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Analytical SVD for reconstruction of the radiating current in inverse EM scattering

S. Bahrami*, A. Cheldavi and A. Abdolali

Department of Electrical Engineering, Iran University of Science and Technology, Narmak, Tehran, Iran

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In this paper, an analytical reconstruction of the radiating current for the inverse scattering problem with a line measurement configuration is presented. Here, a generalized continuous singular value decomposition (SVD) of the scattering integral operator is extracted by means of the spectral representation of Green's function. The proposed formulation can be used in analyzing image resolution and reconstruction of the radiating currents. In addition, the singular value spectrum relation with radiating/non-radiating modes is studied. Study of the singular spectrum gives the opportunity to investigate the growing behavior of evanescent modes and the sub-wavelength focusing property in double negative slab. The singular value spectrum plays an important role in the truncation process of analytical SVD. By virtue of the proposed analytical method, the equivalent current reconstruction can be done in a very short computation time. In addition, the singular system description is based on medium Green's function and it is applicable to 2-D inverse scattering problems.

Keywords: inverse scattering; radiating current; scattering integral operator; singular value decomposition

1. Introduction

The electromagnetic inverse scattering problem, which finds the position and dielectric properties of the obstacles, has been widely studied. Non-linearity, ill-posedness, and computational cost are the particular difficulties in inverse problems.[1] Introducing equivalent current density inside the scatterer is a common way to overcome nonlinearity. The resulting linear (inverse source) problem is still ill-posed and its solution is non-unique and non-stable.[2,3] Non-radiating currents, whose generated fields remain confined (are non-zero only) within the source's region of localization, cause non-uniqueness of the inverse problem.[4]

Many works exploited regularization techniques to tackle the linear inverse problem, such as Tikhonov regularization,[5] truncated singular value decomposition (TSVD), [6,7] and so on.[8–11] In these strategies, considerable computation cost of the singular value decomposition (SVD) is challenging since it resorts to numerical approach. Furthermore, in order to limit the noise magnification to within a certain level, eigenfunctions with small eigenvalues have to be excluded, i.e. truncation of singular values is essential, which should be determined through expensive numerical experiments. Slow convergence and high oscillation kernel of the Sommerfeld integral leads to complicated and time-consuming

*Corresponding author. Email: bahramis@iust.ac.ir