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DETECTION OF MAIZE STREAK VIRUS USING RASPBERRY PI COMPUTER

Ibrahim Isa
Department of Information Technology International Open University, The Gambia
ibrahim.isa@iou.edu.gm

ABSTRACT

Maize is one of the most common food crops grown annually around the world whereby the grains are further processed and used for local foods, manufacturing of cereals, animal feeds and many other uses. As a common food crop some challenges such as virus attacks are faced by farmers in the plant growth process, which can result in poor grain yield on harvesting. In this paper, we present a novel algorithm for detecting a common virus known as maize streak virus (MSV). The proposed algorithm uses an image processing technique to detect the presence of MSV on maize leaves. Therefore, MSV is detected by capturing the images of maize leaves and then sending them to a Raspberry Pi computer which runs an image processing algorithm to determine if the maize plant is infected with the MSV.

KEYWORDS: Image Processing, Python, OpenCV, Virus Detection Algorithm, Raspberry Pi.

1. INTRODUCTION

A severe viral disease of maize is known as the maize streak disease (MSD) which is caused by the maize streak virus (MSV) and is mostly experienced in regions like the Indian Ocean Islands, South of the Sahara in Africa, Mauritius and some others (van Regenmortel & Mahy, 2009). This disease is a major source of insecurity when it comes to the plant yield and also the threat it possesses of spreading to areas that are not affected with the virus. Thus, it should be monitored and taken care of in order to prevent potential problems. The Raspberry Pi is a powerful and cheap credit card sized computer board which basically operates like a normal PC with Interfaces designated for Input and Output devices such as keyboard, mouse, camera, display unit.

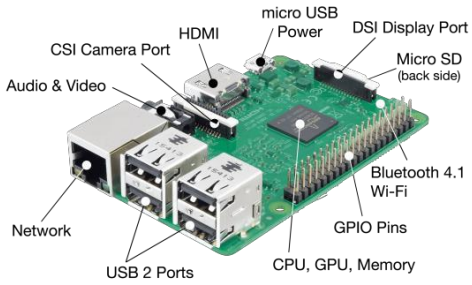

Figure 1. Components of the Raspberry Pi 3 Model B

It is a 64-bit system based on the Broadcom architecture at the speed of 1.2GHZ, with RAM size of 1GB and a micro SD card slot which serves as the hard drive and has the operating system stored.(Maksimović, Vujović, Davidović, Milošević, & Perišić, 2014) Image processing is a phenomenon that involves processing an acquired image which can be a photograph or a frame taken from video into its raw digital data and then having some operations carried on the data in order to manipulate the image or extract information from it (Barbedo, 2013) (Young, Gerbrands, & Van Vliet, 1998). Extraction of information is exploited in areas such as agriculture to detect plants that are infected with diseases without the need for manual inspection by a human. With respect to MSV, the main symptom is the yellowing of the leaves which is known as chlorosis (Martin & Rybicki, 1998). This chlorosis can be small in spots or covering the whole leaf depending on the severity of the infection, this is the main criteria that was used in determining if a leaf is infected or not in this work.

Application of some agricultural techniques can be found in the holy Qur'ān in the story of Prophet Yūsuf عليه السلام on the interpretation of the King's dream, he gave a recommendation in (12:48) where Allāh ﷻ says: ***"Yusuf said: "For seven consecutive years, you shall sow as usual and that which you reap you shall leave it in the ears, (all) except a little of it which you may eat.""***. From Tafsīr Ibn Kathīr the wisdom in Prophet Yūsuf's speech is explained as him providing them with a means of having the harvest stored and preserved in good health so that they would be able to make used of the stored harvest over the period of famine that would befall the kingdom. As such, application of our knowledge to preserve the good health status of plants or their harvest which will be of benefit to humanity is a good act in Islām.

Also from the Hadīth of the Holy Prophet ﷺwe have the story on the pollination of date palm trees, after the migration to Madīnah, he saw the people there pollinating the date-palm trees by hand, and he said to them, *"If you do not do this, it should still be fine."* So, they did not do it, and the crop failed, producing only bad dates. He passed by them and said, *"What is wrong with your date-palms?"* They said, "You told us such-and-such." He said, *"You know best about the affairs*

of your world." (Reported by Muslim, 4358). Here the Messenger of Allāh ﷺ tried to encourage us to do research when it comes to affairs that have to do with worldly matters, which has to do with analyzing and observing our problems and then finding solutions that will assist in optimal development in various fields such as agriculture. This is related to the MSV detection done in this paper with the aim of growing plants that are healthier and increase the yield in their products.

2. REVIEW OF LITERATURE

Literature such as Patil and Kumar (2011) in which a method was proposed for studying plant disease traits with the aid of image processing, which showed how much it can ease the work of scientists. However, there is room for a much better performing algorithm with the aid of genetic algorithms or neural networks. Barbedo (2013) made a survey which includes various methods that are used to detect, classify, and quantify plant disease using image processing giving an insight to various methodologies used in different literatures to solve the problem, but gave just a brief overview of how these methodologies work. Sethupathy and Veni (2016) proposed a disease detection method for mango leaves using the OpenCV Library, which uses the K-means algorithm for disease segmentation and the SVM classifier is further used for classification of the disease. Impressive results were presented from the proposed algorithm however it has a drawback of background dependent image process which affects how the segmentation is done properly and the image is not acquired in real time.

Marathe and Kothe (2013) proposed an AI technique which uses K means clustering, which begins by acquiring the image after which enhancement and restoration is done, and finally the image is analyzed in a computer to extract data used to determine the condition of the plant. This proves to be advantageous over detection with the naked eye when observing a large area however the image processing is done with MATLAB which implies the need for a powerful computer to be running the algorithm continuously which might cost a lot. A simple and efficient algorithm is presented in this paper which is focused on the detection of maize streak virus and easing the work of the farmer especially in situations where the farm area is of several hectares.

3. SYSTEM ARCHITECTURE AND METHODOLOGY

The system basically consists of a Raspberry Pi with a stable DC power supply, the Raspberry pi camera module which is attached to the board via a ribbon cable to the CSI port serving as the input for the image to be processed and a display unit which shows the image undergoing the image processing stages and also displays the health status of the leaf that is being analyzed.

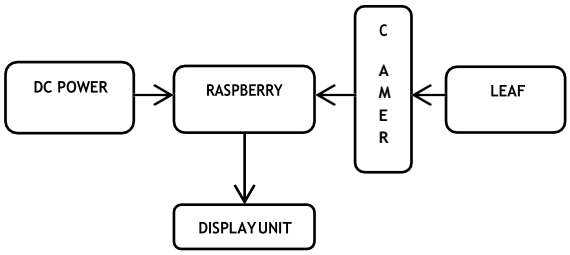

Figure 2. Block System Architecture

Capturing the image is the first step in the process and colored images can be represented by a matrix of the different color channels (RGB) which is represented in OpenCV as (B, G, R), in each pixel as integer value ranging from 0 to 256 on the three different channels, which comes together to give the specific color of the pixel (Pesco & Bortolossi, 2012). The Image below shows an example of a 3X3 pixels image.

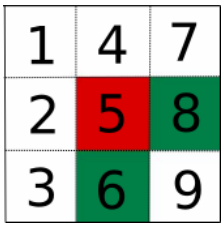

Figure 3. A 3X3 Pixels PNG Image

The pixel 1, 2 and 3 are represent by row 1, row 2 and row 3 on matrixes A such that the first column represents the B channel, the second column represents the G channel, and the last column represents the R channel of its corresponding pixel. Same applies to pixels 4, 5, 6 and pixels 7, 8, 9 represented by matrix B and C, respectively. This image can be further decomposed in its matrix representation as;

[ ]

[ ]

[ ]

Decomposition into individual B, G, R channel is done next where each channel matrix represents the same pixel position in the image, splitting the image above into B, G, R channels we obtain;

[ ]

[ ]

[ ]

The splitting of channels is done in the algorithm in order to obtain the channel with the most dominant color in maize which is the green channel. After obtaining this channel thresholding takes place which is the process of segmenting an image into different components (Sahoo, Soltani, & Wong, 1988) and the type of technique applicable is dependent on the desired result as for this algorithm the binary threshold and binary inverse threshold techniques are used in order to obtain the healthy component of the leaf and the disease infected component of the leaf. These can be mathematically represented as;

( ) ( ) { ( )

( ) ( ) { ( )

Where ( ) and ( ) represents the binary threshold and inverse binary threshold respectively, ( ) is the location of pixel with coordinates as row and column. In the detection algorithm a Health to Virus Ratio ( ) constant is introduced which is derived from healthy leaf samples by summing up the binary thresholds of all the healthy leaf samples and then diving by the inverse binary thresholds of all the healthy leaf samples and then diving by the inverse binary thresholds of the leaf samples which gives an average that can be used to determine the condition of other leaves (Sasakawa, Kuroda, & Ikebata, 1991). This can be represented by

$$\frac{\sum \sum}{\sum \quad \sum} \quad ( )$$

Where is the total number of healthy samples and N the total number of pixels belonging to the Image. With the acquired leaf samples and application of equation (3), an of 1.8 was obtained which is used as the constant to run the algorithm. Having understood the basic overview of the system, the image processing algorithm is as follows;

Leaf Status Detection Algorithm

Input : Camera Image
Output : Leaf Health Status
Initialization
1: B,G,R = split image (Input) to BGR channels
2: BT = Binary Threshold (G, threshold limit)
3: IBT = Inverse Binary Threshold (G, threshold limit)
4: ( )
( )
5: If ( ) then
leafstatus = Not Infected
else
leafstatus = Infected
6: Print (leafstatus)

The above algorithm was implemented in Python code and then run on the Raspberry Pi to generate some results which will be discussed in the next section.

4. RESULTS & DISCUSSION

After the setting up The Raspberry Pi system was set up as shown in figure 2. A DC Power source of 5V 2A was used to power up the Raspberry Pi model B, the camera was connected to the CSI slot on the board and the display was connected via the HDMI port. The algorithm was implemented with Python which included importation of the Opencv Library and some modules form Matplotlib which were used to display some of the Image processing steps. To train the system 5 infected and 5 non infected samples were used to obtain the HvR which was set as a constant in the program. The Binary (BIN) threshold and Inverse binary (INV-BIN) threshold are

necessary for the computation of the HvR and their values are obtained by equation (1) and (2) respectively which is implemented in code with some in built functions with the OpenCV library. In addition, a masked image was added to the output which has the pixel value of the processed infected area set as 0 (black) on the original image in order to illustrate the areas where the algorithm was able to detect chlorosis. Random images of healthy and unhealthy leaves are used for testing and below is some of the outputs of the algorithm.

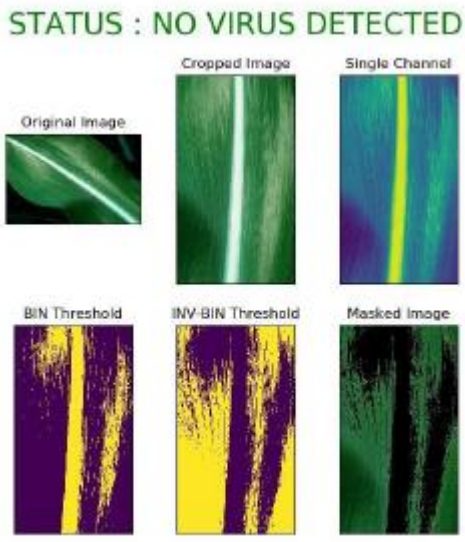

Figure 4. Process on a healthy leaf sample

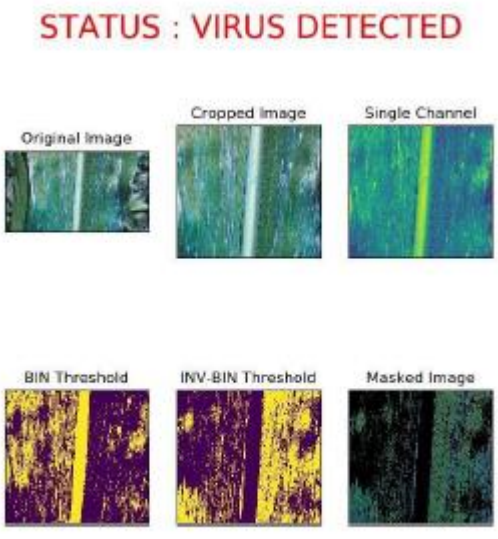

Figure 5. Process on an unhealthy leaf sample

In Figure 4, a healthy leaf is passed into the system which goes through all the processes as explained earlier which the output of each step being showed in order to explain the whole process. The masked image is added to illustrate the magnitude of the green portion which is healthy and can also be used as means of identifying if the leaf is healthy or not, comparing with

that of figure 5. which is an unhealthy leaf it can be seen clearly that masked imaged in Figure 4 has a lot of dark spots which is an indication of MSV as intended with the algorithm.

5. CONCLUSION

This work shows how the traditional method of MSV detection can be done in a computerized way to help ease the intensive labor required for farmers especially when it comes to inspection of large farm areas. Normally a farmer uses his eyes get the visual representation of the leaves after which the human intellect is able to differentiate the infected leaves form the non-infected ones by their color, this is done in a computerized way by having a camera which serves as the human eye and gets the visual representation of the image after which it is sent to the Raspberry Pi where the algorithm works on the image received from the camera serving as the intellectual process in humans thus able to differentiate the infected leaves from the non-infected leaves just as humans do.

The Algorithm designed for the detection of MSV proved to be successful with the numerous leaf samples that were used in the system as such the algorithm can be applied in assisting a farmer in getting his duties done. However, we intend to look further into the tendency of erroneous detections and how to mitigate them using more advanced image processing techniques which can also improve the precision.

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