Automatic Detection Approach of ship using RADARSAT-1

Seung-Joon Kwon*, KiYun Yoo**, Kyoung-Ok Kim*, Chan-Su Yang***

*Electronics and Telecommunications Research Institute

Spatial Information Research Team, Korea

**The School of Civil, Urban & Geo-Systems Engineering, Seoul National University, Korea

***KRISO, Korea Ocean Research & Development Institute, Korea

E-mail: kwonsj@etri.re.kr, kiyun@snu.ac.kr, kokim@etri.re.kr

ABSTRACT: This paper proposes and evaluates a new approach to detect ships as targets from Radarsat-1 SAR (Synthetic Aperture Radar) imagery in the vicinity of Korean peninsula. To be more specific, a labeling technique and morphological filtering in conjunction with some other methods are employed to automatically detect the ships. From the test, the ships are revealed to be detected. For ground truth data, information from a radar system is used, which allows assessing accuracy of the approach. The results showed that the proposed approach has the high potential in automatically detecting the ships

KEYWORDS: Radarsat-1, Otsu's method, morphological filter, ship detection

1.1 INTRODUCTION

There are two fundamentally different ways of detecting ships in space-based SAR images: detection of the ship target itself and detection of the ship wake. Some previous papers regarding this topic employ only either ship wakes or ship target itself to perform the desirable detection. Others regarding this topic employ both possibilities. The work presented in this paper focuses on the procedure of detecting ship target itself in Radarsat-1 SAR imagery in a fully automatic way, because stationary ships and slow moving ships have no wakes and wakes are often not visible. Ships are relatively identified as very bright objects due to the corner reflection. In this paper, the proposed method is to utilize the difference of pixels intensity between ships and sea clutter. The method to search radar bright objects is to fix a global image threshold and then declare any pixel intensities which are above this threshold as targets of interest. A fixed threshold using Otsu's method is applied. Main work is the combination of the labeling technique and morphological filtering to detect ships automatically.

2. DATA INFORMATION

The full scene is shown in figure 1. We select target area for processing.

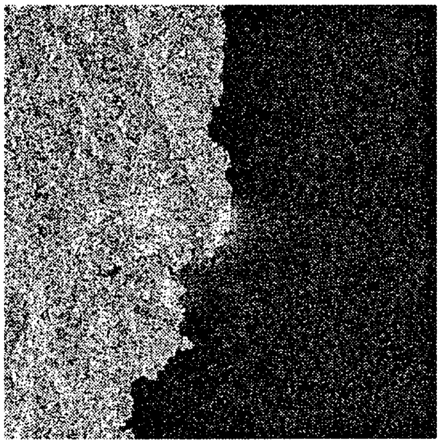

Figure 1. Radarsat-1 image(full scene)

Acquisition date	June. 18, 2004
Area	Ulsan Coast(Korea)
SAR channel indicator	1
Latitude at Image center	35.5547554
Longitude at Image center	129.4373574
Incidence Angle	41.222
Product type	SAR GEOREF EXTRA FINE
Line spacing (m)	3.1250000
Pixel spacing (m)	3.1250000
Orbit	DESCENDING

Table 1. Specification of the Radarsat-1 image

3. SHIP DETECTION ALGORITHM

The proposed structure of the detection algorithm is illustrated in figure 1. After utilizing the Otsu's method for optimal image thresholding, we convert the input image to grayscale format, and then convert this grayscale image to binary by thresholding. The output binary image has values of 0(black) for all pixels in the input image with luminance less than level and 1(white) for all other pixels(because we specify level in the range [0,1], regardless of the class of the input image). Next step is labeling connected components specifying 8-connected objects in a binary image. The pixels labeled 0 are the background. The pixels labeled 1 make up one object, the pixels labeled 2 make up a second object, and so on.

1	1	1	0	0	0	0	0
1	1	1	0	1	1	0	0
1	1	1	0	1	1	0	0
1	1	1	0	0	0	0	0
1	1	1	0	0	0	1	0
1	1	1	0	0	0	1	0
1	1	1	0	0	0	0	0

1	1	1	0	0	0	0	0
1	1	1	0	2	2	0	0
1	1	1	0	2	2	0	0
1	1	1	0	0	0	0	0
1	1	1	0	0	0	3	0
1	1	1	0	0	0	3	0
1	1	1	0	0	0	0	0

Figure 2: This illustrates using 8 connected objects. 8-connected labeling considers these a single object rather than two separate objects.

Next, we find the labeled groups which have more than 10 pixels size, because we primarily focus on the detection of the relatively big ship like Bulk Carrier, Container Ship etc. on the coast. The pixel size threshed in this work will be varied with the pixel dimension of SAR image, Radarsat-1 image used in this work has 3.125m dimension of each pixel.

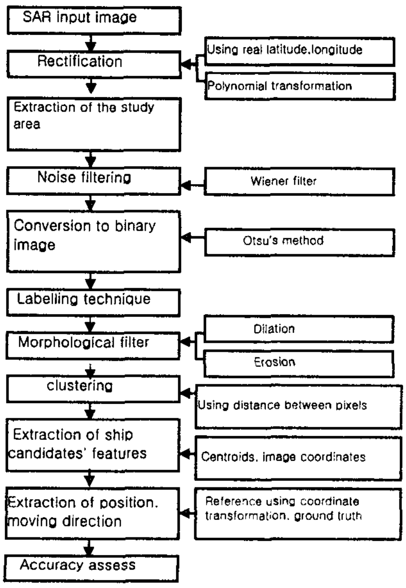

Figure 3. Flowchart of the proposed algorithm

A morphological filtering is performed to reduce suspicious noise which still remains in the previous step. The combination of the dilation and erosion of morphological filtering is processed to enhance the boundary of the identified ship candidates more clearly. Dilation operation fills black pixels inside a ship pixel cluster. Also it can connect neighbor ship candidate pixels. While dilation adds pixels to the boundaries of objects in an image, erosion removes pixels on object boundaries. Erosion operation also weakens geometric distortion after dilation operation. After the ship candidates identification approximately, Clustering with respect to the distance between central values of the individual pixel groups labeled in the previous work should be processed in the whole image for weakening the probability of misidentification of labeled groups using optimal scale factor. But there is still a possibility to misidentify labeled groups by unexpected speckle noise, it is required to make a calculation of the minimum of distance between all pixels which belong to Nth labeled pixel group and all pixels which belong to (N+1)th labeled group. The minimum distance value can be used to refine and re-label pixel groups (ship candidate). That process flow has the potential to reduce the probability of the misidentification in a fast way. And then Target image can be written, accuracy evaluation by comparison with ground truth data from the coast monitoring system was followed. When found true north in the image space, the moving direction of the ship candidates can be determined by centroidal values of those. Because the stern of the ship has larger RCS(Radar Cross Section)s than the head of that.

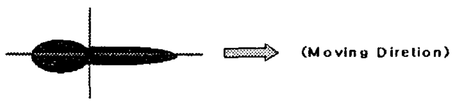

Figure 4. Moving direction of ships using RCS

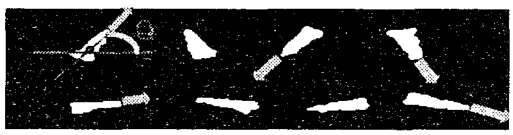

Figure 5. Moving direction types considering the head, stern, angle

4. RESULTS

We applied the method for a Radarsat-1 sample image (300 by 270, figure 4.) in order to evaluate the performance. As with other prescreening algorithms, not all pixels detected by this process will be true ship pixels and further processing is required to remove such pixels.

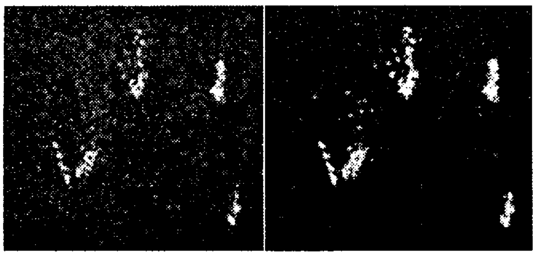

Figure 6. original sample image(left), threshed binary image using Otsu's method(right)

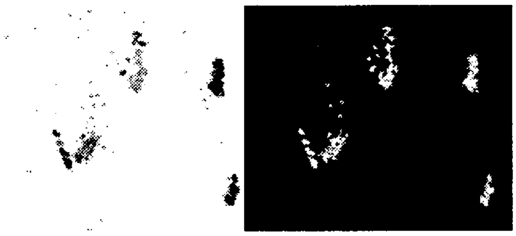

Figure 7. labeled image to RGB color(left), labeled ID>10pixel(scale factor)(right)

ID	1	2	3	4	5	6	7	8	9	10	11
Pixel #	1	4	1	1	1	3	3	2	2	4	2
ID	21	22	23	24	25	26	27	28	29	30	31
Pixel #	160	1	1	1	1	5	457	4	3	1	2
ID	41	42	43	44	45	46	47	48	49	50	51
Pixel #	2	5	14	2	9	6	4	2	1	6	13
ID	61	62	63	64	65	66	67	68	69	70	71
Pixel #	2	6	3	8	8	3	3	6	1	1	2
ID	81	82	83	84	85	86	87	88	89	90	91
Pixel #	15	1	493	2	8	74	2	7	2	40	2
ID	101	102	103	104	105	106	107	108	109	110	111
Pixel #	1	3	1	2	5	4	1	1	2	4	4
ID	121	122	123	124	125	126					
Pixel #	2	3	7	1	1	1					

Figure 8. labeled group ID & pixel numbers

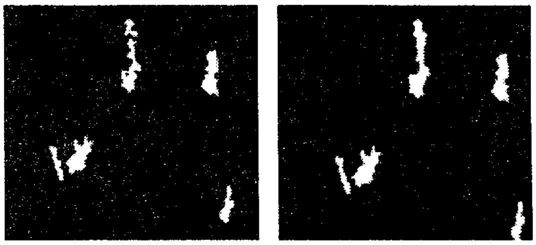

Figure 9. labeled image using morphologic filter(left), clustering centroid of label groups & refining(right)

Figure 10. centroids of label group

We have gained region properties of label group(ship candidate) like centroids(x,y), area, minor axis length from previous step. After evaluating position accuracy with centroids, HACE(figure 11.) is interpreted as the detected ship in the sample image in detail. We confirmed that the position of the ship candidates in the sample region agrees with the position reported in the Ulsan coast monitoring system with the exception of the DEDA ship candidate.

The reason of the misidentification is illustrated on fig. 12 where we circled two areas that embody pixels of another ship candidate due to resonance effects, radar shadow etc.. The problem with such clusters is that their pixel brightness is high enough to be detected.

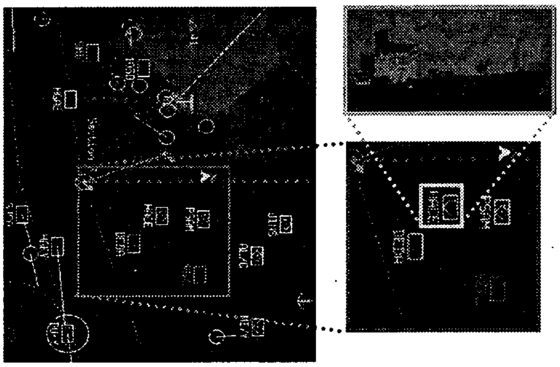

Figure 11. Ground truth for sample region (left, right bottom), HACE ship (right top)

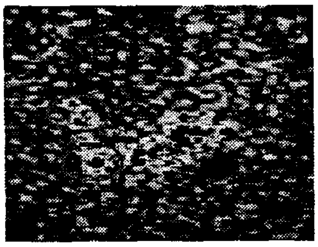

Figure 12. Resonance, radar shadow in the DEDA

We used real latitude/longitude coordinates of the HACE, PSAM, SEAL, DEDA in the field to evaluate the position accuracy. The centroids of the extracted ship candidates can be converted into latitude, longitude unit from the georeference procedure of the experimental data.

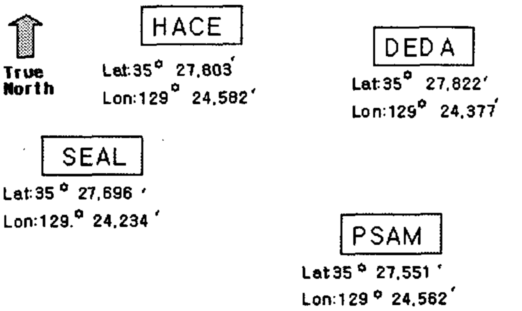

Figure 13. coordinates of ship candidates in the field

We studied the difference between the observed position of the ship candidates in the filed and the computed position by the proposed algorithm converting longitude/latitude coordinates into TM coordinates.

X(south/north) field	Y(east/west) field	X(south/north) experiment	Y(east/west) experiment	S/N difference	E/W difference
218412.003037	236658.757212	218605.196379	237208.529768	-193.193	-549.773
218611.974359	237184.358927	218854.979116	236548.215570	-243.005	636.1434
218145.908115	237155.976315	218353.015377	236802.043448	-207.107	353.9329
218645.860509	236874.085711	218781.140156	236641.273644	-135.28	232.8121

Figure 14. Difference between the position values

The RMSE of X(south/north direction), Y(east/west direction) is around 190m, 400m respectively. When considering the difficulty in processing of maritime application, this figure may be an acceptable result.

5. CONCLUSION

We introduced a ship detection technique using labeling technique, morphological filtering, Otsu's method. The main advantage of the method is the fast and automatic performance considering difference of light intensities between ship and sea. The disadvantage is that not all pixels detected by this method will be true ship pixels and further processing can be required to remove such pixels. In the future, we research more method, and apply the proposed method to a large scale imagery.

6. REFERENCES

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