Analysis and Identification of Aeroplane Images Using Transform Based Methods

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Abstract: Object recognition is one of oldest applications of automatic pattern recognition. The object recognition has generated lot of interest among researchers for a variety of applications like face detection, people counting, vehicle detection, manufacturing industry, online images, security etc. The main objective of this work is to recognize aeroplanes, even if they are of different size (different scale) or even if they are Oriented with different skew angles. This work would be useful in tracking an aircraft for navigation applications. Further the identification of aeroplanes can be used in military applications to detect the enemy aircrafts.

To achieve these objectives, the main challenge is the different shape, size and orientation of aircrafts which pose difficulty in the object recognition. In this work, an aeroplane is identified by extracting and comparing features between the test and training database images. This task is difficult for computers, however for humans; object recognition is effortless and instantaneous. In the first stage, the images of different aeroplanes and helicopters are selected and these images are downloaded from the web page "www.grabcad.com". These images are grouped into two sets. The first set comprises database images which are used for training the system, whereas the second set is used for testing and obtaining the recognition accuracy for different algorithms. All these images are normalized and binarized using the thresholding concept.

In the second stage, 2D- Transforms (2D-FFT and 2D-Hough Transform) are applied to all the pixels of these binarised images (both testing and training database). After applying the transform, the pixel intensity value will have both, the real and also the imaginary values. Since the imaginary values of the pixel, has only "phase information", which is not useful in the recognition of aeroplanes, this imaginary value of all the pixels in all the images are neglected.

The real part of the pixel intensity values (after applying the transform) is only considered for recognition. In this work, all the images are normalized to 50 X 50 size and hence the total number of pixels becomes 2500 for every image. The size of the matrix of each image (both test and database) is converted to (2500 X 1) column matrix from 50 X 50 matrix size. Hence after applying 2D transforms each image is of matrix size (2500 X 1). This matrix of (2500 X 1) size for each image (both testing and training), becomes the feature vector for that particular image. This process is applied to all the images and the features are extracted for all the test and database images.

In the third and the last stage, k-NN (k Nearest Neighbourhood) classifier is used in the identification of an aeroplane. The k-NN classifier with k=1 is the Euclidean distance. Hence, the recognition is achieved by calculating and identifying a database image which has minimum Euclidean distance to the given test image. The test image is shown on the left side of the result image, whereas the identified image of the database is shown on the right side of the result image. The cross validation of the results is also performed in this work. The Recognition accuracy with 2D-FFT is obtained as 88% and the Recognition accuracy with 2D-Hough transform is found to be 82%.

The reason for this difference can be because of the reason that, Hough transforms works on the principle of detection of straight lines in any image. Hence it can be concluded that 2D-FFT has higher Recognition accuracy compared to 2D-Hough transform.

Keywords: k-NN (k Nearest Neighbourhood), 2D- Transforms (2D-FFT and 2D-Hough Transform), phase information.

1. Introduction

In this chapter, the methodology adopted of the proposed method is discussed using block diagram. The block diagram for recognition of aeroplane is discussed in detail and the various operations on the images are also elaborated. The procedure for cross validation of results is also discussed in detail. The key objective is to develop Object recognition techniques which are efficient and less complex. The primary step is to collect the images of aeroplane and divide them into test images and training images. In this project there are 200 training images and 50 test images. In the 50 test images, there 35 aeroplane images and 15 helicopter images. The images are color images and are of different sizes, all the images are stored in JPEG format.

In the pre-processing stage, all the images are selected, cropped, binarized and finally they are normalized to a size of 50 X 50. The color images are conveted to binary images by using Photoshop tool by minimum rectangle method. These images are resized into a size of 50 X 50, so there are totally 50 X 50 = 2500 pixels in all the images. Hence the value of all the pixels of the binary image will be either 0 or 1.

In the first step, to the binary image, both the transforms 2D-FFT and also 2D-Hough Transform are applied. The block diagram for recognition of aeroplane is shown in figure 1. After applying the transform to the test images and database images, each pixel will have values of both real and imaginary part. The imaginary part is not considered since it contains only phase information which is not useful on object recognition. The real part of each pixel becomes feature for a particular image.

Hence, the total number of features of each image becomes 2500 in number. These features are of the size 50 X 50 matrix. The matrix is of each image is reshaped again into (2500 X 1) size and this becomes feature vector for that particular image. This procedure is continued for all the images i.e training and testing images.

In the third side, k-NN classifier with k=1 known as Nearest Neighbour classifier or Euclidean distance is used to classify or identify an aeroplane of testing database. For the single test image which has less Euclidean distance in the entire training images is given as output to the corresponding test image. The block diagram of recognition of aeroplane is shown in figure 1

Figure 1: Block diagram of Recognition of Aeroplane

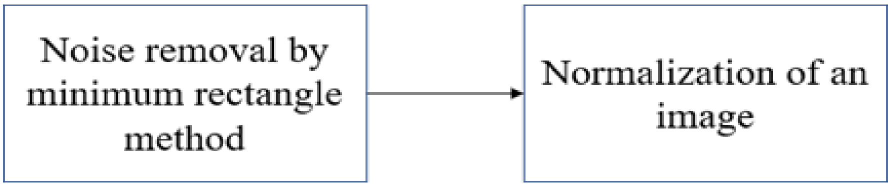

Figure 2: Block Diagram for Pre-Processing stage

The recognition accuracy is defined as,

$$\text{Recognition accuracy} = \frac{\text{Number of matched images}}{\text{Total Number of images}} \quad (1)$$

Figure .3: Sample images of Helicopter and Aeroplane from testing and training database

$$\text{False Alarm Rate} = \frac{\text{Number of images improperly recognised}}{\text{Total Number of images tested}} \quad (2)$$

False Alarm Rate for 2D-FFT becomes False Alarm Rate = $\frac{\mathbf{6}}{\mathbf{50}} = 12\%$

Similarly False Alarm Rate for Hough Transform becomes

False Alarm Rate = $\frac{\mathbf{9}}{\mathbf{50}} = 18\%$

2. Mathematical equations for Euclidean Distance

The Euclidean distance between test image column vector and each of the column vectors of Training/database image is computed Euclidean distance can be found out mathematically between 2 vectors Equation No. 2.1 and 2.2 as follows,

$$A_i = [A_{1,}A_{2,\ldots\ldots\ldots,}A_n] \quad (2.1)$$

$$B_i = [B_{1,}B_{2,\ldots\ldots\ldots,}B_n] \quad (2.2)$$

Where n = number of animals

The Euclidean distance (D) equation is given by

$$D=\sqrt{(A_1 - B_1)^2 + (A_2 - B_2)^2 + \cdots (A_n - B_n)^2} \quad (2.3)$$

Equation No. 2.3 describes the calculation of Euclidean for vectors represented by Equation No. 2.1 and 2.2. Hence Euclidean distance between test image vector and each of the data base images are computed and put in a row matrix as D_j in equation 2.4.

$$D_j = [D_1, D_2, D_3, \ldots \ldots \ldots \ldots D_n] \quad (2.4)$$

Where 1<n<100,

A_i is the A matrix B_i is the B matrix D is the Euclidean Distance

D_j is the D matrix which contains the values of Euclidean distances between the test image vector and each of the training image vector.

4. Experimental Results:

The result images obtained with the proposed system are shown in figure 4. The left-hand side image of each set is the input image whereas the image on the right-hand side is the image of the database matched to the test image.

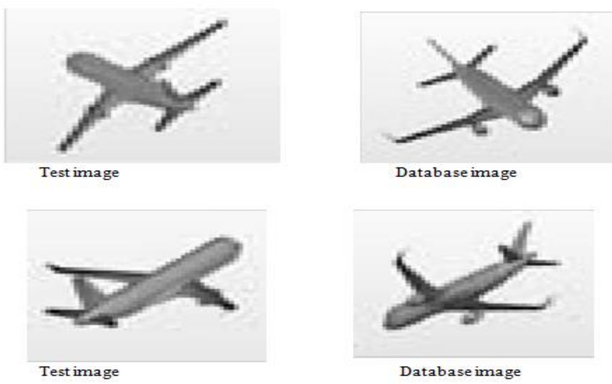

Figure 4: Images of aeroplane correctly identified using 2D- FFT

The results shown above are sample images obtained by using 2D FFT. The figure 6: shows the images of helicopters mismatched with aero plane images, after using 2D- FFT, the Table 1 shows that 44 test sample images were correctly recognized out of 50 test images using 2D FFT. Hence the recognition accuracy becomes **(44/50) 88%.**

The results obtained with the proposed system is shown in figure 5. The first row contains two set of images. The left-hand side image of each set is the input image whereas the image on the righthand side is the image of the database matched to the test image.

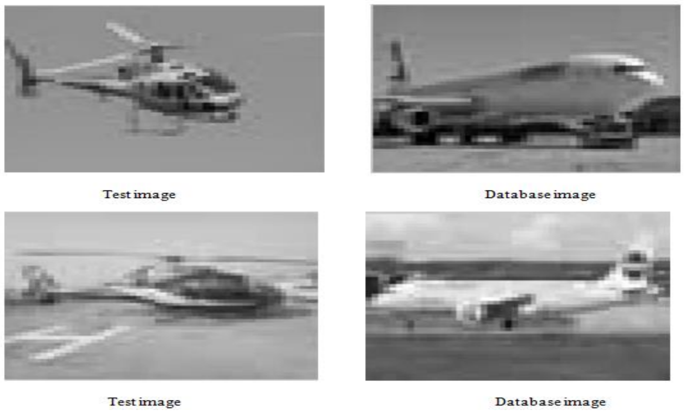

Figure 5: Images of Helicopter mismatched by using 2D- FFT

The table 1 shows the recognition accuracy using 2D-FFT

Table 1: Recognition Accuracy using 2D-FFT

Transform	Trainingimages	Test images	No of recognized samples	Recognition Accuracy
2D FFT	200	50	44	88

Overview of Hough Transform:

Hough Transform is made invariant to size, rotation and shift. The simplest case of Hough transform is the linear transform for detecting straight lines. The Hough transform algorithm uses an array, called an accumulator or image space, to detect the existence of a line y = mx + b. The dimension of the accumulator is equal to the number of unknown parameters of the Hough transform problem. For example, the linear Hough transform problem has two unknown parameters: m and

b. The two dimensions of the accumulator array would correspond to quantized values for m and b. In the image space, the straight line can be described as y = mx

+b and can be graphically plotted for each pair of image points (x, y). Jn the Hough transform, a main idea is to consider the characteristics of the straight line not as image points ($x1$, $y1$) ($x2$, $y2$), etc., but instead, in terms of its parameters, i.e., the slope parameter m and the intercept parameter b. Based on that fact, the straight-line y = mx + b can be represented as a point (b, m) in the parameter space. However, one faces the problem that vertical lines give rise to unbounded values of the parameters m and b. For computational reasons, it is therefore better to use a different pair of parameters, denoted r and θ, for the lines in the Hough transform as shown in figure 6.

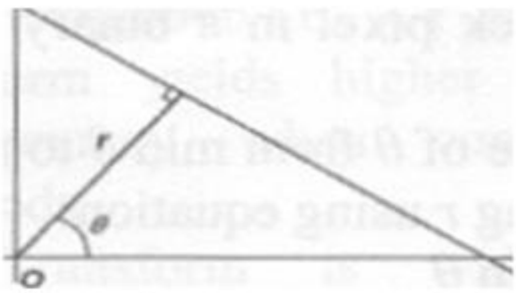

Figure 6: Normal representation of a line

It is therefore possible to associate with each line of the image a pair (r, θ) which is unique if The Hough transform maps N points into N sinusoidal curves that cross at a point (r_0, θ_0) in the r- θ plane. It also be said that the intersection point (r_0, θ_0) of N sinusoidal curves denotes a line in the x-y plane corresponding to (r_0, θ_0) passing through these N points. The r - θ plane is quantified in accumulator cells, where eachcell A (r, θ) keeps track of the number of intersections of sinusoidal curves for that cell. When the mapping is completed for all the data points in the image, the accumulated value in A (r, θ) represents the number of points lying on the corresponding line in the x-y plane. The line detection in a binary image using the Hough transform algorithm can be summarized as follows:

1) Define the Hough transform min r, max r, min θ and max θ
2) Quantify the r-θ plane into cells by forming an accumulator cells array A (r,θ)where r is between min r and max r and θ is between min θ and max θ.
3) Initialize each element of an accumulator cells array A to zero.
4) For each black pixel in a binary image, perform the following:
   a) For each value θ from min θ to max θ, calculate the corresponding r using equationX=r cos θ + y sin θ
   b) Round off the r value to the nearest interval value
   c) Increment the accumulator array element A (r, θ)

Step by Step Algorithm for 2D- Hough Transform:

The step-by-step algorithm is shown in figure 7 below

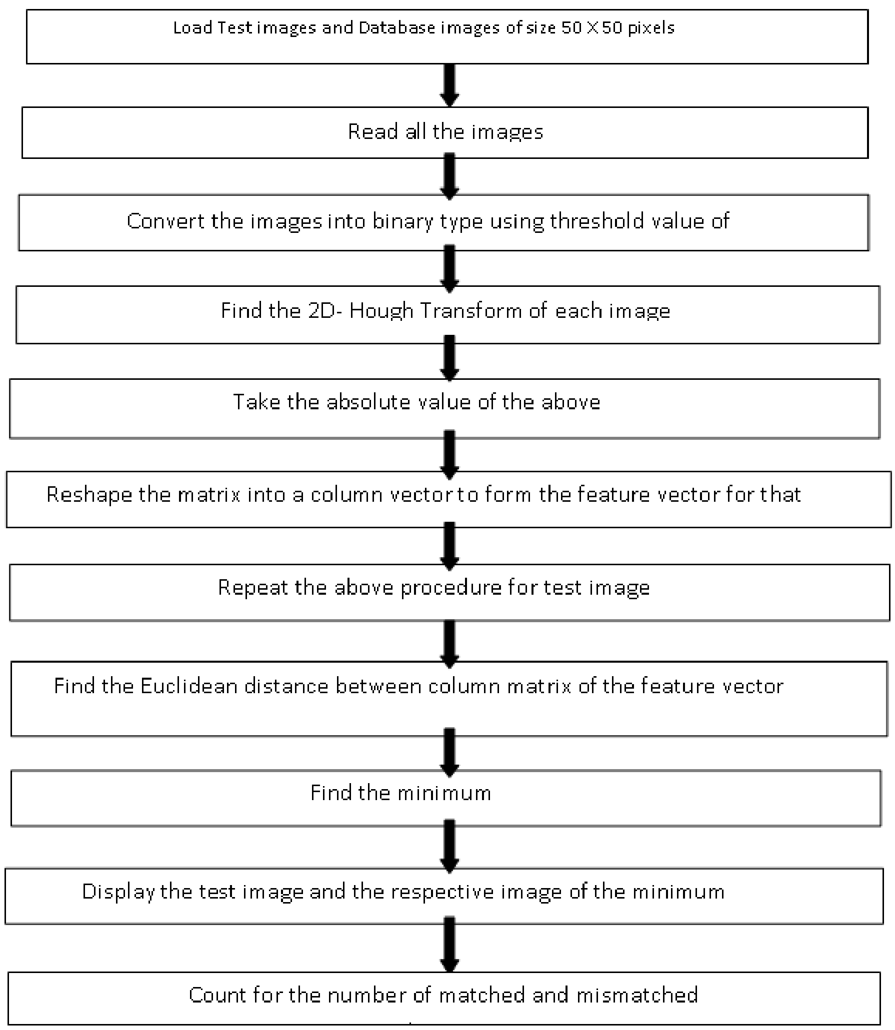

Figure 7: Step by Step Algorithm for Implementing 2D- Hough Transform

Implementation of 2D-Hough Transform: All the experiments were carried out on a PC machine with P4, 3 GHz CPU and 512 MB RAM memory under MATLAB 7.0 platform. The images of various aircrafts obtained by the data acquisition and digitization method (earlier discussed) are used in the implementation of Hough transform. The performance of the proposed system of the recognition process was evaluated on the images obtained from the real data of the downloaded aircraft images. The number of test samples considered in this work is 50 whereas the number of training samples considered are 200. For both the testing and training images, the matrix size of each image is 50 X 50. This matrix is reshaped into a single column of size 2500 X 1. This is obtained by concatenating row by row to form a column matrix. Hence the size of the matrix of training sample becomes 2500 X 200.

The Euclidean distance is found between the test image column matrix with each of the training sample matrix. Hence 200 different Euclidean distances are obtained. Now the smallest Euclidean distance among all these 200 values is found out. The image corresponding to this minimum value of Euclidean distance is displayed in the result image on the righthand side and is considered to be matched with the test image. The total number of correctly matched images are found and ratio of correctly matched images to the total number of images is termed as recognition accuracy.

(ii) Experimental Results using 2D- Hough Transform:

The results obtained with the proposed system is shown in figure 8. The first row contains 2 sets of images. The left-hand side image of each set is the input image whereas the image on the right-hand side is the image in the database matched to the test image.

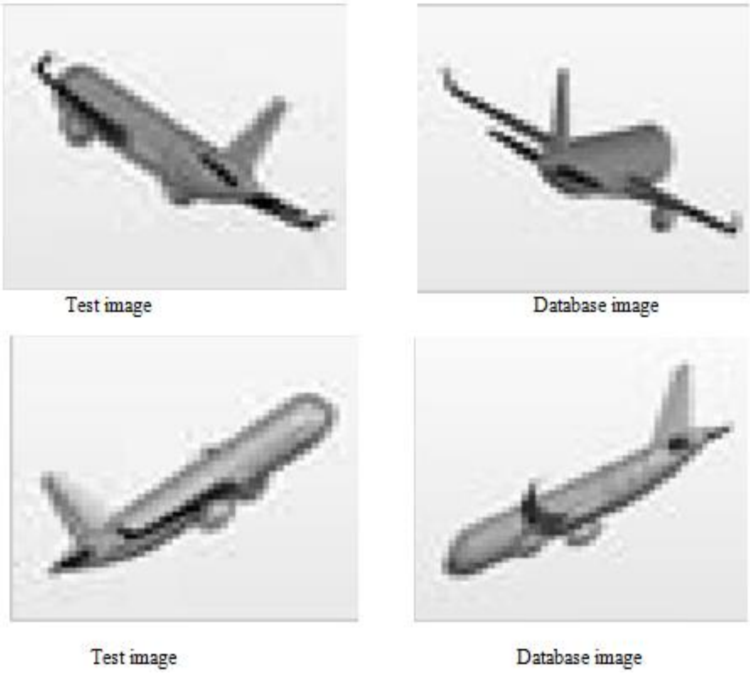

Figure 8: Images of aeroplane correctly identified using 2D- Hough Transform

After extracting the features, each image consists of 2500 features which form a 2500 rows and single column matrix. This procedure is followed for both testing and training samples, if there are Y number of training images, then the size of the training images matrix becomes 2500 X Y size. Every image in the training matrix is also of the size 2500 X 1. Now the Euclidean distance D is calculated between the test image and each of the training image.The total number of Euclidean distances D_1, D_2, D_3 D_Y are calculated. The lowest value of D is found out and its corresponding database image is said to be matched with the test image. The below figure 9 shows the images of helicopter test images which are not matched with helicopter images of database images using 2D- Hough transform.

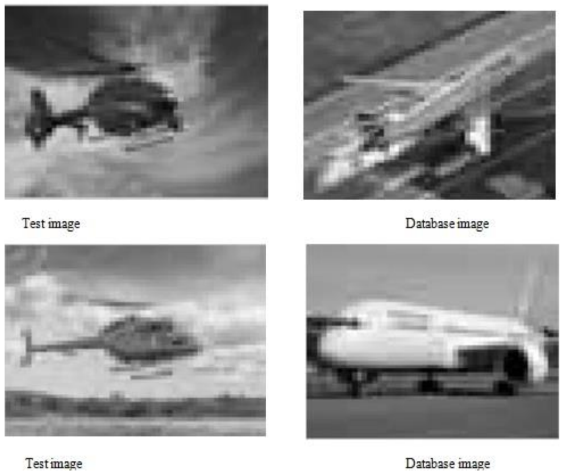

Figure 9: Images of Helicopters mismatched using 2D-Hough Transform

After using 2D-Hough Transform, the Table 2: shows that 41 test sample images were correctly recognized out of 50 test images using 2D Hough transform. Hence recognition accuracy becomes **(41/50) 82%.**

After seeing the figures, the results are noted in tabular form for easy understanding. Table no.2, shows the simulation results using 2D-Hough Transform

Table 2: Recognition Accuracy using 2D-Hough Transform

Transform	**Trainingimages**	**Test images**	**No of recognized samples**	**Recognition Accuracy**
Hough Transform	200	50	41	82

Comparison of results between 2D-FFT and 2D-Hough Transform:

The recognition accuracy using 2D FFT is **88%** whereas recognition accuracy using 2D-Hough Transform is **82%**. The reason for the Hough Transform to have lower recognition accuracy, may be due to the reason that Hough Transform identifies an object using straight lines. The Fourier transform is applied to every pixel and real part of each pixel value (after applying 2D FFT) is considered in the recognition method.

5. Conclusions and Future Scope

In this work, a total of 200 images of aero plane and helicopter were considered as training samples and 50 images as testing set samples which are download from a standard database namely “www.grabcad.com”. The recognition accuracy of these images are analyzed byusing 2D FFT and 2D- Hough Transform. These images were binarized using thresholding concept with a value of 0.70, which could give maximum recognition accuracy. The best recognition accuracy is obtained with 2D-FFT compared to 2D-Hough Transform.

The best recognition accuracy with 0.70 threshold is **88%** when 2D-FFT was applied to the test and training images, The recognition accuracy is found to be **82%** which is lower for 2D- Hough Transforms since the Hough Transform identifies an object using straight lines. For each pixel at (x, y) and its neighborhood, the Hough Transform algorithm determines if there is enough evidence of a straight line at that pixel, if so it will calculate the parameters (r,θ) of that line, and then look for the accumulators bin (that the parameters fall into) and increment the value of that bin. By finding the bins with highest values, typically by looking for local maxima in the accumulator space, the mostly likely lines can be extracted. The False Alarm rate for 2D-FFT is obtained as 12%. It is 18% for Hough Transform.

The time of computation of the algorithm using MATLAB tool is 16.28 seconds using 2D -FFT method and 24.9 seconds for 2D- Hough Transform. Hence even the computation time of MATLAB tool is lower for 2D-FFT compared to 2D-Hough Transform.

In the future scope, results can be obtained and analysed with other transforms. More Number of samples can be downloaded and the results obtained may be analyzed.

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