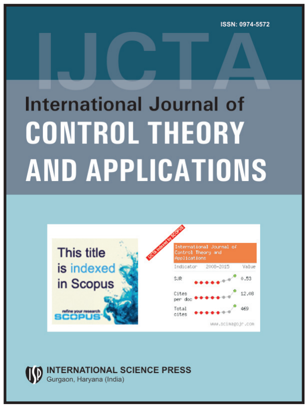

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Banana Plant Diseases Recognizer

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Abstract: This paper presents the development of a knowledge-based system that has capability to identify types of banana plant diseases based on the images of the leave and corm (pseudo stem). The banana plants diseases were spreading widely in Malaysia and has affected to the loss of production. Thus, having a knowledge-based system that can assist the farmers and agricultural officers would be a great tool. Several image processing techniques, including image enhancement, segmentation and feature extraction were applied and then the images were classified using fuzzy rules. The data was collected from several farms in Jelebu, Negeri Sembilan and evaluated by the expert. A total of 240 sample of images from three different categories in wilting diseases (Panama and Blood Disease Bacterium/Moko) were used in this study. Meanwhile, for spot diseases (Sigatoka, Cordana and combine or unknown), another 240 sample of images were used and most of them were recognized successfully but only had problem in differentiating Cordana and Sigatoka which depend on the circularity. Around 20% of Cordana and Sigatoka samples were misplaced due to the problem of too many circle spots that were not similar its circularity. Several techniques of colour space such as HSV and YCbCr were experimented, and the latter technique found to be better than HSV in recognizing the wilting leaf. Hence, YCbCr was used in extracting the corm puke and spot features because it can show the wound more precisely. The processed image features were then integrated with fuzzy sets and Mamdani inference approach in recognizing the leaf disease.

Keyword: Agriculture, Banana Diseases, Classification, Fuzzy Logic, Image Processing.

1. INTRODUCTION

Among of many diseases affected the banana plants are Panama and Moko/Blood Disease Bacterium; and most of farmers are still clueless on the efficient and effective ways in treating these diseases [1]. Moreover, these incurable diseases may be infecting other plants and cause a dead farm which was first discovered attacking the banana crop plant in Johor in 2007 [2]. Inducement of the problem, it may be beneficial for farmers to gain early recognition of these diseases as the diseases can easily spread to the healthy banana. Therefore, the conservation and preservation actions are important in order to control the diseases. This study focused in examining the images with appearance of abnormalities in corm (vascular tissues) and leaf in detecting the diseases. The experiment was done on the Saba hybrid (Musa (ABB Group) 'Saba') cultivar or also known as 'Pisang Nipah' in Malaysia. The study aimed to differentiate two almost similar diseases which are Sigatoka and Cordana for spot disease and, Panama and Moko/Blood Disease Bacterium for wilting disease type.

2. RELATED STUDIES

The most popular disease researched in literatures was Sigatoka since it is distinct in spots appearance [3]–[5]. In [3], Neural Network and K-Neural Network were applied as classifiers in detecting diseased leaves in several types of plant, such as banana, lemon, coconut and mango. Other than that, Owomugisha and colleagues in [4] reported Extremely Randomized Tree is the best method among seven tested classifiers with color histogram feature vectors. Next, the extracted features in [5] were based on region, shape and texture in order to calculate the percentage infected area for Black Sigatoka. Moreover, in other study, fuzzy technique [6] was able to recognize 67% and 70% of Anthracnose and Downy Mildew watermelon leaf respectively by using three inputs dominant pixel RGB (mean). Later, [7] also did apply fuzzy for orchid disease with implementation of Mean of Maximum (MoM), Centre of Area (CoA) and Centre of Maximum (CoM).

Fuzzy classification is a process of classifying the features using fuzzy sets and fuzzy inference approach. By definition, fuzzy logic is a process of allowing partial membership set to be brought rather than the crisp membership sets. The capabilitiy of fuzzy logic is well known in handling imprecise data and transforming the qualitative meaning into quantitative phrase. The integration of image processing and fuzzy logic technique has shown a promising result.

3. DATA COLLECTION AND KNOWLEDGE REPRESENTATION

The images were captured at several farms in Jelebu by the guidance and permission of an expert, who is the officer in Agriculture District Office Jelebu. After that, the images were verified and validated based on the exact type of disease. However, some of them were insufficient enough to be identified and these particular images were removed. Next, the knowledge of these disease types were represented in the form of rules and the rules were generated based on the information and discussion with the expert. These rules were then evaluated to ensure its feasibility for the prototype implementation. Then, the fuzzy values were identified based on the taken images for the corms and leaves. For the leaves the simple low-med-high fuzzy value were considered which was based on the circularity, circle count and colour appearance (i.e. brown, yellow, light green, and green). Besides that, the corm features were the fuzziness of amount of wound (puke) for the centre part compared to the outer part and these features were used in identifying whether it was Moko (BDB) or Panama. The generated rules were adjusted and refined after the training and the testing phases. We implemented training using holdout method for four different sets composition: 60-40%, 70-30%, and 80-20% , which randomly reshuffled for 3 times in each iteration.

4. METHODOLOGY

A. Image Processing

Firstly, the raw images were going through an enhancement process including the process of cropping, brightness, sharpening, threshold, segmentation and resizing. Each image was then filtered and smoothed for the recognition process. The image was also masked to circularly or in free hand to remove any unwanted background like grass or the hand. Next, the conversion process took place to transform the RGB to several colour spaces. After some training on the colours such as Hue Saturation-Value (HSV), YCbCr (Y stands for Luminance or Light (luma), Cb for Chroma Blue (blue minus luma) and Cr for Chroma Red (red minus luma), negative, black and white, and grayscale; the better colour space found for this project were HSV or YCbCr.

B. Feature Extraction

The features were extracted from leaves image are circularity, circle count and colour appearance for brown, yellow, light green, and green; to identify the wilting degree and spot diseases (Sigatoka and Cordana). Both HSV and YCbCr images were used in getting the colour appearance as experimental step in identify which is a better colour for recognizing the wilting stage. But, for the corm, the amount of wound (puke) pixels for the centre part was compared to the outer part in identifying whether it was BDB or Panama. For detecting the circle and circle count, the raw image (RGB) was transformed to YCbCr first, and then to binary form in getting the exact value of wounds since it was found as the best colour to recognize the spot or wounds on the image based on the earlier experiment done as seen in Figure 1.

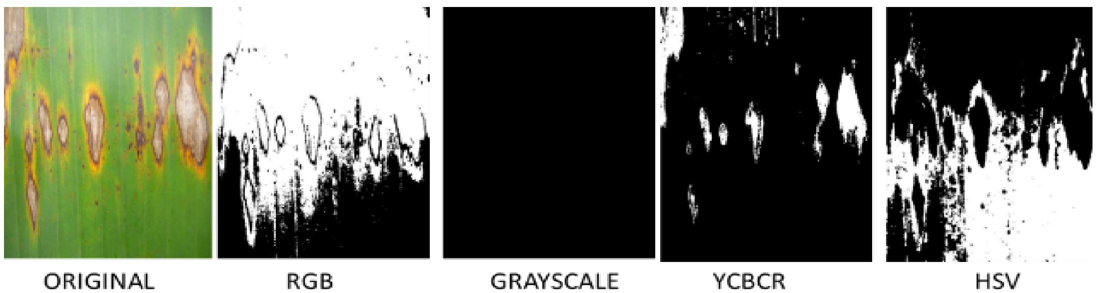


Figure 1: The converted format of image

After the colour conversion, some images were cleaned to remove any hole that is smaller than 30 pixels. These holes were filled and reshaped so that the roundness of the circle can be easily detected. The circularity percentage and circle count were recorded and measured using Eq. 5 and the HSV and YCbCr were converted from RGB by using Eq. 2 - Eq. 3 and Eq. 1 respectively.

$$\begin{pmatrix} Y' \\ C_B \\ C_R \end{pmatrix} = \begin{pmatrix} 65.481 & 128.553 & 24.966 \\ -37.797 & 74.203 & 112.0 \\ 112.0 & 93.786 & 18.214 \end{pmatrix} \begin{pmatrix} Y' \\ C_B \\ C_R \end{pmatrix} \tag{1}$$

$$H = \frac{0.5[(R' - G') + (R' - B')]}{\sqrt{[(R' - G')^2 + (R' - B')(G' - B')]}} \tag{2}$$

$$S = 1 - 3\frac{\min(R', G', B')}{R' + G' + B'} \tag{3}$$

$$V = \frac{1}{3}(R' + G' + B') \tag{4}$$

$$c = \frac{4\pi A}{P^2} \tag{5}$$

In extracting the features for corm puke, the image underwent the cleaning process and the same colour format (binary of YCbCr) were used to achieve better recognition. Then, the images were partitioned into 9 parts in which the 5th part acts as the centroid and others part as the outer part. The pixels of centre region and outer region were recorded. All those features were inserted into Notepad (.txt) files as shown in Figure 2. All these tasks of image pre-processing, feature extraction and classification were done by using MATLAB Mathworks R2015a.

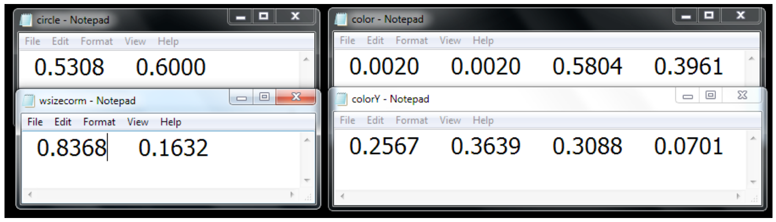


Figure 2: The circle features were extracted and recorded into text files

C. Classification

When the image processing phase was completed, the fuzzy inference engine was developed. Fuzzy classification rule set was used to identify either the banana is diseased or not and to identify which disease that relying on the banana based on the feature extracted previously. The feature was then evaluated in fuzzy engine in order to get the result. The prototype applied Mamdani approach since it is widely accepted. After the disease was detected, the user is given information on the action that is needed based on the diseases. Generally, the process begins by uploading the leaf image in which the engine will detect whether the spot or wilting disease. If the Panama or BDB is detected, the system would start testing the corm condition for wilting. This sequential approach was performed in order to preserve the dynamic abilities in testing either corm or leaf based on the acquired data.

5. RESULT AND FINDINGS

The fuzzy rule set was generated based on several training and testing iterations. The YCbCr color code was found as the best colour space in emphasizing the detection of the wounds on the images. The recognition is successfully done in differentiating the wilting diseases, spot diseases and determining the wilting stage and spot stage. Table 1 shows the success rate for the final testing phase after refinement of the rules with 80/20 ratio. Table 1 and Table 2 show the result of the testing sample in recognizing the diseases. In total the fuzzy rule set contains of 81 rules for identifying wilting stage, 9 rules for spot disease and 9 rules for wilting disease.

Table 1
Result on success rate of wilting stage for HSV and YCbCr

Sr. No.	*Colour Code*	*Expected Wilting*	*Actual Wilting*	*60/40*	*70/30*	*80/20*	*Success Rate (%)*	*Average of Colour Code*
1.	HSV	Safe	Safe	91	88	94	90	97%
2.	HSV	Wilting	Wilting	100	100	100	100	
3.	HSV	Serious	Serious	100	100	100	100	
4.	YCbCr	Safe	Safe	100	100	100	100	100%
5.	YCbCr	Wilting	Wilting	100	100	100	100	
6.	YCbCr	Serious	Serious	100	100	100	100	

Table 2
Result on success rate of types of disease for HSV and YCbCr

Sr. No.	*Image Type*	*Expected Disease*	*Actual Disease*	*60/40*	*70/30*	*80/20*	*Average*
1.	Leaf	Sigatoka	Sigatoka	100	100	100	100%
2.	Leaf	Cordana	Cordana	100	100	100	
3.	Leaf	Combined	Sigatoka	100	100	100	

4.	Corm	BDB	BDB/Moko	100	100	100	100%
5.	Corm	Panama	Panama	100	100	100	
6.	Corm	Normal Wilting	Healthy Corm	100	100	100	

For user interface, it provides the users option to pick either image of corm or leaves, and then entered image processing, feature extraction and recognition phase. Figure 3 shows a screenshot of the user interface.

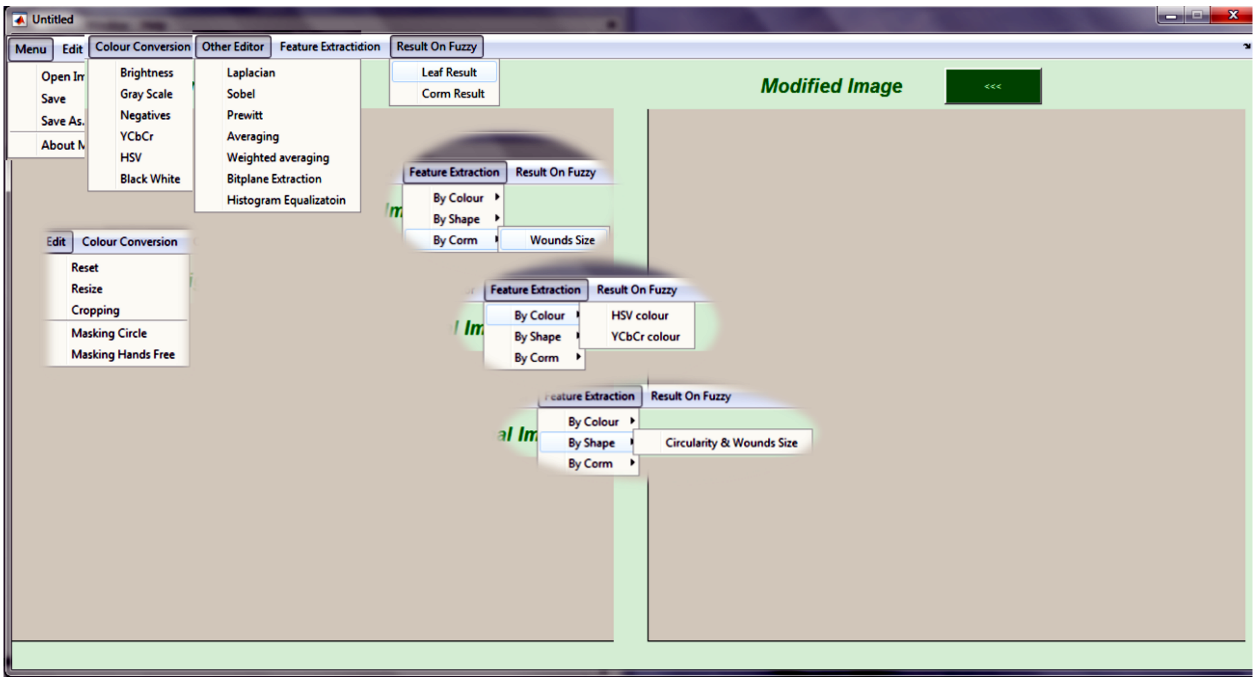


Figure 3: The screenshot of the user interface.

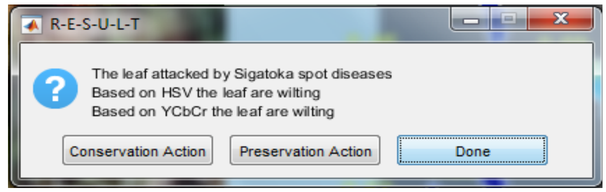
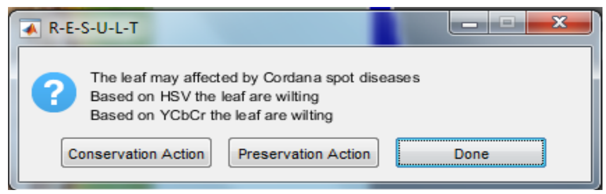
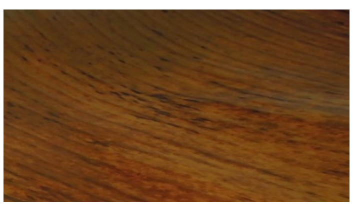
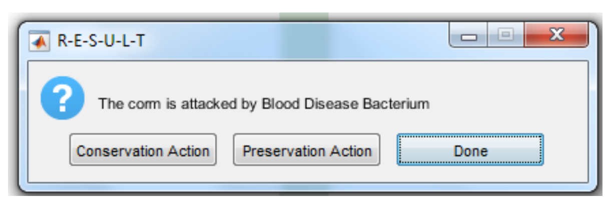
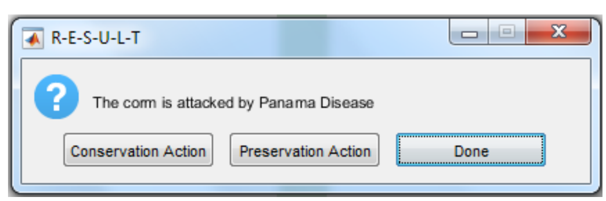
The GUI was developed using MATLAB to give the user-friendly touch by providing the Menu tabs instead of button to show the software in more professional look and versatile. In the image processing phase, user may edit the image to get the required region by cropping, scaling (resize) and masking. Next, the colour conversion and brightness of the image is applied. This prototype also provides other editor such as Sobel and Prewit threshold, so that the user can experimentally tested it in order to get better result. For the Feature Extraction, the user may click the sub menu of Colour, Circularity and Corm. Then, the features are inserted to text files and processed after the user click on the "Result on Fuzzy" (either as leaf or corm), calculated the outcome of fuzzy inference (.fis) and the result will be popped out. After that, the user needs to click either "Preservation" or "Conservation" to see the step of controlling the diseases. The prototype has also been tested by the Agriculture District Office Jelebu for the validation and verification purpose. Table 3 shows the selected images and the agriculture officer view on the leaf with infected disease.

6. CONCLUSION

The fuzzy expert system for Banana Plant Diseases Recognizer, that is integrated with image processing technique had been modelled and evaluated. The result shows that the prototype is capable in recognizing the diseases and differentiating those diseases. We found that the YCbCr technique is a better colour space, circularity and puke pixels' detection on the image compared to the other technique, HSV. For future work, the colour detection algorithm can be improved with a better analysing technique. The detection of spot diseases could include the inside-outside colour and its length based on the fact given by the expert. As a conclusion, the Banana Plant

Diseases Recognizer which is integrating fuzzy rules and image processing technique is an education, assistance system and innovative way in keeping preservation and conservation to banana plantation in Malaysia and probably other countries as well. Hopefully this project will provide some benefits and knowledge for those who need it and bring up success to national crop plantation industry especially in banana planting.

Table 3
Table of result on expert's evaluation

Image	*Expert Assumption*	*Result from the Prototype*
	Sigatoka	Sigatoka 
	Cordana	Cordana 
	Wilting	Wilting (HSV) Seriously Wilting (YCbCr)
	Healthy	Healthy (HSV) Healthy (YCbCr)
	Moko/BDB	BDB 
	Panama	Panama 

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