Preface

Walking robots are complex machines with many degrees of freedom. Designing efficient controllers for such robots can be a daunting task, and the differential equations by themselves usually do not help much when trying to understand the dynamics. Still, research on passive dynamic walking robots has shown that it is possible to make robotic mechanisms walk very naturally and efficiently without using any control! The gap between theoretically well-understood position-controlled walking robots and experimentally-designed uncontrolled passive-dynamic walkers is nevertheless large, and extending a passive-dynamic walker to be more robust and versatile is non-trivial.

The purpose of this work is to present a set of mathematical tools that can simplify studying robotic walking motions and designing energy-efficient controllers. We extend classical dynamic modeling methods and view robots and controllers as energy-exchanging physical systems, which forms the basis of the so-called port-based approach. We show how such methods can be used to analyze walking mechanisms, find efficient walking trajectories, and design controllers that increase robustness and stability with minimal energy cost. We use extensive examples and illustrations with the objective to make the mathematics intuitive and accessible to everyone with an engineering background: we believe advanced math can be beautiful without being difficult!

This book is based on the first author's dissertation work at the University of Twente, as part of the EU-sponsored project GeoPlex. We would like to thank all members of the GeoPlex consortium for their direct and indirect contributions to the results in this book and for the many enlightening discussions we had about the topic. We also thank our colleagues of the Control Engineering Lab at the University of Twente for the extensive collaboration and great working environment. Finally, we want to thank our families and friends for the many years of indispensable non-scientific support.

July 2008

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http://www.springer.com/978-3-540-89917-4

Modeling and Control for Efficient Bipedal Walking Robots
A Port-Based Approach
Duindam, V.; Stramigioli, S.
2009, XIV, 214 p. 81 illus., Hardcover
ISBN: 978-3-540-89917-4