Improving the efficiency of the Forward Problem Solver for 3D resistivity modeling

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Resistivity imaging is a geophysical method that enables scientists to create computer models of the Earth's subsurface based on calculations of apparent resistivity. Two point electrodes are used to send an artificial current through the ground and voltage is measured at separate points in the vicinity. This measured potential difference, along with the known amount of current injected, is used to calculate the apparent resistivity (or conductivity). When creating a computer model of the Earth based on geophysical data, the "forward problem" and the "inverse problem" are terms applied to the problems being solved to create the model. Typically, the forward problem has to be solved many times by the inverse problem solver, so an efficient algorithm is very important. My honors project will examine and improve upon the current algorithm being used for resistivity survey modeling.

Given an Earth model and a set of measurement locations, the forward problem will find the expected values of the measurements. In the case of a resistivity survey, the earth model is a set of conductance values and the expected values are electric potentials (voltages). To solve this problem, a computer needs to solve a large system of equations in the form of the classic matrix equation: Ax=b, where A is sparse and there are multiple right-hand sides. Because of the sparsity of A, current algorithms solve this problem efficiently using a conjugate gradient algorithm, which provides an iterative solution. However, since there are multiple right-hand sides it would be even more efficient to solve this problem with a direct solver.

I will investigate recently developed solvers, such as those published as part of the PARDISO[1] project, which are efficient for sparse systems that have multiple right-hand sides. This will enable me to find a more efficient algorithm for modeling a resistivity survey. Once I have completed a mathematical analysis proving correctness, I will examine its efficiency with consideration of time and space complexity. I will also implement the algorithm and experimentally test its relative effectiveness.

1. *http://www.pardiso-project.org/index.html*

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