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APPLICATION OF A NONLINEAR METHOD OF RESTORATION IN COMBINATION WITH SPARSE ANTENNA ARRAYS IN RADIOMETRIC IMAGING SYSTEMS

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The paper considers methods of elimination of diffraction distortion in radio-engineering imaging systems with sparse antenna arrays. At the first stage the problem of synthesis of antenna array geometry is resolved, while at the second — processing of images is performed by the nonlinear method with constraints. The paper includes results of imitative simulation of the process of creation and reconstruction of images in the radiometric system.

Creation of images of objects with the aid of radio-engineering systems (RES) has a number advantages over similar optical systems due to their ability of round-the-clock observation regardless of atmospheric conditions and with high angular resolving capacity.

In accordance to the theory of linear systems, a RES antenna is a spatial filter with its pulse response corresponding to the antenna radiation pattern (RP) and, hence, has a limited pass-band. The imaging is performed by scanning the antenna main lobe in angular coordinates, with digitization intervals (increments) dictated by the system pass-band and by requirements of the prescribed resolving capacity of the system. The ideal system of imaging has a uniform spatial spectrum up to the maximal spatial frequency, which is defined by the minimal distinguishable elements of the image. Outside the pass-band, the spectrum must be equal to zero.

The process of imaging in RES with noncoherent summation can be described by the Fredholm equation of the first kind [1]:

$$\left|g(\theta,\varphi,x,y)\right|^2=\int_0^{2\pi}\int_0^{\pi}\left|f(\theta,\varphi)\right|^2\left|h(\theta,\varphi,x,y)\right|^2\mathrm{d}\theta\mathrm{d}\varphi+n(\theta,\varphi)$$

where $g(\cdot)$ is the formed image; $f(\cdot)$ is the pre-image to be restored; $h(\cdot)$ is the system pulse response corresponding to RP of the antenna; θ and φ are angular coordinates in the object's plane; x and y are coordinates in the aperture plane; and $n(\cdot)$ is the noise component.

The response $h(\cdot)$ for a plane antenna can be defined by the two-dimensional Fourier transform of the function of amplitude-phase distribution $A(x, y)$ [2]

$$h(\cdot)=\int\int_{-\infty}^{\infty}A(x,y)\cdot\mathrm{e}^{\mathrm{j}(\chi_1x+\chi_2y)}\mathrm{d}x\mathrm{d}y$$

where $\chi_1 = k\sin\theta\cos\varphi$, $\chi_2 = k\sin\theta\sin\varphi$, and k is the wave number.

The inverse Fourier transform of $h(\cdot)$ characterizes its spatial spectrum. Thus, selection of $A(x, y)$ for the antenna aperture makes it possible to obtain the necessary shapes of RP and of the spatial spectrum. However, since the RP and the

REFERENCES

1. G. I. Vasilenko and A. M. Taratorin, Reconstruction of images [in Russian], Radio i Svyaz', Moscow, 1986.

2. I. Prudyus, S. Voloshynovskiy, and T. Holotyak, Mathematical models and spatial characteristics of coherent and incoherent imaging systems, MSMW'98 Symposium Proceedings, pp. 562–564, 1998.

3. I. N. Prudyus and S. V. Voloshynovskiy, Elektrosvyaz', No. 7, pp. 35–37, 1997.

4. I. N. Prudyus, S. Voloshynovskiy, and T. Holotyak, Investigation of spatial antenna system characteristics in active and passive imaging system, Proc. of International Conference of modern problem of telecommunications, computer science and engineer training, TCSET'98, Lviv, Ukraine, pp. 124–125, February 23–28, 1998.

5. I. Prudyus, S. Voloshynovskiy, and T. Holotyak, Sparse antenna array in radar imaging systems, Proc. of the 3rd International Conference on Telecommunications in Modern Satellite, Cable, and Broadcasting Services, TELSIKS'97, Niš, Yugoslavia, Vol. 1, pp. 46–49, 8–10 October 1997.

6. R. T. Hoktor and S. A. Kassam, Proc. IEEE [Russian edition], Vol. 78, No. 4, pp. 135–170, 1990.

7. I. Prudyus, S. Voloshynovskiy, and T. Holotyak, Computer modeling of radiometry imaging system with different types of antennas, Proceedings of the 2nd International Conference "Antenna Theory and Techniques", Kyiv, pp. 101–103, 1997.

8. I. Prudyus and L. Lazko, Numerical method of signal spectrum restoration with prior information about solution usage, Proceedings of International Conference CADSM2001, Lviv, pp. 101–102, 2001.

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