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Solving the Inverse Problem of Remote Radiation Monitoring: Restoring the Surface Distribution of Radiation Pollution Based on Measurement Data

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Abstract In recent times, remote measurement of various physical fields remains one of the most demanded and rapidly developing technologies. Especially, this concerns the revealing and investigations of dangerous fields, in particular intense ionizing radiation. To provide remote sensing of radiation, the small flying machines are extremely useful due to their small sizes, usability, cheapness, the speed of obtaining primary results and other advantages. Among the problems arising at the use of unmanned aerial vehicles (UAV) it is worth noting the need for correction of UAV readings, when we want to identify strongly localized, noised or overlapping peculiarities of gamma-ray fields. To perform the correction, the approach based on the solution of the inverse problem formulated in terms of integral relation is used. In this research, the Tikhonov and Landweber techniques are applied for reconstruction of the surface distribution of the gamma-ray field. As shown as well, the algorithms allow us to distinguish radioactive hot-spots located closely.

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1 Introduction

Implementation of innovative technologies, ideas of rational nature management and safety components provide the sustainable development of economies and human societies. Among various ways for supporting the high rate of development, remote measurement of physical fields plays a notable role because mankind requires rapidly growing amount of information on the changes in the systems created and controlled by the man, state of environment, functioning of hard-to-reach objects and etc. Especially useful and demanded branch of remote sensing application relates to the remote monitoring of radioactive materials, which are not visible to the naked eye and can pose a significant danger to living organisms. To organize the monitoring of radioactive fields, first of all it is worth mentioning about satellites, manned airborne and ground-based surveys [1, 2]. However, due to the technological progress in the area of UAVs [3–7], favorable conditions have been emerged for the widespread use of UAVs in remote monitoring of radioactive gamma fields [1].

Nevertheless, data collected with the UAVs undergo the influence of UAV velocity and high, detector's properties, attenuation, natural radiation, and etc. [8] that requires further processing and corrections. For improving the quality of UAV measurements the approach which is based on the use of a solution of inverse problem is utilized. This problem involves a multiple integral relation, approximation of which, in turn, is not simple but quite solvable task. However, the main issue relates to the construction of a solution to the inverse problem, which demonstrates strong instability, oversmoothing effects, and etc. [9–14]. To overcome this difficulty, many techniques have been developed including the Tikhonov and Landweber algorithms, which we used in these studies.

Thus, in this research, we consider the adaptation of algorithms for the inverse problem which arises during the remote monitoring of distributed gamma-ray radioactive fields. The restoration of the gamma field, distributed over the ground surface, and identification of its local intensities are in our focus.

2 The Mathematical Tool for Remote Sensing of Gamma Ray Field

Now let us start from the description of the general assumptions admitted in problem statement. These investigations continue preceding our studies outlined in [3, 4].

According to numerous experiments [15, 16], the readings of airborne detector as a rule undergo the influence of noise and thus require some corrections. In order to