

## Chapter 2

# Robot Kinematics and Dynamics Modeling

**Abstract** The robotic kinematics is essential for describing an end-effector's position, orientation as well as motion of all the joints, while dynamics modeling is crucial for analyzing and synthesizing the dynamic behavior of robot. In this chapter, the kinematics and dynamics modeling procedures of the Baxter robot are investigated thoroughly. The robotic kinematics is briefly reviewed by highlighting its basic role in analyzing the motion of robot. By extracting the parameters from an URDF file, the kinematics model of the Baxter robot is built. Two experiments are performed to verify that the kinematics model matches the real robot. Next, the dynamics of robot is briefly introduced by highlighting its role in establishing the relation between the joint actuator torques and the resulting motion. The method for derivation of the Lagrange–Euler dynamics of the Baxter manipulator is presented, followed by experimental verification using data collected from the physical robot. The results show that the derived dynamics model is a good match to the real dynamics, with small errors in three different end-effector trajectories.

## 2.1 Kinematics Modeling of the Baxter® Robot

### 2.1.1 Introduction of Kinematics

The robotic kinematics studies the motion of a robot mechanism regardless of forces and torque that cause it. It allows to compute the position and orientation of robot manipulator's end-effector relative to the base of the manipulator as a function of the joint variables. Robotic kinematics is fundamental for designing and controlling a robot system. In order to deal with the complex geometry of a robot manipulator, the properly chosen coordinate frames are fixed to various parts of the mechanism and then we can formulate the relationships between these frames. The manipulator kinematics mainly studies how the locations of these frames change as the robot joints move.

Kinematics focuses on position, velocity, acceleration, and an accurate kinematics model must be established in order to investigate the motion of a robot manipulator. Denavit–Hartenberg (DH) notations are widely used to describe the kinematic model

# Chapter 2 Robot Kinematics And Dynamics Modeling

**Demick Boyden**



## **Chapter 2 Robot Kinematics And Dynamics Modeling:**

*Advanced Dynamics Modeling, Duality and Control of Robotic Systems* Edward Y.L. Gu, 2021-09-23 This book provides detailed fundamental theoretical reviews and preparations necessary for developing advanced dynamics modeling and control strategies for various types of robotic systems This research book specifically addresses and discusses the uniqueness issue of representing orientation or rotation and further proposes an innovative isometric embedding approach The novel approach can not only reduce the dynamic formulation for robotic systems into a compact form but it also offers a new way to realize the orientational trajectory tracking control procedures In addition the book gives a comprehensive introduction to fundamentals of mathematics and physics that are required for modeling robot dynamics and developing effective control algorithms Many computer simulations and realistic 3D animations to verify the new theories and algorithms are included in the book as well It also presents and discusses the principle of duality involved in robot kinematics statics and dynamics The duality principle can guide the dynamics modeling and analysis into a right direction for a variety of robotic systems in different types from open serial chain to closed parallel chain mechanisms It intends to serve as a diversified research reference to a wide range of audience including undergraduate juniors and seniors graduate students researchers and engineers interested in the areas of robotics control and applications

**Robot Modeling and Control** Mark W. Spong, Seth Hutchinson, M. Vidyasagar, 2020-03-30 A New Edition Featuring Case Studies and Examples of the Fundamentals of Robot Kinematics Dynamics and Control In the 2nd Edition of Robot Modeling and Control students will cover the theoretical fundamentals and the latest technological advances in robot kinematics With so much advancement in technology from robotics to motion planning society can implement more powerful and dynamic algorithms than ever before This in depth reference guide educates readers in four distinct parts the first two serve as a guide to the fundamentals of robotics and motion control while the last two dive more in depth into control theory and nonlinear system analysis With the new edition readers gain access to new case studies and thoroughly researched information covering topics such as Motion planning collision avoidance trajectory optimization and control of robots Popular topics within the robotics industry and how they apply to various technologies An expanded set of examples simulations problems and case studies Open ended suggestions for students to apply the knowledge to real life situations A four part reference essential for both undergraduate and graduate students Robot Modeling and Control serves as a foundation for a solid education in robotics and motion planning

*Wearable Robots* José L. Pons, 2008-04-15 A wearable robot is a mechatronic system that is designed around the shape and function of the human body with segments and joints corresponding to those of the person it is externally coupled with Teleoperation and power amplification were the first applications but after recent technological advances the range of application fields has widened Increasing recognition from the scientific community means that this technology is now employed in telemanipulation man amplification neuromotor control research and rehabilitation and to assist with impaired

human motor control Logical in structure and original in its global orientation this volume gives a full overview of wearable robotics providing the reader with a complete understanding of the key applications and technologies suitable for its development The main topics are demonstrated through two detailed case studies one on a lower limb active orthosis for a human leg and one on a wearable robot that suppresses upper limb tremor These examples highlight the difficulties and potentialities in this area of technology illustrating how design decisions should be made based on these As well as discussing the cognitive interaction between human and robot this comprehensive text also covers the mechanics of the wearable robot and its biomechanical interaction with the user including state of the art technologies that enable sensory and motor interaction between human biological and wearable artificial mechatronic systems the basis for bioinspiration and biomimeticism general rules for the development of biologically inspired designs and how these could serve recursively as biological models to explain biological systems the study on the development of networks for wearable robotics Wearable Robotics Biomechatronic Exoskeletons will appeal to lecturers senior undergraduate students postgraduates and other researchers of medical electrical and bio engineering who are interested in the area of assistive robotics Active system developers in this sector of the engineering industry will also find it an informative and welcome resource **"Real-time"**

**Kinematic and Dynamic Analysis and Adaptive Model Following Control of Manipulator Arms** Behzad Ghavimi,1987

Dynamic Modeling of Wheeled Mobile Robots Demick Boyden,1993      Experiments in Cooperative-arm Object Manipulation with a Two-armed Free-flying Robot Ross Koningstein,Stanford University. Department of Aeronautics and Astronautics,1990      **Robot Modeling and Kinematics** Rachid Manseur,2006 Robot Modeling and Kinematics teaches the fundamental topics of robotics using cutting edge visualization software and computer tools to illustrate topics and provide a comprehensive process of teaching and learning The book provides an introduction to robotics with an emphasis on the study of robotic arms their mathematical description and the equations describing their motion It teaches how to model robotic arms efficiently and analyze their kinematics The kinematics of robot manipulators is also presented beginning with the use of simple robot mechanisms and progressing to the most complex robot manipulator structures While mathematically rigorous the book's focus is on ease of understanding of the concepts with interactive animated computer graphics illustrations and modeling software that allow clear understanding of the material covered in the book All necessary computations are concisely explained and software is provided that greatly eases the computational burden normally associated with robotics Written for use in a robotics course or as a professional reference Robot Modeling and Kinematics is an essential resource that provides a thorough understanding of the topics of modeling and kinematics **Applied Mechanics Reviews** ,1987      Efficient Algorithms for Articulated Branching Mechanisms: Dynamic Modeling, Control, and Simulation Kyong-Sok Chang,2000      Design, Dynamics and Control Issues in a Parallel Link Robot Crane Arulkumar P. Shanmugasundram,1995      On Tracking Performance of a Robot Manipulator Under Force Control Seul Jung,1991

**Visual Control of Robots** Peter I. Corke,1996      *Complex Robotic Systems* Pasquale Chiacchio,Stefano

Chiaverini,1998-04-09 Robotic systems have proved themselves to be of increasing importance and are widely adopted to substitute for humans in repetitive or hazardous situations Their diffusion has outgrown the limits of industrial applications in manufacturing systems to cover all aspects of exploration and servicing in hostile environments such as undersea outer space battlefields and nuclear plants Complex robotic systems ie robotic systems with a complex structure and architecture are gaining increasing attention from both the academic community and industrial users The modelling and control problems for these systems cannot be regarded as simple extensions of those for traditional single manipulators since additional complexity arises to accomplish tasks there is the need to ensure coordinated motion of the whole system together with management of interaction between each component of the system This book focuses on two examples of complex robotic systems namely co operating manipulators and multi fingered hands It is addressed to graduate students as well as to researchers in the field      Introduction to Robotics Phillip McKerrow,1991 This book provides an introductory text for

students coming new to the field of robotics and a survey of the state of the art for professional practitioners Some of the outstanding features of this book include A unique approach which ties the multi disciplinary components of robotics into a unified text Broad and in depth coverage of all the major topics from the mechanics of movement to modelling and programming Rigorous mathematical treatment of mature topics combined with an algorithmic approach to newer areas of research Practical examples taken from a wide range of fields including computer science electronic engineering mechanical engineering and production engineering Step by step development of problems and many worked examples      **The**

**International Journal of Mechanical Engineering Education** ,1986      Journal of Mechanisms, Transmissions, and Automation in Design ,1986      Advanced Robot Control János Somló,Béla Lantos,Thuong Cat Pham,1997 Modern Robotics

has a history of not more than 50 years Robot science grew up in this period The basic results of control of these devices were developed in the last 20 years The authors of the present book summarize in an original presentation the most important results and add to those some new contributions Among others robot kinematics trajectory planning dynamics and control problems are discussed in detail The new results include the original treatment of various kinematic and dynamic problems time optimal trajectory planning model reference adaptive control robot dynamic model identification and self tuning adaptive control robotized manufacturing optimization and some others      *Nonlinear Adaptive Formation Control for*

*a Class of Autonomous Holonomic Planetary Exploration Rovers* Farid Ganji,2007      **Memoirs of the Scientific Sections of the Academy of the Socialist Republic of Romania** ,1985      Mechatronics and Robotics Iulian Tabara,Luige

Vladareanu,Cristian Doicin,Nicolae Ionescu,Tom Savu,Adrian Bruja,Constantin Ocnărescu,Constantin Gheorghe

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### Chapter 2 Robot Kinematics And Dynamics Modeling Introduction

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