

# Adaptive Methods for Contact Problems

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**Abstract** This contribution is concerned with the adaptive finite-element-formulation of contact problems. For this, first the theoretical background of continuum mechanics and contact kinematics is given. Next the basic finite element formulation for large deformation contact processes is presented for two-dimensional problems. The development of the discretization of contact contributions follows. Here standard approaches are discussed for the case of frictional and frictionless contact. Finally different adaptive strategies involving as well residual based error estimators as error indicators based on superconvergence patch recovery are derived and formulated to include the contributions due to contact. Also error estimators based on dual principles are discussed. Examples show the performance of the different formulations and adaptive strategies.

## 1 Introduction

Boundary value problems involving contact are of great importance in industrial applications in mechanical and civil engineering. The range of application starts with relatively simple problems like foundations or bearings and includes metal forming processes, rubber sealings, drilling problems, crash analysis of cars, rolling contact between car tires and the road. Other applications are related to biomechanics where human joints, implants or teeth are of consideration. Due to this variety contact problems are today combined either with large elastic or inelastic deformations including time dependent responses. Thermal coupling might have to be considered, see cooling of electronic devices, heat removal within nuclear power plant vessels or thermal insulation of astrosatellite vehicles. For most industrial applications numerical methods have to be applied since the contacting bodies have complex geometries or undergo large deformations. Due to that the appropriate meshing for a problem can often not be found a priori to the computation. Hence there is a need to develop adaptive methods for contact problems.

The main idea of adaptive mesh refinement is depicted in Fig. 1. It shows the basic ingredients of an adaptive method for contact problems. Part 1 is the determination of the contact, part 2 a solution of the problem with a given mesh and finally the adaptive process in part 3 leads to an automatic mesh refinement of the discretization.

Adaptive methods rely on a posteriori error estimators which estimate e.g. the difference between the exact solution  $u$  and the approximate solution  $u_h$  of the displacement field. For an elliptic variational problem of order  $m$  with complete interpolation polynomials of order  $k$  in a norm containing derivatives of degree  $s$ , see Strang and Fix (1973), one

# New Developments In Contact Problems

**Peter Wriggers, Panagiotis  
Panatiotopoulos**

## **New Developments In Contact Problems:**

New Developments in Contact Problems Peter Wriggers,Panagiotis Panatiotopoulos,2014-05-04 The book gives an overview on formulation mathematical analysis and numerical solution procedures of contact problems In this respect the book should be of value to applied mathematicians and engineers who are concerned with contact mechanics

**Mechatronic Modeling of Real-Time Wheel-Rail Contact** Nicola Bosso,Maksym Spiriyagin,Antonio Gugliotta,Aurelio Somà,2013-03-15 Real time simulations of the behaviour of a rail vehicle require realistic solutions of the wheel rail contact problem which can work in a real time mode Examples of such solutions for the online mode have been well known and are implemented within standard and commercial tools for the simulation codes for rail vehicle dynamics This book is the result of the research activities carried out by the Railway Technology Lab of the Department of Mechanical and Aerospace Engineering at Politecnico di Torino This book presents work on the project for the development of a real time wheel rail contact model and provides the simulation results obtained with dSpace real time hardware Besides this the implementation of the contact model for the development of a real time model for the complex mechatronic system of a scaled test rig is presented in this book and may be useful for the further validation of the real time contact model with experiments on a full scale test rig

Novel Approaches in Civil Engineering Michel Fremond,Franco Maceri,2003-11-19 In this edited book various novel approaches to problems of current interest in civil engineering are demonstrated The topics range from dynamic band seismic problems to the analysis of long span structures and ancient buildings Experts associated within the Lagrange Laboratory present recent research results on functionally graded or composite materials granular materials geotechnics as well as frictional or adhesive contact problems

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Modern Practice in Stress and Vibration Analysis J. E. Mottershead,2016-06-23 Modern Practice in Stress and Vibration Analysis documents the proceedings of the conference on Modern Practice in Stress and Vibration Analysis organized by the Stress Analysis Group of the Institute of Physics at the University of Liverpool 3 5 April 1989 The Group has been known in the UK for its contribution in providing meetings with an emphasis on application covering topics which range widely to include modern numerical techniques and advanced experimentation The volume contains 34 papers presented by

researchers at the conference covering a wide range of topics such as the application of the sensitivity analysis method to structural dynamics passive and active vibration control for use in vibration suppression in spacecraft analysis of an ultrasonically excited thick cylinder and the prediction of vibrational power transmission through a system of jointed beams carrying longitudinal and flexural waves It is hoped that the contributions published in this book will be of value to the broad community of practitioners in stress and vibration analysis whom the Stress Analysis Group exists to serve

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**California Journal of Development**, 1927 *Mixed Finite Element Methods and Applications* Daniele Boffi, Franco Brezzi, Michel Fortin, 2013-07-02 Non standard finite element methods in particular mixed methods are central to many applications In this text the authors Boffi Brezzi and Fortin present a general framework starting with a finite dimensional presentation then moving on to formulation in Hilbert spaces and finally considering approximations including stabilized methods and eigenvalue problems This book also provides an introduction to standard finite element approximations followed by the construction of elements for the approximation of mixed formulations in  $H$  div and  $H$  curl The general theory is applied to some classical examples Dirichlet's problem Stokes problem plate problems elasticity and electromagnetism

**Horizons**, 1983 *The Journal of the Society of Automotive Engineers*, 1927

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