

GEOS 622 – Image-processing applications in the geosciences

Homework problem 2 (to be completed and submitted by Tuesday, October 30, 5.00pm; total number of points that can be earned: 15; note, however, that each of the four Homework Problem sets counts equally at towards your final grade)

Image enhancement and delineation of different land/water surfaces in SAR imagery

On the Geophysical Institute ftp server ([ftp.gi.alaska.edu](ftp://ftp.gi.alaska.edu), login as "anonymous" with your e-mail address as password) you will find two images in the directory /pub/eicken/GEOS622/HW2 that you will have to work with to complete this exercise (the scenes that you are working with are copyrighted by the Canadian Space Agency and are not meant for use other than the purpose of completing this exercise).

As part of this homework problem, you will have to generate 3 resulting images. Please transfer these to me by e-mail (hajo.eicken@gi.alaska.edu), on some storage device or via ftp, copying them on the GI anonymous ftp server into the directory /pub/eicken/incoming (note that you cannot obtain a directory listing for that directory, so you will not be able to see the copied files).

1. Download the following images from the ftp server:

SARLena064.TIFF

SARLena191.TIFF

These two images are co-located Radarsat synthetic aperture radar (SAR) scenes of the Lena Delta in the Laptev Sea. The coordinates of the upper left and lower right corner of the image are 73.5°N 128.5°E, 71.5°N 131.0°E (North is up and the scene is rendered in a Universal Transverse Mercator, UTM, projection).

1.1. What are the linear dimensions of the pixels of this scene (do they vary across the image)? What are potential differences between the pixel dimensions and the ground-projected instantaneous field of view (GIFOV)?

2. The image SARLena064.TIFF has been acquired on March 5, 1997 (day 64). The variability in the grey values of individual pixels corresponds to variability in the SAR backscatter signal. The scene can be divided into three different, meridionally aligned zones: the actual delta in the West, a zone of high-backscatter ice in the center and ordinary, low backscatter sea ice in the East. The aim of this exercise is to derive a crude classification for these three regions that is based on a combination of different histogram and spatial filtering techniques.

2.1. What are the mean, mode and standard deviation of grey values for these 3 zones?

2.2. Based on the histogram alone, could you distinguish between the three surface types (land, high-backscatter ice, ordinary sea ice)?

2.3. Develop an algorithm (i.e. by devising a sequential set of operations including for instance gradient or morphological filters) that will yield satisfactory results in outlining the boundary between the high-backscatter sea ice in the center and the low backscatter

ordinary sea ice in the East. Generate an image that delineates the location of this boundary by a narrow line (preferably one pixel wide).

2.4. The high-backscatter, linear features discernible in the low-backscatter sea ice in the East are in most cases regions of deformed ice (pressure ridges) that scatter a significant fraction of the incident signal back to the satellite (e.g., the feature running NW-SE from coordinates $x=94$ $y=67$ to $x=198$ $y=238$). The rectangle defined by the upper left corner $x=230$ $y=590$, and the lower right corner $x=290$, $y=660$ appears to be devoid of any backscatter structure (and hence deformed ice). Check, using histogram transforms whether this is truly the case and briefly state what image enhancement technique you've used to arrive at a conclusion.

3. Distinguishing between the land surface in the West and the high-backscatter sea ice in the central part of the picture is not straightforward based on the scene SARLena064.TIFF alone. To aid in defining a land mask that properly identifies all pixels that are part of the actual delta land surface, a second scene obtained for July 10, 1997 (day 191) has been provided: SARLena191.TIFF. In this scene (same corner coordinates as the first image), the ice has retreated away from the coastline, leaving a broader expanse of open water with lower backscatter signatures.

3.1. What are the mean grey value, mode and standard deviation of the land surface in the West and the open water in the center part of the image? This scene actually has been radiometrically calibrated, with the grey value G derived from the SAR backscatter coefficient σ_0 according to $G = 5(\sigma_0 + 51.0)$. What are the mean backscatter coefficients of the delta land surface and the open water, respectively? How large would you estimate the error associated with the value derived from open water based on the information contained in the image alone?

3.2. Develop an algorithm that will yield satisfactory results in delineating the area that corresponds to the land surface in the delta region and allow you to define a landmask for the delta. Considering the noise and speckle inherent in the open water signal, how could the impact of misclassification of open water pixels as land be minimized? Save the image resulting from the application of this algorithm.

4. Combine the results from Question 2.3 and 3.2 to arrive at a scene that contains a delineation (i.e. a line of one pixel width) of the eastern boundary of the high-backscatter sea ice area and furthermore contains a landmask that covers the entire Delta land region that is contained in the July 10 scene. Save the image that results out of this combination of scenes.