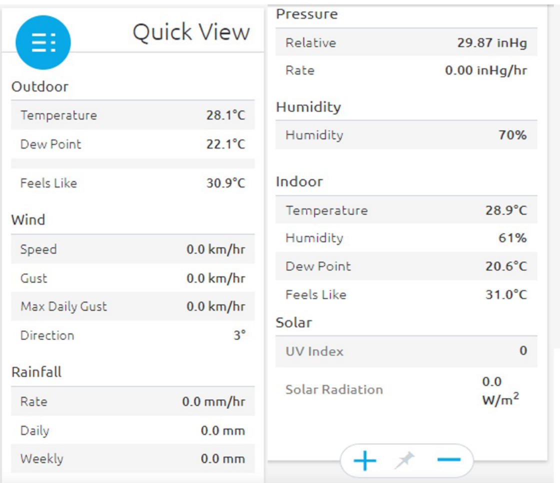

Figure 25.
Temperature displayed with monitoring unit.

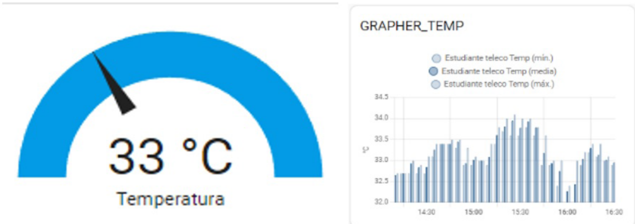

Figure 26.
Temperature emitted by Google servers.

Figure 27.
Humidity displayed with monitoring unit.

Figure 28.
Humidity emitted by Google servers.

Figure 29.
Perceived temperature displayed with monitoring unit.

Figure 30.
Perceived temperature emitted by Google servers.

Figure 31.
Pressure displayed with monitoring unit.

Figure 32.
Humidity displayed with monitoring unit.