PROTOTYPE DESIGN OF DISEASES DETECTOR ON TOMATO LEAVES WITH IOT-BASED DIGITAL IMAGE PROCESSING

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ABSTRACT

Tomato is a vegetable commodity that continues to increase every year. It is caused by the high market demand both domestically and abroad. In addition, the price of tomatoes is stable in the market making the farmers get a big profit. But one thing that concern farmers is tomato plants diseases, especially the disease caused by fungi since it can reduce the quality and quantity of agricultural products[1]. To overcome this problem, a prototype system that can detect tomato plants disease caused by fungi by using image processing and Internet of Things technology is needed. From the test results, it is shown that the disease detector of the of tomato leaves is functioned well in detecting the disease in the leaves of tomato plants, especially those caused by fungi with an accuracy rate of 67%. In the application that was built, there are also ways to prevent and overcome the problem so that they can be expected to facilitate the farmers.

Keywords : Raspberry Pi, Digital Image Processing, Tomato, Internet Of Things, disease.

1. BACKGROUND

Currently, there are many people who grow tomato plants, stable prices and high market demand is one of the reasons for the interests in tomato cultivation. One of the farmers who grow tomato plants is Mr. Ujang who lives in Pasir Datar village, Caringin sub-District, Sukabumi District. Mr. Ujang cultivates tomatoes of globe type with prices range of Rp. 2500,- to Rp. 3000,- per kg.

In the interview with Mr. Ujang, globe tomatoes were planted in February-May and the harvest time ranged from 14-16 weeks. In the journey, many obstacles were found, one of which was the disease in tomato plants, especially those caused by fungi because they had a pattern which is similar to other diseases. To identify the disease, the farmers perform manual checks with eye observation, considering the pattern and appearance of tomato leaves affected by the disease and comparing them to the conditions in each season.

In addition, if farmers find diseased tomato plants, what they do is by giving the liquid pesticiden. This is certainly not efficient because not all diseases can be treated with pesticide formulation. Errors in handling the problem can create a risk of damage to tomatoes

Based on the problems faced, a system that can detect diseases of tomato plants is needed. Therefore, with the concept of IoT (Internet of Thing) and by using digital image processing methods, the researchers are interested in conducting research entitled "Prototype Design for Diseases Detector of Tomato Plant Leaves with IoT based Digital Image Processing Method".

2. CONTENTS OF RESEARCH

2.1 Theoretical basis

The theories that become references in supporting the research made are as follows:

2.1.1 Tomato

Tomato fruit is one of the garden plant products (horticulture) that is bush-shaped with a length of 1-2 meters (depending on the type) and is an annual plant which means the age of tomatoes is only for one harvest period only. Taxonomically, tomato plants classified as follows:

- Kingdom :Plantae,
- Subkingdom :Trachebionta,
- Division :Magnoliophyta,
- Class :Magnoliopsida,
- Subclass :Asteridae,
- Order :Solanales,
- Family :Solanaceae,
- Genus :Solanum
- Species :Solanum Lycopersicum
- Binomial Name : lycopersicon esculentum

2.1.2 Internet Of Things

The Internet of Things is a concept where we can remotely control electronic devices[2]. There are many convenient IoT innovations made. In developed countries, the Internet of Things is widely used for the security installments of homes, cars, printers, and others.

Figure 1. Internet Of Things

2.1.3 Image Processing

Image processing is the resemblance or description of an object. Digital imaging is an image that can be processed by a computer [3]

a) Color Image

The color image has an 8-bit pixel and the maximum number is 256. Color image has two types of 8-bit images but the model that is often used is a 256 color palette with certain RGB mapping

b) Grayscale image

Grayscale image only has a red, green, blue channel value which is used to show the intensity level and the grayscale has white, gray, and black color

c) Binary Image

Binary image is an image that has 2 colors, namely black and white, often also called monochrome

2.1.4 OpenCV

OpenCV is a library used for image processing and vision, for GUIs, data structures, Images and I/O Video[6]. It supports XML, graphics functions and others[4]

2.1.5 Raspberry Pi 3 Tipe B

Raspberry Pi is a Mini-sized Pici shaped and sized like an ATM card. The OS used in Raspberry Pi is Raspbian and currently, the latest version is Stretch Raspbian Version. In addition, Raspberry Pi 3 has an SD Card that is used to boot the OS and also for data storage[5].

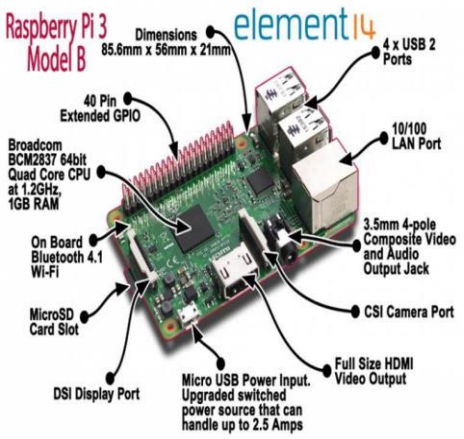


Figure 2. Raspberry Pi 3 Tipe B

2.2 Data Collection Method

1. Identification of problems

The initial step was to identify problems that aim to research and study the research site to be able to find out the problems that occur

2. Data Collection Method

Data collection methods in building the application and prototype are as follows:

a. Literature Study

Data collection was done by collecting journals. Literature, reading about Raspberry Pi, Image Processing and programming languages

b. Observation

The technique of data collection was by conducting research and direct review of the problems taken. In this case, observations were carried out at Mr. Ujang's tomato plantation, located in Pasir Datar Village, Caringin District, Sukabumi.

c. Interview

The interview was conducted by holding a question and answer session directly with the owner of the tomato plantation, which was Mr. Ujang himself.

3. System Analysis

System analysis is a stage to analyze the system to be built

4. System Design

System design is a stage that involves the design to be built on the system.

5. System Implementation

System implementation is the implementation stage of a system that has been previously designed

6. System Testing

System testing is a test that is carried out to find out whether the system created is in accordance with the previous objectives

2.3 Results and Discussion

2.3.1 Problem analysis

The problems found in this research using Raspberry Pi for the development of disease detection systems in tomato plants are as follows:

1. In his daily life, Mr. Ujang and 2 other workers still check the disease in the tomatoes specifically on the leaves using manual methods, in this case if farmers find diseased leaves (seen from the color and pattern of the leaves) they immediately use liquid pesticide even though not all diseases can be cured by using pesticide liquid, this depends on the symptoms caused.

2.3.2 Analysis of Current Systems

System analysis is a stage that provides an overview of the current system. This analysis aims to provide a more detailed description of how the system works.

1. Procedure for the Examination of Tomato Plants

Tomato plant examination procedure is a procedure in which farmers check the condition of their tomato plants. The process that takes place as follows:

1. Farmers come to tomato plantations.
2. When they arrive at the tomato plantation, the farmers will check the condition of the tomato plant.
3. If the disease found, liquid pesticide is administered to tomato plants

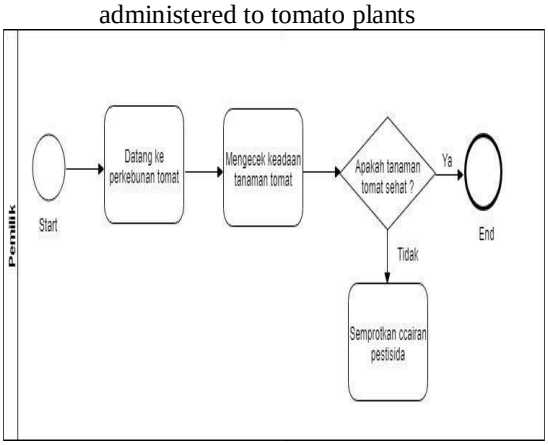


Figure 3. Tomato Examination Procedure

2.3.3 Analysis of Non-Functional Needs

Need analysis is an analysis that aims to determine the input requirements needed by the system, the system output and also the process needed to process an input so that it can produce the desired output.

Table 1. Hardware Needs Analysis

No	Hardware	Specification
1	Processor	1,5 Ghz
2	Monitor	Resolution 1366 x 768 pixels
3	Memory	1 GB RAM
4	Harddisk	5 GB free space
5	VGA	256 MB
6	Mouse	Standard
7	Keyboard	Standard

2.3.4 Analysis of User Needs

Table 2. Analysis of User Needs

User	Duty	Access rights
The Owner	- Capture the leaves taken from the tomato plantation to detect the disease	- See the history of the disease on tomato plants that have been detected before. - Obtain information on disease in tomato plants.

2.3.5 Analysis of System Architecture

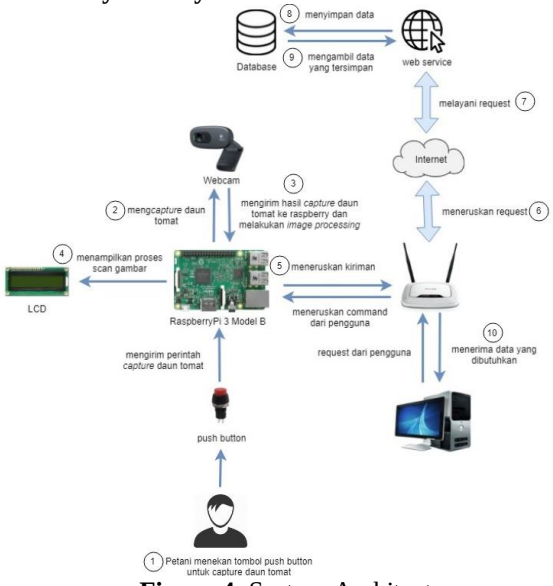


Figure 4. System Architecture

The explanation of Figure 4 is as follows:

1. The farmer will take the leaves of the affected plant and then put it in the acrylic box
2. The farmer presses the push button to send the tomato leaf capture command
3. The webcam will automatically send the captured results to the raspberry and do image processing
4. The LCD will show the status of the image processing process, whether it has been detected or not
5. The data obtained will be processed and sent to the web service that is connected with the WiFi router.

6. Data transmitted to the WiFi router will be forwarded to the web service via the Internet Network.
7. Web service will store data into the database.
8. The farmer enters the web-based system through a PC that is connected to the internet.
9. The farmers choose the menu to see the results of image processing
10. The request will be sent to web service via internet network.
11. Web service processes requests by accessing data in the database.
12. 1Web service sends the data needed from the database to the user with an interface on the web.

2.3.6 Analysis of Data Communication

The analysis of data communication is a stage to analyze how data can be transmitted or channeled so that communication between parts of the system can run smoothly and properly. The following is an explanation of the data communication that was built:

1. Data Sources

   Data sources are parts of the system that function as data providers and also as data senders. The data sources in this system can be described as follows.

   a) Microcontroller

   The microcontroller used is Raspberry Pi 3 Model B. The microcontroller is a control center that connects the modules used. Raspberry Pi 3 Model B has a Stretch Raspbian operating system installed.

   b) Webcam

   The webcam used here is Logitech C170. This webcam has a maximum photo resolution of 1024 x 768. This camera functions to capture tomato plant leaves

   c) Desktop Computer

   The desktop computer or often known as PC is included in the data source because users can input one value into the web system. The data entered can be seen in the description of the system architecture.

2. Transmission media

   The transmission media is a path that connects the process of sending data from the source to the recipient. The transmission media used in this system is wireless. The following equipment is used in the disease detection system on tomato leaves using IoT-based image processing:

   a. WiFi Router

   The WiFi router used is Huawei E5673 MiFi. This device is used as a hotspot so that connected devices can access the internet.

3. Data Recipients

   Data recipients are devices that receive data or information. Devices that receive data are as follows:

   a) Desktop Computer

   Desktop computers or PCs can be the data receiver in this system because the PC receives data in the form of detection of tomato plant disease.

2.3.7 Analysis of the disease studied

Table 3. Analysis of the disease studied

Images of disease			
Name of diseases	Septoria leaves	Brown Spots	Late Blight
Cause	Fungus Septoria Lycopersici	Alternaria solani	Phytophthora infestans
Symptoms begin to appear (in weeks)	Week 4	Week 4	Week 5
Characteristic features	there are many small round light brown spots[6]	spots that look round on the leaves and are brownish black. [7]	Irregular large spots from gray to brownish

2.4 Analysis of Disease Detection Process

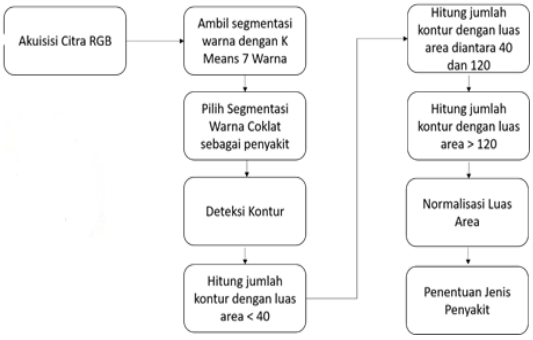


Figure 5. Disease Detection Process

The explanation of figure 5 is:

1. Image acquisition is a process of image retrieval sourced from the camera with commands on OpenCV
2. The image capture results are then broken down into 7 color segmentations with the K-Mean method.
3. Each contour detected is calculated the area and grouped into 3, where the contour with a small area is below 40 pixels. While the medium area is between 40 to 120 pixels and a large area is above 120 pixels. This value is obtained based on the output of all contour areas. After calculating each area group, the value is normalized to a scale of 0-100%.
4. Based on the nature of the disease, it is shown that the first disease has a lot of spots so that if the small contour area is more than 50% then disease is categorized as 1. The medium and large contour ratios are used to determine whether other diseases are 2 or 3. If the area ratio is moderate to Large above 0.4, it is categorized as disease 2, whereas if it is not then it is 3. If there is no contour at all, or one group of contour areas is 0, it is declared as undetectable.

2.3.8 Analysis of Functional Needs

Use case diagrams are diagrams that show how the system's functionality is mutually interacting[8]. Use Case Diagram of the system created can be seen in Figure 6

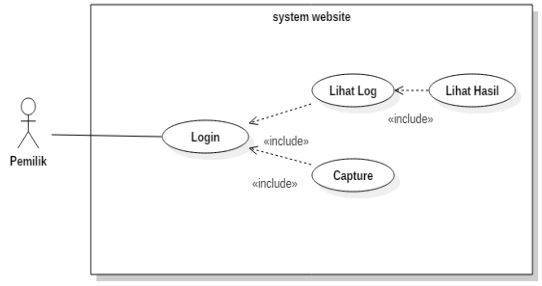


Figure 6. Use Case

2.3.9 Database Design

Database design is a design that aims to map models that have been conceptualized previously to the database model that will be used[9].

1. Relationship Scheme

Relationship scheme is a series of tables that aim to relate to the database[10]. The relation scheme created can be seen in Figure 7.

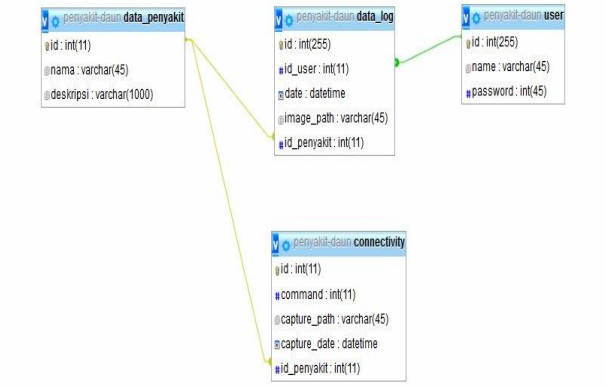


Figure 7. Relationship scheme

2.3.10 Hardware Implementation

Table 4. Hardware Implementation

No	Hardware	Specification
1	Processor	Core i3
2	Monitor	Resolution 1366 x 768 pixels
3	Memory	4 GB RAM
4	Harddisk	5 GB free space
5	VGA	Nvidia Optimus
6	Mouse	Standard
7	Keyboard	Standard

2.3.11 IoT Hardware Implementation

Table 5. IoT Hardware Implementation

No.	Hardware	Information
1	Microcontroller	Raspberry Pi 3 Tipe B
2	Storage Media	Micro SD 32 GB
3	Camera	Logitech 310
4	LCD	I2C LCD 12x6

2.3.12 Software Implementation

Table 5. Software Implementation

No	Software	Use
1	Mini Tool Partition Wizard	Formatting a memory card for raspberry pi OS installation.

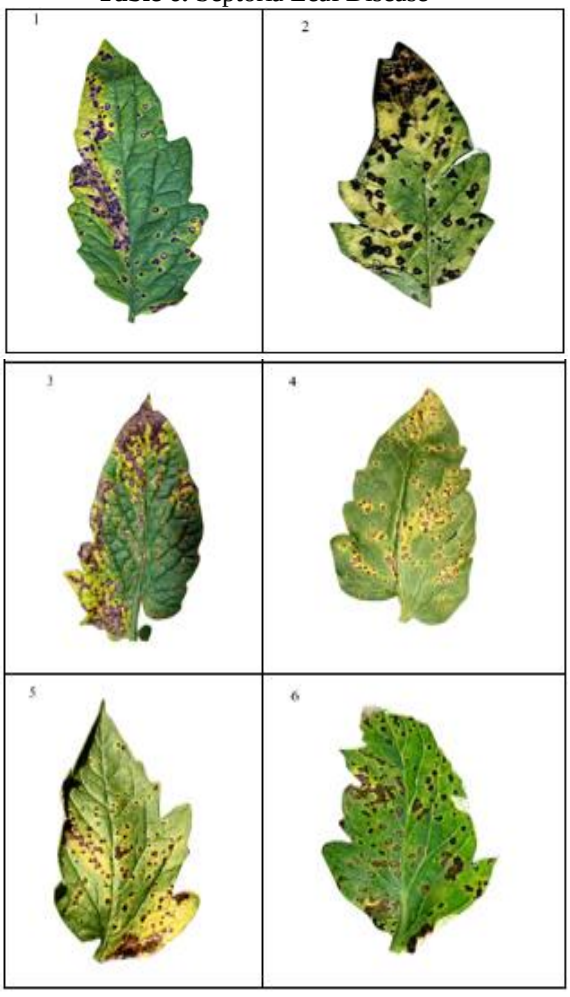
No	Software	Use
2	Win32DiskImager	To write the OS image to a memory card.
3	Raspberry Stretch Version	As the Operating System used in Raspberry Pi
4	Sublime Text	Text Editor to edit web programming syntax.
5	Geany	Text Editor to edit the image processing syntax.
6	XAMPP	An application to simulate a web server to test the source code related to web development locally.
7	PuTTY	Access Raspberry Pi with the *command line* interface.

2.3.14 Overall System Testing

The Overall System Testing is intended to test whether the system made works well.

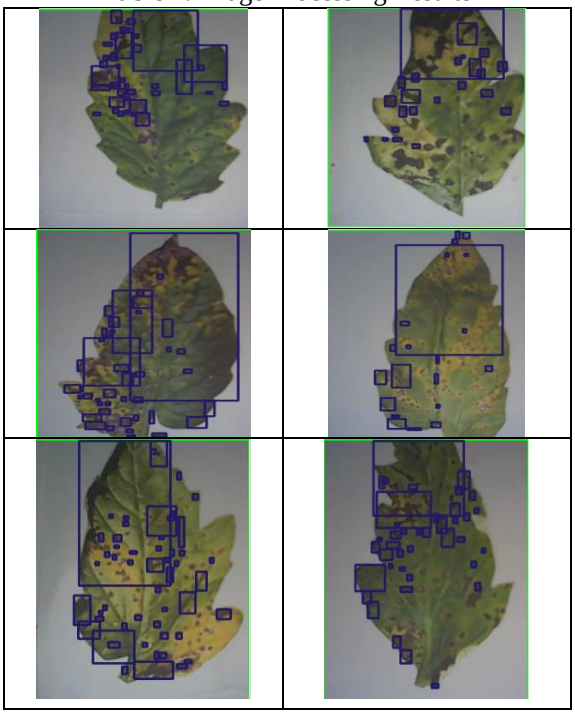
1. The septoria leaf disease test can be seen below:

Table 6. Septoria Leaf Disease



After processing the image, it will look like this:

Table 7. Image Processing Results



For more details, see the table below:

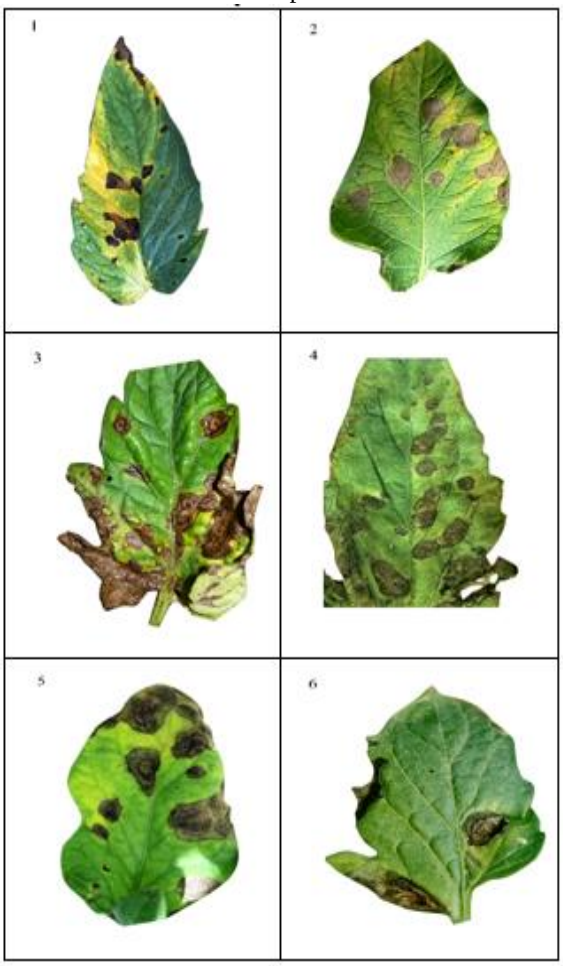
Table 8. Details of Septoria Leaf Disease Test

No	Amount			Total	Result
	Small	Medium	Large		
1	28	5	5	38	TRUE
2	8	12	3	23	FALSE
3	29	10	4	43	TRUE
4	18	1	2	21	FALSE
5	42	4	7	53	TRUE
6	21	10	5	36	TRUE

Of the total 6 tests for septoria leaf disease, it can be concluded that the system can detect the disease with a percentage of 67%.

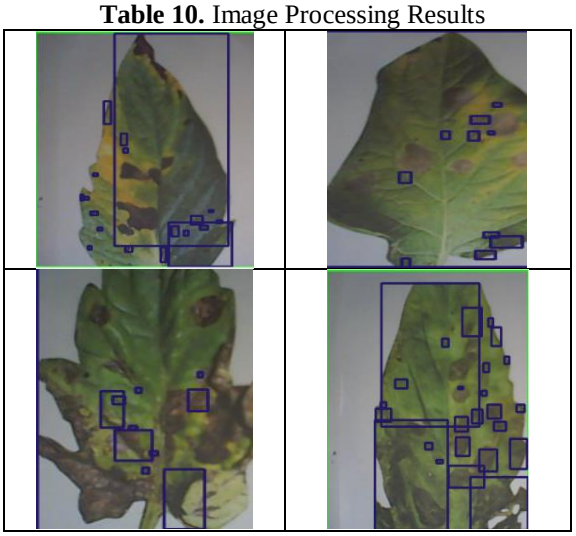
2. The brown spots disease test can be seen in the table below:

Table 9. Brown Spots Disease



After processing the image, it will look like this:

Table 10. Image Processing Results



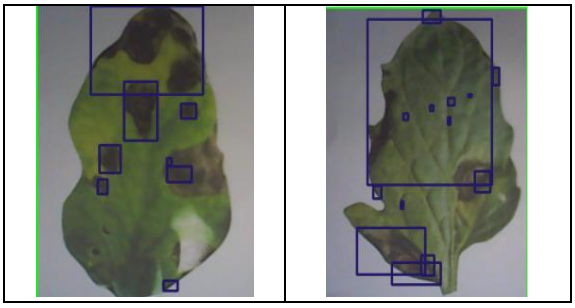


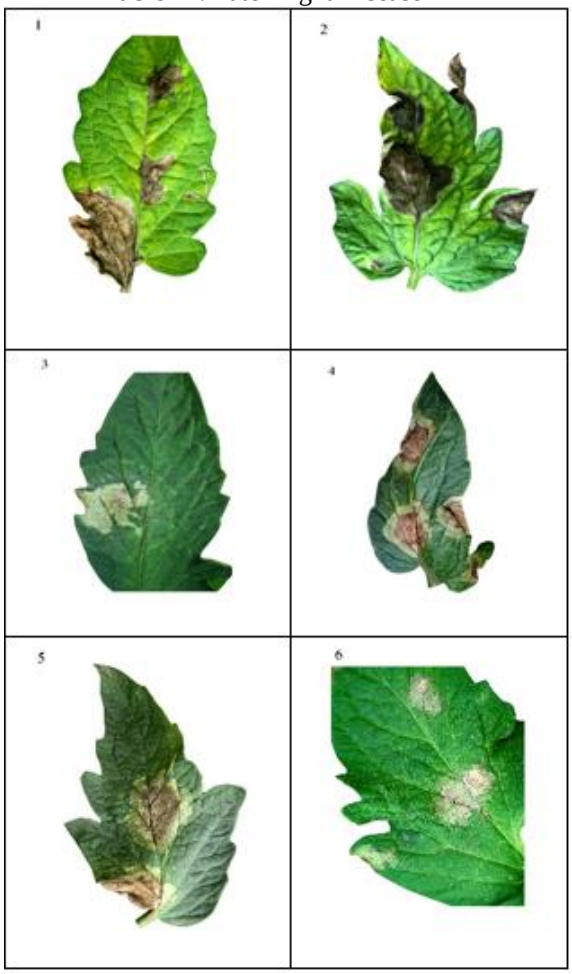
Table 11. Details of brown spots disease test

No	Amount			Total	Result
	Small	Medium	Large		
1	16	1	2	19	TRUE
2	18	2	2	22	TRUE
3	6	0	5	11	FALSE
4	10	6	9	25	FALSE
5	17	1	3	21	TRUE
6	13	4	2	19	TRUE

Of the total 6 tests for brown spots disease, it can be concluded that the system can detect the disease with a percentage of 67%.

3. The late blight disease test can be seen below:

Table 12. Late Blight Disease



After processing the image, it will look like this:

Table 13. Image Processing Results

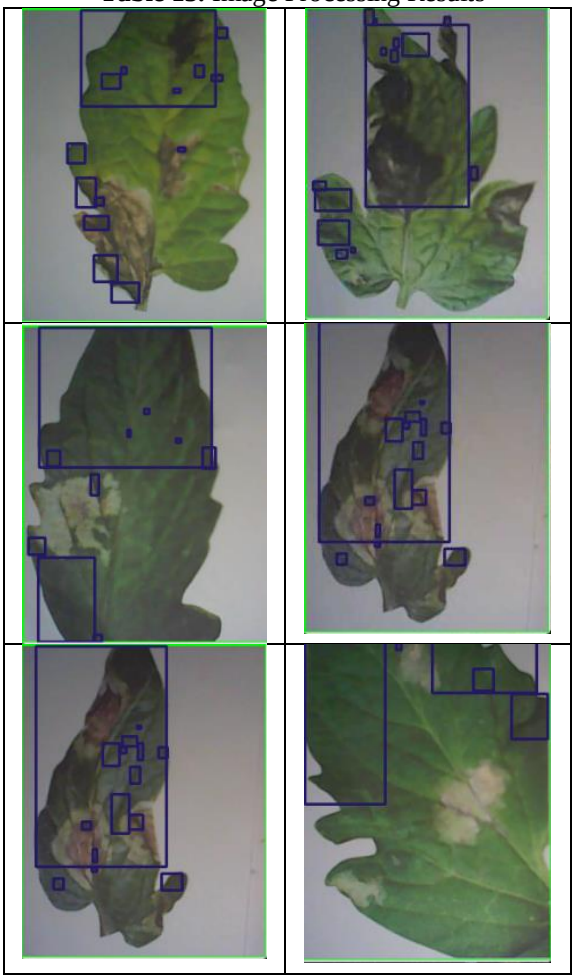


Table 11. Details of late blight disease test

No	Amount			Total	Result
	Small	Medium	Large		
1	8	4	2	14	TRUE
2	9	2	3	14	TRUE
3	12	3	2	17	FALSE
4	9	3	2	14	TRUE
5	5	1	1	7	TRUE
6	11	1	1	13	FALSE

Of the total 6 tests for late blight disease, it can be concluded that the system can detect the disease with a percentage of 67%.

3. CLOSING

3.1 Conclusions

From the results of the tests that have been carried out, it can be concluded that the application and prototype that are made can detect diseases that exist in the leaves of tomato plants with the following conditions.

1. White background required so the identification results are more accurate.
2. The image capture process cannot be recognized if the angle is unnatural or too skewed.
3. Images that want to be identified must be in high resolution so that when the images are processed, the results are more accurate and detectable

3.2 Suggestions

The following suggestions are to be considered for further development of disease detection systems in tomato leaves:

1. It is expected that in the future it can detect various diseases in the leaves of tomato plants other than caused by fungi
2. Creating a detection system that can be done in real-time so that users do not need to press the button again.
3. Using another method that is more accurate when the image is skewed unnaturally.

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