MONITORING OF SOYBEAN RUST THROUGH IMAGES

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Abstract. The automatic occurrence of quality in agribusiness is becoming essential in order to reduce costs and improve quality. Using image analysis techniques, it is possible to carry out pest control in various crops, such as soybean plantations, by obtaining aerial images, for example using drones. An image when scanned has, depending on its format, that is, its construction method, three layers called RGB (Red - Green - Blue) that precede the final image to be demonstrated on monitors, displays and printers. Concepts that the construction of the image depends on the type of sensor used and considering a digital image sensor capable of capturing the luminosity of the images that are projected on it continuously, we have the beginning of the process of capturing a moment of time, called photographs, or for a sequence of images over time. For capturing images in cores, it is common for video cameras to use three types of sensors, known as the 3CCD system, where each sensor has a tri-conical filter on it, and photographic cameras generally have a single image sensor that groups your photo sites under a mosaic of luminosity and color filters. The computational tool developed will allow the soy grower to monitor and identify the appearance of rust in the early stages and will avoid the unnecessary use of fungicides, reducing costs and reducing environmental impacts.

Keywords: Image, Monitoring, Soybean.

1 Introduction

The soybean crop suffered productivity losses due to the attack of Asian Soybean Rust. This disease is caused by a fungus called Phakopsora Pachyrhizi. Losses are estimated at 8.5 million tons of grain in the period 2001 to 2004, according to EMBRAPA Soja [1]. Constant monitoring and application of fungicides are the tools used for its control.

It is known that herbicides have a considerable share in the amount of pesticides, reaching 50.0% of the value of total sales and 49.6% of the quantity of commercial products [2], representing about 10% of the total cost of production of corn and 24.8% of soybeans.

The sales of the agricultural pesticides industry in 2014 was US$ 12,249 billion, of which US$ 3.90 billion are destined to the purchase of herbicides, that is, 31.9% of the sales in 2014; of this amount, 53.7% is destined for soy, 12.4% for sugarcane, 8.7% for corn and 5.9% for the crop corn is destined for the control of weeds [3].

According to Miranda [4], the widespread use of these products, the lack of knowledge of the risks associated with their use, the consequent disregard for basic safety standards, free trade, the great commercial pressure on the part of distributors and producers and the social problems found in rural areas are important causes that lead to the worsening of human and environmental contamination observed in Brazil.

Using image analysis techniques, it is possible to identify Asian Rust Fungus in soybean plantations, because the rust stands out from the soybean leaf because it has a different color compared to this one, making it possible to identify them by a color scale. Lopez Garcia [5], used a mathematical methodology to identify changes in the image pattern considered seeking to identify defects in citrus peel.

The development of digital processing techniques in recent years has enabled the implementation of many applications in various areas of activities and the purpose of this work is to use these available resources, currently at affordable costs, to identify Asian Rust Fungus in the culture of soy in its early stage.

Good performance and low cost are the advantages of modern signal processors. Efforts are applied to develop sophisticated real-time automated systems for the purpose of emulating human skills. One of these skills is vision, the energy contained in the real three-dimensional world we live in is converted into a two-dimensional entity, called an image by an electronic sensor, such as a video camera [6].

An image when digitized has, depending on its format, that is, its construction mode, three layers called RGB (Red – Green – Blue) that constitute the final image to be demonstrated on monitors, displays and printers. Considering that the construction of the image depends on the type of sensor used and considering a digital image sensor capable of capturing the brightness of the images that are projected on it continuously, we have the beginning of the process of capturing a moment in time, called photographs, or for a sequence of images in time [7].

The aim of this work is to develop a system that identifies Asian Soybean Rust by changing the color of the leaves. This alteration is identified by a digital image acquisition and processing system that identifies changes in color of the specimen through the analysis of RGB matrices.

2 Applied methodology

To capture color images, it is common for video cameras to use three types of sensors, known as the 3CCD system, where each sensor has a triconical filter on it, and still cameras usually have a single image sensor that groups their photosites under a mosaic of luminosity and color filters.

Considering that the information contained in a digital file that represents an image and seeking to analyze the mathematical information contained in this digital file, a techniques have been proposed to identify changes in physical properties through this photographic record.

According to Jain [8], artificial vision systems provide measurements and abstractions of geometric properties through the following equation:

$$Vision = Geometry + Measurements + Intrepretation \tag{1}$$

The image matrix is composed of three layers and must be decomposed to obtain RGB layers (red, green and blue) [5]. The RGB matrix is in the form of a three-dimensional matrix. In this matrix, the number of rows and columns correspond to the resolution of the image, that is, the number of pixels in the image, therefore, the larger the matrix dimension, the more precise the result. Each plane must include the red, green, and blue color planes. Image [F] is composed of:

$$[F] = \begin{bmatrix} F_{11} & 0 & \dots & 0 \\ 0 & & & \\ \vdots & & & \\ 0 & 0 & \dots & 0 \end{bmatrix} + \begin{bmatrix} 0 & F_{12} & \dots & 0 \\ 0 & & & \\ \vdots & & & \\ 0 & 0 & \dots & 0 \end{bmatrix} + \begin{bmatrix} 0 & 0 & \dots & 0 \\ 0 & & & \\ \vdots & & & \\ 0 & 0 & \dots & F_{NN} \end{bmatrix} \tag{2}$$

Each $F(x_1, x_2)$ element is called “pixel units” or simply “pixel”. The matrix [F] is not necessarily a square matrix. Each color in the RGB system is identified by a triple ordered (R, G, B) according to Jain [8]:

$$0 \leq R \leq 255, 0 \leq G \leq 255, 0 \leq B \leq 255 \tag{3}$$

In the RGB system each color is defined by the amount of red, green and blue using integer numbers between 0 and 255 to specify these amounts. The Figure 1 shows the three-layer structure.

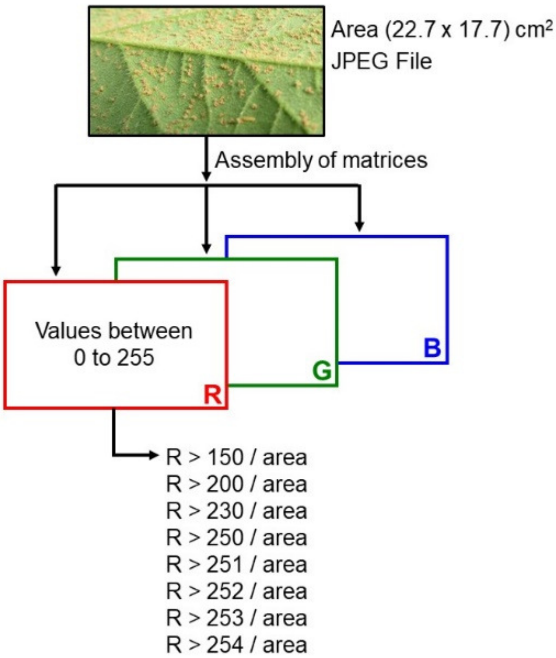

Figure 1. RGB layers.

2.1 Results

By using an image of a soybean leaf infested with Asian Rust Fungus, it is possible to carry out an analysis using computational tools, where it is possible to differentiate this fungus by a color scale, the lightest corresponding to this one. A JPEG file was imported into the environment of the computational math program used, generating a matrix of 1325x1700x3 pixel units. The image matrix was decomposed into three layers and each layer was vectorized.

Figure 2a shows a specimen already infested by the fungus Phakosora Pachyrhizi, which causes Asian Soybean Rust, in an advanced state. Figure 2b shows the graph of the red layer with the color intensity values relative to pixels 1325x1700 and the variation of whole numbers according to the hue of the red color. Figure 2c is the bitwise complement of the red layer matrix, where it is possible to identify the regions with Asian Soybean Rust fungus infestation. It is verified that the results obtained with the complementary color of the red layer matrix showed good agreement with the image of the specimen already infested by the Phakosora pachyrhizi fungus, being, therefore, possible to identify the fungus cited by this method.

Figure 3a shows a blue color map and the Figure 3b shows the green complementary color map for the same fungus-infested species of Figure 2a. The Figure 3b is the bitwise complement of the green layer matrix. Due to sanitary barriers it was not possible to obtain images of the infestation at various stages.

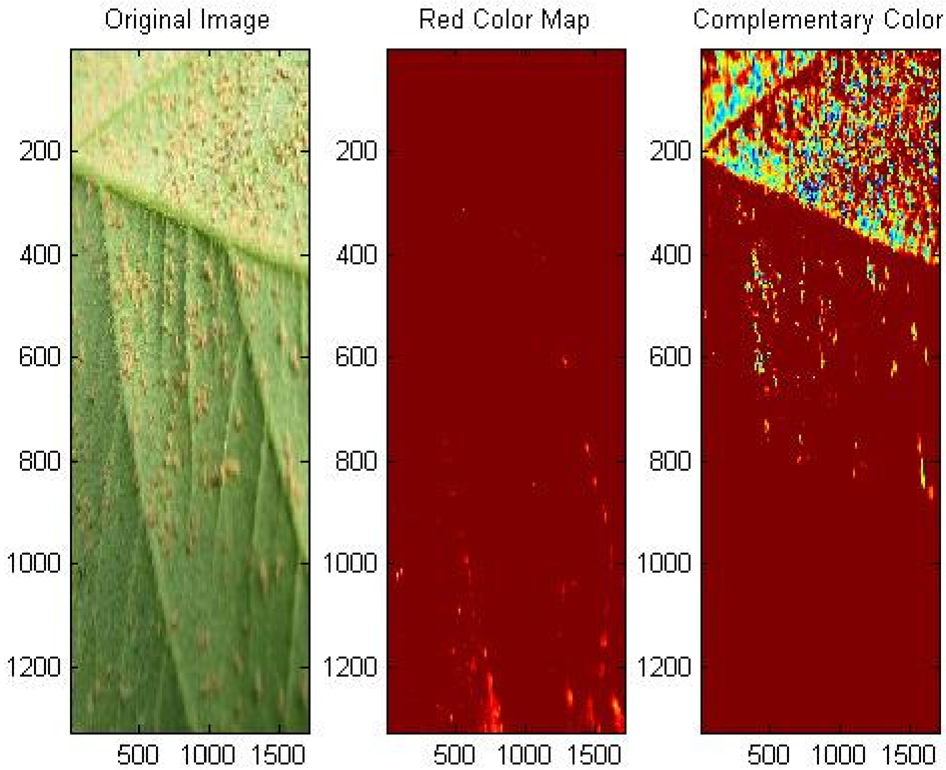

Figure 2. Asian Soybean Rust: (a) Specimen already infested by the Phakosora pachyrhizi fungus, EMBRAPA Soja [1]; (b) Red color map; (c) Complementary color.

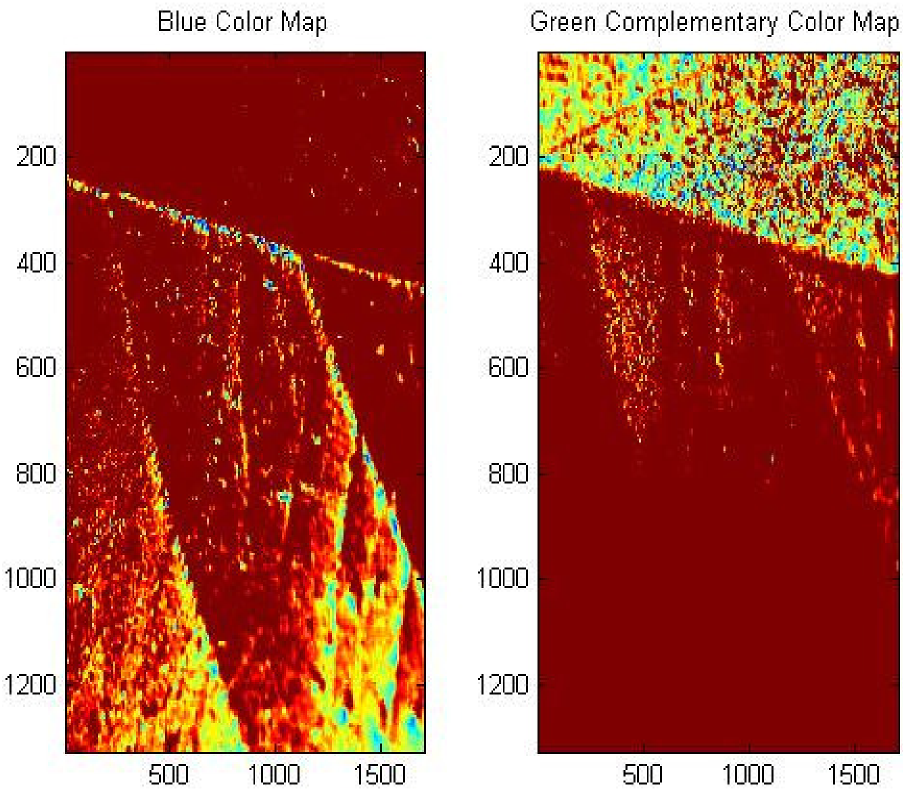

Figure 3. (a) Blue color map; (b) Green complementary color map.

Table 1 shows the R values (Red matrix) of points per unit area (22.7x17.7) cm^2, vectorized greater than 150 to 255. The Red layer was used because the color of the lesion caused by the Asian Rust Fungus is of a bronze color according to Navarini [9], then the most prominent color. According to Jain [8] the bronze color has the value of 205 for Red and other values for Green and Blue. The results show that the number of pixels per area cm^{-2} decreases a lot when we approach red 255.

Table 1. R (Red layer) vector values.

R>	Points Numbers	Pixels. cm^{-2}
150	845810	$2.1x10^3$
200	358375	891.94
230	66101	164.5
250	5052	12.5
251	4240	10.5
252	3529	8.78
253	2889	7.19
254	2340	5.8

The number of lesions caused by Asian Rust Fungus is bronze colored, so several R per area were calculated to identify when the infestation reached the limit to be use the fungicide. As the fungicide causes environmental problems, it must be used at the right time. According to Navarini [9] this point is 5.58 pustules per cm^{-2}, approximately pixel per cm^{-2}, considering a used image acquisition capacity of 800 x 600 pixels resolution of approximately 0.17 mm per pixel [8] sufficient to capture small lesions in the specimen well below 2 mm [1]. So, the R value close to 200 shows that the infestation, in this case, is very high and the pesticide must be used.

3 Conclusions

The proposed method was shown to be able to detect small spores in the specimen and detect these points by varying the intensity of the red matrix layer, which differs from the color of a specimen without the disease. Thus, the method uses the number of points per area to check the amount of infestation and make the decision to use the fungicide at the exact time. To verify the efficiency of the developed method it would be recommended to monitor the evolution of several specimens in different degrees of infestation in the field.

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