Detection of Bridges in SAR Images

DENIZ ALTIN[1], MESUT KARTAL[2]
[1] Informatics Institute
Istanbul Technical University
Istanbul Technical University Ayazaga Kampusu Maslak 34469 Maslak/Istanbul
TURKEY
[2] Departments of Electronics and Communication Engineering
Istanbul Technical University
Istanbul Technical University Ayazaga Kampusu Maslak 34469 Maslak/Istanbul
TURKEY

Abstract: - With the improvement of Synthetic Aperture Radar, the satellite imagery process becomes easier, because of the characteristic of SAR, which can take images day and night, and back from the clouds. With the help of these characteristics, Automatic Target Detection/Recognition becomes more important. Bridge detection is one of the subjects of ATD/R. The information gathered by finding bridge locations, can be used in both civil and military applications. In this paper we studied a new algorithm that finds the bridge positions in SAR image. The algorithm consists of some image processing applications, such as; filtering, segmentation, morphology, connectivity and edge detection. After using these algorithms we applied a "distance finding" algorithm to find the locations of bridges.

Key-Words: - SAR, Remote Sensing and Bridge Detection, Image Processing

1 Introduction

Automatic target detection is a very important subject in image processing applications. In situations where multiple enemy targets have been identified, it is necessary to classify the targets (e.g., according to their importance) in order to plan the actions to be taken to deal with the identified targets [1].One of the targets which is wanted to be identified and classified is bridge. Bridge detection is an important task in ATD/R. The information of knowing the bridge locations of an area, gives precious advantages, such as civil and military applications. In general bridge extraction algorithms are temporized; there are only few studies in the literature [2-4].

SAR images have a dominant multiplicative noise called "speckle". This kind of noise is become from the coherent microwave illumination of SAR [5]. Speckle noise results false intensity values of some pixels, and it makes the data more complex to process. Therefore speckle noise must be reduced from the data.

There are lots of techniques for reducing speckle noise. One method which is used in this paper is Median Filtering [6]. Median filter is chosen because of its characteristic of preserving the edges while reducing the speckle.

After preprocessing operations, the image is segmented into two classes, sea and land. Segmentation is one of the most fundamental problems in image analysis. Its goal is to extract the contours of one or several regions of interest in an image [7]. It is obvious that the bridges are built over the sea, river or lakes. Therefore in the algorithm process, we must separate these two regions. Two peaks method for grey-level segmentation is used in this paper [8].

After segmentation the image is separated (classified) into two regions effectively, as land and sea. But there are lots of unwanted small points appeared in both sea and land region. These small points must be removed. Because the small points in the land region will be understood by algorithm as rivers and lakes over the land. And the small points in the sea region will be understood by algorithm as ships and islands. To avoid these problems mathematical morphology is used for removing these small points in both land and sea. [9][10].

By the end of morphological operations, edge detection technique is applied to the image. Canny edge detection is used as an edge detection method [12]. Canny edge detection method is applied because of making "distance finding algorithm" simple. By applying edge detection only edge pixels are used for computing the distance.

After edge detection, connectivity analysis is applied to the image [11]. We search for 8-connectivity on the image. By using connectivity analysis, we label the connected sea regions with the same label, and the sea regions which are separated by bridges are labeled with different labels.

Lastly we apply a distance finding algorithm, we computed the distances between sea regions and make decision if there is a bridge or not, between two different labeled sea regions, by looking the distance value among them. We used SAR images taken by RADARSAT-1, which is a sophisticated Earth observation (EO) satellite developed by Canada to monitor environmental change and the planet's natural resources, and launched in November 1995. The data used in this paper was collected by Istanbul Technical University/ Center for Satellite Communications & Remote Sensing, Istanbul, Turkey (ITU-CSCRS). The image is in F2 beam mode, 8 meters pixels size, product type is SGF. And it was acquired in 18th November 2003. In the image there are 2 different bridges over sea region. The algorithm was applied and efficient results were taken.

2 Proposed Algorithm

First image is shown in figure 1; the original SAR image of Istanbul Bosporus. There are two different bridges over the sea region

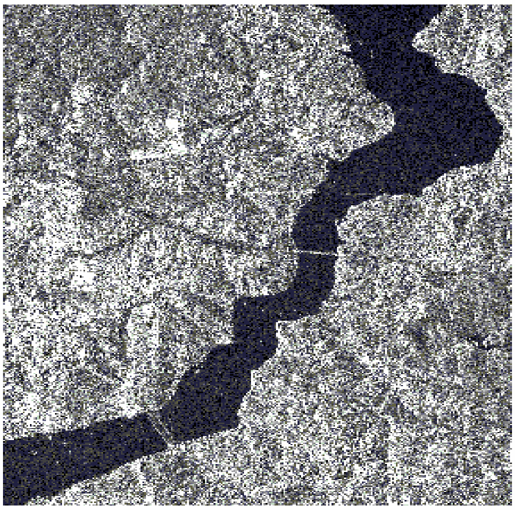

Figure 1 Original SAR image of Istanbul Bosporus

2.1 Speckle Reduction

As it is explained in the introduction part, usually the SAR images have a dominant noise which is called “speckle noise”. This kind of noise occurs only in SAR images because of the kind of illumination SAR sensors use. Satellites using optic sensors, work with the help of the sun illumination on the earth. Although SAR sensors on the satellites have an apparent advantage over the optical satellites, SAR has a speckle noise problem. Because SAR illuminates the earth’s surface by microwave illumination and collects the reflected echoes and process these echoes in order to form the image [5]. But if the illuminated area is a rough surface the reflected echoes will reflected falsely from the surface, that’s why speckle noise problem occurs.

Speckle noise must be removed from the image as a pre-processing operation. In this paper, we use median filtering for this operation. [6] 7*7 median filtering result is seen in figure 2. There are lots of filter types for removing speckle but; median filter is chosen because of its simplicity to apply, and mostly, it’s characteristic of preserving the edges while smoothing the image.

Figure 2 Median filtering result

It is clearly seen in the images that there are lots of speckles in the sea region. We reduced these speckles by median filtering, without deforming the image’s edges.

2.2 Segmentation

Segmentation is an essential process for classifying the image as object and background. In this paper our aim is to separate the regions of image 2 type; as sea, river or lakes and land. Because of the assumption that the bridges are only apparent only over the sea regions, that’s why we do not search for bridges over land region. In the literature there are lots of segmentation methods. In this paper we use “Two Peaks” method [8]. This method is used when a histogram has two peaks which can be clearly seen. In this situation the threshold is selected between the peaks, where these two peaks intersect and have low values. As it is explained in equation 1, the intensity values of pixels are changed with 255, if the interested pixel’s intensity is bigger than threshold. Otherwise, the intensity value is changed with

0. The segmented (thresholded) image is shown in figure 3. It is clear that the segmentation method gives efficient results.

$$f(i,j)=\begin{cases}255 & \text{if } f_i(i,j) \succ \text{threshold} \\ 0 & \text{else}\end{cases} \quad (1)$$

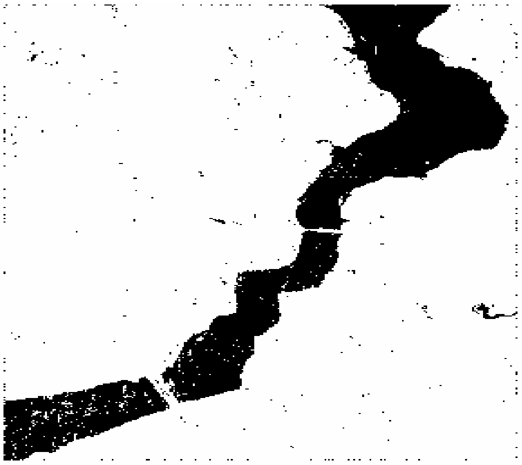

Figure 3 Segmented image

2.3 Mathematical Morphology, Connectivity and Edge Detection

After segmentation it is clearly seen in the image that there are lots of small white points on sea, which behave falsely like islands or ships in the algorithm. And small black points on the land, which behave falsely like lakes, or rivers in the algorithm.

We apply erosion and dilation which are the basis of mathematical morphology, to the images. Erosion is used for removing the dots on the sea region. Because the erosion rule says that; assume the set A, "image", and set B "structuring element" or "mask". Scan the set A with structuring element B, and replace the central point of the mask with the smallest value of image covered by the mask. [9-10]. Then we applied dilation to the image in order to remove the black dots on the land region. Dilation rule says that; scan the set A with structuring element B, and replace the central point of the mask with the largest value of image covered by the mask. Dilation is applied 2 times to the eroded image, because of preserving the bridge edges be broken [9-10].

After morphological operations, we apply canny edge detection algorithm to the image [12]. Canny edge detection is applied because of getting out complexity in distance finding algorithm.

By the end of edge detection algorithm, we search connectivity for labeling with the same value of sea regions which are connected, and labeling sea regions with different value which is divided by a bridge. We use 8-connectivity. All of the pixels scanned, when first white pixel is found, it is labeled with a label, and then all 8 neighbors are searched. If one of the neighbors has the same pixel value it is labeled with the same label of the interested pixel. But if any of neighbors has another pixel value, it is labeled with a different label than the others [11]. The total results of morphology, edge detection, and connectivity are shown in figure 4

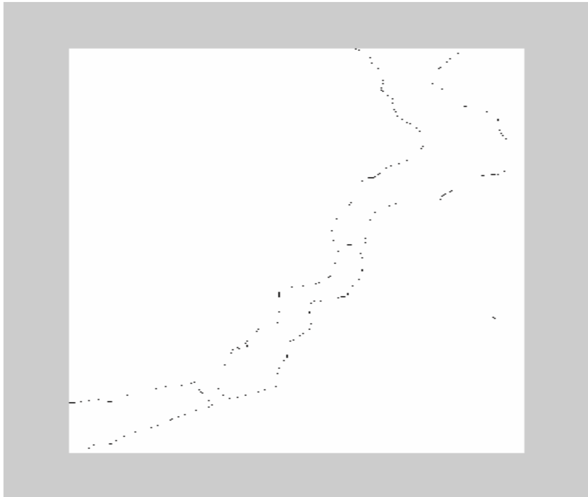

Figure 4 After morphology, edge detection, connectivity

2.4 Finding Distances between Labeled Sea Regions

There are 4 different sea regions in the figure 4, although edges seen discrete, in fact edges are continuous. It is because of the image has so much pixels. The image is 2100*1600 pixels. Bottom left region is 1, the other regions are 2 and 3 respectively. The 4^{th} region is the small region on the land. It is a part of lake. In this part of the algorithm we search for computing distances between images. All of the edge regions are labeled with different numbers as it is explained. Firstly we compute the difference between all the pixels in the edge region "1" and the edge region 2, and then distances between regions 1-3, regions 1-4, regions, 2-3, 2-4, and 3-4 are computed. After computing these distances it is seen that only distances between 1-2, and 2-3 are lower that there can be bridges. The other distances are so much, that it is clearly seen that no bridge can exist between these regions.

When we look at the distances between region 1 and 2, it is seen that the minimum distance is 57.9828 pixels long. After that we started from the first pixel in the region 1, and find a pixel in region 2, which gives the minimum distance of that pixel in region 1 to the region 2. The algorithm search for all pixels in region 1, and finds the corresponding pixels which give the minimum distance of these pixels to the region 2. Then same process is applied for region 2 corresponding to region 1. Finally we found an area where a bridge can exist. For region 1, it is in the interval between pixels (1708:1847,439:552). The corresponding area in the original image is shown in figure 5.

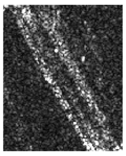

Figure 5 First Bridge found, by algorithm

After that all the process is applied to find the distance and bridge between region 2 and 3. The minimum distance between 2 and 3 is 44 pixels long. The area where a bridge can exist is in the interval between pixels (1016:1067, 939:1037). The corresponding area in the original image is shown in figure 6.

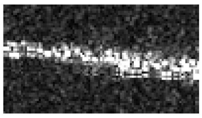

Figure 6 Second Bridge found, by algorithm

3 Conclusion

The proposed algorithm is an efficient way on bridge position extraction. The algorithm can easily be applied to any SAR image by only modifying the filters sizes of speckle reduction and morphology, and thresholding the image with the proper threshold value. Our proposed method is a better method than the previous methods, because previous methods are dependent on terrain features of the interested area. But our algorithm can easily be applicable to any different area, because of the image processing algorithms used in this method.

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