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Milkfish Freshness Detection Utilizing Coiflet Wavelet Transform Method

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ABSTRACT

Fish is a perishable good, which can get easily putrefied in a short span of time. To maintain the fish's quality freshness must be preserved, so as not to cause harm to the consumer. This study is aimed at determining a classification technique on which to base the milkfish's freshness using a modified set of features like wavelet transform coefficients and support vector machine. The Support Vector Machine (SVM) is the tool in which forms a link between feed-forward neural networks and Coiflet wavelet filter. The Coiflet filter uses six scaling functions to increase the pixel averages and differences, resulting in a smoother wavelet and increased performance capability. As a result, the system's output showed that the accuracy result of the eyes is 89.9%, gills 90.9% and body 88.8%. This framework can significantly be beneficial to milkfish growers, dealers and consumers. In general the study shows that the method gains better performance in terms of freshness percentage. However, the system's performance may still be optimized by increasing the number of data sets and classifiers to be used for a specific purpose.

Key words : Fish Freshness; Cascade Trainer; Coiflet Wavelet Filter; Confusion Matrix; Support Vector Machine

1. INTRODUCTION

How can one tell if the milkfish is still as fresh? The end of shelf life or how long the fish lasts before spoilage is usually determined by sensory attributes related to spoilage such as foul odor or the color of the fish's eyes and gills. Mikfish are highly consumable goods [1]. The freshness of fish should be preserved and maintained for human consumption. Unfresh fish meat is toxic to human body. Quality index method (QIM), which uses the distinctiveness of eyes, gills, and skin is the finest way to identify the freshness of the fish [2].The evolution in digital technology and the usage of digital images have also been greater than before. Image feature extraction is vital in image target detection [4]. The majority tool used in feature extraction is time-frequency transform. Furthermore, it is more appropriate for textural feature analysis, making it a tremendously dominant tool for characterizing image textures if it is applied correctly [5].

Several image processing methods to study fish diseases are presented [7]. The image processing is known to be a capable and nondestructive technique used for segmentation and computation of freshness level [8]. The digital image processing method is used to distinguish and categorize fish infection from digital images [9]-[10]. A technique for fish freshness detection from the eye using a regression based method was proposed [11]. Another method for classifying fish freshness is using fuzzy logic [12].

The evolution of sensor technologies was massively developed to address the drawbacks of the usual methods for fish freshness detection, spectrophotometers were used [13], image analyzers [14], colorimeters [15]-[16], tools in various applications of color image analysis [17], tools to test surface electrical properties [18], electronic noses is also presented [19]-[20], etc. All these sensor technologies have these own advantages and disadvantages. All of these methods and techniques are at a standstill in the period of laboratory researches for practical applications. On the basis of several developments of nondestructive methods for fish freshness detection, practical application is still an unresolved objective.

Wavelet transform is frequently used in machine vision as an image processing method for image recognition using surface analysis and applications with integration of high phantom resolution images with high spatial resolution images [21]-[22]. The wavelet coefficients are the transformation values results coming from the method of wavelet transformation as an image processing. The dispute here is how the coefficient can be interpreted to symbolize an object for classification or detection. A regular approach of feature extraction from wavelet transformation is the computation of coefficient distribution over selected mother of wavelet. The expert model used features extraction to evaluate sub-band frequency of wavelet transform.

Based on the previous studies presented, wavelet has vast advantages, but still, there is a weak side that needs to be enhanced. In other studies, the detection of ROI is not included in the classification [1]. With this in mind, the researchers came up with a study which main objective is developing a system that will detect the freshness of the fish, focusing on specific parts or regions of the milkfish, i.e., eyes, gills, and body using the MATLAB's Computer Vision toolbox cascaded object detector.

The Computer Vision Toolbox cascade object detector can detect object categories whose aspect ratio does not vary significantly. The cascade classifier consists of stages. Each stage of the classifier labels the region defined by the current location of the sliding window as either positive or negative. The stages are designed to reject negative samples as fast as possible.

2. SYSTEM OPERATION

2.1 Hardware

The researcher used taken raw images of fresh and not fresh milkfish. Laptop Computer Core i7 – 7700HQ 2.80GHz; Graphics: GE Force GTX1050, 4GB GDDR5; Memory: DDR IV 4GB; Storage: 1TB HDD.

2.2 Software

The researcher used Matlab as software. Matlab is a library of programming functions mainly aimed at real-time computer vision. In simple language it is a library used for image processing. It is mainly used to do all the operations related to images.

2.3 Data

The data were taken from Iloilo State College of Fisheries fish farm located at Brgy. Tiwi, Bartoac Nuevo, Iloilo. The researcher used images of milkfish specifically the body, gills and eyes images. In taking body image, it will be at full angle to get a precise image. The researcher used 40 images of body in full angle, 40 images of eyes, and 40 images of gills. The fish sample was studied and subsequently took an image in every 4-hour interval until it reached the spoilage stage.

2.4 Methods

Vision Cascade Toolbox, Neural Network Toolbox (SVM), and Wavelet Toolbox were used in the development of the program for the freshness detection of milkfish based on Coiflet (coif2) wavelet transform for image processing. Vision Cascade Toolbox trained the system to detect the region of interest. The wavelet transform using coiflet features was used as an input to the SVM model which classified the freshness of the milkfish. The Matlab was also used to validate the results via confusion matrix and feedforward network performance plot.

2.5 Requirements/Planning

The requirement/planning stage of the design covers the analysis of the issues and findings presented in the previous chapters of the study. The software, hardware and data resources specified in Section 2.1, 2.2, and 2.3 were used during the system design and development stage of the study. The developed application addressed the issues related to the computational complexity or high computational method as specified in the objectives of this study.

3. THE DESIGN AND SYSTEM DEVELOPMENT

3.1. Concept of the Study

This study proposes to implement the conceptual framework shown in Figure 1. First, the training of the raw captured images containing the milkfish was segmented using Cascade Object Detector. It started with image acquisition. The dataset refers to the images of milkfish (body, eyes, and gills). These images will be cropped using Cascade Object Detector toolbox of Matlab to establish the region of interest of milkfish (body, eyes, and gills). These cropped images will underwent transformation from the RGB color space into greyscale. The output of RGB images transformation was used for image segmentation. The output of segmented images was used for feature extraction. Feature extraction was the main focus of the study. The coiflet wavelet transform for image processing accepted the segmented images. Once the decomposition was done, respective approximation coefficients of the features were extracted. As wavelet transform domain coefficients had distinct discriminatory features for establishing the freshness classification of the fish, it captured both the spatial and frequency information of an image. The Support Vector Machine Neural Network was used for training. The final output of this study was the classification of milkfish level of freshness.

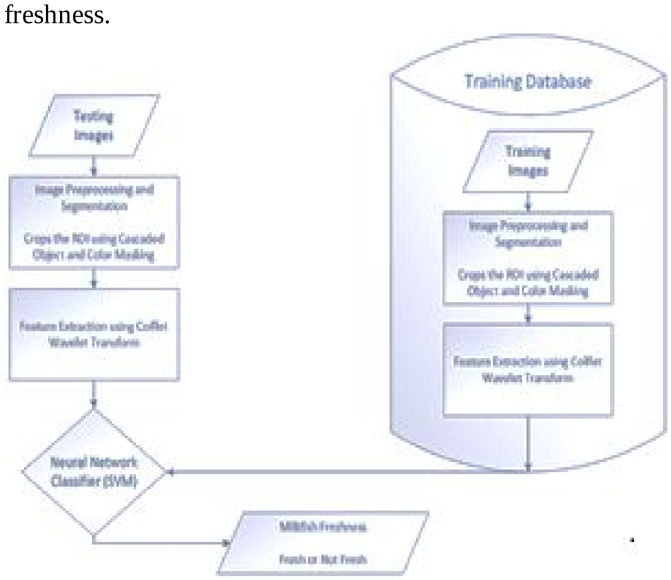


Figure 1 : . Conceptual Framework of the Study

3.2 Development – Freshness Detection of Milkfish Based on Coiflet Wavelet Transform for Image Processing

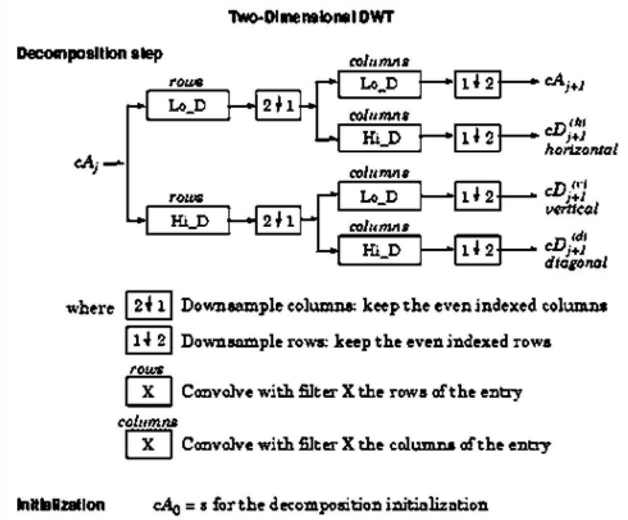


Figure 2 : 2D Discrete-time Wavelet Transform Algorithm (*adapted from mathworks.com*)

Figure 2 shows that the two-dimensional DWT leads to a decomposition of approximation coefficients at level j in four components: the original masked greyscale image, the downsampling of columns to keep the even indexed columns for both the lower diagonal and upper diagonal rows of the greyscale image, the downsampling of rows to keep the even indexed columns for both the lower diagonal and upper diagonal columns of the greyscale image, and the details in three orientations (horizontal, vertical, and diagonal). The said extracted features were inserted to the SVM model using fitcecoc MATLAB command. The same mentioned process was done to the images to be tested and validated. The results were compiled in the confusion matrix which showed the false acceptance ratio, false rejection ratio and the accuracy of the system.

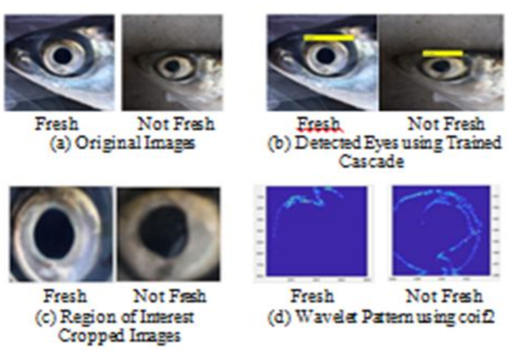


Figure 3 : Eyes of the Milkfish

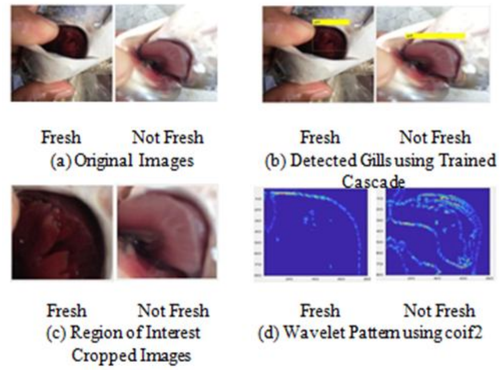


Figure 4 : Gills of the Milkfish

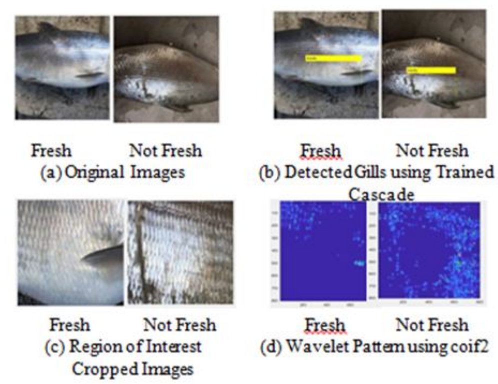


Figure 5 : Body of Milkfish

4. DATA AND RESULTS

4.1 Accuracy Detection of the Milkfish' Region of Interest

The region of interest was set as a classifier to determine the freshness of the milkfish. It is important to set an accurate system before it feeds to the SVM network for milkfish freshness classification.

The accuracy of ROI detection rate is,

$$ROI\ Detection\ Rate = \frac{\sum Extracted\ images\ of\ ROI\ classifiers}{\sum datasets\ used\ for\ ROI\ validation} \quad (1)$$

Figure 6 : System's Cropped Images Fresh Milkfish Eyes in an image

Figure 7 : System's Cropped Images Not Fresh Milkfish Eyes in an image

Figure 6 and Figure 7 shows the fresh and unfresh, (respectively), milkfish eyes detected in the image cropped by the system during image segmentation. The most common error in detecting the eye of the milkfish occurs when there's the same circular pattern present in the raw image, which is in this case the handle of the mug (e.g. eye56 shown in Figure 6) and circular light pattern (e.g. eye100 shown in Figure 7).

There were 119 cropped images used as validation dataset for the eye, 110 of those were validated as fresh. For not fresh eyes, 216 out of 246 are validated as not fresh eyes. Equation (1) gave a 92.437% accuracy for fresh eyes validation and 87.805% for not fresh eyes. These validated datasets were extracted and used as training data input in the SVM Feed-Forward Neural Network for classifying the freshness level.

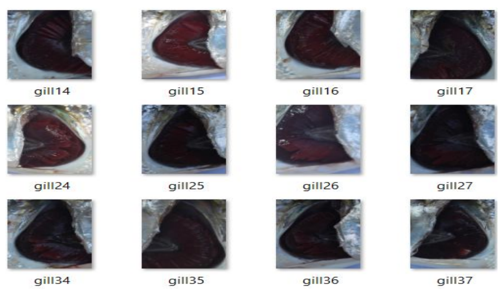


Figure 8 : System's Cropped Images Fresh Milkfish Gills in an image

Figure 9 : System's Cropped Images Not Fresh Milkfish Gills in an image

Figure 8 and Figure 9 shows the fresh and unfresh, (respectively), milkfish gills detected in the image cropped by the system during image segmentation. The most common error in detecting the gill of the milkfish occurs when the gill is not completely exposed in the raw image, making the eye of the fish to be detected as gill (gill51 and gill55 shown in Figure 9).

There were 41 cropped images used as validation dataset for the gills, all of those were validated as fresh milkfish' gills. For unfresh gills, 156 out of 191 were validated. Equation (1) gave a 100% accuracy for fresh gills validation and 81.675% for unfresh eyes.

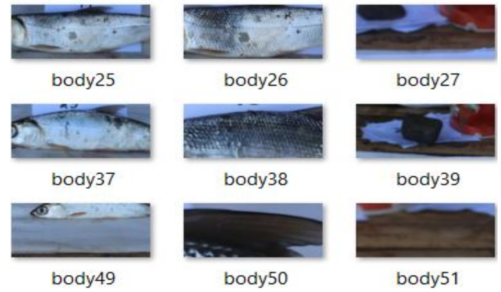


Figure 10 : System's Cropped Images Fresh Milkfish Body in an image

Figure 11 : System's Cropped Images Not Fresh Milkfish Body in an image

Figure 10 and Figure 11 shows the fresh and unfresh, (respectively), milkfish body detected in the image cropped by the system during image segmentation. The most common error in detecting the body of the milkfish occurs when there's the same pattern body as present in the raw image, which in this case, the table top made from bamboo (e.g. body51 shown in Figure 10 and body144 shown in Figure 11). Several milkfish body pattern were detected in the raw images which contributed little accuracy in milkfish body detection.

There were 72 cropped images used as validation dataset for the body, 39 of those were validated as fresh milkfish' gills. For unfresh milkfish body, 193 out of 215 were validated. Equation (1), gave 54.167% accuracy for fresh gills validation and 76.892% for unfresh eyes. Several milkfish fresh body pattern are detected in the raw images which cause small accuracy in milkfish body detection.

After testing the detection of the correct ROI image of the milkfish body, the training dataset was selected based on the correctly detected images.

With a total of 884 images, the accurate data was 755, giving an overall ROI detection rate of 85.407%.

4.2 Classification of Milkfish Freshness Using Confusion Matrix

To measure the performance of the SVM classification algorithm confusion matrix was used. It evaluates the accuracy of the networks classification system for training, validation and testing dataset.

In this study, the focus was on binary classifiers through which milkfish eyes, gills, and body could be identified as fresh or unfresh. The confusion matrix at the following forms is shown in figures 12, 14, and 16:

(1) The predicted class or target class is represented by the column indicating the desired output of milkfish freshness level.

(2) The actual class or the output class is in the rows of the matrix indicating the system's output in determining milkfish freshness.

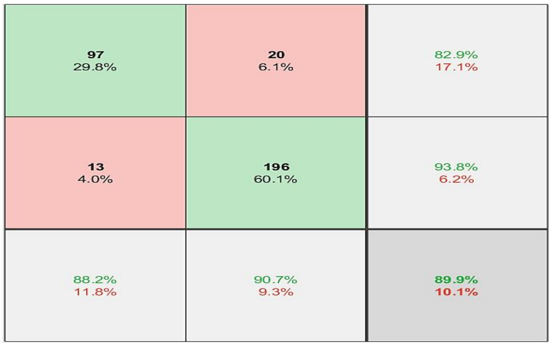
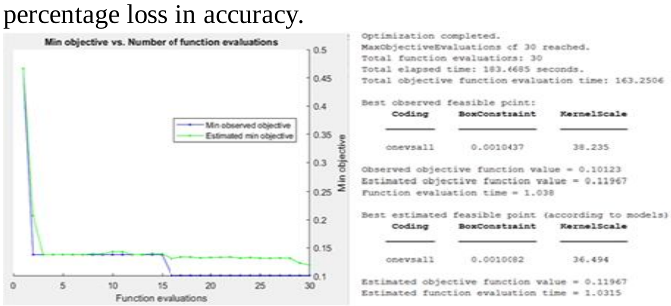


Figure 12 : Confusion Matrix of Milkfish Eye Freshness

Figure 12 shows the confusion matrix for the detection of freshness accuracy for the milkfish eye. The accuracy for the fresh eyes and unfresh eyes yielded 97 out of 110 and 196 out of 216, respectively. The overall accuracy for the milkfish' eye freshness was 89.9%.

For its consistency, accuracy can be checked with the total error of the system which is the total value outside the diagonal of the confusion matrix. To determine the total misclassified test samples, divide it by the total number of test samples to arrive at the total error which is equal to the percentage loss in accuracy.



(a) Performance Curve (b) SVM Train Tool

Figure 13: Feedforward Network Performance for Eye Freshness

Figure 13 shows the performance of the neural network for the milkfish eyes. As seen on the graph, the observed and estimated function values are 0.10123 and 0.11967. It means that the performance of the SVM' feedforward network Neural Network for milkfish eye freshness met the desired output of classifying the milkfish' eyes freshness level.

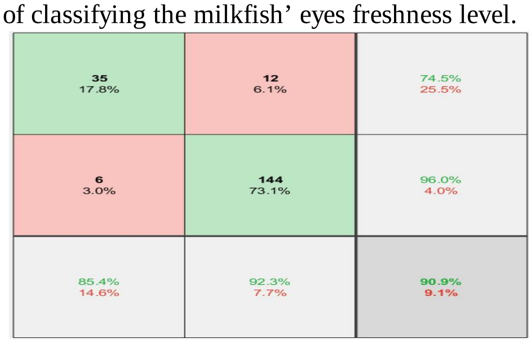
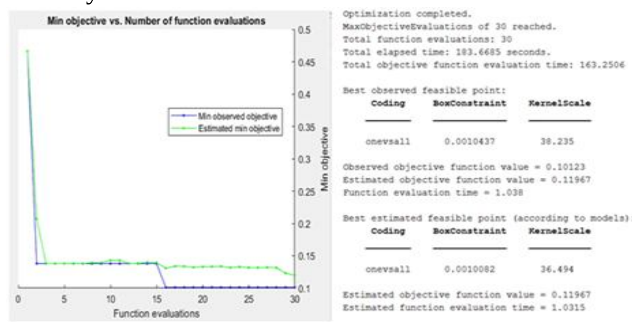


Figure 14 : Confusion Matrix of Milkfish Gill Freshness

Figure 14 shows the confusion matrix for the detection of freshness accuracy for the milkfish gill. The accuracy for the fresh gills and unfresh gills yielded 35 out of 41 and 144 out of 156 respectively. The overall accuracy of milkfish' gill freshness yielded 90.9%.



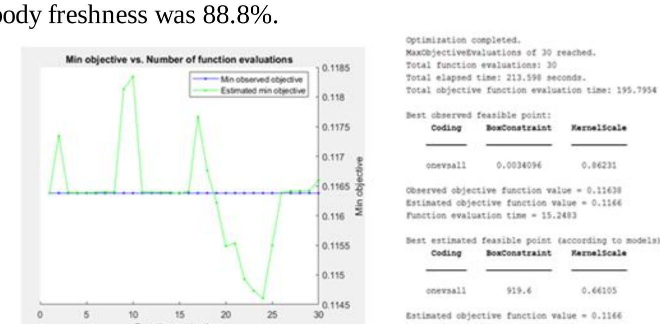
(a) Performance Curve (b) SVM Train Tool

Figure 15 : Feedforward Network Performance for Gill Freshness

Figure 15 shows the performance of the neural network for the milkfish gills. As seen on the graph, the observed and estimated function values are 0.086294 and 0.090961. It means that the performance of the SVM' feedforward network Neural Network for milkfish gills freshness met the desired output of classifying the milkfish' gills freshness level. Compared to the neural network performance for milkfish' gill freshness, the network performance for milkfish' gill freshness performed better since its ROI detection rate is more accurate.

Figure 16 : Confusion Matrix of Milkfish Body Freshness

Figure 16 shows the confusion matrix for the detection of freshness accuracy for the milkfish body. The accuracy for the fresh body and not fresh body yielded 15 out of 39 and 191 out of 193, respectively. The overall accuracy of the milkfish' body freshness was 88.8%.



(a) Performance Curve (b) SVM Train Tool

Figure 17 : Feedforward Network Performance for Body Freshness

Figure 17 shows the performance of the neural network for the milkfish body. Based on the graph, the observed function value is 0.11638 while the estimated function value is 0.1166. It means that the performance of the SVM' feedforward network Neural Network for milkfish' body freshness met the desired output of classifying its freshness level.

5. CONCLUSION

The researcher finally concludes that the classification of milkfish freshness is successfully achieved using MATLAB with cascaded training toolbox applying Coiflet wavelet filter. In application, that do not require huge amount of dataset, too complex computations and training time the authors perform transfer learning. This study used a pre-trained model to train SVM system. Using three ROI's (i.e. eyes, gills, body) as the classifiers, the study achieved the objective. First, it was able to create a system that would detect the region of interest and validate this region using the Coiflet waveform transform in ROI's milkfish freshness classification. And secondly, in measuring the performance of the SVM Neural Network for classifying milkfish freshness, the confusion matrix was able to measure the eyes, gills, and body classifiers accurately. The feedforward network performance has almost zero value for the objective and estimated function values, giving the indication that the desired outputs have been met by the performance of the system.

For future prospective in this study, the current method may be applied on different major fish varieties. Further enhancements can be made for improvements and accuracy of the program implemented through Support Vector Machine. In addition, this study can be implemented through any mobile applications for convenience.

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