

MEDICINE MEETS VIRTUAL REALITY 15

Studies in Health Technology and Informatics

This book series was started in 1990 to promote research conducted under the auspices of the EC programmes' Advanced Informatics in Medicine (AIM) and Biomedical and Health Research (BHR) bioengineering branch. A driving aspect of international health informatics is that telecommunication technology, rehabilitative technology, intelligent home technology and many other components are moving together and form one integrated world of information and communication media. The complete series has been accepted in Medline. Volumes from 2005 onwards are available online.

Series Editors:

Dr. J.P. Christensen, Prof. G. de Moor, Prof. A. Famili, Prof. A. Hasman, Prof. L. Hunter, Dr. I. Iakovidis, Dr. Z. Kolitsi, Mr. O. Le Dour, Dr. A. Lymberis, Prof. P.F. Niederer, Prof. A. Pedotti, Prof. O. Rienhoff, Prof. F.H. Roger France, Dr. N. Rossing, Prof. N. Saranummi, Dr. E.R. Siegel, Dr. P. Wilson, Prof. E.J.S. Hovenga, Prof. M.A. Musen and Prof. J. Mantas

Volume 125

Recently published in this series

- Vol. 124. A. Hasman, R. Haux, J. van der Lei, E. De Clercq and F.H. Roger France (Eds.), Ubiquity: Technologies for Better Health in Aging Societies – Proceedings of MIE2006
- Vol. 123. D. Uyttendaele and P.H. Dangerfield (Eds.), Research into Spinal Deformities 5
- Vol. 122. H.-A. Park, P. Murray and C. Delaney (Eds.), Consumer-Centered Computer-Supported Care for Healthy People – Proceedings of NI2006 – The 9th International Congress on Nursing Informatics
- Vol. 121. L. Bos, L. Roa, K. Yogesana, B. O'Connell, A. Marsh and B. Blobel (Eds.), Medical and Care Computetics 3
- Vol. 120. V. Hernández, I. Blanquer, T. Solomonides, V. Breton and Y. Légré (Eds.), Challenges and Opportunities of HealthGrids – Proceedings of Healthgrid 2006
- Vol. 119. J.D. Westwood, R.S. Haluck, H.M. Hoffman, G.T. Mogel, R. Phillips, R.A. Robb and K.G. Vosburgh (Eds.), Medicine Meets Virtual Reality 14 – Accelerating Change in Healthcare: Next Medical Toolkit
- Vol. 118. R.G. Bushko (Ed.), Future of Intelligent and Extelligent Health Environment
- Vol. 117. C.D. Nugent, P.J. McCullagh, E.T. McAdams and A. Lymberis (Eds.), Personalised Health Management Systems – The Integration of Innovative Sensing, Textile, Information and Communication Technologies
- Vol. 116. R. Engelbrecht, A. Geissbuhler, C. Lovis and G. Mihalas (Eds.), Connecting Medical Informatics and Bio-Informatics – Proceedings of MIE2005

Medicine Meets Virtual Reality 15

in vivo, in vitro, in silico: Designing the Next in Medicine

Edited by

James D. Westwood

Randy S. Haluck MD FACS

Helene M. Hoffman PhD

Greg T. Mogel MD

Roger Phillips PhD CEng FBCS CIPT

Richard A. Robb PhD

and

Kirby G. Vosburgh PhD

IOS
Press

Amsterdam • Berlin • Oxford • Tokyo • Washington, DC

© 2007 The authors.

All rights reserved. No part of this book may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, without prior written permission from the publisher.

ISBN 978-1-58603-713-0

Library of Congress Control Number: 2006939763

Publisher

IOS Press

Nieuwe Hemweg 6B

1013 BG Amsterdam

Netherlands

fax: +31 20 687 0019

e-mail: order@iospress.nl

Distributor in the UK and Ireland

Gazelle Books Services Ltd.

White Cross Mills

Hightown

Lancaster LA1 4XS

United Kingdom

fax: +44 1524 63232

e-mail: sales@gazellebooks.co.uk

Distributor in the USA and Canada

IOS Press, Inc.

4502 Rachael Manor Drive

Fairfax, VA 22032

USA

fax: +1 703 323 3668

e-mail: iosbooks@iospress.com

LEGAL NOTICE

The publisher is not responsible for the use which might be made of the following information.

PRINTED IN THE NETHERLANDS

Preface

in vivo, in vitro, in silico: Designing the Next in Medicine

James D. WESTWOOD and Karen S. MORGAN
Aligned Management Associates, Inc.

Our culture is obsessed with design. Magazines, television, and websites publicize current trends in clothing, architecture, home furnishings, automobiles, and more. We design objects to convey ideas about wealth, status, age, gender, education, politics, religion, accomplishment, and aspiration. Design seems mysteriously vital to our well-being, like sleep and dreaming.

Sometimes designers can fuse utility and fantasy to make the mundane appear fresh—a cosmetic repackaging of the same old thing. Because of this, medicine—grounded in the unforgiving realities of the scientific method and peer review, and of flesh, blood, and pain—can sometimes confuse “design” with mere “prettifying.”

Design solves real problems, however. It reshapes material, image, and data into something more useful than was previously available. It addresses challenges of increasing complexity and data overload. It simplifies tasks to reduce confusion and error. It accelerates adoption and training by making new tools more intuitive to use. It comforts clinicians as well as patients by giving engineering a friendly interface.

This year’s theme acknowledges the importance of design—currently and as an opportunity—within the MMVR community.

in vivo. We design machines to explore our living bodies. Imaging devices, robots, and sensors move constantly inward, operating within smaller dimensions: system, organ, cell, DNA. Resolution and sensitivity are increasing. Our collaboration with these machines is burdened by vast quantities of input and output data. Physician to machine to patient to machine to physician and back again: it’s a crowded information highway prone to bottlenecks, misinterpreted signals, and collisions. Out of necessity, we design ways to visualize, simplify, communicate, and understand complex biomedical data. These can be as basic as color-coding or as advanced as Internet2. In our measurement and manipulation of health, the design of information is critical.

in vitro. Using test tubes and Petri dishes, we isolate *in vivo* to better manipulate and measure biological conditions and reactions. The bold new field of tissue engineering, for example, relies on creating an imitation metabolic system for growing artificial body parts. Scientists carefully design the scaffolding to which cells will group themselves on their own. The artificial guides nature’s path inside a glass container as we strive to improve what nature gives us.

in silico. We step out of the controlled *in vitro* environment and into a virtual reality. The silica mini-worlds of test tubes and Petri dishes are translated into mini-worlds contained within silicon chips. In the *in silico* lab, algorithms replace chemicals and

proteins in the quest for new drugs. On a different scale, we design simulations of biological systems to serve as educational tools. A simulated human body improves learning by utilizing intuition, repetition, and objective assessment. In surgical training, we are replacing patients with computers, in part because the latter is less susceptible to pain and less likely to hire a lawyer.

The future of medicine remains within all three environments: *in vivo*, *in vitro*, and *in silico*. Design is what makes these pieces fit together—the biological, the informational, the physical/material—into something new and more useful.

And what is the next in medicine? We cannot say, but we hope it offers solutions to the very real challenges that are now upon us: an aging global population; disparities between rich and developing nations; epidemic, disaster, and warfare; and limited economic and natural resources. We are eager to see what new tools are designed to confront these old problems, each involving medicine in some way.

We are thankful to all who have made MMVR15 possible and that, after fifteen years, MMVR remains a place where so many talented, visionary, and hardworking individuals share their research to design the next in medicine.

MMVR15 Proceedings Editors

James D. Westwood
MMVR15 Program Coordinator
Aligned Management Associates, Inc.

Randy S. Haluck MD FACS
Associate Professor of Surgery
Chief, Minimally Invasive Surgery and Bariatrics
Penn State, Hershey Medical Center

Helene M. Hoffman PhD
Assistant Dean, Educational Computing
Adjunct Professor of Medicine
Division of Medical Education
School of Medicine
University of California, San Diego

Greg T. Mogel MD
Associate Professor of Radiology and Biomedical Engineering
Keck School of Medicine/Viterbi School of Engineering
University of Southern California

Roger Phillips PhD CEng FBCS CIPT
Research Professor, Simulation & Visualization Group
Director, Hull Immersive Visualization Environment (HIVE)
Department of Computer Science
University of Hull (UK)

Richard A. Robb PhD
Scheller Professor in Medical Research
Professor of Biophysics & Computer Science
Director, Mayo Biomedical Imaging Resource
Mayo Clinic College of Medicine

Kirby G. Vosburgh PhD
Associate Director, Center for Integration of Medicine and
Innovative Technology (CIMIT)
Brigham and Women's Hospital
Harvard Medical School

MMVR15 Organizing Committee

Michael J. Ackerman PhD
Office of High Performance Computing & Communications,
National Library of Medicine

Ian Alger MD
New York Presbyterian Hospital;
Weill Medical College of Cornell University

David C. Balch MA
DCB Consulting LLC

Steve Charles MD
MicroDexterity Systems;
University of Tennessee

Patrick C. Cregan FRACS
Nepean Hospital,
Wentworth Area Health Service

Henry Fuchs PhD
Dept of Computer Science,
University of North Carolina

Walter J. Greenleaf PhD
Greenleaf Medical Systems

Randy S. Haluck MD FACS
Dept of Surgery,
Penn State College of Medicine

David M. Hananel
Surgical Programs,
Medical Education Technologies Inc.

Wm. LeRoy Heinrichs MD PhD
Medical Media & Information Technologies/
Gynecology & Obstetrics,
Stanford University School of Medicine

Helene M. Hoffman PhD
School of Medicine,
University of California, San Diego

Heinz U. Lemke PhD
Institute for Technical Informatics,
Technical University Berlin

Alan Liu PhD
National Capital Area Medical Simulation Center,
Uniformed Services University

Greg T. Mogel MD
Keck School of Medicine/Viterbi School of Engineering,
University of Southern California

Kevin N. Montgomery PhD
National Biocomputation Center,
Stanford University

Makoto Nonaka MD PhD
Foundation for International Scientific Advancement

Roger Phillips PhD CEng FBCS CIPT
Dept of Computer Science,
University of Hull (UK)

Carla M. Pugh MD PhD
Center for Advanced Surgical Education,
Northwestern University

Richard A. Robb PhD
Mayo Biomedical Imaging Resource,
Mayo Clinic College of Medicine

Jannick P. Rolland PhD
College of Optics and Photonics,
University of Central Florida

Richard M. Satava MD FACS
Dept of Surgery,
University of Washington

Rainer M.M. Seibel MD
Inst of Diagnostic & Interventional Radiology,
University of Witten/Herdecke

Steven Senger PhD
Dept of Computer Science,
University of Wisconsin – La Crosse

Ramin Shahidi PhD
Image Guidance Laboratories,
Stanford University School of Medicine

Don Stredney
Interface Laboratory,
OSC

Julie A. Swain MD
Cardiovascular and Respiratory Devices,
U.S. Food and Drug Administration

Robert M. Sweet MD
Dept of Urology,
University of Minnesota

Kirby G. Vosburgh PhD
CIMIT/Brigham & Women's Hospital/
Harvard Medical School

Dave Warner MD PhD
Biodesign Institute/Decision Theater,
Arizona State University;
MindTel LLC; Inst for Interventional Informatics

Suzanne J. Weghorst MA MS
Human Interface Technology Lab,
University of Washington

Mark D. Wiederhold MD PhD FACP
The Virtual Reality Medical Center

Patricia Youngblood PhD
Medical Media & Information Technologies,
Stanford University School of Medicine

Contents

Preface	v
<i>James D. Westwood and Karen S. Morgan</i>	
Conference Organization	vii
Burrhole Simulation for an Intracranial Hematoma Simulator	1
<i>Eric Acosta, Alan Liu, Rocco Armonda, Mike Fiorill, Randy Haluck, Carol Lake, Gilbert Muniz and Mark Bowyer</i>	
Cranial Implant Design Using Augmented Reality Immersive System	7
<i>Zhuming Ai, Ray Evenhouse, Jason Leigh, Fady Charbel and Mary Rasmussen</i>	
SOFA – An Open Source Framework for Medical Simulation	13
<i>J. Allard, S. Cotin, F. Faure, P.-J. Bensoussan, F. Poyer, C. Duriez, H. Delingette and L. Grisoni</i>	
Integrated Lower Extremity Trauma Simulator	19
<i>Bruce D. Anderson, Per Nordquist, Eva Skarman, Mark T. Boies, Gina B. Anderson and David B. Carmack</i>	
Data Acquisition and Development of a Trocar Insertion Simulator Using Synthetic Tissue Models	25
<i>Veluppillai Arulesan, Govindarajan Srimathveeravalli, Thenkurussi Kesavadas, Prashant Nagathan and Robert E. Baier</i>	
Centralized Data Recording for a Distributed Surgical Skills Trainer to Facilitate Automated Proficiency Evaluation	28
<i>Christoph Aschwanden, Craig Cornelius, Lawrence Burgess, Kevin Montgomery and Aneesh Sharma</i>	
Precise Determination of Regions of Interest for Hepatic RFA Planning	31
<i>Claire Baegert, Caroline Villard, Pascal Schreck and Luc Soler</i>	
Virtual Reality and Haptic Interface for Cellular Injection Simulation	37
<i>P. Pat Banerjee, Silvio Rizzi and Cristian Luciano</i>	
The Structure of the Radial Pulse – A Novel Noninvasive Ambulatory Blood Pressure Device	40
<i>Martin Baruch, Katherine Westin Kwon, Emaad Abdel-Rahman and Ross Isaacs</i>	
A 6DOF Gravity Compensation Scheme for a Phantom Premium Using a Neural Network	43
<i>Matthew Birtwisle and Andy Bulpitt</i>	
Endotracheal Intubation Training Using Virtual Images: Learning with the Mobile Telementoring Intubating Video Laryngoscope	49
<i>Ben H. Boedeker, Scott Hoffman and W. Bosseau Murray</i>	

Efficient Modelling of Soft Tissue Using Particle Systems <i>Oliver Buckley and Nigel W. John</i>	55
Requirement Specification for Surgical Simulation Systems with Surgical Workflows <i>Oliver Burgert, Thomas Neumuth, Michel Audette, Antje Pössneck, Rafael Mayoral, Andreas Dietz, Jürgen Meixensberger and Christos Trantakis</i>	58
3D Visualization and Open Planning Platform in Virtual Fluoroscopy <i>G. Chami, R. Phillips, J.W. Ward, M.S. Bielby and A.M.M.A. Mohsen</i>	64
Intra-Operative Registration for Image Enhanced Endoscopic Sinus Surgery Using Photo-Consistency <i>Min Si Chen, Gerardo Gonzales and Rudy Lapeer</i>	67
Evaluating Enhanced Volume Rendering Visualization of Cerebral Aneurysms <i>Marcelo Cohen, Ken Brodlie and Nick Phillips</i>	73
Skills Acquired on Virtual Reality Laparoscopic Simulators Transfer into the Operating Room in a Blinded, Randomised, Controlled Trial <i>P.H. Cosman, T.J. Hugh, C.J. Shearer, N.D. Merrett, A.V. Biankin and J.A. Cartmill</i>	76
Implementing Virtual Worlds for Systematic Training of Prehospital CPR in Medical School <i>J. Creutzfeldt, L. Hedman, C. Medin, C.J. Wallin, A. Hendrick, P. Youngblood, Wm.L. Heinrichs and L. Felländer-Tsai</i>	82
Feasibility of Using Intraoperatively-Acquired Quantitative Kinematic Measures to Monitor Development of Laparoscopic Skill <i>Sayra M. Cristancho, Antony J. Hodgson, Neely Panton, Adam Meneghetti and Karim Qayumi</i>	85
Parametric Eye Models <i>Jessica R. Crouch and Andrew Cherry</i>	91
Real-Time Smoke and Bleeding Simulation in Virtual Surgery <i>Stefan Daenzer, Kevin Montgomery, Rüdiger Dillmann and Roland Unterhinninghofen</i>	94
Modeling Isotropic Organs Using Beam Models for the Haptic Simulation of Blunt Dissections <i>Vishal Dalmiya, Guillermo Ramirez and Venkat Devarajan</i>	100
Determination of Key and Driving Points of a Beam Model for Tissue Simulation <i>Vishal Dalmiya, Sumit Tandon, Pradeep Mohanraj and Venkat Devarajan</i>	106
CIELab and sRGB Color Values of <i>in vivo</i> Normal and Grasped Porcine Liver <i>Smita De, Aylon Dagan, Phil Roan, Jacob Rosen, Mika Sinanan, Maya Gupta and Blake Hannaford</i>	109
A Scalable Intermediate Representation for Remote Interaction with Soft Tissues <i>Dhanannjay Deo, Suvranu De and Shivkumar Kalyanaraman</i>	112

Physics-Based Stereoscopic Suturing Simulation with Force Feedback and Continuous Multipoint Interactions for Training on the da Vinci ® Surgical System	115
<i>Dhanannjay Deo, Suvranu De and Tejinder P. Singh</i>	
A Web-Based Teamwork Skills Training Program for Emergency Medical Teams	121
<i>Eleen B. Entin, Jason Sidman, Gilbert Mizrahi, Barry Stewart, Fuji Lai, Lisa Neal, Colin Mackenzie and Yan Xiao</i>	
Virtual Reality for Robotic Laparoscopic Surgical Training	127
<i>Matthew J. Fiedler, Shing-Jye Chen, Timothy N. Judkins, Dmitry Oleynikov and Nick Stergiou</i>	
Validation System of MR Image Overlay and Other Needle Insertion Techniques	130
<i>Gregory S. Fischer, Eva Dyer, Csaba Csoma, Anton Deguet and Gabor Fichtinger</i>	
Ultrasound and Needle Insertion Simulators Built on Real Patient-Based Data	136
<i>Clément Forest, Olivier Comas, Christophe Vaysière, Luc Soler and Jacques Marescaux</i>	
Use of a Virtual Human Performance Laboratory to Improve Integration of Mathematics and Biology in Sports Science Curricula in Sweden and the United States	140
<i>D. Garza, T. Besier, T. Johnston, B. Rolston, A. Schorsch, G. Matheson, C. Annerstedt, J. Lindh and M. Rydmark</i>	
In Vitro Skin-Tissue Experiment for Increased Realism in Open Surgery Simulations	143
<i>Paul D. Gasson and Rudy J. Lapeer</i>	
Game Design in Virtual Reality Systems for Stroke Rehabilitation	146
<i>Daniel Goude, Staffan Björk and Martin Rydmark</i>	
The Red DRAGON: A Multi-Modality System for Simulation and Training in Minimally Invasive Surgery	149
<i>Scott Gunther, Jacob Rosen, Blake Hannaford and Mika Sinanan</i>	
The Effect of Degree of Immersion Upon Learning Performance in Virtual Reality Simulations for Medical Education	155
<i>Fátima Gutiérrez, Jennifer Pierce, Victor M. Vergara, Robert Coulter, Linda Saland, Thomas P. Caudell, Timothy E. Goldsmith and Dale C. Alverson</i>	
Experiences of Using the EndoAssist-Robot in Surgery	161
<i>Nina Halin, Pekka Loula and Pertti Aarnio</i>	
Comprehensive 3D Visual Simulation for Radiation Therapy Planning	164
<i>Felix G. Hamza-Lup, Ivan Sopin and Omar Zeidan</i>	
Haptic Interface Module for Hysteroscopy Simulator System	167
<i>Matthias Harders, Ulrich Spaelter, Peter Leskovsky, Gabor Szekely and Hannes Bleuler</i>	

Comparative Visualization of Human Nasal Airflows <i>Bernd Hentschel, Christian Bischof and Torsten Kuhlen</i>	170
A Blending Technique for Enhanced Depth Perception in Medical X-Ray Vision Applications <i>Frida Hernell, Anders Ynnerman and Örjan Smedby</i>	176
Surgery on the Lateral Skull Base with the Navigated Controlled Drill Employed for a Mastoidectomy (Pre Clinical Evaluation) <i>M. Hofer, R. Grunert, E. Dittrich, E. Müller, M. Möckel, K. Koulechov, M. Strauss, W. Korb, T. Schulz, A. Dietz, T. Lüth and G. Strauss</i>	179
Localized Virtual Patient Model for Regional Anesthesia Simulation Training System <i>John Hu, Yi-Je Lim, Neil Tardella, Chuyin Chang and Lisa Warren</i>	185
Surface Exploration Using Instruments: The Perception of Friction <i>Cindy Hung, Adam Dubrowski, David Gonzalez and Heather Carnahan</i>	191
An Interactive, Cognitive Simulation of Gastroesophageal Reflux Disease <i>Bruce Jarrell, Sergei Nirenburg, Marjorie McShane, George Fantry, Stephen Beale, David Mallott and John Raczek</i>	194
A Stable Cutting Method for Finite Elements Based Virtual Surgery Simulation <i>Lenka Jeřábková, Jakub Jeřábek, Rostislav Chudoba and Torsten Kuhlen</i>	200
Visualization of Large-Scale Confocal Data Using Computer Cluster <i>Bei Jin, Zhuming Ai and Mary Rasmussen</i>	206
A Haptic-Enabled Toolkit for Illustration of Procedures in Surgery (TIPS) <i>Minho Kim, Tianyun Ni, Juan Cendan, Sergei Kurenov and Jörg Peters</i>	209
Non-Clinical Evaluation of the KAIST-Ewha Colonoscopy Simulator II <i>Woo Seok Kim, Hyun Soo Woo, Woojin Ahn, Kyungno Lee, Jang Ho Cho, Doo Yong Lee and Sun Young Yi</i>	214
A Pneumatic Haptic Feedback Actuator Array for Robotic Surgery or Simulation <i>Chih-Hung King, Adrienne T. Higa, Martin O. Culjat, Soo Hwa Han, James W. Bisley, Gregory P. Carman, Erik Dutton and Warren S. Grundfest</i>	217
Virtual Simulation-Enhanced Triage Training for Iraqi Medical Personnel <i>Paul N. Kizakevich, Andrew Culwell, Robert Furberg, Don Gemeinhardt, Susan Grantlin, Robert Hubal, Allison Stafford and R. Todd Dombroski</i>	223
Training and Assessment of Procedural Skills in Context Using an Integrated Procedural Performance Instrument (IPPI) <i>R. Kneebone, F. Bello, D. Nestel, F. Yadollahi and A. Darzi</i>	229
Real-Time Marker-Based Tracking of a Non-Rigid Object <i>Andreas Köpfle, Florian Beier, Clemens Wagner and Reinhard Männer</i>	232
A New Force-Based Objective Assessment of Technical Skills in Endoscopic Sinus Surgery <i>Toru Kumagai, Juli Yamashita, Osamu Morikawa and Kazunori Yokoyama</i>	235

A Proposal of Speculative Operation on Distributed System for FEM-Based Ablation Simulator	238
<i>Naoto Kume, Yoshihiro Kuroda, Megumi Nakao, Tomohiro Kuroda, Keisuke Nagase, Hiroyuki Yoshihara and Masaru Komori</i>	
Tissue Resection Using Delayed Updates in a Tetrahedral Mesh	241
<i>Kishalay Kundu and Marc Olano</i>	
Organ Exclusion Simulation with Multi-Finger Haptic Interaction for Open Surgery Simulator	244
<i>Yoshihiro Kuroda, Makoto Hirai, Megumi Nakao, Toshihiko Sato, Tomohiro Kuroda, Keisuke Nagase and Hiroyuki Yoshihara</i>	
Semi-Automatic Development of Optimized Surgical Simulator with Surgical Manuals	250
<i>Yoshihiro Kuroda, Tadamasu Takemura, Naoto Kume, Kazuya Okamoto, Kenta Hori, Megumi Nakao, Tomohiro Kuroda and Hiroyuki Yoshihara</i>	
Avatars Alive! The Integration of Physiology Models and Computer Generated Avatars in a Multiplayer Online Simulation	256
<i>Laura Kusumoto, Wm. LeRoy Heinrichs, Parvati Dev and Patricia Youngblood</i>	
Evaluation of a Simulation-Based Program for Medic Cognitive Skills Training	259
<i>Fuji Lai, Eileen B. Entin, Tad Brunye, Jason Sidman and Elliot E. Entin</i>	
Human Factors Engineering for Designing the Next in Medicine	262
<i>Fuji Lai</i>	
In-vivo Validation of a Stent Implantation Numerical Model	265
<i>Denis Laroche, Sebastien Delorme, Todd Anderson and Robert DiRaddo</i>	
Progressive Update Approach to Real-Time Cutting of Finite Element Models in Surgical Simulation	271
<i>Bryan Lee, Dan C. Popescu and Sébastien Ourselin</i>	
Towards an Immersive Virtual Environment for Medical Team Training	274
<i>Chang Ha Lee, Alan Liu, Sofia Del Castillo, Mark Bowyer, Dale Alverson, Gilbert Muniz and Thomas P. Caudell</i>	
Haptic Rendering of Device and Patient Impedances in Catheter-Based Simulation	280
<i>Christopher Lee</i>	
Collaborative Virtual Desktop as Decision Support System for Surgical Planning	283
<i>Pascal Le Mer and Dominique Pavy</i>	
Low Cost Eye Surgery Simulator with Skill Assessment Component	286
<i>Rainer Leuschke, Anuja Bhandari, Brian Sires and Blake Hannaford</i>	
Computer Simulation of Corticospinal Activity During Transcranial Electrical Stimulation in Neurosurgery	292
<i>Daliang Leon Li, H. Louis Journee, Arjen van Hulzen, William T. Rath, Robert J. Sclabassi and Mingui Sun</i>	

An Overview of 3D Video Transmission and Display Technologies for Telemedicine Applications	298
<i>Qiang Liu, Robert J. Sclabassi, Amin Kassam, Feng Zhu, Ron Machessault, Gary Gilbert and Mingui Sun</i>	
Real-Time Image Mosaicing for Medical Applications	304
<i>Kevin E. Loewke, David B. Camarillo, Christopher A. Jobst and J. Kenneth Salisbury</i>	
Magnetically Levitated Nano-Robots: An Application to Visualization of Nerve Cells Injuries	310
<i>Mingji Lou and Edmond Jonckheere</i>	
Telesurgery via Unmanned Aerial Vehicle (UAV) with a Field Deployable Surgical Robot	313
<i>Mitchell J.H. Lum, Jacob Rosen, Hawkeye King, Diana C.W. Friedman, Gina Donlin, Ganesh Sankaranarayanan, Brett Harnett, Lynn Huffman, Charles Doarn, Timothy Broderick and Blake Hannaford</i>	
Application of Hidden Markov Modeling to Objective Medical Skill Evaluation	316
<i>Thomas Mackel, Jacob Rosen and Carla Pugh</i>	
Manual Registration of Ultrasound with CT/Planning Data for Hepatic Surgery	319
<i>Mathias Markert, Stefan Weber and Tim C. Lueth</i>	
2D Ultrasound Augmented by Virtual Tools for Guidance of Interventional Procedures	322
<i>John Moore, Gerard Guiraudon, Doug Jones, Nick Hill, Andrew Wiles, Dan Bainbridge, Chris Wedlake and Terry Peters</i>	
Smooth Haptic Interaction from Discontinuous Simulation Data	328
<i>Jesper Mosegaard, Bo Søndergaard Carstensen, Allan Rasmusson and Thomas Sangild Sørensen</i>	
Cybertherapy – New Applications for Discomfort Reductions	334
<i>José Luis Mosso, Skip Rizzo, Brenda Wiederhold, Verónica Lara, Jesús Flores, Edmundo Espiritusanto, Arturo Minor, Amador Santander, Omar Avila, Osvaldo Balice and Benjamin Benavides</i>	
Applications of Computer Assisted Surgery and Medical Robotics at the ISSSTE, México: Preliminary Results	337
<i>José Luis Mosso, Mauricio Pohl, Juan Ramon Jimenez, Raquel Valdes, Oscar Yañez, Veronica Medina, Fernando Arambula, Miguel Angel Padilla, Jorge Marquez, Alfonso Gastelum, Alejo Mosso and Juan Frausto</i>	
Development of an Interactive Module to Enhance and Understand Cavity Navigation	340
<i>Andrés A. Navarro Newball, Franco Roviello, Domenico Prattichizzo, Francisco J. Herrera and Cesar A. Marin</i>	
Design Methodology for a Novel Multifunction Laparoscopic Tool: Engineering for Surgeons' Needs	343
<i>Carl A. Nelson, David J. Miller and Dmitry Oleynikov</i>	

A User-Friendly Interface for Surgeons to Create Haptic Effects in Medical Simulation	349
<i>Liya Ni, David W.L. Wang, Adam Dubrowski and Heather Carnahan</i>	
Modeling and Rendering for a Virtual Bone Surgery System	352
<i>Qiang Niu and Ming C. Leu</i>	
A Serious Gaming/Immersion Environment to Teach Clinical Cancer Genetics	355
<i>Thomas M. Nosek, Mark Cohen, Anne Matthews, Klara Papp, Nancy Wolf, Gregg Wrenn, Andrew Sher, Kenneth Coulter, Jessica Martin and Georgia L. Wiesner</i>	
Surgical Scissors Extension Adds the 7th Axis of Force Feedback to the Freedom 6S	361
<i>Marilyn J. Powers, Ian P.W. Sinclair, Iman Brouwer and Denis Laroche</i>	
An Adaptive Framework Using Cluster-Based Hybrid Architecture for Enhancing Collaboration in Surgical Simulation	367
<i>J. Qin, P.A. Heng, K.S. Choi and Simon S.M. Ho</i>	
From Simulations to Automated Tutoring	373
<i>Sowmya Ramachandran and Barbara Sorensen</i>	
Haptics-Constrained Motion for Surgical Intervention	379
<i>Jing Ren, Huaijing Zhang, Rajni V. Patel and Terry M. Peters</i>	
Development of a Guiding Endoscopy Simulator	385
<i>Klaus Rieger and Reinhard Männer</i>	
A Novel Approach for Training of Surgical Procedures Based on Visualization and Annotation of Behavioural Parameters in Simulators	388
<i>Mikko J. Rissanen, Yoshihiro Kuroda, Megumi Nakao, Tomohiro Kuroda, Keisuke Nagase and Hiroyuki Yoshihara</i>	
NeuroVR: An Open-Source Virtual Reality Platform for Clinical Psychology and Behavioral Neurosciences	394
<i>Giuseppe Riva, Andrea Gaggioli, Daniela Villani, Alessandra Preziosa, Francesca Morganti, Riccardo Corsi, Gianluca Faletti and Luca Vezzadini</i>	
Cellular Phones for Reducing Battlefield Stress: Rationale and a Preliminary Research	400
<i>Giuseppe Riva, Alessandra Grassi, Daniela Villani and Alessandra Preziosa</i>	
Managing Exam Stress Using UMTS Phones: The Advantage of Portable Audio/Video Support	406
<i>Giuseppe Riva, Alessandra Grassi, Daniela Villani, Andrea Gaggioli and Alessandra Preziosa</i>	
Employing Graphics Hardware for an Interactive Exploration of the Airflow in the Human Nasal Cavity	409
<i>Marc Schirski, Christian Bischof and Torsten Kuhlen</i>	
Task Sequencing Effects for Open and Closed Loop Laparoscopic Skills	412
<i>Elizabeth A. Schmidt, Mark W. Scerbo, Gayatri Kapur and Adair R. Heyl</i>	

Evaluating Tool-Artery Interaction Force During Endovascular Neurosurgery for Developing Haptic Engine	418
<i>Anindita Sengupta, T. Kesavadas, Kenneth R. Hoffmann, Robert E. Baier and S. Schafer</i>	
Validating Metrics for a Mastoidectomy Simulator	421
<i>Christopher Sewell, Dan Morris, Nikolas H. Blevins, Sumit Agrawal, Sanjeev Dutta, Federico Barbagli and Kenneth Salisbury</i>	
Evaluating Drilling and Suctioning Technique in a Mastoidectomy Simulator	427
<i>Christopher Sewell, Dan Morris, Nikolas H. Blevins, Federico Barbagli and Kenneth Salisbury</i>	
Patient Specific Simulation and Navigation of Ventriculoscopic Interventions	433
<i>R. Sierra, S.P. DiMaio, J. Wada, N. Hata, G. Székely, R. Kikinis and F. Jolesz</i>	
Developing Performance Criteria for the e-Pelvis Simulator Using Visual Analysis	436
<i>Jonathan Silverstein, Gene Selkov Jr., Lawrence Salud and Carla Pugh</i>	
Immersive Virtual Anatomy Course Using a Cluster of Volume Visualization Machines and Passive Stereo	439
<i>Jonathan C. Silverstein, Colin Walsh, Fred Dech, Eric Olson, Michael E. Papka, Nigel Parsad and Rick Stevens</i>	
Virtual Open Heart Surgery: Obtaining Models Suitable for Surgical Simulation	445
<i>Thomas Sangild Sørensen, Jean Stawiaski and Jesper Mosegaard</i>	
Virtual Open Heart Surgery Segmentation	448
<i>Jean Stawiaski, Jesper Mosegaard and Thomas Sørensen</i>	
A Virtual-Reality Approach for the Treatment of Benign Paroxysmal Positional Vertigo	451
<i>Karl V. Steiner, Michael Teixido, Brian Kung, Mads Sorensen, Robert Forstrom and Patrick Coller</i>	
Medical Student Evaluation Using Augmented Standardized Patients: New Development and Results	454
<i>Bo Sun, Frederic D. McKenzie, Hector M. Garcia, Thomas W. Hubbard, John A. Ullian and Gayle A. Gliva</i>	
Design of the Next-Generation Medical Implants with Communication and Energy Ports	457
<i>Mingui Sun, Steven A. Hackworth, Zhide Tang, Jun Zhao, Daliang Li, Sharon E. Enos, Brian Errigo, Gary Gilbert, Ronald Marchessault, Sylvain Cardin, Troy Turner and Robert J. Sclabassi</i>	
Development of a Surgical Robot System for Endovascular Surgery with Augmented Reality Function	460
<i>Naoki Suzuki, Asaki Hattori, Shigeyuki Suzuki and Yoshito Otake</i>	

Surgery Simulation Using Patient-Specific Models for Laparoscopic Colectomy <i>Shigeyuki Suzuki, Ken Eto, Asaki Hattori, Katsuhiko Yanaga and Naoki Suzuki</i>	464
Development and Evaluation of a Virtual Intensive Therapy Unit – VITU <i>A. Theodoropoulos, R. Kneebone, B. Dornan, R. Leonard and F. Bello</i>	467
Low Fidelity Simulation of Temporal Bone Drilling Leads to Improved But Sub-Optimal Outcomes <i>Cory Torgerson, Ryan Brydges, Joseph Chen and Adam Dubrowski</i>	470
Objective Surgical Performance Assessment for Virtual Hysteroscopy <i>Stefan Tuchschnid, Michael Bajka, Daniel Bachofen, Gábor Székely and Matthias Harders</i>	473
Interactive Physically-Based X-Ray Simulation: CPU or GPU? <i>Franck P. Vidal, Nigel W. John and Romain M. Guillemot</i>	479
Device Connectivity for Image-Guided Medical Applications <i>Jochen von Spiczak, Eigil Samset, Simon DiMaio, Gerhard Reitmayr, Dieter Schmalstieg, Catherina Burghart and Ron Kikinis</i>	482
Natural Orifice Transluminal Endoscopic Surgery (NOTES): An Opportunity for Augmented Reality Guidance <i>Kirby G. Vosburgh and Raúl San José Estépar</i>	485
Immersive Visualization with Automated Collision Detection for Radiotherapy Treatment Planning <i>J.W. Ward, R. Phillips, T. Williams, C. Shang, L. Page, C. Prest and A.W. Beavis</i>	491
Obstacle Crossing in a Virtual Environment with the Rehabilitation Gait Robot LOKOMAT <i>Mathias Wellner, Thomas Thüring, Eldin Smajic, Joachim von Zitzewitz, Alexander Duschau-Wicke and Robert Riener</i>	497
GPU-Friendly Marching Cubes for Visualizing Translucent Isosurfaces <i>Yongming Xie, Pheng-Ann Heng, Guangyu Wang and Tien-Tsin Wong</i>	500
Can We Remember Stiffness? <i>Yasushi Yamauchi</i>	503
VR Enhanced Upper Extremity Motor Training for Post-Stroke Rehabilitation: Task Design, Clinical Experiment and Visualization on Performance and Progress <i>Shih-Ching Yeh, Albert Rizzo, Margaret McLaughlin and Thomas Parsons</i>	506
Clinical Evaluation of the KAIST-Ewha Colonoscopy Simulator II <i>Sun Young Yi, Hyun Soo Woo, Woojin Ahn, Woo Seok Kim and Doo Yong Lee</i>	512
Virtual Worlds for Teaching the New CPR to High School Students <i>Patricia Youngblood, Leif Hedman, Johan Creutzfeld, Li Fellander-Tsai, Karl Stengard, Kim Hansen, Parvati Dev, Sakti Srivastava, Laura Kusumoto, Arnold Hendrick and Wm. LeRoy Heinrichs</i>	515

Towards an Understanding of Conventional Surgical Haptics for Use in MIS <i>John S. Zelek and Hao Xin</i>	520
--	-----

Author Index	523
--------------	-----