WAVELET ALGORITHM FOR SHORELINE CHANGE MODEL FROM RADARSAT-1 SAR IMAGES

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Key Words: Wavelet, RADARSAT-1 SAR, edge detection, Shoreline change rate.

Abstract

This paper introduces a new approach for utilizing the multi-resolution wavelet decomposing for shoreline change rate detection from RADARSAT-1 SAR image. The wavelet approximation of the Two RADARSAT-1 SAR images (1998-2004) defined by the sum two-dimensional wavelet functions at different scales and locations. The raw RADARSAT-1 SAR images were decomposed into a low and high frequencies images and then reconstructed. Then the zero-crossing was applied to the reconstructed image. Finally, the degree of the contribution Doc was applied to overcome the isolated pixels problem a long the coastline. The result shows that the clear edge detection of the coastline was performed by applying Doc. The result shows the shoreline rate change can be easily estimated by using the edge detection concept based on multi-resolution wavelet decomposing.

1.0 Introduction

Wavelets are considered as an excellent tool for variety of remotely sensing data analysis. Researchers and scientists found that wavelets have a potential application in removing speckle noise from radar images (Niedermeier et al., (2000)), texture analysis and classification (Cheng and Kuo 1993) and merging high spectral resolution images with high spatial resolution images (Zhou et al., 1998). Recently Ishida et al., (2004) utilized a multresolution wavelets transform for edge detection from SPOT image. Niedermeier et al., (2000) used the wavelet-based edge detection algorithm was introduced by Mallat et al., (1992) to extract the coastlines from SAR images. They found that the thresholding the wavelet transform modulus maxima can separate additive stationary white noise from singularities (edges) up to a certain degree. Niedermeier et al., (2000) also found that the edges extracted by the wavelet algorithm are still no continuously connected steady coastline. In this case, Niedermeier et al., (2000) used an active contour model or snake to link the pixels of coastline. The objective of this paper is to utilize a multi-resolution wavelet transform from Ishida et al., (2004) to model the shoreline change from historical RADARSAT-1 SAR images.

2.0 Wavelets Algorithm

Two RADARAT-1 SAR images were acquired 29 November 1998 and 23 March 2004 with wide mode have been used in this study. The step for coastline extraction and shoreline change rate estimation are shown in Figure 1. We consider RADARSAT-1 SAR image *I* of size N x N pixels in the azimuth direction (x) and range direction (y), respectively. RADARSAT-1 SAR image *I* (x,y).

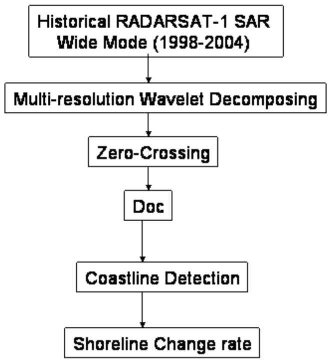

Figure 1. block diagram of Shoreline Change Rate Estimation from Multi-resoluion Wavelet

The wavelet approximation $\bar{I}(x,y)$ of image I (x,y) can be defined by the sum of two-dimensional wavelet functions at different scales and locations as described by Ishida et al., (2004),

$$\bar{I}(x,y)=\sum_{k=1}^{N/2^j-1}\sum_{n=1}^{N/2^j-1}C_{j,k,n}^{(j)}\phi_{j,k,n}(2^j x-k)(2^j y-n)+\sum_{j=1}^{j}\sum_{dir}\sum_{k=1}^{N/2^{j-1}}\sum_{n=1}^{N/2^{j-1}}d_{j,k,n}^{dir}\varphi_{j,k,n}^{dir}(2^j x-k)(2^j y-n) \quad (1.0)$$

where $\phi(x,y)$ represents the smooth and low frequency signals along the RADARSAT-1 SAR image in the azimuth and range direction, respectively. $\varphi(x,y)$ represents high frequency signals in RADARSAT-1 SAR image. j is the level of resolution which corresponds to resolution of $2^j.r$. By defining the resolution level of the original image equals zero, in this case corresponding to a spatial resolution r. Then the wavelet scale functions are defined with respect to a scaling factor 2^j for *j=1,….,J* and translation vector *(k,n)* into the azimuth and the range directions, respectively. $C_{j,k,n}^{(j)}$ and $d_{j,m,n}^{dir}$ are the wavelet transform coefficients which represent the smooth signals of the RADARSAT-1 SAR image at level j and level deviations of different directions. Following Zhou et al., (1998) $C_{j,k,n}^{(j)}$ can be given by

$$C_{j,k,n}=\iint\phi_{j,k,n}(x,y)\varphi_{j,k,n}(x,y)I(x,y)dxdy \qquad (2.0)$$

The coefficient $d_{,k,n}^{dir}$ can given by the following formula

$$d_{jk,n}^{dir}=\sum_{k}\sum_{n}g_{j-2n}\,\bar{h}_{k-2n}\,C_{j,k}^{n-1} \qquad (3.0)$$

where $\{h_k\}_{k\in N}$ are the orthonormal wavelet filter coefficients and $(g_k=(-1)^{k-1}h_{1-k}),N$ is a set of positive integers. Following Ishida et al., (2004) the edge detection was performed after the original image C^J where j is zero reconstructed with the exception of the image from low frequencies for both azimuth and range directions. Then the image $D_j(x,y)$ derived from the removal f low frequencies by the zero-crossing scheme in order to detect the edge segments in the wavelet-transformed image. The edge detection approximation of an image at a resolution level *j-1* can be derived from the sum of smooth and edge details images at resolution level j by following formula

$$C_{j-1}(x,y)=C_{j,k,n}(x,y)+\sum_{dir}D^{dir}(x,y) \qquad (4.0)$$

where $D_j^{dir}(x,y)$ is represent the object edges in the azimuth and range directions, respectively.

Excessive edge detection features can increase computation times which required to reduce the number of edge contour features. The degree of the contribution Doc can be used to in such situation and can be given by

$$Doc(k,n) = \sum_{k(3N+1)} \frac{(D(j,n) - D(k,n))^2}{\sum_{n=1} (D(j,n) - D(k,n))^2} \qquad (5.0)$$

The smallest value of *Doc* has a little impact on the edge detection results while the large *Doc* represents that the dimension *(k,n)* is principle in edge detection discrimination. When $D_j^{dir}(x,y)$ images are utilized, the number of different edge feature vector becomes *k(3M+1).* After the edge detection of coastline has been detected, the two vector layers of RADARSAT-1 SAR image overlaid together to estimate the rate change of shoreline. To validate the output results the ground data of shoreline change during the ARADARSAT-1 SAR (23 March 2004) over pass was used.

3.0 Results and Discussion

Figure 2 shows the original RADARSAT-1 SAR image with speckle noises. The edge detection features are not clear. Figure 3 shows the out put image was processed by using multi-resolution wavelets decomposition. It is obvious a white and black color a long the tested RADARSAT-1 SAR image. These two color were represented a positive and a negative pixel values.

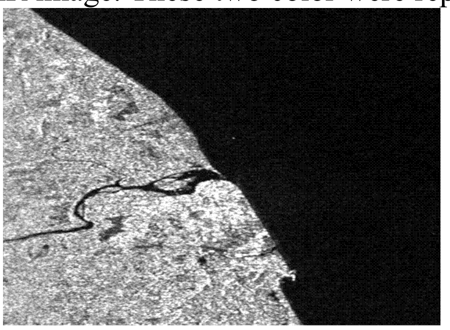

Figure 2. Raw RADARSAT-1 SAR Data

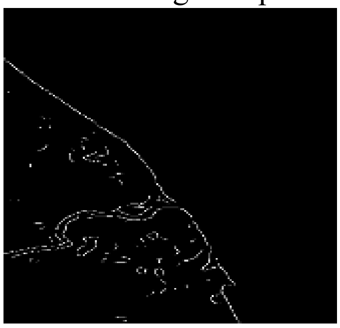

Figure 3 Coastline Detection from Multi-resolution Wavelet

According to Ishida et al., (2004) the image resulting from a smaller hierarchy level contains a larger number of noises which evaluated by number of the isolated coastline pixels. To overcome such case, we applied the Doc algorithm on the image has been processed by the zero-crossing (Figure 4). In Figure 4, we noticed that a clear classified edge features. It can be recognized in Figure 4 that Doc algorithm based multi-resolution wavelets could map different texture features with providing an edge enhancement between different features. Figure 5 shows the shoreline change estimated by using the integration between Doc and multi-resolution wavelets algorithm.

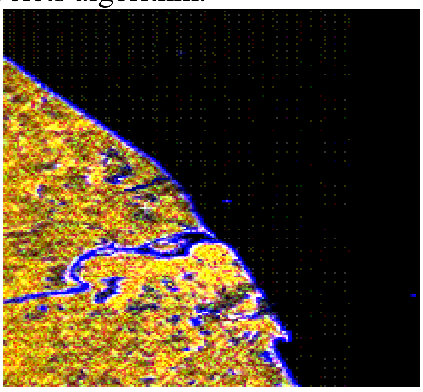

Figure 4. Edge Detection Extracted by Doc

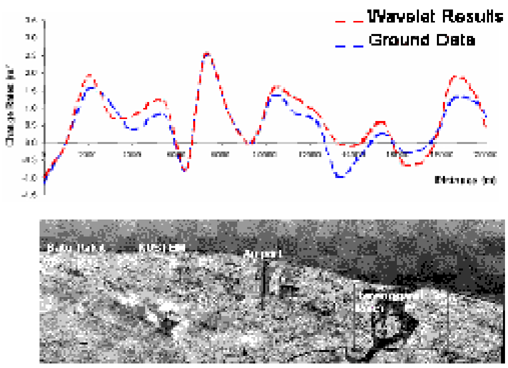

Figure 5. Rate of shoreline Change Estimated from Wavelet Transform and Ground Data

Conclusion

It can be said that the multi-resolution wavelet algorithm can provide edge discrimination between different features. This concept was used to extract the coastline boundary layer in different two RADARSAT-1 SAR images to determine the rate of shoreline change. Doc algorithm was integrated with multi-resolution wavelet algorithm to produce a sharp edge detection for coastline features. The results obtained here required more work to obtained high accuracy model for estimation the shoreline change rate by using edge detection concept from RADARSAT-1 SAR image.

References

Cheng, t., T., and J.Kuo, (19930. Texture Analysis and Classification with Tree Structured Wavelet Transform. IEEE Transactions on Image Processing, 429-441.

Ishida,T., S. Itagaki, Y., Sasaki and H., Ando., (2004) . Application of Wavelet Transform for extracting Edges of paddy Fields From Remotely Sensed Images. Int.J. Remote sensing, 25, 374-357.

Mallat, s., and W.L., Hwang, (1992). Singularity Detection and processing with Wavelet . IEEE Trans., Inform. Theory, 38, 617-643.

Niedermeier, A., E., RomaneeBen, and S.Lehner, 2000. detection of Coastlines in SAR Images Using Wavelet Methods. IEEE Tran. On Geoscience and Remote Sensing, 38, 2270-2281.

Zhou,J., D., CIVCO and J.a., Silander, (1998). A Wavelet Transform Method to Merge Landsat TM and SPOT Panchromatic data. Int.J. Remote sensing, 19,743-757.