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Original article

Projector preconditioning and transformation of basis in FETI-DP algorithms for contact problems

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Abstract

Two strategies, using edge averages, for FETI-DP (dual–primal finite element tearing and interconnecting) methods for contact problems are considered. The first one is a preconditioning technique by a conjugate projector, where the Lagrange multipliers corresponding to the variables of the coinciding edges are aggregated. The second one is an explicit transformation of basis introducing edge averages as new, additional primal variables. It is shown that both methods iterate in the same space and thus have the same rate of convergence. The theoretical result is confirmed by the solution of a model boundary variational inequality.

Keywords: Transformation of basis; Edge averaging; Preconditioning by conjugate projector; Contact problems; FETI-DP

1. Introduction

We are concerned with the partially bound constrained quadratic programming problem to find

$$\min_{\mathbf{u}\in\Omega}\phi(\mathbf{u}),\quad \Omega=\{\mathbf{u}\in\mathbb{R}^n:\ \mathbf{u}_{\mathcal{I}}\geq\boldsymbol{\ell}_{\mathcal{I}}\},\quad \mathcal{I}=\{1,\ldots,k\},\tag{1}$$

where

$$\phi(\mathbf{u})=\frac{1}{2}\mathbf{u}^T\mathsf{K}\mathbf{u}-\mathbf{u}^T\mathbf{f},\tag{2}$$

ℓ and $\mathbf{f}$ are given column n-vectors, $1\leq k\ll n$, and K is an $n\times n$ symmetric positive definite matrix. We are interested in large, sparse problems, such as those arising from the discretization of elliptic boundary variational inequalities [6,11].

A class of efficient algorithms for the solution of (1) that is relevant for our research is based on Polyak's implementation of the active set method. In this paper we use the modified proportioning with reduced gradient projections algorithm (MPRGP), proposed by Dostál and Schöberl [7]. This algorithm uses the conjugate gradient method to explore the face of the feasible region defined by the current iterate and the reduced gradient projection with the fixed steplength to expand the active set.

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