Analysis of Banana Plant Disease Characterization Using Thermal Camera with Tressolding Method

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Abstract

Banana is a fruit plant that is widely produced in Indonesia. Unfortunately, this plant is very susceptible to diseases which can reduce the quality and quantity of the crop. This paper proposes disease detection in banana plants using a thermal camera. The detection is carried out using image processing techniques with multilevel thresholding methods. The image is captured using a thermal camera, then the image is pre-processed to suit what is desired. After that, so that the position is the same as the image taken using a digital camera, the image produced by the thermal camera is carried out by an image registration process. The image processing result is compared with the ground truth image obtained from a digital camera to determine the effectiveness of the proposed method. The effectiveness of the proposed method is measured using the parameters Recall, Precision, F-measure, and Accuracy. The effectiveness of the proposed method is quite effective because it produces parameter values above 80%, namely the recall value of 86,59%, the Precision of 99,1%, the F-measure of 92%, and the accuracy of 89,78%.

Keywords: banana plant disease, thermal image, multi thresholding

I. INTRODUCTION

Fruit plants are a major part of people's lives. Fruit is a food that people consume almost every day because of its various benefits. Of the various types of fruits, bananas are one of the fruits that provide many benefits to the body. Bananas contain lots of fiber, antioxidants and vitamins that are good for the body besides bananas can also improve digestive health. The leaves are usually used by people to wrap food because they give a fragrant aroma and make food tastier and have health benefits.

Lampung Province produce a lot of pineapple and papaya. Banana production in Lampung in 2017 reached 1,642,000 tons. Apart from local consumption, this fruit is also exported abroad, especially to China, Singapore and Spain. For local consumption it is usually used to make banana chips and various other preparations. Banana production in 2017 decreased by 54.6 thousand tons from the previous year due to a disease that attacks banana plants [1]. The main diseases that attack banana plants include Sigatoka spots, Fusarium wilt, and also Moko. This disease can cause death in banana plants or cause the plant to produce fruit that is poor and unsuitable for consumption. Symptoms of disease in banana plants can generally be observed from changes in the color of the leaves.

The leaves experience yellowish spots or change in color from green to yellowish then turn brown and eventually die. This leaf color change does not occur suddenly but rather slowly and each disease has a certain pattern. When observed using the human eye, the change in leaf color cannot provide information quickly. However, if you use a visual sensor, information on changes in leaves that indicate disease can be recognized quickly. The use of visual sensors and appropriate image processing methods can detect the presence of this plant disease early. This color change on the leaves occurs due to changes in temperature on the leaves.

It is necessary to use a thermal camera to be able to take pictures of temperature changes in each part of the leaf. The results of the temperature change image are used to determine the characteristics of each disease that attacks banana plants. Research on disease in banana plants has been widely carried out before. Research has been carried out at home and abroad, especially by banana-producing countries.

Previous study has been conducted regarding the causes of blood disease in banana plants, namely the insect *Trigona sp.* [2]. While other researcher has been conducted study on a bacterial wilt in banana plants by directly testing banana plants [3,4]. Based on this statement, this study focuses on determining the characters of banana plants exposed to disease. Banana plant images are captured using a scheduled thermal camera. The plants that were taken were diseased plants that were visible to the naked eye.

The image obtained is processed by preprocessing to get the desired image where the features that will be used in the segmentation are more visible. After the preprocessing image is obtained, the segmentation process is carried out using the multilevel thresholding method. Areas that experience changes in the leaves are determined to determine whether or not there is disease in the plant. The effectiveness of the proposed method is measured using standard object detection parameters using image processing, namely Recall, Precision, F-measure, and Accuracy. The output of this study was to determine the color characteristics of banana plants exposed to disease [4-6].

II. MATERIALS AND METHODS

This research used multi thresholding method, the research was conducted in banana plantations for image data retrieval, while the data processing was carried out in the Electronics Lab, Electrical Engineering Department, Engineering Faculty, University of Lampung. Data processing was performed using an i5 computer with 4GB memory, 2GB GPU, Windows 7 Enterprise 32 bit, and the MatLab programming language [7-9]. Meanwhile, the camera used in this study is a thermal FLIR camera. This study uses the stages as shown in the block diagram of image processing methods, as on figure 1.
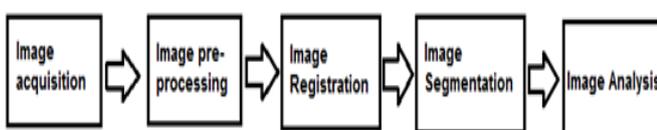
Figure 1. Image processing method block diagram

2.1 Image Acquisition

The results of image data retrieval are stored in external storage to be processed using a computer. An example of image data collection is shown in Figure 4 where 4a is an image of a banana tree taken using an ordinary digital camera and 4b is an image of a banana tree taken using a thermal camera. Data retrieval is carried out on a scheduled basis with the same object [10-13].

2.2 Image Registration

The difference in format and capturing angle of data resulted in the image being captured cannot be identical. It is necessary to register the image so that the two images approach the same shape so that they can be compared. The image registration process is the process of placing objects in the form of pixels in an image that does not yet have a coordinate system reference into a specific coordinate and projection system [14-17]. In this research, the image of a Banana tree was taken using a thermal camera and an ordinary digital camera with a distance of 3 meters, a camera height of about 1.5 meters, and an upward angle of 30°, as presented on Fig. 2
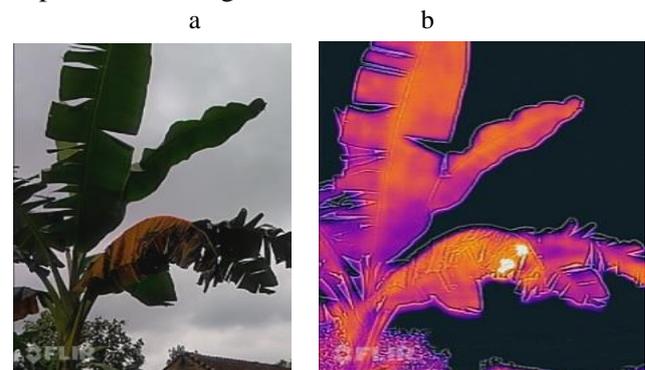
Figure 2. Example of image data.

The image registration process involves two images that have overlapping image scopes. Where one image is used as a reference and others adjust it. This registration process is carried out using the Matlab program. Image registration procedure is as follow:

The first step is reading the reference image and the image to be registered, then the second step is for selecting a control point on the image, which is to mark a location that is considered the same in both images, for example the location of a road intersection in both images [18-19].

Step three is to save control points into the MatLab workspace. Followed by the fourth step to re-detailing the control points so that the registration process produces the same exact image. Then the fifth step is to determine the type of transformation and its parameters required so that the control-point predetermined can move according to the target corresponding to the

control point. Finally, to perform the registration.

An example of the results of the image registration process is shown in Figure 3, where on fig. 3a has the same position as on fig. 3b.

a   b

Figure 3. Results of the image registration process.

2.3 Image Segmentation

The thresholding process is an important technique in the image segmentation process because it produces images that have a small file size, fast processing, and ease in the manipulation process [20]. The thresholding technique can be done in bi-level or multi-level depending on the number of image segments desired. In the bi-level thresholding process, the image is divided into two different areas. Pixels with a gray value greater than a certain threshold are classified as object pixels, and other pixels with a gray value smaller than the threshold are classified as background pixels. Mathematically, the bi-level thresholding is expressed using Equation (1).

$$f'(x,y) = \begin{cases} a_1 & \text{if } f(x,y) < T \\ a_2 & \text{if } f(x,y) \geq T \end{cases} \tag{1}$$

where f '(x, y) is the new intensity of the pixel at position (x, y), a1 the lower intensity value, a2 the upper intensity value, f (x, y) the intensity of the old image at position (x, y), and T are set threshold value.

In multi-level thresholding, the pixels are compared against some set threshold values. The number of threshold values depends on the number of image segments that want. Mathematically, the multi-level thresholding process is expressed using Equation (2).

$$f'(x,y) = \begin{cases} a_1 & \text{if } f(x,y) < T_1 \\ a_2 & T_1 \leq f(x,y) < T_2 \\ a_3 & \text{if } f(x,y) \geq T_2 \end{cases} \tag{2}$$

where f '(x, y) is the new intensity of the pixel at position (x, y), a1 the lower intensity value, a2 the middle-intensity value, a3 the upper-intensity value, f (x, y) the old image intensity at position (x, y), and T1 is the lower threshold value and T2 is the specified upper threshold value.

The Multi-level thresholding allows as many as n desired segments.

2.2 Image Analysis

The system effectiveness is calculated based on the parameters Recall, Precision, F-Measure, and accuracy. This calculation uses Equation (3), (4), (5), and (6).

$$\text{Recall} = \frac{TP}{TP+FN} \tag{3}$$

$$\text{Precision} = \frac{TP}{TP+FP} \tag{4}$$

$$F - \text{Measure} = 2 \times \frac{\text{Recall} \times \text{Precision}}{\text{Recall} + \text{Precision}} \tag{5}$$

$$\text{Accuracy} = \frac{TP+TN}{TP+FP+TN+FN} \tag{6}$$

where TP is the true positive region, TN is the true negative region, FP is the false positive region, and FN is the true negative region.

True positive (TP) is an overlap part between the ground truth and detection results. The part which is included in the ground truth, but not in the detection result and this part is False Negative (FN). The part which is included in the detection result, but not in the Ground Truth and this part is False Positive (FP) [21].

III. RESULTS AND DISCUSSIONS

Taking an image using a thermal camera obtained the image shown in figure 4.
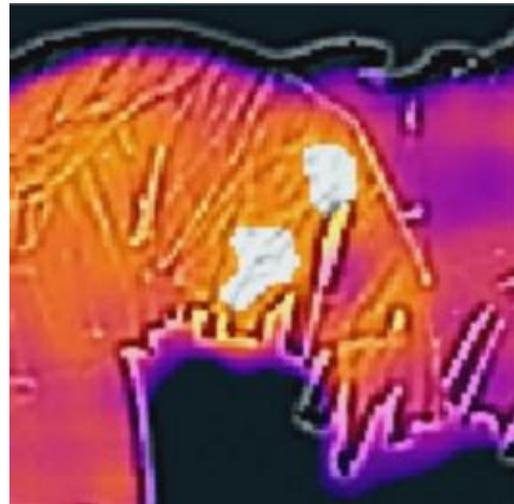
Figure 4. Image of leaves on banana plants that have spots caused by plant diseases.

To determine whether a leaf spot can be detected, it is necessary to compare it using images taken using a digital camera. The image is taken at the same position, shown in figure 4. In order to have the same position, it is necessary to carry out an image registration process.
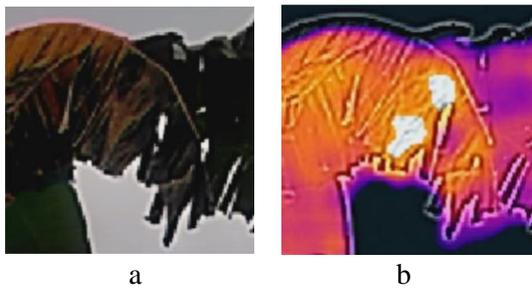
Figure 5. Using a digital camera (a) and using thermal camera (b)

Figure 5 shows images that was taken using a digital camera (a) when compare to the thermal camera (b) in the same position. The image from the digital camera is used as a guide for the position of the leaf spot by turning it into a ground truth image, shown in figure 6. The ground truth image is created by manually marking the position of the spots in the image.

a. Original image   b. Ground Truth
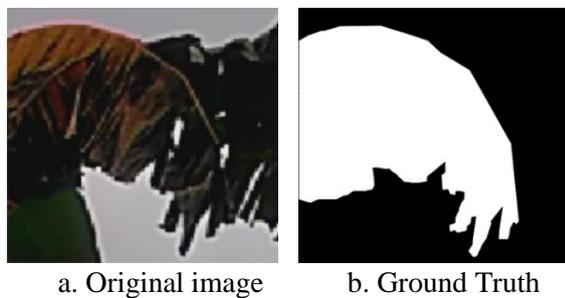
Figure 6. Result of making ground truth manually

The image obtained by using a thermal camera is processed to produce a black and white image where the white color shows the leaf spots and the black color is the background. Image processing used is a multi-level thresholding technique. Image processing results are shown in figure 7.

a. GT Manual   b. Segmentation   c. Results
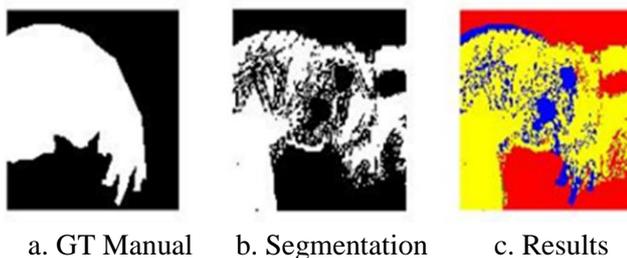
Figure 7. Result from processing thermal image

The resulting image from thermal image processing is compared with the ground truth image to obtain true positive, False Negative, False Positive, and True Negative values. Image comparisons are shown in figure 7. The comparison of the two images produces the pixels including 183179 pixels of True Positive, 45173 false negatives, 1047 false positives, and 118701 true negatives. The image size is 590 pixels wide by 590 pixels high, as can be calculated as follow:

$Recall$ = TP / (TP + FN) = 183,179 / (183,179 + 45,173) x 100% = 80,22%

$Precision$ = TP / (TP + FP) = 183,179 / (183,179 +1,047) x 100% = 99,43%

$F\text{-}Measure$ = 2 x $(Recall x Precision)/(Recall+ Precision)$ = 2 x 0,44398 = 88,79%

$Accuracy$ = (TP + TN) / (TP + FP + TN + FN) = 301,880 / 348,100 = 86,72%.

The effectiveness of the method offered can be measured by calculating the values of Recall, Precision, F-Measure, and Accuracy [21]. The method offered is considered quite effective if the Recall and Precision values are greater than 60%.

IV. CONCLUSIONS

This paper proposes a technique to detect disease-induced leaf spot in banana plants using a thermal camera. The proposed method is quite effective in detecting disease-induced spots on banana leaves. This is obtained from the recall value which reached 80,22% the Precision value was 99,43%, the F-Measure value was 88,79%, and the accuracy level reached 86,72%. The future work may be conducted on the observations to determine the speed at which the disease is spreading and to study on how to prevent the condition.

REFERENCES

[1] Triwidodo H, Tondok ET, Shiami D A 2020 The Influence of Plant Varieties and Different of the Ages on Population Numbers and Infestation Rate of Banana (*Musa sp.*) Pests and Diseases in Sukabumi Regency. Jurnal Agrikultura vol. 31 issues 2 pp 68-75.

[2] Sibarani SMA, Joko T, Subandiyah S 2019 Detection and Identification of Banana-associated Phytoplasma Using Nested-PCR Method. Jurnal Perlindungan Tanaman Indonesia vol 23 no 1 pp 148–155.

[3] Singh V, Misra AK 2017 Detection of plant leaf diseases using image segmentation and soft computing techniques vol 4 pp 41-49.

[4] Varshney S, Dalal T 2016 Plant Disease Prediction Using Image Processing Techniques - A Review International Journal of Computer Science and Mobile Computing, 5(5): 394-398.

[5] Vipinadas MJ, Thamizharasi A 2016 Banana Leaf Disease Identification Technique. International Journal of Advanced Engineering Research and Science (IJAERS) vol 3 issues 6 pp 120-124.

[6] Vipinadas MJ, Thamizharasi A 2016 Detection and Grading of diseases in Banana leaves using Machine Learning. International Journal of

Scientific & Engineering Research (IJSER), vol 7 issues 7 pp.916-924.

[7] Kumar V, Gokulpriya D, Subharatha R, Dineash V 2018 Banana Tall Plant Disease Detection and Classification Using Image Processing and Artificial Neural Network. International Journal of Advanced Science and Engineering Research vol 3 issues 1 pp 452-459.

[8] Tigadi B, Sharma B 2016 Banana Plant Disease Detection and Grading Using Image Processing. International Journal of Engineering Science and Computing (IJESC) vol 6 issues 6 pp 6512-6516.

[9] Silva, SHMG, Moraes,WS, Bendini, HN, Padovani, RC, Lima, JD, Rozane, DE, Modenese, JF 2008 Digital image processing for identification of Black Sigatoka. Proceedings of the International Conference of Agricultural Engineering, XXXVII Brazilian Congress of Agricultural Engineering, International Livestock Environment Symposium - ILES VIII.

[10] Shaikh S, Akhter N, Manza R 2019 Current Trends in the Application of Thermal Imaging in Medical Condition Analysis. International Journal of Innovative Technology and Exploring Engineering (IJITEE) vol 8 issues 8 pp 2708-2712.

[11] Choda G, Rao GHR 2020 Thermal Imaging for the Diagnosis of Early Vascular Dysfunctions: A Case Report. Journal of Clinical Cardiology and Diagnostics vol 3 no 17 pp 1-7.

[12] van Doremalen RFM, van Netten JJ, van Baal JG, Vollenbroek-Hutten MMR, van der Heijden F 2020 Infrared 3D Thermography for Inflammation Detection in Diabetic Foot Disease: A Proof-of-concept. Journal of Diabetes Science and Technology vol.14 no 1 pp 46-54.

[13] Patil TG, Shekhawat SP 2018 Thermal Image Processing in Holticulture Sector -A Review International Journal of Science, Spirituality, Business, and Technology (IJSSBT). Vol 6 no1 pp 46-53.

[14] Aryalekshmi BN, Biradar RC, Ahamed JM 2019 Thermal Imaging Techniques in Agricultural Applications International Journal of Innovative Technology and Exploring Engineering (IJITEE) vol 8 no 12 pp 2162-2168.

[15] Yang N, Yuan M, Wang P, Zang R, Sun J, Mao H 2019 Tea diseases detection based on fast infrared thermal image processing technology. Journal Sci Food Agric vol 99 pp 3459–3466.

[16] Lubis A 2020 Thermal Imaging Detection of Leaf Damage in Chili Plants. Riau Journal of Computer Science vol 6 no1 pp 81-83.

[17] Oerke E-C, Steiner U, Dehne H-W, Lindenthal M 2006 Thermal imaging of cucumber leaves affected by downy mildew and environmental conditions. Journal of Experimental Botany vol 57 no 9 pp 2121–2132.

[18] Raza S-A, Prince G, Clarkson JP, Rajpoot NM 2015 Automatic Detection of Diseased Tomato Plants Using Thermal and Stereo Visible Light Images. PLoS One vol 10 no 4 pp 1-20.

[19] Al-doski J, Mansor S, Mohd Safri HZ 2016 Thermal Imaging for Pests Detecting—A Review. International Journal of Agriculture, Forestry, and Plantation, vol 2 pp 10-30.

[20] Arora S, Acharya J, Verma A, Panigrahi P K 2008 Multilevel Thresholding for Image Segmentation Through a Fast Statistical Recursive Algorithm Pattern Recognition. Letters vol 29 pp 119–125.

[21] Setyawan FXA, Tan JK, Kim H, Ishikawa S 2014 Detecting moving objects from a video taken by a Moving Camera using sequential inference of background images. Artificial Life Robotics vol 19 pp 291-298.