Project

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Comparison of various methods for numerical solutions of boundary problems involving Laplace equations.

Description : The Laplace equation is one of the most ubiquitous equations in physics with applications ranging from fluid flow to electrostatics to the descriptions of heat transfers. It is therefore of fundamental importance to not only develop an efficient numerical algorithm for its solution but also to determine the errors and the ease of various methods vis-a-vis different grades of problems, each exhibiting different constraints (boundary or otherwise).

To this end, I would like to examine the following methods and study the various features associated with each to come up with an optimum algorithm for the sundry problems :

1. Finite Difference Method
2. Relaxation technique
3. Complex Methods[1]

Other methods as might be suitable can also be added to this list.

I hope to start with the 1-D case and then proceed on to the the 2-D and 3-D cases.

An important part of this will be to study the error analysis associated with each method and their ramifications.[2]

A useful extension of the project could be to solve the partial differential equation in the presence of a source i.e. solving the Poisson's equation.

As an extrapolation of the project, a study of spherical harmonics related to the "Associated Legendre polynomials" can also be done.[3]

References :

1. Comparison of complex methods for numerical solutions of boundary problems of the Laplace equation
-Engineering Analysis with Boundary Elements 28 (2004) 615–622
2. Error Analysis When Solving Laplace's Equation Numerically by Iteration
-IEEE Transactions on Education, Vol. 31, No. 1
3. Numerical Recipes in C++ : Section 6.8