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Classification of Squids Using Morphometric Measurements

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Abstract

Rising interest in conservation and biodiversity increased the demand for accurate and consistent identification of biological objects, such as species. Among the identification issues, squids identification at the species level has been strongly addressed. Squid, is a carnivorous marine cephalopod mollusk. Each species of the squids has got its own characteristic patterns and to accurately classify the squids. In this paper we extracted the morphometric features of the squids using image processing techniques. Here, the process begin with removing the noise of images, and then crop the images by using Region of Interest (ROI) for specified features. Edge detection methods can be employed to characterize edges to represent the image for further implementation. Then the morphometric features i.e., mantle, fin and head are measured to identify the squid species. Finally, for the classification of squids the Artificial Neural Network (ANN) has been used to classify the species based on extracted morphometric features.

1. INTRODUCTION

Squids play an important role in the marine food chain. They belong to the third trophic level in the food chain. They contain about 500 species for squids in different seas and oceans. The automatic recognition of squid species by their patterns is a very interesting field. The need for computer based squid species recognition systems that can automatically recognize species of squids from digital images is expected to increase in the near future[1][2]. In general it is not easy for a human being to inspect and recognize the bulky amount of squid species and more over it is extremely cost effective. Automatic classification of the squid species is necessary to overcome the errors caused by manual sorting of squid species which is completely based on the human expertise. A basic squid has two fins, mantle, head, eight arms and two tentacles, each endowed with hooks and/or suckers and sucker rings. In this paper, we will focus on the absolute basics of squid anatomy and some frequently cited measures, particularly Mantle Length, Mantle Width, Head Length, Head Width, Fin Width and Total length [3, 4].

Hence, based on these morphometric feature measurements, easily classify different types of squids. The main idea of this paper is to identify the squids by using their morphometric features which gives a way for selecting one suitable technique for identifying the species of squid. Many aspects of their life history and structural characteristics are poorly known. In the present research, the morphometric characters beside some proportional measurements of the squids are studied. A simplified account of squid morphology (fig.1) shows differences between squids based on their morphometric measurements for classifying the species. In the first step resizing, rgb to gray scale conversion and noise removal is done. Then the second step is cropping the certain features of squid like mantle, head and fin by using ROI. It is very complex to find the category of a squid with its internal structure, hence we used edge detection techniques for identify the major features of squid at edges only. Edge detection is one of the mostly used operations in image analysis.

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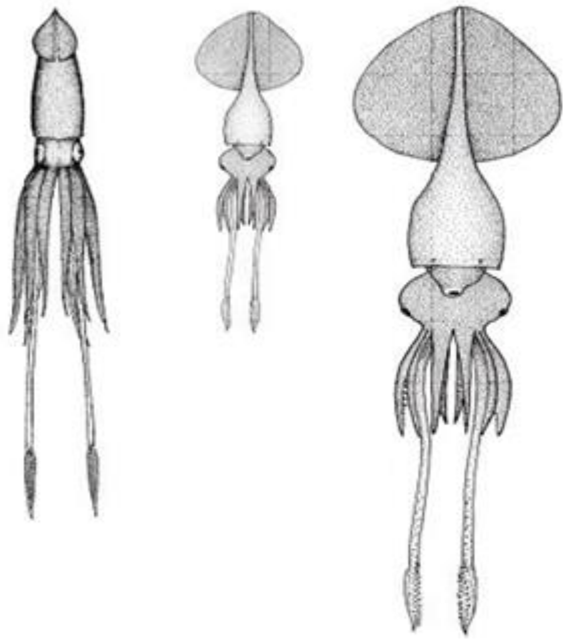


Fig.1. *Differences between squids morphometric measurements*

Then the next step we measure the external features of edge based squid like mantle, head and fin of squid by using distance tool. After extracting the features, classification is necessary for classifying the features of different types of squids. Hence, Neural Network is used for classifying different types of squids based on features.

2. PROBLEM DOMAIN

Squid are cephalopods of the order Teuthida, which includes around 304 species. Like all other cephalopods, squid have a distinct head, a mantle, and arms. The main body mass is enclosed in the mantle, which has a swimming fin along each side. Some features may vary among different squids species.

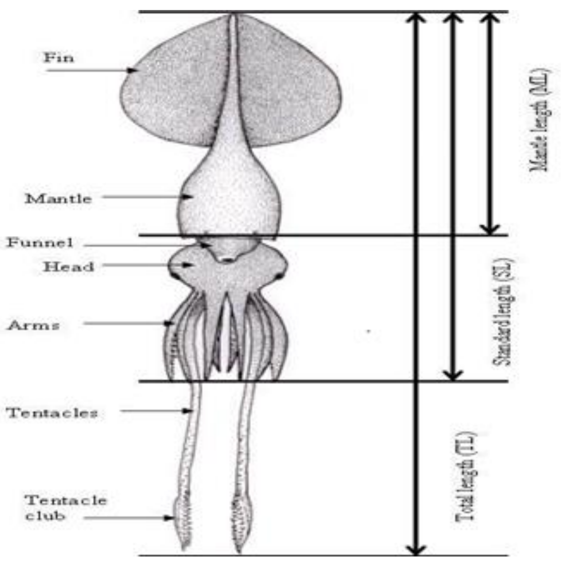
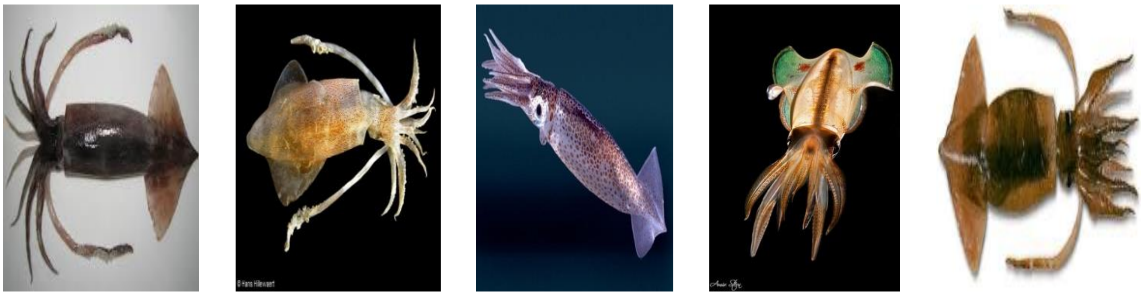


Fig. 2. *Basic squid morphology and terminology*

There is a difficulty in identifying the different species of squids. The classification is made by analyzing squid with the various features as shown in Fig. 2. The various species of squids with different morphometric features look identical. It has to be extracted by using the image processing techniques. The image processing concept mainly deals with three aspects. The first is segmenting the features, second is edge detection of the squid, followed by feature extraction and then measure the morphometric measurements and finally classify the squids using neural network.

3. DATA COLLECTION: IMAGES

Images of squids species were collected from the National Geographic photo gallery and squid world [5, 6].



(a) (b) (c) (d) (e)

Fig. 3. *Samples of squid species (a) Todarodes pacificus (b) loligo forebesii (c) Collosal (d) Backlight (e) Illex argentines*

4. METHODOLOGY

The objective of this system is the classification of the squids based on the Morphometric measurements in the image by using image processing techniques.

4.1. Image Processing

The Image preprocessing is done in three essential steps.
1. Image resize
2. Conversion of color images to Gray scale images.
3. Noise Removal

Image Resize: Fig. 3 shows samples of squid species. The squid image input is resized to 256 x 256 pixels. This is done to maintain steadiness and to reduce the time of processing .

Gray Scale Conversion: After resizing the image the squid image is converted into gray scale image as shown in Fig.4. The value range of gray scale level is 0-255. RGB values converted into gray scale values by a weighted sum of the R, G, and B components using 0.2989 * R + 0.5870 * G + 0.1140 * B.

Noise Removal : Image smoothing is done in order to remove noise and negligible fluctuations in an image.

(a) (b) (c)

Fig.4. *a) Original image b) Gray Scale Images c) Resized Image*

4.2. Feature Extraction

Although image masks can be created by manually tracing around squids edge on binary image mask from the ROI object. Therefore for image processing, masking is usually a semi-automated work. Images are first segmented on the basis of pixel intensity, in metamorph the segmented overlay squid then extracted to a separate image stack for the purpose of creating a binary mask. A binary mask fully has pixel intensity values of “0” (background) or “1”(object)[7]. Masking image allows the Image Processor to discriminate Regions of Interest(ROI). These may also be referred to as areas of interest. Fig.5 shows the methodology of extracting squid features. A second reason to mask image is to prevent artifacts arising from dividing background by background values. Then next step calculate the area in pixels that they drew then get the coordinates of the boundary of the freehand drawn region.

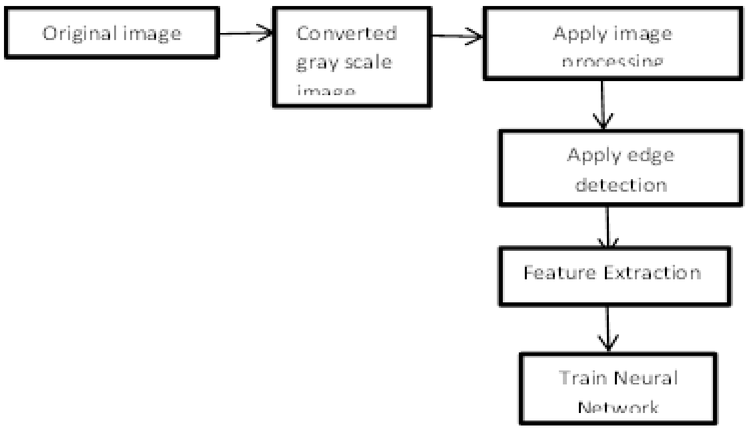


Fig.5. *Feature extraction algorithm*

1-Area is the total number of pixels of the specimen area, and is defined as:

$$A(s) = \int_x \int_y I(x, y)dydx$$

I(x, y) depended on the limits of the shape and burn line into image by setting it to 255 wherever the mask is true. Then calculate the mean, now do the same but blacken inside the region. Now crop the image according to topline of image, left column of image, height and width of image. The ROI of the squid is cropped by getting the coordinates of the boundary of squid mantle. The proposed ROI automatic detection based on edge segmentation has identified the ROI of these images by edge detection and morphology processes[8][9]. In this way we extract all the features of squids like mantle, fin and head. Features are extracted from the shape descriptors represented by the binary images of the ROI using region properties function. Fig.6 shows the segmenting the part of mantle of squid.

4.3. Edge Detection Techniques

In image analysis the problem of fundamental importance is given to edge detection. Since it is very complex to find the category of a squid with its internal structure, hence we used edge detection techniques for identify the major features of squid at edges only.

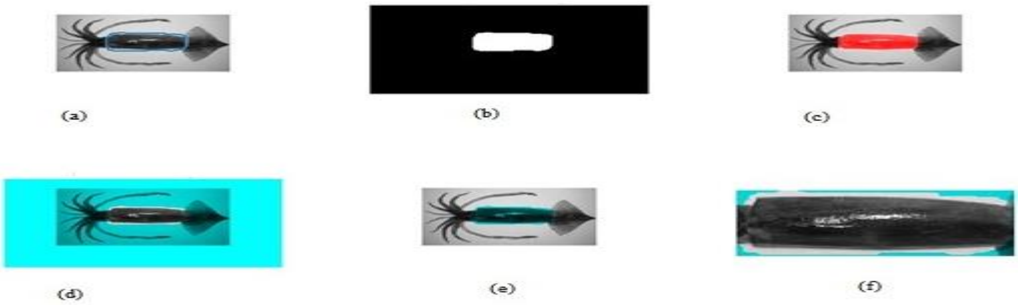


Fig. 6. *(a) Original grayscale Image (b) binary mask of the region (c) highlight region (d) masked outside region (e) masked inside region (f) cropped image*

Edges describe the object boundaries which are useful for segmentation, and identification of objects[10]. Edges can be detected in many ways such as Roberts, Sobel, Canny. Here these edge detection techniques are applied on various parts of squid such as mantle, fin and head of squids.
Fig. 7 shows detecting the edges on mantle of squid. Edges can be detected in many ways such as Roberts, Sobel and Canny. Sobel method is good for detecting vertical and horizontal edges.

Fig. 7. *Edge detection techniques on mantle of squid species*

The operator has pair of 3x3 convolution kernels in sobel edge detector as shown in Table1. The two convolution masks Gx and Gy is used by this sobel operator which as shown in Table1. This can be joined together for finding the entire magnitude and the orientation of the gradient. Gradient magnitude given by

$$|G| = \sqrt{(G_x^2 + G_y^2)}$$

Where Zi, i=1,2,…9 are intensity levels of each pixel in the window, the magnitude of the gradient is threshold. Finally, Sobel operator is effective method to find the edges in image. The sobel operator is used frequently for detecting vertical and horizontal edges.

Table 1. *Masks Used by Sobel*

-1	0	1
-2	0	2
-1	0	1

-1	-2	-1
0	0	0
1	2	1

$$G_x = -1z_1 + 1z_3 - 2z_4 + 2z_6 - 1z_7 + 1z_9$$
$$G_y = 1z_1 + 2z_2 + 1z_3 - 1z_7 - 2z_8 - 1z_9.$$

However, sobel edge detection method is used in this module due to its performance[11]. All of these three edge detection techniques are implemented in MATLAB2015a on mantle part of squid images.

4.4. Performance Measures

Performance measures such as Accuracy, Precision and Recall are derived using the Confusion Matrix. A Confusion Matrix is a table which is used to define the performance of a classifier on a set of test data for which the true values are known. The Confusion Matrix is shown in Table 2.

Table 2. *Confusion Matrix*

Predicted class

Actual class		Yes	No
	Yes	True positive (TP)	False Negative (FN)
	NO	False positive (FN)	True Negative (TN)

True Positive (TP): Correctly predicted true instances.
False Positive (FP) : Incorrectly predicted false instances
True Negative (TN): Correctly predicted false instances.
False Negative (FN): Incorrectly predicted true instances.

Accuracy is the number of samples correctly classified. Both Precision and Recall are used to evaluate the accuracy of the classifiers which are associated with false positives and false negatives. Precision and Recall are only measure classification on the positive class. For Squids data set along with Accuracy, Recall and Precision are the most considerable Measures[12].

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

$$\text{Recall or Sensitivity} = \frac{TP}{TP + FN}$$

$$\text{Precision or Confidence} = \frac{TP}{TP + FP}$$

4. EXPERIMENTS AND RESULTS

The Research work is being carried out experimentally using the squid species. In this research work 50 squid species images are considered which are available in internet and six morphometric features are extracted. The work is implemented in MATLAB 2015a by extracted morphometric features of squids. In this study to define the ideal parameters of squids species like mantle length, mantle width, fin width, head length and head width.

4.1. Estimation of Morphometric Measurements

After finding the edges of images the focus is now how well one can estimate the measurement of image from the pixel area by using distance tool in MATLAB2015a. In this context, it is also interesting to examine how well length and width is estimated from image, and to compare length and width estimates based on pixel area[13]. The morphological features are concentrated on the organization of pixels.

Table. 3 describes the comparison between morphometric variations in different types of squids species represented in pixels. Morphological variability between squids species are measured by their physical measurements of mantle length, mantle width, fin width, head length and head width. Based on these measurements to classify the type of squids such as Todarodes pacificus, Collossal, loligo vulgaris, back squid, Illex argentines.

Table 3. *Experimental result with different Squids Morphometric measurements*

Morphometric measurements of squids (pixels)						
Input image	Mantle Length	Mantle width	Head Length	Head width	Fin width	Total Length
	222.58	87.01	30.07	59.03	197.06	258.44
	285.04	92.97	70.49	61.06	156.52	434.95
	268.68	95.26	63.2	55.01	182.04	439.65
	139.46	142.24	26.00	131.86	298.06	298.06
	177.14	120.04	81.06	138.03	356.01	356.01

The comparison of morphometric features of squid species are given in graphical representation Fig. 8. lengths, and mantle width is higher in back squid, Collosal head length is higher . Here, the Collossal squid total length is higher than the remaining squid species, and comparing to the mantle length loligo vulgaris and colossal squid are having same than the other squid species and then Illex argentines having the highest fin width and head width comparing to the all squid species.

Classification: Along with squid species detection based on morphometric measurements is essential for identification. For this various methods are available but in this study we used artificial neural networks [14][15]. A new squid dataset with extracted features are identified. Further classification using ANN is performed on new squid dataset. Multilayer perceptron (MLP) a popular widely used ANN Structure with back propagation algorithm is consider to classify the squid dataset into five classes. i.e.,

1- Todarodes pacificus
2- Collosal
3- Loligo vulgaris
4- Back squid
5- Illex argentines

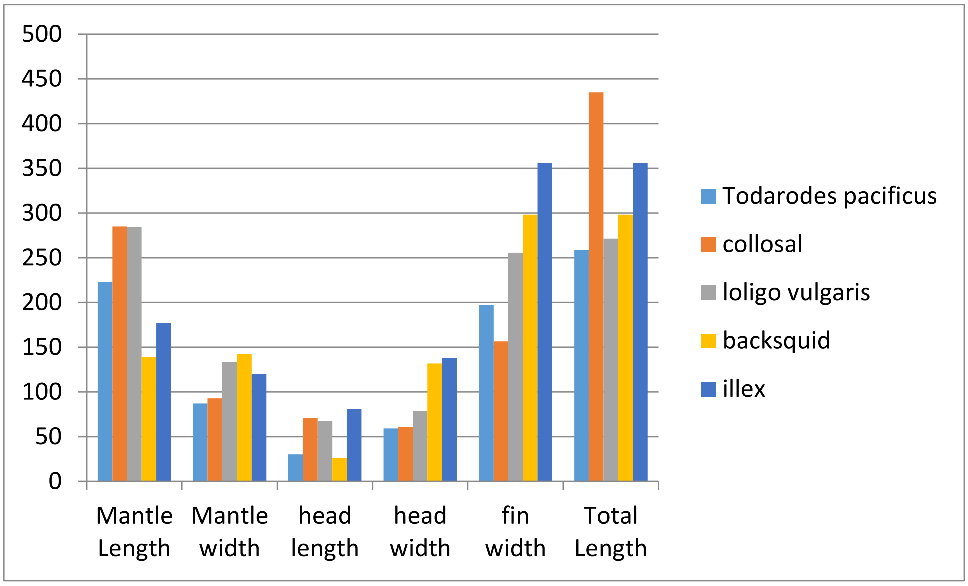


Fig. 8. *Variation of squid morphometric measurements.*

Fig. 9 shows classification of squid identification stage by using back propagation neural network. The ANN comprised three layers (one input layer, one hidden layer and one output layer) trained by back propagation feed forward neural network. In this experiment the MLP neural network is trained with using different Back Propagation algorithms.

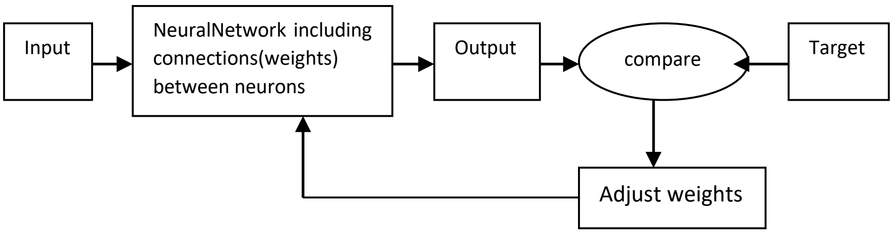


Fig. 9. *Neural Network*

A one layer feed-forward network was trained with back propagation algorithm based on ten neurons at the hidden layer and five neurons at the output layer was shown in Fig.10.

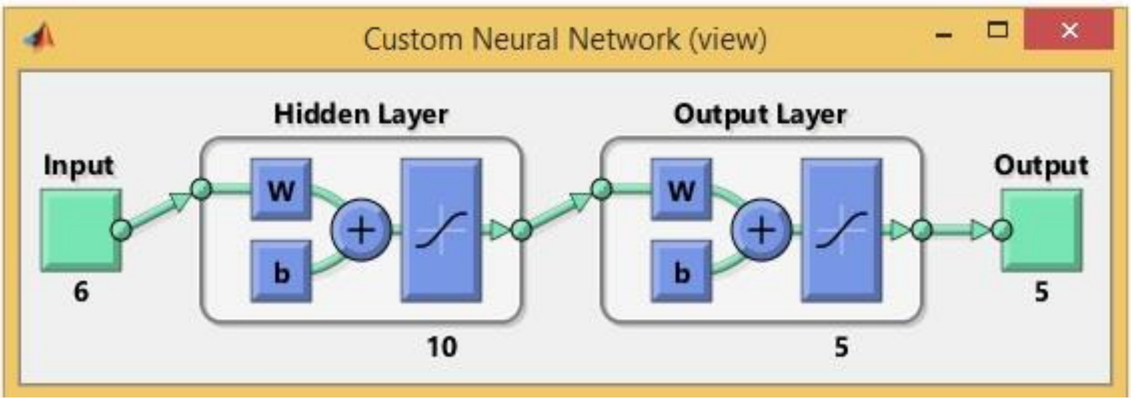


Fig 10. *Custom Neural Network Training*

The best trained network was found with 14 iterations. The best validation performance in the trained network had a MSE of 0.14638 at epoch 14 (Fig. 11). Using MLP 70% of squid species used for training, 15% of species are validation and 15% of species are using for testing.

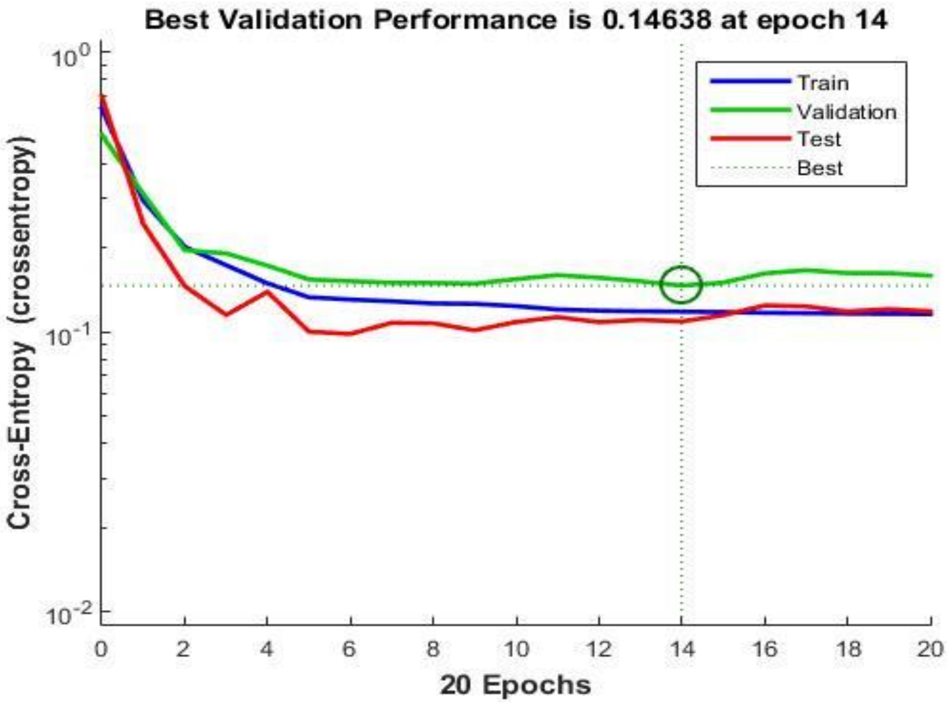


Fig.11. *Neural Network training performance*

Result from the confusion matrix showed overall 98.6% of correct classification of all samples in the training, validation and testing sets. Finally classified the squid data with an accuracy 98.6%.

MLP With Back Propagation Algorithm			
Network Performance Measures (%)	Accuracy	Recall	Precision
	98.6	98.6	100

5. CONCLUSIONS

In this work morphometric features of squid species images are extracted and new squid dataset was formed. MLP with backpropagation classified the new squid data into five classes such as Todarodes pacificus, Collosal, Loligo vulgaris, Back squid, Illex argentines with an accuracy 98.6%. in future work same may be conducted shape of squid species.

CONFLICT OF INTEREST

No conflict of interest was declared by the authors

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