2D Image Reconstruction using SAR

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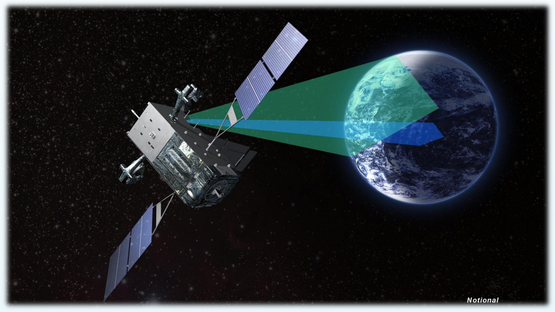
Problem Statement

This project presents the methodologies followed to improve the images taken by SENTINEL-1 SAR satellite and the processes used to cancel the noise that comes from many sources . In addition , The Sentinel Application Platform (SNAP) and MATLAB were used to analyze the terrestrial terrain features on the earth surface .



Objectives

The previous methodologies were utilized to find the area of the residential areas in any image and an approximation for the amount of water lost in Tiberias Lake (in Occupied Palestinian Territories) between the years 2014 to 2019 .

SENTINEL 1 Toolbox

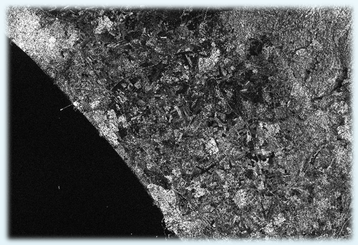
The Sentinel Application Platform -or SNAP - in short is a collection of executable tools and Application Programming Interfaces (APIs) which have been developed to facilitate the utilisation, viewing and processing of a variety of remotely sensed data. The functionality of SNAP is accessed through the Sentinel toolbox. This toolbox provide us with many pre-processing stages which included but not limited to :

- **Apply orbit file:** provides accurate satellite position and velocity information. Based on this information, the orbit state vectors in the abstract metadata of the product are updated.
- **Radiometric calibration:** Provide imagery in which the pixel values can be directly related to the radar backscatter of the scene.
- **Speckle filter :** the main objective is noise reduction because SAR images have inherent salt and pepper like texturing called speckles , which degrade the quality of the image and make interpretation of features more difficult. Speckles are caused by random constructive and destructive interference of the de-phased but coherent return waves scattered by the elementary scatters within each resolution cell.

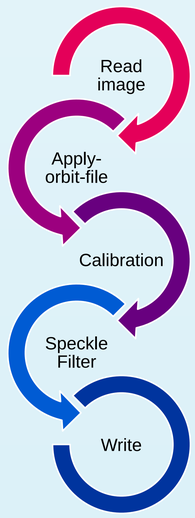
Image download/Subset

SAR images are taken by the SENTINEL-1 satellite orbiting at 693 km then it's stored in a database that is free and reachable by everyone from the site www.asf.alaska.edu.

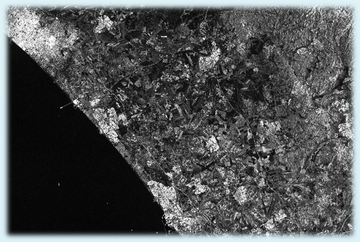
The original image was cropped into what is called a (subset) which is a smaller portion of the original image that has lower pixel density and smaller size , and this is done to reduce the size of the image therefore reducing the processing time and the storage needed.



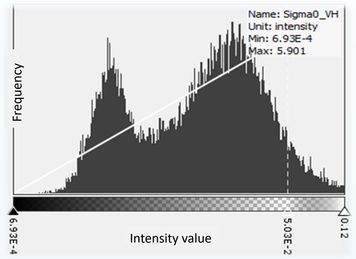
Pre-Processing



Pre-processing is a series of filters that are used to eliminate noises and to improve contrast in the intensity values of the pixels.



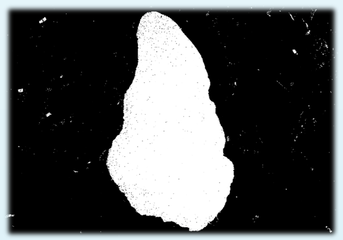
Surface classifications using Histogram



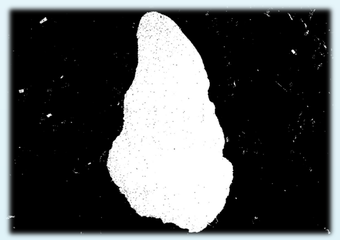
Histogram is a graph showing the number of pixels in an image at each different intensity value found in that image, For an 8-bit grey scale image there are 256 different possible intensities.The histogram can be used to find the intensity values at which each surface type is present

Surface type	Sea	Land	Residential areas
Intensity value range	0.00159 0.00322	0.007 0.12	0.01 0.12

By applying a band math function which is :
(band name)< 5x10-2 +255) to convert the pixels in the range of [$5x10^{-2}$ — $12x10^{-2}$] to black pixels (255) , so the resulted picture is a white and black one .



Tiberias lake in *2014*



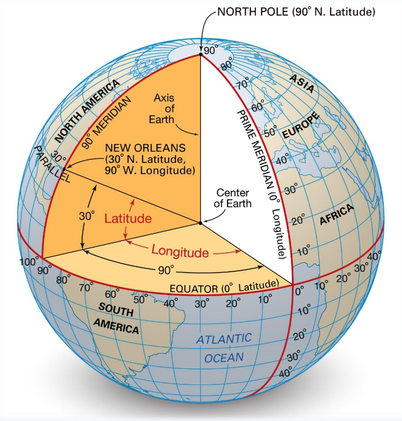
Tiberias lake in *2019*

The two images above represent Tiberias Lake after being processed at an intensity value of $5x10^{-3}$.

Geographic Coordination System

It takes in consideration the curvature of the surface of the earth and gives the area between a certain longitude and latitude .

$$A = \int_{\varphi 1}^{\varphi 2} \int_{\theta 1}^{\theta 2} R^2 \, \mathrm{Sin}(\theta) \, d\varphi \, d\theta$$



Results

Target	Percentage of water surface (%)	Total area (Km^2)	Target area (Km^2)	Intensity value $\times 10^{-3}$
Tiberias lake in 2014	23.82	491.18	116.95	5– 5.45
Tiberias lake in 2019	22.87	501.73	114.74	5 – 5.45

Target	Intensity value $\times 10^{-3}$	Target area (km^2)	Total area(km^2)
Residential areas	5– 12	98.26	1399.85

Conclusion and future work

SAR images can be used to provide useful information for many sorts of applications including but not limited to population counting , farming ,rain rate changes , water surfaces analysis and many others. So we built an algorithm based on the power intensity for each surface to classify each type of surfaces . this algorithm can be applied to an AI system to do an extensive learning program to teach the program to find the intensity values for certain surfaces by itself in the future .