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Control Problems; 2.4 Direct Collocation Methods; 2.4.1 Local Methods; 2.4.1.1 Trapezoidal Method; 2.4.1.2 Hermite-Simpson Method; 2.4.1.3 Optimality of the Discretised Problem; 2.4.1.4 Convergence; 2.4.2 Example: Simple Problem with Analytical Solution; 2.5 Practical Aspects; 2.5.1 Scaling; 2.5.2 Sparse Nonlinear Programming 2.5.3 Efficient Sparse Differentiation 2.5.4 Measures of Accuracy of the Discretisation; 2.5.5 Mesh Refinement; 2.5.6 Multi-phase Problems; 2.5.7 Potential Pitfalls; 2.6 Example: Space Vehicle Launch Problem; References; Chapter 3 Formation Flying Control for Satellites: Anti-windup Based Approach; 3.1 Introduction; 3.2 Relative Position Control; 3.2.1 Relative Position Plant Model; 3.2.2 Relative Position Controller; 3.2.3 Relative Position Actuator Model; 3.2.3.1 The Influence Matrix; 3.2.3.2 Thruster Saturation; 3.2.3.3 Allocation Function; 3.2.4 Relative Position Closed-Loop Model 3.3 Anti-windup on the Relative Position Control 3.3.1 Anti-windup Compensator Synthesis; 3.3.1.1 Static DLAW Synthesis; 3.3.1.2 Dynamic DLAW Synthesis; 3.3.1.3 MRAW and EMRAW Synthesis; 3.3.2 Simulations on Relative Position Control; 3.4 Conclusion; References; Chapter 4 The ESA NLP Solver WORHP; 4.1 Introductory Remarks; 4.2 Nonlinear Optimization; 4.2.1 Sequential Quadratic Programming; 4.2.1.1 Interior-Point Methods; 4.2.1.2 Constraint Relaxation; 4.2.1.3 Merit Functions; 4.2.1.4 Line Search; 4.2.1.5 Filter; 4.2.1.6 Hessian Regularization; 4.2.2 WORHP Implementation 4.2.2.1 Derivative Approximations

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## Sommario/riassunto

This volume presents a selection of advanced case studies that address a substantial range of issues and challenges arising in space engineering. The contributing authors are well-recognized researchers and practitioners in space engineering and in applied optimization. The key mathematical modeling and numerical solution aspects of each application case study are presented in sufficient detail. Classic and more recent space engineering problems – including cargo accommodation and object placement, flight control of satellites, integrated design and trajectory optimization, interplanetary transfers with deep space maneuvers, low energy transfers, magnetic cleanliness modeling, propulsion system design, sensor system placement, systems engineering, space traffic logistics, and trajectory optimization – are discussed. Novel points of view related to computational global optimization and optimal control, and to multidisciplinary design optimization are also given proper emphasis. A particular attention is paid also to scenarios expected in the context of future interplanetary explorations. Modeling and Optimization in Space Engineering will benefit researchers and practitioners working on space engineering applications. Academics, graduate and post-graduate students in the fields of aerospace and other engineering, applied mathematics, operations research and optimal control will also find the book useful, since it discusses a range of advanced model development and solution techniques and tools in the context of real-world applications and new challenges.

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