

YAGUANG YANG

# **SPACECRAFT MODELING, ATTITUDE DETERMINATION, AND CONTROL**

Quaternion-Based Approach



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A SCIENCE PUBLISHERS BOOK

# Spacecraft Attitude Dynamics And Control

**Yaguang Yang**



## **Spacecraft Attitude Dynamics And Control:**

Spacecraft Dynamics and Control Anton H. de Ruiter, Christopher Damaren, James R. Forbes, 2012-12-05 Provides the basics of spacecraft orbital dynamics plus attitude dynamics and control using vectrix notation Spacecraft Dynamics and Control An Introduction presents the fundamentals of classical control in the context of spacecraft attitude control This approach is particularly beneficial for the training of students in both of the subjects of classical control as well as its application to spacecraft attitude control By using a physical system a spacecraft that the reader can visualize rather than arbitrary transfer functions it is easier to grasp the motivation for why topics in control theory are important as well as the theory behind them The entire treatment of both orbital and attitude dynamics makes use of vectrix notation which is a tool that allows the user to write down any vector equation of motion without consideration of a reference frame This is particularly suited to the treatment of multiple reference frames Vectrix notation also makes a very clear distinction between a physical vector and its coordinate representation in a reference frame This is very important in spacecraft dynamics and control problems where often multiple coordinate representations are used in different reference frames for the same physical vector Provides an accessible practical aid for teaching and self study with a layout enabling a fundamental understanding of the subject Fills a gap in the existing literature by providing an analytical toolbox offering the reader a lasting rigorous methodology for approaching vector mechanics a key element vital to new graduates and practicing engineers alike Delivers an outstanding resource for aerospace engineering students and all those involved in the technical aspects of design and engineering in the space sector Contains numerous illustrations to accompany the written text Problems are included to apply and extend the material in each chapter Essential reading for graduate level aerospace engineering students aerospace professionals researchers and engineers **Spacecraft Attitude, Dynamics and Control** Brij N. Agrawal, 2001-12 *Spacecraft Attitude Dynamics and Control* Vladimir A. Chobotov, 1991 Written for aerospace engineering courses of senior undergraduate or graduate level this work presents basic concepts methods and mathematical developments in spacecraft attitude dynamics and control Topics covered include rigid body dynamics environmental effects and linear control theory *Fundamentals of Spacecraft Attitude Determination and Control* F. Landis Markley, John L. Crassidis, 2014-05-31 This book explores topics that are central to the field of spacecraft attitude determination and control The authors provide rigorous theoretical derivations of significant algorithms accompanied by a generous amount of qualitative discussions of the subject matter The book documents the development of the important concepts and methods in a manner accessible to practicing engineers graduate level engineering students and applied mathematicians It includes detailed examples from actual mission designs to help ease the transition from theory to practice and also provides prototype algorithms that are readily available on the author's website Subject matter includes both theoretical derivations and practical implementation of spacecraft attitude determination and control systems It provides detailed derivations for

attitude kinematics and dynamics and provides detailed description of the most widely used attitude parameterization the quaternion This title also provides a thorough treatise of attitude dynamics including Jacobian elliptical functions It is the first known book to provide detailed derivations and explanations of state attitude determination and gives readers real world examples from actual working spacecraft missions The subject matter is chosen to fill the void of existing textbooks and treatises especially in state and dynamics attitude determination MATLAB code of all examples will be provided through an external website Spacecraft Attitude Dynamics and Control Fabio Bacconi,2006 Spacecraft Attitude Determination and Control J.R. Wertz,2012-12-06 Roger D Werking Head Attitude Determination and Control Section National Aeronautics and Space Administration Goddard Space Flight Center Extensive work has been done for many years in the areas of attitude determination attitude prediction and attitude control During this time it has been difficult to obtain reference material that provided a comprehensive overview of attitude support activities This lack of reference material has made it difficult for those not intimately involved in attitude functions to become acquainted with the ideas and activities which are essential to understanding the various aspects of spacecraft attitude support As a result I felt the need for a document which could be used by a variety of persons to obtain an understanding of the work which has been done in support of spacecraft attitude objectives It is believed that this book prepared by the Computer Sciences Corporation under the able direction of Dr James Wertz provides this type of reference This book can serve as a reference for individuals involved in mission planning attitude determination and attitude dynamics an introductory textbook for students and professionals starting in this field an information source for experimenters or others involved in spacecraft related work who need information on spacecraft orientation and how it is determined but who have neither the time nor the resources to pursue the varied literature on this subject and a tool for encouraging those who could expand this discipline to do so because much remains to be done to satisfy future needs *Spacecraft Dynamics and Control* Marcel J. Sidi,2000-07-03 Satellites are used increasingly in telecommunications scientific research surveillance and meteorology and these satellites rely heavily on the effectiveness of complex onboard control systems This 1997 book explains the basic theory of spacecraft dynamics and control and the practical aspects of controlling a satellite The emphasis throughout is on analyzing and solving real world engineering problems For example the author discusses orbital and rotational dynamics of spacecraft under a variety of environmental conditions along with the realistic constraints imposed by available hardware Among the topics covered are orbital dynamics attitude dynamics gravity gradient stabilization single and dual spin stabilization attitude maneuvers attitude stabilization and structural dynamics and liquid sloshing **Spacecraft Attitude Dynamics** Peter C. Hughes,2012-05-23 Comprehensive coverage includes environmental torques energy dissipation motion equations for four archetypical systems orientation parameters illustrations of key concepts with on orbit flight data and typical engineering hardware 1986 edition Spacecraft Attitude Control Chuang Liu,Xiaokui Yue,Keke Shi,Zhaowei Sun,2022-01-31 Spacecraft Attitude Control A

Linear Matrix Inequality Approach solves problems for spacecraft attitude control systems using convex optimization and specifically through a linear matrix inequality LMI approach. High precision pointing and improved robustness in the face of external disturbances and other uncertainties are requirements for the current generation of spacecraft. This book presents an LMI approach to spacecraft attitude control and shows that all uncertainties in the maneuvering process can be solved numerically. It explains how a model like state space can be developed through a mathematical presentation of attitude control systems allowing the controller in question to be applied universally. The authors describe a wide variety of novel and robust controllers applicable both to spacecraft attitude control and easily extendable to second order systems. Spacecraft Attitude Control provides its readers with an accessible introduction to spacecraft attitude control and robust systems giving an extensive survey of current research and helping researchers improve robust control performance. Considers the control requirements of modern spacecraft. Presents rigid and flexible spacecraft control systems with inherent uncertainties mathematically leading to a model like state space. Develops a variety of novel and robust controllers directly applicable to spacecraft control as well as extendable to other second order systems. Includes a systematic survey of recent research in spacecraft attitude control.

**Spacecraft Dynamics and Control** Yongchun Xie, Yongjun Lei, Jianxin Guo, Bin Meng, 2021-07-13

This book presents up to date concepts and design methods relating to space dynamics and control including spacecraft attitude control orbit control and guidance navigation and control GNC summarizing the research advances in control theory and methods and engineering practice from Beijing Institute of Control Engineering over the years. The control schemes and systems based on these achievements have been successfully applied to remote sensing satellites communication satellites navigation satellites new technology test satellites Shenzhou manned spacecraft Tianzhou freight spacecraft Tiangong 1 2 space laboratories Chang e lunar explorers and many other missions. Further the research serves as a guide for follow up engineering developments in manned lunar engineering deep space exploration and on orbit service missions.

**Fundamental Spacecraft Dynamics and Control** Weiduo Hu, 2015-09-03 An extensive text reference includes around an asteroid a new and important topic. Covers the most updated contents in spacecraft dynamics and control both in theory and application. Introduces the application to motion around asteroids a new and important topic. Written by a very experienced researcher in this area.

**Space Vehicle Dynamics and Control** Bong Wie, 1998 A textbook that incorporates the latest methods used for the analysis of spacecraft orbital attitude and structural dynamics and control. Spacecraft dynamics is treated as a dynamic system with emphasis on practical applications typical examples of which are the analysis and redesign of the pointing control system of the Hubble Space Telescope and the analysis of an active vibrations control for the COFS Control of Flexible Structures Mast Flight System. In addition to the three subjects mentioned above dynamic systems modeling analysis and control are also discussed. Annotation copyrighted by Book News Inc Portland OR

**Spacecraft Dynamics and Control** Enrico Canuto, Carlo Novara, Donato Carlucci, Carlos Perez-Montenegro, Luca

Massotti,2018-03-08 Spacecraft Dynamics and Control The Embedded Model Control Approach provides a uniform and systematic way of approaching space engineering control problems from the standpoint of model based control using state space equations as the key paradigm for simulation design and implementation The book introduces the Embedded Model Control methodology for the design and implementation of attitude and orbit control systems The logic architecture is organized around the embedded model of the spacecraft and its surrounding environment The model is compelled to include disturbance dynamics as a repository of the uncertainty that the control law must reject to meet attitude and orbit requirements within the uncertainty class The source of the real time uncertainty estimation prediction is the model error signal as it encodes the residual discrepancies between spacecraft measurements and model output The embedded model and the uncertainty estimation feedback noise estimator in the book constitute the state predictor feeding the control law Asymptotic pole placement exploiting the asymptotes of closed loop transfer functions is the way to design and tune feedback loops around the embedded model state predictor control law reference generator The design versus the uncertainty class is driven by analytic stability and performance inequalities The method is applied to several attitude and orbit control problems The book begins with an extensive introduction to attitude geometry and algebra and ends with the core themes state space dynamics and Embedded Model Control Fundamentals of orbit attitude and environment dynamics are treated giving emphasis to state space formulation disturbance dynamics state feedback and prediction closed loop stability Sensors and actuators are treated giving emphasis to their dynamics and modelling of measurement errors Numerical tables are included and their data employed for numerical simulations Orbit and attitude control problems of the European GOCE mission are the inspiration of numerical exercises and simulations The suite of the attitude control modes of a GOCE like mission is designed and simulated around the so called mission state predictor Solved and unsolved exercises are included within the text and not separated at the end of chapters for better understanding training and application Simulated results and their graphical plots are developed through MATLAB Simulink code

#### **Fast Satellite Attitude Maneuver and Control Dong**

Ye,You Li,Yan Xiao,2022-08-02 Fast Satellite Attitude Maneuver and Control introduces the concept of agile satellites and corresponding fast maneuver attitude control systems systematically and comprehensively presenting recent research results of fast maneuver attitude control for agile satellites by using advanced nonlinear control techniques This reference book focuses on modeling and attitude control considering different actuator combinations actuator installation deviation actuator fault and flexible appendage coupling effect for agile satellites The book provides a unified platform for understanding and applicability of agile satellites fast maneuverer and stabilization control for different purposes It will be an excellent resource for researchers working on spacecraft design nonlinear control systems vehicle systems and complex control systems Unifies existing and emerging concepts concerning nonlinear control theory fault tolerant and attitude control for agile satellites Provides a series of the latest results including but not limited to fast maneuverer and stabilization control hybrid actuator

control nonlinear attitude control fault tolerant control and active vibration suppression towards agile satellites

Comprehensively captures recent advances of theory technological aspects and applications of fast maneuverer and stabilization control in agile satellites Addresses research problems in each chapter along with numerical and simulation results that reflect engineering practice and demonstrate the focus of developed analysis and synthesis approaches Contains comprehensive up to date references which play an indicative role for further study      *Web-based Tools for Spacecraft Attitude Dynamics and Control Simulation* Daniel L. Quock, 2001 Provides attitude dynamics and control simulation tools utilizing the advantages of the World Wide Web      **Flexible Spacecraft Dynamics, Control and Guidance** Leonardo Mazzini, 2015-10-27 This book is an up to date compendium on spacecraft attitude and orbit control AOC that offers a systematic and complete treatment of the subject with the aim of imparting the theoretical and practical knowledge that is required by designers engineers and researchers After an introduction on the kinematics of the flexible and agile space vehicles the modern architecture and functions of an AOC system are described and the main AOC modes reviewed with possible design solutions and examples The dynamics of the flexible body in space are then considered using an original Lagrangian approach suitable for the control applications of large space flexible structures Subsequent chapters address optimal control theory attitude control methods and orbit control applications including the optimal orbital transfer with finite and infinite thrust The theory is integrated with a description of current propulsion systems with the focus especially on the new electric propulsion systems and state of the art sensors and actuators      Spacecraft Modeling, Attitude Determination, and Control Yaguang Yang, 2019-02-06 This book discusses all spacecraft attitude control related topics spacecraft including attitude measurements actuator and disturbance torques modeling spacecraft attitude determination and estimation and spacecraft attitude controls Unlike other books addressing these topics this book focuses on quaternion based methods because of its many merits The book lays a brief but necessary background on rotation sequence representations and frequently used reference frames that form the foundation of spacecraft attitude description It then discusses the fundamentals of attitude determination using vector measurements various efficient including very recently developed attitude determination algorithms and the instruments and methods of popular vector measurements With available attitude measurements attitude control designs for inertial point and nadir pointing are presented in terms of required torques which are independent of actuators in use Given the required control torques some actuators are not able to generate the accurate control torques therefore spacecraft attitude control design methods with achievable torques for these actuators for example magnetic torque bars and control moment gyros are provided Some rigorous controllability results are provided The book also includes attitude control in some special maneuvers such as orbital raising docking and rendezvous that are normally not discussed in similar books Almost all design methods are based on state spaced modern control approaches such as linear quadratic optimal control robust pole assignment control model predictive control and gain

scheduling control Applications of these methods to spacecraft attitude control problems are provided Appendices are provided for readers who are not familiar with these topics      **Chaos in Attitude Dynamics of Spacecraft** Yanzhu Liu, Liqun Chen, 2013-04-13 Attitude dynamics is the theoretical basis of attitude control of spacecrafts in aerospace engineering With the development of nonlinear dynamics chaos in spacecraft attitude dynamics has drawn great attention since the 1990 s The problem of the predictability and controllability of the chaotic attitude motion of a spacecraft has a practical significance in astronautic science This book aims to summarize basic concepts main approaches and recent progress in this area It focuses on the research work of the author and other Chinese scientists in this field providing new methods and viewpoints in the investigation of spacecraft attitude motion as well as new mathematical models with definite engineering backgrounds for further analysis Professor Yanzhu Liu was the Director of the Institute of Engineering Mechanics Shanghai Jiao Tong University China Dr Liqun Chen is a Professor at the Department of Mechanics Shanghai University China      *Attitude Dynamics and Control of a Spacecraft Using Shifting Mass Distribution* Young Tae Ahn, 2012  
    *Spacecraft Attitude Determination and Control* Computer Sciences Corporation. Attitude Systems Operation, 1978



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