Indonesian Journal of Electrical Engineering and Informatics (IJEEI)
Vol. 3, No. 4, December 2015, pp. 185~190
DOI: 10.11591/ijeei.v3i4.200

Image Registration Methode in Radar Interferometry

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Abstract

This article presents a methodology for the determination of the registration of an Interferometric Synthetic radar (InSAR) pair images with half pixel precision. Using the two superposed radar images Single Look complexes (SLC), we developed an iterative process to superpose these two images according to their correlation coefficient with a high coherence area. This work concerns the exploitation of ERS Tandem pair of radar images SLC of the Algiers area acquired on 03 January and 04 January 1994. The former is taken as a master image and the latter as a slave image.

***Keywords**: InSAR, image registration, iterative process, coherence, implementation, up-sampling*

1. Introduction

Image registration is an essential step in many images processing application that involves multiples images for comparison, analysis, medical imaging, and interferometry SAR. SAR interferometry is a useful technique for the generation of digital elevation model (DEM), it exploits the length difference of the wave's journey to and fro during acquisition of two radar images. The proposed technique for the half pixel co-registration of an Interferometric synthetic Aperture radar pair images, which is an extension of the phase correlation method based on one pixel precision [1]-[5].

In our work, we implemented an algorithm of co-registration to keep the common part between the two radar images (ERS-1 image acquired January 3, 1996 taken as a master and ERS2 image acquired on January 04, 1996 as the slave image) then we validate the result by generating the final interferogram after eliminating the orbital fringes [1].

1.1. Interferometry Process

1.1.1. Principale

The geometry of INSAR is shown in Figure 1; where S, M are the two satellites positions.

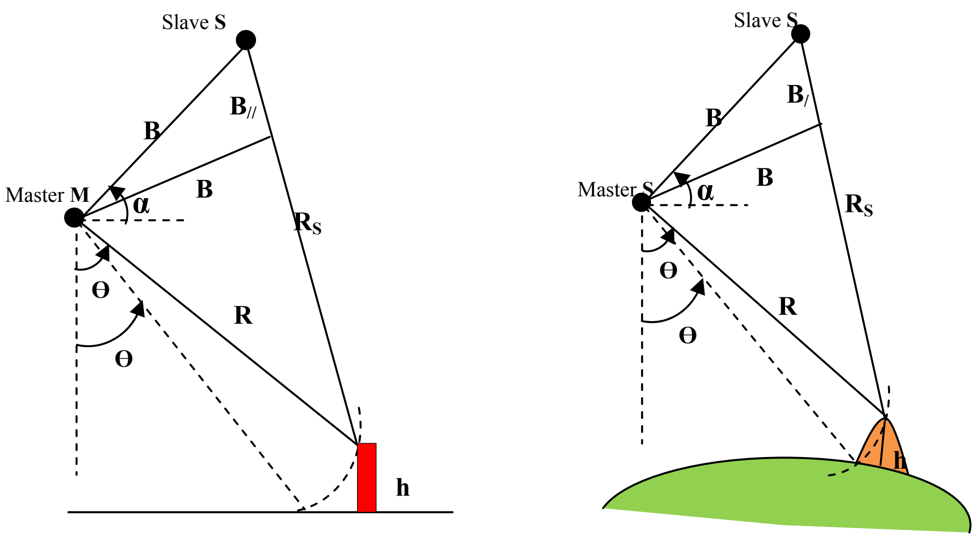

Figure 1. Radar

Received August 22, 2015; Revised October 27, 2015; Accepted November 10, 2015

The phase signal of a radar image measure the distance between the satellite and the target on the ground, the interferogram is defined as the phase difference. Where R_M, R_S are the distance between P and S, M. $B_{//}$ et $B_\perp$ are respectively the horizontal component and vertical component of the baseline, α is the tilt angel and θ is the incidence angel.

The phase of the target relative to the two acquisitions is:

$$\varphi_M = -\frac{4\pi}{\lambda} R_M + \varphi_{erreur\ M} \tag{1}$$

$$\varphi_S = -\frac{4\pi}{\lambda} R_S + \varphi_{erreur\ S} \tag{2}$$

R is the distance between target and satellite, Φ_{error} is the phase error due to signal delay caused by several phenomena (acquisition system, atmosphere etc ....).

The interferogram is obtained by this interferometric product:

$$S_M \times S_S^* = A_M.A_S.\exp\{\Delta\varphi\} \tag{3}$$

S is the complex image.
A is the amplitude of the complex image.

The phase difference Δφ is expressed as:

$$\Delta\varphi = -\frac{4\pi}{\lambda}(R_M - R_S) + \Delta\varphi_{erreur} \tag{4}$$

If we assume that the phase error of the two images are the same especially when the same satellite took the two images (double pass) and the atmospheric conditions are neglected. The phase difference becomes:

$$\Delta\varphi = \varphi_E + \varphi_{tpg} \tag{5}$$

with: $$\varphi_E = -\frac{4\pi}{\lambda} B\sin(\theta_0 - \alpha). \tag{6}$$

$$\varphi_{tpg} = -\frac{4\pi}{\lambda} B_\perp d\theta \tag{7}$$

This phase is divided into topographic phase which is proportional to the elevation and a flat-earth phase which is the result of the baseline and the radar acquisition [2].

1.1.2. Diagram of process

The interferometric process is done in Figure 2, in this work; we limit to the co-registration step witch conditions the result of this process giving a good quality of the generated interferogram.

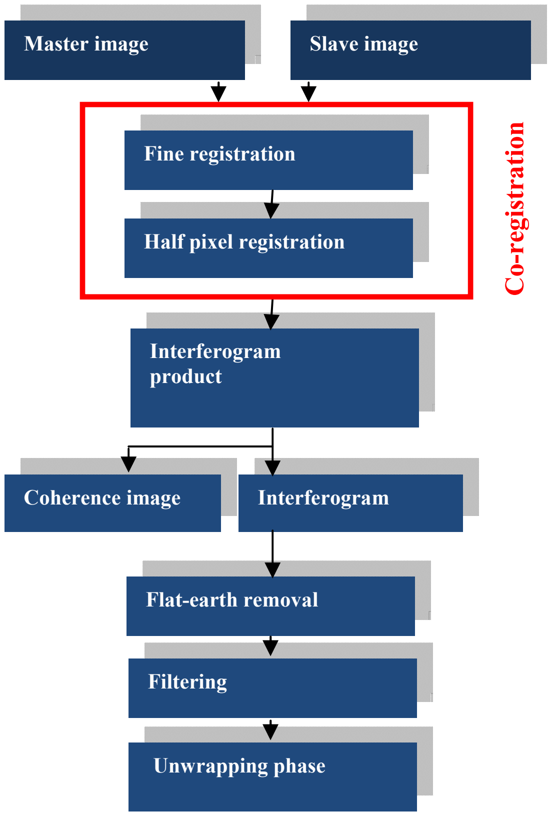

Figure 2. Interferometric process

Co-registration

The InSAR co-registration step is divided on two parts:

a. Fine registration

After extracting the common area between the two images (master and slave image), which is the preliminary step of the interferometric registaration step [1], for getting the best result, we developed this step, we start using the Fourier transforms propriety; the integer translation between the couple of the images in the range and azimuth direction is computed after calculating the cross spectre of these images [1],[4],[6].

b. Half pixel registration

The shifting values in the range and azimuth direction are computed with a half pixel precision, we up-sample the two images and for a set of windows over the images with maximising the coherence. We shift these windows with one pixel in the right and left direction according to the range axis and shifting the up-sampled images with one pixel in the up and down direction according to the azimuth axis. The right shifting is detected according the maximum of correlation. This part is explained in Figure 3.

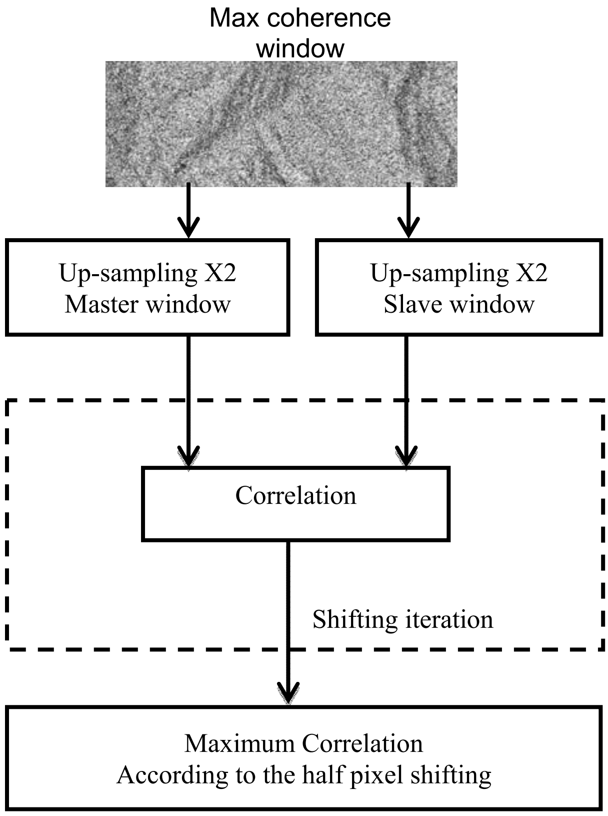

Figure 3. Block diagram of the half pixel registration

2. Application and Results

In our work, we used a pair of radar images of tandem ERS1-ERS2 type SLC (single look complex image) of the Algiers region. Their characteristics are given in the Table 1:

Table 1. Data Used

Mission tandem ERS		
Satellite	**ERS1**	**ERS2**
Produit type	SLCI	
Date	03/01/1996	04/01/1996
Orbite	23371	3698
Station of reception	Italian -PAF	Italian -PAF
Mode	Descendant	Descendant
Doppler frequency	386 Hz	
Frame	2871	
Track	00337	
Basline	190m	
Size	4900*26581 pixels	4900*26544 pixels

After extracting the common area between the two images (master and slave image), the fine registration application give a good superposition.

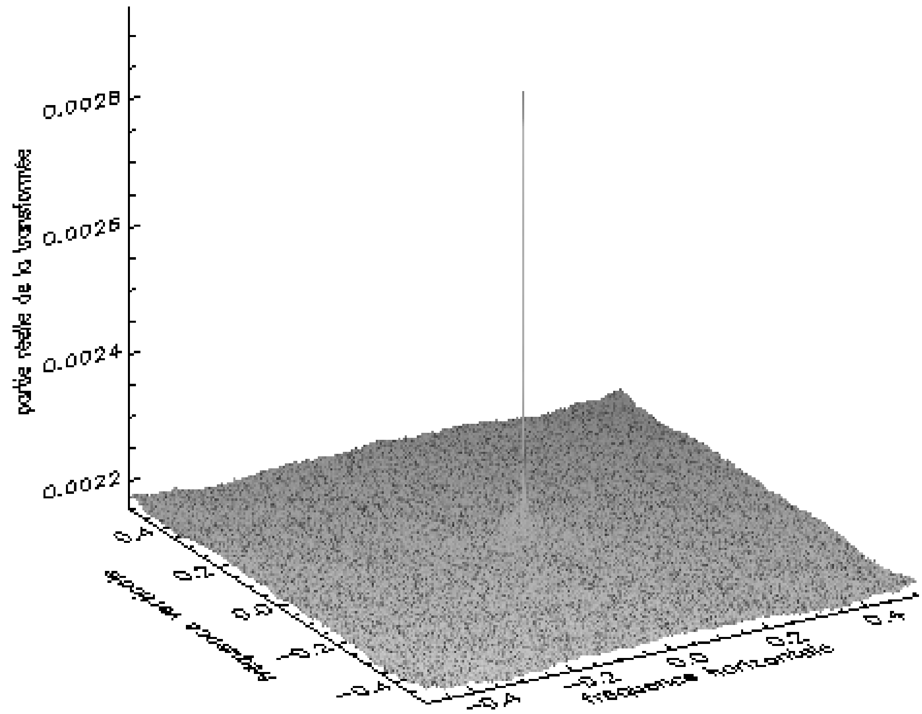

Figure 4. Integer shifting coordinates

Figure 4 shows the integer shifting between the two images, it give 10 pixels according the range direction and 0 pixels with the azimuth direction. Applying the diagram given in Figure 3, the correlation result corresponding to the different shifting of the two up-sampled windows is given in this table.

According the Table 2, the maximum of correlation is 0.5370 with the (0, 0) shifting respectively in the range and azimuth direction. This result corresponds to the final shifting 10.0 in the range direction and 0.0 in the azimuth direction. The coherence image and the final interferogram are given in Figure 5.

Table 2. Correlation Result

Horizontal Shifting / vertical Shifting	-1	0	+1
-1	0.4501	0.5281	0.5028
0	0.4529	0.5370	0.5196
+1	0.4273	0.5016	0.4934

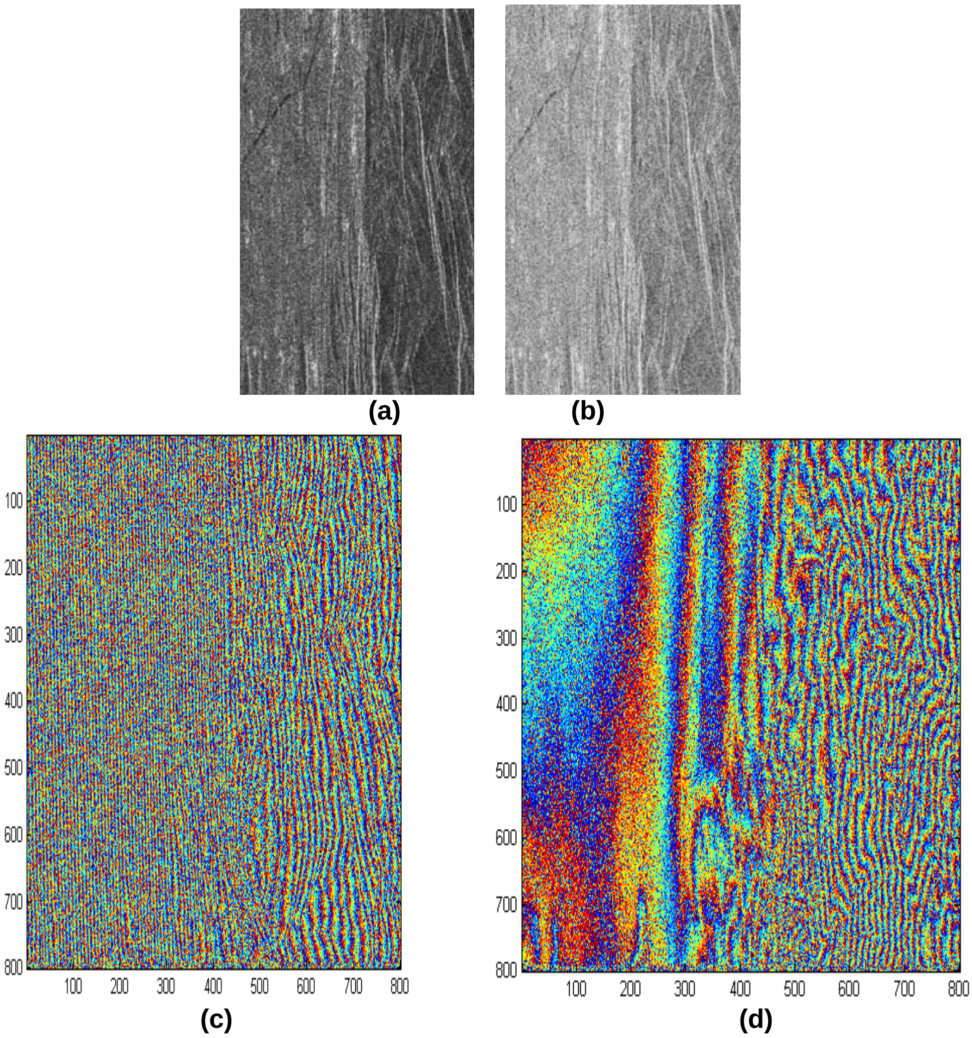

Figure 5. The coherence image and the final interferogram are given in

3. Conclusion

This work presents a new approach based on two steps, for the registration of an interferometric SAR pair images with half pixel precision. First, using the fine registration, we find the integer shifting by the phase correlation in the Fourier domain. Then, we introduce the half pixel registration that maximizes the correlation between both up-sampled images on window according to the coherence parameter using an iterative process. In future we intend to apply a sub-pixel registration with comparison of the different existing methods.

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