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PROTOTYPE SMART VEGETABLE GARDENS SMART GARDENS PROTOTYPE INTELLIGENT GARDEN PROTOTYPE

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Abstract: By analyzing the various applications of the Internet of Things (IoT) and the benefits of having a vegetable garden at home, the idea arises to integrate both in a single project through the development of a web platform that allows the visualization and analysis of information on the development of crops, improving the management of home gardens. This proposal arises from the recent problems in society to obtain food: inadequate distribution, rising costs, low quality of products and the use of agrochemicals that contaminate food with substances harmful to health. The objective is to design and implement urban or home gardens using the Internet of Things (IoT) technology, mainly benefiting small farmers, housewives, families and seniors in the eastern region of Morelos, who can enjoy growing their own food and who, regardless of space, location, time or distance; will be able to control their garden through mobile devices or computers, which optimizes the time needed for basic care and facilitates its management. Thus, they will have access to healthy vegetables, spices and condiments, in addition to enjoying the satisfaction of producing their own food in a recreational and therapeutic activity suitable for the whole family. This will allow them to consume fresh and seasonal products, with greater nutritional value, taking advantage of any available space due to its ease of adaptation. The platform was designed with an intuitive and accessible user interface, allowing its use by people without technical experience. It is scalable, reliable and accessible to a wide range of users. It includes didactic resources and technical support to optimize the use of the platform. In addition, real-time monitoring and diagnostic functionalities were developed through the integration of the Internet of Things (IoT).

Keywords: Home gardens, Web platform, Internet of things.

INTRODUCTION

A home garden is a plot of land adjacent to the home where fresh vegetables are grown intensively and continuously throughout the year, which involves planting in a staggered manner. The food produced is generally used for family consumption, but the surplus can be marketed to produce additional income. Home gardens are also known as solar or backyard crops. Their main function is to provide food through traditional and alternative production practices that promote the conservation of natural resources. They are considered in situ germplasm conservation sites due to the diversity of species, structures and associations present.

The incorporation of ecotechnologies in home gardens provides additional resources that contribute to the sustainability of the systems. An example of this is the use of fertilizers and manure from biodigesters and dry toilets (Gutierrez, 2024). (Gutierrez, 2024).. The advantages of having home gardens are the following: they make it possible to obtain agricultural products at more accessible prices, of higher quality and free of insecticides or herbicides and without the use of sewage water (SADR, 2023). (SADR, 2023). This project integrates IoT technology with an advanced user interface to provide an efficient and practical tool for monitoring, optimizing and controlling the state and growth of crops using organic nutrients to obtain healthy, pesticide-free and high quality products.

The Internet of Things is one of the technologies belonging to the fourth industrial revolution. This technology is gaining more and more importance and impacting the daily life of human beings, due to the large number of applications it can have in different sectors (industrial, health, education, agriculture, mining, etc.). Its main objective is to obtain data for interpretation from objects connected to the network, making use of embedded systems, cloud storage, web and mobile appli-

cations, as well as a variety of protocols for communication, security, etc. IoT technology is a major game changer in people's lives as it can bring new opportunities in the area of education, security, healthcare or transportation (Silvestre & Salazar, 2019).

Family, urban or home gardens are a proposal that arises in response to the problem of access to fresher, healthier and organic food in today's society, since a garden allows users to harvest food in not very large spaces of land, as long as there is good lighting and a water source. The horticultural activity represents multiple advantages to the family, not only with respect to obtaining food, but also brings benefits to the economy, health and mental well-being.

This prototype involves the installation of several sensors and/or components in the orchard to collect real-time data on critical parameters such as temperature, soil moisture and other factors essential for the proper growth of the produce. This data is transmitted, via an Internet connection, to a central platform, where it is stored in a database. The frontend of the application acts as the user interface, allowing growers to interact with the collected data. It provides clear and understandable graphs and visualizations that allow users to monitor the conditions of their orchard over time.

In addition to data visualization, the frontend can provide suggestions and recommendations based on data analysis, such as when plants need to be watered or how to protect them from adverse weather conditions. In short, this IoT-based frontend offers a comprehensive solution for home garden management, providing real-time monitoring and personalized recommendations. It is a powerful tool that can improve the efficiency and success of small-scale farming by leveraging advanced IoT technology.

As a background we can mention a smart garden prototype developed in Yucatan, Mexico that has IoT application to urban gardens, focusing mainly on the implementation of an automatic irrigation system, in order to maintain the soil moisture required by the crop, to allow proper development of the fruit and save on water consumption. The orchard was implemented in an area of two meters long by one meter wide, where two crops of the region were planted in direct soil, pumpkin and Yucatecan sweet chili bell pepper (Palma, 2017).

Another highly detailed project is the Tekax application for the control of hydroponic crops using IoT, carried out at the Instituto Tecnológico de Acapulco, where a hydroponic prototype was used as a base and AM2302 (temperature and humidity sensor) and HC--SR04 sensors were used for automation and to measure the amount of liquid stored in the nutrient solution container of the hydroponic prototype. Automation using IoT technology proved to have good results, as crop development was good. In addition to monitoring and automating the process, it was possible to graph the behavior of the crops, a point that allows knowing the improvement needs for future crops. (Colón, 2020)..

MATERIALS AND METHODS

Before starting the development of the project, it was necessary to carry out a preliminary investigation of the technologies to be used for the solution of the problem. For this purpose, a review of the waterfall methodology, also known as Waterfall, a project management method, like the PERT diagram, based on the development in sequence of phases that flow like a waterfall, was carried out. In other words, it divides the project into different phases, with each phase starting only when the previous one has been completed. In this aspect, the team members will work in a linear fashion following a set final objective. (Zemsania, n.d.). The Waterfall methodology that includes the following stages:

• Requirements. This phase comprises the initial planning process in which the team members meet to analyze the information for the development of the project.

• Design. Based on the analysis and knowing the essential requirements of the system, we proceeded with the design of the web system, which consisted of defining the general structure of the application, that is, defining the main components, their relationship with each other and their communication, as well as selecting the technologies to be used. The technologies used for the development of the project were: programming languages, frameworks, databases and other technological tools.

• Implementation. The installation and configuration of the development environment is important. Therefore, it is necessary to previously install the appropriate software for the creation of each of the activities. In this case different softwares were installed such as: Figma, Visual studio, Code angular, JavaScript and other extensions within visual studio code as HTML and CSS language.

• Verification, in this phase most of the pages were developed to know in a general way what will be embodied in the website. The Frontend was made with Angular software, Framework developed by Google, which allows the creation of web applications. (Gudiño Quinteros, 2019).. The development and maintenance phases will be discussed in the results section.

PROCEDURE

To start the process, surveys were conducted among older adults, housewives and small farmers in the eastern region of the state of Morelos in order to identify which vegetables, aromatic plants or condiments they wanted to grow. The survey was implemented using a Google form and the results obtained were subsequently analyzed. The main objective of this project was to design an intuitive and accessible interface that allows home garden owners to access and use the functions related to the control and data analysis of their crops in a simple way.

DEVELOPMENT

To install the orchard, an area within the facilities of the Instituto Tecnológico de Cuautla was selected and arranged with the corresponding authorities. The selected area was delimited with a mesh to prevent access by harmful fauna and/or people outside the project. Care was taken to ensure that the area had electricity to power the Iot device. To control the excess of sunlight and the high temperatures of the area, a mesh was placed on the top so as not to affect the development of the crops, but to protect them from heat shocks. Subsequently, the substrate was prepared and planted in seedbeds and pots. The materials used were the following: Peat Moss: it is relatively inexpensive, has the desired physical characteristics, decomposes slowly, retains a great deal of water and oxygen (Berger, 2023) Agrolite perlite: light, inorganic, sterile, inert, neutral material, improves aeration, water and nutrient holding capacity. It can be used in the germination and development of any vegetable. (Acosta, 2024)Vermiculite, vermicompost, worm humus, normal floury soil, cucumber seed, tomato seed, radish seed, coriander seed, mint cuttings and water. The substrates were mixed in the proportion proposed by the advisors, weighed, placed in a container

and mixed to obtain the desired mixture. The containers were filled with the mixture and the planting of each crop was carried out, as shown in Illustration 1.

Illustration 1. Cucumber sowing in seedbeds.

The placement of the crops in the orchard consisted of transplanting the seedlings in pots aligned and separated, in order to have space between each one to walk and install the monitoring device in a simple way. It was planned to place the monitoring device buried in the central part of the orchard, for which a wooden structure was created to contain the sensors inside and protect them from the environment.

Once all the sensors were configured, they were placed inside the wooden casing. In order to arrange them, the electronic components were attached to the paper casing. Once the device and all the sensors were in place, it was ready to start working. Figure 2 shows the monitoring device and irrigation system already installed in the orchard.

Monitoring device and irrigation system installed in the orchard.

RESULTS

Once the network extender was configured, it was moved to an area closer to the orchard, where the device will be able to connect and start sending data to the cloud. The network name and password used to send data in the ESP32 is the same as the one created when configuring the network extender, since the device is connected to the extender, not to the modem. The network extender, Figure 3, was placed inside a box to protect it from the sun. Finally, the weather coats, Figure 3, were installed to protect the sensors from humidity, since they are the ones that present the greatest risk of damage.

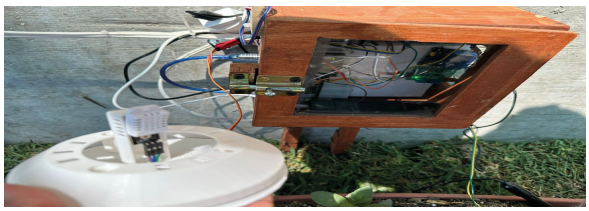

Illustration 3. Weather shelter for the temperature and humidity sensor

Once the prototype is implemented and connected to a wifi network, it can be seen how it begins to reflect data, first in the database, where they begin to update correctly with each change, regardless of whether the data are observed from different devices as they continue to be updated, which proves that there is a correct connection to the database and the sensors are working. Figure 4 shows the home page, which can be accessed by entering the e-mail address and password or by registering if you are not yet registered.

Illustration 4. Login screen.

The registration of users and administrators to access the mobile application is shown in Figure 5.

Figure 5. Registration to the mobile application.

Visual cards representing the different sections or functionalities of the app, such as profile, new crop, sensors, stage registration, tutorials and logout, to facilitate access to different areas of the application are presented in Figure 6.

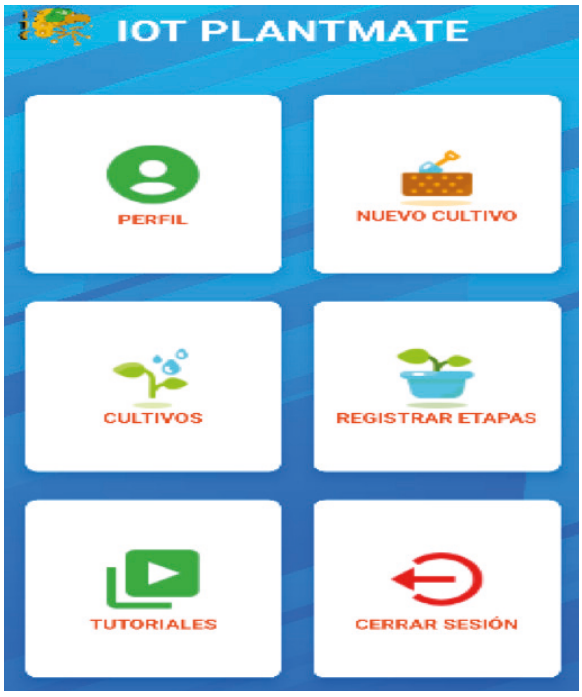

Illustration 6. Sections of the application.

The figure 7, shows the registration of a new crop in the database.

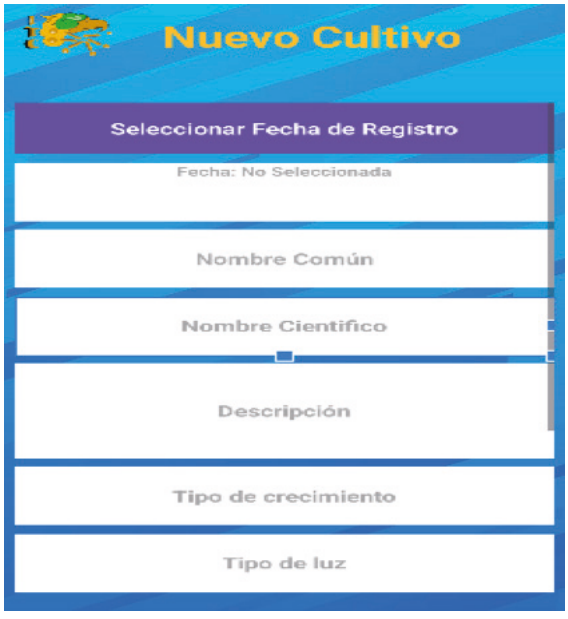

Illustration 7. New crop.

Once the crop data has been stored, a screen like the one shown in Figure 8 appears.

Figure 8. Crop data.

With the development of the mobile and Web application, the aim is to provide an accompaniment to the work of starting a crop with the intention of offering advice on soil preparation, the most appropriate times to plant, keep track and finally harvest. This prototype includes a meteorological shelter for the sensors that collect climate data, since this shelter fulfills the function of protecting these sensors from the weather and extreme weather when exposed directly to the sun's UV rays such as rain, precipitation and condensation in order to provide adequate ventilation and at the same time protecting the integrity of the same from any other risk factor for the sensors, since they fulfill an important function which is to send the signal to the web platform for monitoring.

DISCUSSION

Applying technology to home gardens is a way of combining traditional gardening with modern technology and new applications are being found all the time. As mentioned above, one of the first uses of technology in home gardening was the automation of irrigation systems by adjusting it to the needs of the plants through sensors that can also measure temperature, humidity and light intensity in order to decide the best place to place the gardens and/or adjust the conditions, it is also possible to measure the levels of nutrients in the soil to adjust fertilization according to the specific needs of the crop. Other systems monitor, by means of cameras, the state of the plants to detect any problems such as pests or diseases. (Aldana Pulido, 2022).

Orchard automation not only reduces manual activity, but also allows a more efficient management of each crop, maximizing yields in limited spaces. It contributes to sustainability and resource conservation since, by using sensors and other devices, it is possible to adjust the supply of water and nutrients according to the real needs of the plants, avoiding waste and reducing water consumption, as well as reducing the use of pesticides and chemical products, thus achieving the production of healthy and environmentally friendly food. (Green Horizons, 2024).

CONCLUSIONS

This project was designed as an alternative to support housewives, senior citizens and any other person interested in crops, since at the same time that a leisure activity is performed, the family economy is supported by not having the need to spend on vegetables, since it will only be necessary to approach the garden and harvest fresh, quality and pesticide-free products.

The platform serves as a tool to reduce the most common mistakes that occur when having an urban garden, such as: using the wrong substrate, planting at any time of the year, planting wrongly without considering the size of the seeds, fertilizing and/or watering excessively, inadequate sunlight, pruning times and treatments for pests and diseases. (La huertina de Toni, 2020) The user is provided with all the information in a simple and intuitive way in order to guarantee a healthy and nutritious harvest.

This alternative allows them to produce their own food at home or on small plots of land without depending on a third party, with the assurance that the products are free of chemicals that can eventually cause damage to health. It also makes it possible to contribute to the generation of additional economic resources through the commercialization of surplus production and to use what is grown for regular consumption by having the products when they are needed. On the other hand, it is an activity that can be carried out jointly by all the members of the family nucleus since it reduces stress.

The most common production in this type of scheme are legumes, aromatic plants and condiments for family consumption. This proposal in relation to traditional methods of cultivation, aims to report on a sustainable alternative in the production of fresh food supported with IoT technologies, to facilitate the process and ensure that the products obtained are of higher quality, which have the necessary nutrients to promote healthy eating habits and the satisfaction of consuming own products, saving resources and valuing nature, through the care and good management of small backyard plantations. Some of the advantages of urban vegetable gardens are as follows:

- Access to quality food, guaranteeing food security for families.
- Efficient use of space, using it for food production and improving the urban landscape.
- It links the family to nature and the food production process.
- Reduces product transportation and logistics costs.
- Improves the economic conditions of producer/consumer families.
- Saving energy and benefiting the environment.

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