Fish Species Classification Using Probabilistic Neural Network

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Abstract. The number of varieties of fish species in the same family causes difficulties in classifying fish species directly. Currently, the process of fish species classification accomplished in the fisheries section uses direct eye observations and knowledge assumption and then compares the existing characteristics with reference books. Therefore, an image processing and neural network approach are needed to classify fish species effectively and efficiently. In this study, there are three fish species classified in the Scombridae family, those are skipjack tuna, tongkol, and tuna with ‘out of water’ conditions. The proposed approach utilizes ROI (Region of Interest) in the form of a fish belly. The combination of GIM (Geometric Invariant Moment) feature extraction, GLCM (Grey Level Co-occurrence Matrix) texture feature extraction, and HSV (Hue Saturation Value) colour feature extraction was used to extract features in the image. For the process of determining the type of fish species, the method used is Probabilistic Neural Network. Based on the results of research on 112 images of data training and 29 images of data testing, an accuracy rate of 89.65% was obtained.

1. Introduction

Indonesia has been called a maritime country referring to the largest archipelagic country in the world which consists 2/3 of the territorial sea and 1/3 of the land area. Indonesia has 6,315,222 km2 area of water, 99,093 km2 coastline length and 13,466 islands named and coordinated [1]. Along with this strategic area, the role of the sea becomes significant and has a great potential to deliver Indonesia to the economy progression. One of the sectors that supporting the Indonesian economy besides the shipping sector is the fisheries sector. This situation is supported by Indonesia's geographically strategic position that is located on the equator and flanked by two continents and two oceans. Therefore, Indonesia has wealthy marine resources and is dominant in the water sector. The amount of fish species varieties cause difficulties in recognition of fish species directly. Currently, the process of classification of fish species in the field of fisheries has done directly using eye observation and with knowledge assumptions. Classification is done not only based on color pattern analysis; but also, the number of spines and rays in different fins, the number of scales along the line lateralis, the shape of the head, the shape of fins, and so on. After obtaining the data, the classification is done by matching the existing features with the reference book. These all are done manually so it takes a long time and bring through a high level of human error.

Several studies that related to the fish classification have previously been done with various methods, both in terms of feature extraction and classification systems. [2] Conducted a research by extracting RGB (Red Green Blue) color features with a color histogram that was then followed by texture feature extraction based on GLCM (Gray Level Co-occurrence Matrix). By doing the image segmentation by
focusing on the fish’s stomach, the researchers managed to classify fish based on the family, especially to distinguish toxic and non-toxic fish. Some fish species have color similarities that cause classification difficulties. Extraction of texture features using GLCM helps to identify specific characteristics of species that have similarities. From 610 dataset images, the level of accuracy obtained using the backpropagation classification reached 84%. [3] Classification of tuna using GLCM texture feature extraction and extraction of certain form features. The image of tuna fish is segmented first by recognizing the edges of fish objects with Sobel filter. After that, the extraction of the GLCM texture feature is done with focus on the bottom of the fish belly. Classification of yellowfin and bigeye can be done by looking at differences in head shape using form feature extraction. Classification is done using a decision tree with an accuracy rate of 88%. [4] Designed a classification system for koi fish. This research implements feature extraction based on HSV (Hue Saturation Value) color space. On koi fish’s datasets, 281 acquired images with blue background color, image segmentation to separate background and foreground are done using K-Means. Segmented images are converted to HSV color space. Color feature extraction is done by quantizing HSV colors. The highest accuracy percentage obtained using Naïve Bayes without validation, which is 97.92%. While the lowest accuracy uses SVM without validation, which is 94.50%. In this study, the use of datasets uses controlled images (blue background) so that background and foreground separation does not cause noise in feature extraction. Classified fish are varying and contrasts in color so that they can be classified using only color feature extraction. [5] Designed an identification system using 75 images of reef fish with combination of HSL (Hue Saturation Lightness) color feature extraction and GLCM texture feature extraction. The researcher did the experiment with image taking at distances of 20 cm, 30 cm, and 40 cm and comparing the best degrees of GLCM, that are 0°, 45°, 90°, and 135°. From the research conducted, the best distance of image retrieval was 40 cm with a degree of GLCM 45°, 90°, and 135°. By using PNN (Probabilistic Neural Network) classification, the values of smooth are 0.7, 0.8, 0.9, and 1; the level of accuracy obtained is 93.48%. The lowest accuracy level (41.30%) was obtained at 20 cm image taking distance with degree GLCM 0° and the smooth value was 0.1 in PNN. The fish species recognition was carried out by [6] with extraction of GLCM texture features, HSV color feature extraction, and feature extraction features of Invariant Moment. By using 24,150 images data samples, the classification system that implements hierarchical classifier has an accuracy rate of 97.5%. Based on these studies, in this study, fish classification was carried out using a combination of Geographical Invariant Moment feature extraction, texture extraction features of Gray Level Co-occurrence Matrix, and Hue Saturation Value color feature extraction. The purpose of the feature extraction combination is to obtain specific fish image information. After obtaining the information of fish image, classification of fish species is done using Probabilistic Neural Network.

2. Methodology
The general architecture that describes the method in this study is shown in Figure 1.

2.1. Input
Input is in image form from fish species images dataset, which are images that obtained from observation (acquired using smartphone camera based on Android operation system).
2.2. Pre-processing
At this stage, the cropping stage is done to cut the image to have a dimension size of 16:9. After that, the scaling stage is done to obtain an image with dimensions of 1296 × 2304 pixels. Determination of ROI (Region of Interest) has dimension of 560 × 200 pixels in the form of fish belly is calculated 1052 pixels horizontally and 452 pixels vertically from the upper left corner of the image. Figure 2 shows the image sample resulting from the ROI (Region of Interest) determination stage.

![Figure 2. Sample image from determination stage of ROI.](image)

After obtaining ROI (Region of Interest), the next step is to change the image to grayscale color mode. This is intended to facilitate the calculation of objects in the image. RGB to grayscale color pixel conversion is the first step taken in extracting Geographical Invariant Moment feature characteristics and Gray Level Co-occurrence Matrix texture feature extraction. Figure 3 shows a sample of RGB to grayscale color conversion imagery.

![Figure 3. Sample of image colour conversion from RGB to grayscale.](image)
For Hue Saturation Value’s color feature extraction, the image color mode used is HSV. Changing the image color mode from RGB to HSV is done by the following steps:

- **RGB color pixel normalization**
  Normalization of RGB color pixels into a percentage of an image pixel consists of three components, namely r, g, and b.

- **Convert RGB color pixels to HSV**
  The next thing to do is to convert RGB color pixels to HSV. Conversion is done by changing the value in r, g, and b to the values in the H, S, and V layers. Figure 4 shows a sample of the RGB color conversion image to HSV.

![RGB (Red Green Blue) and HSV (Hue Saturation Value)](image)

**Figure 4.** Sample of image color conversion from RGB to HSV.

### 2.3. Feature Extraction (Geographical Invariant Moment)

This stage is the extraction of characteristic features in the image of fish species. By using Geographical Invariant Moment, it is possible to recognize image characteristics even though changes are made in the form of translation / shifting, reflection, scale dilation / scale change, and rotation. The first step is the feature characteristic extraction using Geographical Invariant Moment according to [7] is looking for the moment values.

### 2.4. Feature extraction (Geographical Invariant Moment)

This stage is the extraction of texture features in the image of fish species. At this stage the texture of fish species will be identified through four vector features that are Contrast, Correlation, Homogeneity, and Energy. Each of these feature extractions consists of four angular directions, namely 0°, 45°, 90°, and 135° [8]. The first step of extracting texture features using Grey Level Co-occurrence Matrix is calculating the value of the co-occurrence matrix. The co-occurrence matrix is obtained by calculating the number of pixel pairs with the same intensity and entering the value into the work area of the GLCM matrix. In determining the pixel pairs, the overall value of the grayscale matrix is placed in the cooccurrence matrix by referring to the grayscale colour grey level mode (8-bit image) in the form of $2^8=256$. Thus, the size of the co-occurrence matrix is $256 \times 256$. The next step is to calculate the symmetrical matrix value. The co-occurrence matrix can be converted into a symmetrical matrix by adding up the co-occurrence matrix with the matrix the transition. After obtaining a symmetric matrix value, normalization is carried out to obtain a value in the form of probability. After the probability matrix is formed, what is done is to calculate the second-order statistical characteristic that represents the image into a feature vector value. The characteristics used are Contrast, Correlation, Homogeneity, and Energy [9].

### 2.5. Feature extraction (Hue Saturation Value)

This stage is in the form of color feature extraction in the image of fish species. At this stage each pixel image of a fish species is recognized in the form of a histogram by quantizing the color of the image in 72 bins. The steps of color feature extraction using Hue Saturation Value are quantization of color histogram. After obtaining the HSV matrix, the process carried out is the color histogram quantization. This process is carried out to improve performance and reduce the computational load from image pixel calculations. Quantification of color histograms according to [10]. After obtaining all three vectors for HSV, the process of vector composition into one dimension to form a histogram according to [11] was carried out.
2.6. Classification
The next step after getting the value of feature extraction is to enter the value of the characteristic, texture, and color extraction features as input values for the Probabilistic Neural Network process. Furthermore, the classification results are obtained by comparing the output values in the training process with the output value in the testing process. The first step to classify fish species using Probabilistic Neural Network is to receive input in the form of feature extraction. The results of the characteristic, texture, and color extraction features are input values in the input layer. The number of inputs consisted of 83 data, 7 extraction data of Geographical Invariant Moment characteristic features, 4 extraction features of Gray Level Co-Occurrence Matrix texture data, and 72 Hue Saturation Value color feature extraction data. After that, the calculation of the similarity value (the distance of the weight vector data input with the weight vector data training) according to [12] is done by a probability density function.

2.7. Post-processing
After obtaining the classification results in the form of fish species that are inputted, information on fish species will be added by humans. This information is in the form of description, taxonomy, ecology, size, and the level of consumption safety. The addition of this information is intended to produce information more specifically related to the image of fish species.

3. Result

3.1. Data collection
The data that used in this study are images obtained through direct observation. Observations were made at the fishing port in Sibolga City, North Sumatra Province and the market in Medan City, North Sumatra Province. The obtained image was acquired using a smartphone camera based on the Android operating system with portrait orientation settings and dimensions 4608 x 2592 pixels (16:9 ratio).

The condition of data images obtained is stated as "out of water" data. Image with "out of water" conditions consists of fish specimens that are taken out of their natural habitat with varied backgrounds and outdoor lighting conditions from sunlight.

Total of data obtained amounted to 141 images and then combined into a dataset of fish species images. In classification testing, all data are divided randomly into data training and data testing with a ratio of 80:20. So, amount of 112 images are used as data training and a total of 29 images are used as data testing. In the dataset, skipjack tuna was identified as Class I, tongkol identified as Class II, and tuna identified as Class III. The sample data used with the "out of water" condition can be seen in Figure 5:
3.2. Flow of the works
In this study, the fish species classification system consists of several steps. Before carrying out the classification process, the input is in the form of images from the dataset of fish species images. To the image then, performed preprocessing stage to obtain ROI (Region of Interest) of fish belly in grayscale color mode and HSV. Furthermore, the extraction of characteristics, texture, and color features are done to obtain information on fish species. Classification of fish species is carried out using Probabilistic Neural Network. After the steps are taken, the results obtained are in the form of fish species’ name with the information related to the fish species. This information will be displayed on smartphones in Figure 6.

![Fish Details](image)

**Figure 5.** Skipjack tuna (left), tongkol (centre), dan tuna (right) with “out of water” condition.

![Fish Details](image)

**Figure 6.** Description of fish classification result.

Each step taken will be elaborated in detail in the following sections. The process of classification can be seen in Figure 7.

![Fish Classification Process](image)

**Figure 7.** Classification process.
System training uses the Probabilistic Neural Network method with data training used in the form of 80% of the dataset of fish species images used table 1.

Table 1. Parameter used in the system training.

| Parameter            | Nilai |
|----------------------|-------|
| Batch size           | 128   |
| Training steps       | 0.1   |
| Standard deviation   | 1     |

Batch size is the size of many batches in the form of images that will be trained in one unit of time (one training times). The value of 128 is chosen based on the default value in the library used and is a value that provides optimal performance during the training process. Training steps are the amount of stages needed to train the image. A value of 0.1 is selected based on the default value in the library that has been used and is the most accurate value based on the results of the training. Standard deviation becomes the smoothing value or Gaussian smoothing parameter. A value of 1 is chosen based on the most accurate value based on the results of the training.

System testing using the Probabilistic Neural Network method with data testing used in the form of 20% of the dataset image of fish species. Each image in testing dataset first going through preprocessing and feature extraction. The value of the feature extraction is used as an input value on the Probabilistic Neural Network. The acquisition of accuracy values from the results of system testing is calculated by calculating the amount of the correct data testing and divide by the total number of testing data multiplied by 100%. Thus, the acquisition of accuracy values from the results of system testing is 89.65%.

4. Conclusion and future works

Based on the testing of classification system of fish species using Probabilistic Neural Network obtained the following conclusions:

- Probabilistic Neural Network method can classify fish species very well, from 29 testing data obtained 89.65% accuracy rate.
- Using GIM (Geometric Invariant Moment) feature extraction, GLCM (Gray Level Co-occurrence Matrix) texture feature extraction, and HSV (Hue Saturation Value) colour feature extraction is a combination of good feature extraction as input in the process of fish species classification.
- The distance of taking and the angle of image acquisition has an influence on the success of classification on the system. In this study, the distance used so that the image can be acquired properly is no more than one meter with a 90° angle horizontally towards the object of the fish species.

Future Works

- The researcher can then add an object recognition feature in the form of fish species before conducting a classification to ensure that the object classified is a fish species.
- Determination of ROI (region of interest) of fish species in this study was carried out statically through the calculation of the researcher. Further researchers are expected to develop the determination of ROI (Region of Interest) dynamically adjusted to the location of objects in the form of fish species.
- Adding datasets to the image of fish species in various conditions, for example in a state of minimum light intensity that allows the system to perform various classifications conditions with relatively high accuracy.
- Adding the number of classification classes in the image dataset of fish species that are in the same class or genus.
• Addition of different feature extraction features, such as feature size feature extraction and feature extraction geometric features.

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