Class 06 – Radar Image Processing

1. Speckle noise elimination

The radiometric quality of SAR data is affected by factors that are inherent to the instrument, as well as to the geometry of the illumination. The two main causes of radiometric distortions that impair the interpretation of radar imagery are: speckle noise, and the antenna pattern effect.

Speckle noise is one of the main factors in the degradation of the SAR image quality. Speckle is a multiplicative noise that is proportional to the intensity of the received signal. The visual effect of such noise is a grainy texture that can hamper the interpretation of the radar imagery, reducing the distinction among land use classes, lithologic types, etc...

There are two methods for the reduction of Speckle: filtering and the multi-look processing. The filters should maintain the mean value of backscatter, preserve the borders and the texture information of the image.

Speckle Noise Filters

***Frost Filter** [Frost – 1982]: is a convolutional linear filter, derived from the minimization of the mean square error over the multiplicative model of the noise. This filter incorporates the statistical dependency of the original signal, since it presupposes that an exponential spatial correlation exists between pixels. It is an adaptive filter that preserves border structures.*

***Lee Filter** [Lee – 1981]: adopts a multiplicative model for the noise and obeys the criterion of a **local linear minimum mean square error. Local** because it uses local statistics of the pixel to be filtered, admitting the non-stationarity of the mean and variance of the signal. It is a linear filter because it performs a linearization by*

*Taylor series expansion of the multiplication of the signal and the noise around the means, using only the linear terms. The results of this linearization transform the multiplicative model of the noise into additive, that is, the noise and the signal become independent; and finally, **minimum square error** because it minimizes the mean square error through a Wiener filter (filter based on the criterion of minimum square error). The Lee filter is an adaptative and general filter.*

***Kuan/Nathan Filter** [Kuan et al.-1982]: adopts the multiplicative method. The procedure is similar to that of Lee, where the point to point estimation is done with a Wiener filter. The difference between them, however, consists in the fact that in the Kuan/Nathan filter no approximation is performed. It is also an adaptative and general filter.*

⇒ ***Elimination of Speckle noise:***

*Windows: **#Start - Spring<version><Language><system> - Spring<version> <Language>***

Linux: # Command to be typed on the Console (Shell) - # s_spring

*MAC: #Dock - Launchpad - Spring <version> < **language** >*

SPRING

Load database **Course*

Load project **Radar*

View the image **Ima_radar*

- [Image][Filtering...]

Filtering

- (Types   Radar)

- (Speckle Noise Filters   Lee)

- (Type   Adaptative)

- {Image Output: Sarex_Lee}

- (Bounding Box...)

Bounding Box

- (Cursor - yes)

** Select the area using the cursor on the image*

- (Acquire)

- (Apply)

Filtering

- (Apply)

*Perform the same procedure for filter **Kuan** {Image Output: Sarex_Kuan}

* If the option "Automatic Visualization of infolayer created" is actived in the tool "Environment Configuration", by clicking "Apply" your IF will be automatic drawn on the assistant page.

*Perform the same procedure for filter **Frost** with:

Filtering

- {Image Output: Sarex_Frost}
- (Correlation Coefficient 89)

*View and compare the results

2. Antenna pattern correction

The algorithm consists in generating a pattern through the average of the image columns. The average of the columns should be taken in regions (windows) as homogeneous as possible. We must guarantee that the average value exists in all range directions.

The pattern obtained from the average of the columns should be filtered (adjusted) to obtain only the low frequency variations.

Two methods can be used in the filtering (adjustment). The first method is the moving average, which consists in filtering the pattern through a mean filter, where the number of points, considered in the mean calculations, is defined by the size of the interface window. The second method is the polynomial adjustment, where the degree of the polynomial is selected in the interface.

Antenna pattern correction

Windows: **#Start – Spring<version><Language><system> – Spring<version> <Language>**

Linux: # Command to be typed on the Console (Shell) – # s_spring

MAC: #Dock – Launchpad – Spring <version> < **language** >

SPRING

*Load database **Course**

Load project* ***Tapajos*

View the image* ***Sarex*

- [Image][Antenna Pattern Correction...]

Antenna Pattern Correction

**select a sample on the image*

- (Acquire)

**repeat until all the color variations are acquired*

- (Pattern Adjustment ⇔ Moving Mean)

- (Adjust), (View...)

**Test (Moving Average) and (Polynomial) to select the best*

- {Output Image: Sarex_cpa}

- (Apply)

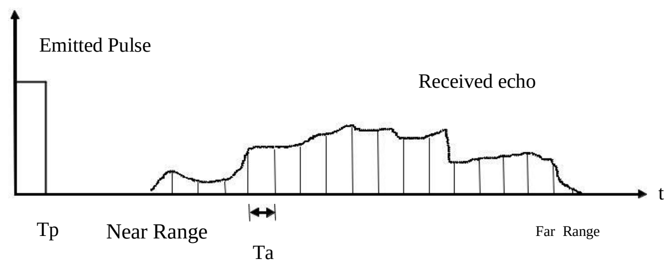
** If the option "Automatic Visualization of infolayer created" is actived in the tool "Environment Configuration", by clicking "Apply" your IF will be automatic drawn on the assistant page.*

3. Slant to ground range conversion

Besides the geometric distortion caused by the antenna pattern, another type is the one caused by the radar side looking. The side looking makes the acquired image have an inclined projection related to the ground; this provokes a compression of the image. Such compression varies along the imaged stripe; the closer the image pixels are from nadir the more they will be compressed.

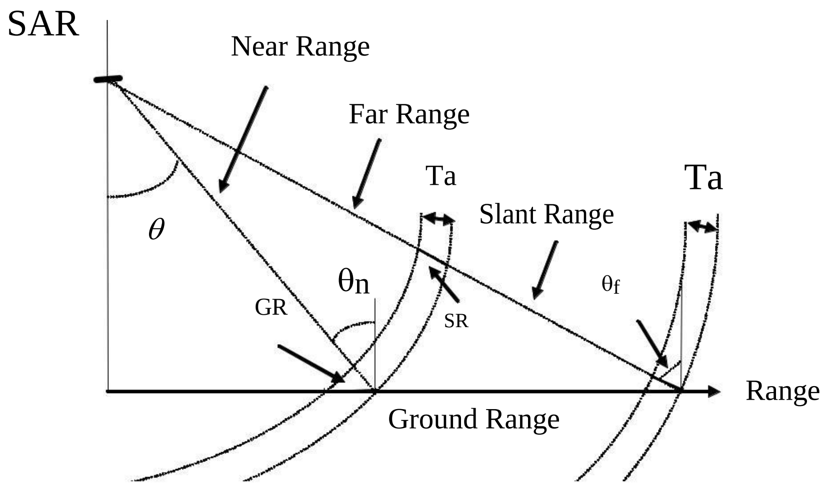
The conversion of the inclined projection image to ground projection is called slant to ground range.

The slant image (in the inclined projection) is related to the acquisition mode of side looking radars. The following figures show how the data acquisition process is performed.



The sampling of echo received at intervals Ta

The sampling process makes the information contained on each Ta interval to have different areas for samples in the near range as compared with the far range, due to the incidence angle θ, as is shown in the following figure.



Slant and Ground Range Image

The image that is formed is called "inclined" or in slant range. Such image presents geometric distortion, for the equally spaced SR samples in the imaged stripe are not equally spaced on the ground, GR. In order to be able to register and geocode the image the ground samples must be equally spaced, that's why we need to convert from slant to ground range.

The conversion consists in projecting the samples (pixels) on the ground and then resampling them with uniform spacing. In order to perform such conversion one has to use some parameters referred to the geometry of the SAR, like height of flight, minimum distance (the distance between the sensor and the first pixel), and minimum time (the time measured between the sensor and the first pixel). These parameters are in general present in the header of the selected image. If they are not, one must fill in the fields of ***height,*** *and* ***minimum inclined distance****, or* ***minimum incidence angle****, or* ***minimum time****. Any one of the three last parameters is enough for the conversion.*

Another information that should be considered is the position of the imaging, either right or left side, that can be identified by the shadows in the image provoked by the side looking feature of the SAR.

To resample the inclined image, in order to obtain a uniform ground sample, three types of interpolators can be used:

Nearest Neighbor *– this interpolator must be used when it is desired to keep the gray levels of the image without generating intermediate values, such interpolator preserves the statistics of the image.* ***Linear*** *– interpolates using a straight line.*

Cubic *– interpolates using a parabola.*

The relationship between the slant range, δ_{SR}*, and the ground range,* δ_{GR}*, resolutions depends on the incidence angle* θ *as follows:*

$$\delta_{GR} = \delta_{SR} / \cos(90 - \theta)$$

The ideal conversion is the one that takes into account the numeric model of the terrain, allowing the correction of the distortions caused by the effects of layover, shadowing, and shortening.

In general, the DTM that corresponds to the image is not available. Images of non-mountainous areas acquired by airborne platforms are generally converted to ground range by considering a plane earth. In such type of image the incidence angle is high due to the low altitude of the platform, the layover effect if almost nonexistent, leaving only the shadowing problem, provided the region is mountainous.

⇒ *Slant to Ground Range Conversion*

Windows: ***#Start – Spring<version><Language><system> – Spring<version> <Language>***

Linux: # Command to be typed on the Console (Shell) – # s_spring

MAC: #Dock – Launchpad – Spring <version> < ***language*** *>*

SPRING

** Load database* ***Course***

** Load project* ***Tapajos***

** Visualize image* ***Sarex_cpa***

- *[Image][Slant   Ground Range Conversion...]*
    - ***Slant to Ground Range Conversion***
    - *{Sensor altitude (m): 5000}*
    - *{Minimum Incidence Angle (deg.): 45}*
    - *(Side ⇔ Left)*
    - *{Name: Sarex_sgr}*
    - *(Interpolator ⇔ N-Neigh)*
    - *(Apply)*
    - *(Close)*

** If the option "Automatic Visualization of infolayer created" is actived in the tool "Environment Configuration", by clicking "Apply" your IF will be automatic drawn on the assistant page.*