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Banana Fruit Classification using Convolutional Neural Network

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Abstract: Identifying and recognition is the one of main importance process that has been used in many industries nowadays. To make this process more efficient, the technology such image processing needs to be used. One of industry which is in a lot of demand nowadays is fruit industry. The quality care for fruit plant should be emphasized by the farmers to ensure the fruit that produced is healthy. People usually use guide books or website to recognize the fruit maturity and this consuming a lot of time and hard to bring the accurate result. An automated detection system can help to identify the types of fruit maturity with more efficient. The purpose of this research is to build a banana fruit classification system for identifying whether the banana fruit is raw, ripe or overripe. This project uses 90 images of three different type of banana fruit ripeness. The method used in this research contains several stages, the stages that involved in this research is input image, preprocessing image, segmentation, classification and performance measure. The input images are from the three types of banana fruit ripeness which is raw, ripe and overripe. The dataset is divided into three categories which is training, validation and testing. 20 images from each category are used for training and validation while the remaining dataset used for testing process. In preprocessing stage, resizing input image, conversion from RGB image to grayscale image and reducing noise using median filtering method are performing in thisstage. In segmentation stage, the images are segment using Sobel edge extraction. Inclassification stage, the features extraction and identifying process of the banana fruitripeness is performing in this stage using Resnet-50 classifier. The performance measureis the calculation of mean squared error (MSE), peak signal-to-noise ratio (PSNR), accuracy, and error. The proposed method is capable to determine whether it raw, ripeor overripe. The proposed method also shows that the accuracy and error for raw banana is 92.70% and 7.30% respectively while for ripe banana is 94.32% and 5.68%respectively and lastly, for overripe banana is 95.41% and 4.59% respectively. In conclusion, this project achieved the objective which is to develop a banana fruit classification system using convolutional neural network to determine whether the banana is raw, ripe and overripe.

Keywords: Convolutional Neural Network, Classification

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1. Introduction

In recent years, computer vision based Convolutional Neural Networks (CNNs) approaches have become extremely popular to solve several real-life challenges such as traffic categorization, weather forecasting, fruits, and vegetables' classification due to its high prediction accuracy/categorization in the target applications [5]. Convolutional Neural Network A convolutional neural network is a special class of neural network that is best suited for the intelligent processing of visual data [6]. In this project, convolutional neural network will be used to classify the banana fruit.

Fruit classification is an important task to improve the productivity of agri- food production. Image processing technology has been used to make this process more efficient. Image processing is a technique for performing operations on a digital image. Thus, this operation helps to analyze and control the image's information. The image processing method in this project proposal will be based on classified the fruit using convolutional neural network.

Agricultural productivity is an important product for a country's economy. Banana fruit is one agricultural product that is in high demand right now. Normally, banana fruit is used to make foods such as banana fritters, 'cekodok pisang,' and desserts. Bananas of any maturity level provide similar benefits. Knowing the level of maturity, on the other hand, can help determine what type of banana the body requires. Overripe bananas, for example, are not recommended for diabetics due to their high sugar content. Classification of banana fruit maturity is required to assist customers in selecting bananas based on the level of banana maturity required for consumption.

The banana plant is one of the crops that are commercialized abroad. However, the process to determine the maturity of bananas is still done manually. Fruit classification is an important and challenging task in the agriculture industries such as food production, marketing, packaging, and education as well [2]. One of the most expensive demands in agricultural production is the acquisition of skilled farm workers. In such consequence, automation can reduce the labor cost and increase production rapidly [2].

This paper about to propose an automated system that can identify the types of banana fruit by applying Convolutional Neural Network (CNN). The levels of ripeness measured are raw, ripe, and overripe. The image processing tools from MATLAB software is used to perform all this process into the banana fruit image. The suitable algorithm such as median filtering technique, Sobel edge extraction and Resnet-50 classification is applied into the process to identify the type maturity of the banana fruit.

S. R. N. M. Ayyub and A. Manjramkar [10] have proposed a project to identify and classify the fruit disease using image processing. K-means clustering algorithm is used for segmentation of disease and for training and classification multi-class support vector machine is used as classifier. From S. Lu, Z. Lu, S. Aok and L. Graham [3], proposed the classification method based on fruit image and deep learning. The project designs a six-layer CNN to identify 9 different types of fruit. G. Zeng [7] proposed a novel fruit and vegetables classification system based on image saliency and VGG model. The image preprocessing based on image saliency is added to reduce interference and noise caused by complex background on feature extraction. M. I. Dinata, S. Mardi Susiki Nugroho and R. F. Rachmadi [8] proposed a classification system of six leaf disease in strawberry plants by using convolutional neural network. The stage that involves is image acquisition, image preprocessing and classification. For preprocessing stage, the image is enhanced by scaling and changing contrast and brightness. For classification, eleven-layer CNN model is used to classify the leaf disease.

The structure for this study is presented as follows, Section 2 is a part explanation for method use in the study. While for Section 3, it discusses about the result that achieve from study. Finally, the overall summary for this study is conclude in Section 4

2. Research Methods

The stages that are involved in this research are input image, preprocessing image, segmentation image, classification image and performance measure. The input images are from the three types of banana fruits maturity which are raw banana, ripe banana, and overripe banana. The preprocessing image stages are resizing image, converting RGB image to grayscale image, filter image using median filtering method and calculation of mean squared error (MSE) and peak signal-to-noise ratio (PSNR). Segmentation image stage is segmenting the filtered image using Sobel edge detection method. The classification stage is applied Resnet classifier to classify the banana categories. Lastly, performance measurement stage is the calculation of accuracy and error of the classification system. Figure 1 shows the flowchart of the overall system.

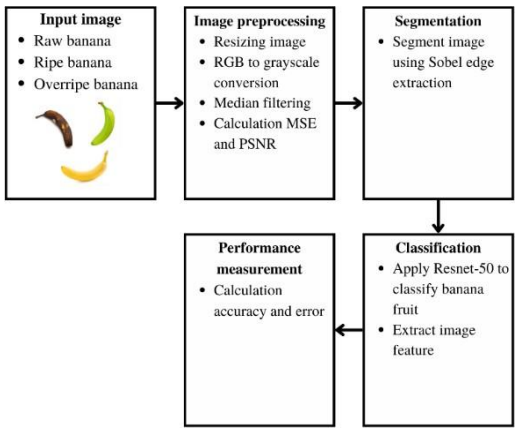


Figure 1: Block diagram for proposed system

2.1 Image Acquisition

The process of retrieving an image from a source is known as image acquisition.The images are selected from the dataset in order for the system to analyze the images. Inthis project, the dataset is obtained from Kaggle and Google website. The dataset contain 30 banana fruit images for each type of fruit maturity which are ripe, raw and overripe. On this system, the dataset is used for training, validation, and testing. 20 images will be used for training and validation, with 20% used for training, 80% used for validation, and 10 images used for testing each category type.

2.2 Image preprocessing

Image preprocessing method is a necessary step in image processing. This step is required to clean the input data image for use in the next process. By resizing the input image, the system begins the image processing process. The input RGB image is then converted to grayscale, and noise is reduced using median filtering techniques. Finally, the mean squared error (MSE) and peak signal-to-noise ratio (PSNR) are calculated to evaluate the input image's quality improvement. Figure 2 shows the output of resizing image, conversion RGB to grayscale and median filter.

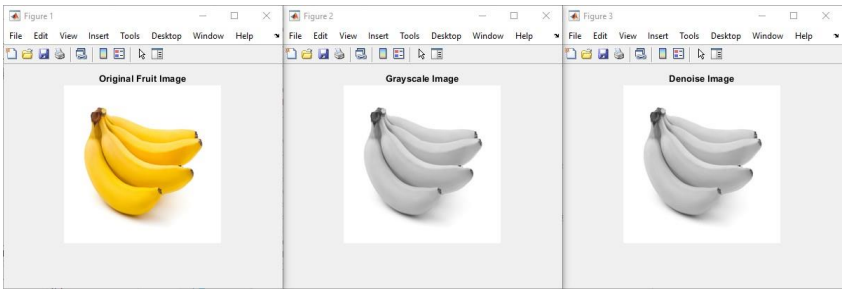


Figure 2: Output for image preprocessing

2.3 Image segmentation

The segmentation process in this system is using Sobel edge detection. The filter Sobel is one of the most common algorithms to detect edges. The differential method is discrete and measures a gradient representation of the image intense function. The analysis is based on converting the image into a horizontal and vertical direction with a small, separable, and integer value filter, making computing inexpensive. As an orthogonal gradient operator, the gradient is a derivative operator and the first derivative operator. Figure 3 represent the result of applying Sobel edge extraction.

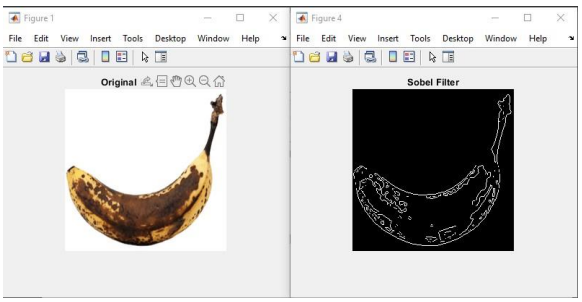


Figure 3: Output for Sobel edge extraction

2.4 Classification

In any detection system, the classification process is the most important. The classification process in this system is intended to determine whether the banana fruit is raw, ripe, or overripe. To solve the classification problem, convolutional neural networks (CNNs) are used. Resnet classifier is applied in the system to classify the banana fruit. In the classification process, a group of datasets for train data is required to identify the desired data information to be classified. The first layer of ResNet-50 is defined as input dimension and the final layer is defined as the classification layer. The "fc100" layer is responsible for extracting features from the input image. Figure 4 illustrated the first layer of Resnet.

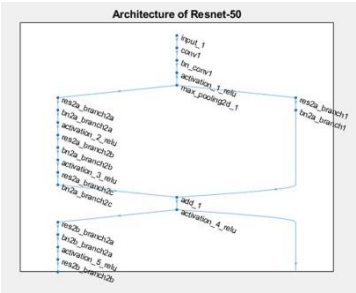


Figure 4: Architecture of Resnet-50

2.5 Performance measurement

In this process, MSE, PSNR, accuracy and error are calculated to indicate the performance of preprocessing stage. Image compression qualities are compared using MSE and PSNR. MSE is the cumulative squared error between the compressed and original images,and PSNR is the measured peak error. The smaller the MSE value when calculating the error, the smaller the error and the higher the PSNR when calculating the PSNR, the better the quality of the compressed or reconstructed image. Equation 1 and Equation 2 represent the formula for MSE and PSNR.

$$MSE = \frac{\sum_{M,N} [I_1(m,n) - I_2(m,n)]^2}{M * N} \quad (Eq\ 1)$$

$$PSNR = 10 \log_{10}\left(\frac{R^2}{MSE}\right) \quad (Eq\ 2)$$

Accuracy is defined as the percentage of images correctly classified by the classification system. True positive (TP), true negative (TN), false positive (FP), and false negative (FN) are the terms used in the calculation. TP indicates both the actual and predictive results are True. FP is an error which indicates the actual result should be False, but the predictive result is True. TN indicates both the actual and predictive results are False. FN indicates the actual result should be True, but the predictive result is False. Table 1 below shows the formula that has been used to calculate the system performance.

Table 1: Performance measurement formula

Measurement	Performance formula
Accuracy	$accuracy = \frac{(TN+TP)}{(TN+TP+FP+FN)}$
Error	$error = \frac{(FP+FN)}{(TN+TP+FP+FN)}$

3. Results and Discussion

3.1 Performance measurement

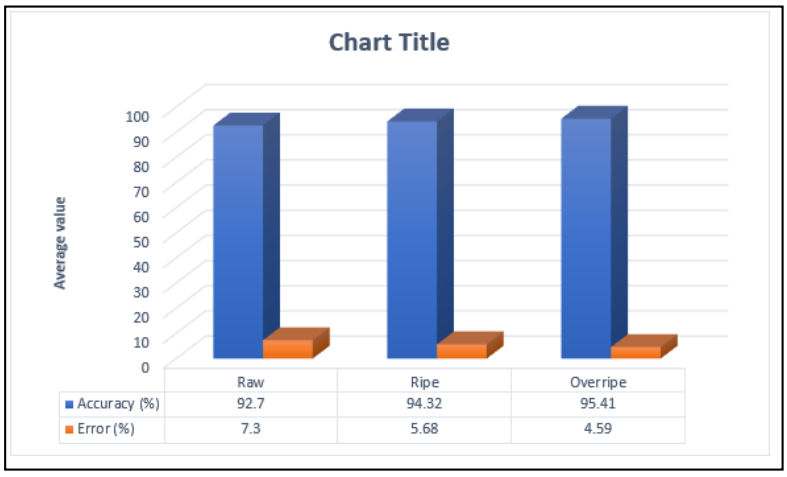
Table 2 shows the result of MSE and PSNR for each type banana fruit maturity. The MSE and PSNR result represent the performance of preprocessing image process. The closer the MSE value is to zero, the better the results produced. From the result, ripe banana fruit category achieved the MSE value nearest to zero. For PSNR, the higher the value of PSNR, the better the quality of the image. Ripe banana fruit category has the highest value of PSNR than raw and overripe banana fruit category.

Table 2: MSE and PSNR result

Category	MSE	PSNR
Raw	0.07	64.05
Ripe	0.00	72.92
Overripe	0.01	71.76

The performance of the classification process is measure by accuracy and error. Graph 1 illustrate the comparison of accuracy and error between raw, ripe and overripe banana fruit category. The average accuracy performance of overripe banana fruit category is higher than raw and ripe banana fruit category. For the error, overripe banana fruit category has lower error value than raw and ripe banana

fruit category. This result represents that this system able to classify the type of banana fruit maturity precisely.



Graph 1: Performance comparison between raw, ripe and overripe banana

3.2 Graphic User Interfere (GUI)

Graphic User Interface (GUI) is a program that gives the user a better perspective to understand the system. In this GUI, there are four push buttons to analyze the image which are load image button, conversion from RGB image to grayscale image button, filter image button and segment the image button. The user can use any image of banana fruit to test the system. For classify the image, user must click the class push button in the classification section to classify the banana fruit image. There are four push buttons in the result section to calculate the performance measurement which are mean square error button, peak signal noise ratio button, accuracy button and error button. Figure 5 shows the blank GUI for the system.

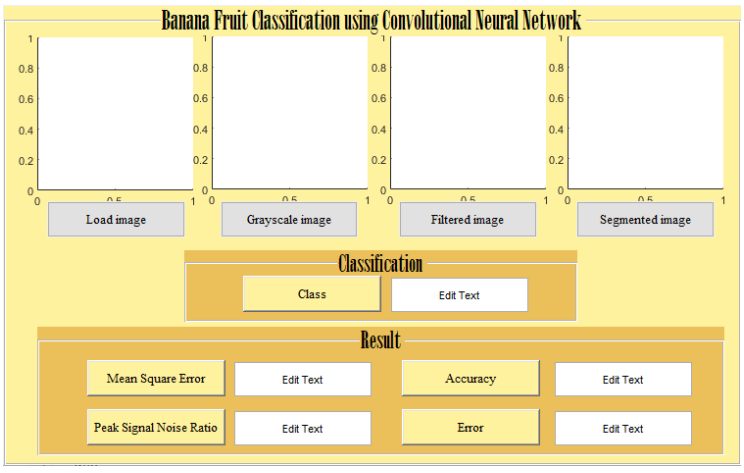


Figure 5: Blank GUI

After the user clicks all the buttons, the analyze image will be displayed and the user can classify the banana fruit image. Figure 6 shows the result of GUI for raw banana. The result shows the original image and their result after be analyzed. The input image has been converted into grayscale image and filtered by using median filtering. The edge of the image has been extracted in the segmentation process. After all the process, the system classifies the banana fruit image and the result of classification is raw category. In the result section, the calculation of mean square error and peak signal noise ratio indicate the performance of the system in preprocessing image stage. The calculation of accuracy and error

represent the measurement of the performance in classification process. The same process is used to analyze ripe and overripe banana fruit image. Figure 7 and Figure 8 are the result for ripe and overripe banana fruit.

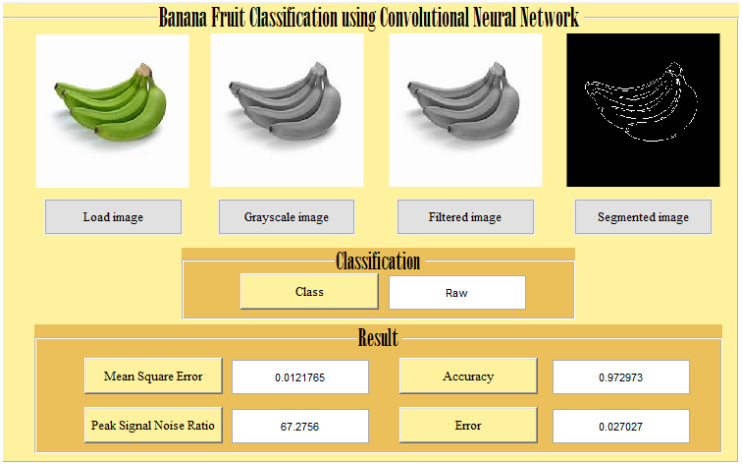


Figure 6: GUI for raw banana

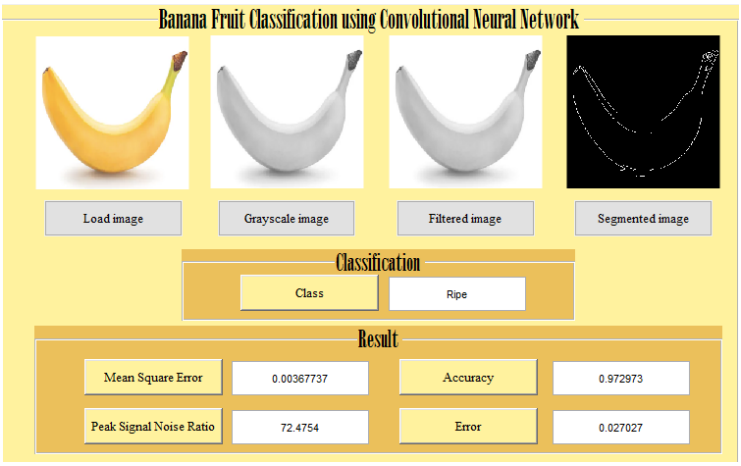


Figure 7: GUI for ripe banana

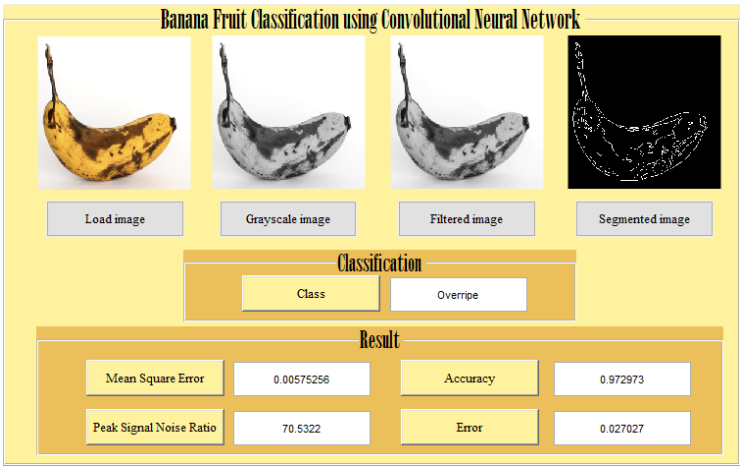


Figure 8: GUI for overripe banana

4. Conclusion

The aim for this project is to develop a classification system for banana fruit using Convolutional Neural Network (CNN). The result of the proposed system has been completed where the system has been tested and validated using the raw, ripe, and overripe databases. This project able to evaluate a system that can analyze the many types of banana fruit images to identify the maturity of the banana fruit. The objective to segment the banana fruit using image processing technique clearly achieved by using Sobel extraction. To verify the effectiveness of the method, its performance is measured in terms of accuracy and error. By classifying the ripeness of banana fruits, the results show that the proposed system works well.

In the future, the research can be improved by collecting more dataset from different resources to ensure the classifier can train the data efficiently. The system will be more accurate by increasing the amount of data on the train. In other words, the more the train data, the more accurate, sensitive and specific the classification process in the system. Besides, the system can be improved by improving image preprocessing method to enhance the input image for resulting more accurate in performance measurement. Lastly, the proposed system can help farmer to classify the fruit more efficient and effective by the proposed system applied on the smartphone

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