

Preface

As the emerging technologies of robotics, dynamic balancing for mechanisms and parallel robots has become one of the bottleneck issues for the applications in modern manufacturing industries, space, medical industries, military, and social service. Research and development of various dynamic balancing methods is now being performed more and more actively in every applicable field. This book will introduce state-of-the-art research in these technologies from theory to practice in a systematic and comprehensive way.

Any vibrations in mechanisms will cause inaccuracy while they are in operations. Traditional counterbalance methods make the whole mechanism heavier and have more inertia; the book entitled *Dynamic Balancing of Mechanisms and Synthesizing of Parallel Robots* will be the first book that describes the up-to-date technologies in dynamic balancing of mechanisms and parallel robots. It systematically and thoroughly not only deals with different dynamic balancing principles but also comprises recent advances on dynamic balancing of mechanisms with minimum increase of mass and inertia, synthesizing of parallel robots based on decomposition and integration concept, and finally optimization and control issues for balancing are discussed at length within this book.

We would like to express our deep appreciation to all the authors for their significant contributions to the book. Their commitment, enthusiasm, and technical expertise are what made this book possible. We are also grateful to the publisher for supporting this project and would especially like to thank Ms. Merry Stuber, Editorial Assistant of Springer US, and Ms. Lesley Poliner, Springer US Science and Business Media Project Coordinator, for their constructive assistance and earnest cooperation, both with the publishing venture in general and the editorial details. We hope the readers find this book informative and useful.

This book consists of 20 chapters. Chapter 1 introduces the recent advances on reactionless mechanisms and parallel robots, and the dynamic balancing through reconfiguration concept is proposed. Chapter 2 presents methods and principles used

for balancing of planar mechanisms without counterrotations. Chapter 3 considers the shaking moment and shaking force balancing through the use of additional Assur groups mounted on the mechanism to be balanced. Two types of mechanisms are considered, the in-line four-bar linkage and the planar parallel robots with prismatic pairs. Chapter 4 discusses the development of reactionless planar parallel manipulators by using base-mounted counterrotations and inertia flywheel rotating with a prescribed angular velocity. Chapter 5 introduces a new general method to find the dynamic balancing conditions based on the use of natural coordinates for planar mechanisms, and the method has been shown in its application to the design and dynamic balancing of plane mechanisms. Chapter 6 deals with the shaking force and shaking moment balancing of single degree of freedom planar mechanisms by employing the traditional technique of addition of counterweights and counterrotating inertias. Chapter 7 proposes a force balancing method called adjusting kinematic parameters for robotic mechanisms or real-time controllable mechanisms. Chapter 8 proposes a formulation, which can be seen as a tool in selecting appropriate solution(s) according to the expected operation conditions, to address the effects of balancing on mass distributions and dynamic performance. A case of study has been developed by referring to a three degrees-of-freedom spatial parallel manipulator by designing proper counter-rotary counterweights. Chapter 9 focuses on dynamic balancing with respect to a given trajectory for the parallel link robots by modeling control system. Chapter 10 addresses the class of problems that require movement of a dynamic bipedal system according to stringent state-space and temporal requirements despite actuation limits and disturbances. Chapter 11 presents an optimization technique to dynamically balance planar mechanisms by minimizing the shaking forces and shaking moments due to inertia-induced forces. Chapter 12 investigates the dynamic response of mechanism having revolute joints with clearance, and a 4R four-bar mechanism whose two joints have clearances is considered as a model mechanism. Chapter 13 minimizes the shaking force and moment fluctuations at the planar mechanism by employing the genetic algorithm. Chapter 14 presents the optimal balancing for the open-chain robotic system based on the indirect solution of open-loop optimal control problem. Chapter 15 studies the dynamics and control of planar, translation, and spherical parallel manipulators by means of the constraint equations. Chapter 16 deals with the dynamic modeling and control of balanced parallel mechanisms, highlights the importance of the dynamic modeling process, and discusses the impact of the dynamic model, developed in accordance with the methodology, for the control strategy of parallel mechanisms. Chapter 17 describes the control principles necessary for an articulated biped model to accomplish balanced locomotion during walking and climbing. Chapter 18 focuses on the control of a 10-dof biped robot, and a spline-based control system is described in order to generate the servo inputs. Chapter 19 deals with an approach to formulate balancing conditions for the

shaking force and shaking moment of planar mechanisms and spatial mechanisms. Chapter 20 addresses the static balancing of six degree-of-freedom articulated wheeled vehicles with multiple leg-wheel subsystem.

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