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To cite this article: S Winiarti *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **821** 012039

IOP Conf. Series: Materials Science and Engineering **821** (2020) 012039 doi:10.1088/1757-899X/821/1/012039

Consumable Fish Classification Using k-Nearest Neighbor

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Abstract. Fish is beneficial for the human body because it has high protein content. Consuming fish is necessary and expert knowledge is needed to identify fresh fish that are suitable for consumption. In this study, we developed a classification system to identify four classes of consumable fish by grouping fish images based on texture extraction and color features. We use fish meat and fish scale as identification parameters. Fish meat image is measured using the HSV colors model (Hue, Saturation, and Value) and GLCM (Gray Level Co-occurrence Matrix) method. We use these values for texture feature extraction of scales. Then we use k-Nearest Neighbor (kNN) as the classifier. The test results from 320 sample images show that the identification accuracy of tilapia meat is 90% and 97.5% for mackerel meat. Meanwhile for the scales, the accuracy up to 87.5% for tilapia scales and 95% for mackerel scales.

1. Introduction

Fish has high protein content and has a lot of benefits for the human body [1]. The freshness of fish usually determines the quality of consumable fish. Due to the high protein and water content, fish is a highly perishable commodity. Consumers must be careful and have the expertise to identify fresh fish that are suitable for consumption.

Several kinds of research have been done to determine fish freshness using hardware and or software approach. Metallic Potentiometric Electrodes have been proposed to analyse fresh fish. Information from the electrodes is combined and analysed with fuzzy logic [2]. Electrode sensors are used to measure dielectric properties of the skin of fish and muscles [3].

The Torrymeter sensor (a tool to measure the freshness of fish) and RGB (Red, Green, Blue) color indices are compared to detect fresh fish [4, 5]. The result of the comparison shows that Torrymeter produces fast analysis, friendly usage, and shows the exact measurement when compared to the RGB color index [4]. The electronic nose, which consists of 8 metal oxide sensors, are used to evaluate the freshness of mackerel. Information from sensors is classified and combined with Support Vector Machine (SVM) and k-Nearest Neighbour (k-NN) method [5].

Image processing is the basis of detection techniques that can be applied to identify an object or its condition. It can be used to identify fresh fish [6-8], another animal such as birds[9], fruit[10], or food product [11]. The combination of changes in the value of the grey iris and the surface texture of the fish body can be combined to achieve detection in image processing [12]. Other variables to detect the freshness of fish are fish gills [3, 6-8, 13], muscle [3], and fish skin [3].

Data from those variables are classified into several algorithms to detect fish freshness, such as Artificial Neural Networks [14], ensemble learning using SVM and NN classifiers [15], Support Vector

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Machine [5, 13], k-Nearest Neighbor [5, 15]. Classification is also carried out with the relationship between electrical parameters and the stage of fish decay [17]. The statistical data-fitting model is a general and effective analysis method for fish freshness classification.

In previous studies, the freshness of fish can be classified into several types. Artificial Neural Networks was used to classify seven fish freshness classes by the storage time: 1, 3, 5, 7, 9, 11, and 13 days [14]. A Matlab Program utilizing Support Vector Machine (SVM) classifier has been developed to determine the freshness of fish and shelf life, but only classified into two classes: fresh and not fresh fish [13].

Another study also classified fish into two classes: fresh and not fresh fish [16]. The parameters that are used to measure the quality of fish are general appearance, eyes, and gills. The types of fish studied were Giant Gourami, Red Snapper and Tilapia. Fish image is taken, cropped and summarized into RGB values. Then, the results of RGB values are classified using the kNN algorithm with the help of WEKA tools.

In this study, the key contributions are summarized as follows. First, we develop a classification system to classify four classes of fish freshness: very suitable for consumption, suitable for consumption, less suitable for consumption, and not suitable for consumption. We identify fish freshness in mackerel and tilapia fish by utilizing 320 meat and scale image samples. Fish meat image is converted from RGB into HSV (Hue, Saturation,Value) color model for meat identification. Fish scale image is converted into a grayscale image and use GLCM (Gray Level Co-occurrence Matrix) for scale texture feature extraction. Then, we classify the converted image using kNN algorithm and develop the algorithm using MATLAB.

Finally, we present the performance evaluation of our fish freshness classification system using mackerel and tilapia fish image. We measure the effectiveness of our classification system by comparing our classification result with expert judgment and calculate the classification accuracy. The remainder of this paper is organized as follows. Section 2 discusses our method for classifying fish freshness based on fish meat and fish scale image. Then, we discuss the demonstration and performance evaluation of our classification system in Section 3. Finally, we conclude our work in Section 4.

Image processing is the basis of detection techniques that can be applied to identify an object or its condition. It can be used to identify fresh fish [6-8] , another animal such as birds [9], fruit[10], or food product [11].

The combination of changes in the value of the grey in and the surface texture of the fish body can be combined to achieve detection in image processing [12]. Other variables to detect the freshness of fish are fish gills [3] [6-8, 13], muscle [3], and fish skin [3].

Data from those variables are classified into several algorithms to detect fish freshness, such as Artificial Neural Networks [14], ensemble learning using SVM and NN classifiers [15], Support Vector Machine [5, 13], k-Nearest Neighbor [5, 16]. Classification is also carried out with the relationship between electrical parameters and the stage of fish decay [17]. The statistical data-fitting model is a general and effective analysis method for fish freshness classification.

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2. Research Method

In this section, we explain how to identify fish quality based on fish meat and fish scale image. We first present the overall process of classification from fish meat and fish scale image. We then provide a detailed description of each process. Figure 1 depicts the general process in our classification system using the k-NN classifier. There are two kinds of inputs for our system: fish meat and fish scale image. Both images should be in RGB mode.

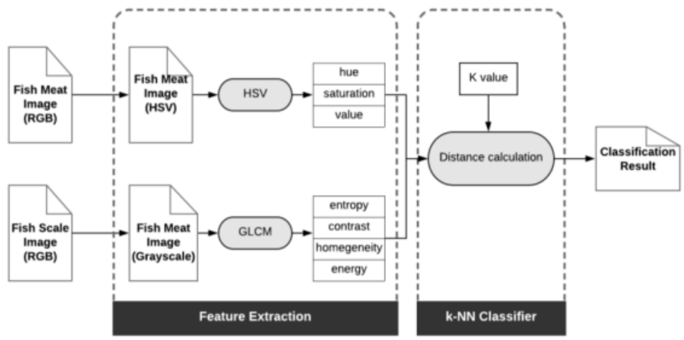

Figure 1. Classification System

There are two main processes in our system, which is the feature extraction process and classification process. Feature extraction process involves converting RGB value into another color mode. Meat image is converted into HSV color model and the extraction result is hue, saturation, and value. Scale image is converted into grayscale and then processed using GLCM method, which resulted in four values: entropy, contrast, homogeneity, and energy.

In the classification process, the k-NN classifier uses those values along with K value from the user to calculate the distance and then display the classification result.

2.1. *Fish Meat Measurement*

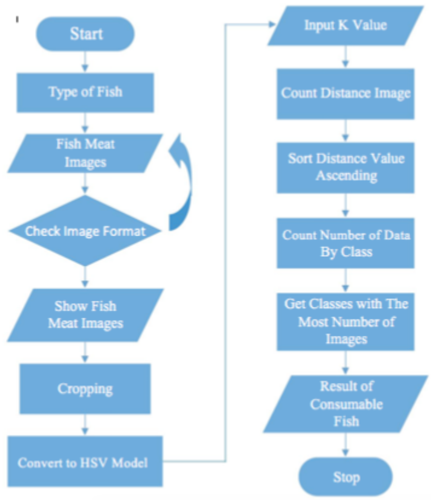

Figure 2. Flowchart for measuring fish freshness using fish meat image

Figure 2 shows the flowchart for fish meat measurement in our system. The first step is to select the type of fish to be identified. Then, the image of fish meat in *.jpg or *.bmp format is loaded and displayed. If the image format is correct, then image will be cropped to focus on the image. The system will perform a conversion from RGB into HSV color model into hue, saturation, and value. These values are used as input for classifier.

To perform classification, the user must fill in the K value to find the amount of closest fish meat image data to the image of the tested fish meat. The system will calculate the distance between the testing image and the training image using kNN. The calculation results will determine the image of fish meat that follows class K (fish class results are suitable for consumption). The final result of the system is the conclusion of the fish freshness class.

2.2. *Fish Scale Measurement*

Figure 3 shows the process for fish scale measurement. The differences between Figure 2 and Figure 3 are the addition of RGB to grayscale image conversion step. After converting into grayscale image, then the system calculates feature extraction values using GLCM method that produces entropy, contrast, homogeneity, and energy values.

Similar to the process in fish meat measurement, the classification process uses values from the feature extraction process and K value from the user to calculate the distance and display the classification result.

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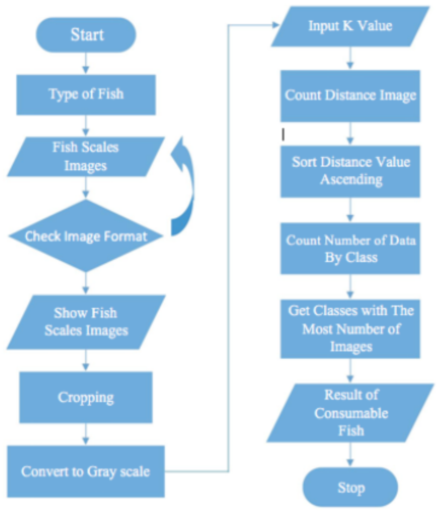


Figure 3. Flowchart for measuring fish freshness

3. Experimental Result

Our fish classification system is developed with Matlab and has two main features, namely identification based on fish meat and fish scales. Users can choose the identification process according to fish image data. We captured the fish meat and scale images using the digital camera and all sample data are recorded into 320 image samples. These image samples are tested using developed Matlab program to get the classification result.

Using the Matlab program that has been created, the image data is analyzed. A total of 320 images were analyzed by grouping 160 images of mackerel and tilapia. Each fish image group consists of two types of images: the image of fish meat and the image of fish scales.

This image data consists of:

40 images of mackerel meat as training data.
40 images of mackerel meat as testing data.
40 images of tilapia meat as training data.
40 images of tilapia meat as testing data.
40 images of mackerel scales as training data.
40 images of mackerel scales as testing data.
40 images of tilapia scales as training data.
40 images of tilapia scales as testing data.

3.1. Fish Meat Measurement

An example result of the identification of fish meat is shown in **Error! Reference source not found.**. A user can demonstrate classification process based on the flowchart in Figure 2. A user only needs to click the button in the Matlab program. Button Open Images to load the fish image, button Crop Images to crop the fish images, button Process to perform fish classification. After the identification process is finished, a user can get the result of the classification directly in the program GUI.

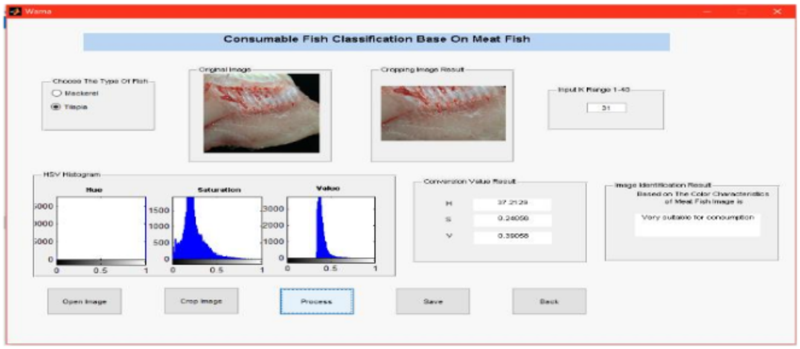


Figure 4. Matlab program for measuring fish meat

Table 1 and
Table are HSV values from mackerel and tilapia, respectively. These values from each of 40 sample data that have been analyzed in testing are used to determine classification results.

Table 1. HSV Value for mackerel meat testing image

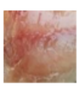
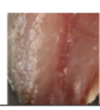
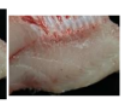
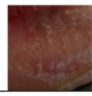
#	Image	Cropping Image	HSV Value			Result
			H	S	V	
1			31,6225	0,72686	0,42503	Very suitable for consumption
2			31,477	0,73413	0,43282	Suitable for consumption
3			32,0623	0,73078	0,42179	Less suitable for consumption
4			8,3675	0,75102	0,45932	Not suitable for consumption

Table 2. HSV Value for tilapia meat testing image

#	IMAGE	Cropping Image	HSV Value			Result
			H	S	V	
1			26,4842	0,71565	0,39163	Very suitable for consumption
2			118,9415	0,73051	0,45276	Suitable for consumption

#	IMAGE	Cropping Image	HSV Value			Result
			H	S	V	
3			120,5819	0,74068	0,46318	Less suitable for consumption
4			15,917	0,77547	0,50307	Not suitable for consumption

3.2. Fish Scale Measurement

Figure 5 shows an example of fish identification using fish scale images as an input. The steps to perform classification based on the fish scale image is similar to that of classification based on fish meat image.

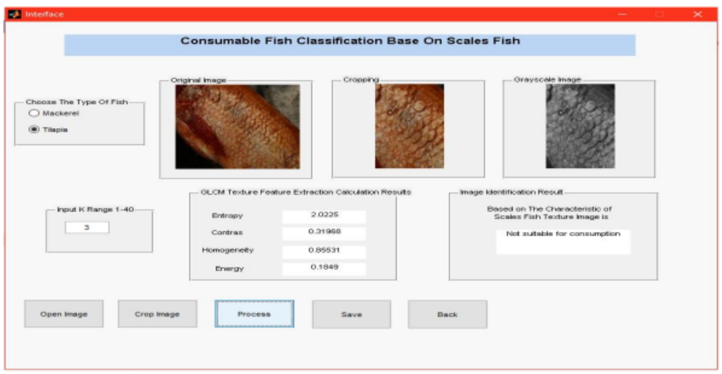
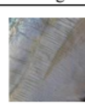


Figure 5. Matlab program for measuring fish scales

Based on the flowchart in Figure 3, the image of the fish scale is converted into grayscale and analyzed using GCLM method to produce four values: entropy, contrast, homogeneity, and energy. **Error! Not a valid bookmark self-reference.** shows the four features extraction values from mackerel and

Table shows four features from tilapia fish scale. These values will be used to calculate the distance in the next step. The result for classification is also displayed directly in the program GUI.

Table 3. Feature extraction for mackerel scales testing image

#	IMAGE	Cropping Image	Feature Extraction				Result
			Entropy	Contrast	Homogenity	Energy	
1			0,64109	0,21189	0,89569	0,32906	Very suitable for consumption

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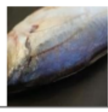
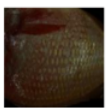
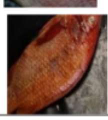
2			1,0092	0,43618	0,81827	0,13267	Suitable for consumption
3			0,99192	0,24722	0,88247	0,16219	Less suitable for consumption
4			0,95466	0,1631	0,9198	0,15385	Not suitable for consumption

Table 4. Feature extraction for tilapia scales testing image

#	IMAGE	Cropping Image	Feature Extraction				Result
			Entropy	Contrast	Homogenity	Energy	
1			0,45411	0,069207	0,9654	0,47975	Very suitable for consumption
2			0,85319	0,18405	0,90918	0,18212	Suitable for consumption
3			0,68564	0,10422	0,94789	0,26642	Less suitable for consumption
4			0,78624	0,30847	0,86304	0,23388	Not suitable for consumption

To ensure the results of the classification obtained from the Matlab program, an assessment of experts in the fisheries field is carried out to conduct testing. Table shows testing accuracy between our Matlab program and expert judgment using four scales features. Table 5(a), 5(b), and 5 (c) show testing accuracy for mackerel scales, tilapia scales, and overall accuracy result for all fish, respectively. From Table 5(c) we can see that distinguishing very suitable for consumption and not suitable for consumption category using scales feature results in the most higher accuracy. The lowest accuracy is for suitable for consumption category. The overall accuracy using scales features is 91.25%.

Table 5. Testing accuracy for scales

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Clustering Result	Validation Expert Judgment	
	Match	Unmatch
Very suitable for consumption	10	0
Suitable for consumption	10	0
Less suitable for consumption	8	2
Not suitable for consumption	10	0
Accuracy (%)	**(38/40)x100% = 95%**	

(a) Mackerel scales

Clustering Result	Validation Expert Judgment	
	Match	Unmatch
Very suitable for consumption	10	0
Suitable for consumption	5	5
Less suitable for consumption	10	0
Not suitable for consumption	10	0
Accuracy (%)	**(35/40)x100% = 87.5%**	

(b) Tilapia scales

Clustering Result	Validation Expert Judgment		
	Match	Unmatch	Accuracy
Very suitable for consumption	20	0	100%
Suitable for consumption	15	5	75%
Less suitable for consumption	18	2	90%
Not suitable for consumption	20	0	100%
Overall Accuracy (%)	**(73/80)x100% = 91.25%**		

(c) Overall result for all scales

Error! Reference source not found. shows the results of the accuracy testing for meat features between our Matlab program and expert judgment. Table 6(a), 6(b), and 6(c) display the testing accuracy for mackerel meat, tilapia meat, and the overall result for all fish, respectively. Classification using meat features has overall accuracy of 93.5% for all fish. The lowest accuracy result is for not suitable for consumption category. Based on the overall accuracy assessment, an average value of 92.5% accuracy of the Matlab program has been developed.

Table 6. Testing accuracy for meat

Clustering Result	Validation Expert Judgment	
	Match	Unmatch
Very suitable for consumption	10	0
Suitable for consumption	10	0
Less suitable for consumption	10	0

Clustering Result	Validation Expert Judgment	
	Match	Unmatch
Very suitable for consumption	10	0
Suitable for consumption	10	0
Less suitable for consumption	10	0

Not suitable for consumption	9	1
Accuracy (%)	**(39/40)x100% = 97.5%**	

(a) Mackerel meat

Not suitable for consumption	6	4
Accuracy (%)	**(36/40)x100% = 90%**	

(b) Tilapia meat

Clustering Result	Validation Expert Judgment		
	Match	Unmatch	Accuracy
Very suitable for consumption	20	0	100%
Suitable for consumption	20	0	100%
Less suitable for consumption	20	0	100%
Not suitable for consumption	15	5	75%
Overall Accuracy (%)	**(75/80)x100% = 93.5%**		

(c) Overall result for all meat

Conclusion

By applying k-Nearest Neighbor algorithm, the user can find information about the classification of fish freshness from fish meat and scale image. The test results of our system show that the identification accuracy for tilapia meat is 90% and 97.5% for mackerel meat. Meanwhile, for the scales, the accuracy is up to 87,5% for tilapia scales and 95% for mackerel scales. In the future, this approach can be implemented in a mobile application so that users will find it easier to identify fish suitable for consumption

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