Sea Ice Detection using Synthetic Aperture Radar Algorithm in Image Processing

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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: Radarsat1 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.

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 2 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.

Table 1. Comparison of Different Types of Sensors

<table>
<thead>
<tr>
<th>Type of sensor</th>
<th>Satellite Used</th>
<th>Polarization Channel</th>
<th>Spatial Resolution</th>
<th>Swath Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMSR-E</td>
<td>AQUA</td>
<td>Horizontal &amp; Vertical</td>
<td>6.25 km</td>
<td>1450 km</td>
</tr>
<tr>
<td>MODIS</td>
<td>TERRA &amp; AQUA</td>
<td>Horizontal &amp; Vertical</td>
<td>250m, 500m, 1000m</td>
<td>2330 km</td>
</tr>
<tr>
<td>SCATTEROMETER</td>
<td>QuickSCAT</td>
<td>HH, VV</td>
<td>50km</td>
<td>600²</td>
</tr>
<tr>
<td>SAR</td>
<td>RADARSAT1</td>
<td>HH</td>
<td>10-100 m</td>
<td>45km - 510km</td>
</tr>
<tr>
<td>SAR</td>
<td>RADARSAT2</td>
<td>HH, VV, HV, VH</td>
<td>3-300m</td>
<td>105-170km</td>
</tr>
</tbody>
</table>

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 temperate 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.
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 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

<table>
<thead>
<tr>
<th>RADARSAT1</th>
<th>RADARSAT2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. RADARSAT-1 is Canada’s first commercial earth observation satellite and developed under the management of Canadian Space Agency.</td>
<td>1. RADARSAT-2 is Canada’s next generation commercial radar satellites and owned by Macdonald, Dettwiler and Associates Ltd (MDA).</td>
</tr>
</tbody>
</table>

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.
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.

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.

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]

<table>
<thead>
<tr>
<th>Method</th>
<th>Bands</th>
<th>Accuracy (%)</th>
<th>K</th>
<th>C1</th>
</tr>
</thead>
<tbody>
<tr>
<td>HH</td>
<td>1</td>
<td>72.14</td>
<td>0.57</td>
<td>7</td>
</tr>
<tr>
<td>HH &amp; HV, ADWA</td>
<td>2</td>
<td>83.92</td>
<td>0.77</td>
<td>3</td>
</tr>
<tr>
<td>HH &amp; HV, VFG</td>
<td>2</td>
<td>84.70</td>
<td>0.78</td>
<td>3</td>
</tr>
<tr>
<td>HH &amp; HV, MAX</td>
<td>2</td>
<td>84.19</td>
<td>0.77</td>
<td>3</td>
</tr>
<tr>
<td>HH &amp; HV, CG</td>
<td>2</td>
<td>83.92</td>
<td>0.77</td>
<td>3</td>
</tr>
<tr>
<td>HV</td>
<td>1</td>
<td>48.37</td>
<td>0.30</td>
<td>5</td>
</tr>
<tr>
<td>HV/HH</td>
<td>1</td>
<td>57.51</td>
<td>0.41</td>
<td>5</td>
</tr>
</tbody>
</table>

### Table 4. Results of Synthetic Image [15]

<table>
<thead>
<tr>
<th>Method</th>
<th>Bands</th>
<th>Accuracy (%)</th>
<th>K</th>
<th>C1</th>
</tr>
</thead>
<tbody>
<tr>
<td>HH</td>
<td>1</td>
<td>78.87</td>
<td>0.70</td>
<td>7</td>
</tr>
<tr>
<td>HH &amp; HV, ADWA</td>
<td>2</td>
<td>98.08</td>
<td>0.97</td>
<td>3</td>
</tr>
<tr>
<td>HH &amp; HV, VFG</td>
<td>2</td>
<td>98.25</td>
<td>0.98</td>
<td>3</td>
</tr>
<tr>
<td>HH &amp; HV, MAX</td>
<td>2</td>
<td>98.28</td>
<td>0.98</td>
<td>3</td>
</tr>
<tr>
<td>HH &amp; HV, CG</td>
<td>2</td>
<td>98.09</td>
<td>0.97</td>
<td>3</td>
</tr>
<tr>
<td>HV</td>
<td>1</td>
<td>83.14</td>
<td>0.76</td>
<td>5</td>
</tr>
<tr>
<td>HV/HH</td>
<td>1</td>
<td>93.61</td>
<td>0.91</td>
<td>7</td>
</tr>
</tbody>
</table>
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.

REFERENCES

[12] Pham, Tuan D. “Image texture analysis using geostatistical information entropy” IEEE 2012
[18] Yuliya Tarabalka et.al “Shape-Constrained Segmentation Approach For Arctic Multiyear Sea Ice Floe Analysis”, IEEE 2012