Algorithms of 3D Radio-Wave Imaging in Airborne Doppler Radar

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Abstract—Estimation algorithms of coordinates of the Earth surface elements in 3D radio-wave imaging system based on the airborne Doppler radar during the low-altitude flight were proposed. In addition, the applicability of the algorithms was demonstrated by using the computer simulation method.

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INTRODUCTION

A concept of dataware (informational support) of low-altitude flying (LAF) based on the airborne radar [1] and directed on enhancing the safety of such flying under conditions of complex terrain profile had emerged in the late 1990s. The possibility of viewing obstacles along the flight course was mostly achieved by forming a narrow antenna radiation pattern (ARP) in azimuth and its scanning in the real beam mode. However, such mode does not allow us to view a detailed image of obstacles. A number of papers dealing with the superresolution based on the methods of image restoration during the ARP scanning were published, for example paper [2]. However, the effect of enhancing the resolution in terms of angular coordinates at the expense of the restoration proved to be small (no more than 3 times).

Radio-wave imaging based on the airborne Doppler radar in the mode of Doppler beam sharpening (DBS) [3] makes it possible to improve the angular resolution by tens of times and form a detailed two-dimensional amplitude radar image (2D-RI) of the terrain in coordinates range – Doppler frequency. In the DBS mode it is also possible to generate three-dimensional RI (3D-RI) and height map [4], however the error of height measurement is commensurable with the linear width of ARP in terms of the angle of elevation.

There are several approaches available for generating the matrix of terrain relief heights [3] that can be applied in a Doppler radar. They include the use of high-precision interferometric system, the formation of height matrix at the expense of scanning in terms of the angle of elevation, and the height measurement by using the radar shade. The analysis of these approaches at the algorithmic level indicates the need of applying special procedures for alignment of two (interferometric method) or larger number (scanning method) amplitude 2D-RI and segmentation of 2D-RI (method of radar shade). In this case, the complexity of implementing such alternative approaches is at least 5 times as high as the complexity of the algorithms proposed in this paper and operating in DBS mode.

From the viewpoint of the efficiency of obtaining data about the height of obstacles during the low-altitude flying (LAF), it is expedient to generate the matrix of heights without applying complex procedures. A method of forming 3D-RI based on airborne Doppler radar was developed [5, 6] at the expense of parallel operation of several channels of primary processing of received signals in estimating the coordinates of Earth surface. However, the specified method has not been algorithmically completed, and the computer simulation was not available. The present paper fills this gap.

The purpose of the paper is to develop the algorithms for estimating the spatial coordinates of Earth surface elements during the formation of 3D-RI in airborne Doppler radar and the computer simulation of their performance. The practical significance of this study is determined by the growing requirements of safe landing of civil aircraft in complex meteorological conditions.

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REFERENCES


