Accepted Manuscript

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PII: S0377-0427(18)30288-7
DOI: https://doi.org/10.1016/j.cam.2018.05.017
Reference: CAM 11682

To appear in: *Journal of Computational and Applied Mathematics*

Received date : 6 September 2017
Revised date : 11 May 2018

Please cite this article as: R.D. Haynes, F. Ahmed, Linearized domain decomposition approaches for nonlinear boundary value problems, *Journal of Computational and Applied Mathematics* (2018), https://doi.org/10.1016/j.cam.2018.05.017

Linearized Domain Decomposition Approaches for Nonlinear Boundary Value Problems

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June 22, 2018

Abstract

Linearized (Schwarz) domain decomposition approaches for nonlinear boundary value problems of the form $u'' = f(x, u, u')$, subject to Dirichlet boundary conditions, are proposed and analyzed. In the presence of subsolutions and supersolutions, we construct a globally convergent, linear, monotone iteration suitable for implementation in a distributed computing environment. These iterations provide an alternative to the typical, locally convergent, approach of discretizing and solving the resulting non-linear algebraic equations using a Newton iteration. The work also extends previous results obtained in the case where f has no dependence on the derivative of the solution. The Schwarz iteration is first proposed and studied in detail on two subdomains. The result is then generalized to an arbitrary number of subdomains. Both alternating and parallel Schwarz iterations are analyzed. Numerical results are provided to demonstrate the theory and the utility of the proposed iterations.

1 Introduction

In this paper we consider the solution of nonlinear boundary value problems (BVPs) of the form

$$u'' = f(x, u, u'),\ 0 < x < 1, \quad u(0) = u(1) = 0. \tag{1.1}$$

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