ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Landsat Image Enhancement using SAR Image (Case Study: High Aswan Dam, Egypt)

Elnazer, A. A. [(1)]; Ewida, E. H. [(2)]; Sayed, W. M. [(3)]

(1) Geological Sciences Department, National Research Centre, Dokki, Cairo, Egypt
(2) Remote Sensing Unit, Soil Water and Environment Research, Institute Agricultural Research Center, Giza, Egypt.
(3) Faculty of Engineering, Cairo University, Giza, Egypt.

Manuscript Info

Manuscript History:

Received: 15 October 2015
Final Accepted: 22 November 2015
Published Online: December 2015

Key words:

Enhancement, SAR, Landsat Images, Fusion, De-speckle, Filtering, High-Dam, Egypt.

****Corresponding Author***

Elnazer, A. A

Abstract

In this research, fusion of SAR image (high resolution image -0.2 m) with Landsat image (low resolution image-30.0m) is done to enhance resolution of multispectral image for better identification of High Aswan Dam region that specific important part from Egypt.

Preprocessing of both SAR and Landsat images is critical to get the best Enhancement. For SAR image, the information utilized for terra-SAR-x, getting backscatter image is our issue. Calibration done first then de-speckling to evacuate dot happened in accumulation SAR information, this system done by different methods of filtering, after that an appraisal done to get the best image from all strategies done, then utilize the image for doing combination with Landsat image in the wake of doing subset for our region of hobby. The outcomes demonstrated that utilizing mean with (7*7) portions issuing us great results instead of different systems.

Fusion of Landsat image by SAR data was done using principal component method. A geologic interpretation is applied to the processed image.

INTRODUCTION

Remote sensing is useful for watching the earth with sensors from high over its surface. These days, remote sensing, otherwise called earth perception, is mostly done from space by utilizing sensors mounted on satellites. [1]

Satellite remote sensing for earth perception began in 1972 with the first dispatch of Landsat satellite. Landsat satellites (TM and ETM+), SPOT, and Indian Remote Sensing (IRS) LISS are examples of sensors. New group satellites are recognized with high geometric determination (IKONOS-2, QuickBird-2, OrbView-2, and Geoeye-1).

Radar has long been utilized for military and non-military purposes in a wide assortment of utilizations, for example, imaging, direction, remote sensing and worldwide situating. Another method for attaining to better determination from radar is sign preparing. Synthetic Aperture Radar (SAR) is a procedure which uses sign handling to enhance the determination past the constraint of physical reception apparatus gap [2].

Study area:

Our study area is for a large hydroelectric dam on the Nile in Aswan governorate, Egypt. One of the biggest three Dams in the world, it was established in 1960s. It is located on the south of Egypt at a latitude of 23° 58' 12" North and longitude of 32° 52' 48" East and the time zone is GMT + 2:00. (Fig. 1) shows the study area.

The high dam is 3,830m long, 980m wide at the base, 40m wide at the crest and 111m tall. The reservoir, named Lake Nasser, is 550 Km long and 35 Km at its widest with a surface area of 5,250 Km2. It holds 132 Km3 of water. In The 1981 an earthquake with magnitude 5.5 happened after the reservoir had reached its seasonal maximum. The seismicity occurred at two depths between 0-10 km and 15-25 km [3].

Mekkawi [4] stated that the seismic activity and high electrical conductivity are related and the link between them is the presence of crustal fluids which are presumably the cause of the high conductivity observed.

Egypt also relies heavily on the dam as one of its primary sources of energy. The Aswan High Dam produces about 15% of the country's needs each year. Results brought many benefits including electricity for every city, town, and village in Egypt, as well as agricultural improvements through irrigation, fewer disastrous floods, and better navigation on the Nile.

Materials and Methods:

Materials:

Satellite data:

- **Landsat:** The enhanced thematic mapper plus (ETM+) sensor on the Landsat 7 satellite was the best quality of all, the collected data for path 174 and row 44 on 2011.
- **TerraSAR-X:** The input SAR imagery is acquired by a German earth observation satellite, TerraSAR-X which is launched on 15th June, 2007, with resolution of 0.2 m. The image is collected on 2013.

Software used:

We used ERDAS v. 2014 and ENVI v5.0 programs. The software used to process the data is SENTINEL 1 version 1.0.3 beta version. SENTINEL is the latest version of NEST that is used for reading, post-processing, analyzing and visualizing the large archive of data (from Level 1) of ESA SAR missions including ERS1 & 2, ENVISAT, as well as third party SAR-data from JERS SAR, ALOS PALSAR, TerraSAR-X, Radarsat-1&2 and Cosmo-Skymed. NEST helps the remote sensing community by handling ESA SAR products and complimenting existing commercial packages.

Methodology and analysis:

In (Fig. 2), there are four steps, two steps done in parallel, one of them is doing de-speckling on SAR image, and the second is getting subset for area of study from Landsat image, then doing fusion using various methods, and final image classification.

SAR Image De-speckling:

Synthetic aperture radar (SAR) imaging, due to its powerful imaging capability in all weather conditions, day and night, sunny and cloudy, has become more and more popular in our daily lives and in military tasks. But unfortunately, speckle noise, caused by the coherent imaging, makes interpretation and analyzing of SAR images very difficult. So the goal of preprocessing in SAR images is to remove the multiplicative speckle noise and to preserve all texture features efficiently.

There are different speckle reduction filters accessible to process SAR pictures. Some give better visual understandings while others have great clamor diminishment or smoothing capacities. The utilization of every filter relies on upon the determination for a specific application. By and by, the standard speckle filters, for example, Median, kuan, Statistical Lee, standard Frost, improved Frost and Gamma or MAP channels are by and large utilized.

Each of these filters has an extraordinary spot decrease filter that performs spatial separating in a square-moving window known as kernel. The filtering is taking into account the measurable relationship between the focal pixel and its encompassing pixels.

Each of these speckle filters performs the filtering in light of either nearby measurable information given in the filter window to focus the noise difference inside the filter window, or assessing the neighborhood commotion fluctuation utilizing the equivalent number of looks (ENL) of a SAR picture. The assessed noise difference is then used to focus the measure of smoothing required for every filter image. The noise difference decided from the nearby filter window is more appropriate if the intensity of a zone is consistent [5].

Speckle filters are illustrated as follows:

1. **Kuan filter:** The Kuan filter is based on a Minimum Mean Square Error (MMSE) criterion. A MMSE estimate is first developed for and additive noise model (y = x + n). The multiplicative noise model is then considered under the form (y = x + (n- 1) x) from which the corresponding linear filter is deduced. [6]. The Kuan filter is optimal when both the scene and the detected intensities are Gaussian distributed. Under the unit-mean noise assumption, the pixel value estimate $\hat{x}$ is given by:

$$\hat{x} = \bar{y} + \frac{\sigma_x^2 * (y - \bar{y})}{\sigma_x^2 + \frac{\overline{y^2} + \sigma_x^2}{L}} \quad \& \quad \sigma_x^2 = \frac{L * \sigma_y^2 - \bar{y}^2}{L+1} \quad \ldots \text{Eq. (1)}$$

2. **Lee filter:** The Lee filter (more precisely Lee MMSE filter) is a particular case of the Kuan filter when the term (σ^2 /L) is removed in Eq. (1). This term does not show up in Lee's unique inference because of a straight estimate made there for the multiplicative noise model. [7]
3. **Gamma filter:** The Gamma filter is a Maximum A Posteriori (MAP) filter based on a Bayesian analysis of the image statistics [8]. It assumes that both the radar reflectivity and the speckle noise follow a Gamma

distribution. The ‘’superposition’’ of these distributions yields a K-distribution which is recognized to match a large variety of radar return distributions of land and ocean targets. The estimate $\hat{x}$ is given by:

$$\hat{x} = \frac{\overline{\alpha - L - 1(\square)y} + \sqrt{\bar{y}^2(\alpha - L - 1)^2 + 4 * \alpha * L * \bar{y}}}{2 * \alpha} \quad \& \quad \alpha = \frac{L + 1}{L * \left({}^{\sigma_y}/_{\bar{y}}\right) 2 - 1} \quad \text{… Eq. (2)}$$

4. **Frost filter:** The Frost filter [7] is an adaptive Wiener filter which convolves the pixel values within a fixed size window with an exponential impulse response (m) given by:

$$m = e^{[-KC_y(t_0 * |t|)]} \quad \& \quad C_y = {}^{\sigma_y}/_{\bar{y}} \quad \text{… Eq. (3)}$$

Where K is the filter parameter, t_0 represents the location of the processed pixel and $|t|$ is the distance measured from pixel t_0. This response results from an autoregressive exponential model assumed for the scene reflectivity x.

Fusion:

Numerous methods have been implemented to fuse multi-temporal, multi-sensor, and multiresolution data. Principal Component Analysis method (PCA): The PCA method is based on the application of a classical statistical procedure of principal component analysis of the original bands of the multispectral image. In the calculation process of the principal components, most of the common information of the set of multispectral bands is contained in the first component. This component is substituted by the panchromatic band, equivalent in load of radiometric information, but with a better spatial resolution. The inverse transformation allows obtaining the fused image. The panchromatic image is histogram matched to the first principal component (sometimes to the second). It then replaces the selected component and an inverse PC transform takes the fused dataset back into the original multispectral feature space. The advantage of the PC fusion is that the number of bands is not restricted (such as for the original IHS or Brovey fusions). It is, however, a statistical procedure which means that it is sensitive to the area to be sharpened. The fusion results may vary depending on the selected image subsets [9].

Results and discussion:

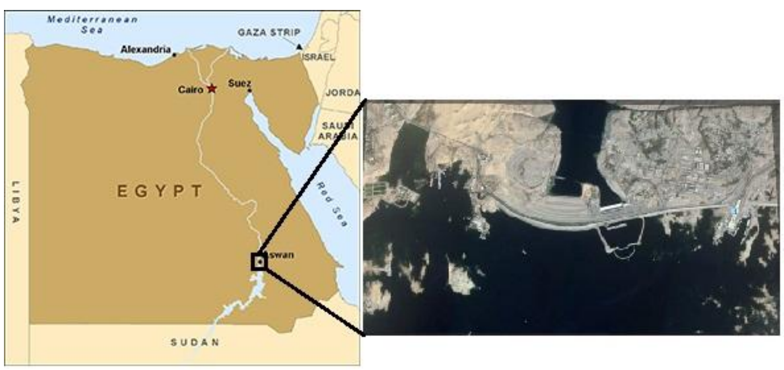


Figure 1: High Aswan Dam, Aswan, Egypt.

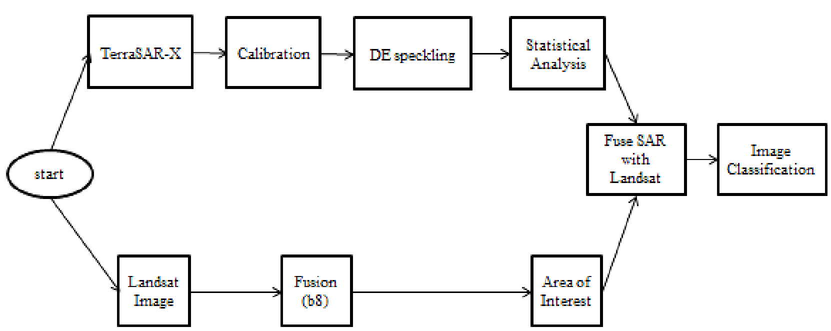


Figure 2: Flow chart of process

Processing of SAR data is a hard work due to the huge amount of data for small area, Figure (3) shows the results from doing de-speckle using mean, median, frost, gamma, lee, and refined lee filter methods.

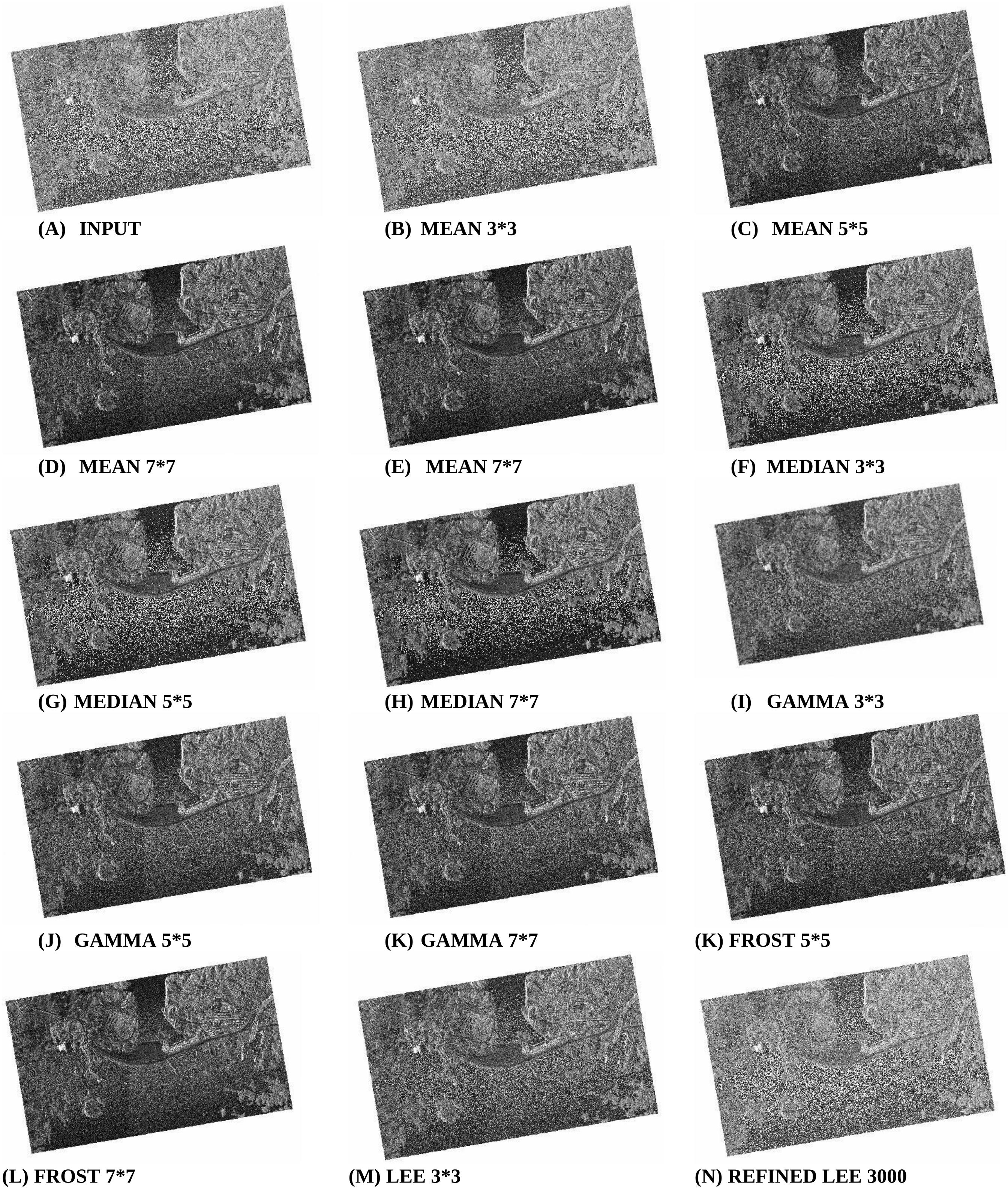


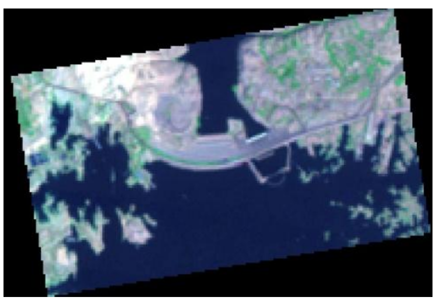
Figure 3: SAR input (A) and different speckle filter outputs (B to N).

From the visual interpretation median, gamma, lee, and refined lee filter images can be excluded from expectation due to the bad presentation, and from statistics and calculating ENL as shown in table(1) for each filter, mean filter with (7*7) kernels are the best to explain this area of interest.

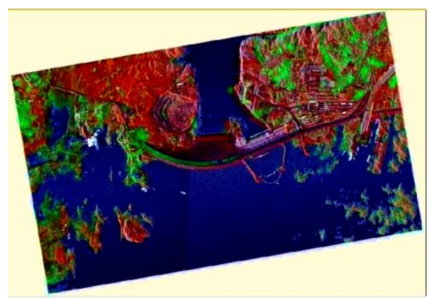
Table-1: Statistics of different filters for de-speckling

		NO.OF PIXLES	MEAN	STD	CV	ENL
1	INPUT	1349925001	-3.937	7.69	-2.05	0.238
2	MEAN 3*3	1349925001	-3.830	6.824	-1.811	0.305
3	MEAN 5*5	1349925001	-3.843	6.634	-1.801	0.321
4	MEAN 7*7	1349925001	-3.860	6.456	-1.721	0.338
8	GAMMA 3*3	1349912776	-3.830	6.581	-1.749	0.327
9	GAMMA 5*5	1349912776	-3.830	6.581	-1.749	0.327

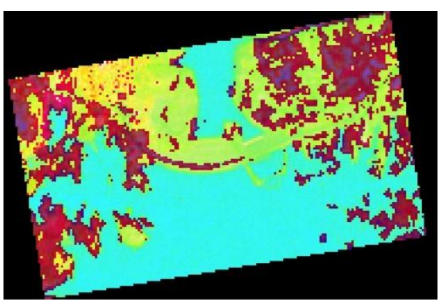
As shown in Figure (4), Landsat Image fused with panchromatic band (8) has low information to extract from it as its resolution is 15.0 meter only, so different methods of fusion were done using SAR image to enhance the resolution. Principal Component analysis (PCA), Multiplicative, and Intensity Hue Saturation (IHS) fused methods were applied. PCA displayed as the best for enhancement and classification, and fused image with SAR image has more details to be used in classification and interpretation of High Dam area, as shown in figure (5).



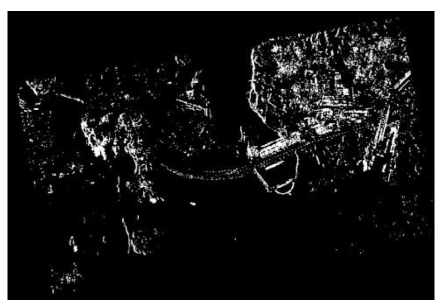
(A) Fused Landsat with band (8)



(B) PCA method

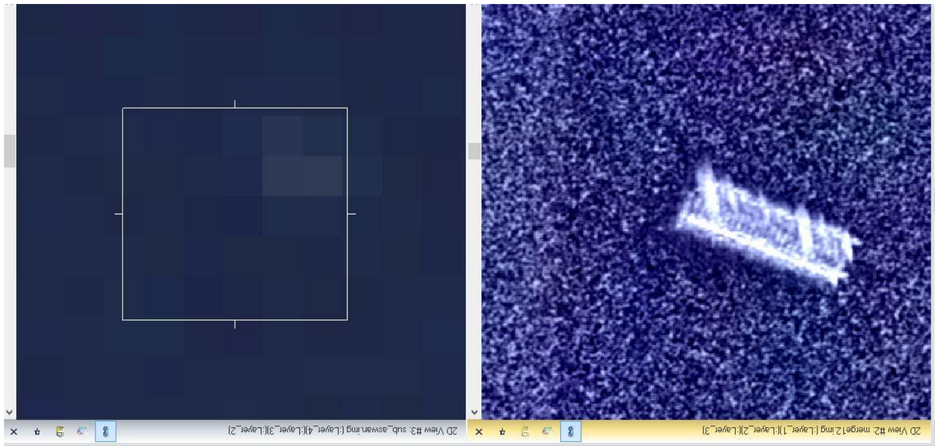


(C) IHS method



(D) Multiplicative method

Figure 4: image processing HIS, MIHS, and Fusion.



Fused With 15.0 m resolution Fused with 0.2 m resolution

Figure 5: Fusion using 15.0 resolution (left), and using 0.2 resolution (right)

Using geographic map that describe tectonic places in Aswan area as shown in figure (6), which mean that High Dam is located in the area of focal depth (0-2 Km). [10] The upper shallow (depth <5 km) crustal earthquakes are mostly influenced by the fluid saturated heterogeneous rock matrix.

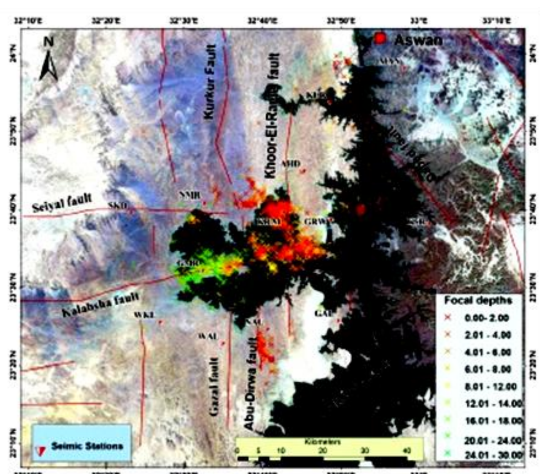
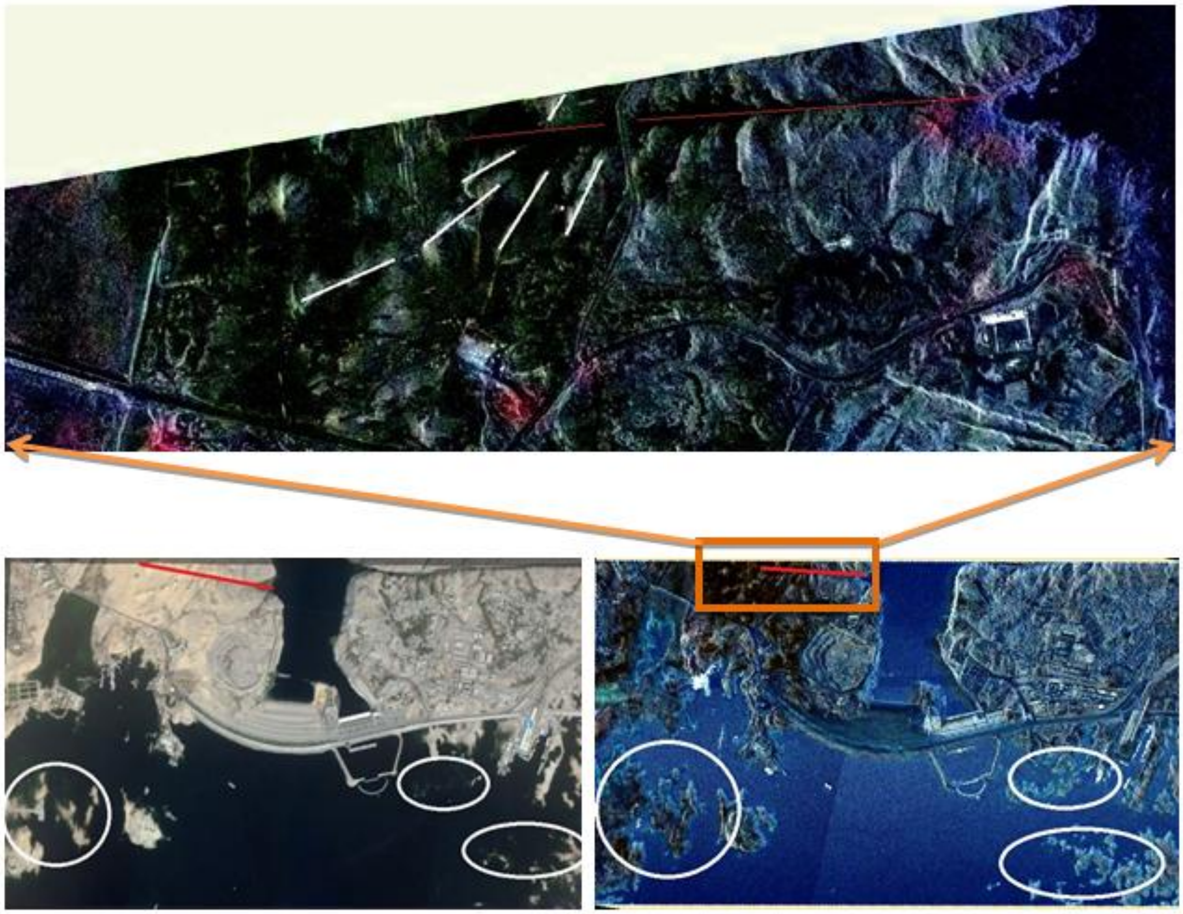


Figure 6: Tectonics and seismicity 1986–2003 in Aswan area. [11]

Using fused image from SAR, a proposed fault can be detected as shown doted red line, in the structurally controlled Wadi, the dykes put in white lines, and the rocks behind the Dam is more obvious and sharpen that can be obstructive and dangerous for boats (white circle), see figure (7).



Google earth image SAR image

Figure 7: Interpretation of SAR image [Red for fault/White lines for dykes /White circles for rocks]

Acknowledgment:

The authors gratefully thank all members in the Indian Institute of Remote Sensing (IIRS), Dehradun, India, and specially Mr. Shashi Kumar, and Mr. Mohamed Musthafa for their support during our course there.
Thank you for Dr. Farouk El-Baz for hosting the first author at the Boston university center for remote sensing to encourage scientific research using satellite image data.

References:

1. Jenson, J. R.; (2005): Introductory Digital Image Processing: A Remote Sensing Perspective, Upper Saddle River, NY, And Prentice Hall.
2. Chan, Y. K.; Koo, V. C.; (2008): An introduction to synthetic aperture radar (SAR) Progress in Electromagnetics Research B, Vol. 2, 27–60.
3. Mohamed, A. E. M. S.; (1993): The High Dam reservoir and earthquakes in Aswan, Egypt. Acta Geodaetica, Geophysica et Montanistica Hungarica, 28(3-4), pp 397-412.
4. Mekkawi, M.; Schnegg, P.; Arafa-Hamed T.; Elathy, E.; (2005): Electrical structure of the tectonically active Kalabsha Fault, Aswan, Egypt Earth and Planetary Science Letters 240 P. 764–773.
5. Tan. H. S.; (2001): Denoising of Noise Speckle in Radar Image, B.E. Thesis, School of Information Technology and Electrical Engineering, the University of Queensland, In: Jappreet Kaur; Jasdeep Kaur; manpreet kaur; (2011); Survey of DE speckling Techniques for Medical Ultrasound Images. Int. J. Comp. Tech. Appl., Vol 2 (4), 1003-1007

6. Kuan, D. K.; Sawchuk, A. A.; Strand, T. C.; Chavel, P. ; (1985):Adaptive Noise Smoothing Filter for Images with Signal-Dependent Noise", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. PAMI-7, pp. 165-177.
7. Frost,S.V.; Stiles, J.A.; Shanmugan,K.S.; Holtzman,J.C.; (1982):A Model for Radar Images and Its Application to Adaptive Digital Filtering of Multiplicative Noise", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. PAMI-4, pp. 157-166.
8. Lopes, A.; Nezry, E.; Touzi, R.; Laur, H.; (1993): Structure Detection and Statiscal Adaptive Speckle Filtering in SAR Images", Int. J. Remote Sensing, Vol. 14, pp. 1735-1758.
9. Chavez, P. S.; Sides, S. C.; and Anderson,J. A.; (1991): Comparison of three different methods to merge multiresolution and multispectral data: Landsat TM and SPOT panchromatic. Photogrammetric Engineering & Remote Sensing, 57, 295-303.
10. Haggag, H. M.; Bhattacharya, P. M.; Kamal, S.; Kayal, J. R.; (2009): Seismicity and 3D velocity structure in the Aswan Reservoir Lake area, Egypt. Tectonophysics 476 p. 450–459.
11. Telesca, L.; Mohamed, A.A.; Elgabry, M.; Abou Elenean, K.M.; (2012): Time dynamics in the point process modeling of seismicity of Aswan area (Egypt); CHAOS SOLITONS & FRACTALS 45(1):47-55.