

Article

# Variational Estimation Methods for Sturm–Liouville Problems

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**Abstract:** In this paper, we are concerned with approach solutions for Sturm–Liouville problems (SLP) using variational problem (VP) formulation of regular SLP. The minimization problem (MP) is also set forth, and the connection between the solution of each formulation is then proved. Variational estimations (the variational equation associated through the Euler–Lagrange variational principle and Nehari’s method, shooting method and bisection method) and iterative variational methods (He’s method and HPM) for regular RSL are unitary presented in final part of the paper, which ends with applications.

**Keywords:** BVP nonlinear problems; variational methods; estimating nonlinearities; Green function

**MSC:** 34A12; 34A45



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## 1. Introduction

Nonlinearities are different from linear type by a function, an operator or a system that is nonlinear or is the case in which only some characteristics of it are known. The existence of the solution and the dependence of conditions for solving some classes of differential equations described by an operator is specified by the general framework of the Sturm–Liouville problem, with parametric conditions at the limit. The general framework of the Sturm–Liouville problem with parametric conditions at the limit is specified in the first part of the paper. The existence of the solution and the dependence of conditions is specified through the connection between the differential operator and Green’s function. Based on the properties of Green’s function, the operator used to analyze the behavior of the solution of the parameters given by the boundary conditions is specified. Variational problems derived from the initial RSLP are outlined with different type conditions in order to estimate the solution.

Let be the operator  $L = -\frac{d}{dx} \left[ p(x) \frac{d}{dx} \right] + q(x)$  as part of the regular Sturm–Liouville problem (RSL). The Sturm–Liouville (SL) problem expressed by the differential equation and the boundary conditions

$$a(x) \frac{d^2 u}{dx^2} + b(x) \frac{du}{dx} + c(x)u - \lambda d(x)u = 0, \quad (1)$$

$$\begin{aligned} B_1 : & \alpha_1 u(a) + \alpha_2 u'(a) = 0, \quad |\alpha_1| + |\alpha_2| \neq 0, \alpha_1, \alpha_2 \in \mathbb{R}, \\ B_2 : & \beta_1 u(b) + \beta_2 u'(b) = 0, \quad |\beta_1| + |\beta_2| \neq 0, \beta_1, \beta_2 \in \mathbb{R} \end{aligned} \quad (2)$$

could be written as

$$Lu + \lambda s(x)u = 0, \quad x \in (a, b) = I, \lambda \in \mathbb{R} \quad (3)$$

# Stable Methods For Illposed Variational Problems

**Puja Mehta**

A decorative graphic element consisting of a light blue horizontal bar with a rounded right end, and a red circular glow behind it.

## **Stable Methods For Illposed Variational Problems:**

Regularization Algorithms for Ill-Posed Problems Anatoly B. Bakushinsky, Mikhail M. Kokurin, Mikhail Yu.

Kokurin, 2018-02-05 This specialized and authoritative book contains an overview of modern approaches to constructing approximations to solutions of ill posed operator equations both linear and nonlinear These approximation schemes form a basis for implementable numerical algorithms for the stable solution of operator equations arising in contemporary mathematical modeling and in particular when solving inverse problems of mathematical physics The book presents in detail stable solution methods for ill posed problems using the methodology of iterative regularization of classical iterative schemes and the techniques of finite dimensional and finite difference approximations of the problems under study Special attention is paid to ill posed Cauchy problems for linear operator differential equations and to ill posed variational inequalities and optimization problems The readers are expected to have basic knowledge in functional analysis and differential equations The book will be of interest to applied mathematicians and specialists in mathematical modeling and inverse problems and also to advanced students in these fields Contents Introduction Regularization Methods For Linear Equations Finite Difference Methods Iterative Regularization Methods Finite Dimensional Iterative Processes Variational Inequalities and Optimization Problems Stable Methods for III-Posed Variational Problems Alexander Kaplan, Rainer

Tichatschke, 1994-09-13 Iterative prox regularization methods for solving ill posed convex variational problems in Hilbert spaces are subject of this book A general framework is developed to analyse simultaneously procedures of regularization and successively refined discretization in connection with specific optimization methods for solving the discrete problems This allows an efficient control of the solution process as a whole In the first part of the book various methods for treating ill posed problems are presented including a study of the regularizing properties of a number of specific optimization algorithms In the second part a new class of multi step methods is introduced which is based on a generalization of the iterative prox regularization concept Compared with former methods these new methods permit a more effective use of rough approximations of the infinite dimensional problems and consequently an acceleration of the numerical process Special versions of these methods are given for ill posed convex semi infinite optimization problems and elliptic variational inequalities with weakly coercive operators including some problems in elasticity theory Ill-posed Variational Problems and Regularization Techniques Michel Thera, 1999-11-17 This book presents recent developments in the field of ill posed

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*Nonlinear Ill-Posed Problems* A.N. Tikhonov,A.S. Leonov,A.G. Yagola,1998 Professor A N Tikhonov was the founder of nonlinear ill posed problem theory This two volume book introduces the reader to the theory and shows its applications in the natural sciences The first volume introduces the foundations of the theory and provides the background necessary for the design of numerical methods The second volume presents the finite dimensional variants and modification of these methods to help readers use current computer software It considers applications in linear algebra vibrational spectroscopy astrophysics and medicine **Linear Semi-Infinite Optimization** Miguel A. Goberna,Marco A. López,1998-03-11 A linear semi infinite program is an optimization problem with linear objective functions and linear constraints in which either the number of unknowns or the number of constraints is finite The many direct applications of linear semi infinite optimization or programming have prompted considerable and increasing research effort in recent years The authors aim is to communicate the main theoretical ideas and applications techniques of this fascinating area from the perspective of convex analysis The four sections of the book cover Modelling with primal and dual problems the primal problem space of dual variables the dual problem Linear semi infinite systems existence theorems alternative theorems redundancy phenomena geometrical properties of the solution set Theory of linear semi infinite programming optimality duality boundedness perturbations well posedness Methods of linear semi infinite programming an overview of the main numerical methods for primal and dual problems Exercises and examples are provided to illustrate both theory and applications The reader is assumed to be familiar with elementary calculus linear algebra and general topology An appendix on convex analysis is provided to ensure that the book is self contained Graduate students and researchers wishing to gain a deeper understanding of the main ideas behind the theory of linear optimization will find this book to be an essential text **Solutions of Ill-posed Problems** Andreĭ Nikolaevich Tikhonov,Vasiliĭ Iĭkovlevich Arsenin,1977 **Nonlinear Ill-posed Problems** Andreĭ Nikolaevich Tikhonov,A. S. Leonov,Anatoliĭ Grigor'evich Āgola,1998 **Eesti Teaduste Akadeemia Toimetised** ,1996

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