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Rapid Computation of Low Frequency Magnetically Induced Electric Field Using Radial Basis Functions

Lianlong Zhang(1), Junqing Lan(2), and Yinliang Diao* (1)
(1) South China Agricultural University, Guangzhou, China; e-mail: diaoyinliang@ieee.org
(2) Chengdu University of Information Technology, Chengdu, China; e-mail: ljqcuit@163.com

Human are exposed to complicated environmental electromagnetic fields. Under the exposure to low frequency electromagnetic fields (< 100 kHz or 10 MHz), potential adverse stimulation effects may appear in the central or peripheral nerve systems. To protect against such adverse effect, ICNIRP and IEEE ICES established guidelines and standards setting the exposure limits. The basic restriction (BR) in ICNIRP guidelines (equivalent term is dosimetry exposure limit in IEEE standard) is developed based on the threshold of the substantiated adverse effect with the consideration of reduction factor.

As the measurement in the human body or body phantom is often technically impossible or laborious. Computational approaches were often adopted. One difficulty is incorporating the source of a real product into the dosimetric simulations. Several methods, including dipole moment, equivalent loop etc., have been mentioned in previous studies. In [1], a radial basis function (RBF) network was proposed to reconstruct the source.

In general, computation of induced electric field is time-consuming, although can be accelerated by parallel techniques or multigrid methods. [2] proposed to use multipole as basis, the real source was approximated by a set of multipole sources. The electric field induced in the human model for each multipole was computed off-line, then the total induced field was obtained by supposition. Following that study, we adopted a similar idea but using a set of RBF in term of a inverse-quadraid function as the basis as used in [1]. The induced electric field for each basis source were pre-computed. Then the total electric field can be considered as a summation:

$$E_{tot}^{ind} = \sum_i w_i E_i^{ind} \tag{1}$$

The E_i^{ind} are induced electric field for the i^{th} RBF source and should be computed offline. The coefficients w_i are obtained by fitting the external magnetic field. As a demonstration of the concept, a coil source with current of 1A at 100 kHz, and a cylindrical human model were considered. A total of 49 RBF functions were used to reconstruct the coil source. Figure 1 a) illustrates the normalized induced electric fields for several principal RBF sources. The total electric field obtained using the proposed method was shown in Figure 1 b). The distributions of the field resemble that obtained by simulation using the coil as source, the difference in the maximum electric field is less than 5% for the simulated case. The effect of the number of basis function on the accuracy will also be investigated.

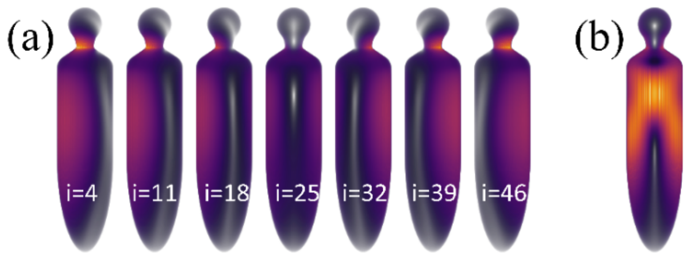

Figure 1. Distributiosn of (a) the electric field for several basis sources, and (b) the total induced fields.

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2. F. Tavernier, R. Scorretti, N. Burais, H. Razik, and J.-Y. Gaspard, "Real-Time Numerical Dosimetry of Low-Frequency Electromagnetic Fields by Using Multipoles," *IEEE Trans. Magn.*, **57**, 6, 2021, pp. 1–4.