

On Tikhonov's Method for Ill-Posed Problems*

By Joel N. Franklin

Abstract. For Tikhonov's regularization of ill-posed linear integral equations, numerical accuracy is estimated by a modulus of convergence, for which upper and lower bounds are obtained. Applications are made to the backward heat equation, to harmonic continuation, and to numerical differentiation.

1. Introduction. Tikhonov's method applies to the integral equation

$$(1.1) \quad \int_0^1 k(x, y) u_0(y) dy = g_0(x) \quad (0 \leq x \leq 1).$$

The problem is to find u_0 if k and g_0 are known.

This problem is ill-posed if k is any measurable kernel. That follows from Riemann's lemma:

$$(1.2) \quad \int_0^1 k(x, y) \sin \lambda y \, dy \rightarrow 0 \quad \text{as } \lambda \rightarrow \infty$$

which shows that a small change in the data, δg_0 , may correspond to a large change in the answer, δu_0 : for some large λ , let $\delta g_0(x)$ equal the integral (1.2); this is a small data-change corresponding to the large answer-change $\delta u_0(y) = \sin \lambda y$.

Many ill-posed problems can be stated as integral equations. In this paper, we will discuss three ill-posed problems: the *backward heat equation*, *harmonic continuation*, and *differentiation*. All will be stated as integral equations. To each, we will apply Tikhonov's method, and we will find the *rate of convergence*. The rate of convergence gives an estimate of the accuracy of the computed solution.

2. Tikhonov's Method. We suppose that $u_0(y)$ solves the integral equation (1.1). The kernel $k(x, y)$ is known, and a function $g(x)$ is known such that

$$(2.1) \quad \|g - g_0\| \leq \epsilon.$$

We will use the notation $\|\varphi\|$ to mean the L_2 -norm:

$$\|\varphi\| = \left(\int_0^1 \varphi^2(x) dx \right)^{1/2}$$

The assumption (2.1) is used instead of $g = g_0$ because, in practical applications, the

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A Conservative Meshless Framework for Conservation Laws with Applications in Computational Fluid Dynamics Kwan Yu Chiu, 2011 Mesh generation which is essential to most traditional numerical discretizations often remains the bottleneck of the simulation process. Many researchers have developed meshless algorithms to circumvent mesh generation. Unfortunately, almost all existing meshless methods suffer from the lack of formal discrete conservation, which can lead to unpredictable numerical errors in the presence of discontinuities. This thesis addresses the issue of non-conservation in existing meshless methods. It focuses on the formulation and implementation of a novel conservative meshless scheme and its applications in computational fluid dynamics (CFD). The scheme, first of such nature documented in the literature, is formulated based on obtaining derivative approximations using function values and generated coefficients satisfying a set of reciprocity and polynomial consistency conditions. The required coefficients are generated by the solution of a global quadratic program. They minimize an upper bound of a representation of the global discretization error in addition to satisfying the necessary conditions. A generalization of the derivative approximation allows the use of arbitrary consistent interface values in the derivative operator while maintaining discrete conservation. This creates a flexible framework within which a wide variety of numerical flux schemes, such as those previously developed for finite volume discretization, can be used with no additional costs. The practicality of this new framework is demonstrated by solving compressible flow problems using, without modifications, a piece of software designed for finite volume discretization. The meshless numerical results show superconvergence and compare well with those obtained using meshed finite volume discretizations and other meshless schemes, highlighting the validity of the new framework and its potential to be applied to problems of greater complexity and scale.

Queen's Papers in Pure and Applied Mathematics Queen's University (Kingston, Ont.), 2001

Smart Intelligent Computing and Communication Technology V.D. Ambeth Kumar, S. Malathi, V.E. Balas, 2021-10-07 Recent developments in the fields of intelligent computing and communication have paved the way for the handling of current and upcoming problems and brought about significant technological advancements. This book presents the proceedings of IConIC 2021, the 4th International Conference on Intelligent Computing, held on 26 and 27 March 2021 in Chennai, India. The principal objective of the annual IConIC conference is to provide an international scientific forum where participants can exchange innovative ideas in relevant fields and interact in depth through discussion with their peer group. The theme of the 2021 conference and this book is Smart Intelligent Computing and Communication Technology, and the 109 papers included here focus on the technological innovations and trendsetting initiatives in medicine, industry, education, and security that are improving and optimizing business and technical processes and enabling inclusive growth. The papers are grouped under 2 headings: Evolution of Computing Intelligence and Computing and Communication, and cover a broad range of intelligent

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Towards a Quarter Century of Public Key Cryptography brings together in one place important contributions and up to date research results in this fast moving area Towards a Quarter Century of Public Key Cryptography serves as an excellent reference providing insight into some of the most challenging research issues in the field Modern Cryptography Volume 1 Zhiyong Zheng, 2022-04-16 This open access book systematically explores the statistical characteristics of cryptographic systems the computational complexity theory of cryptographic algorithms and the mathematical principles behind various encryption and decryption algorithms The theory stems from technology Based on Shannon s information theory this book systematically introduces the information theory statistical characteristics and computational complexity theory of public key cryptography focusing on the three main algorithms of public key cryptography RSA discrete logarithm and elliptic curve cryptosystem It aims to indicate what it is and why it is It systematically simplifies and combs the theory and technology of lattice cryptography which is the greatest feature of this book It requires a good knowledge in algebra number theory and

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Vertical Density Representation and Its Applications Marvin Dean Troutt,Wan-Kai Pang,Shui-Hung Hou,2004 This book presents a new research topic in statistics vertical density representation VDR The theory of VDR has been found to be useful for developing new ideas and methodologies in statistics and management science The first paper related to VDR appeared in 1991 Several others have since been published and work is continuing on the topic The purpose of this book is to survey the results presented in those papers and provide some new unpublished results VDR may be regarded as a special kind of transformation By assuming that a variate is uniformly distributed on the contours of a given function in real n dimensional space and considering the density of the ordinate of the given function the density of the original variate can be represented The book discusses basic results and extensions In particular the uniform assumption on contours is relaxed to the general case Applications are presented in Monte Carlo simulation chaos based uniform random number generation and what may be called behavioral estimation In addition the authors include a new result in analyzing correlation into two separate components which provides flexibility in modeling correlated phenomena such as when combining expert estimates

Computational Perspectives on Number Theory Duncan A. Buell,Jeremy T. Teitelbaum,A. O. L. Atkin,1997 This volume contains papers presented at the conference Computational Perspectives on Number Theory held at the University of Illinois at Chicago in honor of the retirement of A O L Atkin In keeping with Atkin s interests and work the papers cover a range of topics including algebraic number theory p adic modular forms and modular curves Many of the papers reflect Atkin s particular interest in computational and algorithmic questions

Neutrosophic Sets and Systems, Vol. 43, 2021 Florentin Smarandache,Mohamed Abdel-Basset,Said Broumi, Neutrosophic Sets and Systems has been created for publications on advanced studies in neutrosophy neutrosophic set neutrosophic logic neutrosophic probability neutrosophic statistics that started in 1995 and their applications in any field such as the neutrosophic structures

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