dSARsim

Dummy Synthetic Aperture Radar Simulator

Basic Principles

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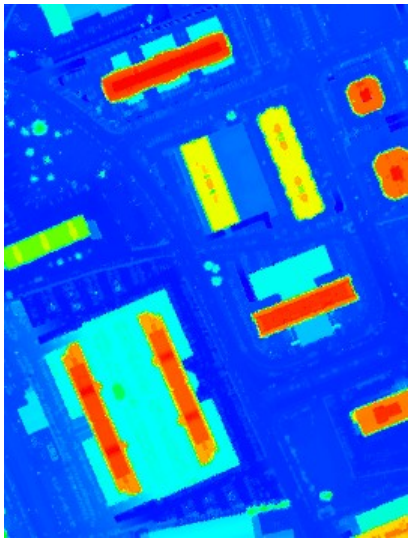
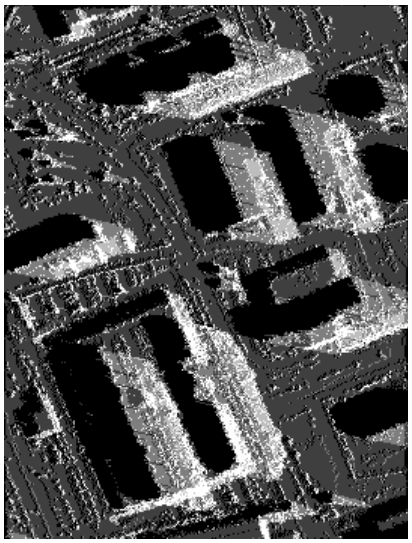
Introduction

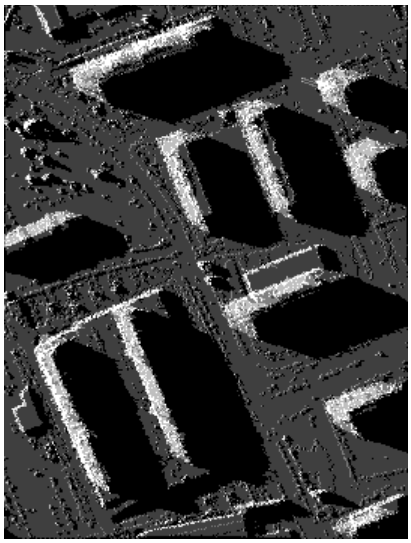
dSARSim creates Synthetic Aperture Radar (SAR) pseudo-simulations using as input a Digital Terrain Model (DTM) or a Digital Surface Model (DSM). Only the geometry of the scene is taken into account. Therefore, the “radiometry” of the output image has no physical meaning. So, for instance, do not expect to see double bounce lines or point scatterers of windows in correspondence of building façades. Similarly, an asphalt road and a grass field appear equal in the output although their surface roughness is different (unless you use a cm-resolution input DSM that shows such a difference...). Figure 1 shows two examples of pseudo-simulations.



(a) DSM of some buildings in the North area of the city of Trento, Italy[1].
Scale: blue = 186 m, red = 226 m.



(b) pseudo-simulation obtained using:
view direction = East to West, incidence angle = 30º,
aspect angle = 12º. Scale: black = 0, white = 4.



(b) pseudo-simulation obtained using:
view direction = West to East, incidence angle = 54º,
aspect angle = 20º. Scale: black = 0, white = 4.

Figure 1

[1]: these data are owned and freely distributed by Ufficio Sistemi Informativi, Servizio autorizzazioni e valutazioni ambientali, Provincia Autonoma di Trento. Downloaded from http://www.territorio.provincia.tn.it/.

Scene geometry

The main geometrical parameters involved in the pseudo-SAR simulation are: incidence angle, aspect angle and viewing direction.

- The incidence angle is considered constant all over the input area and equal to what has been set by the user, i.e. there is no difference between near range and far range, and Earth curvature is not taken into account.
- The aspect angle is defined as the angle between the North-South direction and the path of the SAR sensor (see Figure 2). Aspect angle = 0 means that the sensor is following the North-South axis from North to South.
- The viewing direction indicates which side of the SAR path is actually imaged. In dSARsim this is defined assuming the sensor going from North to South with aspect angle = 0, and can be West to East or East to West.

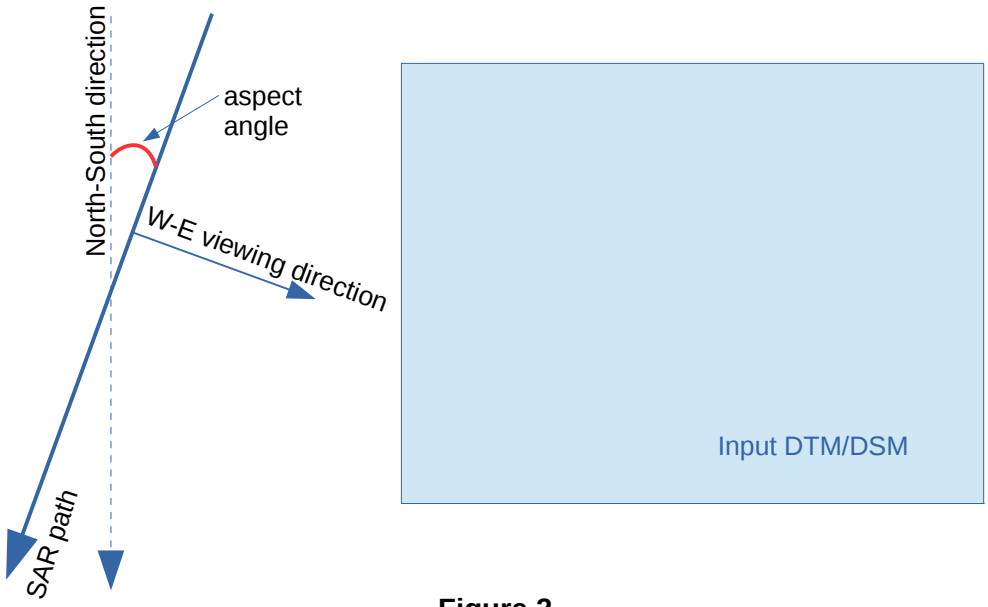


Figure 2

Pseudo-simulation process

The pseudo-simulation is performed independently for each line of the input DTM/DSM[2] using a simple rule: if a position within the current line is visible from the SAR (considering all the viewing parameters and the slant range geometry), it scores +1 in the output image at the corresponding slant range position (+1 means that 1 is added to the pixel value at the slant range position whatever its previous value was). Moreover, in correspondence of any position of the DTS/DSM the algorithm checks and models the following conditions:

- The current input position generates a shadow: the end of the shadow is calculated and the positions within the shadow area are marked to be skipped by the algorithm (i.e. they cannot score on the output image);
- The current input position generates a layover area: the beginning and the end of the slant range area covered by the layover are calculated and the whole area scores +1 on the output image. The case of partial layover due to a partially shadowed altitude step (e.g. a building façade partially shadowed in the bottom part from another building closer to the SAR sensor) is also taken into account.

The value of the pixels of the output image can thus be interpreted as the number of scatterers corresponding to the considered slant range position. In particular, we can distinguish between:

- 0: the pixel belongs to a shadow area;
- 1: the pixel belongs to an area that is visible from the SAR and does not generate or is not covered by any layover;
- > 1: the pixel belongs to a layover area. The greater the value, the higher the number of targets that scatter in the current pixel.

Figure 3 illustrates these concepts graphically.

[2]: in the case of aspect angle different from zero, the software rotates the input DTM/DSM by an angle equal to the aspect angle before starting the pseudo-simulation procedure. With this workaround the pseudo-simulation procedure can be still carried out “horizontally” line by line on the rotated input image giving the desired result and keeping the process simple.

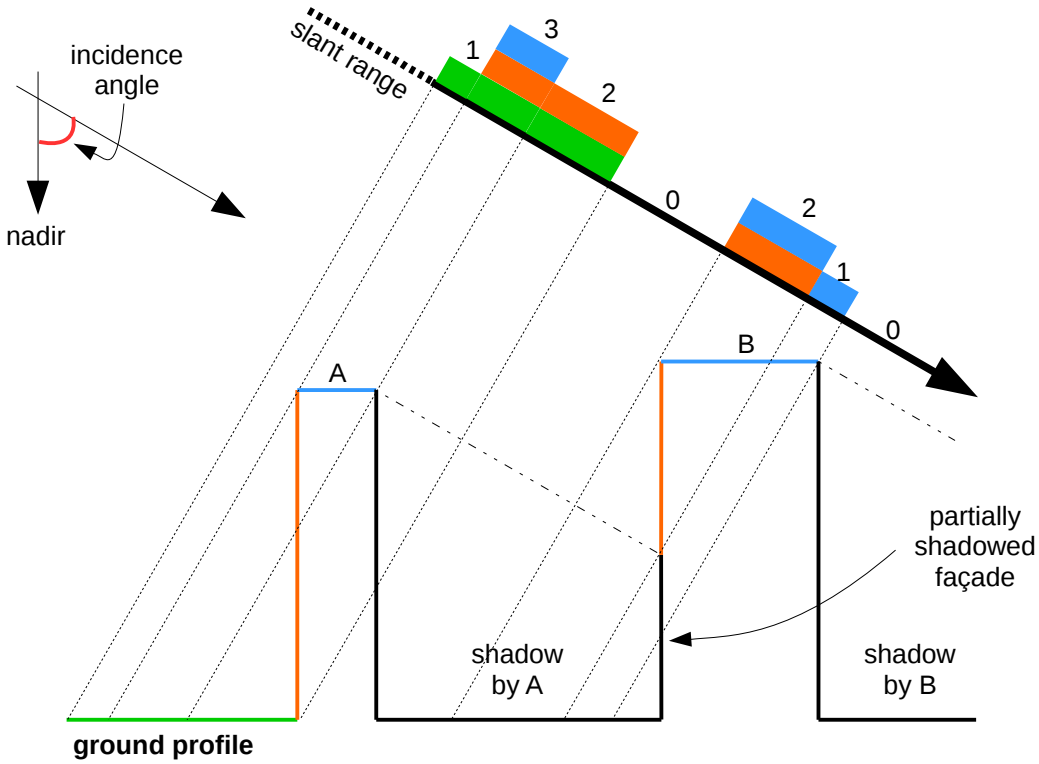


Figure 3: example of result of the pseudo-simulation process applied to a ground profile showing two adjacent buildings. The output image, which is in slant range geometry, is equal to 0 when a ground position is shadowed (e.g. between the two buildings). When the output is equal to 1 it means that only one target is scattering (e.g. the rightmost part of the top of building B, which is not layovered with the building façade as the latter is partially shadowed by building A). Finally, if the output is greater than 1 it means that more scatterers are present in the considered slant range position (e.g. in correspondence of the top of building A, in slant range geometry three contributions are present: the ground, in green; the building façade, in orange; and the building top, in blue).