Radar Determination of Moving Ground Objects in the Millimeter Wavelength Range

A. V. Totskii, A. L. Teplyuk, V. E. Morozov, G. I. Khlopov, and S. I. Khomenko

N. E. Zhukovskii National Aerospace University (KhAI), Kharkiv, Ukraine
Institute of Radiophysics and Electronics of National Academy of Sciences of Ukraine, Kharkiv, Ukraine

Received in final form June 14, 2007

Abstract—The problem of radar determination of moving surface targets in the millimeter wavelength range has been studied using the analysis in the frequency-time domain of the short-term power spectrum of nonstationary signal. A procedure was proposed for generating the informative attributes on the basis of separate processing of the envelope and phase of signal reflected from a surface object. In addition, the presented results of experimental studies corroborated the efficiency of the identification algorithm discussed.

DOI: 10.3103/S0735272708120042

INTRODUCTION

In recent years the methods of obtaining the so-called noncoordinate information have been actively developed, in particular, for solving the problems of object identification. Radar determination is part of the scientific direction of image identification [1, 2], where the process is formalized to a sufficient degree. The most developed methods are the techniques of making a decision on the affiliation of the object observed to one or another class of objects using mathematical tools of the theory of statistical decisions that makes it possible to obtain the most valid results [3].

At the same time, the process of building up the informative attributes is most difficult to formalize since a variety of physical features of the object under consideration sometimes hamper the use of specific recommendations and rules. That is why the search and analysis of stable informative attributes is a governing factor in solving the problem of identification of radar images.

In order to obtain such attributes, attempts were undertaken time and again to use broadband signals with high resolution in terms of the range while building up the so-called range portraits [4] or for measuring the resonance frequencies of the equivalent scattering area (ESA) of the target [5]. The common disadvantage of the specified methods is their low stability under conditions of the varying aspect angle of the object. For improving this stability it was proposed to use the multifrequency radar signals [6, 7]. Higher stability is intrinsic to the identification methods based on analyzing the fine structure of the Doppler spectrum of reflected signals, for example, in the case of using the analysis of the turbine effect of the air target [8]. The application of radio waves in the millimeter range (MMR) ensures a rapid enrichment of the backward scattering spectrum at the slightest movements of target, including vibrations of the structure elements that significantly increases the informative content of such methods.

The purpose of this paper is to study the formation of attribute space for surface moving objects using the estimation of a short-term spectrum of nonstationary radar signals of the millimeter wavelength range in the frequency-time domain [9, 10] on the basis of separate processing of the amplitude and frequency modulation of reflected signals with due regard for peculiarities of the backward scattering of radio waves in the millimeter range.

FORMATION OF INFORMATIVE ATTRIBUTES OF GROUND MOVING OBJECTS

The signals reflected from complex objects in MMR have a relatively narrow instantaneous spectrum since the distance between separate “bright dots” of object \( L_{mn} \) is usually sufficiently large \( kL_{mn}\sigma_\phi \gg 1 \) [11, 12] \( (\sigma_\phi^2 \) is the dispersion of angles of target swaying). In this case, the reflected signal represents a narrow-band process, the correlation interval of which does not practically depend on the pattern of angles of