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ERS Interferometric Products Development at ASI-Space Geodesy Center

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Abstract

The scope of this work is to describe the two ERS Interferometric Products developed at ASI-Space Geodesy Center. These products will be available to the users as "application independent interferometric raw data" that will simplify the processing activities. The first product "SRI" (Single look complex Registered Image) is a multiband image obtained registering one or more slaves SLC to a master SLC. The final data consists of a set of annotated complex images. The second product "WFI" Wavenumber shift Filtered Image is a multiband product, derived by the SRI, containing the following layers: complex and filtered interferogram, coherence map and Interferogram Flattened on the earth ellipsoid.

Keywords: Interferometry, Coherence, Interferometric processing, Wavenumber Shift Filtering

Introduction

A lot of work has been done in the Research and Validation of the SAR Interferometry. Although the technique is well proven, to develop an applications, the users often has to start from the standard SLC products and has to properly process these data. Due to the presence at CGS of the Italian Processing and Archiving Facility, an effort has been done to define and develop a set of interferometric products which will make possible the use of the SAR Interferometry in an operational way.

An extensive papers review has been carried out to define a products set which could be useful for a wide spectrum of applications and the best processing algorithms available.

Data processing has been structured in a pipeline fashion, which permits to obtain all the intermediate products and simplify both the SW test and product validation. Furthermore the absence of manual operator intervention results in a well stable product quality.

In this paper a overview of the products characteristics and of the processing algorithms is presented. The first product is called SRI (Single look complex Registered Images) and contains a couple of registered complex images with some annotations like the baseline value for every image line. The second called WFI (Wavenumber shift Filtered Interferogram) is composed by a set of image layers: wavenumber effect filtered images, complex interferogram (optionally flattened on the earth ellipsoid) and coherence map.

SRI (Single look complex Registered Images)

The input data for the Image Registration step is a couple of complex products (e.g. ERS.SAR.SLC), in slant range/azimuth coordinate system, given as a IQ data sequence with each channel quantized in signed 16 bit format. The key point in the SLC registration is the derivation of the distortion function (hereinafter called the warp function WF). The WF sets up a corrispondence between the pixels of the master image and those of the slave image.

The WF is derived using: orbital & geographic informations, image morphology, phase information. From the master and slave image geographic location and the orbit, a Very Coarse Registration is derived. The precision of this first estimate of the warp is poor (10-20 pixels) but has the great advantage of a completly automatic processing. No tie points and no image visualization is necessary during this step.

The next operation (the Coarse Registration) refines this registration extracting and correlating a set of master-slave cells. The cell extraction is done using the corrispondence obtained from the previous step and the cross correlation is interpolated to reach a 0.1 - 0.5 pixel precision. Because the correlation is done between the cells amplitude, no phase information is used.

The last step in the warp evaluation is called Fine Registration and uses the APF (Average Phase Fluctuation) algorithm to find a high precision shift between the master-slave cell couple. The slave cell is shifted using the FFT properties and the cell interferogram is then derived. A two dimensional minimization is used to find the shifts which produce the minimum phase noise. Knowing the precise shifts parameters in every cell, a best fit polynomial WF is obtained. Three degrees are available spanning from the first to the third. The next operation consists in the slave interpolation on a new grid defined by the WF. Due to the dimensions of the images, first of all the slave SLC is segmented in small blocks (e.g. 200x200 pix) and then each tile is registered onto the master. The interpolator function has to be carefully selected because: in the azimuth direction the warp function shows small variation but the spectra is not zero centered and so no "simple" low pass interpolator can be used; in the range direction the spectra are zero centered but the variation of the warp function are high. For these reasons we have chosen the following interpolation type: a FFT in azimuth, evalued for every line and a cubic convolution in range computed for every pixel. The master image is resized to contain only the portion common to both the images.

As last step, a coarse baseline computation is done, based on the propagated orbits and the WF knowledge. Using the WF it is possible to sincronize the time of the two orbits and to evaluate the baseline as vector function of the range line. The coefficients of the polinomial which give the baseline are annotated in the output product.

WFI (Wavenumber shift Filtered Interferogram)

The presence of a terrain slope seen in slight different way by the master and the slave sensors produce a shift in the range spectra of the interferometric couple [1] [2]. This effect, called wavenumber shift has to be properly handled if we want to avoid the interferogram decorrelation associated to the geometry. To correct this decorrelation effect, a filtering of both the images must be done, with a couple of "wavenumber" filters. These filters must be generated starting from the knowledge of the local interferogram fringe frequency (related to the local terrain slope).

In the first step, a subdivision of the SRI data is done, selecting a set of cells equally spatially in the image. The sampling is done with a somewhat high spatial frequency because the frequency shift has a strict dependency from the slope change in the imaged terrain zone. For each cell, the relative frequency shift is estimated deriving a local range fringe frequency map. The "wavenumber" filters (distinct for the master and slave image) are then generated as range and azimuth dependent functions and a standard method (like Overlap & Save) is used to filter the entire SRI data. It is worth to say that, before the filtering, the images are interpolated in range by two, using a FFT and zero pad, to avoid the aliasing effect during the interferogram formation step. The resulting output product is called WFI - (Wavenumber effect Filtered Images) and is constituted by a wavenumber effect filtered master-slave couple.

From the previous WFI couple the complex interferogram is simply obtained multiplying the master WFI with the coniugate of the slave WFI. This leads to a complex image which has as amplitude the product of the master and slave amplitude, and as phase the phase difference between the two images. The coherence map can be evalued as usual but correcting the topographic factor (as given from the local 2D fringe frequency) and using "non biased" coherence estimation algorithms [3][4]. In such way the coherence map is derived and given as a further layer of the WFI data.

Given a certain geometry of a couple of side looking SAR sensors, only one half of the fringe frequencies has a physical meaning. The other half comes from the noise and the layover effect. The geometry determines which is the right half spectrum and so the sign of the layover filter. Once this filter is evalued, the complex interferogram can be filtered giving in output another layer of the WFI product, the complex filtered interferogram.

Using the baseline, the orbital data and the earth ellipsoid shape the phase contribution which depends by the presence of a "mean terrain", can be computed. The subtraction of this effect from the interferogram is called "flat terrain removal". After this step, the interferogram fringes depends only by the elevation above the ellipsoid.

The last step is the phase unwrapping of the interferogram, which recovers the true phase from its residual modulus 2 PI. At present many algorithms exists, each with advantages and drawbacks [5]. For this reason we are actually analyzing the various approaches, to find the best solution to the unwrapping problem into a operational context.

Conclusions

A first descripription of the I-PAF Interferometric products has been given. The product SRI is under validation and will be soon available to the users. The WFI product, without the unwrapped layer, is in advanced development phase and will be released in the early 1997.

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