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SAR Image Classification by Wavelet Transform and Euclidean Distance with Shanon Index Measurement

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Abstract— Synthetic Aperture Radar Image Classification is one of the four problem domains in the field of Automatic Target Recognition. This paper proposes Wavelet transform based Euclidean distance with Shanon Index measurement to classify the SAR image, which consists of three steps including preprocessing, feature extraction and classification. Preprocessing removes the speckle noise present in the image. Daubechies wavelet is used to extract the features by obtaining the approximated image. Finally, the classification process is completed using Euclidian distance with the help of Shannon index measurement. The performance of the existing system is compared with the existing Maximum Likelihood Classifier in terms of accuracy and an accuracy of 95.3% is achieved in classification for the proposed method.

Keywords— SAR, image classification, feature extraction, Daubechies Wavelet, Euclidean distance and Shannon index measurement.

I. INTRODUCTION

Synthetic Aperture Radar (SAR) image classification takes place in many remote sensing applications, including forest vegetation mapping and classification, urban and land usage, and in the determination of water resources. Scientists and practitioners have made great efforts in developing various classification approaches and techniques for improving classification accuracy. However, classifying SAR image data into thematic map remains as challenge because many factors, such as the complexity of landscape on selected area, selected SAR data, processing of image and classification approaches may affect the classification accuracy. Hence, SAR image classification requires consideration of many factors. The major steps of the image classification may include selection of training samples, preprocessing, feature extraction, selection of classification approach and accuracy assessment. In general, a classification system is designed based on the user's need, spatial resolution of selected data, image processing and classification algorithms available and time constraints. Many potential variables were used in classification spectral ignatures, vegetation indices, transformed images, textural or contextual information, multi temporal information and ancillary data.

Focusing on above factors, many authors have addressed the classification issue in various ways and using different algorithms and environmental conditions. In [2] Histogram based contextual classification is proposed in which contextual information is used to crate mixture model in both pixel and class domain using local histogram and auto logistic regression. But, the local histogram constituted by using pixels in small window will result in overlapping window, This will increase the cost and time consumption of the algorithm. Semantic classification approach [7] classifies the land cover in the patch level by semi supervised learning. Hence reduces the workload of selecting patch and also decreases the searching space in similarity calculation. However this approach assumes image patch belongs to single semantic but SAR image patch has multiple semantics.

In super pixel based classification approach [6] image is partitioned into super pixels that preserve the most of the characteristics necessary for information extraction which is further followed by final classification. Though it is flexible approach, the number of classes involved in image is large and relation among different class is unbalanced. Local primitive pattern(LPP) based classification [8] uses

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local primitive feature vector with information like intensity levels and contrast differences. Then, kernel based classification is done. This approach will be successful only if multiple parameters are involved in LPP. CRF (Conditional Random Field) with RCC (Region Connection Calculus) model [9]classifies the image into multi super pixels via image pyramid. This strategy needs iterative process to get better detailed classification. Patch based image classification [10] encodes the image into sequence of ordered patches and then carry out the classification. Double kernel is needed for improved classification performance.

The proposed wavelet based Euclidean distance has two important process, feature extraction and classification. For feature extraction Daubechies4 wavelet is used which is effective in preserving the detailed feature of high spatial resolution data at various scale level. Classification process is done using Euclidian distance that, calculates the distance between the test image and training samples based on the Shannon index measurement. It improves the effectiveness of the algorithm. Thus the proposed approach achieved the 95.3% accuracy in classification

II. METHODOLOGY

In proposed method, SAR image classification is done by Euclidian distance according to their Shannon index calculated. In proposed work test image and training image is taken and processed through three important modules (i) preprocessing (ii) feature extraction and (iii) classification. The block diagram of proposed method is represented in Fig.1.

A. Preprocessing

Median filter is chosen for preprocessing to remove the noise from image and also to smoothen the image. It takes pixel by pixel from image for process. Instead of replacing the mean value of neighboring pixel median filter uses median value of the neighboring pixel. First, it arranges the pixel according to its numerical order then take the middle pixel value from the surrounding pixel of each individual pixel and replace it by the middle value. Compare to other filters median filter is more robust to the single unrepresentative pixel, it preserve the edge and deal images with high spatial and frequency detail.

B. Feature Extraction

Feature extraction is done using Daubechies4 Wavelet which is, DWT(Discrete Wavelet Transform). Daubechies4 wavelet is Shift invariant. It employs the overlapping iterations hence, detail changes can be preserved compare to other wavelets like Haar wavelet. As its name implies, it is based on four filter coefficients C(0), C(1), C(2) and C(3) whose equation can be expressed as,

$$C(0) = \frac{1+\sqrt{3}}{4\sqrt{2}} \quad (1)$$

$$C(1) = \frac{3+\sqrt{3}}{4\sqrt{2}} \quad (2)$$

$$C(2) = \frac{3-\sqrt{3}}{4\sqrt{2}} \quad (3)$$

$$C(3) = \frac{1-\sqrt{3}}{4\sqrt{2}} \quad (4)$$

the following steps are involved in Daubechies4 wavelet transform,

- Transform matrix W is applied to the column vector of the image data.
- Odd numbered rows generates the weighted sum S for each row which are the convolution of data vector with all four coefficients. each of the sum vector is smoothing coefficient. Together it is known as H filter.
- Similarly even numbered row generates the quantity D for each row which are known as detail coefficients. Together it is known as G filter.
- Combination of this G and H filter is QMF (Quadrature Mirror Filter)of the Transform.
- As image passes through the QMF of Daubechies4 wavelet it actually processed through the pair of tow G filter and par of two H filters.
- Hence this wavelet transform produce four sub image from the original image Which are AP (approximated image), HD (horizontal detail), VD (vertical detail) and DD(diagonal detail).

From the four transformed image approximated image is taken for the next subsequent process. Since it has low frequency content with details of original test image.

After wavelet transform Shannon index is measured to find the richness and evenness of the image. Richness is referred to the number classes and evenness is referred to the class distribution among the image. Shannon index can be measured using the following equation,

$$SHAN = -\sum_{i=1}^{M}\sum_{j=1}^{N} C(i,j) * \log C(i,j) \quad (5)$$

Where C(i, j) is a wavelet coefficient of the sub image. Above wavelet decomposition and Shannon index measurement are done for all training samples and test image. Hence, feature vector for test image and training samples are obtained

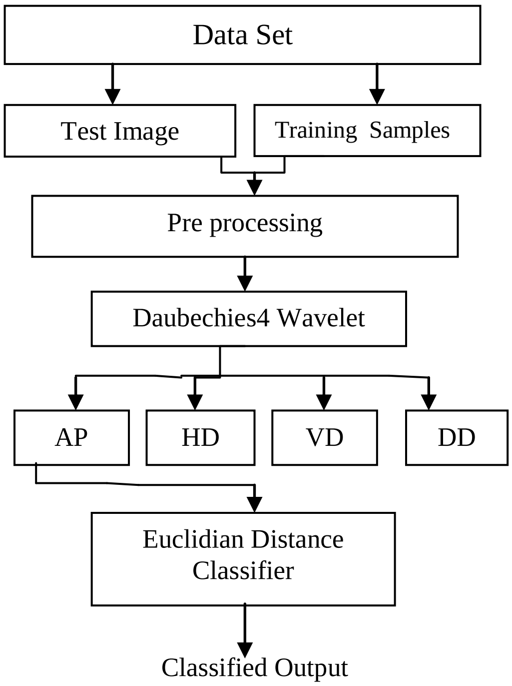

Fig 1. Pipeline of the proposed method

C. Classification

Classification is done using Euclidian distance using feature values obtained from sub image (AP from test image) and training samples. Here, Q is taken as the feature vector of the test image and P is taken as the feature vector of the training samples distance between these two feature vector is R. Hence, Euclidian distance is defined as,

$$R_k = \sqrt{\sum_{j=1}^{N} \left(q_j - p_{k,j}\right)^{\wedge}2} \qquad (6)$$

Where, q_j is the jth value in the Q vector and $p_{k,j}$ is the jth value in vector P. N is the number of feature values in the feature vectors.

III. EXPERIMENTAL RESULTS

Images from the Quick Bird Data set are taken to check the effectiveness of the proposed system. Images of Quick Bird Data set is taken over central region in the city of Peru, South America acquired on Jan 9,2005. The radio metric resolution of the taken test image is 24 bit with dimension 763 X 623 pixels. Training sample for the selected classes were selected using visual identification and Google Earth. Test image and Corresponding Gray scale image is shown in Fig 2 and Fig 3. Preprocessed image using Median filter is shown in Fig 4.

Fig 2 : Test image from Quick Bird Data set Taken in the city of Phoenix.

Fig 3: Gray scale image of the test image.

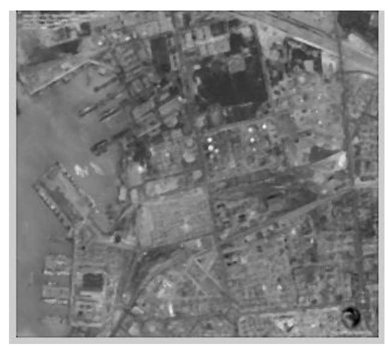

Fig 4: Preprocessed image using median filter.

After preprocessing edge smoothened image is obtained as shown in Fig 4. Then the preprocessed image is transformed using Daubechies4 wavelet. Resultant four sub image is shown in Fig 5a,5b,5c and 5d which represents the approximated sub image(AP), horizontal detail (HD), vertical detail(VD) and diagonal detail(DD) respectively. apart from AP all three sub image consist high frequency component. Hence, these three sub image contains only the noise content as shown in figures.

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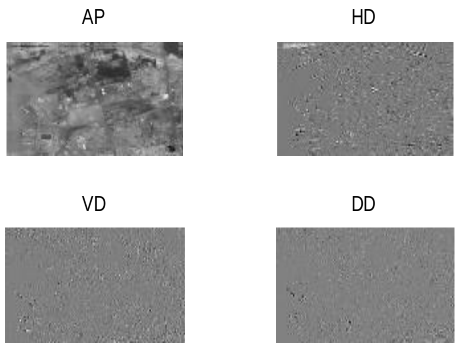
Classified output shown in Fig 6 which is obtained using



Euclidian distance which calculates the distance between the feature vectors of test mage and training samples. Feature vector is obtained using Shannon index of the test image and training image. Here training samples for five classes are used. Hence, five classes can be mapped in the classified result. Five classes with corresponding color is tabulated in Table 1.

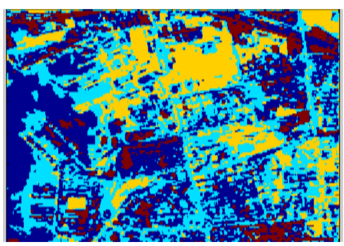


Fig 6: Classified Output Generated Using Euclidian Distance

Table 1: Classes With Corresponding colors That Are Classified in the Output Map

Class	Color
Sky Blue	Buildings
Yellow	Grass
Brown	Land
Blue	Water Bodies
Forest	Not Present In Given Test Image

IV. PERFORMANCE MEASURES

Accuracy is calculated to test the proposed classification method using the formula,

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \qquad (7)$$

$$Sensitivity = \frac{TP}{TP + FN} \qquad (8)$$

$$Specificity = \frac{TN}{TN + FP} \qquad (9)$$

Where Sensitivity refers to the percentage of positive labeled instances that are predicted as positive. Specificity refers to the percentage of negative labeled instances that are predicted as negative. Accuracy is the percentage of predictions that are correct.

TP = True Positive, Correctly accepted,
TN= True Negative, Correctly rejected,
FP= False Positive, Falsely accepted,
FN= False Negative, Falsely rejected.

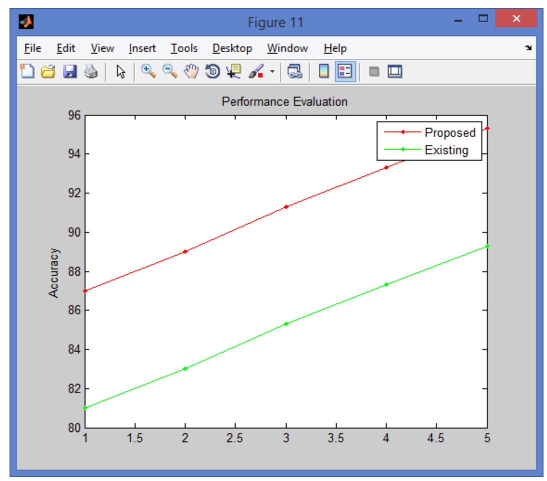


Fig 7: Accuracy measure of the output.

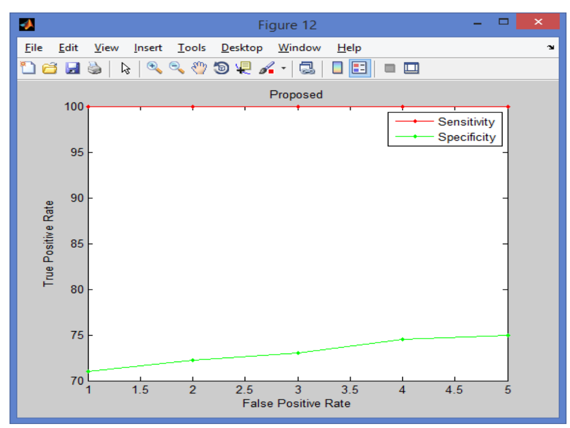


Fig 8: Sensitivity and Specificity Measure of the Output.

Performance comparison graph between Maximum likelihood classifier and the Proposed Wavelet Based Classifier is shown in Fig 7 based on the accuracy of both

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classifier. Sensitivity and Specificity measure for the Wavelet based classifier is shown in Fig 8.

Performance measure of the Proposed and Maximum likelihood classifier is given in Table 2.

Table 2: Performance Measure

Parameters	Maximum Likelihood Classifier	Wavelet Based Classifier
Sensitivity	82.3%	97.5%
Specificity	80%	75%
Accuracy	89.3%	95.3%

V. CONCLUSION

In this paper, we investigate SAR Image classification using Wavelet based Euclidean Distance with Shanon Index measurement. The performance of the proposed Wavelet Based Classification algorithm is compared with the existing Maximum Likelihood Classifier. The experimental results shows that the proposed Wavelet based Euclidean Distance method produces 95.3% classification accuracy which is higher than the Maximum Likelihood classifier and proves to be the most effective approach for classification of SAR images.

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Authors Profile

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