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Satellite Remote Sensing Image Based Aircraft Recognition Using Wavelet and Curvelet Transforms

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Abstract: This paper deals with the accurate recognition of aircrafts in satellite images using feature extraction and classification algorithms. Automatic recognition of an aircraft is a tough task. In previous recognition method, direction estimation technique was used to bring the aircraft into same direction, and the recognition was done by converting the recognition process into reconstruction process. Jigsaw algorithm was used in this reconstruction process. The major drawback of this method is that it has less accuracy while in recognition due to it's pixel to pixel matching process it also affected by noise. In order to improve the accuracy, noise components was removed by means of PCA algorihm, DWT and FDCT techniques were used for segmentation. Then the feature values of segmented images are get extracted using GLCM matrix. Recoganition of aircraft was done by comparing the feature values of input images with data base images using Probablistic Nueral Network (PNN), finally performance metrics was analyzed with the help of OTSU method. Experiments were done on more number images, it reveals that the suggested method got 96.15% of accuracy.

Keywords: Aircraft recognition, PCA algoritm, Feature extraxtion, Segmentation, Classification algorithm.

I. INTRODUCTION

Recognition of Aircraft plays significant role in surveillance and navigation. In real-time environment, based on the available information an abrupt and accurate judgment is necessary. A soldier must have the intelligence to identify both threat and friendly aircraft on the battelfield.

The security of battlefield is also achieves with help of advancement in image acquisition. The satellite captured aircraft images have the higher resolution, spatial information, texture and color. This information provides good opportunity for aircraft recognition. However, automatic recognition of aircraft is complex problem.

Different kinds of aircrafts are differing in size, shape and color, they have complex structure. At different scenarios the same type of aircrafts also having dissimilar intensity and texture. Furthermore, recognition frequently suffers from multiple conflicts such as various textures, clutters, noise, different orientations and contrasts. To avoid all the conflicts, highly robust methods are required.

In remaining paper is organized as follows, Section II deals with related work. Proposed methodology for aircraft recognition briefly discussed in Section III. Recognition efficiency of proposed algorithm over the Jigsaw algorithm is also detailed in terms of experimental results in Section IV. Finally the paper was concluded in Section V.

II. RELATED WORK

The natural object and aircraft recognition processes are two dissimilar things because the limited number of aircrafts and each kind has its specified size and shape. There are several conventional methods are proposed for this recognition process. In the literature, S.A. Duadani et al., proposed a technique to detect the six kinds of aircrafts automatically [2] by extracting the Hu moment invariant features from the input binary image. In addition [3], L. Fu, Y. Peng combined the Zernike moment invariant algorithm with independent component algorithm for the recognition purpose. Z. Yanan and Y. Guoqing are used the moment invariants and neural networks [4] for the recognition. In this method noise was eliminated by using the contour tracking. All these methods are working based on extraction of rotation invariant features.

In addition, for the recognition of aircraft, non-uniform rational B-splines [5] and cross ratios characteristics are utilized by Tien and Chai. There is several recognition methods were working based on direction estimation from the binarized image. This method requires more number of characteristics like size and shape (fuselage and symmetry). It also requires the binarized aircraft image for the direction estimation and need less fractured contour. Based on this concept Qichang Wu et.al., proposed a method for the recognition [1], direction estimation technique was used to bring the aircraft into same direction, and the recognition was done by converting the recognition process into reconstruction process. Jigsaw

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algorithm was used in this reconstruction process. All these methods are less accurate while in process of recognition. In this paper, a technique for recognition of aircrafts in satellite images was proposed. The Input satellite captured images have noise component, it was removed by means of PCA [6] algorithm. DWT [7] and FDCT [8] techniques were used for segmentation. Then the segmented images feature values are get extracted using GLCM [10] matrix. Recoganition of aircraft was done by comparing the feature values of input images with data base images using Probablistic Nueral Network [9] (PNN), finally performance metrics was analyzed with the help of OTSU method. These techniques were applied on more several number of images, it reveals that the suggested method got 96.15% of accuracy.

III. PROPOSED METHODOLOGY

In this paper a more accurate approch was proposed to recognize the aircraft in millatery, survelliance and naviagtion applications. The proposed system has those main modules, those are pre-processing, extraction of features, aircraft recognition and performance analysis as shown in the block diagram

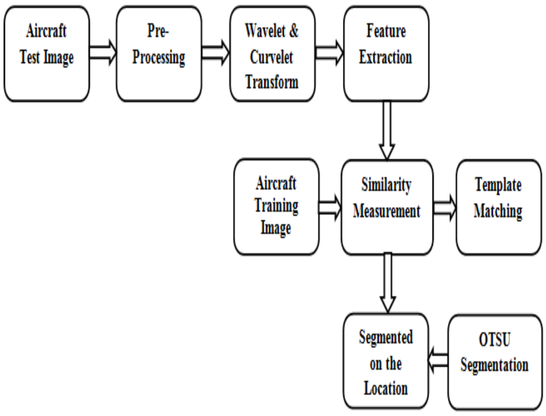


Fig.1. Block diagram of the aircraft recognition

In pre-processing stage noise components present in the input image are removed. Feature values are extracted for quality enhancement. For the recognition classification algorithm is used, finally aircraft parameters and performance characteristics are extracted.

A. Pre-processing

Pep-rocessing stage was used to enhance the quality parameters lile noise, shape, size, orientation and texture. In this proposed method, each aircraft image in the input remote sensing satellite captured image would be effected with all the above mentioned quality parameters. Therefore, for image pre-processing Principle Component Analysis (PCA) technique was used. The PCA method include four major steps.

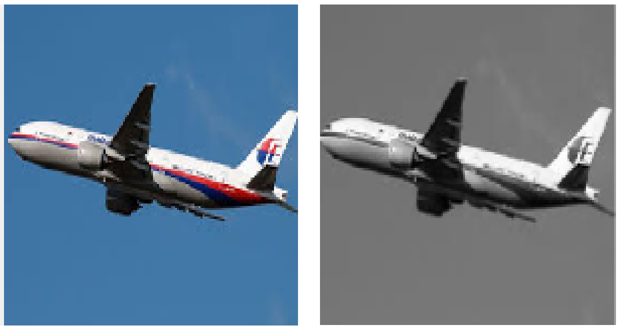
Step1: In practice, each input aircraft image size should be [256×256]. This image size will converted into [3×3] by dividing with 3.

Step2: Double the size of [3×3] image.

Step3: Now find the eigen values i.e., diagnoal values of doubled image by using convolution process.

Step4: Multiply the maimum values of diagnoal values with non diagnoal values of the image.

Pre-processing results are shown in Fig. 2.



(a) Input image (b) Pre-processing image

Fig. 2. (a) input image (b) Enhanced output image using PCA algoritm

B. Feature Extraction

Each aircraft image have similar size, shpe and orienations, after the peprocessing stage. Then, the characterstics are represented by extracting the four features. Contrast, energy, entropy, homoginity are the four features we inculded for the quality enhancemet. The accuracy of the recgonition was improved alot by means of thease features. The featrures are extracted from the segmented image, GLCM matrix was used for. Discrete Wavelet Transform (DWT) and Fast Discrete Wavelet Transform (FDCT) techniques were used for segmentation process.

a. Discrete wavelet transform

DWT is an angle based segmentation process, uses 0^0 and 90^0 angles. The pre-processing image will segmented into four sub-bands using DWT technique. Those four bands includes LL, LH, HL, HH as shown in the Fig. 3. Each band reresents each kind of image.

LL : Input pre-processing image.
LH : Vertical image.
HL : Horizontal image.
HH : Noise image.

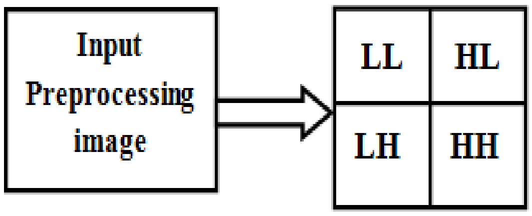


Fig. 3.Segmentation of pre-processing image into four subbands using DWT.

The low and high values are computed by following equations

$$Low = \frac{Even + Odd}{2} \quad (1)$$

$$High = \frac{Even - Odd}{2} \quad (2)$$

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From the equations (1) and (2), we have an observation that the lower suband values are get added and the higher values are get subtracted so the lower subands have more quality than the higher subband images as shown in the Fig. 4.

(a) Pre-processing image (b) DWT output

Fig.4. (a) Pre-processing (b) Corresponding DWT segmented output

b. Fast discrete curvelet transform

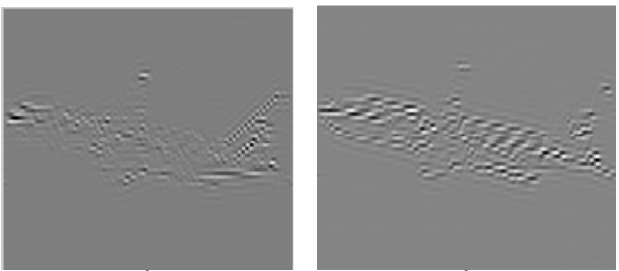
To get more accuracy in the recognition process we used Fast Discrete Curvelet Transform (FDCT) technique. The lower subband out put of DWT process is segmented using FDCT technique. It uses 8 segmented angles from 45^0 to 360^0. Thus, the FDCT have more accuracy than the DWT. FDCT can implemented in two ways, one is Unique Spaced FFT (USFFT) and another one is wrapping technique. Both these techniques are second generation curvelets. The USFFT relies on interpolation, where wrapping doesn't. The segmentation process was done by using FDCT via wrapping.

Initially set the wrapping inputs, based on these input values the Lower subband image will segmented into 8 angles from 45^0 to 360^0.

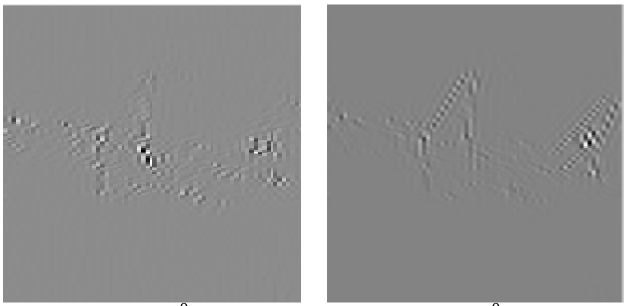
Table 1: Feature values of FDCT outputs (45^0 to 360^0)

Angle	Contrast	Correlation	Energy	Homogeneity
45^0	3.860	0.7819	0.265	0.815
90^0	3.964	0.7840	0.277	0.825
135^0	18.142	-0.248	0.117	0.454
180^0	18.262	-0.220	0.118	0.454
225^0	3.906	0.786	0.251	0.823
270^0	3.8906	0.794	0.261	0.825
315^0	18.288	-0.260	0.119	0.452
360^0	17.210	-0.175	0.128	0.480

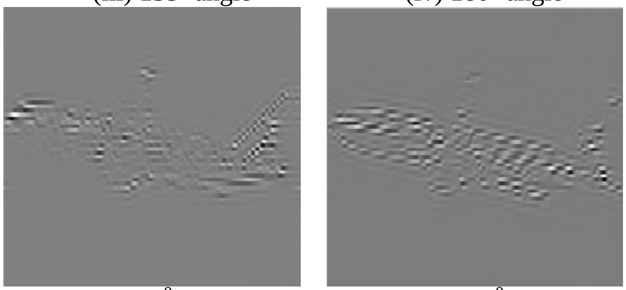
The 8 angles segmented output images are shown in the Fig.5 and each angle feature vales are given in table 1.



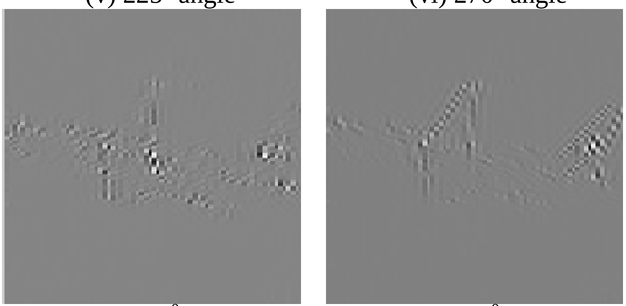
(i) 45^0 angle (ii) 90^0 angle



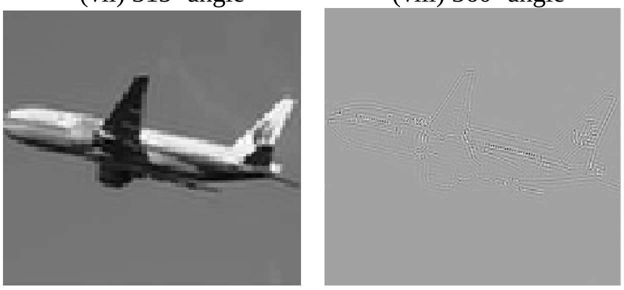
(iii) 135^0 angle (iv) 180^0 angle



(v) 225^0 angle (vi) 270^0 angle



(vii) 315^0 angle (viii) 360^0 angle



(ix) Top angle (x) Bottom angle

Fig. 5. FDCT segmented outputs (45^0 to 360^0) via wrapping

The top and bottom images don't have any significance while doing the recognition. Now apply the Inverse FDCT (IFDCT) technique to all segmented outputs to get better quality image.

After doing the segmentation using DWT and FDCT techniques, Gray Level Co-occurance Matrix (GLCM) matrics was used to extracrt the features from segmented outputs. A co-occurance matrix is also referred as co-occurance distribtuion. It was defined over an image to be the distribution of co-occurring values at a given offset, it also defined as represents the distance and angular spatial relationship over an image sub-region of specific size. The GLCM was created from a gray-scale image. Contrast, energy, correlation and homoginity are the four features extracted using the GLCM for better recognition.

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c. Aircraft Recognition

We have to recognize the aircraft whether it was present or not in the given input satellite image. The preprocesing and feature extaction all are done before for better recognition. The aircraft recognition was done using classification algorithm. The procedural block diagram was shown in the Fig. 6.

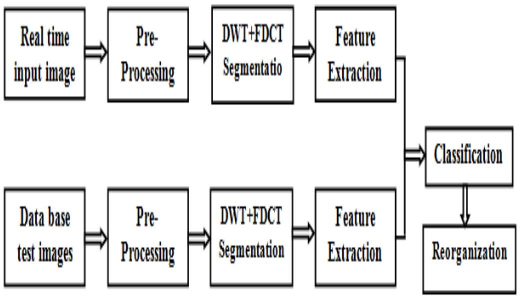


Fig. 6. Block diagram for aircraft recognition using classification algoritm

Till now, the input image features are get extracted. Now by using the same procedure we are extracted the feature values of data base images. Both these feture values are given as input to the clasification algorithem. Where we are are using the Probabilistic Neural Network (PNN) as a classifier. PNN have better and faster outputs than compared to other neural networks. It has four layers, Input layer, Pattern layer, summation or category layer and output layer as shown in Fig.7. From the diagram when the input image feature values are available, the pattern layer finds the distance between the input feature vector values to the data base images vector feature values. The pattern layer generates a vector. The vector indicates the closeness of input and database inputs. Summaion layer sum up each output values of pattern layer and generates a probability vector from the net output. Finally, the compare the all probability values of summation layer and picks the largest probablity value. If the probability value is 1 the aircraft was recognized and if it is 0 the aircraft was not recognized.

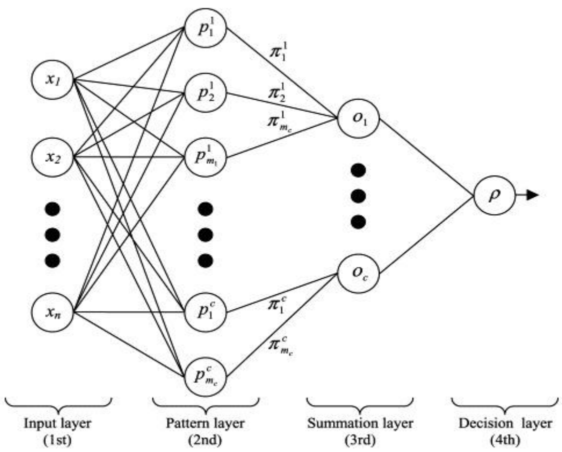
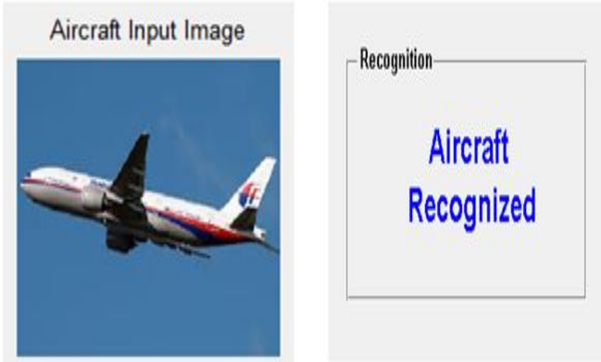


Fig. 7. Architecture of Probablistic Neural Network

In the Fig. 8. both recognized and non-recognized outputs with respective to the inputs are shown.



(a) Recognized output

(b) Non-recognized output

Fig. 8. (a) recognized (b) Non-recognized outputs of aircraft using PNN

IV. EXPERIMENTAL RESULTS

For analyze the size and shape of aircraft, different parametrs of aircraft are calculated using thresholding technique. Performance of proposed algoritm is compared with jigsaw algorithm.

A. Parameter Analysis

Performance of proposed recognition was depends upon, how well it can find the location and shape of the aircraft. The shape extraction is nothing but extracting the boundaries from the input image. For this purpose OTSU multiple thresholding technique was used. Because other bonadary extraction techniques are not much accurate. OTSU is used to separate the foreground and backround it also refered as converting the RGB or Gray scale image into black and white image i.e., binary image(0's and 1's) as shown in Fig.9. The pose estimation for location finding. As shown in the Fig.10. boundaries of the aircraft are represented in red color.

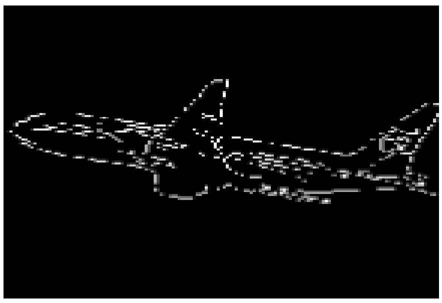


Fig.9. Boundaries extracted using OTSU

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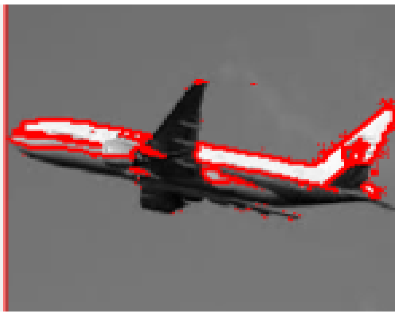

Fig.10. Location finding using pose estimation

The shape and size of the aircraft is depend on the area, perimeter, eccentricity and equivalent diameter. Direction was dependent on orientation of the aircraft. The tracking parmeters for the input aircraft image are listed in table 2.

Table 2: Tracking Parameters

Tracking Parameter	Value
Area	241
Perimeter	61.89
Eccentricity	0.848
Equivalent Diameter	76.16
Orientation	17.51

B. Performance Analysis

For ease of assessment, both the proposed approach and reference approach results are furnished in table 3. We used to compare our proposed method with the previously proposed direction estimation algorithm with jigsaw algorithm. For the comparison we use, direction estimation based algorithm and for recognition purpose jigsaw algorithm was used at the final stage. By observing the table, proposed recognition method was more accurate than the previous method and it also have better PSNR, precision and MSE values.

Table 3: Comparison between previous and proposed methods

Performance Parameters	Jigsaw Algorithm [1]	Proposed Method
Accuracy (%)	92.3	96.15
Precision (%)	79.41	90.60
PSNR (dB)	27.5462	64.7392
MSE	0.1845	0.0218

V. CONCLUSION

In this paper, new hierarchical and robust-type method was proposed for aircraft recognition from the remote sensing satellite images. The major advantage of this proposed method is accuracy. In this method, initially the noise was removed at pre-processing stage using PCA algorithm. Feature values extraction was the major step in the recognition, GLCM was used for this purpose. GLCM need segmented inputs, so for the better segmentation DWT and FDCT techniques were used. The aircraft was recognized by using PNN. It needs both the input and database feature values. PNN is used to solve the classification problems. Finally Performance characteristics are computed using OTSU thresholding technique. Experimental results have proved that the proposed method was more accurate and attain better performance.

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