AUTOFOCUS OF RADAR IMAGE BY ESTIMATING ITS FRAGMENT'S GRAVITY CENTER DISPLACEMENT

Petrov N.Yu.
Scientific center «ZAVOD LENINETZ», Russian Federation
E-mail: Nekit1003@gmail.com

Abstract — In this paper, a new autofocus algorithm for synthetic aperture radar (SAR) is proposed. The advantages and disadvantages of the algorithm are discussed.

1. Introduction

The modern onboard radars use synthetic-aperture principles to obtain detailed images of an earth surface. High quality of radar images (RI) can be achieved if a motion path of an aircraft on a synthetizing interval is known to within a wavelength. This data normally comes from navigation system (NS). Its errors bring to image blurring. To minimize this error one can use two ways: special NS or autofocus (AF). Now AF is considered to be more effective and perspective then NS. A novel AF algorithm is presented hereafter.

2. The main part

Assume that platform of SAR surveys the ground at any constant angle. Then in the situation of front-side or side observation, the RI obtained onboard will be displaced during the flight. If an AF interval is less than the time spent by the platform for flying up the size of the RI, then there is a common part in the radar images obtained from the beginning and the end points of the AF interval (fig. 1). Then the following AF algorithm can be proposed.

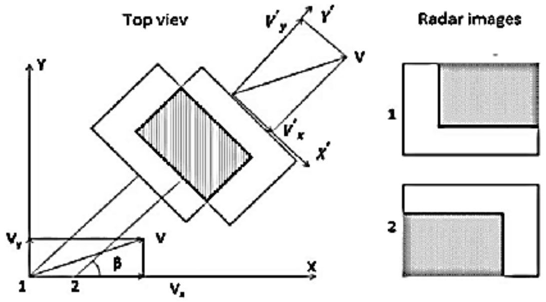

Fig. 1

The estimation of speed projections on axes X and Y can be obtained by estimating the displacement of the gravity center (GC) of the common part of the radar images during the AF interval (eq. 1, 2):

$$\hat{V}_x = \frac{\Delta x_{g.c.}}{T} = \frac{x_{g.c.2} - x_{g.c.1}}{T}; \qquad (1)$$

$$\hat{V}_y = \frac{\Delta y_{g.c.}}{T} = \frac{y_{g.c.2} - y_{g.c.1}}{T}. \qquad (2)$$

These speed estimations can be used for phase correction of the pinpoint target function. Then this corrected function is used to obtain a RI from the input data (track signal).

Every RI has a size in pixels of $[N_x \times N_y]$. The common part in the images can be obtained using navigation data in the following way:

1) In the RI from the beginning point of the AF interval, the right top part of the RI must be used (fig. 1, top image). The number of unused pixels (k_x and k_y by axes *X* and *Y,* respectively) is calculated by eq. 3 and 4:

$$k_x = \left[\frac{\hat{V}'_x T}{x_\Delta} \right] = \left[\frac{\hat{V}'_x T}{\hat{V}'_x T_r} \right] = \left[\frac{T}{T_r} \right]; \qquad (3)$$

$$k_x = \left[\frac{\hat{V}'_y T}{\rho_y} \right], \qquad (4)$$

where x_Δ — the distance the platform flies during a pulse repetition period (T_r); ρ_y — the SAR resolution in range; $\hat{V}'_x$, $\hat{V}'_y$ — the platform speed estimations from the NS converted to the RI coordinate system and [ ] shows the transformation to the integer argument.

Therefore, in the RI obtained from the beginning point, the GC must be calculated for the part of the RI with bounds in pixels: $[k_x + 1, N_x;\ k_y + 1, N_y]$.

2) In the RI from the end point of the AF interval, the left bottom part of the RI must be used (fig. 1, bottom image). It can be shown that in this situation the GC must be calculated in the bounds: $[1, N_x - k_x + 1;\ 1, N_y - k_y + 1]$.

The gravity center's coordinates of the part of an image are calculated using the following algorithm.

Coordinate *x* of the GC of every range line is calculated by the formula

$$x_{g.c.j} = \frac{\sum_i I_{i,j} \cdot i}{\sum_i I_{i,j}}. \qquad (5)$$

The gravity of every range line (μ_j) is

$$\mu_j = \sum_i I_{i,j}. \qquad (6)$$

Then, the coordinate *x* of the gravity center of the whole image takes the following form

$$x_{g.c.} = \frac{\sum_j x_{g.c.j} \cdot \mu_j}{\sum_j x_{g.c.j}}. \qquad (7)$$

The coordinate *y* of the GC of the whole image can be obtained in a similar way like *x* (using eq. (5)…(7)), but with substituting *y* for *x* and changing indexes *i* and *j*.

Then, the obtained speed estimations are used for SAR signal processing as a speed for getting the pinpoint target function.

The advantages of the algorithm are the following:

— it doesn't need any special reflectors in the target scene (e.g. bright targets);

— a displacement of the GC is not discretized as a distinct from the displacement of the pinpoint target. So, the phase error can be estimated more accurately.

The disadvantage of the algorithm is a requirement to the unchangeability of the target scene during the AF interval.

3. Conclusion

In summary, the proposed AF algorithm can be used for improving SAR images onboard. The AF algorithm needs low computational resources. The main advantage of the AF algorithm is that it doesn't need for any special reflectors in the target scene. The AF algorithm should be supplemented with some other algorithms for using in situations of changing the target scene.