A NEW APPROACH TO IMPROVE THE ACCURACY OF BASELINE ESTIMATION FOR SPACEBORNE RADAR INTERFEROMETRY

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1. INTRODUCTION

Interferometric synthetic aperture radar (InSAR) has demonstrated its value as a cost-effective technique for topographic mapping. The obvious advantages of InSAR compared to those of photogrammetry are that it can be used under all weather conditions, at any time of day or night. It has developed rapidly since it was first applied to earth observation by Graham [1]. This technique has also been employed in spaceborne systems. In such systems the separation of the antennas, called the *baseline,* is obtained by utilising a single antenna in a repeat pass [2].

To obtain high-quality topographic maps using spaceborne InSAR requires an accurate determination of the baseline. Inaccurate baseline information will lead to incorrect flat-earth fringe removal and erroneous interferometric phase-to-terrain height conversion. There are three approaches to baseline estimation. (1) Orbit method, which relies commonly on the direct subtraction of the two satellite orbits, using satellite emphemeris data [3], [4]. (2) GCPs (Ground Control Points) can be used to estimate the baseline based on the unwrapped phase image. However, the quality of the GCPs has a significant influence on the accuracy of the estimated baseline [5]. (3) Baseline can also be estimated directly using direct measurements such as for example dual-frequency GPS and wireless/laser measurements between two satellites [6]. (4) Frequency method, which is based on the frequency feature of interferogram. The basis of this method is that the phase of the interferogram is a function of slant range and the height of target [7].

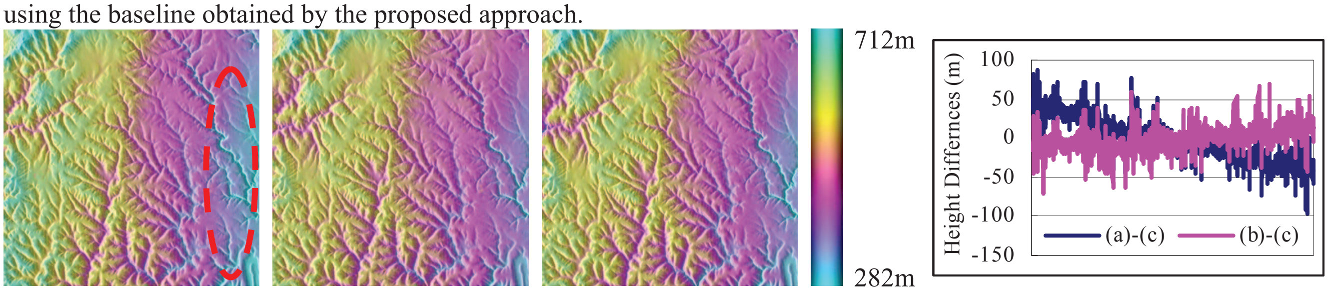
2. METHODOLOGY

In this paper, a new approach to improve the accuracy of baseline estimation for spaceborne radar interferometry has been developed which requires no phase unwrapping and no GCPs. To start, an existing digital elevation model (DEM) acquired by the Shuttle Radar Topography Mission (SRTM) with coarse pixel resolution is used to simulate the SAR intensity image based on the geometry of a real SAR image (master) as a reference. The simulated SAR image is then co-registered with the master image. The information from the external DEM can be projected from the DEM coordinate into the radar coordinate based on the pixel offset polynomials calculated from the co-registration step. Tie points are evenly selected from the master image based on an n-by-n grid. Then the x, y and z vector components of the baseline at the tie-points are calculated based on the satellite emphemeris data and the external DEM information, and hence a preliminary baseline is computed using a least-squares fitting process. The preliminary baseline is represented by three polynomials corresponding to the three dimensional components (namely x, y and z) with the azimuth and range time as variables.

Another SAR image, the slave, is used to form an interferometric pair with the master image. The preliminary baseline and the external DEM information are used to simulate the flat-earth phase and the topographic phase. These phases are then subtracted from the interferometric phase between the master and slave images to generate the differential interferogram. Fast Fourier Transform (FFT) is applied to the differential interferogram to estimate the number of fringes in both the azimuth and range directions. Because most of the topographic phase information has already been removed, the remaining fringes are mainly due to the baseline error. The phase error is then calculated from the frequency of the remaining fringes. Finally, the coefficients of the three polynomials described above are optimised by using an error equation based on the phase error with the preliminary baseline parameter as initial values. Therefore, a more accurate baseline can be obtained for the interferometric pair after iteration.

3. EXPERIMENTAL RESULT

An ALOS PALSAR pair is used in this study to verify the effectiveness of the proposed approach. Two DEMs are generated with the ALOS PALSAR pair (Master: date = 14/08/2007 orbit = 8277 mode = FBD; Slave: date = 29/09/2007 orbit = 8948 mode = FBD; both are from path = 370, frame = 649, polarisation = HH, acquired over Appin, Australia) by using the baseline which is obtained by the conventional InSAR approach (Fig. 1a) and comparing with the proposed approach (Fig. 1b). The baselines obtained from both approaches are used for flat-earth fringes removal and the conversion of the interferomeric phases into absolute surface heights. The DEMs generated by both approaches are compared with a reference 25m resolution DEM (Fig. 1c). By comparing the three DEMs, it can be seen that the DEM generated by the proposed approach matches well with the reference DEM with a root mean square error (RMSE) of 21.21m. On the other hand, the RMSE between the DEM generated by the conventional InSAR approach and the reference DEM is much larger, being 30.27m. Remaining flat-earth fringes can be easily observed from the DEM generated by the conventional InSAR approach, as highlighted by the red broken line in Fig. 1a. It can be also seen from Fig. 1d, which represents the profile of height differences between the reference DEM and the DEMs described above, the quality of the DEM is considerably improved by using the baseline obtained by the proposed approach.



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

Fig. 1. DEMs generated by using the baselines which are obtained by (a) the conventional InSAR approach and (b) the proposed approach; (c) 25m resolution DEM (d) Profile of height differences

4. CONCLUSION

A new approach to improve the accuracy of baseline estimation for spaceborne radar interferometry has been proposed in this study. It requires no phase unwrapping and no GCPs. The approach has been compared with the conventional InSAR method and tests have shown that the proposed method is able to obtain a more accurate estimation of the baseline, and hence can generate DEM with higher accuracy.

5. REFERENCES

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