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SAR Image Segmentation Using Artificial Bee Colony Algorithm

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***Abstract*—**Due to the presence of speckle noise, segmentation of synthetic aperture radar (SAR) image is still a challenging problem. First decompose the original image by discrete wavelet transform. The parameters that are used to evaluate the speckle reduction are, PSNR (peak signal to noise ratio), Entropy and mean. Edge detection method in the field of image processing is an important application area. Currently, image processing is being exploited in many areas. This paper proposes a fast SAR image segmentation method based on artificial bee colony algorithm. In this method, threshold estimation is regarded as a search procedure that searches for an appropriate value in a continuous gray scale. Hence, ABC algorithm is introduces to search for the optimal threshold.

Keywords— SAR image, Image segmentation, psnr, entropy, mean.

I.INTRODUCTION

Digital images are several types of noise. Noise is an error in image acquisition process that results in pixel values that do not reflect the true intensities of the real scene. There are several ways to introduced noise in an image, depending on how the image is created. For example if the image is scanned from a photograph made on film, the film grain is a source of noises. Noise can also damage the results in film, or introduced by scanned itself. If the image is acquired directly in a digital format, the mechanism for gathers the data (such as a CCD detector) can introduce noise. Electronics transmission of image data can introduce noise. Noise is considered to be much measurement that is not a part of the phenomena of interest. Noise can be categorized as image data independent noise and image data independent noise and image data dependent noise. Image denoising still remains a challenge research because noise removal introduced artifacts and causes blurring of the images. This paper, describers different methodologies for noise reduction (or denoising) giving an insight as to which algorithm should be used to find the optimization. Synthetic aperture radar is a radar technology that is used from satellite technology. It provides high resolution images of earth's surface by using special signal processing techniques. However acquisitions of SAR images face certain problems. SAR images contain speckle noise which is based on multiplicative noise. Speckle noise degraded the appearance and quality of SAR images.

2. TYPES OF IMAGES

1) **Medical images:** It is a part of biological imaging e.g.: medical photography.
2) **Still images:** An images is an artifact that depicts or record visual perception, for example a two dimensional picture.
3) **Satellite images:** Satellite imagery consisting of images of earth or other planets collected by artificial satellites.

3. TYPES OF NOISES

3.1) Additive and Multiplication Noises: Noise can be present in an image either in an additive or multiplicative form. An additive noise follows the rule $w(x,y)=s(x,y)+n(x,y)$ While the multiplicative Noise satisfied $w(x,y)=s(x,y)*n(x,y)$,where $s(x,y)$ is the original signal, $n(x,y)$ denotes the noise introduced into the signal to produce the corrupted image $w(x,y)$ and (x,y) represents the pixel location. The above algebra is done at pixel level.

3.2) Gaussian noise Gaussian noise is evenly distributes over the signal this means that each pixel in the noisy image is the sum of the true pixel values and a random Gaussian distributed noise value , As the name indicates, this type of noise has a Gaussian.

$$F(g) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(g-m)^2/2\sigma^2} ,$$

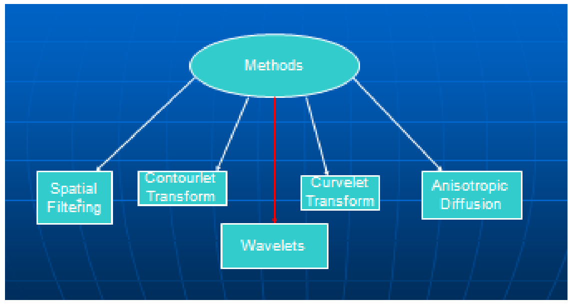
Distribution, which has a bell shape probability distribution function, where g represents the gray level, m, is the mean or average of the function and σ is the standard of the noise.

3.3) Salt and pepper noise: Salt and pepper noise is an impulse type of noises, which is also referred to as an intensity spikes. This is caused general due to the errors in data transmission. It has only two possible values, a and b. The probability of each is typically less than 0.1.

3.4) Speckle noise: Speckle noise is a multiplicative noise. These types of noise occur in almost all coherent imaging systems such as laser, acoustics and SAR (Synthetic Aperture Radar) images. The source of this noise is attributed to random interference between the coherent returns. Fully developeds speckle noise has the characteristic of multiplicative noise.

3.5) Poisson noise: In probability theory and statistics, the Poisson distributions, is a discrete probability distribution that expresses the probability of a given number of events occurs in a fixed interval of time and /or space if these events occur with a known averages rate and independently of the times in the last event.

From our experiment, it has been observed that the filtering approach does not produce considerable denoising for image corrupt with Gaussian noise or speckle noise.



Wavelets play a very important role in the removal of the noise.

DWT: Discrete wavelet transform is a types of wavelet transform for which the wavelets are discretely sampled. As with other wavelet transforms, a key advantages it has over Fourier transforms is temporal resolution: it captures both frequency and location information (location in time).

Advantages Wavelets allows complex information such as music, speech, images and patterns to be decomposed into elementary forms at different types of positions and scales and subsequently reconstructed with high precision. The wavelet representation of a function is a new technique. Wavelet transform of a function is the improved version of Fourier transform. Fourier transform is a powerful tool for analysis the components the stationary signal. But it is failed for analyzing the non stationary signal transform of a function is the improved version of Fourier transform. Fourier transform is a powerful tool for analyses the components of a stationary signal. But it is failed for analyzing the non stationary signal where as wavelet transform allow the components of a non-stationary signal to be analyzed. In time-frequency analysis of a signal, the classical Fourier transform analyses are inadequate because Fourier transform of a signal does not contain any local information. This is the major drawbacks of the Fourier transform. The modern application of wavelet theory as diverse as wave propagations, data compression, signal processing, image processing, pattern recognition, computer graphics, the detection of aircraft and submarines, improvements of CAT scans and some other medical image technology etc.

4. WAVELET FAMILIES: Several families of wavelets that have proved to be especially useful are included in the wavelet toolbox. The details of this wavelet Family have been shown below:

A.Haar Wavelets:

Haar wavelet is the first and simplest.Haar wavelet is discontinuous, and resembles a step functions. It represents the same wavelet as Daubechies db1.

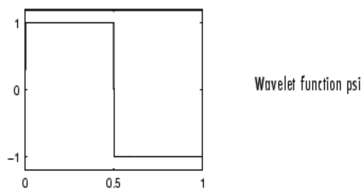


Figure 1: Haar Wavelet Function Waveform.

B.Daubechies Wavelet:

Ingrid Daubechies, one of the brightest stars in the world of wavelet research, invented what are called compactly supports orthonormal wavelets thus making discrete wavelet analysis practicable. The names of the Daubechies family wavelets have been written as dbN, where N is the order, and db is “surname" of the wavelet. The db1 wavelet, as mentioned above, is the same as the Haar wavelet. Here is the wavelet functions psi of the next nine members of the family.

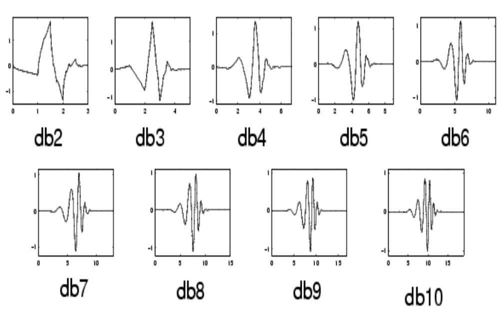


Figure 2: DB Wavelet Function Waveforms.

C.Symlet Wavelets: symN: In symN, *N* is the order. Some author’s use 2*N* instead of *N*. Symlets is only near symmetric; consequently some authors do not call them symlets. More about the symlets can be found in [Dau92].By typing wave info ('sym') at the MATLAB command prompt; you can obtain a survey of the main properties of this family.

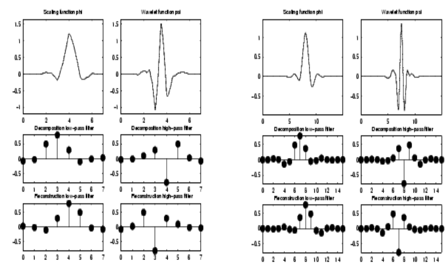


Figure 3: Symlets sym4 on the Left and sym8 on the Right.

Daubechies proposes modification of her wavelets that increase their symmetry can be increased while retaining greater simplicity. The idea consist of reusing the function mo introduced in the *dbN*, considering the $|mo(\omega)|^2$ as a function *W* of $Z = e^{i\omega}$. Then we can factors *W* in several different ways in the form $W(Z) = U(Z)\bar{U}(Z)$ because the roots of *W* with modulus not equal to 1 go in Z By selecting *U* such that the modulus of all its roots is strictly less than 1, we build Daubechies wavelets *dbN*. Where *U* filter is a "minimum phase filter." By making another choice, we obtain more symmetrical filters; these are symlets. The symlets have other property similar to those of the *dbN*s.

5. ABC algorithms

As a kind of social insects, honey bees live in colony and exhibit many features. These features include bee foraging, bee dance, queen bee, task selections, collective decision making, nest site selection, mating, pheromone laying and navigation systems, which can be used as model for intelligent applications. Actually, a lot of researchers have been inspired to develop algorithms by the behaviors of bees. A survey of the algorithms based on the intelligence in bee swarms and their applications has been present in the ABC algorithm proposed by Karaboga and Basturk is one of the most popular algorithms. The following discusses its working mechanism. In ABC algorithm, an artificial bee colony consists of employed bee, onlookers and scouts. A bee waiting on the dance area to obtain the information about food sources is called an onlooker, a bee going to the food source is named as a employed bee, and a bee carry's out random search is called a scout. The positions of a food source denote a possible solution to the optimization problem, and the nectar amount of a food source represents the quality of the associated solutions. Initially, a randomly distributed population is generates. For every food sources, there is only one employed bees. So the number of employed bees is equal to the number of food sources. Thereafter, the positions (solutions) will be updates repeatedly with the following cycles until the maximum iterations are reached or stop conditions are satisfiers. Each employed bee always remembers its previous best position, and produced a new position within its neighborhood in its memory. According to the greedy criterion, the employed bee updated its food source. In other words, when the new food source is better, the old food source positions are updated with the new one. After all employed bees finished their search process; they share the information about the directions and distance to food sources and the nectar amounts with onlookers via a so-called waggle dance in the dancing area. By the observations on the waggle dance, each onlooker chooses a food source depending on the probability value. Associated with the food source, and search the area within its neighborhood to generate a new candidate solution. And then, the greedy criterion is applied a gained just as it works in the employed bees. If a position cannot be improved after a predetermined number of cycles, the positions should be abandoned; meanwhile, the corresponding employed bee becomes a scout. The abandoned position will be replace with a new randomly generates food source.

The main steps can be described as follows:

1) Initialize the bee colony $X = \{xi[i = 1,2....n]\}$, where n denotes the population size, xi is the ith bee.

2) According to the fitness function, calculate the fitness fi of each employed bee xi, and record the maximum nectar amount as well as the corresponding food source.

3) Each employed bee produces a new solution vi in the neighborhood of the solution in its memory by $vi = xi + (xi - xk) * \Phi$ where k is an integer near to i, $k \neq i$ and Φ is a random real number in [1, 1].

4. Use the greedy criterion to update xi. Compute the fitness of vi. If vi is superior to xi, xi is replaced with vi, otherwise xi is remained.

5. According to the fitness fi of xi, get the probability value pi via formulas (1) and (2).

$$pi = \frac{fiti}{\sum_{i=1}^{n} fiti} \quad (1)$$

$$fiti = \begin{cases} \frac{1}{1+fi}, & if\ fi < 0 \\ 1 + abs(fi), & if\ fi \geq 0 \end{cases} \quad (2)$$

6) Depending on the probability pi, onlookers choose food sources, search the neighborhood to generate candidate solutions, and calculated their fitness.

7) Use the greedy criteria to update the food sources.

8) Memorize the best food source and nectar amount achieved.

9) Check whether there are some abandoned solutions or not. If true, replace them with some new randomly generated solutions by $xi = \min + (\max - \min) \times \Phi$ where Φ is a random real number in [0, 1], min and max stand for lower and upper bounds of possible solutions respectively.

10) Repeat steps (3)-(9), until the maximum number of iterations (k max) is reached or stop conditions are satisfied.

As mentioned above, the fitness function is a key component of ABC algorithm, which evaluates the foraging quality of the colony, i.e. the accuracy of possible solution. Besides, some control parameters, such as the number of employ bees or onlooker bees, the limits times for abandonment, the maximum number of iterations or stop conditions, need to be assigned. They would have a direct influence on the speed and stability of convergence.

6. Improved two-dimensional grey entropy

6.1 Grey number in Grey theory: Grey theory, developed bythe Deng in 1982, is an effective mathematical means of resolving problems containing uncertainty and indetermination. This multidisciplinary and generic theory deals with systems containing poor information. Now, field covered by grey theory include society, economics, finance, agriculture, industry, mechanics, ecology, Hydrology, geology, medicine, etc.

In grey theory, random variables are regarded as a grey number and a random process is treated as a grey process within a certain ranges. A grey system is defined as a system containing information presented as grey number. Here, we only give some simple conceptions used in our segmentation method.

Definition1. Let x denote a closed and bounded set of real number. A grey number x is defined as an unknown value for $x : x \in \left[\underline{\Phi}x, \bar{\Phi}\right]$.Where $\underline{\Phi}x$ and $\bar{\Phi}x$ are the in an interval with known lower and upper bounds lower and upper bounds of Φx, respectively.

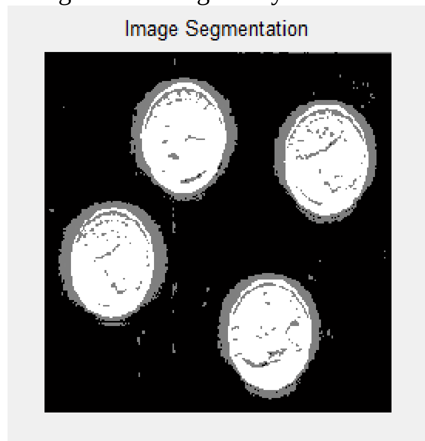
Definition2. The whitening of a grey number means to specify a deterministic value for it in its defined interval. The whitened value $\tilde{\Phi}x$ of a grey number x is defined as deterministic value between the lower and upper bounds of x. It can be expressed as $\otimes^{-} x = x'$

$$x' \in \left[\underline{\otimes}x, \bar{\otimes}x\right].$$

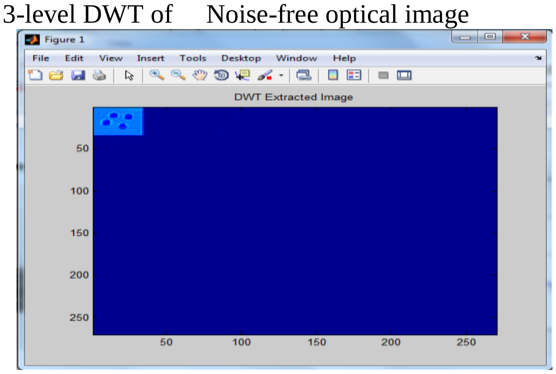
7. Experiment result

Figure1: Noise-free optical image

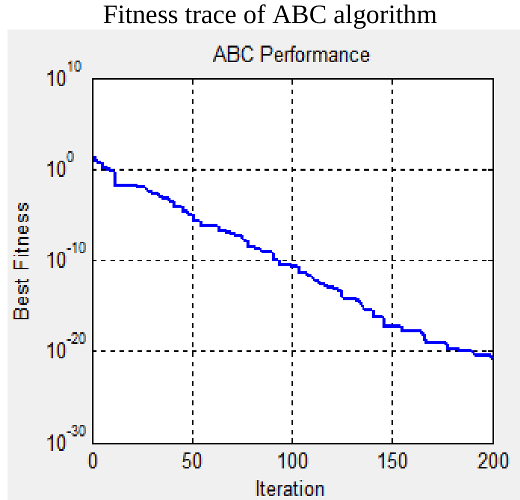
Segmented image of by our method



3-level DWT of Noise-free optical image



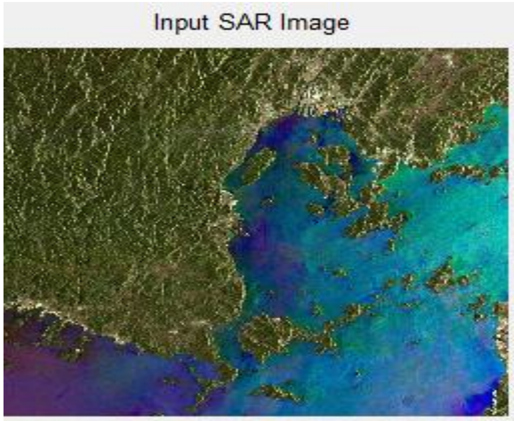
Fitness trace of ABC algorithm



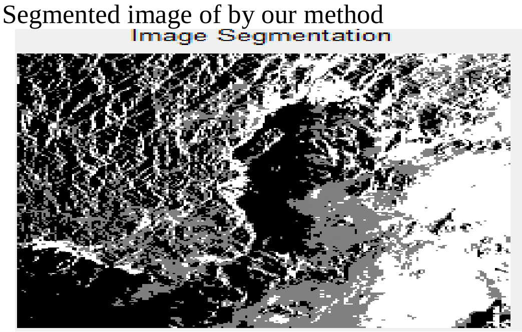
	PSNR	Entropy	Mean
SYM8	26.0555	0.4184	565.9322
HAAR	1.9901	0.1909	485.2819
DB4	5.0004	0.0531	484.7333

Noise-free optical image using 3 wavelets.

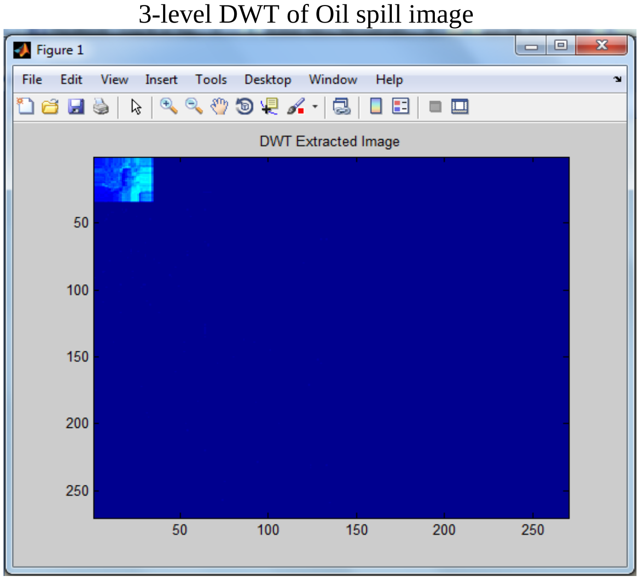
Figure2: Oil spill image



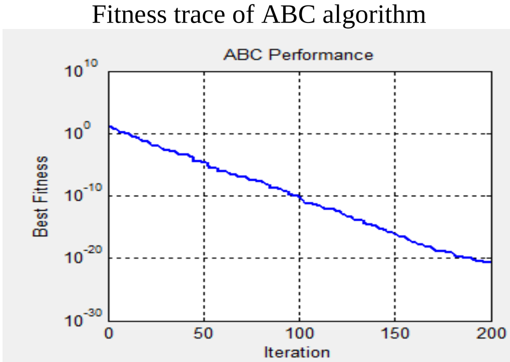
Segmented image of by our method



3-level DWT of Oil spill image



Fitness trace of ABC algorithm



	PSNR	Entropy	Mean
SYM8	34.3020	0.6793	513.9427
HAAR	10.2366	0.3046	478.5208
DB4	13.2469	0.1939	478.4777

Oil spill image using 3wavelets.

8. Evaluation

The MSE represents the cumulative squared error between the compressed and the original image, whereas PSNR represents a measure of the peak error. To compute the PSNR, the block first calculates the mean-squared error usingthefollowingequation:

$$MSE = \frac{\sum m,n\left[I1(m,n) - I2(m,n).^{\wedge}2\right]}{M * N * 255}$$

In the previous equation, M and N are the number of rows and columns in the input images, respectively. Then the block computes the PSNR using the following equation:

$$PSNR = 10\log 10\left(\frac{R^2}{255}\right)$$

In the previous equation, R is the maximum fluctuation in the input image data type. For example, if the input image has a double-precision floating-point data type, then R is 1. If it has an 8-bit unsigned integer data type, R is 255, etc

Entropy

E = entropy(I) returns E, a scalar value representing the entropy of grayscale image I. Entropy is a statistical measure of randomness that can be used to characterize the texture of the input image. Entropy is defined as

$$Entropy = E(I0 + rand(1))$$

Where I0 is the original image and the rand function generates arrays of random numbers whose elements are uniformly distributed in the interval (0, 1).

By default, entropy uses two bins for logical arrays and 256 bins for uint8, uint16, or double arrays. I can be a multidimensional image. If I have more than two dimensions, the entropy function treats it as a multidimensional grayscale image and not as an RGB image.

9. Conclusion

In this paper, we propose a fast segmentation method for SAR images. The method regards threshold estimation as a search process and employs ABC algorithm to optimize it. In order to provide ABC algorithm with an efficient fitness function, we integrate the concept of grey number in Grey theory, multilevel DWT, low-pass filtering and maximum conditional entropy to get improved two-dimensional grey entropy. In essence, the fast segmentation speed of our method owes to ABC algorithm, which has an outstanding convergence performance. On the other hand, the segmentation quality of our method is benefit from the improved two-dimensional grey entropy, for the fact that noise almost completely disappears, and most useful information about edge and texture is preserved. Experimental results indicate that our method is superior to GA based or AFS based methods in terms of segmentation accuracy, segmentation time, and convergence speed. However, as a new heuristic model in swarmintelligence, sophisticated relationships of bees and various foraging possibilities make ABC algorithm go a long way before it becomes mature. For Example, ABC algorithm is still weak in mathematics. As for image segmentation discussed in this study, little evidence in theory may be referred to and some control parameters have to be specified by experiences. We would like to point out that, like all global thresholding techniques; the proposed method using a single threshold merely partitions the entire image into two kinds of regions, objects and backgrounds, which is suitable for simple SAR images. However, the content of most real SAR images is complex and diverse. The contribution of this paper is to demonstrate and confirm the feasibility of ABC-based image segmentation, and offers a new option to the conventional methods with the merit of simplicity and efficiency. With the efforts of researchers at home and abroad, it is hoped that ABC algorithm will be widely used like GA and PSO in the future.

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