A hybrid EFG-FE solution to the EIT forward problem based on the complete-electrode model

Maedeh Hadinia[1], Reza Jafari[2] and Manuchehr Soleimani

[1] Faculty of Electrical Engineering, K. N. Toosi University of Technology, Tehran, Iran, m_hadinia@ee.kntu.ac.ir
[2] Faculty of Electrical Engineering, K. N. Toosi University of Technology, Tehran, Iran, jafari@eetd.kntu.ac.ir
[3] Engineering Tomography Lab (ETL), Electronic and Electrical Engineering, University of Bath, Bath, UK,
m.soleimani@bath.ac.uk

Abstract: A hybrid element-free Galerkin–finite element method is presented for solving the complete electrode model of electrical impedance tomography.

1 Introduction

Some of the literature has used the finite element (FE) [1] and element-free Galerkin (EFG) [2] methods to solve the complete electrode model (CEM) forward problems in electrical impedance tomography (EIT). The FE method and EFG method are accurate numerical techniques. However, the FE technique has meshing task problems and the EFG method is computationally expensive, therefore, a combination of two methods is preferred. In [3], an approach based on the combination of EFG and FE methods were proposed to solve the EIT forward problem based on the gap model. In this paper, the EIT forward problem based on the CEM is solved.

2 Methods

In the proposed method, the domain is divided into two regions formulated by the FE and the EFG methods. To couple FE and EFG methods, the Lagrangian multipliers technique is adopted to enforce the continuity conditions on the interface boundary between the two regions.

3 Example I. A homogeneous problem

In this example numerical results are validated with experimental data [4] for a homogeneous case. Table I illustrates errors and execution times corresponding to the three cases for both the FE and hybrid element-free Galerkin–finite element (EFG-FE) methods.

4 Example II. An inhomogeneous problem

This example is an inhomogeneous example, in which a circular phantom including two circular inhomogeneities is studied and the effects of radius of EFG region on voltages at electrodes are investigated. The domain of study is divided into outer and inner domains discretized for the FE and the EFG methods, respectively, as shown in Figure 1. The voltages at electrodes corresponding to the four radiuses obtained with the hybrid EFG-FE method are compared with the exact solution in Table 2.

5 Conclusion

In this paper, the EIT forward problem based on the CEM is solved by the hybrid EFG-FE method. The results have been achieved and evaluated using experimental data. The comparisons reveal in all cases, unlike the execution time of computations, the mean relative error in the hybrid EFG-FE method is less than that of in the FE method. Results show that the accuracy of the hybrid EFG-FE method is increased as the radius of EFG region increases.

Table1. Comparison of the performance of the hybrid EFG-FE methodand standard FE method

Case	FE method			Hybrid EFG-FE method		
	Total degrees of freedom	RE%	CPU (s)	Total degrees of freedom	RE%	CPU (s)
1	176	18.39	0.14	172	16.65	0.65
2	653	6.77	0.23	652	4.56	0.72
3	2522	1.90	1.68	2518	1.15	2.71

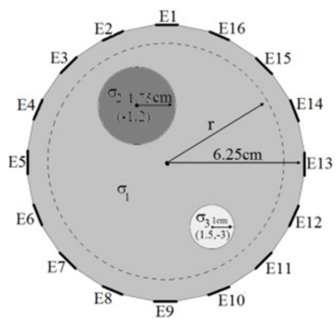

Figure 1.The circular inhomogeneous model and the configuration of electrodes.

Table 2. Comparison of errors of voltage and execution times at electrodes for several radiuses of EFG region

r	FE region	EFG region	Number of common nodes	Total degrees of freedom	RE%	CPU (s)
	Number of nodes /elements	Number of Nodes				
4.50cm	2596/4824	628	144	3080	1.25	4.83
5.00cm	2222/4054	1014	166	3070	1.21	5.30
5.50cm	1626/2818	1630	194	3062	1.15	5.67
6.00cm	721/976	2574	226	3069	0.83	6.29

References

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