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Determination of Position and Orientation of Conducting Rod Using a Neural Network

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Abstract—The problem of electromagnetic wave diffraction by a conducting rod has been solved using the integral equation technique. The diagram of backward scattering has been plotted. A wavelet packet decomposition of the obtained characteristic has been carried out. Based on the values of Shannon entropy for decomposition components we have constructed the feature vector. We have trained a neural network based on radial basis elements, which allows one to determine the position of a rod and its spatial orientation based on the feature vector. Numerical simulation and statistical analysis of the numerical results have been carried out.

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INTRODUCTION

Neural networks have proven themselves in problems of numerical simulation, classification and approximation. At the moment they find ever-widening applications in various fields of science and technology. The ability of neural networks to be trained has led to their utilization in image recognition system, voice processing systems, in development of prediction models in economics etc. [1, 2].

In this article we propose the utilization of a neural network with radial basis functions for the solution of the problem of position and orientation determination for the metal rod based on the diagram of backward scattering. This problem belongs to the class of inverse diffraction problems, when based on the configuration of the reflected field one needs to determine the geometrical and/or electrical parameters of the scatterer [3]. Similar problems arise in radiolocation during the determination of target parameters, during the detection of metal objects, which are hidden under the soil or located behind the dielectric wall etc.

A particular problem in the case of neural networks application for the recognition, classification, and approximation problems is the construction of a feature vector based on the received signal. In this paper we have utilized the approach of energy feature vector based on the wavelet packet decomposition, which is used for the recognition of geometric textures [4].

DIFFRACTION PROBLEM SOLUTION

In this paper we consider the case of plane harmonic wave scattering by a perfectly conducting rod with given length a. The rod is located in the polarization plane of the incident wave. The coordinate system is introduced in such a way that the applicate axis coincides with the direction of incident wave propagation, the axis x passes through the scatterer's plane, and the ordinate axis complements the previous two to the right-hand triple (Fig. 1).

Perpendicular to the rod forms an angle θ relative to the applicate axis. The calculation of the value of the reflected field amplitude is performed on the interval of the length L, which is located on the abscissa axis of the coordinate system.

The problem consists in the determination of a displacement h of the rod center from the abscissa axis, s, which is the offset from the applicate axis and of the inclination angle θ. It is assumed that the values of these parameters fall within a known range.

In order to determine the scattered electromagnetic field we have used the electric field integral equation (EFIE) technique [5–7]. The incident electromagnetic wave induces the current in a thin conducting rod with