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# Automatic Ship Types Classification in Silhouette Images

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***Abstract— Object identification or object classification is an important task in computer vision and pattern recognition. Silhouette image comprises many features which can be used for these demands. In this paper Discrete Hartley Transform (DHT) and Discrete Cosine Transform (DCT) are used for feature extraction from silhouette image. These features are then applied to the neural network for ship type classification. Ship features from different view (only 4 features in each image) were trained with feed forward back propagation neural network and accuracy was satisfied for testing over 50 images, also this algorithm is stands up robustly against the noise and can be used for classification another things such as animals, people , vehicles,etc.***

***Index Terms— Pattern recognition, object classification silhouette image, DHT (Discrete Hartley Transform), DCT, ship type classification.***

## I. INTRODUCTION

Pattern recognition is concerned with automatic detection and classification of objects or events. This is a very important task in each image analysis system including computer vision, robotic and so on. An effective shape descriptor is a key component for describing objects and then classifying them. Silhouette contain information about the shape of objects that may be used for classifying animals, human, vehicles ,ships, etc. Paul Withagena used structural features of Infra-Red images for automatic classification of ships [1]. L. Gagnon and R. Klepko classified ships using extracted features from SAR images [2]. V. Gouallier and L. Gagnon classified ship silhouette using PCA [3]. J. Alves used edge-histogram and scale-invariant moments of a silhouette to classify the ship types [4]. In this paper, we present a useful approach for classification of ship type .The silhouette features from different angles of view for every ship type was trained with feed forward back propagation neural network. As we know, in object recognition with a supervised learning network, it is necessary to store a complete set of templates from every angle of view. We proposed a method for decreasing the feature space of the templates. To approach a small set of good features, DCT and DHT**,** are used for feature selection**.** These transforms have been used as discriminant transforms and also to minimize feature space.Section 2 describes silhouette image, section 3 involves pre-processing step and extraction contour from noisy image,

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Section 4, 5 introduces the basic concepts of DCT **and** DHT, section 6 describes feature extraction method and section 7 describes classification based on feed forward back propagation network. Sequence of our work is shown in figure 1.

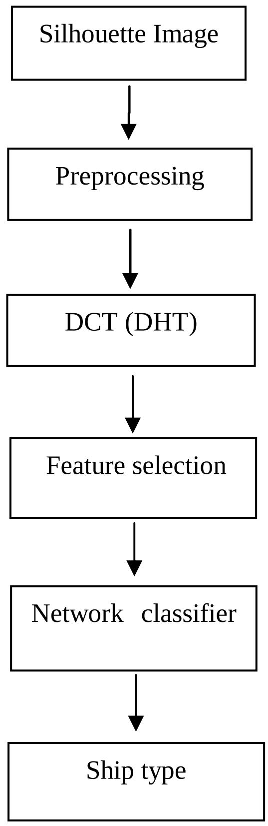


**Figure (1) Block Diagram of Algorithm Operation**

## II. SILHOUETTE IMAGE

Different descriptions of shape information of objects such as points, boxes, silhouettes and blobs are available for classifying objects. In a pattern recognition program, an object can be defined as anything that is of interest for further analysis. For instance, ships, fish, vehicles, planes, people or any other things. These objects can be represented by their shapes and appearances. Contour representation defines the boundary of an object, and the region inside the contour is called the silhouette of the object. Silhouette and contour contain many detailed information that can used for recognition complex shapes. Figure 2 shows a sample of silhouette image that we used in our database.



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**Figure (2) Sample of Silhouette Image**

## III. PREPROCESSING

First requirement for extracting silhouette contour is the noise reduction in received images. Here we can use different filtering methods.Figure3.b shows the filtering result of the adaptive filtering of a noisy image as shown in figure3. In this part, Wiener adaptive filter was used for noise reduction. To extract contour from image, we can use different edge detection operators, such as Canny and Susan. We tested this operators and figure3 (c, d) show the result of them. As it is shown, Susan operator has a better result in many aspects. Also using the Susan algorithm for preprocessing can reduce the space and computational time required for analyzing the image [7, 8]. Figure 3.d shows the result of applying the Susan algorithm to the noisy image and segmentation steps.

Image segmentation can be performed to extracting the disconnected points in contour.

**Figure 3 (a) Original Image [4]**

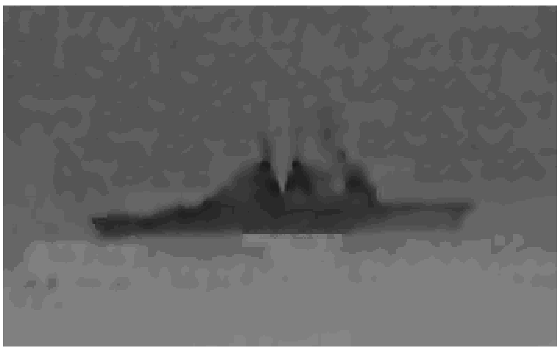

**Figure 3 (b) Result of Filtering on Figure 3.a (Wiener Filter)**

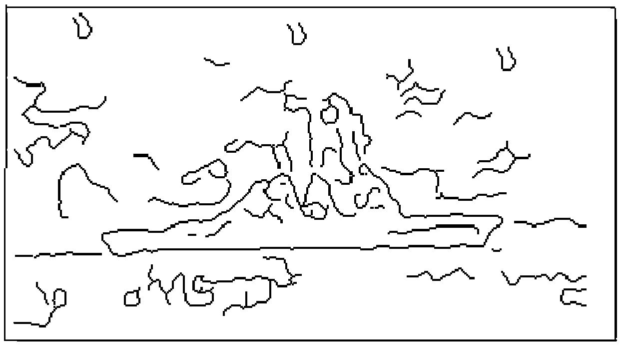

**Figure 3 (c) Result of Canny Edge Detector of Figure 3.b**

**Figure 3 (d) Susan Algorithm Result of Figure 3.b**

## IV. DHT (DISCRETE HARTLEY TRANSFORM)

The Hartley transform is a form of the Fourier transform [5]. The Hartley transform can be calculated from the Fourier transform as follows:

$$H(u) = Re[F(u)] - Im[F(u)] \tag{1}$$

Where $Re[F(u)]$ and $Im[F(u)]$ are the real and imaginary parts of the Fourier transform, respectively. Most of important information about the image is concentrated in coefficients that are shown in figure 4.

**Figure (4) DHT of Figure 2**

## V. DCT (DISCRETE COSINE TRANSFORM)

The Discrete Cosine Transform (DCT) is a real transform that that has great advantages in energy compaction [5] and represents an image as a sum of sinusoids of varying magnitudes and frequencies. One advantage of DCT is the property that, for a typical image, most of the important information about the image is concentrated in just a few coefficients of the DCT [6] as shown in figure 5, and its definition is as follow.

$$DP_{u,v} = \begin{cases} \frac{1}{N^2}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} P_{x,y} \rightarrow if: u=0, v=0 \\ \frac{2}{N^2}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} P_{x,y} \times \cos(\frac{(2x+1)u\pi}{2N}) \times \cos(\frac{(2y+1)v\pi}{2N}); else \end{cases} \tag{2}$$



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**Figure (5) DCT of Figure 2**

## VI. FEATURE SELECTION

The features used to distinguish a ship type from others, may be size parameters, location and height of superstructures , moment invariant functions (both of binary and gray level images) ,hot spot & cold spot, centroid of binary image[1], compactness, length of boundary, minimum distance from a point in silhouette to the contour, etc. Image contour is also a feature that may be used with classifiers. We used DCT and DHT as discriminant transforms for silhouette classification. By selecting the more important regions of DCT and DHT as shown in figures(6,7,8) and using the zigzag algorithm (fig.9),the size of feature space can be reduced from 4500 (for 45×100 pixel images used in our experiment) to only 4 in every view's image. So this transform is very useful for this classification method, because a good classification requests a small number of good features that can discriminate the classes. These extracted data are then presented to a feed forward back propagation neural network for classification.

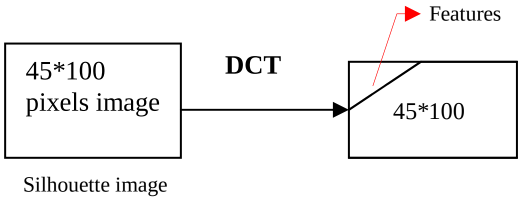


**Figure (6) Feature Extraction with DCT from Silhouette Image**

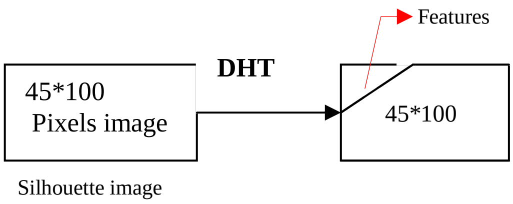


**Figure (7) Feature Extraction with DHT from Silhouette Image**

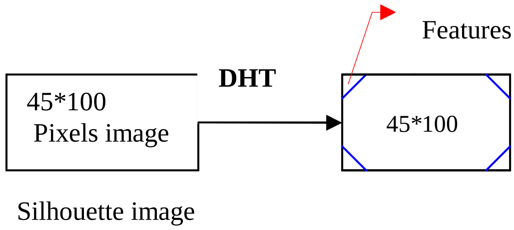


**Figure (8) Features Selected from 4 Corners in DHT Method**

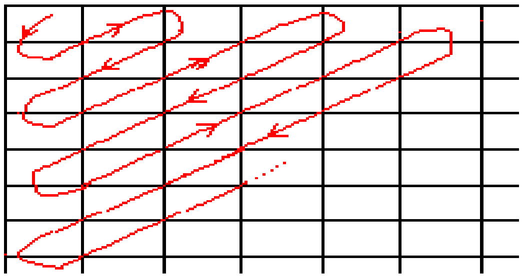

**Figure (9) Schematic for Zigzag Algorithm for Select the Features from an Image**

## VII. CLASSIFICATION BASED FEED FORWARD BACK ROPAATIONNEURALNETWORK

Extracted features must be classified with a suitable classifier .There are many classifiers that may be used for classify the feature vectors. For instance a classifier may be Nearest Neighbor classifier, linear classifier or a Neural Network classifier. Object recognition can be performed by learning the network by different object views from a set of examples using a supervised learning mechanism. Feed forward back propagation net allows the important performance in classification. In a feed forward back propagation net, each output unit has a known class. Since it uses supervised learning. Figure (10) shows the structure of feed forward back propagation network, used for classifying data. This network is constructed with three layers. First and second layers are the layers that learn to classify input vectors, and third layer is a linear layer. The linear layer transforms the hidden layer's classes into target classifications defined by the user. A pattern is classified as belonging to the same class of the training pattern that is closest to it. In Fig.10, F is the feature space, N1, N2 are the number of hidden neurons for hidden layers and C is the number of ship classes. In this work F is minimized to 4 and N1,N2 are 7,and C is 5(equal to number of ship classes) and sigmoid transfer function is assigned to first and second layers, and linear transfer function is assigned to third layer, and training function is Levenberg-Marquart back propagation .

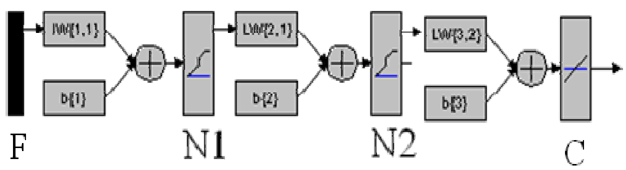


**Figure (10) Structure of Neural Network**



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Features of five classes of the ships contour that are shown in figure.2 were presented to the neural network. For each class, 90 angles of view (each sector is 2 degree) were trained. Testing error in testing 450 images of all classes was equal to zero, thus the results are very acceptable. In order to recognize the new ship classes except these five classes, we can decide on the result of DHT and DCT at a same experiment. If the recognition result of two transforms was equal, then the output is confirmable result. Another way to find the new classes is using threshold technique on first and second winner neuron's values in third layer because difference between highest (rank 1) neuron output and next (rank 2) neuron output is so high that the separability feature is highlighted, for example in table.1, if the amount of second winner neuron is further than 0.001(such as shown in table.1), then we infer there is a new ship class that presented to the algorithm.

## VIII. STABILITY AGAINST NOISE AND CHANGING THE INPUT

The results from testing noisy input show that the network is robust in noise. As a result, with density 0.025 in salt and pepper noise (as show in fig.11) and total correct classification is equal to 95%.

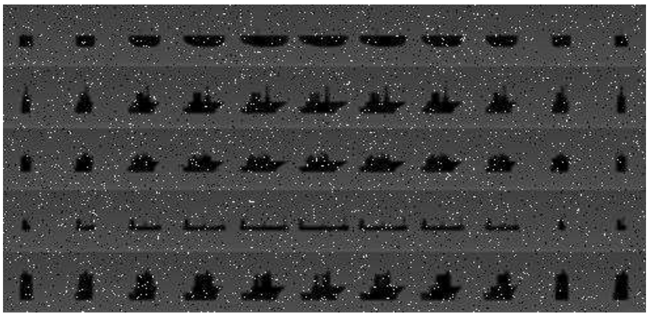

**Figure (11) Sample of Database in Salt and Pepper Noise**

## IX. CONCLUSION

Using the Susan algorithm for preprocessing can reduce the space and computational time required for analyzing the image. In this work many transforms such as distance transform, FFT, and simple two dimension features (i.e. centroid, compactness, momentum and so on) of the silhouette and combination of these features, trained to the network. DCT and DHT transforms were better for discrimination and minimization the features space and the best results obtained from training the selected regions of DCT and DHT of the silhouette image and an image with size 45*100(in our experiments),assigned to only 4 features.We infer that this transforms are very robust to distinction the silhouette feature, because we could decrease the feature space to 4 feature for every image's view and total correct classification obtained is 95% on testing experiments and so this algorithm stands up robustly against the noise. We can use this algorithm for classification more number of ship classes (compare with reference [3]). Also this algorithm can be generalized for classification another things such as animals, people, planes, vehicles, etc [9].

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**Table 1 Examples for Thresholding on First and Second Winner Neuron's Values**

| First neuron | Second neuron | Third neuron | Fourth neuron | Fifth neuron | First winner neuron **(Ship Class)** | Second Winner neuron |
|---|---|---|---|---|---|---|
| -0.0001 | **0.0001** | 0.0000 | 0.0000 | 1.0000 | 5 | 2 |
| -0.0001 | **0.0001** | 0.0000 | 0.0000 | 1.0000 | 5 | 2 |
| -0.0002 | **0.0001** | 0.0000 | 1.0001 | 0.0000 | 4 | 2 |
| -0.0001 | **0.0001** | 0.0001 | 1.0000 | 0.0000 | 4 | 2 |
| **0.0001** -0.0001 | 0.0001 | 0.9999 | -0.0000 | -0.0000 | 3 | 1 |
| | **0.0001** | 0.9999 | -0.0000 | -0.0000 | 3 | 2 |
| -0.0001 | 1.0000 | -0.0000 | **0.0000** | 0.0000 | 2 | 4 |
| -0.0001 | 1.0001 | **0.0000** | 0.0000 | 0.0000 | 2 | 3 |
| 1.0000 | -0.0001 | -0.0000 | -0.0000 | **0.0000** | 1 | 5 |
| 1.0000 | -0.0001 | -0.0000 | **0.0000** | 0.0000 | 1 | 4 |
| **0.2436** | 1.0893 | -0.0954 | -0.0271 | -0.5902 | New ship | 1 |
| -0.5842 | **0.2522** | -0.0934 | -0.0289 | 1.0817 | New ship | 2 |
| -0.5965 | -0.0551 | **0.1645** | -0.0257 | 1.1242 | New ship | 3 |
| -0.6804 | 0.0281 | -0.1907 | **0.1542** | 1.2149 | New ship | 4 |
| -0.4610 | 0.9527 | -0.0617 | -0.0305 | **0.3495** | New ship | 5 |



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