Segmentation of Multi Resolution Remote Sensing Images Using Pyramidal Watershed Transform

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***Abstract*-Image segmentation is a decisive and fundamental step for remote sensing information retrieval and classification. In remote sensing image analysis, extraction of patterns presents challenges related to size, accuracy and complexity. Due to the large amount of data detail present in satellite images, extraction becomes a challenging task. This paper presents an efficient method for image segmentation based on a multiresolution application of a wavelet transform and watershed segmentation algorithm. The segmentation procedure consists of a pyramid representation, and image segmentation. Pyramid representation creates a set of multiresolution images using a wavelet transform and image segmentation segments the lowest-resolution image of the pyramid using a watershed segmentation algorithm. The watershed transformation is a useful morphological segmentation tool for a variety of grayscale images.**

The presented method can be applied to the segmentation of noise or degraded images as well as reduce over-segmentation. The framework is validated by applying it to remote sensing images.

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Keywords - Multiresolution, Wavelet, Watershed

I. INTRODUCTION

Various techniques and algorithms have been proposed for image segmentation. They are classified into three major categories: clustering, edge detection and region extraction (Gonzalez and Woods, 2002; Pal and Pal, 1993). Clustering consists of identifying a homogeneous cluster of points and labeling each cluster as a different region. The disadvantage of this method is that the number of clusters is unknown. It also does not consider spatial interactions between neighboring pixels. Edge detection detects edge boundaries of various regions by normally trying to locate points of abrupt change in intensity values. Different edge operators such as the Sobel, Prewitt, Canny, etc., can be used for edge detection. However, not all edges produced by these operators are relevant, and post processing is required to identify significant edges (Pal and Pal, 1993).

Other conventional segmentation approaches range from the split-and-merge method to morphological segmentation. Among them, morphological segmentation techniques rely on morphological tools, which are ve

useful to deal with object-oriented criteria such as size and contrast.

II. THE WAVELET TRANSFORM

The wavelet transform is a mathematical tool that can be used to describe images in multiple resolutions. According to Mallat's pyramidal algorithm, the original image is convolved with low-pass and high-pass filters. The study area chosen here is a multispectral IKONOS image of 4m resolution. Wavelet transform is applied to the image which produces four sub images. The first sub image has low frequencies in both the directions and is called the Approximation image. The Second one corresponds to low frequencies in the horizontal direction and high frequencies in the vertical direction and are called the horizontal coefficients. The high frequencies in horizontal and low frequencies in the vertical are called vertical coefficients and high frequencies in both directions are called diagonal coefficients.

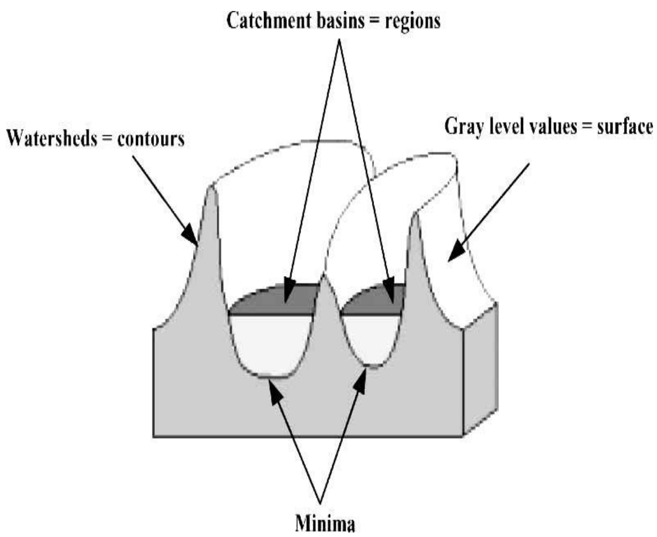
Pyramidal representation

A multiresolution application is used for the pyramidal representation of the image. Multiresolution methods attempt in obtaining a global view of the image by examining it at various resolutions. Several types of multiresolution image decomposition exist such as Gaussian pyramids, Laplacian pyramids and wavelets. The Gaussian pyramid provides a representation of the same image at multiple scales using simple low-pass filtering and decimation techniques. The Laplacian pyramid provides a coarse representation of the image as well as a set of detailed images at different scales. These methods usually imply a loss of information since the original image cannot be exactly reconstructed. Unlike these methods, the wavelet transform provides a complete image representation and performs decomposition according to both scale and orientation.

The wavelet transform is used to reduce the resolution of each frame in the sequence. Therefore, the processing is conducted on a low-resolution image, reducing the computation cost. A great advantage in the multiresolution method is the possibility of determining the dimensions of regions to be segmented. Thus, over-segmentation of the watershed segmentation algorithm and noise in the image can be reduced.

III. THE WATERSHED ALGORITHM

The watershed algorithm is viewed as a flooding procedure. The progressive flooding of the catchment basins in the gradient image is performed, starting with the lowest catchment basin. Starting from this lowest altitude, the water gradually fills up the first catchment basin. Suppose the flooding reaches a given level h. If a pixel has a labeled pixel as its neighbor, it is assigned the same label as that neighbor. If a pixel does not have a labeled pixel as its neighbor, it corresponds to a local minimum. This pixel is then assigned a new label and is taken as a new catchment basin. Therefore, at each level of the flooding procedure, the labeled catchment basins are extended and new catchment basins are detected. This procedure is repeated until every pixel in the image has been assigned a label. The pixels at lower altitudes are flooded first, as are pixels closer to the water if they are on the same altitude. The flooding procedure terminates when the level is higher than that of the maximum gradient values as shown in Figure.



The watershed algorithm is known to be a very fast algorithm for spatial segmentation of images. It starts by creating a gradient of the image to be segmented. Each minimum of the gradient leads to a region in the resulting segmentation.

Conventional gradient operators generally produce many local minima that are caused by noise or quantization error.

IV. METHODOLOGY

A major problem with the watershed segmentation algorithm is that it produces severe over-segmentation due to the great number of minima and various noises within an image or its gradient.

There are two main drawbacks when applying the watershed algorithm to image segmentation: sensitivity to strong noise and high computational requirements to merge the over-segmented regions. These D

problems can be overcome when this segmentation algorithm is integrated within a multiresolution approach. To alleviate these problems, operation is carried out on the low-pass filtered low-resolution images from the wavelet transform. In turn, the computational complexity is simplified and reduced dramatically by operating on a low resolution image. The study area considered is first applied to the wavelet transform that produces a set of compressed images. A low resolution compressed image is used to reduce the computational complexity and increase efficiency. The resulting image is then applied to watershed segmentation.

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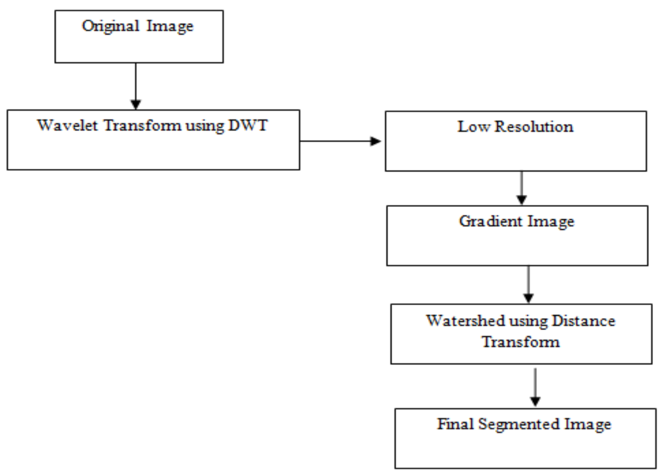

Figure1. Implemented algorithm forimage segmentat

V. RESULTS

All the computation involving wavelet transform, edge detection and watershed transform are implemented using MATLAB. The wavelet transform take a very short time due to the fast decompositions. Figure 2 shows the original image. Figure 3 shows the wavelet transform applied. Figure 4 shows the preprocessed image by morphological preprocessing. Figure 5 shows the binary image and Figure 6 shows the watershed ridge lines. Figure 7 shows the distance transform and Figure 8 shows the superimposed image. The superimposed image shows better segmentation accuracy when compared to the watershed ridge lines.

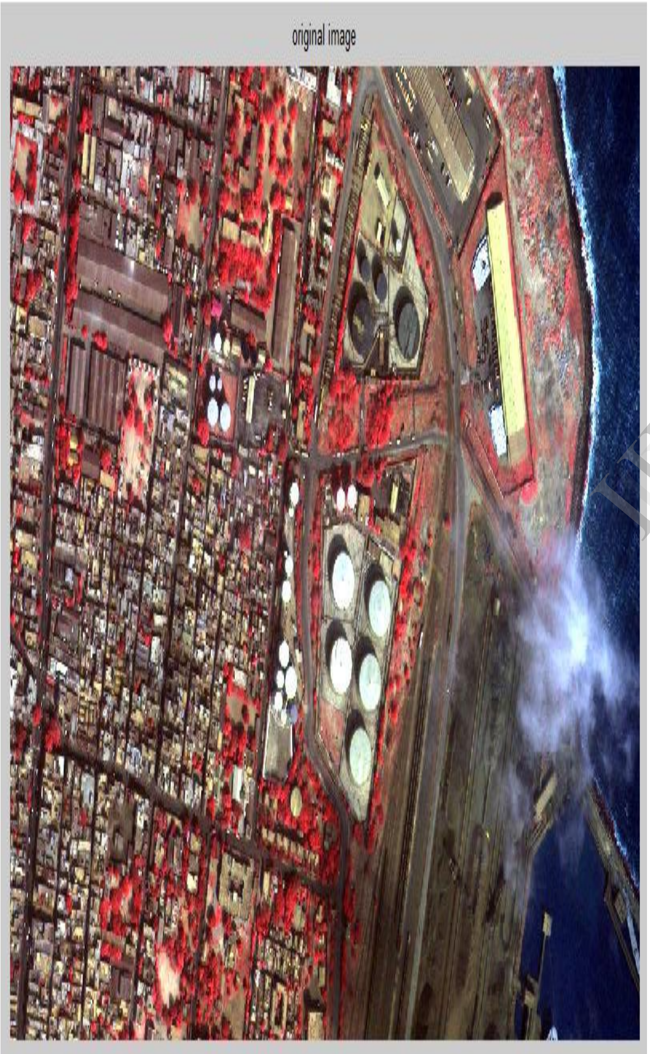

Figure 2. Original Image

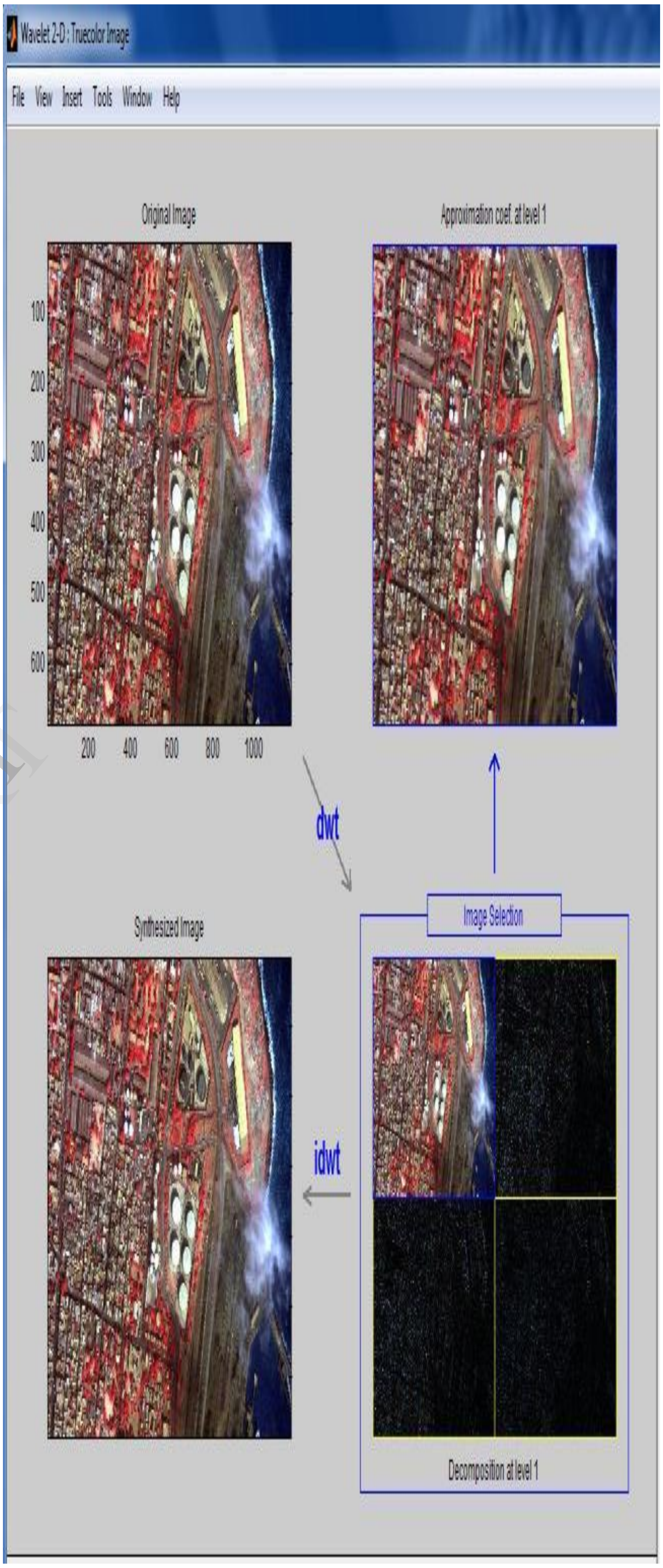

Figure3. Image showing wavelet transform applied to the original image

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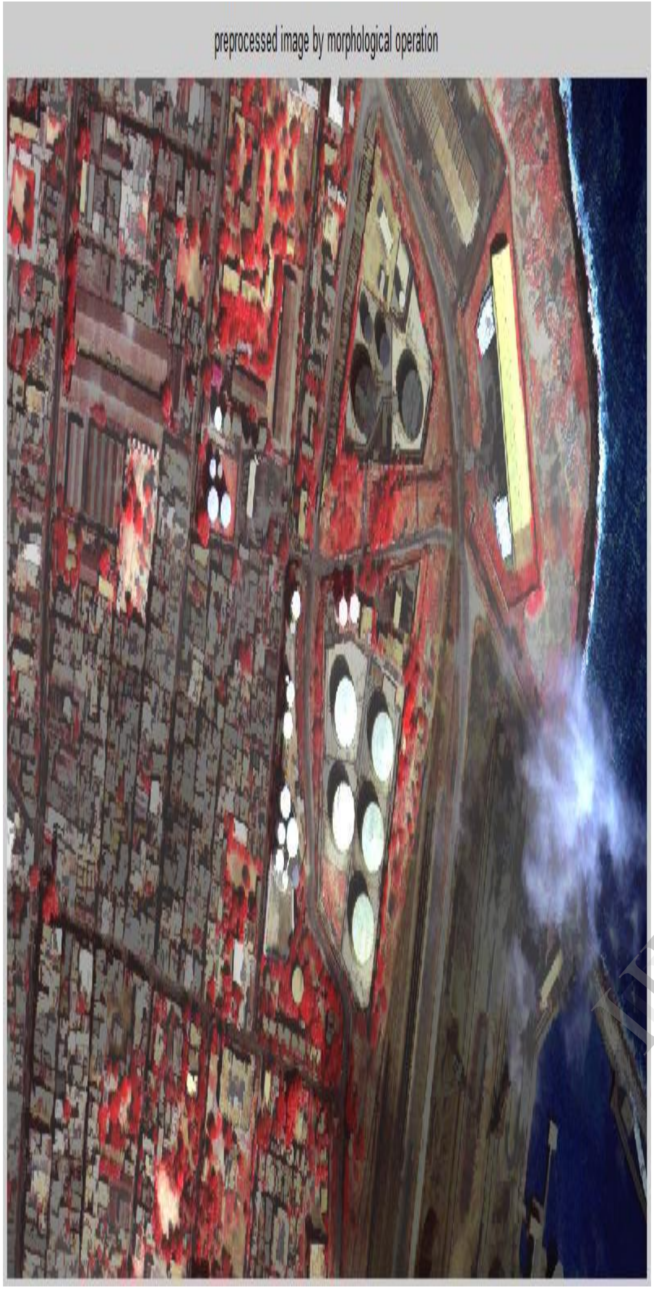

Figure4.Processed image by morphological operation

Figure 5. Binary Processed image

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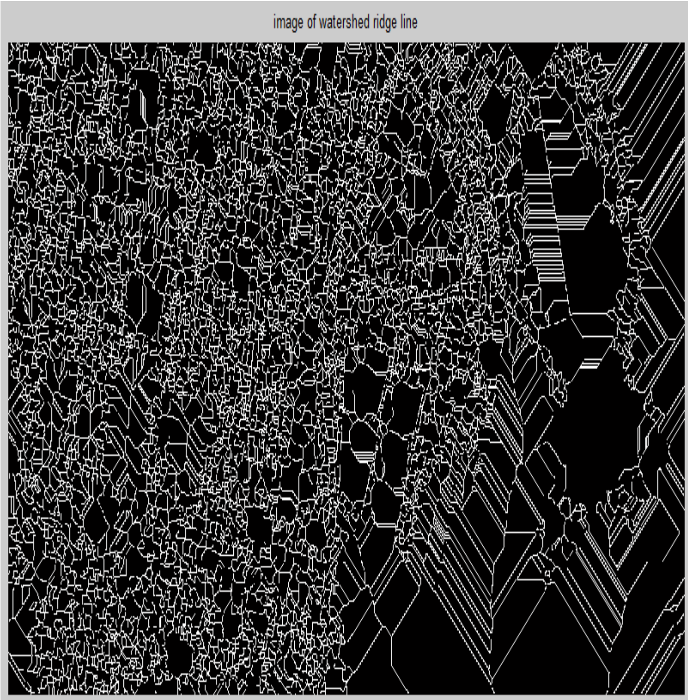

Figure 6. Watershed ridge lines

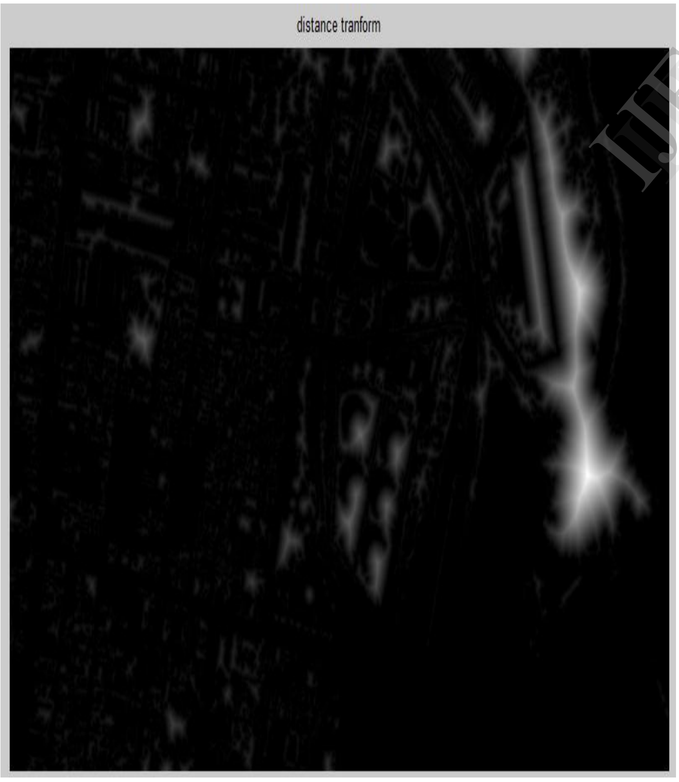

Figure 7. Superimposed Image

Figure 8. Superimposed Image

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VI. CONCLUSION

In this work, we have described an approach for image segmentation by combining the two wavelet and watershed transforms. Watershed transform is very sensitive to noise and we will have over segmentation. To solve this problem, we combined watershed and wavelet transform for increasing result accuracy. Resolution reduction by wavelet is depended on amount of noise in the image and also the desired target size. Future work will concentrate on extending this approach to color image segmentation and analysis. The obtained results in this work show that segmentation using wavelet and watershed method produce better segmentation results.

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