USE OF DEEP LEARNING AND K-NEAREST NEIGHBOR ALGORITHMS FOR RECOGNITION OF FRUIT TYPES

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Abstract

fruit recognition was done in this research specifically for fruit image. Most of the fruit detection process is still done manually, which is time-consuming and prone to inconsistencies and inaccuracies [5]. The recognition of fruit in this study can be implemented to know the number of fruits that exist. Fruit image trained into several labels (fruit types) that are classified by data testing. The purpose of this research is to increase the accuracy of the results with several processes and methods undertaken in this research until the classification process, one of this i.e. Gaussian filter to improve the quality of fruit image recognition. Furthermore, the feature extraction process uses Gabor filter and for feature selection, PCA technic is respectively used to select some of the best features. The selected feature will be classified using deep learning and k-nearest neighbor (k-NN) method. Moreover, the results of the processes done carried out in achieving an accuracy of 95.01%.

Keywords: Deep learning, Fruit recognition, Gaussian filter, Gabor filter, k-nearest neighbor (k-NN), Principal component analysis.

1. Introduction

The recognition of this type of fruit is often considered very important because the object that is detected is a human need in life. In terms of detecting the type of fruit, the system must be able to accurately, recognize the type. To recognize the problem of fruit detection accuracy, many researchers propose detection algorithms based on deep learning [1]. Fruit recognition can help fruit sellers to identify and differentiate various types of fruit that have the same similarities [2]. This is in line with the research conducted by Jun Lu; Nong Sang[3] using robot media to detect citrus fruits. As is the case with fruit detection, using an RGB camera as a detector of choice (for its practicality and ease of implementation) involves detecting fruit characteristics such as color, shape, and texture[4]. Fruit detection is often done by several researchers with the intention to facilitate in recognizing the faction or type of fruit, without having to think in advance if the person does not have much knowledge about the type of fruit. Most of the fruit detection process is still done manually, which is time-consuming and prone to inconsistencies and inaccuracies [5]. Research on the introduction of objects is mostly done in the field of medicine, to detect the type of a human disease. In principle, fruit is a good food for human growth. Therefore, the recognition of fruit type in this research is necessary for researchers as a contribution to the treasury of science, and to help most men in the recognition of fruit types.

Image processing technology is now widely applied in various areas of life. In the field of trade, image-processing technology is used in reading barcodes listed on goods in supermarkets. Image processing is also applied in the field of medicine, such as NMR (Nuclear Magnetic Resonance), robotic fruit recognition [3] and Reconstruction of Ultrasound Images.

Digital images can be grouped into two parts: a silence image that is a single image that is not moving and a moving image is a series of silence images displayed in a row, thus giving the impression on the eyes as moving images. Each image in the circuit is called as a frame.

A discrete (not continuous) of digital image, whether for its coordinate position or color, can be described as a matrix, in which the row index and the column index of the matrix represent the position of a point in the digital image and the price of the matrix element represents the color of the image at that point. According to Ryszard S. Choras [5], the digital image can also be expressed as a two-dimensional function f (x, y), where x or y are coordinate positions while f is the amplitude at position (x, y) which is often known as intensity or grayscale.

Refer to a research done by M. Omid et al [6] stated that the digital image is an image expressed in a digital data set and can be processed by a computer. The acquisition of digital imagery is carried out using various digital devices. For example, a cloud image is obtained through a digital camera as stated by D.M. Bulanon et al [7], the image of a newspaper article is obtained through a scanner, and the image of a signature is obtained through a light pen, the cells obtained through a microscope.

In this study, the research scope of a recognition is specifically for fruits. It is in-line with the research of Hulin Kuang et al [8]. The purpose of fruit recognition is to provide thorough information about the fruit as

well as to give consideration and recommended-fruit to people.

1.1. Analog Image Conversion

The digital image is a two-dimensional array or a matrix which elements express the gray level of the image element. Images are an important component in machine learning algorithms as well as in applications such as feature extraction, object detection, and object classification [9]. Therefore, the information contained is discrete, but the digital image is not always a direct result of the recording data of a system. Sometimes the data recordings are continuous like the images on television monitors, photos, rays, and so forth. Thus to obtain a digital image required a conversion process, so that the image can then be processed by a computer [6]. To convert a continuous image into a digital image is required the process of making the horizontal and vertical direction clues so that the image obtained in the form of a two-dimensional array. The process is known as the process of digitizing or sampling. In these elements, the array is known as a picture or pixel element. The division of an image into pixels by the size of this point will determine the spatial resolution obtained, which means the smaller the pixel size the smoother the image obtained because the information lost by gray level clustering on the lattice grid making process will be smaller.

Table 1. several correlated researches on fruit detection and recognition

Authors	Research RoI	Method	Result (Accuracy (%))	Year
R.M. Alonso-Salces et al	Fruit maturity	MLF-ANN	97 - 99	2004
J. Blasco et al	Citrus skin damage	Bayes theorem, morphology	82	2009
Jyoti Jhawar	Fruit color and texture	EMSNN, Linier regression	90 - 98	2016
Peng Wan et al	Fruit maturity	BPNN	99.31	2018
D.M. Bulanon et al	Fruit harvesting	halogen artificial lighting, thresholding-based segmentation, histogram tail	Average true positive rate of 0.70 and a false positive rate of 0.06	2008

The further required process in the above-mentioned conversion is the quantization process. In this process, the gray level of each pixel is expressed by an integer price. The integer price limit or the size of the gray level area used to denote the pixel gray level, which will determine the brightness resolution of the obtained image. If three bit is used to store the integer price, it will be obtained as many as eight levels of gray. The greater the number of gray levels used the better the image will be obtained because the continuity of the gray level will be higher that will have an approach to the original image.

In this research, we use image filtering technique i.e. Gaussian filter as technic for preprocessing phase, and Gabor filtering as the technic for feature extraction phase. Then for the feature selection technique, we use principal component analysis (PCA). From the process of feature selection, the matrix will be generated and then used as input in the classification process, using deep learning and k-nearest neighbor (k-NN) algorithms. Therefore, in this research, we use the image as input, and the result of the classification process, resulting accuracy that will determine the type of fruit to the dataset that we use.

According to a research conducted by R.M. Alonso-Salces et al [10], who examines the recognition of species based on the maturity of the fruit. In the sense that the type of fruit is classified by determining the ripe and raw fruit. In their research [10] a multivariate approach is used, which can accommodate some of the features presented in the image dataset. The method used was multilayer feed-forward artificial neural network (MLF-ANN), as a method of the classification process. The results obtained in the study they obtained with a ratio between 97 to 99% are categorized on the final label is "mature" and "raw".

Fruit type detection is also investigated by J. Blasco et al [11] who stated about the importance of early detection of fruit fragments such as rotting, wilting and others, in order to not contagious on other fruits. The data used in their research [11], is based on multispectral data. While the features available as a determinant component for the classification process is based on morphological features. That feature is used to clarify the image at the time of recognition or detection of fruit density.

The approach to or recognition of fruit types depends mostly on the visual characteristics of fruit and the methods used in distinguishing fruit types

from other objects using image processing techniques; however, the use of this method can be affected by environmental effects such as complex backgrounds, variable light, overlapping, and occlusion with other plants, making it difficult to recognize fruit accurately[12].

Fruit maturation detection is also done by Jyoti Jhawar [13], with methods used to classify fruit maturity is Edited Multi-Seed Nearest Neighbor (EMSNN) technique and Linear Regression technique. A system built using linear regression technique can recognize the maturity of the fruit with an accuracy of 90 to 98% and can group the fruit that has not been known labeled before. The built system, working on the recognition of the color and texture of recognizable fruit for recognition classification and unrecognized fruit for clustering. Another study that performed tomato maturity detection was performed by Peng Wan et al [14] by utilizing computer vision as a medium to detect the maturity of tomatoes. It is related to automated harvesting using machine vision [7]. The study of the machine vision implementation [14] was performed in a laboratory or in another word referred to as in vivo research. The object studied was the tomato and detection system focused on the color of the tomato fruit. At the level of identification of tomato maturity, also used back-propagation neural network (BPNN) method.

2. Research Methods

To obtain maximum results in recognizing the type of fruit, then a system that we proposed in this study described in the form of images as shown in Figure 1. There are two processes in our research. The first phase is to make the input that shapes the image into a matrix. The use of images has a target: to get a classifier that can identify a much wider variety of fruit [15]. The conversion process from image to matrix uses Gaussian filter and Gabor filter. According to Mohammad Haghighat et al [16] stated that this Gabor technique is in terms of its invariance of scale, rotation, translation of the tested image. Mohammad Haghighat et al [16] also stated that this technique can reduce the amount of noise in the process of classification or other determinations of the image processing, as well as sometimes troublesome with photometric. Then the result of the filter is used to then be selected using one of the many features of the selection technique, but the technic that we used in this research is principal component analysis (PCA). From the process of this feature selection, which then produces a matrix-shaped image representation. From the resulting matrix, then the next process is to input the matrix of the image into the process of classification, which uses deep learning and k-nearest neighbor (k-NN) algorithms. In this classification process, the matrix image as an input is classified by their respective region. This classification process is done repeatedly due to the matrix classification method is using deep learning that is applied to image processing. In this research, to determine the type of fruit, we categorized the fruits used in the training dataset, by compartmentally based on the region present on the fruit.

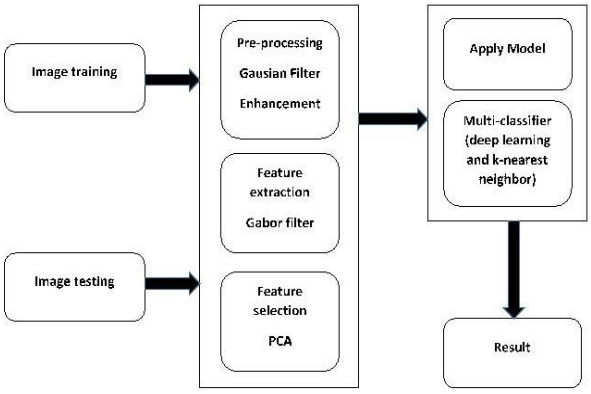


Figure 1. the framework of proposed system

In our research, we use a dataset contained with a number of two hundred sixty (260) public raw datasets of fruit images that had not been preprocessed, extracted and selected the features, and all were downloaded from https://www.kaggle.com/moltean/fruits/data. The fruit dataset in this study consisted of two thousand six hundred (2.600) data, which is formed as image pixels available for the training process. Those available data is used for the validation process, spread over twenty-six (26) labels. This dataset is scaled down so that it does not take a long time in computing with a 10x10-pixel size. Twenty-six (26) of the label consist of apple red 1, apple red 2, apple red 3, apricot, avocado, brae burn (apple) cherry Apple Golden 1, Apple Golden 2, Apple Golden 3, Granny Smith (Apple), Grape, Grapefruit, Kiwi, Lemon, Nectarine, Orange, Papaya, Peach, Peach flat, Pear, Plum, Pomegranate, and Strawberry.

In this research, we conducted experiments using a personal computer (PC) with the following specifications: Processor: Intel (R) Core (TM) i3-2370M, CPU 2.40 GHz. RAM used: 3.00 GB (2.44 GB usable). System type: 64-bit Operating System. For the VGA installed: NVIDIA GeForce 610M. The operating system running on this personal computer is Windows seven (7). With these personal computer specifications used, the computation time for classification phase to perform the experiment ranges from twelve (12) seconds. For the first process that is input image to the preprocessing, then feature extraction process, we use C # application. Up to the feature selection phase, i.e. principal component analysis (PCA), we used a Rapid miner

Studio application tool. This is done in order to get the output of these processes into the matrix. Then it proceeds to the classification phase, in order to get the expected results of classification, the deep learning, and k-nearest neighbor (k-NN) algorithms are implemented.

To recognize the type of fruit, it takes several techniques and methods that can be regarded as a grip to achieve the expected results. Some of the techniques and methods we use in this study are as outlined below.

2.1. Pre-Processing Phase

To eliminate noise in the process before classification, the Gaussian filter is used, which works to improve the image for better. Refer to the research of Ryszard S. Choras [17] stated that filtering is included into preprocessing phase and the output of this preprocessing phase is formed as the image region and object. This is needed for the next process.

2.2. Feature Extraction Phase

Feature extraction is used to know the pattern of the image, which will be taken from the characteristics of each image into several features. A feature that has been formed will be used for the classification process of training and testing data. In this research, we used the Gabor filtering technique.

2.3. Feature Selection Phase

Feature selection, in accordance with the research of Ryszard S. Choras [17], is used to determine the characteristics of patterns and reduce the features that are not significant for classification phase and that greatly affect the classification process. This feature selection aims to accelerate the process of classification and obtain high accuracy. In this research, we use one of the techniques in image segmentation, namely principal component analysis (PCA). In terms of image segmentation, it is important to do so that in the process, the desired accuracy value can be achieved.

2.4. Classification Phase

Classification is used for the recognition process of the fruit image. Classification method used in this research is the deep neural network and k-nearest neighbor (k-NN) algorithms. In this research, we also use the feature formed as Bag-Of-Words (BoW) feature representation as the input from two thousand six hundred (2.600) features as the initial input, and all have not been processed using preprocessing techniques against it, extracted using Gabor filter feature extraction and principal component analysis (PCA) feature selection. From the features entered, and then carried a forward propagation algorithm by inputting all the features. In stages, from the input layer proceed to the hidden layer until the output layer. From the resulting value in within hidden layer, we perform the calculation using the error function to measure the error rate that occurs during the process between the inputted feature through each layer being compiled and then to the output layer generated. From the use of the error function, then from the result of error obtained we apply backward propagation algorithm to achieve the minimum error until found convergence of feature value. While these results also calculated using k-nearest neighbor (k-NN) algorithm.

As well as deep learning with the concept, in general with a combination of several hidden layers, then some processes such as the use of back propagation algorithm, in this case, the weighting process is done to give a load on each weight of each neuron in each layer. By applying the weight, the epoch will get the desired value form updated weight. Deep learning has a better ability to detect an object compared to previous methods [18].

In this research, we also use hyperbolic tangent activation function (TanH) which is implemented to our hidden layer which according to Duc-Hong Pham; Anh-Cuong Le [19], can simplify the model built to interact with the dataset used i.e. mainly documents or text. In addition, for the activation function that is implemented to the output layer, we use softmax activation function. It can be argued that the use of this activation function can facilitate models built to effectively compile data, as well as affiliated with providing a more powerful gradient than the sigmoid activation function.

$$\text{FTanH(t)} = \frac{eq^{t} - eq^{-t}}{eq^{t} + eq^{-t}} \qquad (1)$$

For the design we use on the application of deep learning and k-nearest neighbor (k-NN) for the classification of the fruit recognition, we use as many as eight (8) dimension of classes feature image inputs in the form of features, which is the results from feature selection process using principal component analysis (PCA) technique. From these features, then the next process is into the hidden layer that we use three (3) hidden layers, for each of which amounted to 50 neurons. From that process, the epoch process takes place, which terminates at the output layer. In this research, we use twenty-six (26) final label, which contained kinds of fruits.

3. Results and Discussions

In this research, we convert from image to matrix, which then makes it as input for the classification process. Therefore, to measure the

effectiveness of all processes to the expected result, we used a measurement of results, which, according to Abinash Tripathy et al [20], in their research stated that this is widely applied to the process of classification text. In fact, in this research, our result is in the form of text with the accuracy obtained, though; the input is in the form of an image. In the process of determining the results of all processes from preprocessing of the dataset used, to the classification process using the deep neural network and k-nearest neighbor (k-NN) algorithms.

The result of our implementation of several processes including preprocessing, feature extraction, feature selection, and classification method usage until prediction show that the accuracy is achieving 95.01%. Through using the Gaussian filter as the feature extraction, Gabor filter as the feature selection technic and Deep Neural Network and k-Nearest Neighbor (k-NN) as the hybrid classifier gained to recognize the fruit types based on our dataset available. To extend the understanding to the result of the discussion, presented the result in graphs and tables with values of kappa, and root mean squared error (RMSE), mean squared error (MSE) and the accuracy in the form of a table.

Table 2. Result of classification

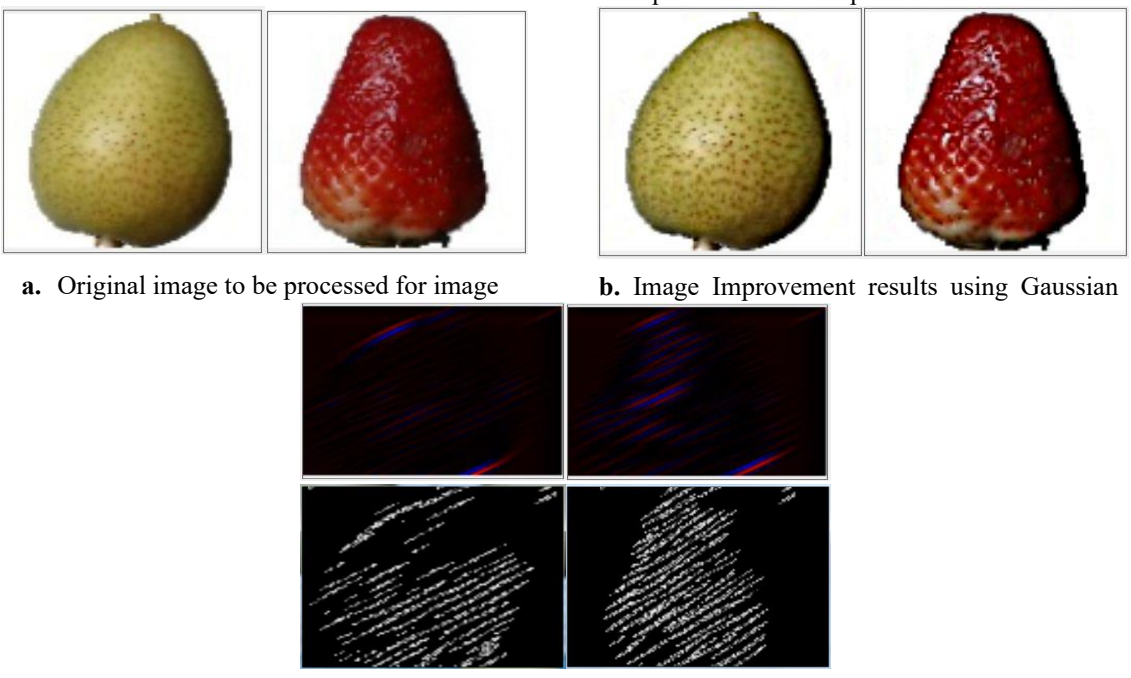
	Value%			
	Accuracy	Kappa	RMSE	MSE
DNN and k-NN	95,01	0,948	0.223	0.626479

Table 2: shows the values of accuracy, kappa, RMSE, and MSE retrieved from classification phase using Deep Neural Network (DNN) and k-nearest neighbor (k-NN) classifiers and obtained by the Gaussian filter for preprocessing technic, Gabor filter as the feature extraction technic and principal component analysis (PCA) as the feature selection technic.

4. Conclusion

From the research we conducted with some of the processes and the methods used to obtain good accuracy results, it can be concluded that the implementation of deep learning and k-nearest neighbor (k- NN) classification methods can reduce the excessive errors in fruit recognition process. With root mean squared error (RMSE) value of 0.223, mean squared error (MSE) achieved 0.62647986 and some filtering technics can give better image result, so that an accuracy of 95.01 is obtained. To emphasize pre-classification processes i.e. preprocessing, feature extraction and features selection using C# programming tools. From the form of an image input into the matrix. Then from the results of the matrix, we use another programming tool that is Rapid miner studio used in the process of classification based on the available label of twenty-six (26) label data. In another sense, it can be mentioned that the focus of its contribution is on the transition of some process, which eventually results in the recognition of the fruit type.

For further research is expected to apply the incorporation of several methods of classification as well as the incorporation of several feature selection techniques such as Chi-square test and others.



a. Original image to be processed for image **b.** Image Improvement results using Gaussian

c. The result of the Gabor filter process that will be extracted

Fig 2: the original images and result after being proceeded using Gaussian and Gabor filtering technics

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