# EFFECTIVE NUMERICAL TREATMENT OF BOUNDARY INTEGRAL EQUATIONS: A FORMULATION FOR THREE-DIMENSIONAL ELASTOSTATICS

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#### SUMMARY

The field equations of three-dimensional elastostatics are transformed to boundary integral equations. The elastic body is divided into subregions, and the surface and interfaces are represented by quadrilateral and triangular elements with quadratic variation of geometry and linear, quadratic or cubic variation of displacement and traction with respect to intrinsic co-ordinates. The integral equation is discretized for each subregion, and a system of banded form obtained. For the integration of kernel-shape function products, Gaussian quadrature formulae are chosen according to upper bounds for error in terms of derivatives of the integrands. Use of the integral formulation is illustrated by the analysis of a prestressed concrete nuclear reactor pressure vessel.

#### INTRODUCTION

The boundary integral equation method consists of the transformation of the partial differential equations describing the behaviour of the unknown inside and on the boundary of the domain to an integral equation over the boundary, and the numerical solution of this equation for functions on the boundary alone. If values at interior points are required, they are calculated afterwards from the surface data. The system of equations resulting from discretization of the boundary integral equation is smaller than that obtained by, for example, the finite element method, and the field equations are satisfied exactly everywhere inside the domain; but the matrix is non-symmetric and fully populated. A matrix of banded form can, however, be obtained by dividing the domain into subregions, for each of which the integral equation is written.

The integral equations considered here are those obtained directly from the divergence theorem and the elementary solution for the partial differential equation (e.g. the displacement of an infinite elastic space subjected to a concentrated force). The method is therefore applicable only where the elementary solution is known; this, however, is not a severe restriction because, for an elliptic operator with constant coefficients, the solution can be calculated by Hörmander's method.

Jawson and Ponter<sup>2</sup> and Symm<sup>3</sup> solved in 1963 some simple boundary value problems for Laplace's equation in two dimensions, by the boundary integral equation method. The boundary is represented by straight segments, over each of which the unknown function is supposed to be constant, and the integral equation is written at the centre of each segment. The kernels of the integral equation are integrated by Simpson's Rule. The formulation for plane clastostatics by Rizzo<sup>4</sup> is similar, except in that the integration is done analytically. A large number of boundary segments are still required for the solution of practical problems.

Received 28 May 1975 Revised 15 July 1975

# **Numerical Treatment Of Integral Equation**

**Christian Constanda, Paul Harris** 

### **Numerical Treatment Of Integral Equation:**

The Numerical Treatment of Integral Equations Christopher T. H. Baker, 1977 This book is concerned with the numerical analysis of integral equations We are not principally concerned with the abstract theory of integral equations nor with applications of mathematics where integral equations arise but the first chapter is devoted to a review of the theory of integral equations The survey of certain aspects of numerical analysis in chapter 2 is intended to emphasize various topics which are of relevance in the study of numerical methods for integral equations Integral Equations Wolfgang Hackbusch, 1995-06-01 The theory of integral equations has been an active research field for many years and is based on analysis function theory and functional analysis On the other hand integral equations are of practical interest because of the boundary integral equation method which transforms partial differential equations on a domain into integral equations over its boundary This book grew out of a series of lectures given by the author at the Ruhr Universitat Bochum and the Christian Albrecht Universitat zu Kiel to students of mathematics The contents of the first six chapters correspond to an intensive lecture course of four hours per week for a semester Readers of the book require background from analysis and the foundations of numeri cal mathematics Knowledge of functional analysis is helpful but to begin with some basic facts about Banach and Hilbert spaces are sufficient The theoretical part of this book is reduced to a minimum in Chapters 2 4 and 5 more importance is attached to the numerical treatment of the integral equations than to their theory Important parts of functional analysis e g the Riesz Schauder theory are presented without proof We expect the reader either to be already familiar with functional analysis or to become motivated by the practical examples given here to read a book about this topic We recall that also from a historical point of view functional analysis was initially stimulated by the investigation of integral equations **Integral Equations** Wolfgang Hackbusch, 2011-11-01 The theory of integral equations has been an active research field for many years and is based on analysis function theory and functional analysis On the other hand integral equations are of practical interest because of the boundary integral equation method which transforms partial differential equations on a domain into integral equations over its boundary This book grew out of a series of lectures given by the author at the Ruhr Universitat Bochum and the Christian Albrecht Universitat zu Kiel to students of mathematics The contents of the first six chapters correspond to an intensive lecture course of four hours per week for a semester Readers of the book require background from analysis and the foundations of numerical mathematics Knowledge of functional analysis is helpful but to begin with some basic facts about Banach and Hilbert spaces are sufficient The theoretical part of this book is reduced to a minimum in Chapters 2 4 and 5 more importance is attached to the numerical treatment of the integral equations than to their theory Important parts of functional analysis e g the Riesz Schauder theory are presented without proof We expect the reader either to be already familiar with functional analysis or to become motivated by the practical examples given here to read a book about this topic We recall that also from a historical point of view functional analysis was initially stimulated by

the investigation of integral equations The Numerical Treatment of Integral Equations Christopher T. H. Baker, 1971 The Numerical Treatment of Integral Equations Christopher T. H. Baker, 1978 **Colloquium Numerical Treatment** Numerical Treatment of Inverse Problems in Differential and of Integral Equations H. J. J. te Riele, 1979 **Integral Equations** Deuflhard, Hairer, 2012-12-06 In many scientific or engineering applications where ordinary differential equation OOE partial differential equation POE or integral equation IE models are involved numerical simulation is in common use for prediction monitoring or control purposes In many cases however successful simulation of a process must be preceded by the solution of the so called inverse problem which is usually more complex given meas ured data and an associated theoretical model determine unknown para meters in that model or unknown functions to be parametrized in such a way that some measure of the discrepancy between data and model is minimal The present volume deals with the numerical treatment of such inverse probelms in fields of application like chemistry Chap 2 3 4 7 9 molecular biology Chap 22 physics Chap 8 11 20 geophysics Chap 10 19 astronomy Chap 5 reservoir simulation Chap 15 16 elctrocardiology Chap 14 computer tomography Chap 21 and control system design Chap 12 13 In the actual computational solution of inverse problems in these fields the following typical difficulties arise 1 The evaluation of the sen sitivity coefficients for the model may be rather time and storage con suming Nevertheless these coefficients are needed a to ensure local uniqueness of the solution b to estimate the accuracy of the obtained approximation of the solution c to speed up the iterative solution of nonlinear problems 2 Often the inverse problems are ill posed To cope with this fact in the presence of noisy or incomplete data or inevitable discretization errors regularization techniques are necessary Treatment of Integral Equations by Numerical Methods London Mathematical Society,1982 **Colloquium Numerical Treatment of Integral Equations** Numerical Treatment of Differential and Integral Equations Tarek El-Sheshtawy, Hassan Hermanus I. te Riele, 1979 El-Hawary, Salah E. El-Gendi, 2011-10 Numerical methods for solving ordinary and partial differential equations have always been important in scientific investigations With the advent of computers the use of numerical methods has been popularized and more importantly people are now able to tackle those problems which are fundamental to our understanding of scientific phenomena but were so much more difficult to study in the past Spectral methods is the name given to a numerical approach for the solution of differential integral and integro equations Our intension in this book is to develop formulas which are new to the best of our knowledge for the generation of higher order pseudospectral integration matrices. This is used for solving integral and ordinary differential equation applying the proposed formulas transforms the linear integral equation into a system of linear equations which can be solved using any of the well known numerical methods Numerical Treatment of Integral Equations / Numerische Behandlung von Integralgleichungen ALBRECHT, COLLATZ, 2013-11-22 Numerical Treatment of an Integral Equation Originating from a Twodimensional Dirichlet Boundary Value Problem. (Paper) Presented at Workshop on Numerical Treatment of Integral Equations, Oberwolfach 1979 S.

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