Sea Ice Detection using Synthetic Aperture Radar Algorithm in Image Processing

Amanpreet Kaur
M.Tech CSE, Research Scholar
Global Institute of Management & Technology,
Amritsar, India

Sandeep Singh Kang, PhD
Professor & Head of Department
Deptt of Computer Science & Engg
Global Institute of Management & Technology,
Amritsar, India

ABSTRACT
In this paper I describe detection of sea ice using synthetic aperture radar algorithm. Sea ice detection is one of the important appliances of remote sensing technology. Remote sensing is a technique through which information can be acquired without physical contact. It is a safe supervision for ships to understand the climate conditions of oceans and to navigate the formation of ice maps. The main purpose of sea ice monitoring is to generate the maps of sea ice across the ocean according to their geographical locations. So, in this we will work on sea ice analysis using automated algorithms.

Keywords
Radar, SAR, RADARSAT 1, RADARSAT 2, MIRGS

1. INTRODUCTION
Sea ice is a constituent unit of cryosphere where the water in solid form. Solid water found on the surface of earth as a snow cover. Coverage of ice depends upon the climate variance. Sea ice is having some physical properties due to which energy exchanged between surface and atmosphere. Some properties like possession to transfer heat and change state. Northern hemisphere consists of maximum area covered by snow ice and it depends upon influence of seasonal cycle. Sea ice detection is routinely performed by two types of sensors: passive microwave radiometers, which observe the natural emission of the earth's surface [2] and active microwave scatterometer, which collect the energy reflected from an initially transmitted pulse [4].

In this paper, I explained detection of sea ice using microwave sensors: Radasat1 and Radarsat2 by implementing Synthetic aperture radar algorithm. The different parameters of ice like sea ice velocity, thickness and concentration can be calculated.

2. SEA ICE MAPPING
Sea ice mapping is one of the important appliances of remote sensing technology. Monitoring of sea ice is a major challenge to scientists. The ice sheet on the surface of a body of water has changed significantly during last decades. The coverage of sea ice changes according to climate variance. By studying the factors of sea ice formation, we can understand the aspects which affect its seasonal growth. Sea ice cover has different effects on earth's climate system as it reduces the heat, moisture and momentum across the sea ice atmosphere interface. Remote sensing is a technique through which information can be acquired without physical contact with the object. It is a safe supervision for ships to understand the climate conditions of oceans and to navigate the formation of ice caps. The main purpose of sea ice monitoring is to generate the maps of sea ice across the ocean according to their geographical locations. Sea ice covers 10% of the ocean's total area. For image data, we use different satellites are RADARSAT 1 (R1) and its advancement RADARSAT 2 (R2) offered by Canadian Synthetic Aperture Radar. RADARSAT 1 was launched in November 1995 by Canadian Space Agency. It is Canada's first Earth observation satellite. RADARSTAT 2 is Canada's next generation commercial radar satellite. It enhances the functions of R1 and it has some additional features like marine surveillance, ice and environment monitoring, disaster management etc.

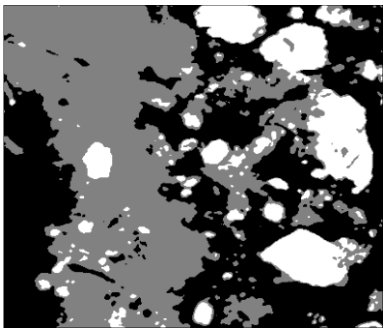

Fig 1: Mapping of ice [20]

3. LITERATURE SURVEY

There are many research works carried on which explains the detection of sea ice by using different algorithms and sensors. Some research papers work is explained as below:

In June 2012 [1], author has segmented the image based on the properties of the object. So, the aim of segmentation is to identify the shape of object, color, etc. The author has given a proposed technique to overcome the problem of watershed segmentation. Author has used the pre processing methods for improvement and adjusts the intensity of image and reduces the noise. Author also used the Prewitt operator instead of Sobel operator to detect the edges.

In Sept 2012 [18], author used the MODIS data from multiyear of sea ice floes and proposed a new Temposeg method for multi temporal segmentation. This new method segments the each image of MODIS data from a time series to into two regions that is floe and background. This technique is based upon Region growing method which is best shape constrained technique. They successfully implemented this method on a set of MODIS data of the year August- October 2008 and estimated floe and perimeter of the floe of interest over the given period of time.

In January 2013 [8], author introduced at the high resolution and dual polarization of SAR amplitude, a CFAR detecting method aims at adaptive detection of ship to differentiate the ship from clutter easily and to improve the signal to clutter ratio, a Novel PMA detector is being designed. Different type of experiments is being performed on measured dual polarization. The better performance of the proposed Constant False Alarm rate (CFAR) detecting method is demonstrated by Terra SAR-x images. The goal of this paper is to commence a dominant detector in a high resolution and dual polarization SAR images for ship detection. At the other side, the signal to clutter ratio can be improved by this detector to enhance the moving targets.

In 2014 [16], author explained the watershed segmentation with intensity based merging algorithm for a SAR image. This intensity based algorithm is also works for pre processing and median filtering. In this paper, the Region Adjacency Graph (RAG) has been used for merging. Region adjacency Graph is used to determine the adjacent regions. In a merging process, regions should be based on a minimum distance about one pixel between two regions. By comparing this algorithm with others, we come to know that the proposed algorithm provides more accurate and fast segmentation for a SAR image. The results of the segmentation are labeled separately and expressed as regions. So, analytical information of a specific region can be collected easily.

4. METHODS AND ALGORITHM

Fig shows a general workflow to retrieve the detection results of ice at various locations in sea. In the first step, take a RADARSAT image and then followed by region based segmentation. Segmentation subdivides the image into various parts. Then apply the Synthetic Aperture Radar algorithm to retrieve the accurate results.

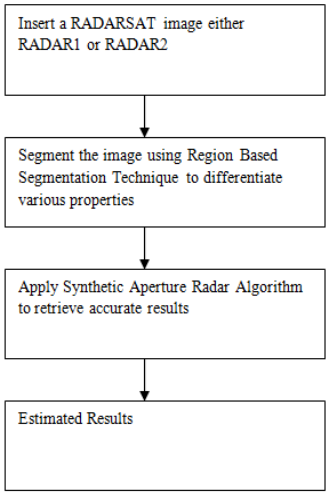

Fig 2: General Workflow

4.1 Region Based Segmentation

Region based segmentation can be defined as partition the image into regions. Region is an important concept to depict the image because regions may correspond to objects in the scene. In this, the pixels of the same object are grouped together and marked to indicate the formation of region.

In this technique, the image is considered as a matrix in the form of m*n. in the image there can be various properties of it and we have to differentiate these properties. That's why we have to divide the image into various segments to retrieve the accurate results of ice and to differentiate it from water.

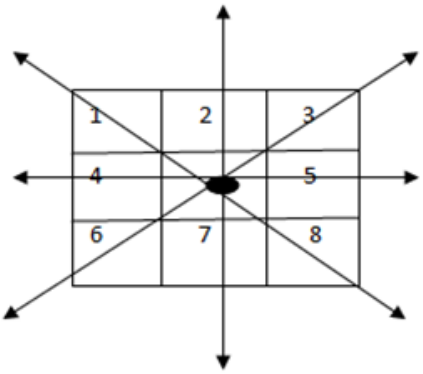

Fig 3: Neighbors of pixels with different orientations

4.2 Synthetic Aperture Radar Algorithm

Radar has been used for broad range of applications such as remote sensing, imaging and global positioning in military as well as nonmilitary services. Synthetic aperture radar is used to generate images of an object such as earth, ocean, island etc. it uses the motion of SAR antennas over a target region. To create the images radio waves are used. Radio waves determine the range, altitude, direction or speed of objects. Radio waves are being transmitted to highlight the target object to create a SAR image. Images can be acquired in intemperate environment during day and night. It is capable to capture imagery in all-weather atmospheric conditions using active microwave sensing. SAR used in aerial and satellite platforms for taking satisfactory sufficient resolutions for the purpose of sea ice discrimination resolutions. SAR sea ice images are explained using unsupervised segmentation. So SAR imaging is most important source for mapping or segmentation of ice. We should have knowledge about RADARSAT 2, to understand the concept of SAR. The system is abide of space shuttle with the SAR appliance moving along orbit which traces the orbital track along the earth's surface.

Table 1. Comparison of Different Types of Sensors

Type of sensor	Satellite Used	Polarization Channel	Spatial Resolution	Swath Width
AMSR-E	AQUA	Horizontal & vertical	6.25 km	1450 km
MODIS	TERRA & AQUA	Horizontal & Vertical	250m, 500m, 1000m	2330 km
SCATTEROMETER	QuickSCAT	HH, VV	50km	600*2
SAR	RADARSAT1	HH	10-100 m	45km - 510km
SAR	RADARSAT2	HH, VV, HV, VH	3-300m	105-170km

The SAR systems transmit microwaves from earth surface. The length of antennas needed to build high resolution images that are too huge to initiate into orbit for conventional RADAR. To solve the problem of antenna's length, SAR uses signal processing techniques and activity of space shuttle to achieve the effect of large antenna. This is process is possible with giving rise to synthetic aperture. The two dimensional SAR images of the surface can be generated because space shuttle also allow the view of the landscape or field in the direction of motion. SAR systems can transmit and receive electromagnetic energy in different polarization. Radar are reflected by different materials with different intensities. Different ice types have incredible characteristics of reflection of waves that can be measured by SAR. So, each ice type has different factors like surface roughness, volumetric structure and salinity.

4.2.1 MIRGS (Multivariate Investigate Region Growing with Semantics)

MIRGS is an automated sea ice analysis algorithm which is used to find the accurate results. MIRGS used in capture the SAR imagery from RADARSAT 1 using one channel single polarization. RADARSAT is enhancement of RADARSAT1 in which the concept of dual polarization is used to take the SAR imagery for sea ice mapping. To distinguish ice types more accurately, dual polarization imagery provide more information and one of the channel is less sensitive to changes in the backscatter caused by the SAR incidence angle parameter.

5. THE DATA SET

5.1 RADARSAT1

RADARSAT1 is the basic source for taking the images of sea, earth and other geographical areas. RADARSAT 1 was launched in November 1995 by Canadian Space Agency. It is Canada's first Earth observation satellite. It uses single channel polarization.

5.2 RADARSAT2

RADARSAT 2 is Canada's next generation commercial radar satellite. It enhances the functions of R1 and it has some additional features like marine surveillance, ice and environment monitoring etc. The most important enhancement provided by R2 for operational sea ice mapping is selective dual polarization scan SAR wide mode.

Table 2. Comparison of RADARSAT1 and RADARSAT2

RADARSAT1	RADARSAT2
1. RADARSAT-1 is Canada's first commercial earth observation satellite and developed under the management of Canadian Space Agency.	1. RADARSAT-2 is Canada's next generation commercial radar satellites and owned by Macdonald, Dettwiler and Associates Ltd (MDA).
2. RADARSAT-1 launched in November 1995.	2. RADARSAT-2 launched in December 2007.
3. Launch mass of it was 2750kg.	3. Launch mass of it was 2200kg.
4. Mission design year of it was 5 years.	4. Mission design year of it was 7 years.
5. Power = 2100 watt	5. Power = 2.4 watt
6. Frequency of RADAR1 is 5.3 Ghz.	6. Frequency of RADAR2 is 5.405 Ghz.
7. Spatial resolution of RADAR1 is 8-100 m.	7. Spatial Resolution of RADAR2 is 1-100 m.
8. Beam modes are seven.	8. Beam modes are twelve.
9. It is SAR instrument which imaging earth's surface through cloud cover and darkness.	9. It is also SAR instrument which images Earth surface in any intemperate conditions.
10. Polarization channel of RADAR1 is HH.	10. Polarization channel of RADAR2 are HH, VV, HV, VH.
11. It provides detail information about the environment, agriculture, oceans etc.	11. It is used for marine surveillance, ice monitoring, disaster management etc.
12. RADAR1 looks in only Right direction.	12. RADAR2 looks in both directions that are Right and Left.

6. RESULTS & DISCUSSION

In June 2012 [1], author applied the Prewitt operator instead of Sobel operator using watershed segmentation technique to segment the image.

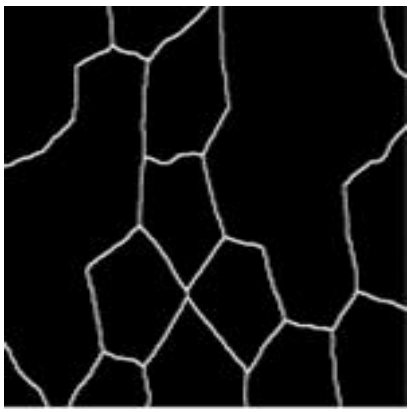

Fig 4: Segmented Ridge lines using Prewitt operator [1]

In September 2012 [18], author taken Reprojected MODIS image and applied Temposeg method to calculate the ice floe area as a function of time.

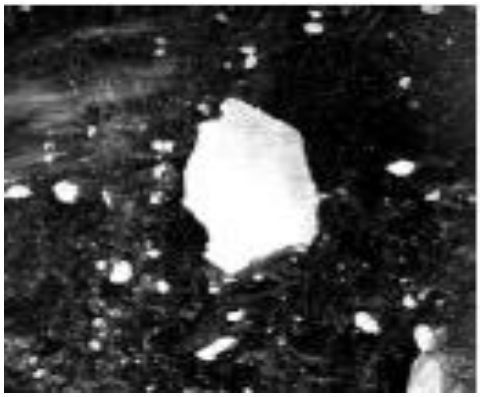

Fig 5: Segmented ice floe area [18]

In January 2013 [8], author worked on detection of moving ship in sea. Author has designed a PMA detector to detect ship more accurately and to improve signal to clutter ratio.

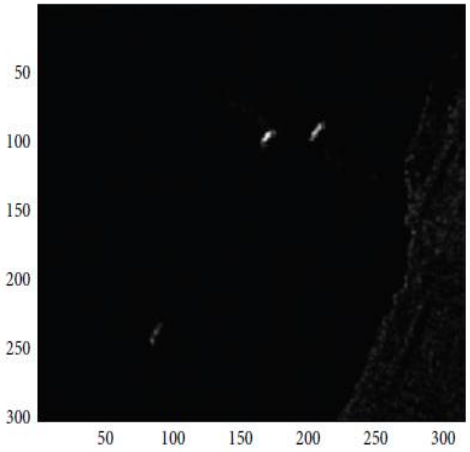

Fig 6: Position of moving ship [8]

In 2014 [16], author has used various segmentation techniques like threshold, watershed and active contours. Author applied synthetic aperture radar algorithm to a tested image which contains small pieces of ice.

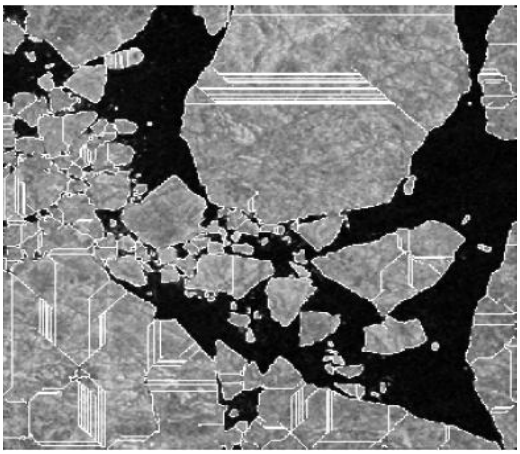

Fig 7: Segmented results of ice using watershed segmentation [16]

In the following tables, Author used the RADARSAT2 (R2) data for synthetic aperture radar algorithm. The most important enhancement provided by R2 for operational ice mapping is selective dual polarization scan SAR wide mode. Author has implemented MIRGS algorithm with different number of band inputs. Based on these inputs, the overall accuracy, coefficient (k) of tested methods and MIRGS parameter C1 has been calculated and represented in the form of graphs.

Table 3. Results of Real image [15]

Method	Bands	Accuracy (%)	K	C1
HH	1	72.14	0.57	7
HH & HV, ADWA	2	83.92	0.77	3
HH & HV, VFG	2	84.70	0.78	3
HH & HV , MAX	2	84.19	0.77	3
HH & HV, CG	2	83.92	0.77	3
HV	1	48.37	0.30	5
HV/HH	1	57.51	0.41	5

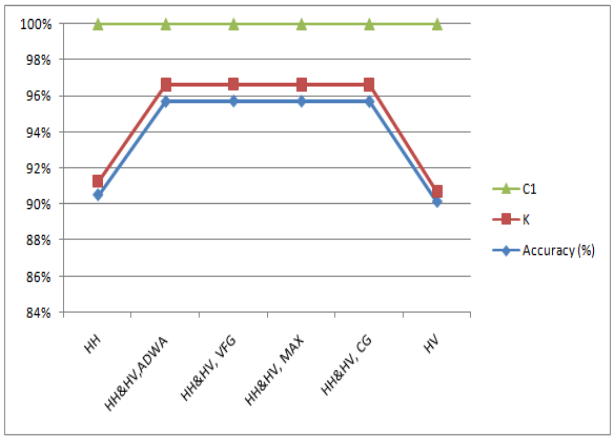

Fig 8: Graphical Representation of Real Image

The values of the synthetic image are enhanced values which improve the values as compare to the real image. Based on different band inputs, values of the overall accuracy, coefficient (k) of tested methods and MIRGS parameter C1 has been enhanced and represented in the form of graph.

Table 4. Results of Synthetic Image [15]

Method	Bands	Accuracy (%)	K	C1
HH	1	78.87	0.70	7
HH & HV, ADWA	2	98.08	0.97	3
HH & HV, VFG	2	98.25	0.98	3
HH & HV , MAX	2	98.28	0.98	3
HH & HV, CG	2	98.09	0.97	3
HV	1	83.14	0.76	5
HV/HH	1	93.61	0.91	7

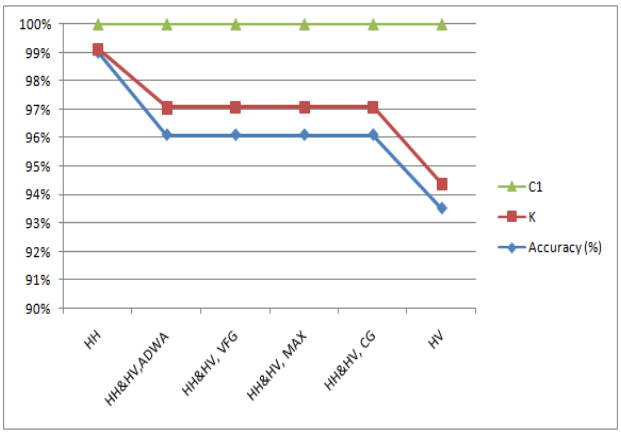

Fig 9: Graphical Representation of Synthetic Image

7. CONCLUSION AND FUTURE WORK

We have studied SAR algorithm to detect the sea ice to save the ship from any kind of damage. So that ship does not strike with ice. We studied pixel based segmentation algorithm to segment the ice. Due to this we can differentiate the ice based on the properties it and we can calculate the properties like velocity of ice, thickness and concentration of ice with the help of mesh graph. In further work we have to enhance this automated SAR algorithm to get more accurate result using RADARSAT1 and RADARSAT2 data and have to reduce the number of iterations and residuals to increase the detection of recovered ice.

8. REFERENCES

[1] Anju Bala, "An improved watershed Image Segmentation Technique using MATLAB", 2012

[2] Cavalieri, D.J., Parkinson, C.L., Gloersen, P., Comiso, J.C., Zwally, H.J., "Deriving long term time series of sea ice cover from satellite passive microwave multisensor datasets", J. Geophys. Res., Vol. 104, No. C7, pp. 15803-15814, 1999.

[3] Bernd Scheuchl et.al, "Potential of RADARSAT-2 data for operational sea ice monitoring", CJRS, 2004

[4] Anderson, H.S., Long, D.G., "Sea ice mapping method for Seawinds", IEEE Trans. Geosci. Remote Sens., Vol. 43(3), 2005.

[5] B. Scheuchl, R. Caves, D. Flett, R. Abreu, M. Arkett, and I. Cumming "ENVISAT ASAR AP data for operational sea ice monitoring" In Proc. IEEE,International Geoscience and Remote Sensing Symposium, volume 3, Sept. 2004

[6] Huawu Deng, David A. Clausi, "Unsupervised Segmentation of Synthetic Aperture Radar Sea Ice imagery using a Novel Markov Random Field Model", IEEE 2005.

[7] Ehmann, J. "Structural Texture Similarity Metrics for Image Analysis and Retrieval", IEEE 2013

[8] Gui Gao, Gongtao Shi and Shilin Zhou, "Ship Detection in High-Resolution Dual-Polarization SAR Amplitude Images" IJAP, volume 3 issue 5, pp- 213-2-15, 2013

[9] Kanchan S. Deshmukh, "Texture Image Segmentation using FCM" 012 IACSIT Hong Kong Conferences IPCSIT vol. 25 2012, IACSIT Press, Singapore

[10] Mandeep Kaur, Gagandeep Singh, " A Review on Sea Ice Analysis", IJSR, 2012.

[11] Marta, Antonio, " Models For Synthetic Aperture Radar Texture Analysis" IEEE 2009

[12] Pham, Tuan D. "Image texture analysis using geostatistical information entropy" IEEE 2012

[13] Peter Yu, A.K Qin, David A. Clausi, "Feature Extraction of dual-pol SAR imagery for sea ice image segmentation ", CASI 2012

[14] Qiyao Yu and David A. Clausi, "SAR Sea Ice Image Analysis Based on Iterative Region Growing Using Semantics ", IEEE 2007

[15] Salem Saleh Al-amri, N.V. Kalyankar and Khamitkar S.D, "Image Segmentation by Using threshold techniques", 2010

[16] Toluope Bamidele Ijitona, Jinchang Ren, Phil Byongjun Hwang, "SAR Sea Ice Image Segmentation Using Watershed with Intensity Based Region Merging" IEEE 2014.

[17] Waller, Ben M., Mark S. Nixon, and J. N. Carter. "Analysing Micro-and Macro-Structures in Textures." In Signal Image Technology and Internet Based Systems (SITIS), 2012 Eighth International Conference on, pp. 246-253. IEEE 2012.

[18] Yuliya Tarabalka et.al "Shape-Constrained Segmentation Approach For Arctic Multiyear Sea Ice Floe Analysis", IEEE 2012

[19] Zujovic, Jana, Thrasyvoulos N. Pappas, and David L. Neuhoff. "Structural similarity metrics for texture analysis and retrieval." In Image Processing (ICIP), 2009 16th IEEE International Conference on, pp. 2225-2228. IEEE 2009.

[20] Mapping of ice, Image. Available online: http://vip.uwaterloo.ca/files/research_images/fig2.PNG