Lab Exercise II: SAR Interferometry – Generation of Digital Elevation Models

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Synthetic aperture radar interferometry is widely used for the generation of digital elevation models (DEM). The topographic information is derived by exploiting the phase differences of the coherent radar signal from 2 complex-valued SAR images (defined as Master and Slave image), which are acquired from slightly different orbit positions. Three essential steps are the main components of the standard InSAR processing (Fig. 1):

1) coregistration of the two complex images
2) interferogram generation and coherence estimation
3) phase unwrapping

The exercise will be split into three parts according to the above mentioned components.

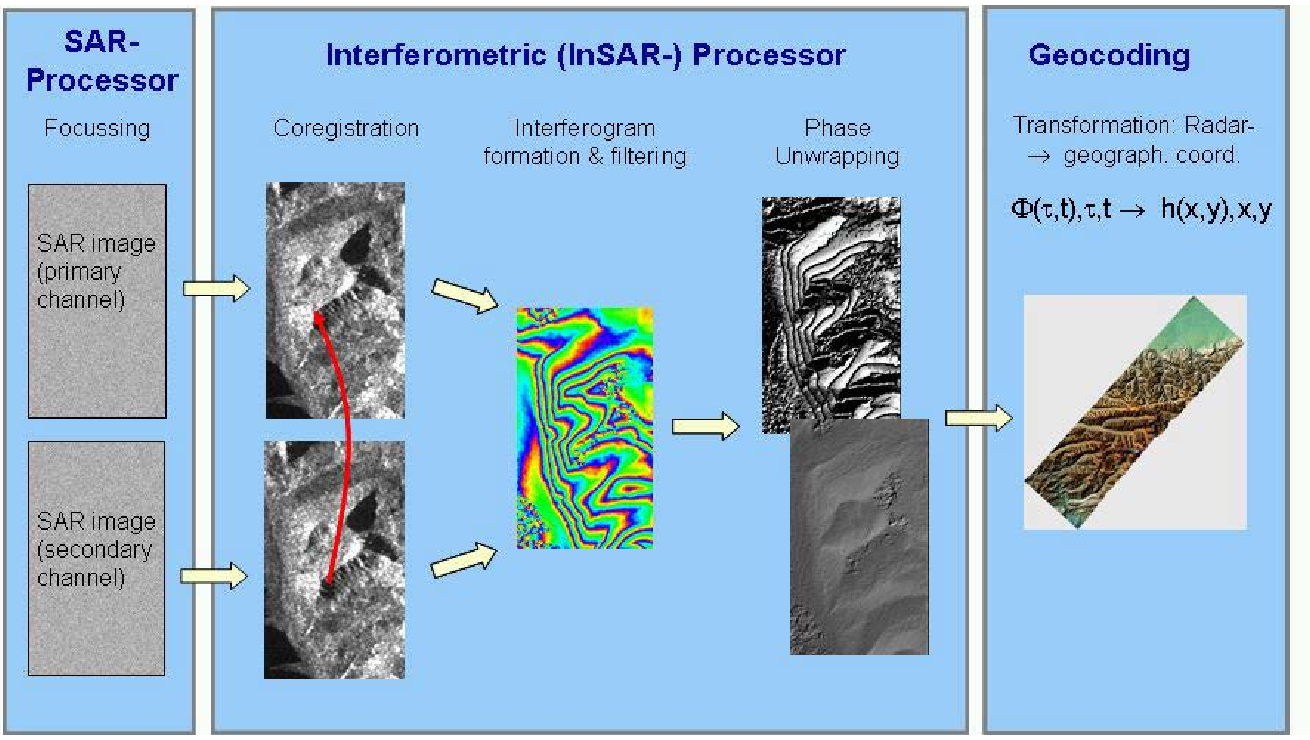

Figure 1: interferometric processing

Task 1: Coregistration

In order to extract the correct interferometric phase differences, the images have to be sub-pixel precisely coregistered before the actual interferometric processing. An imprecise co-registration causes a coherence loss between the two SAR signals which will have a great influence on the interferogram noise and the impact of the DEM quality.
Coregistering is done by calculating offsets in range and azimuth direction between the two images. Therefore the cross-correlation of the **intensity (squared amplitudes)** is commonly used to find the homogenous points. The shifts or displacement vectors define the transformation to match the slave image with the master.

Working steps:

1) Load the data (Master.mat, Slave.mat), convert amplitudes to **intensities**, visualize images (units: dB)
   For the sake of simplicity continue exercise with data scaled to dB.
2) Coarse coregistration: find one common point or two in both images and extract the offset from the coordinate differences. Hint: zoom into city areas, try to find bright points in master and search for the corresponding point in the slave dataset.
3) Fine coregistration: cut small regions (e.g. 28x28 pixels from slave image and 32x32 pixels from master image) around selected points used for coarse registration. Oversample both (small) datasets by factor 8 (2D zero-padding in frequency domain) to get sub-pixel accuracy after cross-correlation. Cross-correlate the two oversampled images. The peaks (wrt. the center) of the correlation matrix indicate the shift vectors.
4) Resampling: For this exercise just cut the full data matrices (corresponds to shift using rounded shift values)

Hints:

- Scale intensities to dB: 10*log10 (intensity)
- Fine coregistration: after ifft data may be complex; use abs() to correct

Useful Matlab functions:

- load & imagesc: load data & visualize data matrix
- abs & angle: get amplitude & phase angle of complex number
- ginput: get position from axes in figure
- zeropad2d: zero-padding 2-dimensional matrix
- fft2 & ifft2: 2-dimensional fast fourier transformation & inverse transformation
- xcorr2: correlation function of 2-dimensional data