Change Detection of SAR Images by using Log Gabor Filtering and Morphological Analysys

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Abstract **-In this paper a novel change detection scheme for synthetic aperture radar(SAR) images using Log Gabor filtering and morphological analysis. Various methods have been proposed for change detection in single-channel synthetic aperture radar (SAR) images .The method of change detection consist of mainly three steps filtering, difference map extraction and threshold segmentation. First a Log Gabor Filtering is introduced to describe the filtering process and texture analysis for difference map extraction. Difference map extraction consist of texture and similarity measure. A new similarity measure is proposed to quantify the degree of evolution between the statistical characteristics of SAR images that can be done by morphological analysis. A gray threshold segmentation by using Otsu's method applied to extract the changed areas.**

Keywords-Log Gabor Filter, morphology ,thresholding, Otsu method.

I. INTRODUCTION

Change detection is the process that measures how the attributes of a particular area have changed between two or more time periods or Change detection compare the predefined image and the problematic or changed image.Applications of change detection are Shifting cultivation,predicting crop,damage detection,deforestation, impact of natural disasters like tsunamis,earth quakes etc.. Various methods have been proposed for change detection in single-channel synthetic aperture radar (SAR) images. The clutter distribution models is the previous method for change detection. The clutter distribution models proposed for SAR change detection can be divided into two categories: homogeneous and heterogeneous clutter models. homogeneous clutter models is a Gaussian distribution model, which has been used in low resolution images.One commonly used inhomogeneous clutter model is the spherically invariant random vector (SIRV) distribution model. This model is a compound Gaussian model,and it assumes that the spatial inhomogeneity is incorporated by modeling the target scattering vector as a product between the square root of a scalar random variable and an independent zero-mean complex circular Gaussian random vector . In the SIRV definition, the probability density function (pdf) of the texture random variable is not explicitly specified. Speckle is a granular 'noise' that inherently exists in and degrades the quality of the active radar, synthetic aperture radar (SAR). Speckle noise in SAR is generally serious, causing difficulties for image interpretation. It is caused by coherent processing of backscattered signals from multiple distributed targets.The objective of this paper is to present a novel change detection method for SAR images.

II. PROPOSED CHANGE DETECTION METHOD

SAR change detection involves four major steps :preprocessing filtering, difference map extraction include morphological analysis, threshold segmentation, hole filling. The detailed process of the change detection method for SAR images using the proposed method is shown in Fig.1. We first use the Log Gabor filter to fit the statistical characteristics of images, and we apply the proposed measure to quantify the difference between the statistical characteristics of SAR images. After the extraction of the difference map, we use the gray threshold segmentation to extract a binary mask for change detection.

III. FILTERING PROCESS

The proposed change detection method is a pixel-to-pixel processing with a moving neighborhood window; therefore, the speckle incoherent in SAR images will effect on the accuracy of change detection. However, although a speckle reduction, a Lee filter will not only weaken the effect of noise but will also degrade the statistic distribution of SAR data.Lee filter is multiplicative and adaptive filter which changes its characteristics according to the local statistics in the neighborhood of the current pixel. The Lee filter is able to smooth away noise in flat regions, but leaves the fine details (such as lines and textures) unchanged. The Lee filter is designed to eliminate speckle noise while preserving edges and point features in radar imagery. Based on a linear speckle noise model and the minimum mean square error (MMSE) design approach, the filter produces the enhanced data. It uses small window (3×3, 5×5, 7×7). Within each window, the local mean and variances are estimated. The major drawback of the filter is that it leaves noise in the vicinity of edges and lines.It did not applicable for texture analysis.

A. Log Gabor Filter

Log-Gabor filters basically consist in a logarithmic transformation of the Gabor domain which eliminates the annoying DC-component allocated in medium and high-pass filters. The Log-Gabor filter is mainly used in this

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paper for filtering and texture analysis. In signal processing it is useful to simultaneously analyze the space and frequency characteristics of a signal. While the Fourier transform gives the frequency information of the signal, it is not localized. This means that we cannot determine which part of a signal produced a particular frequency. It is possible to use a short time Fourier transform for this purpose, however the short time Fourier transform limits the basis functions to be sinusoidal. To provide a more flexible space-frequency signal decomposition several filters have been proposed. The Log-Gabor filter is one such filter that is an improvement upon the original Gabor filter. The advantage of this filter over the many alternatives is that it better fits the statistics of natural images compared with Gabor filters and other wavelet filters.

The Log-Gabor filter has been used in applications such as image enhancement, pattern recognition,edge detection,speech analysis, and image denoising among others. A one dimensional Log-Gabor function has the frequency response:

$$G(f) = exp\left(\frac{-\left(log(f/f_0)\right)^2}{2\left(log(\sigma/f_0)\right)^2}\right)$$

where f_0 and sigma are the parameters of the filter. f_0 will give the center frequency of the filter. sigma affects the bandwidth of the filter. It is useful to maintain the same shape while the frequency parameter is varied. the log-Gabor filter has seen great popularity in image processing. Because of this it is useful to consider the 2-dimensional extension of the log-Gabor filter. With this added dimension the filter is not only designed for a particular frequency, but also is designed for a particular orientation. The orientation component is a Gaussian distance function according to the angle in polar coordinates .

The design of two dimensional filter bank the whole aim of applying the filter bank is to obtain information about our signal, if a filter's outputs are highly correlated with those of its neighbours then we have an inefficient arrangement of filters that do not provide as much information as they should. To achieve independence of output the filters should have minimal overlap of their transfer functions.several interdependent parameters are minimum and maximum frequencies, filter bandwidth to use, scaling between centre frequencies of successive filters,number of filter scales,number of filter orientations to use,angular spread of each filter.

Filter construction of log Gabor filter include various steps .The first step is to compute a matrix the same size as the image where every value of the matrix contains the normalised radius from the centre on the matrix. Filters are constructed in terms of two components.

1. The radial component, which controls the frequency band that the filter responds to
2. The angular component, which controls the orientation that the filter responds to.

The two components are multiplied together to construct the overall filter.constructing the radial component of the filter given some desired filter wavelength. The bandwidth of the filter is controlled by the parameter sigma A problem is that for small wavelengths the filters can extend into the higher frequencies in the 'corners' of the FFT, whereas in the vertical and horizontal directions the filters are cut off by the boundary. This uneven coverage depending on direction can upset the normalisation process when calculating phase congrunecy. To make the coverage uniform in all directions the filters are multiplied by a low-pass filter that is as large as possible, yet falls away to zero at the boundaries. For most filter scales, other than the highest frequency ones, this has no appreciable effect on the filter.calculate the angular component that controls the orientation selectivity of the filter. This is simply a Gaussian with respect to the polar angle around the centre. The Gaussian is centred at some angle , and has standard deviation . If we take the inverse Fourier Transform of this filter the even-symmetric component will be in the real part of the result and odd-symmetric component will be in the imaginary part of the result.

IV. MORPHOLOGICAL ANALYSIS

Binary images may contain numerous imperfections. In particular, the binary regions produced by simple thresholding are distorted by noise and texture. Morphological image processing pursues the goals of removing these imperfections by accounting for the form and structure of the image. These techniques can be extended to grey scale images.

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. Morphological operations can also be applied to greyscale images such that their light transfer functions are unknown and therefore their absolute pixel values are of no or minor interest.Morphological techniques probe an image with a small shape or template called a structuring element. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighbourhood of pixels. Some operations test whether the element "fits" within the neighbourhood, while others test whether it "hits" or intersects the neighbourhood. A morphological operation on a binary image creates a new binary image in which the pixel has a non-zero value only if the test is successful at that location in the input image.

The structuring element is a small binary image, i.e. a small matrix of pixels, each with a value of zero or one.The matrix dimensions specify the size of the structuring element,the pattern of ones and zeros specifies the shape of the structuring element,an origin of the structuring element is usually one of its pixels, although generally the origin can be outside the structuring element.Stucturing elements play in morphological

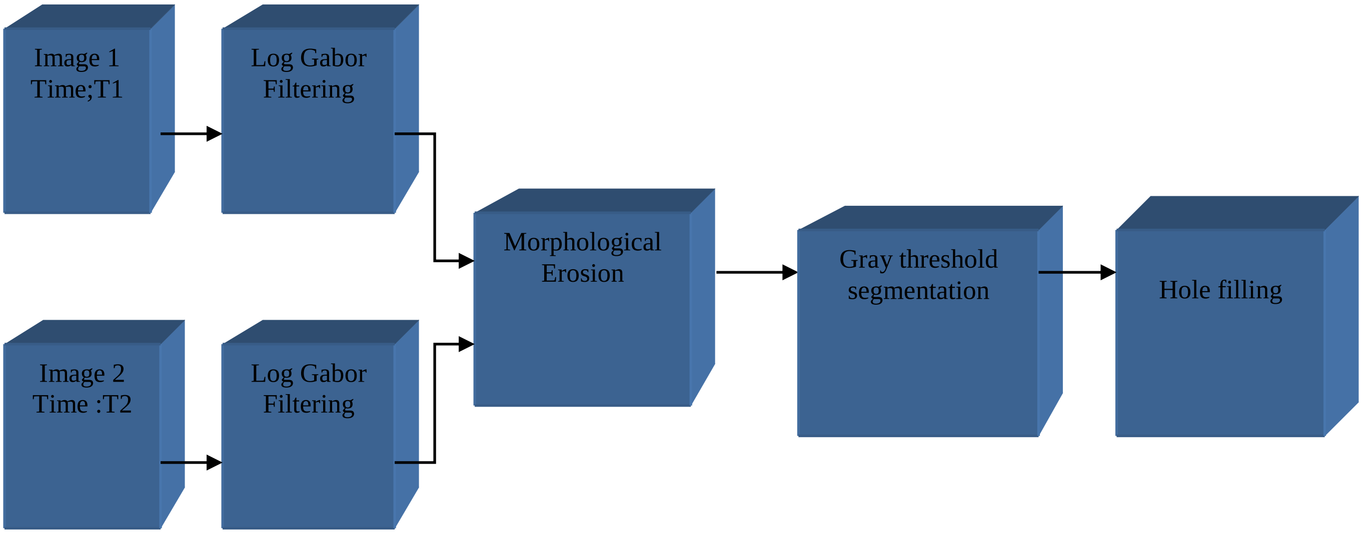

Fig.1 Flow chart of the proposed change detection algorithm.

image processing the same role as convolution kernels in linear image filtering. When a structuring element is placed in a binary image, each of its pixels is associated with the corresponding pixel of the neighbourhood under the structuring element. The structuring element is said to fit the image if, for each of its pixels set to 1, the corresponding image pixel is also 1. Similarly, a structuring element is said to hit, or intersect, an image if, at least for one of its pixels set to 1 the corresponding image pixel is also 1

A. Erosion

The erosion of a binary image f by a structuring element s (denoted $f \ominus s$) produces a new binary image $g = f \ominus s$ with ones in all locations (x,y) of a structuring element's origin at which that structuring element s fits the input image f, i.e. g(x,y) = 1 is s fits f and 0 otherwise, repeating for all pixel coordinates (x,y). Erosion with small (e.g. 2×2 - 5×5) square structuring elements shrinks an image by stripping away a layer of pixels from both the inner and outer boundaries of regions. The holes and gaps between different regions become larger, and small details are eliminated .Larger structuring elements have a more pronounced effect, the result of erosion with a large structuring element being similar to the result obtained by iterated erosion using a smaller structuring element of the same shape. If s_1 and s_2 are a pair of structuring elements identical in shape, with s_2 twice the size of s_1, then $f \ominus s_2 \approx (f \ominus s_1) \ominus s_1$.

Erosion removes small-scale details from a binary image but simultaneously reduces the size of regions of interest, too. By subtracting the eroded image from the original image, boundaries of each region can be found:

$b = f - (f \ominus s)$ where f is an image of the regions, s is a 3×3 structuring element, and b is an image of the region boundaries.

B. Hole filling

Hole means background region surrounded by a connected border of foreground pixels. Algorithm based on set dilation, complementation, and intersection Let A be a set whose elements are 8-connected boundaries, each boundary enclosing a background (hole).
Given a point in each hole, we want to fill all holes start by forming an array X0 of 0s of the same size as A the locations in X0 corresponding to the given point in each hole are set to 1. Let B be a symmetric se with 4-connected neighbors to the origin Compute $X_k = (X_{k-1} \oplus B) \cap A^c$ k = 1; 2; 3;Algorithm terminates at iteration step k if $X_k = X_{k-1}$, X_k contains all the filled holes $X_k \cup A$ contains all the Filled holes and their boundaries. The intersection with A^c at each step limits the result to inside the ROI also called conditioned dilation.

V. THRESHOLD SEGMENTATION

After the calculation of difference map, we need to extract a binary map to a the problem of discrimination between the
"change" and the "no-change" classes in the difference image can be viewed as an image binarization problem. The most
common solution to this problem is based on the use of a thresholding algorithm to select the threshold in the difference image histogram automatically. Gray threshold method is used for segmentation in this case. Gray threshold means Global image threshold that computes a global threshold (level) that can be used to convert an intensity image to a binary image .level is a normalized intensity value that lies in the range [0, 1]. The gray threshold function uses Otsu's method, which chooses the threshold to minimize the intra class variance of the black and white pixels. Otsu's method is used to automatically perform clustering-based image thresholding, or, the reduction of a gray level image to a binary image. The algorithm assumes that the image contains two classes of pixels following bi-modal histogram (foreground pixels and background pixels), it then calculates the optimum threshold separating the two classes so that their combined spread is minimal.

CONCLUSION

This paper has developed a new change detection method for SAR images. This model consists of mainly two parts: Log Gabor filtering and morphology. The results show that Log Gabor filter gives the information of texture and speckle reduction ,this is the well suited and efficient method for change detection.

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