2D validation of numerical resistive modeling with differential quadrature on an irregular mesh

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Abstract

A fresh perspective is presented for modeling resistive phenomena near a galvanic source in the presence of a cylindrically symmetric body. This approach employs a 2D electromagnetic formulation using a differential quadrature technique to approximate the solution of a partial differential equation. In contrast to conventional methods, we use an unstructured mesh where the linear combinations of the system contain radial Gaussian basis functions as weights. These functions dynamically adapt to a given number of grid nodes and provide local approximations to the solution. To simplify the problem and ensure two-dimensionality, we assume that the electrical point sources (source and sink) are oriented perpendicular to the axis of the cylindrical heterogeneity. In this way, we eliminate one dimension and make the problem more manageable. Our formulation uses secondary potentials to eliminate the singularities associated with the source points. A key aspect of our approach is the accurate computation of derivatives within the problem. This step is crucial to construct a linear system that can be solved effectively. We dedicate special attention to this aspect to ensure the reliability and efficiency of our methodology. To demonstrate the effectiveness of our method for solving the boundary value problem of galvanic current flow, we provide two illustrative examples. These examples demonstrate the accuracy and effectiveness of the differential quadrature method when coupled with unstructured grids. Our results show that this approach can successfully model current flow through circular boundaries separating different conducting media. This approach has potential for various applications in fields such as electrical engineering, materials science, physics, and geophysics. In addition, we are developing a semi-analytical solution for the scattering of point electrodes from a cylindrical anomaly of arbitrary resistivity or conductivity. This allows us to quantify the errors in our numerical results and validate the overall methodology. In addition, these results provide a deeper understanding of the electrical behavior of two-dimensional structures, which is critical for various applications, especially in the field of geophysical research.