Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER
Comput. Methods Appl. Mech. Engrg. 194 (2005) 5139–5158
Computer methods in applied mechanics and engineering
www.elsevier.com/locate/cma

Two aggregate-function-based algorithms for analysis of 3D frictional contact by linear complementarity problem formulation

H.W. Zhang [a,*], S.Y. He [b], X.S. Li [a]

[a] *Department of Engineering Mechanics, State Key Laboratory of Structural Analysis of Industrial Equipment, Dalian University of Technology, Dalian 116024, China*
[b] *Computer Center, Dalian University of Foreign Languages, Dalian 116002, China*

Abstract

Three dimensional frictional contact is formulated as linear complementarity problem (LCP) by using the parametric variational principle and quadratic programming method. Two aggregate-function-based algorithms, called respectively as self-adjusting interior point algorithm and aggregate function smoothing algorithm, are proposed for the solution of the LCP derived from the contact problems. A nonlinear finite element code is developed for numerical analysis of 3D multi-body contact problems. Four numerical examples are computed to demonstrate the applicability and computational efficiency of the methods proposed.
© 2005 Elsevier B.V. All rights reserved.

Keywords: 3D frictional contact problem; Linear complementarity problems; Aggregate function; Interior point algorithm; Smoothing algorithm

1. Introduction

Contact problems with friction are very important in engineering practice. They are also among the most difficult ones in mechanical problems. The main difficulties lie in several aspects, such as the unknown contact surface and the unknown boundary conditions on the contact surfaces during loading. The contact and friction laws are non-smooth and multi-valued relations. Frictional contact problems have been extensively studied in the literatures, which are focused on different aspects of contact problems, such as constitutive

* Corresponding author. Tel./fax: +86 411 470 8769.
E-mail address: zhanghw@dlut.edu.cn (H.W. Zhang).

0045-7825/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.cma.2005.01.002

friction modeling, variational formulations and the finite element method. The corresponding literatures are referred to the review papers [1–3], book [4] and the references therein for detailed descriptions.

It is well known that the contact problems can be formulated as complementarity problem formulations [5–11] or nonlinear equation formulations [1,12]. Although many standard methods such as pivotal method (e.g. Lemke's method) [5–8], homotopy method [9,10], interior point method [1], *B*-differential equation method [1] and smoothing Newton method [12–14] have been developed for solving of LCPs, it is still of significance to develop new algorithms for efficient solution to the 3D contact problems.

In [16], some aggregate function-based algorithms for complementarity problems are developed, among them are self-adjusting interior point algorithm and aggregate function smoothing algorithm, which have been used to solve some mechanics problems [14]. The self-adjusting IPM is developed based on replacing the central equation of the standard IPM by the optimality condition of a new proximity measure function. In paper [17], this method is developed to solve linear programming problems. The basic idea of aggregate function smoothing algorithm is to smooth the equivalent non-differentiable equations of complementarity problems using aggregate function. Then a Newton-type method is used to solve the derived smoothing equations.

In this paper, based on the parametric variational principle [5,6,15], 3D discretized frictional contact problems are formulated as LCPs. Two algorithms, i.e. the self-adjusting interior point algorithm and aggregate-function smoothing algorithm are respectively applied to solve LCP derived from 3D contact problems. Numerical examples are presented and the comparison of efficiency is made between the two algorithms.

2. Governing equations

Consider two candidate contact bodies (see Fig. 1), under the assumption of small deformation, using component notation and the summation convention for indices i, j, k and l, the governing equations and constraints for the 3D frictional contact problems can be concluded as follows:

Equilibrium equations:

$$\mathrm{d}\sigma_{ij,j} + \mathrm{d}b_i = 0, \quad \text{in } \Omega,\ \ i,j = 1,\ldots,3; \tag{1}$$

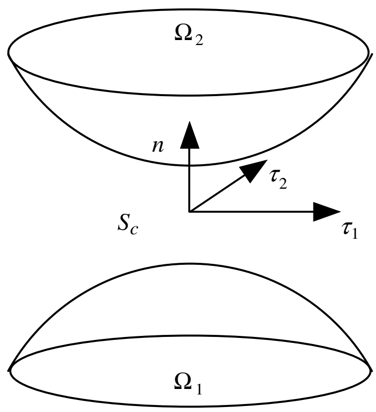

Fig. 1. Two contact bodies.

Download English Version:

https://daneshyari.com/en/article/9667079

Download Persian Version:

https://daneshyari.com/article/9667079

Daneshyari.com