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A New Method of Ship Sketch Matching in Digital Ship Images using MLBP features with DWT

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Abstract: The problem of matching a ship sketch to a gallery of mug shot images is addressed in this paper. Previous research in ship matching offered solutions to matching highly accurate sketches that were drawn while looking at the subject. Ship sketches differ from viewed sketches in that they are drawn by a sketch artist using the description provided by who is typically unfamiliar with the subject. To solve the problem of matching ship sketches, use a robust framework called Local Feature-Based Discriminant Analysis (LFDA). In LFDA, both sketches and photos are represented using Multi Scale Local Binary Patterns (MLBP). Multi Scale Local Binary Patterns (MLBP) has also been applied at dense grids (dense MLBP) which have been shown to lead to better performance for tasks such as object categorization, texture classification, image alignment and biometrics. A discriminant projection method is then used on the feature-based representation for minimum distance matching and applies the LFDA method to match a dataset of ship sketches against a mug shot gallery containing images. Though these methods address the image matching, they do not take in to account noise caused by the quality of paper, charcoal pencil, scanning noise etc. This paper presents a method where in pre-processing of the image to address such noise is introduced using discrete wavelet transforms (DWT). This when used along with MLBP gave superior results.

Keywords: Local Feature-Based Discriminant Analysis (LFDA), Multi Scale Local Binary Patterns (MLBP), Discrete wavelet transforms (DWT), Viewed sketches, Ship sketches.

I. INTRODUCTION

Ship detection is one of the hottest issues in many fields, such as harbor dynamic surveillance, traffic monitoring, and maritime management. Only few reports focused on the ship detection issue. The main reason is that the background in the harbor scene is much more complex than that in the sea.

Ship sketches are the figures, drawn by trained artists on a piece of white paper with a single pencil or a bunch of pencils. In general, sketches are classified into two categories: 1) Viewed sketches and 2) Ship sketches.

Viewed Sketches: These are the sketches drawn by an artist, directly looking at the subject or the photograph of the subject. Figure shows examples of Viewed sketch and its corresponding photograph.



Fig 1. Viewed Sketch and Its Corresponding Photograph

A. Ship Sketches

1) *Ship Sketches*: These are the sketches drawn by specially trained artists based on the description of subject. Figure shows examples of ship sketch and its corresponding photograph.

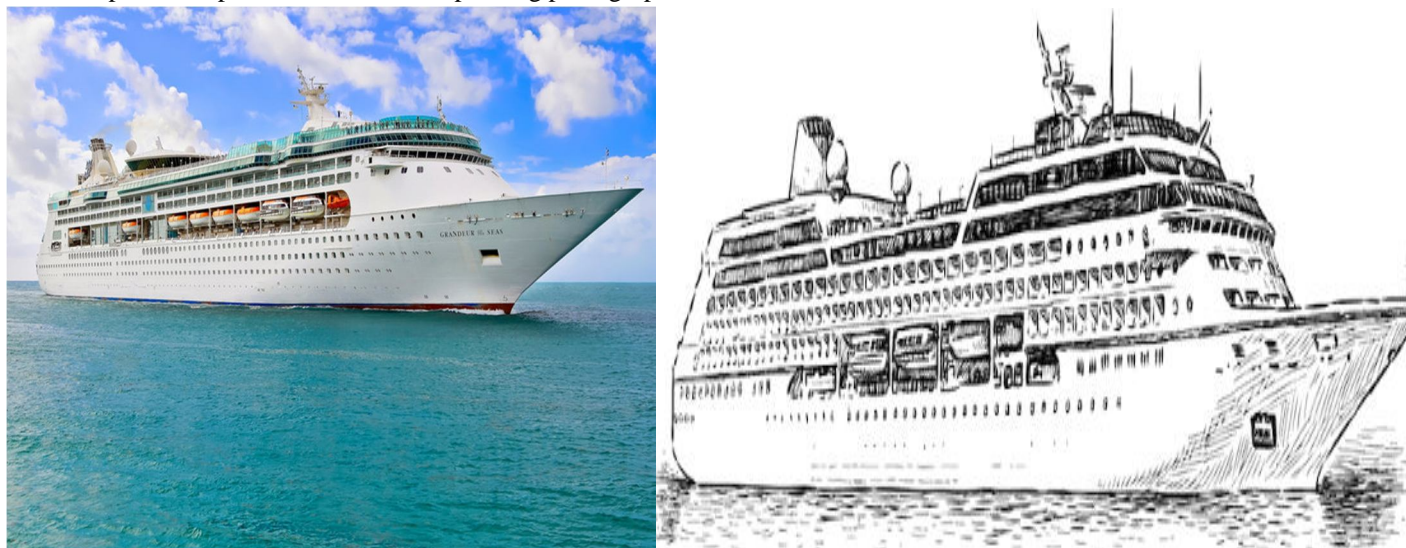


Fig 2. Ship Sketch and Its Corresponding Photograph

Ship sketch to photo matching to this point has primarily focused on matching viewed sketches despite the fact that real-world scenarios only involve ship sketches. However, ship sketches pose additional challenges due to the inability to exactly remember the appearance of a ship and her subjective account of the description, which often results in inaccurate and incomplete ship sketches.

To highlight two key difficulties in matching ship sketches:

- a) Matching across image modalities and
- b) Performing ship recognition despite possibly inaccurate depictions of the ship.

In order to solve the first and second problems, use Local Feature-Based Discriminant Analysis (LFDA) to perform minimum distance matching between ship sketch and ship photos.

B. Ship Sketch Recognition

Even though there existed multiple ship recognition schemes since the past two decades, research on ship sketch to photo matching started only a decade ago. This is because of the difficulty in the problem compared to traditional recognition. And also, the best recognition levels in photo matching came only at the onset of past decade.

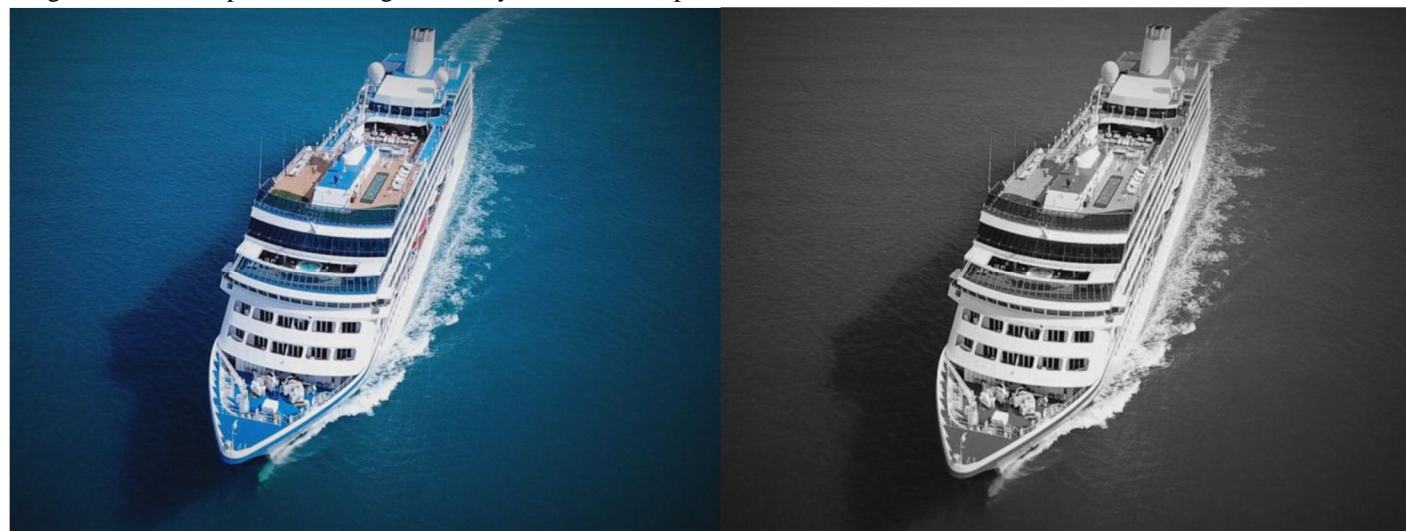


Fig 3. Example of Viewed Sketches And Its Corresponding Photographs

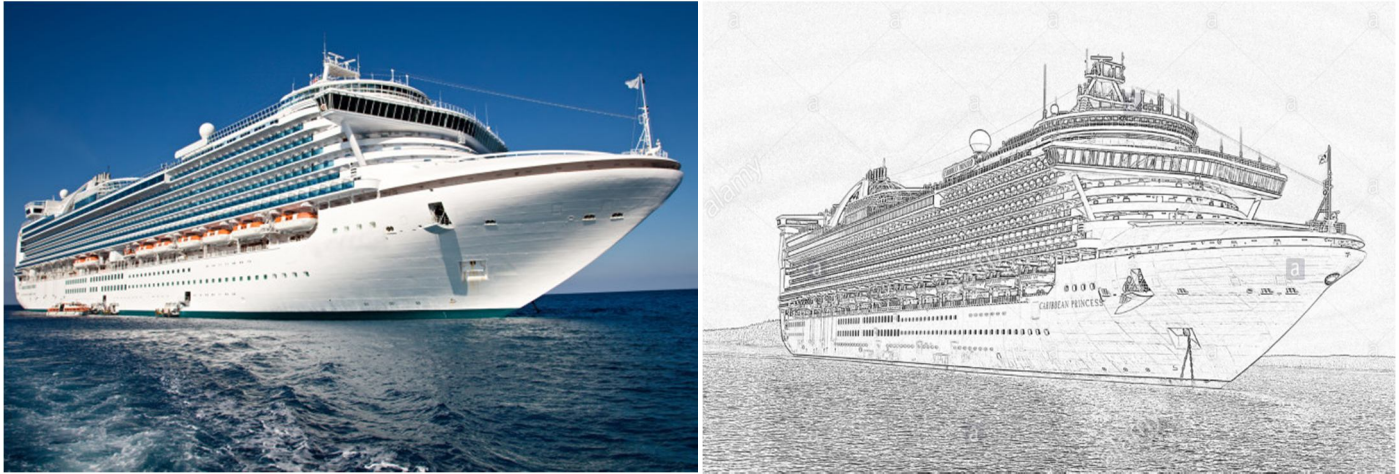


Fig.4 Ship Sketches and Its Corresponding Photographs

The ship sketches are mainly drawn using pencils and for a sketch, at most 4-5 pencils are used pertaining to different darkness levels. So a sketch has at most 4-5 grey levels. The photographs on the other hand are taken with a camera that can capture 256 grey levels (If a color image is present, it could be easily converted to a 256 grey level image). So to match 4-5 grey levels against 256 grey levels is a near impossible problem. Contrast stretching, in which we convert the 256 grey levels into 3-4 grey levels is tried by various researchers, but proven to be ineffective. Throughout the past decade, scientists have been trying various methods like synthetic photograph generation, spectral regression, using feature based descriptors etc., out of which some have proven to be fruitful. Based on the past research in sketch recognition, and the research done on the cognitive ability of human mind, a new method is proposed here, that could effectively solve the problem of ship sketch recognition to a great extent. Figure 1.3 and Figure 1.4 shows examples of two different kinds of sketches that are available (viewed sketches and ship sketches). But we emphasize on matching of ship sketches. Nevertheless, viewed sketches acted as a baseline for ship sketches and helped us perform continuous experiments on them, before proceeding to experiment with ship sketches.

II. LITERATURE SURVEY

Tang and Wang first approached the problem using an eigen transformation method ^[1] to either project a sketch image into a photo subspace, or to project a photo image into a sketch subspace. Once projected into the same image subspace, they were matched using a PCA-based matcher.

An improvement to this method was offered by Wang and Tang ^[2] where the relationship between sketch and photo image patches was modeled with a Markov random field. Belief propagation was used to minimize the energy between the selected patches and their corresponding sketch or photo mates as well as their selected neighboring patches. Here, the synthetic sketches generated were matched to a gallery of photographs using a variety of standard object recognition algorithms.

Most of the work, for representing face was performed by Amit R. Sharma and Prakash. R. Devale ^[3] which is based on the features which use geometric relationship among the facial features like mouth, nose and eyes. Feature based face representation is done by independently matching templates of three facial regions i.e. eyes, mouth and nose. Principal Component Analysis method which is also called Eigen faces is appearance based technique used widely for the dimensionality reduction and recorded a greater performance in face recognition.

To identify sketches much efficient algorithm was performed by Timo Ahonen, Abdenour Hadid and Matti Pietikainen ^[4]. Both sketches and photos are considered for extracting feature descriptors using Scale Invariant Feature Transform (SIFT). The goal is to build a system that accurately matches sketches with their corresponding photo images using feature based approach.

Yong Zhang, Christine McCullough, John R. Sullins and Christine R. Ross ^[5] compared the performances of humans and a principle component analysis (PCA)-based algorithm in recognizing face sketches. The experiments were carried out by matching sketches in a probe set to photographs in a gallery set.

A feature-based method for matching sketches was presented by Klare and Jain ^[6] which serves as the motivation for the sketch matching method presented. In this feature-based sketch matching, both sketch and photo images using SIFT and MLBP feature descriptors at different scales.

III. PROPOSED METHOD

A sketch image conveys a lot of information about identity and emotional state of the ship. Sketch recognition is an interesting and challenging problem and impacts important applications in many areas such as military application, harbor traffic management, dynamic surveillance and maritime management etc. In our research work, we empirically evaluate ship recognition which considers both shape and texture information to represent ship image based on Multi Scale Local Binary Pattern (MLBP). The ship area is divided into small regions from which Multi Local Binary Pattern histogram are extracted and concatenated into a single feature vector. This feature vector forms an efficient representation of the ship and is used to measure similarities between images.

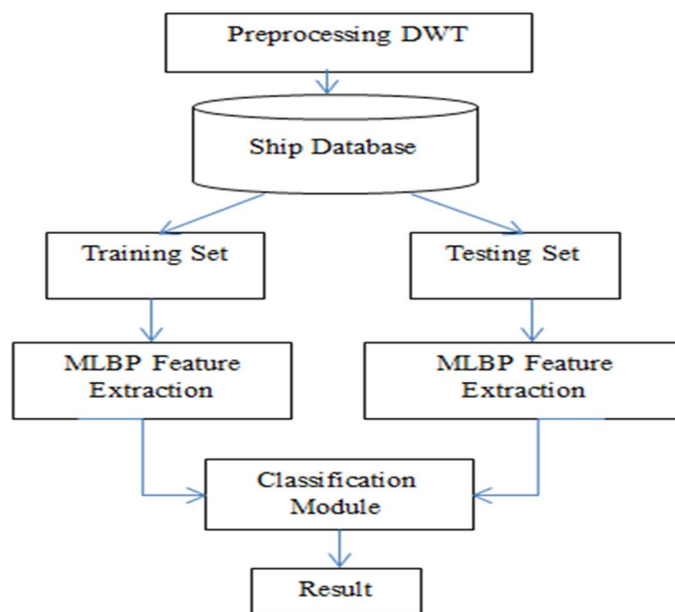


Fig 5. Proposed System

A. Multi Scale Local Binary Pattern (MLBP)

In this proposed work we empirically evaluate ship recognition which considers both shape and texture information to represent ship image based on Multi Scale Local Binary Pattern. The ship area is divided into small regions from which Multi Local Binary Pattern histogram are extracted and concatenated into a single feature vector. This feature vector forms an efficient representation of the ship and is used to measure similarities between images.

The Multi Scale Local Binary Pattern (MLBP) operator works with the eight neighbors of a pixel, using the value of this center pixel as a threshold. If a neighbor pixel has a higher gray value than the center pixel (or the same gray value) than a one is assigned to that pixel, else it gets a zero. The LBP code for the center pixel is then produced by concatenating the eight ones or zeros to a binary code.

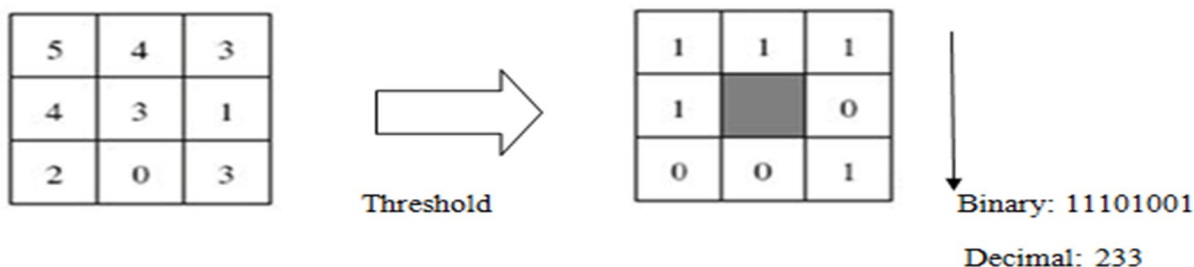


Fig 6. Threshold Value

Later the Multi Scale Local Binary Pattern (MLBP) operator was extended to use neighborhoods of different sizes. In this case a circle is made with radius R from the center pixel. P sampling points on the edge of this circle are taken and compared with the value of the center pixel. To get the values of all sampling points in the neighborhood for any radius and any number of pixels, (bilinear) interpolation is necessary. For neighborhoods the notation (P, R) is used.

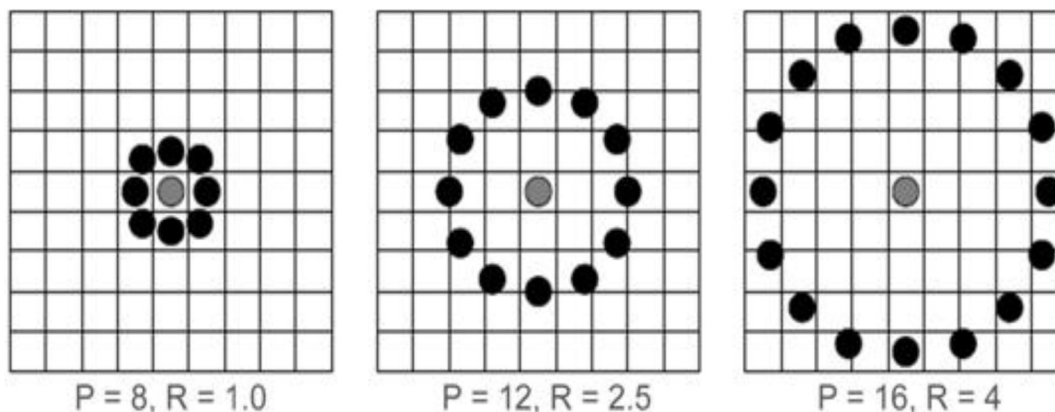


Fig 7. Illustrates Three Neighbour-Sets For Different Values Of P And R.

If the co-ordinates of the center pixel are (x_c, y_c) then the coordinates of its P neighbors (x_p, y_p) on the edge of the circle with radius R can be calculated with the sines and cosines:

$$x_p = x_c + R \cos(2\pi p/P) \dots\dots\dots(1)$$

$$y_p = y_c + R \sin(2\pi p/P) \dots\dots\dots(2)$$

If the gray value of the center pixel is g_c and the gray values of his neighbors are g_p , with $p = 0, \dots, P - 1$, than the texture T in the local neighborhood of pixel (x_c, y_c) can be defined as: $T = t(g_c, g_0, \dots, g_{P-1})$.

B. Pre-Processing Algorithm (DWT)

The digital images may be noisy and of sub-optimal quality because of the printing and scanning of images. Though these methods address the image matching, they do not take in to account noise caused by the quality of paper, charcoal pencil, scanning noise (device noise/errors) etc. Sketch -digital image pairs of lower visual quality may lead to reduced matching performance as compared to good quality sketch-digital image pairs. Matching ship sketches to mug shot photos using a robust feature based method LFDA with additional pre-processing of the image to address such noise is introduced using discrete wavelet transforms (DWT). This when used along with MLBP gave superior results.

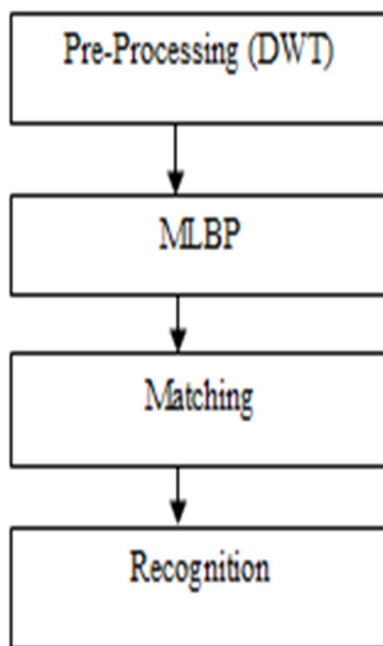


Fig 8. Pre-Processing Method

IV. RESULT ANALYSIS

A. A database of 84 sketch-photo pairs is made consisting of 37 ship sketches. These images were collected from following different sources

- 1) 08 Images from the ship sketch artist Lois Gibson
- 2) 10 Images from the ship sketch artist Karen Taylor
- 3) 11 Ship sketches provided by the Maharashtra State Government.
- 4) 08 Ship sketches provided by the Pinellas County Sheriff's Office.

The experiments are performed using the combination of viewed sketches and ship sketches to increase the size of dataset. Initially training was performed on all the sketches with its corresponding photographs and the probe set consisting of 37 ship sketches were used to match against a gallery of 84 gallery images.

B. The steps involved in sketch to photo matching are as follows

- 1) For all the given set of images, apply feature extraction techniques on each of them and store results in the database.
- 2) In training set of data each image divided into either 154 overlapping patches or 720 overlapping patches.
- 3) Each patches producing 236 dimensional MLBP descriptors.
- 4) The MLBP operator works with the eight neighbours of a pixel, using the value of this center pixel as a threshold. If a neighbour pixel has a higher gray value than the center pixel (or the the same gray value) than a one is assigned to that pixel, else it gets a zero.
- 5) To train the LFDA, use a training set consisting of pairs of a corresponding sketch and photos of n subjects.
- 6) In the LFDA framework each image feature vectors ϕ is first divided into smaller slices correspond to the concatenation of feature descriptor vectors from each column of image patches.
- 7) To train the LFDA, use a training set consisting of pairs of a corresponding sketch and photos of n subjects. Sketch $I_s^i = F [I_s^i]$ and $\Phi_p^i = F [I_p^i]$
- 8) Combine these feature vectors as a column vectors in training matrices and refer them.
 - a) $X^s = [\Phi_s^i \Phi_s^i \dots \Phi_s^i]$ for all sketch.
 - b) $X^p = [\Phi_p^i \Phi_p^i \dots \Phi_p^i]$ for all photo.
 - c) $X = [\Phi_s^i \Phi_s^i \dots \Phi_p^i \Phi_p^i \dots \Phi_p^i]$ for the sketch and photo combined.
- 9) The first step in LFDA is to separate the image feature vector into multiple sub vectors or slices.
- 10) Given the $M * N$ array of patches consisting of MLBP descriptor, we create one slice for each of the N patch columns. With a d-dimensional feature descriptor, each of the N slices is of dimensionality.
- 11) Next reduce the dimensionality of each training slice matrix using the PCA matrix with eigenvectors.
- 12) Reduce the intrapersonal variation between the sketch and the photo, a whitening transform is performed.
- 13) Final step is to compute a projection matrix that maximizes the intrapersonal scatter by performing PCA.

Recognition is performed after combining each projected vector slice into a single vector and measuring the normed distance between a probe sketch and a gallery photo.

PCA (principal component analysis) is a statistical procedure that uses orthogonal transformation to convert a set of observation of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components and PCA is applied to the new feature vector to remove redundant information among the feature slices to extract the final feature vector.

Accuracy: Accuracy is calculated as how accurately the correct photo is retrieved at the top-most position when a particular sketch is given as input.

C. Accuracy is calculated as follows

$$\text{Rank} = \frac{\text{Number of correct matches}}{\text{Total number of input sketches}} * 100$$

In ship sketch matching, we are matching a sketch to a photo, and that sketch is drawn just based on the description of image. Hence, there are a lot of chances for ambiguity. Here, we take P to be Rank-50. Hence, number of correct matches is considered from top-50 retrieved images.

- 1) In our sketch matching framework with MLBP feature descriptor.
- 2) From training operation we can use a training set which consist the pair of a ship sketch and ship photo of n subjects. For all the given set of images, apply feature extraction techniques on each of them and you can store results in the database.
- 3) From testing operation matching algorithm is used to find a proper match between the ship sketches with the mug shot images.
- 4) Out of 37 ship sketches you can select any one ship sketch for matching with accurate images.
- 5) One sketch image is selected as an input given to matching system to identify perfect match from available mug shot images.

Rank-1 Accuracy: Rank-1 accuracy is defined as the top one retrieved photo image of the ship at the Rank-1 position from entire database of 84 mug shot images.

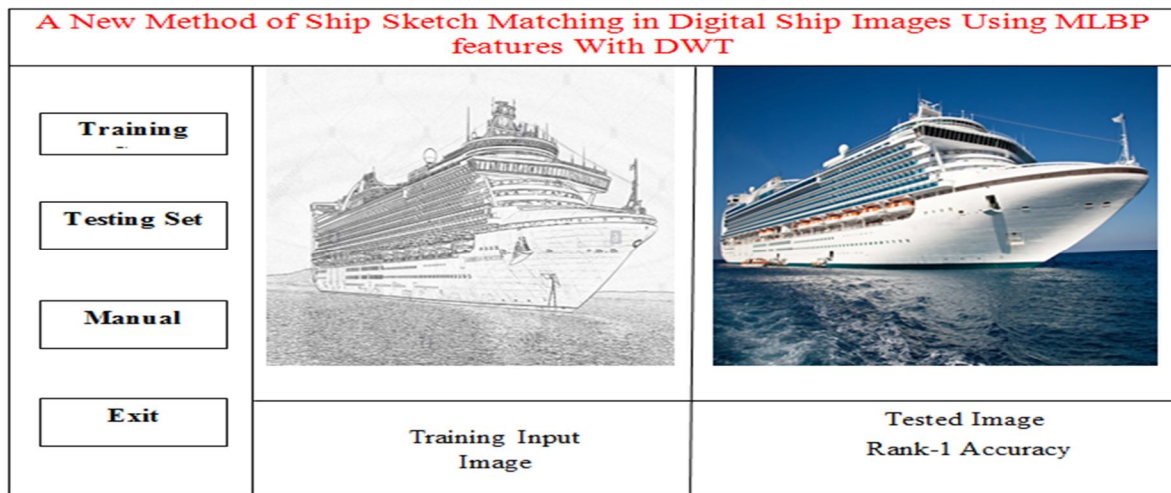


Fig 9. Rank 1 Accuracy

Comparison: Comparison of all the other methods with the proposed method at Rank-50 accuracy is shown as follows in Table 1.

TABLE 1 Comparison of Rank-50 Accuracy

Methods	Rank-50% Accuracy
LFDA with Pre-Processing (DWT)	77.69%
SIFT	61.92%
LBP	60.00%

The cumulative match curve (CMC) curve for comparison between the proposed approach and other two methods i.e. Scale invariant feature transform (SIFT) and Local binary pattern (MLBP) is also shown as given below in Figure 10. From the CMC curve it can be shown that how the rank-50 accuracy of proposed system is better than the previous method.

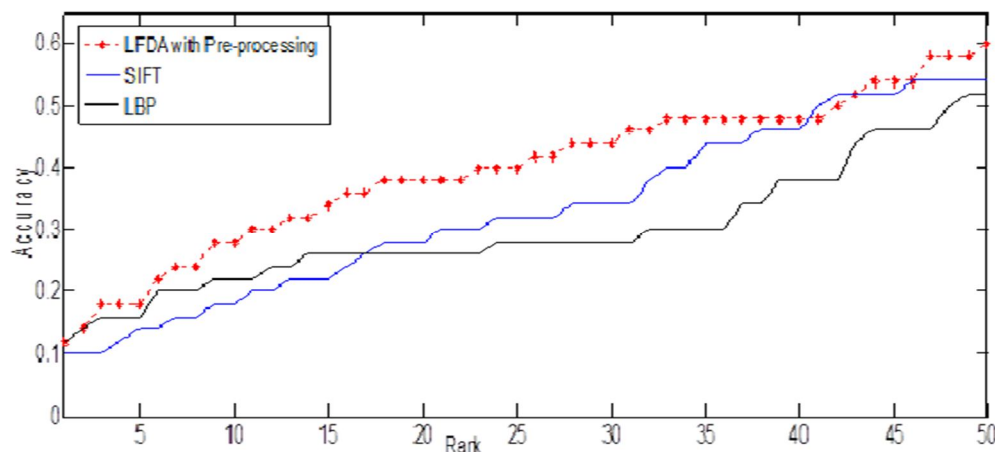


Fig 10. CMC Curve

V. CONCLUSION

This problem of matching a ship sketch to a gallery of mug shot images is addressed in this paper. In this paper, represented a solution to solve the problem of matching ship sketches to photos using local feature based discriminant analysis(LFDA)framework using multi scale local binary pattern(MLBP) feature descriptors with discrete fourier transform (DWT). In this LFDA framework both ship sketches and photo are represented by using MLBP feature descriptors and computing minimum distance matching between ship sketches to photos. In MLBP image content is transformed into local features and coordinates that are invariant to translation, rotation, scale and other image parameters. The MLBP features are local so individual features can be matched to a large database of the objects and many features generated even for small objects. MLBP can easily extend into wide range of different feature types with each adding robustness. Another contribution of this paper is to use LFDA with additional pre-processing method (DWT). This pre-processing algorithm (DWT) helps to enhance quality of ship images and improve the identification performance by removing the irregularities and noise caused by quality of paper, charcoal pencil, scanning noise etc.

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