INSAR PERMANENT SCATTERERS SELECTION USING SAR SVA FILTERING

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1. INTRODUCTION

The interferometric SAR technique has demonstrated its capability to measure ground deformation in wide range of application. However, they still have limitations due to temporal and geometric decorrelation. These disturbances strongly compromise the accuracy of the results, but reliable measurements can be obtained over a large multi-temporal population of interferograms.
Previous works showed that the problem of decorrelation can be solved using the Permanent Scatterers (PS) technique [1]. Ferretti and al. are the first team who define the PS notion but since 2000 several works use this approach to measure and monitor ground deformation by a millimetric precision.
This technique allows the identification and the use of natural stable scatterers which are not disturbed by decorrelation noise such as buildings, rocks, etc. starting from a multi-temporal database of interferometric images. The first identification phase make possible to extract these pixels based on a selected criteria. It is the most difficult task. Then, the ground movement estimation is done starting from these reliable and precise pixels phase values and generalized on the entire image.
In this paper, we develop a new technique allowing the selection of permanent scatterers based on SVA (Spatially Variant Apodization) filtering [2]. This method is a nonlinear sidelobes reduction technique that improves mainlobe level and preserves its resolution at the same time. It implements a bidimensional finite impulse response filter with adaptive taps depending on image information and has been already used in SAR filtering applications [3]. The idea is here to select pixels with high reflectivity (high mainlobe level) over long period of time which is the main feature of PS pixels as shown in [1]. Finally a comparison between PS candidates (PSC) defined in [1] and SVA selected pixels (SVAP) conclude this study.

2. SVA PERMANENT SCATTERERS SELECTION

The radar impulse response system is theoretically a sin cardinal (sinc) function. Thus in cases of isotropic strong reflectors, the sinc function sidelobes are spread around this reflector and cover his response of weaker surrounding reflections. In the literature, several methods were developed to lower the importance of these lobes. The simplest solution which has been traditionally used in SAR imagery reduces sidelobes by applying an amplitude weighting function as example the Hamming weighting function. Many other functions have been developed for a variety of purposes but they all are a compromise between a narrow mainlobe and low sidelobes which cause a degradation of the image resolution. More advanced techniques show that apodization can be accomplished on a pixel-by-pixel basis, using non linear operators to suppress sidelobes while preserving the main lobe resolution. We are interested especially in SVA methods, initiated by Stankwitz [3]. The originality of this approach is that it seeks in each pixel of the image, the optimal window which preserves the mainlobe.

2.1. SVA and PS correspondence

A Permanent Scatterers pixel (PS) is characterized by keeping good coherence over long periods. It is thus not affected by decorrelation noise for each interferogram of the multi-temporal database. According to Ferretti and al [1], PS pixels are also characterized by a strong reflectivity starting from the fact that phase dispersion is almost equal to amplitude dispersion for high signal to noise ratios.
Thus if we make analogy with the definition of SVA filtering process described above, a PS pixel will be the maximum of the sinc function (amplitude radar response). The neighborhood pixels which have relatively strong answer will be located on sidelobes distribution. Hence the equivalence between PS pixels and filtered SVA ones is established.
Indeed, SVA filters identify pixels being on the maximum of the sinc function mainlobe while eliminate sidelobes. This feature allows these pixels to keep the same reflectivity, a strong reflectivity, for any radar image, or for the whole multi-temporel database.

2.2. Adaptative SVA filtering

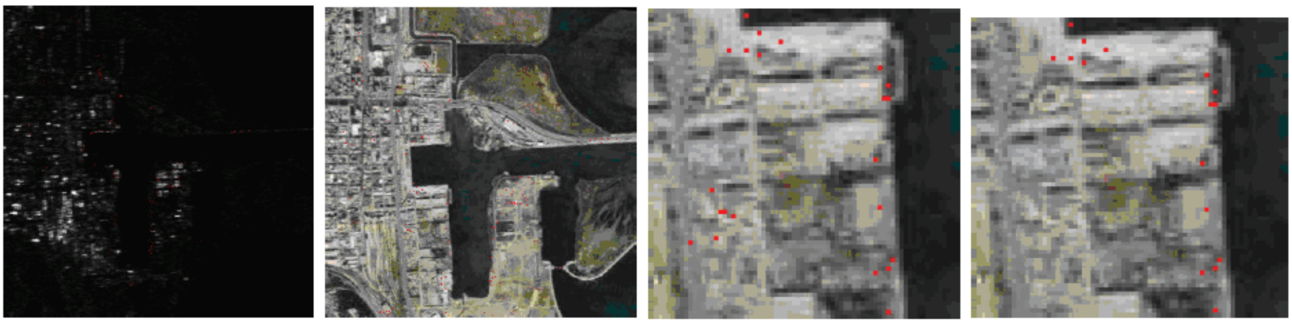
The SVA 2D filter we use here is the product of two 1D filters (horizontal filter and vertical filter) whose spectral apodisation windows are cosine-on-pedestal weightings. The produced 2D filter has the advantage of depending only on two coefficients A and B of both 1D filters. These two parameters which play a symmetric role are calculated starting from pixels values inside a 3x3 window by an exact and non iterative method proposed in [2]. According A and B, an adaptive filtering will be applied to interferometric images. We considered the following cases:

- (A= 0; B = 0): pixels are not modified.
- (A= 0.5; B = 0.5): local Hanning filtering.
- (A= 0.5; B = 0): Hanning filtering according to Ox, no filtering according to Oy.
- (A= 0; B = 0.5): Hanning filtering according to Oy, no filtering according to Ox.
- $(A,B) \in]0,0.5[$: In this case, A and B are solutions of a polynomial of degree 2 and a polynomial of degree 3 [2].

In the last case, if B (respectively A) is solution of the polynomial of degree 3, we are in the presence of a SVAP. If B (respectively A) is solution of the polynomial of degree 2 then the signal norm is equal to zero.
After applying SVA filtering on each radar image in order to identify pixels with maximum reflectance. Permanent scatterers SVAPs are those selected as SVA for the entire database.

3. EXPERIMENTAL RESULTS

This work was experimented using 26 radar archive ENVISAT images (acquired by means of ESA project C1P.5054) covering the region of Tunis City (Tunisia, North Africa). During the last years, Tunis City has launched a huge city planning project by banking water areas and has known a big growth in urban building and infrastructure. Nevertheless, this investigation may conduct to some residual consequences on the area notably the ecological system perturbations causing some local and slow ground movements. PS technique is applied to this region is order to get subsidences accurate measurements. Both SVA filtering and dispersion amplitude thresholding are applied to select respectively SVAP and PSC pixels.
When superposing the two sets of pixels, we notice an important result which is that all pixels SVAP are Permanent Scatterers Candidates (see figure1). Thus SVA filtering technique is more discriminating than PSC selection. In future work, this set of SVAP will be compared to real PS pixels to evaluate the potential of the proposed method.



(a) (b) (c) (d)

Figure1: Are selected SVAP PSC? (a) Superposition of SVAP mask on radar image (b) Superposition of SVAP mask on a Google Earth image (c) Zoom on PSC pixels location (d) Zoom on selected SVAP location.

4. REFERENCES

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