Electromagnetic Nondestructive Test (ENDT) Data Inversion by a Neural Network Approach

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Abstract— **With this paper we aim at presenting a neural based approach to conductivity distribution reconstruction by eddy current (EC) data inversion.**

Keywords— **Electromagnetic non-destructive test, Eddy current inspection, Maximum-likelihood data inversion.**

I. Numerical determination of variation in impedance

In the paper, a conductive specimen is supposed to be affected by a defect located deeply in its volume. A probe is moved on a grid over the specimen's accessible surface and a set of differential complex impedance values are thus collected. As the distribution of the impedance depends on the defect location and shape, it is possible to reconstruct its profile by properly treating the impedance data [2]. The value of the differential impedance in function of the defect and probe location must be evaluated by numerical methods, because the computation of the 3D distribution of current and magnetic field for real configurations and geometries is a hard analytical task. To this aim, we used a finite difference discretization of the Maxwell's equations, written in frequency domain and in integral form, by means of Yee's three-dimensional spatial grid [3], in order to obtain the decomposition of the domain under analysis in cells containing homogeneous material. Moreover, the implemented grid-maker has the possibility to define cells with variable spatial steps, in order to obtain a more accurate discretization in those regions where high variations of the values of the electromagnetic field are expected or where the eddy current analysis is particularly important. In order to avoid numerical instabilities, the resulting set of complex algebraic equations must be solved by means of a dedicated Complex BiConjugate Gradient method [1].

II. Electromagnetic model approximation and inversion

We employ an inversion technique allowing to recover the conductivity profile of the specimen from the measures [4]. A strong discontinuity in the homogeneity of the conductance profile in a spatial location clearly evidences the presence of a defect in that zone of the volume. The problem at hand may be formally represented as the inversion of a model which returns the distribution of the differential impedance over the accessible object's surface from the profile of conductivity inside the object's volume. A widely used inversion method is the well-known recursive maximum likelihood technique [5]. In its simplest form, the model needs to be linearized at each iteration around the current solution, thus the Jacobian of the non-linear model must be repeatedly computed. In order to overcome the problem of analytically study the electromagnetic interaction between the probe and the specimen, in this work we propose to approximate it, along with its linearization, through a neural network trained by means of a set of conductance/impedance patterns. An exemplary result of the good approximation capability of a Multilayer Perceptron [6] is shown in the Figure 1, where the approximated differential impedance profile for a small spherical defect is depicted. Complete results about inversion will be given in the final version of the paper.

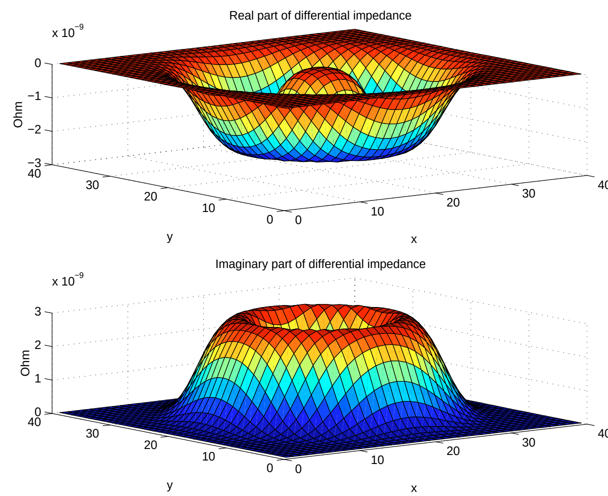

Fig. 1. Profile of differential impedance (top: real part, bottom: imaginary part) as reconstructed by a Multilayer Perceptron of topology 5-12-25-2 for a defect localized in (0.46, 0.39, -0.15) cm.

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