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A case-study vision

Mobile application for the detection of black Sigatoka

Aplicativo móvil para la detección de Sigatoka negra

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Abstract: Black Sigatoka is one of the main problems that affect the quality and production of the banana crop, it´s because of this, the development of systems to detect diseases, generate an important tool for the monitoring and control carried out by the farmer. The proposed system leverages hardware on mobile devices to implement computer vision techniques to determine the percentage of affected area of the plant.

The smartphone is used to acquire data and capture the disease through images. The detection of diseased pixels is then performed through a segmentation algorithm with histogram analysis.

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A model for the calculation of the affected area is then computed. Finally, the information is presented through the user interface.

To validate the proposed method, a database is created with images taken by the application to compare it´s efficiency through the RMS error between manual segmentation and the result of the algorithm. Finally, usability and response time tests are performed.

Keywords: Black Sigatoka, mobile application, mobile device.

Resumen: La Sigatoka Negra es uno de los principales problemas que afectan la producción del cultivo de plátano, es por esto, que el desarrollo de sistemas que permitan la detección de enfermedades, generan una herramienta importante para el monitoreo y control realizado por el agricultor. El sistema propuesto, aprovecha el hardware en dispositivos móviles para implementar técnicas de visión por computador que permitan determinar el porcentaje de área afectada de la planta.

El Smartphone es utilizado para adquirir datos y capturar la enfermedad a través de imágenes. Después se realiza la detección de los píxeles enfermos a través de un algoritmo de segmentación con análisis por histograma. Posteriormente se computa un modelo para el cálculo del área afectada. Por último, se presenta la información a través de la interfaz de usuario.

Para validar el método propuesto, se crea una base de datos con imágenes tomadas por medio del aplicativo para comparar su eficiencia a través del error RMS entre la segmentación manual y el resultado del algoritmo. Finalmente se realizan pruebas de usabilidad y tiempo de respuesta.

Palabras clave: Sigatoka Negra, aplicativo móvil, dispositivo móvil.

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1. Introduction

The tropical climate and fertility of the Colombian soil have allowed the necessary conditions so that in the country, banana crops are produced in various regions throughout the annual season. In the last year (2018), banana production reached 4,316,726 tons, generating more than 1,500,000 jobs, making it one of the most representative crops in the country [1].

Despite this, Colombia became the second country that imports the highest amount of bananas in Latin America, a situation that is worrying considering that there is enough quantity and quality of soils to meet national demand. Another worrying fact, reveals that only 26% of the national production in the last year, was generated by small farmers, since the banana sector is dominated by large multinationals [1].

This is because small farmers do not develop technical processes nor have specialized equipment for capturing and processing information in their crops. There are also no technological developments on the market that allow work such as disease detection and whose implementation is low cost. Therefore, an efficient control of variables that affect crops is not performed, which increases the likelihood of fungus as Black Sigatoka which generates spots on banana leaves altering the photosynthetic process and causing losses of up to 100% of production if proper management is not performed [2].

In this sense, the inclusion of technology through areas of science such as computer vision or digital image processing allows the development of systems that detect diseases with defined visual characteristics, generating all the potential to reduce the quality gap between multinationals. and small producers [3-4].

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In search of solutions that improve processes in agriculture, methods have been developed to detect different diseases that produce visual changes in the leaves or fruit. It is common to find methodologies whose purpose is to segment the disease, one of the most used color spaces in this process is HSV [5] in which, operations are performed with Gaussian filters, morphological filters and then binarize the image using thresholds [6]. However, these developments are limited to the use of synthetic databases with a reduced number of samples. Other approaches make use of supervised learning methods. For this, they extract descriptors such as the Wavelet transform, HOG, Sift and histograms [7] in representation systems such as I3aI3vH, HSV, TSL, LAB [8]. This allows to extract distinctive information of the disease under study, finally healthy and diseased images are classified using vector support machines, neural networks and decision trees [9-10].

However, the proposed developments contemplate theoretical solutions and in none of the cases the cultural and economic limitations of small farmers have been considered. It is necessary that technological developments be made using tools that farmers have available on a day-to-day basis which would allow a greater cultural acceptance.

Current studies reveal that 9 out of 10 Colombians connect to the Internet at least once a week through their smartphones [11]. This is due to government policies that seek the proliferation of new technologies, therefore, it is easy to find farmer families who have at least one smartphone in their home, which has allowed farmers to use social networks, email, among others traditional uses. In addition to the daily use of the smartphone, this presents interesting features for the capture of information, since they currently have transducers that capture data of physical variables, allowing access to different sensors such as accelerometers, gyroscopes and digital

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cameras to the majority of ordinary people, including farmers. Which creates an opportunity to use these devices to support agricultural processes, such as disease detection.

Given the potential generated by the use of the smartphone, mobile applications have been developed that solve traditional problems such as classifying sign language, diseases in the tongue and ear, monitoring reference patterns in augmented reality applications [12-14].

However, there are few app developments that serve as a tool to improve processes in agriculture. In [15] a mobile application was developed to classify 20 types of plants from images of their leaves using SIFT and Bag of Bow features. However, the system is limited to determining the type of plant and it is not possible to detect diseases in the sampled leaves.

In other mobile applications, image distortion is eliminated, a threshold that segments healthy and diseased pixels is computed to later compose clusters that generate distinctive information [16]. In [17] a mobile application was developed that allows filtering, feature extraction and classification operations using a Bayesian model to detect borer beetle in coffee crops from a digital image.

Since Black Sigatoka is determined by visual inspection, systems have been developed whose purpose is to detect the disease through digital images. In [8], it is proposed to apply smoothing and segmentation filters using a threshold to detect if a plant has Black Sigatoka. In [18] it is proposed to use a pre-trained convolutional neural network called MobileNetV1 to classify banana leaves determining whether the leaf is healthy or sick. However, the proposed applications for Sigatoka detection are limited to generating healthy and diseased labels, ignoring the fact that the disease has different levels of severity and that in each of them it is necessary to perform a different corrective action.

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On the other hand, in [19] an analysis is presented by means of histograms in RGB color spaces, segmenting the pixels where the disease is located and then calculating the percentage of area affected by Black Sigatoka disease. However, the proposed database does not have an adequate capture protocol, in addition, a theoretical solution is generated, ignoring the possibility of a field implementation.

As a result, there is a need to create a mobile application for the detection of Black Sigatoka, which allows the farmer to know the percentage of affected area of the leaf, providing adequate information for the control of this disease. A system with these characteristics would provide the farmer with a technological tool that could increase the efficiency and quality of agricultural processes.

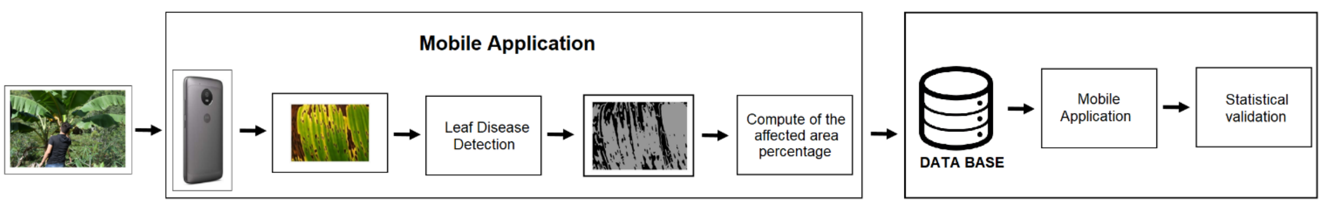
This document presents the design and implementation of a mobile application that computes the percentage of affected area of a banana leaf with Black Sigatoka disease using digital images. The main contribution of this article is a method for the Black Sigatoka detection that can be implemented in a mobile application, from which the percentage of affected leaf area is determined, which does not happen in other works, that are limited to detect presence or absence of the disease. The method involves a first phase of design of the detection algorithm, which consists of the construction of a database with images of banana leaves with Black Sigatoka disease and the implementation of an image processing algorithm that segments the pixels that possess the disease, to later compute the percentage of affected area of the leaf.

In the second phase, an application for smartphones is implemented, based on the algorithm previously designed, which contains tools such as camera opening and cell phone gallery, so that the capture process or the image selection can be performed to which the Black Sigatoka detection study will be performed. Finally, the validation of both the operation of the application and the detection algorithm was performed, so it was necessary to do a manual study in which the area affected by the disease is indicated, to compare it with the results obtained by the application.

2. Materials and Methods.

This section presents the proposed work structure, as shown in Figure 1, a mobile application for the detection of Black Sigatoka disease in banana crops is developed, the app has a visualization component that allows the farmer to know the percentage of affected area. This is achieved by computing a digital image processing algorithm that segments the disease, then the percentage of affected area is calculated and presented in the user interface.

Figure 1. Block diagram of the proposed methodology.



Source: own.

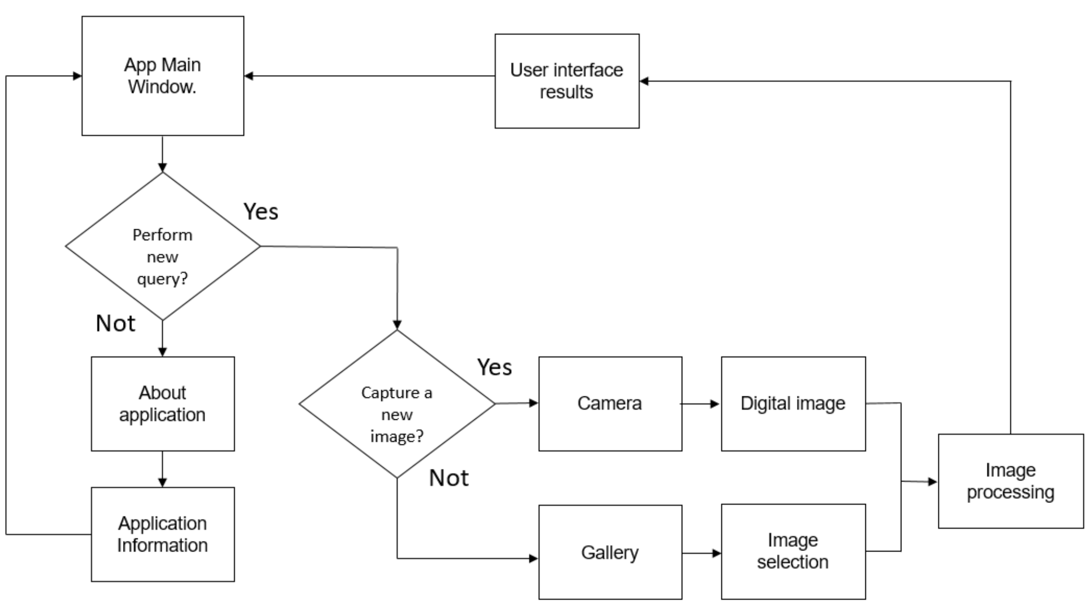
2.1. Mobile application.

The mobile application was implemented in the Android Studio environment, this allows the integration of the Kotlin language with the methods of image processing through the OpenCV library, in addition the developed app is compatible with all devices that have Android operating system. The mobile application consists of 2 sub-stages, initially the design of the user interface that is displayed on the smartphone when the application is executed is presented, from which the study of the disease is carried out. Then, an algorithm was implemented for the automatic disease detection and the calculation of the percentage of affected area.

2.1.1. Graphic interface of the mobile application.

The graphic interface of the mobile application was designed in order to allow an easy and intuitive use for farmers, as shown in Figures 2 and 3, the main application window has three buttons. Should the farmer require information about the app, it has a button called "About", which displays information about the application and instructions for use. Once the evaluation of a plant is desired, two options are presented, the “Camera” button that allows new samples to be captured through the camera of the mobile device and the “Gallery” button through which images previously taken are selected from the gallery. After selecting an image in the application, the pixel disease detection is performed as presented below.

Figure 2. Block diagram of the mobile application functionality.



Source: own.

Figure 3. Main window of the mobile application.

Source: own.

2.2. Automatic disease detection.

Because current mobile devices still have limitations in data processing capacity, at this stage we seek to develop a methodology with a low computational cost allowing the detection of Black Sigatoka disease from an image captured on a smartphone.

The implemented algorithm, resizes the image to a size of 1000x1000 pixels, this size was selected in a heuristic way reducing the images to a point where the disease detection is not affected and the smartphone responds appropriately when processing the image .Then, a Gaussian filter that smooths the noise generated when the image is scanned, is applied, then transforming the RGB color space to HSV and the V channel is selected, this space representation allows a greater separability on diseases detection applications [8,20]. Then the mean and standard deviation for the selected channel are calculated. Subsequently a threshold of $\mu \pm 3\sigma$ is established, any pixel that is outside the range will be considered sick and its value will become zero. Thus, obtaining an image with the segmented disease. Figure 4 shows the implemented pseudocode.

Figure 4. Algorithm for automatic disease detection.

// Image Disease Detection

Input: Image (I)
Output: Segmented image (Irgb)

Start

Resize image to size 1000x1000
Apply Gaussian space filter to Iv (x, y), σ=5
$Ihsv \leftarrow rgb2hsv(I)$
$Iv \leftarrow Ihsv(:,:,3)$
Compute the statistical Moments to Iv
$M \leftarrow Mean\ (Iv)$
$D \leftarrow Std(Iv)$

$$A(i,j) = \begin{cases} 1, & if\ Iv(i,j) \leq (\mu - (\sigma * 4))\ \ ||\ if\ Is(x,y) \geq (M + (D * 4)) \\ 0, & Other\ Case \end{cases}$$

$$I_{RGB}(x,y) = \begin{cases} R = I(x,y)(:,:,0), G = R = I(x,y)(:,:,1), B = R = I(x,y)(:,:,2), & If\ A(x,y) = 1 \\ pixel = pixels + 1 & If\ A(x,y) = 1 \\ R = 0, G = 0, B = 0, & If\ A(x,y) = 0 \\ pixels2 = pixels2 + 1 & If\ A(x,y) = 0 \end{cases}$$

End

Source: own.

2.2.1. Percentage of affected area computation.

Once the segmented image is obtained, the percentage of affected area is calculated, for this the ratio between the number of pixels that have the disease and the total amount of pixels in the image is calculated as shown in equation 1.

$$Percentage\ of\ affected\ area\ (\%) = \frac{Number\ of\ sick\ pixels}{Total\ number\ of\ pixels} * 100 \qquad (1)$$

2.2.2. Statistical validation

In order to validate the proposed methodology, a database was created, and the algorithm developed is computed, then it's compared with respect to a manual segmentation as presented below.

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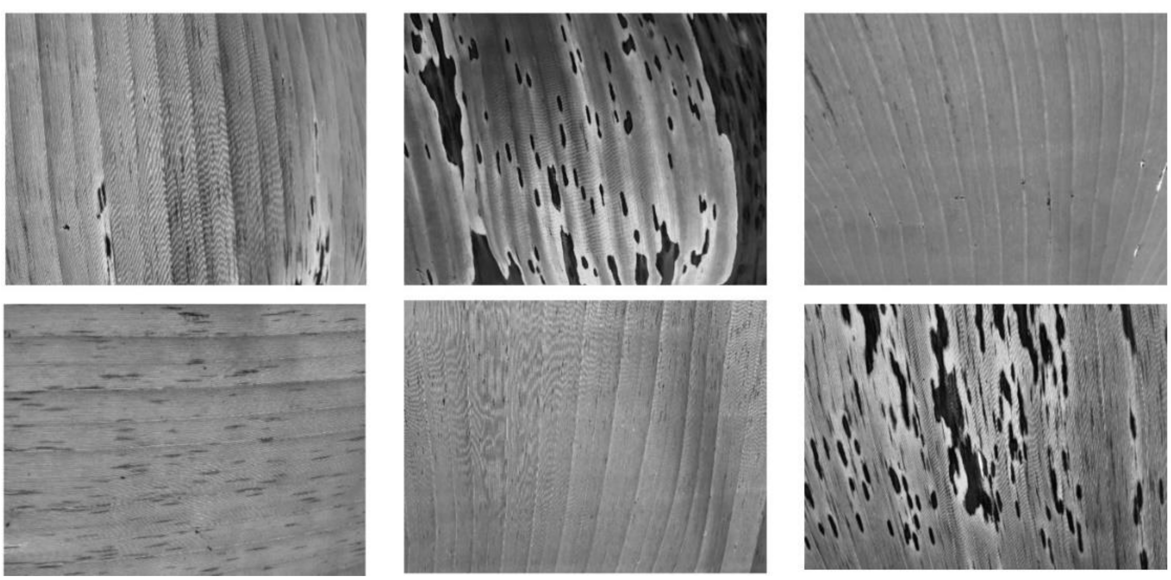
2.3. Database

In the state of the art there are databases of leaves images affected by Black Sigatoka, however, the samples taken were not made under an appropriate capture protocol [16] or are closed access [21], which makes it impossible to replicate and compare similar proposals. Due to the above, a database is constructed with the characteristics required in this work.

One hundred samples were captured on banana farms in the department of Risaralda, using two smartphones with the digital camera in automatic mode, with a resolution of 9.6MP (4128x2322) and 13Mp (3120x4160), in jpg format. And the following capture protocol is followed:

The samples are captured at a distance of 30cm, in sunny conditions, backlighting, sampling only the banana leaf, avoiding the background, central rib or any aspect other than the leaf as shown in Figure 5.

Figure 5. Samples of the database.



Source: own.

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2.4. Segmentation of the region of interest

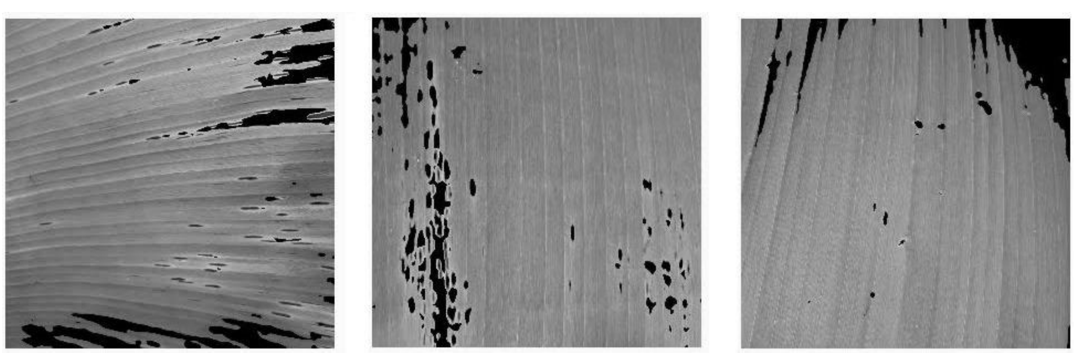
In order to validate the proposed methodology, a manual segmentation process of the disease pattern is carried out based on the visual inspection carried out by an expert according to the Stover procedure. For this, the GIMP software which allows to obtain the number of pixels selected as sick is used, from this value the RMS error is calculated with respect to the proposed automatic detection algorithm. The result of manual segmentation is presented in Figure 6.

Figure 6. Manual segmentation of the disease.

Source: own.

In this section we show the results of the experiment by applying the proposal methodology

Figure 7. Automatic detection algorithm's results of the disease.



Source: own.

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The Figure 7 shows the segmented pixels sample by the automatic detection algorithm of the mobile app. The section (a), (b) and (c) correspond to the leaf with high, middle and low state of the disease. The segmentation of the first cases is good, however, in section (c), the algorithm detects pixels although they are not sick. Nevertheless, the results are suitable due to the famer's regular control.

We compute the whole set of images and we get the total error of the database which is 2.97%±3.04%. The value of standard deviation is due to error increase in early steps of the disease as it is showed in Figure 7 section c. However, the algorithm detects the majority of the pixels with the illness allowing the app generates a tool for the agricultural control.

We calculate the app computational cost by capturing new samples for two mobile devices as it is showed in Table 1, besides, we present the features of each equipment. The times are suitable because they allow the implementation in low cost devices.

Table 1. Algorithm computational cost.

Mobile Devices	Tech Features	Time (s)
Samsung J7 prime 2016	RAM 2GB at 1.6Ghz, Processor Cortex-A53	22.78 ±0.25
Huawei Mate 20 Lite	RAM 4GB a 2.2Ghz, Processor Kirin 710	3.37± 0.21

Source: own.

3. Conclusions

We design a mobile app that execute an algorithm for Black Sigatoka automatic detection and achieves the affected area percentage of the disease in a banana's leaf. The system generates

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a tool for disease detection, which allows us to improve the disease detection processes carried out by farmers long time ago.

The detection algorithm is efficient when the disease characteristic pattern is showed in an image, however, in samples where show little trail of the illness (State 1 according from the Fouré Scale) the error's value is 9.21% ± 1.4%.

Even if the increase of compute capacity allows great things in current computational application, there are still limitations that restricts the use of techniques with high computing cost, nevertheless, we appreciate how new technologies allow to implement robust algorithms with high efficiency.

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