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Application for the detection of physiopathologies in blueberry crop

Aplicación para la detección de fisiopatías en los cultivos de arándanos

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Abstract

Mexico is the 6th. worldwide producer of blueberry with 48,999 tons; where Guanajuato contributes 11% of the national total, ranking 7th. producer of the country (Secretariat of Agrifood and Rural Development, 2020). One of the main physiopathies that occurs in blueberry plants is root suffocation, which limits the ability of plants to breathe through the roots (Generalitat Valencia, 2022). Identifying the severity of the damage caused by physiopathies is essential for timely treatment and the prevention of its transmission; however, it is complex due to the lack of classification criteria. In this context, an application was developed whose purpose is to detect the level of affectation by physiopathies in blueberry leaves, calculating the percentage of damage severity, using artificial intelligence (AI). The results allow us to conclude that AI provides an easy and incremental progression as it is applied to different varieties of physiopathies, through the analysis of photographs. The application is useful for blueberry farmers and greenhouse owners, providing convenient information for the prevention and spread of crop diseases and improving decision-making.

Artificial intelligence, Physiopathy, Agriculture

Resumen

México es el 6º. productor mundial de arándano con 48,999 toneladas; donde Guanajuato aporta el 11% del total nacional, ocupando el 7º. lugar como productor del país (Secretaría de Desarrollo Agroalimentario y Rural, 2020). Una de las principales fisiopatías que se presenta en las plantas de arándano es la asfixia radicular, que limita la capacidad de respiración de las plantas a través de las raíces (Generalitat Valencia, 2022). Identificar la severidad de los daños causados por las fisiopatías es fundamental para su tratamiento oportuno y la prevención de su transmisión; sin embargo, resulta complejo debido a la falta de criterios de clasificación. En este contexto, se desarrolló una aplicación cuyo propósito es detectar el nivel de afectación por fisiopatías en hojas de arándano, calculando el porcentaje de severidad del daño, utilizando inteligencia artificial (IA). Los resultados permiten concluir que la IA proporciona una progresión fácil e incremental al ser aplicada a diferentes variedades de fisiopatías, mediante el análisis de fotografías. La aplicación es útil para los agricultores de arándanos y los propietarios de invernaderos, ya que proporciona información conveniente para la prevención y propagación de las enfermedades de los cultivos y mejora la toma de decisiones.

Inteligencia artificial, fisiopatía, agricultura

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Introduction

The timely identification of the level of damage or affectation of a blueberry crop is vital to initiate the necessary actions to reduce the risk of spreading to the entire crop.

According to the Sustainable Development Goals (SDGs) adopted by the United Nations in 2015, goal 2 "Zero Hunger", proposes target 2.4, which states that between now and 2030, it is important to integrate resilient agricultural practices that increase productivity, production and contribute to the maintenance of ecosystems (Government of Mexico, 2017).

P-Search is an application that detects the level of disease affectation in blueberry leaves, using AI to speed up the process and provide reliable data to support decision making, reducing the risk of transmission to the entire crop.

Problem statement

When calculating the percentage of severity manually, there is a high probability of generating differences at the time of classifying the leaves of the blueberry crop according to the level of infection they present, because there is no standard of typing, but a visual evaluation is performed, which leads to variations among the different members of the work team, regarding the results obtained by each one.

The problem is addressed with the following question: How to facilitate the calculation of the severity level by physiopathologies, using artificial intelligence ?

Objective

To provide a fast and accurate diagnosis in the detection of pathologies in blueberry crop, through the design and implementation of an AI-based application.

Specific objectives

- Contribute to the timely diagnosis of localized physiopathologies in blueberry crops.
- Develop a web application that uses a machine learning algorithm for image classification.
- Conduct functional testing of the application to ensure its feasibility.

Justification

P-Search is an application that contributes to the improvement of the grading process of blueberry crop leaves by considering the degree of infection by physiopathies, calculating the percentage of severity and providing a standard measure for leaf grading.

This tool uses AI to recognize each sheet quickly and accurately, obtaining an accurate and unanimous result.

Scope

The project is aimed at small farmers or owners of greenhouses where blueberry trees are mainly grown and who do not have a vast knowledge on the detection and calculation of the level of severity level of pathophysiological diseases in this species.

Frame of reference

Theoretical basis

Artificial Intelligence (AI)

AI is intelligence carried out by machines and is developed through different disciplines, including: computer vision, natural language processing, neural networks, and machine learning (Mohd Shafri et al, 2019).

Machine Learning

Machine learning is a discipline of AI, applied in various fields. Its objective is to discover various patterns in data and develop solution methods or techniques that allow machines to learn, i.e., as they are exposed to new data, they generate new learning (IBM Cloud Education, 2020).

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Model KNN

The KNN (K-Nearest Neighbour) algorithm is a non-parametric supervised learning model that uses proximity to make classifications or predictions about the clustering of an individual data point.

The steps to run the KNN algorithm are: choosing the number of k and a distance measure, finding the k-nearest neighbors of the sample to be classified, and assigning the class label by majority vote (Mirjalili et al, 2019).

Physiopathies

Physiopathology is understood as any anomaly in the normal development of the tree, by which the whole tree or any of its parts is threatened in its existence or in its normal functioning (Generalitat Valencia, 2022).

State of the art

For the development of the project, applications, platforms and tools available that use artificial intelligence in the area of agriculture and other fields were reviewed, among which the following stand out:

According to Cañas (2020), the implementation of AI software has allowed the automation of palm recognition, as well as the accurate counting and obtaining of its real state. This has made it possible to reduce the costs and time required to identify these anomalies in palm cultivation in Colombia.

According to the research of Mohd Shafri et al. (2019) the use of supervised learning intelligences, as well as the use of sensors, has allowed a better control over palm crops, allowing to have a database that will serve as a reference to identify the growth and possible affectations within them.

Casas et al. (2019) state that the use of artificial intelligence has been of great help when recognizing, classifying and displaying information about food, which has allowed obtaining useful information to maintain a balance between the meals consumed by diabetic people.

According to Machacado et al. (2022) the use of artificial intelligence has been of great help in the medical field, as it has shown great efficiency in revealing diseases or foreign bodies in a shorter period of time.

According to Cáceres et al. (2015), the use of computer vision allows pest diagnosis, as well as the identification of the damage caused by the pest in the sugar flower crop.

In turn, Francisco Gutiérrez et al. (2022) demonstrate that through a mobile application that takes photographs and selects images using a trained neural network, it is possible to recognize and classify Mexican banknotes in circulation to achieve detection and classification that is effective in at least 90% of the cases.

Tereza Yallico (2019), developed the "DruBot", which is a robotic prototype that performs authentication by comparison of facial proportions, through image recognition to keep track of attendance and detect impersonation in evaluations.

Fernanda Herrera (2021) in her project "Ai Krops", shows that with the use of AI it is possible to obtain a preventive diagnosis of crop diseases to avoid vulnerability and increase production.

Morán Espinosa (2021) states that the use of artificial intelligence for image recognition through the use of algorithms that allow pattern recognition should be used by public and private organizations for decision making.

Therefore, technological tools such as *machine learning* are considered to provide a more progressive and premature response that gives possibilities to the area of agriculture, as it allows reducing crop loss and costs for crop recovery (NDLC, 2022).

Methodology to be developed

The study is carried out using the quantitative method because it allows to support the hypothesis raised about the problem, as well as to collect and compare different data to obtain concise information in the research and to have a defined parameter.

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The project started on June 7, 2022. To date, the application is hosted in the cloud and has more than 600 registered images.

The following tools were used to carry out the project:

- Computer equipment. A computer with a 2.10 GHz processor, 8 GB of RAM and Windows 10 operating system was used for programming the P-Search web application, and an Internet connection was required for the operation of the supervised intelligence and for hosting the web application.
- Camera. Access to the computer camera is required to operate the intelligence operation and perform training.
- Visual Studio Code. This code editor was used for web programming with HTML and CSS languages, in addition to PHP and JavaScript for the programming and operation of the intelligence.
- Internet browser. It is recommended to use *Microsoft Edge* or *Chrome* browser, for a better user experience.
- Codeigniter. This framework is used to have a more optimal code organization.
- Hosting service. The web hosting used to upload the application to the cloud was 000webhost.com.

The development of the web application "P-Search" was carried out in the ICarnegie room of the Information Technology area and the pilot tests were conducted in Greenhouse 1 of the Sustainable and Protected Agriculture area of the Technological University of the Southwest of Guanajuato (UTSOE), located in Valle de Santiago, Guanajuato.

Figure 1 Carnegie Room of the UTSOE
Source: Own elaboration

Figure 2 UTSOE Greenhouse 1
Source: Own elaboration

The methodology used in the development of the project is an iterative model in which five phases were defined, as described below:

1. Detection of needs. An analysis of the process of preventing pests or damage to blueberry crops was carried out with professors from the Sustainable and Protected Agriculture career, identifying that the time lapses in obtaining the level of severity vary between 10 and 15 minutes for every 20 leaves analyzed and approximately 10 seconds to classify each leaf in a level of affectation (Figure 3).

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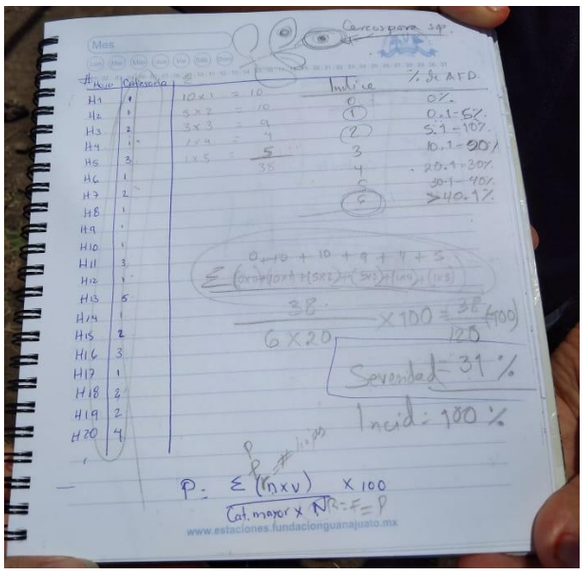

Figure 3 Severity level calculation
Source: Own elaboration

This process is performed manually, using a visual damage assessment scale, to determine the percentage of severity.

2. Documentary research. An exploratory type of research is used, where the comparative advantages and disadvantages of each project are obtained from the state of the art and the requirements to be met by the application are complemented.

3. Project definition. A solution proposal is defined, in which the idea of developing an application that facilitates the calculation of severity is proposed, defining the proposal with objectives, scope and expected results.

4. Project planning. A chronogram is elaborated, specifying the times and people in charge; where two weekly meetings are established to verify progress. The learning algorithm is also selected: KNN model, as well as the most appropriate development tools.

5. Development and implementation. The data repository is structured, interfaces are designed, coded and functionality tests are performed in a controlled environment.

The application has been built using an evolutionary development model (Figure 4), which consists of developing an initial prototype and refining it through different versions that are presented to a sample of end users. This model allows the application of a technique or exploratory development that involves working with the client, starting the development of the proposal with the requirements that are most understood, and then adding new proposed attributes until the final version is reached (Sommerville, 2005).

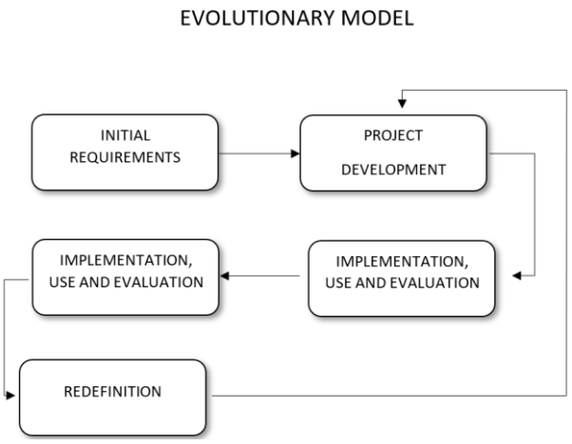

Figure 4 Evolutionary model
Source: Sommerville, 2005

In order to verify the assertiveness of the intelligence, experimental type research was considered; when testing the test images, the percentage of certainty that the KNN model has about coincidences found in its record was incorporated.

Results

The main interfaces of the application are:

- Main interface. It presents a description of the application and key concepts.

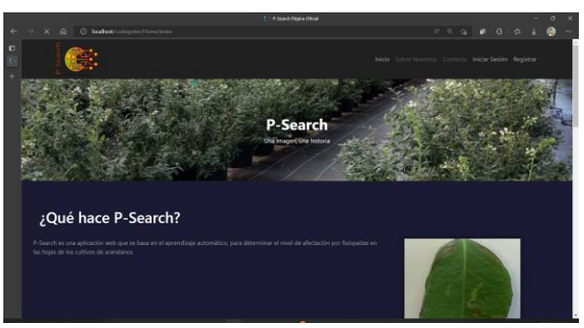

Figure 5 Main interface
Source: P-Search

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- Startup interface. Two access profiles are managed: administrator and standard user.

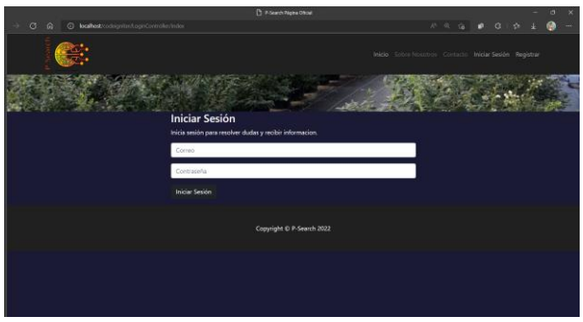

Figure 6 Startup interface.
Source: P-Search.

- Registration module. The user must register in the application.

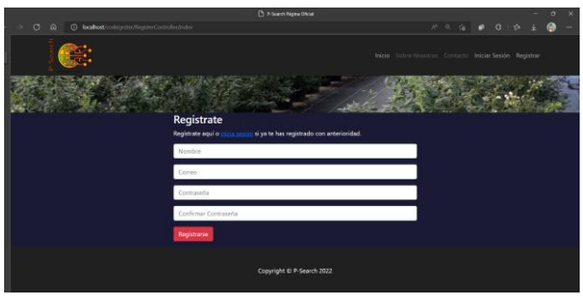

Figure 7 Registration module.
Source: P-Search.

- Analysis module. Access to the device's camera is automatic and the KNN algorithm starts the image recognition process, looking for color and shape matches. It then displays the percentage of severity level and classifies it.

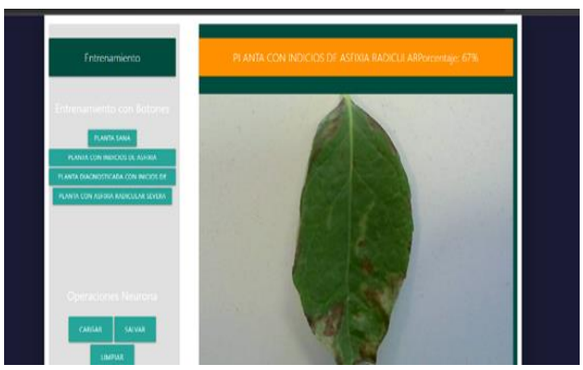

Figure 8 Analysis module.
Source: P-Search.

- Classification section. More than 600 photographs of blueberry leaves have been used, classifying them into different levels: healthy leaf, leaf with signs of root suffocation, leaf diagnosed with beginnings of root suffocation and leaf with severe root suffocation.

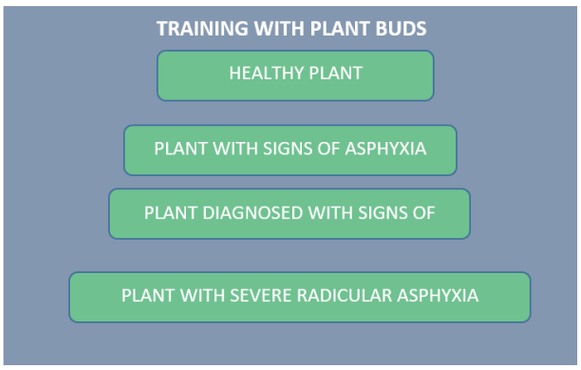

Figure 9 Classification section.
Source: P-Search.

To carry out the P-Search tests, 5 groups of 20 leaves of blueberry crops were used, supervised by professors from the Sustainable and Protected Agriculture and Information Technology careers, obtaining the following results:

The average time for the algorithm to classify each leaf into an affectation level is 5 seconds, investing a total of 100 seconds for all samples.

Therefore, the time reduction is significant, approximately 8 minutes, compared to the manual process, which takes between 10 and 15 minutes.

Analysis of results and discussions

From the results obtained, the operation of the current prototype is validated and it is corroborated that the application is useful for the timely detection of physiopathologies, as well as the prevention of their propagation to the rest of the crop.

Future lines of research

In the second phase of development, we intend to implement the automatic calculation to obtain the severity level of the crop, using the key values of the sampling.

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P-Search will contribute to resilient agricultural practices, in line with SDG target 2.4.

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Conclusions

Artificial intelligence allows a progressive and simple advancement as it is implemented in different variations of pathophysiological conditions.

The application benefits owners of a greenhouse or blueberry crop by providing useful information for the prevention of diseases or growth deficits in their crops.

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