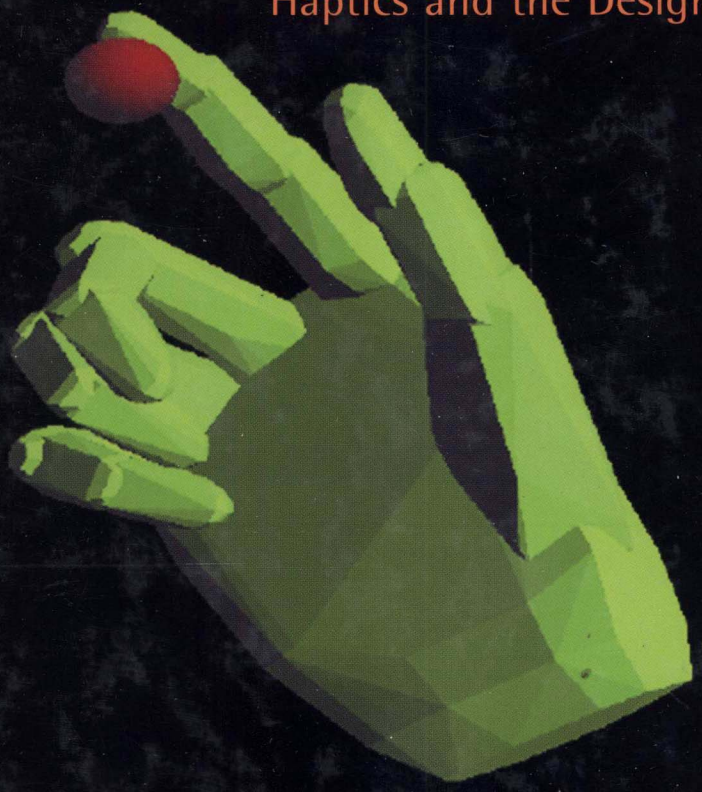
TOUCH IN VIRTUAL ENVIRONMENTS

Haptics and the Design of Interactive Systems



- Devices, rendering, and control of haptic interfaces
- Human factors engineering
- Practical applications in training and museum environments
- Assistive technologies for people with disabilities

Edited by:
Margaret L. McLaughlin • João P. Hespanha • Gaurav S. Sukhatme

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Prentice Hall PTR
Upper Saddle River, NJ 07458
www.phptr.com

Library of Congress Cataloging-in-Publication Data
McLaughlin, Margaret L.
Touch in virtual environments : haptics and the design of interactive systems / Margaret L. McLaughlin, João Hespanha, Gaurav Sukhatme.
p. cm. — (Prentice Hall IMSC Press multimedia series)
Includes bibliographic references and index.
ISBN 0-13-065097-8
1. Human-computer interaction. 2. Virtual reality. 3. Touch. I. Hesppanha, João II. Sukhatme, Gaurav. III. Title. IV. Series.

QA76.9.H85 M42 2001
006—dc21 2001036948

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Prentice-Hall, Inc.
Upper Saddle River, New Jersey 07458

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Printed in the United States of America
10 9 8 7 6 5 4 3 2 1

ISBN: 0-13-065097-8

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Haptics and the Design of Interactive Systems

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The Integrated Media Systems Center (IMSC), a National Science Foundation Engineering Research Center in the University of Southern California's School of Engineering, is a preeminent multimedia and Internet research center. IMSC seeks to develop integrated media systems that dramatically transform the way we work, communicate, learn, teach, and entertain. In an integrated media system, advanced media technologies combine, deliver, and transform information in the form of images, video, audio, animation, graphics, text, and haptics (touch-related technologies). IMSC Press, in partnership with Prentice Hall, publishes cutting-edge research on multimedia and Internet topics. IMSC Press is part of IMSC's educational outreach program.

Preface

The *haptic* interface is becoming an increasingly important component of immersive systems. Haptics refers to the modality of touch and the sensation of shape and texture an observer feels when exploring a virtual object, such as a three-dimensional model of a tool, instrument, or art object. Researchers in the field are interested in developing, refining, and testing haptic devices and interfaces, and applying findings from psychological studies of human touch to the simulation of the tactile sense in virtual environments. *Touch in Virtual Environments: Haptics and the Design of Interactive Systems* is an outgrowth of a one-day conference on haptics held at the University of Southern California in February, 2001, sponsored by USC's Integrated Media Systems Center, a National Science Foundation Engineering Research Center, the Annenberg School for Communication at USC, and the IEEE Control Systems Society. Many of the chapters were first presented as papers at that venue. The contributors to this volume, who represent a variety of academic disciplines and institutional affiliations, are researchers who can fairly be said to be working at the cutting edge of engineering science, in an area that is just beginning to have an impact in the design of immersive systems.

In Chapters 1–8 of this book, the contributors ponder questions about the *haptic interface*, such as: How can current state-of-the-art haptic displays be improved via better sensing? What are the software tools and models needed to facilitate multi-user tactile exploration of shared virtual environments? How can we optimize low-level force control for haptic devices? What algorithms and techniques are needed to convey the feel of deformable objects? How do we capture users' exploration with haptic devices? How do we compress hap-

tic exploration data so that it becomes possible to store or transmit long interactive sessions? In Chapters 9–12, the contributors consider the impact of the unpredictable, and highly variable, "human-in-the-loop." They examine questions like the following: How can we make haptic displays more usable for blind and visually impaired users? What are the differences between perceiving texture with the bare skin and with a probe, and how do factors like probe size and speed contribute? What can we learn about human thresholds for detecting small haptic effects that will be useful for the design of hand-held devices? To what extent do vision, sound, and haptics complement or interfere with one another in multimodal interactive systems?

In addition to exploring basic research issues in haptics such as acquisition of models, contact detection, force feedback, compression, capture, collaboration, and human factors, the contributors to *Touch in Virtual Environments* describe in detail several promising applications. A primary application area for haptics has been in surgical simulation and medical training. Haptics has also been incorporated into scientific visualization, providing an intuitive interface to complex displays of biological and geoscientific data. In some projects haptic displays have been used as alternative input devices for painting, sculpting and computer-assisted design. There have also been instances of the application of haptics to military training and simulation, providing an accurate source of orientation information in land, sea, and aerospace environments. In Chapters 13–15 the reader will find accounts of applications to telesurgery and surgical simulation, sign language recognition, and museum display.

Many persons contributed to the success of the "*Touch in Virtual Environments*" conference from which this volume emerged. In particular we would like to thank IMSC's visionary leader, Max Nikias, now Dean of USC's School of Engineering, for his encouragement and the substantial investment of time and resources that he has made in USC's program of haptics research. Thanks also are due to Geoffrey Cowan, Dean of the USC Annenberg School, and Patti Riley, Director of the School of Communication, for their continuing support of the kind of interdisciplinary collaboration needed to make haptics a human-centered engineering science. We are also grateful to Linda Wright, IMSC's Events Coordinator, for her outstanding efforts in creating a hospitable environment for our haptics conference, and to the Annenberg School's Rad Probst and Geoff Baum and IMSC's Lisette Garcia-Miller, Gloria Halfacre, Rick Keir, Sue Lewis, Issac Maya, Regina Morton, Nichole Phillips, Sandy Sawchuk, Seth Scafani, Ann Spurgeon, Allan Weber, Cheryl Weinberger, and our students Minoo Akbarian, Rajiv Garg, and Weirong Zhu for their generous gift of time and toil in helping to make the event a success. We would like to thank Andy Tescher, of compression|SCIENCE, Inc., Chair of IMSC's Scientific Advisory Board and Editor of IMSC Press, and Bernard Goodwin of Prentice Hall for their encouragement throughout this process. Finally, we extend our appreciation to the contributors for the many hours of thought-provoking discussion they have provided for us, and, we hope, for you as the reader.

Margaret L. McLaughlin, João Hespanha, and Gaurav Sukhatme
Los Angeles, California
October 2001

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