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«Application of the autofocusing algorithm for the synthesis of X and L band radar image»

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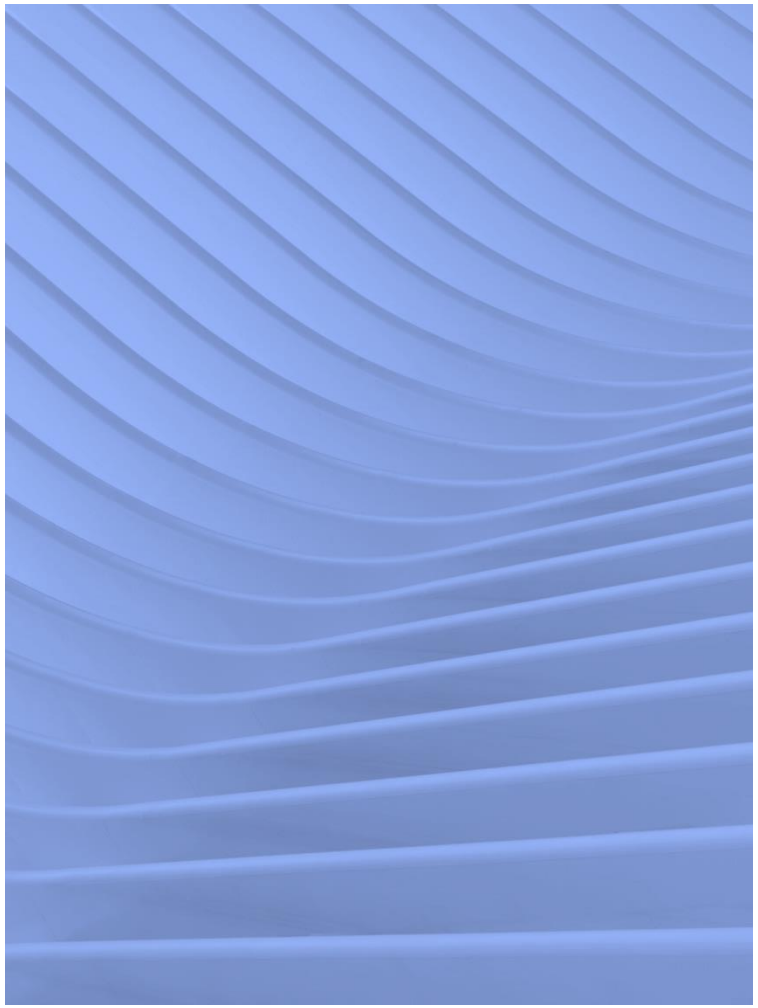
Problem statement



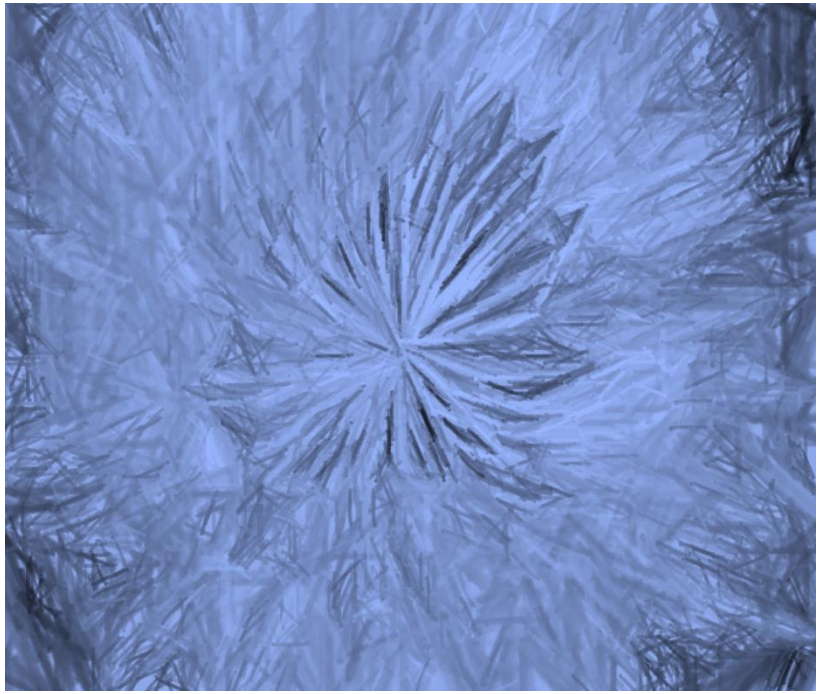
The process of synthesizing the antenna aperture is a coherent accumulation of echo signals during the translational movement of the radar carrier.

Antenna radiation pattern illuminates a certain area on the Earth's surface, and surface elements form a group echo signal received by the antenna. The repetition rate of radio pulses is such that each surface element in the capture zone is irradiated multiple times. As a result of this kind of signal accumulation, a radio hologram is formed.

For high-quality restoration of the radar image, it is necessary to know the exact phases of the signals in the direction of the track range. Unfortunately, many factors introduce an error into the phase portrait, among them: instability of the flight path, limitations of the accuracy of the micronavigation system, natural oscillations of the carrier body, inhomogeneity of the signal propagation medium, instability of master oscillators, etc.

Numerous works are investigating the possibilities of image autofocusing in order to compensate for phase instability in the directional direction. This paper investigates the application of the autofocusing algorithm based on minimizing the entropy of the image.

Solution methods



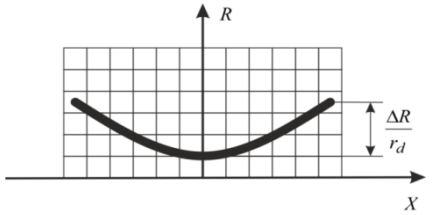
Synthesis of radio images with compensation for range migration

The distance to a point reflector can be described by the following expression:

$$R(t) = R_0 + \Delta R = R_0 + \frac{v^2 t^2}{2R_0},$$

where R_0 is the slant range, v is the carrier speed.

Migration by range channels:



Doppler frequency versus time law:

$$f(t) = \frac{2v^2 t}{\lambda R_0},$$

where λ id the wavelength.

Autofocusing of radio images by minimum entropy

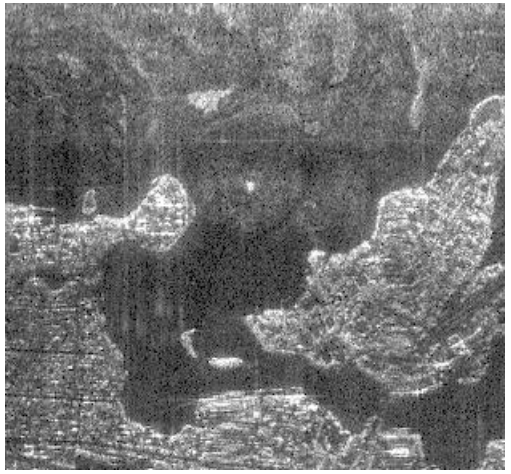
To calculate the entropy of an image, we use the following definition:

$$H = -\sum_i^M \sum_j^N p_{ij} log(p_{ij}),\ p_{ij} = \frac{|\dot{e}_{ij}|^2}{P},\ P = \sum_i^M \sum_j^N |\dot{e}_{ij}|^2$$

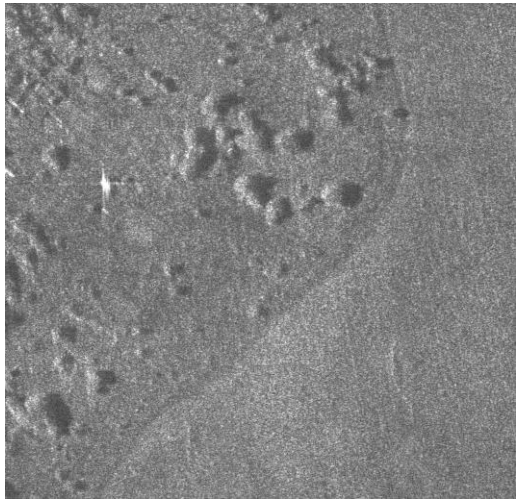
where $\dot{e}_{ij}$ is the complex readout of the radar image at the point.

Results

- The synthesis of radar images performed in this work reflects the possibilities of applying methods for the synthesis of radar images, taking into account the range migration and autofocusing algorithms at the minimum entropy in the absence of navigation data
- Anthropogenic objects in the L range represent the elements with the greatest brightness, while in the X range the contrast of image elements is much lower



Radar image in L band after autofocusing procedure with a spatial resolution of 2.5 m



Radar image in the X band after autofocusing procedure with a spatial resolution of 0.5 m

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