

A Gentle Introduction to the Boundary Element Method in Matlab/Freemat

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Abstract—The Boundary Element Method is developed in its most simple form; for the solution of Laplace's equation in an interior domain with a straight line approximation to the boundary. The direct and indirect approaches to the boundary element method are included. The methods are developed in Freemat, a language similar to Matlab.

The codes for the solution of Laplace's equation in a general domain with a general (Robin) boundary condition are developed. The codes are applied to a typical test problem. The codes are made available as open source (BEM-LAP-MAT package) and can be downloaded from this paper or from the websites listed below². The overall package is expected to become a teaching aid in the MSc course³ that is presently being developed by the authors.

I. INTRODUCTION

The boundary element method (BEM) is an important computational analysis technique that engineers and scientists can apply to a range of problems. There are a number of textbooks on the BEM^{1,2}. The purpose of this article and the accompanying software is to meet the needs of scientists and engineers who are somewhat unfamiliar with the BEM, but have an understanding of numerical methods and computer programming, or would like to apply the BEM to appropriate engineering problems with minimal fuss.

The application of the boundary element method to an appropriate scientific or engineering problem essentially requires a mesh of the boundary of the domain only, and the determination of the boundary condition on the surface. The computational solution then yields the approximate solution at selected points in the domain.

The BEM is generally more efficient to apply and execute than competing methods, such as the finite element or finite difference methods. Hence the application of the BEM presents an attractive option to scientists and engineers. The authors are developing an MSc and this package is expected to act as a teaching aid on one of the modules in that course.

On the other hand the underlying mathematical derivation and numerical analysis is extremely involved. Unfortunately, most textbooks on the BEM concentrate on the mathematics underlying the BEM, considering the ranges of integral equation formulation, ranges of element types, ranges of method derivation. In this article the elegance of the solution method is not lost in a mass of mathematical derivation and analysis. A simple notation is used to assist in the understanding of the development of the BEM.

In this work, the so-called *direct* and *indirect* boundary element methods for the solution of the interior Laplace equation are developed. Laplace's equation is the most straightforward problem to which the BEM can be applied. Laplace's equation also models a number of physical phenomena, such as steady state heat conduction and electrostatics. There is substantial recent research on the application of the BEM to Laplace's equation³⁻¹⁰.

Over recent decades, Matlab¹¹ has become an increasingly important language for scientific computation. Freemat¹² is a freely available alternative compiler for Matlab. All codes are developed in Freemat, but they can be also used in the Matlab environment. Matlab/Freemat is based on Matrix arithmetic, allowing an economy of coding and naturally allows parallel processing, if it is available.

II. THE BOUNDARY ELEMENT METHOD

Over recent decades, the boundary element method (BEM) has received much attention from researchers and has become an important technique in the computational solution of a number of physical

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²www.cast.lancashire-ees.ac.uk

³www.kirkup.info/open-source

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