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Beef Freshness Classification by Using Color Analysis, Multi-wavelet Transformation, and Artificial Neural Network

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***Abstract*—Any radiation techniques have been performed such as gamma radiation, X-ray, and infrared to determine the level of reduction in physical beef quality. The main difference of the techniques is the radiation wavelength exposure. One way to determine the level of beef freshness is by image processing. Image acquisition's results in the form of 8 bits digital data at each base color RGB (Red, Green, Blue) is converted into the HSV (Hue, Saturation, Value) color space to see the difference of its brightness. The steps of classification process of beef freshness through image acquisition by using digital camera, pre-processing the image, and extracting its feature by using color analysis & multi-wavelet transformation. The last process is the classification process by using Nearest Neighbor & artificial neural network Back-propagation. This system can perform 75% accuracy by using NN classification with computation time in 10.683 second, while the best accuracy from using back-propagation is 71.4286% with the computation time 15.800086 second.**

Keywords—beef freshness; color analysis; multi-wavelet transformation; Back-propagation; nearest neighbor.

I. Introduction

Beef marketing model often used on the market traders as well as in supermarkets, is available in the form of hanging meat, termed as dried meat and stored in a refrigeration appliance termed fresh meat moist. Both kinds of the storage method certainly have its advantages and disadvantages. Although dried meat method is relatively safer than moist meat condition, it still has the risk of insect contaminations. Unlike the moist storage method, microbial contamination factors easily lead to a bacteria decreasing, and even damage.

Until now, some efforts toward determining the level of reduction in physical beef quality has not gained scientific information and even used as a standard. Moreover for the commodities stored too long or under conditions of low temperature refrigeration appliance. Marketing of frozen foods generally form a negative potential changes in nutrient levels. To anticipate the fact that the survival of food security is assured, then it is necessary to look for a reference from a research's result that its accuracy can be considered as beneficial. The existence of irradiation technology in meat surface has been done, especially in developed countries. However, sourced from several references, known that the amount of radiation dose standards for any food is different. This certainly will be applied especially in Indonesia for the future. That is why the image acquisition results in digital data form base on Red, Green, and Blue (RGB) color. That input image then converted into Hue, Saturation, and Value (HSV) color space to see its brightness differences.

The next step is to conduct a detailed analysis of color by taking the color values and classify it into several groups according to the beef freshness standard [1], [2], [4]. The process of color value grouping is done with k-means clustering method. Multi-wavelet transform method also was used to analyze the characteristics of the image acquisition results. The last process is classification by using artificial neural network Back Propagation and k nearest neighbor.

II. Methodology

This section describes the methodology of the system.

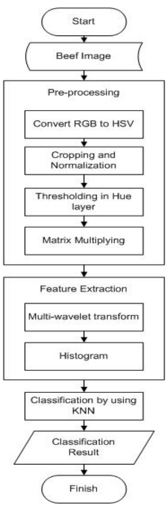

Fig. 1 Classification process by using Nearest Neighbor.

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The explanation consist of the design of classification system including its step of implementation. In this research, the classification process is done by two method, Nearest Neighbor and Backpropagation Neural Network method. The steps of classification process by using Nearest Neighbor Classification & Back-propagation Neural Network are shown in Fig.1.

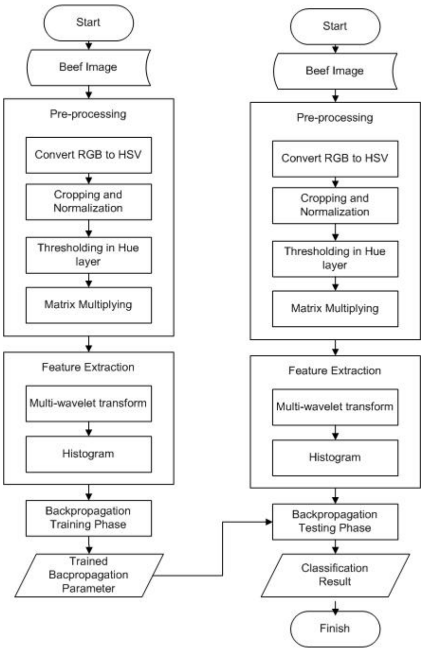

Fig. 2 Classification process using back-propagation.

Pre-processing process is the first process in system design. This process is purposed to prepare beef irradiated image before acquiring its feature. By this process, the image will have minimal noise with the optimal condition. The steps of pre-processing process are described below:

- Beef irradiated image will be scaled into 0.2 of its original image.

Fig. 3 Scaling to 0.2 of the original image.

- After that, the image formatted in .jpeg in the form of digital data 8 bits at each base color RGB (Red, Green, Blue) will be converted into the HSV color space (Hue, Saturation, Value) to see the difference of its brightness.

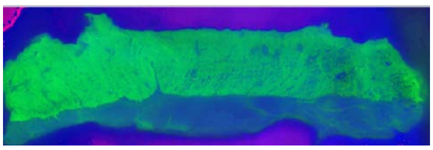

Fig. 4 Convert RGB to HSV color space.

- The next step is thresholding the value of each layer so that we can get the beef's position or we can distinguish the beef from the background itself.

Fig. 5 Thresholding to separate the background and the beef image.

- The next step is matrix multiplying from HSV image and the image resulted from thresholding process.

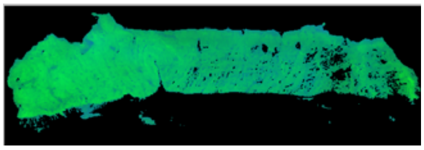

Fig. 6 Matrix multiplying process between HSV image & thresholding image.

Feature extraction is the next step conducted. Feature extraction is a feature-taking process which describes the characteristic of the image. Feature resulted from feature extraction process is used to compare between one character to another character. Feature extraction method used in this research is GHM Multi-wavelet Transformation. Multi-wavelet can only process a square matrix of pixels and the block size must be multiplying result of 2 [1], [4], [7], [9], [10], whether the data result from pre-processing is not a square matrix. Therefore, in this research, the size of block result is normalized into some block size, 32, 64, 128, and 256 size block and rounded to the nearest value.

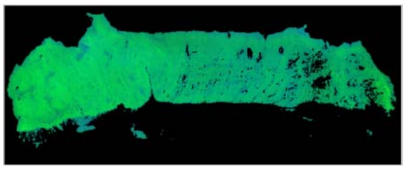

Fig. 7 A non-square matrix as multi-wavelet'input image.

Fig. 8 Image segmentation to small square blocks size.

The next step is multi-wavelet GHM process for each blocks. The GHM basis offers a combination of orthogonality, symmetry, and Compaq support which cannot be achieved bay any other scalar wavelet. Since the GHM filter has two scaling and two wavelet functions, it has two low pass and two high pass sub bands in the transform domain [1], [4], [7], [9], [10]. Due to that, the decomposition of multi-wavelet transformation would appear as in Fig. 9.

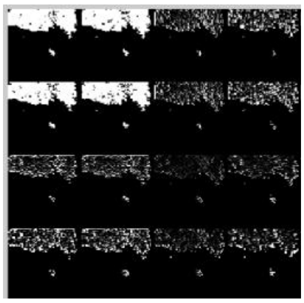

Fig. 9 Multi-wavelet's Decomposition.

The highest information is placed in 1st block, which is L1L1. So we get one feature for each small square block. The next step is making an array from all square blocks, and we get the feature of multi-wavelet process.

Fig. 10 Array of LL band from the multi-wavelet process.

The next information to classify beef freshness is by its color. The color of a fresh beef is different with the color of a unfresh beef [2], [3], [5]. Histogram can show the red-color differences. The results from multi-wavelet transform are then divided into four kind of feature, they are:

1. The basic feature
2. The basic feature normalized with the total feature
3. The basic feature normalized with the maximum feature
4. The basic feature normalized with the standar deviation.

From the process, 16 feature are ready to be the input for classification system as shown in the table below:

TABLE 1 Features input for classification system

Feature	Size of Block			
Basic Feature	32	64	128	256
Basic feature normalized with the total feature	32	64	128	256
Basic feature normalized with the maximum feature	32	64	128	256
Basic feature normalized with the standar deviation	32	64	128	256

The histogram result from this process for size of block of 256 can be seen in Figs. 11-14. All parameters resulted from multi-wavelet and histogram feature extraction will be used to classify beef freshness. This classification is a process of grouping image into three classes, according to the level of beef freshness classes which are class 1 (fresh beef), class 2 (less fresh beef), and class 3 (non fresh beef). The 1st class or the class for fresh beef is comes from the data feature of day 1, day 2, and day 3. The 2nd class or the less fresh beef class comes from the data feature of day 4 and day 5. The 3rd class or the non fresh beef class comes from the data feature of day 6 and day 7. The classification process itself done by using two method, which are Nearest Neighbor Classification and Back-propagation Neural Network Classification.

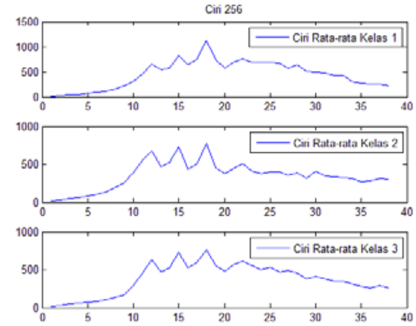

Fig. 11 Histogram value from basic feature of 256 block size.

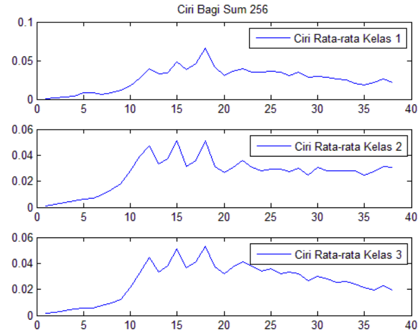

Fig. 12 Histogram value from basic feature normalized with the total feature of 256 block size.

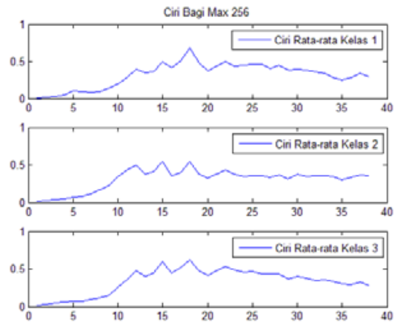

Fig. 13 Histogram value from basic feature normalized with the maximum feature of 256 block size.

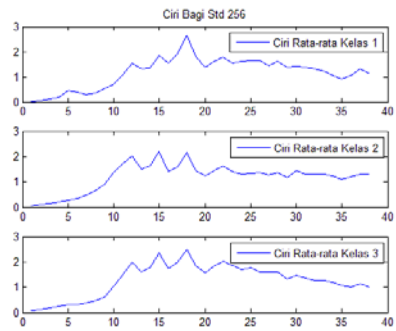

Fig. 14 Histogram value from basic feature normalized with standard deviation of 256 block size.

In Back-propagation neural network, there are some parameters that define how the system works to process new input. In this research, parameters that being tested are the amount of hidden layer, the amount of learning rate, the amount of neuron in each layer, and the activation function in hidden and output layer. In testing phase, 84 data sets are used as training data, and 112 data sets are used as testing data.

Each network can own more than one hidden layer, even do not own at all. If a network owns some hidden layers, then the last hidden layer will be the one who receive input from input layer. Another parameter called learning rate is used to define the learning rate. The bigger learning rate, then the training process will be done faster. But, if learning rate is too big, the algorithm becomes unstable. This research will observe the impact of the amount of hidden layer and learning rate. The parameter set is error tolerated = 10^{-10}, epoch = 500, activation function = logsig. From the result, the best hidden layer and learning rate can be taken to be the fixed parameters in system.

III. RESULT & DISCUSSION

The accuracy and computation time of Nearest Neighbor classifications using 16 features are shown in Tables 2 and table 3 below:

1. List of accuracy from 16 features (in %)

TABLE 4 Accuracy from 16 features by using KNN (in %)

Block Size/Feature	32	64	128	256
Basic Feature	71.4286	69.04760	72.619	75
Basic feature normalized with the maximum feature	71.4286	69.04760	72.619	75
Basic feature normalized with the total feature	71.4286	69.04760	72.619	75
Basic feature normalized with the standard deviation	71.4286	69.04760	72.619	75

From the TABLE 2, it can be concluded that the kind of feature doesn't impact the accuracy, but the block size does give an impact to the accuracy. The best accuracy is given with the block size of 256 with 75%. Therefore, for the next classification system (backpropagation neural network) the 256 block size will be used.

2. List of Computation time from 16 features (in second)

TABLE 2 Computation time from 16 features by using KNN (in second)

Block Size/Feature	32	64	128	256
Basic Feature	0.67229	0.69394	0.75264	10.683
Basic feature normalized with the maximum feature	0.67229	0.69394	0.75264	10.683
Basic feature normalized with the total feature	0.67229	0.69394	0.75264	10.683
Basic feature normalized with the standard deviation	0.67229	0.69394	0.75264	10.683

From the TABLE 3, it can be concluded that the kind of feature doesn't impact the computation time, but the block size does give an impact. It can be seen also that the bigger the block size, the longer it takes for the system to compute. The fastest computation time is given from 32 block size, which is 0.67229 second.

The accuracy result of Back-propagation Neural Network Method from the test can be seen in the table 4 below:

TABLE 3 Accuracy result from various learning rate and amount of hidden layer (in%)

Feature/Hidden Layer/Learning Rate	1	2	3
	0.02	0.02	0.02
Basic Feature	30.60872	27.748232	49.5246
Basic feature normalized with the maximum feature	10.751629	16.528081	22.893523
Basic feature normalized with the total feature	10.799773	15.234657	16.390534
Basic feature normalized with the standard deviation	10.908808	13.922928	21.670742

From the TABLE 4, it can be seen that learning rate is giving an impact to the accuracy. When learning rate is set into 0.02, it reduces the accuracy. The best accuracy is 71.4286% which is given from learning rate=0.01 and amount of hidden layer = 2. The next result is computation time that can be seen in Table 5.

TABLE 5 Computation time from various learning rate and amount of hidden layer (in second)

Feature / Hidden Layer / Learning Rate	1	2	3
	0.02	0.02	0.02
Basic Feature	60.7143	55.9524	61.9048
Basic feature normalized with the maximum feature	48.8095	54.7619	48.8092
Basic feature normalized with the total feature	50	52.381	51.1905
Basic feature normalized with the standard deviation	51.1905	57.1429	59.5238

From TABLE 5, it can be seen that learning rate is giving an impact into the computation time. If the learning rate is set into 0.02, the computation time become slower. The fastest computation time is 10.381059 second which is given from learning rate=0.01 and amount of hidden layer=1.

Beside of classifying the beef freshness into some classes, The False Acceptance Ratio (FAR) is important to find. The False Accpetance Ratio (FAR) is defined as the percentage of identification instances in which false acceptance occurs. This can be expressed as a probability. In this research, the false acceptance ratio is 15%, it means that the probability of the system to give the right classification is 85%.

IV. CONCLUSION

From the research that has been done, it can be concluded:

1. The use of NN classification gives a better accuracy compare to backpropagation neural network application, 75% with the computation time in 10.683 second, while the best accuracy from using backpropagation is 71.4286% with the computation time 15.800086 second.
2. The best time to keep beef in 7º is for 3 days only, after that, the beef is not proper to consumed based on the level of red-color-classification.
3. The weakness of this experiment is that by using color anlaysis which come from 32 until 256 size of block of pixels, the decision of beef freshness classification have not able to give the sharp classification.
4. The feature between 1st class and 2nd class is significantly different, the feature between 1st class and 3rd class is significantly different tto. But the feature between the 2nd class and the 3rd class haven't been significantly different.

Topics for future work include:

1. Color analysis for the next time should be more sensitive.
2. The size of pixels should be bigger to get the more sensitive system.
3. Try another feature extraction process to improve the feature quality.
4. Try to build a more complex system to classify freshness of beef by using sensor.

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