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SAR Image Classification for Land Cover Patterns

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Abstract **-- In this paper, we propose classification of SAR (Synthetic Aperture Radar) Image into various land cover/land use patterns namely water, urban, vegetation areas. We shall use Gaussian filter to de-speckle the image after that four band wavelet decomposition. Texture features of image can be computed using local estimator. Classification can be employed on the image with the design of Neural Network.**

Keywords **-- SAR (Synthetic Aperture Radar), CEOS (Committee on Earth Observing Satellite) format, etc.**

I. INTRODUCTION

There are many types of satellite images available in different operating frequencies. SAR image helps in identifying nature of terrain or building areas, types of agriculture crops etc. SAR image in CEOS (Committee on Earth Observing Satellite) format is available. We shall read this SAR Image in CEOS format and obtain necessary information. Then, despeckling is carried out using Gaussian Filter. In this procedure, suitable techniques of filtering and its effects have to be studied. These are preprocessing operations required for SAR image to apply classification process.

Four-band Deb wavelet decomposition is applied on the preprocessed SAR image to get 16 bands at level 1 and 256 sub bands at level 2.Texture Features of sub band images are then calculated. Features are ranked with the help of K-means clustering. Classification can be employed on the image with the design of adaptive neuro-fuzzy algorithm.

In particular this paper is organized as follows:

Section II represents the actual work flow of project reading SAR image, preprocessing the SAR image with the help of Gaussian Filter. After preprocessing wavelet transform then feature extraction and K-means clustering for ranking the features. Finally Neuro-fuzzy is applied to get classified image.

Section III represents the Mathematical Model that describes the input, output functionalities along with the success and failure cases.

Section IV represents the System Design.

Section V represents the Data set.

Section VI contains the implementation details of our system.

Section VII concludes this paper.

II. TYPE STYLE AND FONTS

A. Read SAR Image and Display

SAR Image is in CEOS format. This format contains different types of files such as:

1. Volume Directory File
2. SAR Leader File
3. Null Volume Directory File and
4. SAR Data File.

B. Image Cropping

The image which we have displayed is cropped for further processing. We are going to accept co-ordinates from user to crop image.

C. Applying Gaussian Filter

Gaussian Filter is applied on cropped image to smoothen it. Gaussian Filter removes noise from the image. We are using 3 x 3 Gaussian Filter to de-speckle image. Equation of Gaussian Filter is as follows:

$$G_\sigma(x,y) = \frac{1}{2\pi\sigma^2} e^{\frac{x^2+y^2}{2\sigma^2}}$$

Where,
(x, y) are the co-ordinates of pixels and σ is spread factor.

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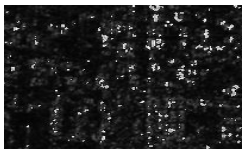
3 × 3 Gaussian Filter Matrix:

1/16 ×

1	2	1
2	4	2
1	2	1

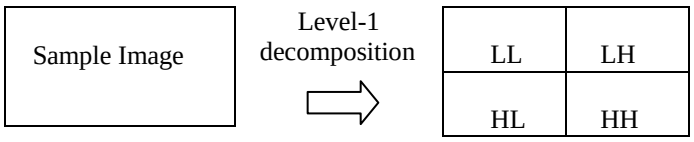


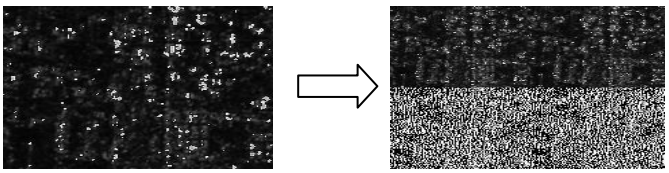
a

Thus we have got the de-speckled image and we pass it to the Four-band Deb wavelet decomposition.

D. Wavelet Decomposition

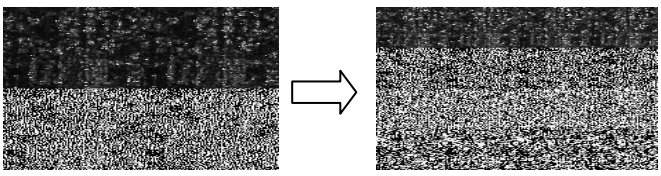
The image is then passed to the Four-band Deb4 wavelet decomposition and we get decomposed image consist of 256 sub-bands at level4.Output we got after applying 4D wavelet decomposition is in LL,HH,HL,LH form.





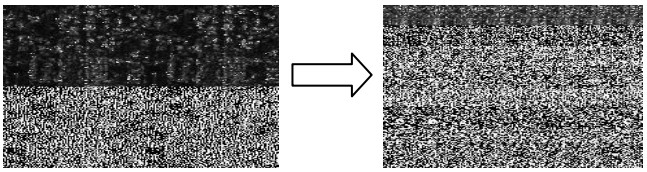
a b

a- Sample Image b- Decomposed Image at level-1



B c

b- Decomposed Image at c- Decomposed Image at



c d

c- Decomposed Image at level-2 d- Decomposed Image at level-3

These sub-bands are then used further to calculate energy.

E .Energy Calculation

By applying energy calculation few subbands at Level1 and Level2 are selected.
Energy can be calculated as

Energy = (p1xp1+p2xp2+……+pn x pn)/n

Where,
p1,p2,pn are pixels and
n is total number of pixels.

F. Feature Extraction

We did Feature Extraction for getting information about different textures. After applying Wavelet Decomposition we can extract some important features such as Mean, Standard Deviation (STD) and Variance.

$$mean = \frac{1}{RS}\sum_{r=0}^{R-1}\sum_{s=0}^{S-1} f(r,s)$$

$$STD = \sqrt{1/RS \sum_{r=0}^{R-1}\sum_{s=0}^{S-1}(f(r,s) - mean)^2}$$

$$\text{Variance} = \frac{\sum_{r=0}^{R-1}\sum_{s=0}^{S-1}(f(r,s) - mean)^2}{R \times S}$$

Where, $f(r,s)$ is value of the pixel in this position.

III. MATHEMATICAL MODEL

S is a system that classifies image I into different classes from set C. I' will be classified image.
Hence, S= {I, CI, WI,F,SF,I',C}.
Where
p={x, y, v} where x, y are co-ordinates and v is magnitude

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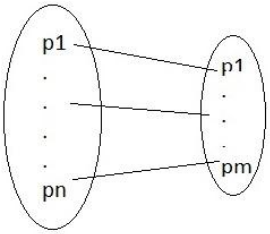
I = {p_1, p_2, p_3… p_n} where p is pixel.
CI= {p_1, p_2, p_3… p_m} cropped image
I_1= {p_1, p_2, p_3… p_m} De-speckled image.
WI= {IL1, IL2} Set of sub-band images
Where
IL1= {I_1', I_2'… I16'}
IL2= {I_1'', I_2''… I256''}
F= {F_1, F_2 ….F_j} set of features
SF= {F_1, F2….Fi} set of selected features
I' = {p_1', p2', p3',…….,p_n'}
C= {c_1, c_2, c_3} where c is class.

A. Crop Image

Crop(I,lat,long)= CI={p_1,p_2,p_3,……,p_m}



B. Gaussian Filter

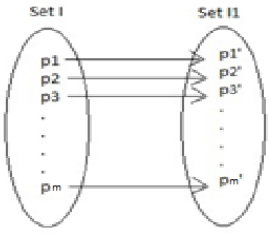
F(CI,M)=I_1

$$G_\sigma(x,y) = \frac{1}{2\pi\sigma^2} e^{\frac{x^2+y^2}{2\sigma^2}}$$

Where
CI is cropped image,
M is Gaussian Matrix

$$(1/16)\times \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

I_1 is de-speckled image

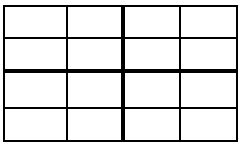


B. 2D Wavelet Transform

WT (I_1) =g (I_1), h (I_1) =I_1', I2', I3', I4'

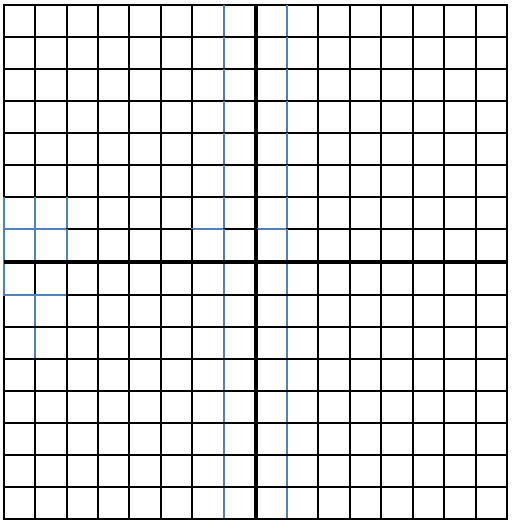
Where
g(x) is low pass filter
h(x) is high pass filter

I_1'	I_2'
I_3'	I_4'



Level-1

WT(I_1)= IL1={I_1',I_2',…,I_{16}'}



Level-2

WT (IL1) = IL2= {I_1'', I2''… I256''}

WI= {IL1, IL2}

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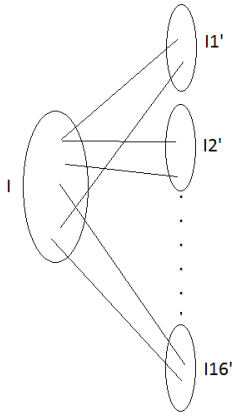
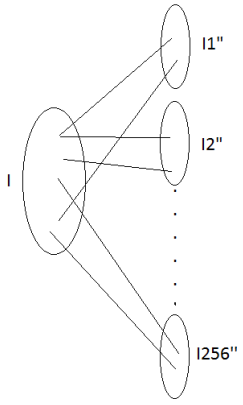


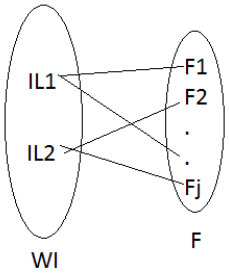
Level-1 2D wavelet transforms



Level-2 2D wavelet transforms

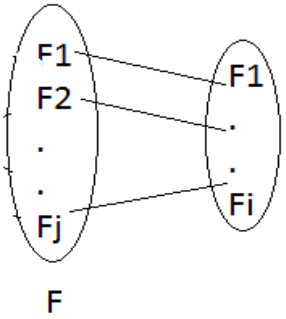
C. Feature Extraction

It is used for feature extraction.
Extracted features will be set F.
Extract F (WI) =F= {F_1, F2….F_j}



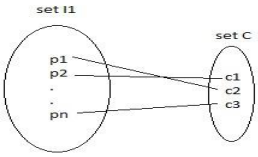
D. Adaptive Neuro Fuzzy for feature selection

It is used for feature selection which will be used for classification of image in next step.
ANF (F) = SF= {F_1, F2….Fi} where i<=j



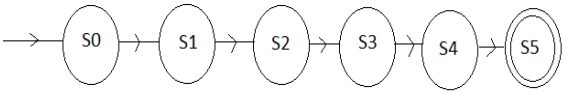
E. Neural Network

Now by applying neural network on SF the on the basis of feature F, F(I,SF)=I'
Where I' is classified image.



F. State Diagram

S0: Crop image
S1: Gaussian Filter
S2: Wavelet Transform
S3: Feature Extraction
S4: Neural Network
S5: Classified Image



IV. SYSTEM DESIGN

We design the system for classification of SAR images into 3 different classes such as land, water and urban area. We select five samples from each class i.e. land, water and urban area then wavelet decomposition is applied to get features which help us to differentiate between these classes. These features are then given to neural network to train it. Finally, we take input image and we pass small parts of 10x10 size of it to

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neural network. Neural network classifies each part into different classes and we get classified image.

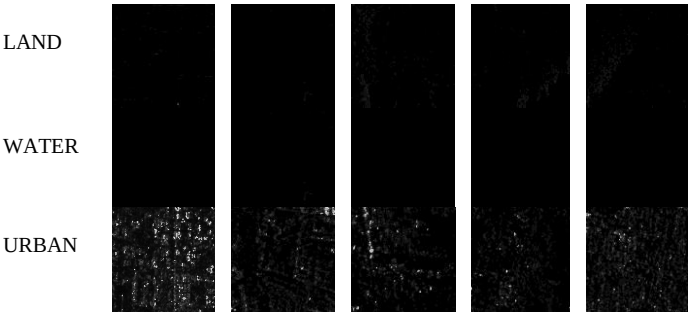


Figure 1. Illustrated three groups of textures.

V. IMPLEMENTATION DETAILS

The system is developed in Java using Eclipse HELIOS and JDK 7. The basic requirement for the system would be Windows OS and minimum 4 GB RAM. User has to provide SAR image path to system and system would classify the input image into three different classes.

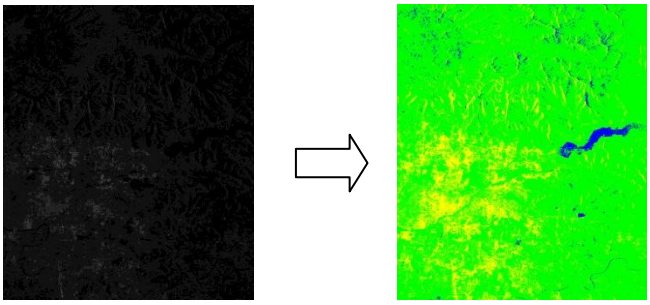
VI. RESULTS

We have developed a system that has following functionality:

1. Read and display SAR image
2. Crop SAR image
3. Classify SAR image into different land-use patterns

Result is obtained as follows-

a)Blue-Water
b)Green-Land
c)Yellow-Urban



Input Image Output Image

VII. CONCLUSION

From the satellite image, i.e. SAR image obtained for the Pune(India) area is classified into water, urban and land areas. This research will help in a great way for ecosystem monitoring, plan for city, framing up of policies by the government related to land use, effective utilization of cultivable land etc.

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