Desarrollo de un aplicativo móvil que contribuya a la detección de enfermedades en el fruto del cacao CCN-51 a través de la experimentación de redes neuronales convolucionales, en la finca Basante - Jiménez, ubicada en la ciudad de ventanas, provincia de los Ríos, Ecuador

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Application of convolutional neural networks for the detection of diseases in the CCN-51 cocoa fruit by means of a mobile application.

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ABSTRACT

CCN-51 cocoa, one of the two main varieties exported worldwide by Ecuador, due to the lack of technology and poor agronomic practices, is constantly attacked by a number of pests that affect its production, affecting the growth stages of the plant. Another factor that causes damage to the plant is the constant changes in climate, mostly due to excessive rainfall that causes an increase in humidity, damaging the flowering and fruit set, producing Moniliasis as one of its main diseases and being the crops far from the urban area, the analysis is time consuming and very costly, taking as an alternative for most producers the excessive use of chemicals to cure and maintain the pests and diseases of the plant. Where, this research project is proposed, consisting of developing a mobile application that by scanning images in a controlled environment allows the detection of diseases in the CCN-51 cocoa fruit. The mobile application will use its camera to scan the fruit and, using a trained image recognition model, predict a diagnosis of the disease present in the cocoa fruit.

Keywords: Agri-technology, Agronomy, Artificial Intelligence, Cloud, Mobile Application, Neural Network, Software

1. INTRODUCTION

Despite the enormous effort made by the world to reduce plant loss and food security, several references [1], [2], confirm that more than 20% of crop losses in the global scenario are due to plant diseases. This problem has worsened in the last decade due to the impact of pollution and climate change. With the recent development of various agricultural technologies, farmers opt for plant disease databases or consult local pathologists via telephones, instead of the classical procedure of sending plants to the diagnostic laboratory to propose the appropriate treatment. In addition, there are many attempts to use ICT tools to improve the efficiency of agricultural development, taking advantage of the widespread use of mobile phones.

Regarding plant disease detection, there are many articles introducing this application using one of the standard CNN design architectures [3], such as SqueezeNet [4], ResNeXt (Aggregated Residual Transformations for Deep Neural Networks) [5], ResNet (Deep Residual Learning for Image Recognition) [6], NiN (Network In Network) [7], GoogLeNet [8], VGGNet [9], ZFNet [10], AlexNet [11], and so on. Numerous techniques and applications have been developed to reduce crop loss due to diseases.

Cocoa is one of the most important agricultural products in world markets [12]. For this reason, the focus of this project is to detect potential threats to cocoa by taking a photograph that will be processed and issued with an analysis of the fruit, based on the similarity in detecting quality in other fruits. This approach has been practical since the advent of Deep Learning, which is powerful in image classification [13][16]. It is also the preferred method for other computer vision tasks, unlike the traditional method which is based on feature extraction algorithm such as SIFT [17], SURF [18], PCA and LDA. This fact was first demonstrated by Girshick et al. [19] for object detection, which became popular for other computer vision tasks.

2. BACKGROUND

2.1 Importance of Cocoa in Ecuador

Latin America is known as the birthplace of cocoa and recent archaeological research suggests that the place of origin of cocoa is Ecuador. Ceramic remains of cocoa were found in the Amazon rainforest dating back to 3300 BC, which means that cocoa beans have been cultivated in Ecuador for more than 5,000 years [20].

In 1790, with the abolition of the law prohibiting the export of cocoa, Guayaquil became the world's leading cocoa port, maintaining a monopoly that lasted almost 150 years [20]. Today, Ecuador is the leading cocoa producer in Latin America and the fifth largest in the world, according to reports from the FAO Food and Agriculture Organization of the United Nations, although the lack of technology and low resistance to pests and diseases is a limiting factor [21].

Cocoa CCN-51. A cocoa variety originating in Ecuador, obtained in the 1960s by producer Homero Castro Zurita, in the canton of Naranjal, Guayas province. Among the benefits of planting this cocoa variety are its adaptability to the country's different climatic zones, high productivity with good crop management and resistance to diseases and pests [22]. CCN-51 cocoa has organoleptic characteris-tics demanded by the international market, being one of the second most produc-tive and internationally recognized varieties [22].

2.2 Cocoa Pests

Cocoa fly. Caused by the Monalonion dissimulatum bug, exclusive of cocoa, the insects feed on the shoots when young, and when they reach adulthood, they feed on the pods, causing pustules or circular wounds in the apical half of the fruit [23].

Bull's horn. Caused by the sucking insect Hoplophorion pertusa, which in its adult stage feeds on the sap of the shoots and young branches, sucking the juices from the plant with its stylet. Excessive shade in the cocoa plantation predisposes to a greater attack by the pest [23].

2.3 Cocoa Diseases

Moniliasis. Caused by the fungus Moniliophthera roreri, it affects the fruits, having variable symptoms according to the age of the fruit, as the infection progresses, a spot with white cottony tissue appears, this tissue turns grey due to the appearance of spores or seeds, ending with the mummification and deformation of the fruit [23].

Witches' broom. Disease caused by the fungus Crinipellis pernicosa, it causes an abnormal sprouting at the level of both terminal and auxiliary buds, presenting a concentration of branches from a single point known as broom, in the affected floral cushions the flowers remain attached to this for a longer time than normal, developing unfertilised ovules, if the fruits are attacked it produces malformations similar to those caused by moniliasis [23].

2.4 Technology in agriculture

Technology goes hand in hand with farming, as farmers have always sought to make the hard work of farming easier. From the moldboard plough to tractors connected via satellite to your mobile phone, technology in agriculture means advances and improvements in the efficiency of your farm, defining technology in agriculture as an advance in the model of working and improving the efficiency and exploitation of the farm, technology should help to optimize profitability and therefore the farmer's economy [24], an example of which is the digitalization of production processes, increasing yields and saving costs; on the other hand, we have the automation of fruit and seed selection processes, applying monitoring and photogrammetry techniques in the process.

3. SYSTEM ARCHITECTURE

The selected architecture is based on the C4 Model where the specific model for the development of the API has been considered in its first iteration, this component will implement an onion architecture that will allow it to be tolerant to change. The respective components for the web and mobile clients are external to the implementation and depend heavily on the API, so the design of its architecture will be clearer in the next iteration, as shown in Figure 1.

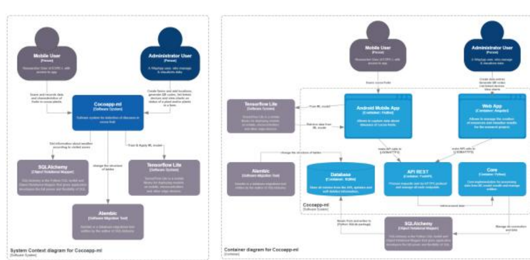

Figure 1. First iteration of the cocoa fruit disease detection system represented by the C4 Model and Structure of the application.

4. SYSTEM DEVELOPMENT

Based on the C4 model, we sought to represent the structure and different modules that the application will have, dividing the system into two main modules, the Mobile User and the administration module. In the case of the first module (Mobile User), it will be an Android application, using the Dark programming language in Flutter, which will communicate with an API in charge of sending the information emitted by it for comparison with a dataset trained by means of TensorFlow Lite.

The second module (Administrator User) will be a web application that will also communicate with the database through the REST API, facilitating this connection thanks to SQLAlchemy and SQLite using Alembic for the Data versioning.

The development of the application is divided into 4 modules (see Fig. 2):

Development of the web application. Corresponding to the administration application, starting with the layout phase and subsequent development in the Angular frame-work for the front-end and Python in conjunction with Fast-Api for the consumption of the API-Rest, using Alembic and making the connection to SQLite.

Development of the mobile application. Developed in Flutter, incorporating the use of QR codes to link the benefactor farm with the data collection, in addition to the creation of the CNN for image analysis.

Dataset generation and training. This consists of the preparation of the data, which includes the selection and processing of the images for the use of the model.

Testing. This stage includes the training of the neural network with the previously prepared data, the evaluation of the accuracy of the model and the adjustment of the hyperparameters to improve its accuracy, which will later be exported for the use of the app.

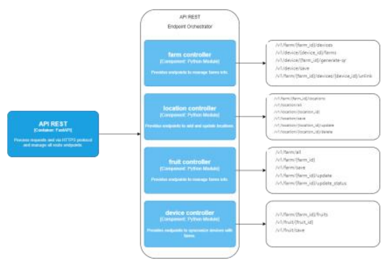

Figure 2. Stages of development of the CACAO disease detection application.

4.1 Deploy

The application consists of a main API, in charge of receiving and providing the necessary information to manage the cocoa fruit visualization and analysis cycle, the image below shows a diagram of the available endpoints. The deployment of the project is intended to be deployed in the Azure cloud, using the "Docker Container Registry" and "Web App for containers" services through which the project can be made available on the web (Fig. 3).

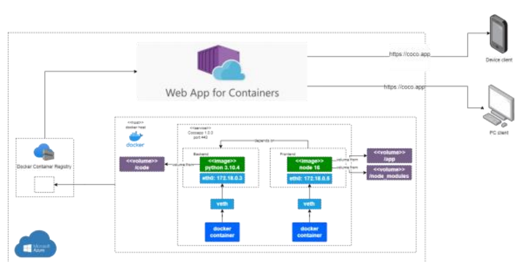

Figure 3. Available endpoints and deployment of the application.

5. RESULT AND DISCUSSION

This section presents the results obtained in the development and deployment of the CCN-51 cocoa fruit disease detection application, divided into two stages: i) interaction with the system, which explains how the application works, and ii) validation of the application, which analyses the results obtained once the planned tests were carried out when deploying the app.

5.1 Interaction with the system

The application consists of two modules, each one in charge of a specific function, such as:

Web Module. Web module being the administrator module which is responsible for registering the various farms that access the system, as well as allowing to see the connected devices, the established locations and a detail of the analyzed fruits.

Mobile application. It presents the user with a flow that allows the user to quickly adapt to the system, with 1) an introductory tutorial, 2) a guide to the various diseases of cocoa, 3) the camera section that allows the user to take a photo of the fruit. This photo will be loaded into the database for further analysis and finally 4) the results display screen, which will show the photo of the fruit and the percent-age of infection it has (see Fig. 4).

Figure 4. Execution flow of the mobile application and execution process

This photo will be loaded into the database for further analysis and finally 4) the results display screen, which will show the photo of the fruit and the percent-age of infection it has.

5.2 Validation

The application has a success rate of 80 to 99.5%. These results were obtained after subjecting the application to different environments and climate changes that could affect the quality of the photographs.

In addition, a comparison was made between the traditional methods in the area and the application, obtaining the following results (see Table 1).

Table 1. Analysis of results.

Comparison of traditional methods && System		
	% Failure	% Hit
Traditional method	30 % - 50%	50%
Laboratory analysis	0.1% - 1%	99%
Application	0.4% - 20%	80 – 99%

As can be seen, the application has a high percentage almost comparable to the analysis carried out in a laboratory, with the difference of being a quick and more accessible means of prevention, as well as requiring less time for the detection of a pest or disease in cocoa fruits.

6. CONCLUSION AND FUTURE WORK

The creation of tools and means of technology that allow a faster reach in the prevention of diseases in the production fields, is an alternative that will allow the growth and improvement of the product, in addition to a quick prevention eliminates part of the chemicals used for the cure of these pests, this improves both the quality of the product and the shelf life of the plant, maintaining the taste of the same.

Finally, the long-term objective of this project is to extend this application to the whole area of the city of “Ventanas”, located in the province of “Los Rios”, Ecuador.

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