Computational Dynamics for Robotic Systems on Land and Under Water

DISSERTATION

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by

Scott McMillan, M.S.E.E., B.S.

* * * * *

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Dissertation Committee:

David E. Orin

Robert B. McGhee

P. Sadayappan

Approved by

Adviser
Department of Electrical Engineering

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To my family

Abstract

Motivated by the need for more complex robotic systems to accomplish more difficult tasks such as hazardous waste cleanup, assembly operations, and deep-sea construction and exploration, this dissertation presents the development of efficient dynamic simulation algorithms for multiple chain robotic systems on land and under water. These algorithms can be used in the development of control algorithms, and with real-time rates, hardware- and human-in-the-loop applications also become possible. These uses of simulation can significantly reduce the cost of design, development, and operation of complex robotic systems.

In Part I, land-based systems are examined which include multiple manipulator systems and multilegged vehicles. For multiple manipulator systems, an efficient closed chain dynamics algorithm based on the Composite Rigid Body (CRB) method is presented. To increase computational rates in an effort to achieve real-time, temporal and spatial forms of parallelism are implemented, and algorithms that are robust in the presence of manipulator singularities are developed. Then, the decoupled tree-structure (DTS) approach is used to develop a new efficient, CRB-based algorithm for legged vehicles on land.

In Part II, the development of a real-time simulation system for underwater robotic vehicle (URV) systems is presented. Hydrodynamic forces on submerged rigid bodies are investigated, and an efficient dynamic and hydrodynamic simulation algorithm based on the Articulated Body (AB) method is developed. Finally, an implementation of this algorithm capable of simulating a general class of tree structured mechanisms having star topologies is undertaken. Object oriented design techniques such as object hierarchies, encapsulation, inheritance, and polymorphism are applied to this task and a general but very efficient implementation results.

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Vita

March 8, 1966	Born—Wilmington, DE, U.S.A.
1984 – 1988	R. F. Poole Scholar, Clemson University, Clemson, SC, U.S.A.
May 1988	B.S. Computer Engineering Clemson University
Summer 1988	Digital Design Engineer Experimental Physics Laboratory E.I. DuPont de Nemours & Co., Inc. Wilmington, DE, U.S.A.
1988 – 1992	DuPont Fellow in Electrical Engineering The Ohio State University Columbus, Ohio, U.S.A.
1988 – Present	University Fellow The Ohio State University
June–September 1989	Graduate Research Associate The Ohio State University
January –June 1990	Graduate Teaching Associate The Ohio State University
June 1990	M.S. Electrical Engineering The Ohio State University
1990 – 1994	AT&T Ph.D. Scholar The Ohio State University
Summer 1991, 1992	Member of Technical Staff Computing Architectures Res. Dept. AT&T Bell Laboratories Holmdel, NJ, U.S.A.
Summer 1993	Visiting Engineer Naval Postgraduate School/MBARI Monterey, CA, U.S.A.

Publications

"Real-Time Simulation of a Robotic Manipulator Using a Parallel Integration Method," Masters Thesis, The Ohio State University, Columbus, Ohio, June 1990.

"Real-Time Robot Dynamic Simulation on a Vector/Parallel Supercomputer," *IEEE Int. Conf. on Robotics and Automation*, Sacramento, pp. 1836–1841, April 1991 (with D. E. Orin and P. Sadayappan).

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"Efficient Computation of Articulated-Body Inertias Using Successive Axial Screws," *IEEE Trans. on Robotics and Automation*, vol. 11, no. 4, pp. 606–611, August 1995 (with D. E. Orin).

Fields of Study

Major Field: Electrical Engineering

Studies in Robotics:	Professors D. E. Orin, C. A. Klein, K. J. Waldron
Studies in Computer Engineering:	Professors S. C. Ahalt, F. Özgüner, D. E. Orin
Studies in Control Engineering:	Professors S. Yurkovich, Ü. Özgüner, K. Passino
Studies in Mathematics:	Professors G. R. Baker, A. Bloch, G. Majda

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