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IMAGE RESTORTION OF A SMALL AIR TARGET. SOLUTION OF THE THEORETICAL PROBLEM OF BACKSCATTERING

One of the important tasks of Ukraine's security ensuring is protection of critical state infrastructure objects from various types of terrorist threats. One of the main threats to these facilities is unmanned aerial vehicles (UAVs) that systematically attack critical infrastructure facilities [1,2].

Investigation of small air targets properties as objects that reflect and scatter electromagnetic waves shows [3] that energy potential of each radar station (RS) is determined by its technical parameters and characteristics of air targets display. Knowing numerical characteristics parameters of air targets display will ensure more effective operation of the radar. It in turn ensures security of guarded strategic objects.

The result of UAV irradiation by a stream of parallel electromagnetic rays is reflected signal or linear integral of the function j. Such function describes absorption of electromagnetic waves by each point x of the radar target. It is possible to reconstruct functions j corresponding to each beam and obtain reconstructed image of small aerial target based on the set of these integrals.

Equation that describes reflection process of electromagnetic waves from radar target into the Rytov approximation will take the form

$$u_I w_R(x) = -f \int_{R^2} H_0\left(f|x-y|\right) j(y) u_I(y)\, dy \quad (1)$$

where, u_I – stream of rays approaching the target,
w_R - Rytov approximation,
f - electromagnetic wave frequency,
R^2 - object that scatters electromagnetic waves,
H_0 - Hankel function of the first kind of zero order,
x,y - readings along the abscissa and ordinate axes.

If equation (1) is solution of the direct scattering problem within the Rytov approximation, then it is necessary to find j, knowing u_s of the scattering object (radar target) to solve the inverse scattering problem.

$$\int_{\theta \cdot x = s} j(x)\, dx = -2i w_R\left(r\theta + s\theta^{\perp}\right) \quad (2)$$

where r - fixed number greater than one, that changes outside the circle of radius r,
$\theta \in S^1$ - unit vector that determines the direction of wave propagation,
$\theta^{\perp}$ - orthogonal to the unit vector.

The obtained solution of the inverse scattering problem of electromagnetic wave makes possible to find the effective area of the radar target silhouette along the sounding line. In other words, shape (configuration) determining of the radar target is equivalent to restoring of characteristic function of the radar target by its plane integrals R2. This version of solving the backscattering theoretical problem for image restoration of small air target within the Rytov approximation allows obtaining of numerical result of the effective surface area of the silhouette along the sounding line.

References

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