Lecture Notes in Computer Science 6801

Commenced Publication in 1973
Founding and Former Series Editors:
Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Gábor Székely Horst K. Hahn (Eds.)

Information Processing in Medical Imaging

22nd International Conference, IPMI 2011
Kloster Irsee, Germany, July 3-8, 2011
Proceedings

Springer

Volume Editors

Gábor Székely
Swiss Federal Institute of Technology
Computer Vision Laboratory
Medical Image Analysis and Visualization Group
ETH-Zentrum, Sternwartstr. 7, 8092 Zurich, Switzerland
E-mail: szekely@vision.ee.ethz.ch

Horst K. Hahn
Fraunhofer MEVIS
Universitätsallee 29, 28359 Bremen, Germany
E-mail: horst.hahn@mevis.fraunhofer.de

ISSN 0302-9743 e-ISSN 1611-3349
ISBN 978-3-642-22091-3 e-ISBN 978-3-642-22092-0
DOI 10.1007/978-3-642-22092-0
Springer Heidelberg Dordrecht London New York

Library of Congress Control Number: 2011929993

CR Subject Classification (1998): I.4, I.5, I.2.5-6, H.3, J.1, J.3, I.3

LNCS Sublibrary: SL 6 – Image Processing, Computer Vision, Pattern Recognition, and Graphics

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

It is a great pleasure and an honor for us to present the proceedings of the 2011 International Conference on Information Processing in Medical Imaging (IPMI), the 22nd in the series after the successful meetings held in Kerkrade, The Netherlands, in 2007 and in Williamsburg, VA, USA, in 2009. Biannually, IPMI brings together excellent young investigators, experienced researchers and some of the old stagers in medical image formation, analysis and interpretation. After the first meeting in 1969, IPMI has developed into a highly prestigious event and is said to be the longest-running international scientific workshop on medical image analysis. Many important developments in the field were first presented at IPMI and, with its unique format that allows for intensive and comprehensive discussion of new ideas and a variety of clinical applications, the series was always committed to a rigorous scientific approach to information processing in medical imaging.

IPMI 2011 was held during July 3–8, 2011 at the Irsee Monastery in Bavaria, Germany. Topics of the conference include image and signal processing, shape representation and analysis, image registration and fusion, functional and molecular imaging, computational physiology, statistical and mathematical models, computer-aided detection and image interpretation, image reconstruction, objective assessment of image quality, data visualization, and novel image acquisition methods. Most of these topics were covered by a relatively small number of talks within single-track sessions plus a number of poster presentations. We received 224 full-length submissions before the deadline in December 2010, from which we selected 24 for oral presentation and 39 as posters during the all-plenary five-day conference. This corresponds to an overall acceptance rate of 28%. All papers were carefully judged by at least three reviewers, each of whom performed at least nine reviews and also provided a relative ranking of the reviewed papers. On this basis, the paper selection committee assessed all papers in a two-stage process that focused on clarity of presentation, justification of the methodological approach, scientific rigor, quality and depth of evaluation, and novelty. The selection of the best papers was a difficult task, but based on the high-quality reviews, a unanimous decision could finally be made. The quality of the submissions was very high, such that due to size limitations of the conference, a number of valuable submissions could unfortunately not be accepted.

The number of active researchers permitted to attend was limited to just above 100, and like past meetings, the unique study group concept was implemented to foster deep scientific exchange. Each participant was member of one study group, which focused on reading and discussing two papers in advance. Within its respective session, the study group led the discussion after each author's presentation before it was opened to the plenum. As an important IPMI rule, in-depth discussions were allowed to stretch far beyond the allocated session

time to permit a detailed understanding of the presented paper, including its limitations and comparison to existing methodology. In addition, this year we introduced the special focus session as a new concept. Selected poster contributions on topics of great common interest were presented in a summary fashion by the members of the study group, while offering the authors the opportunity to reply, clarify raised issues, and comment on the assessment before the discussion was opened to the audience. This highly interactive mode greatly contributed to intensifying and broadening the discussion of high-interest papers. As an additional stimulus, the François Erbsmann Prize was awarded for the best contribution by a young scientist giving an IPMI talk for the first time. This year, over half the participants attended their first IPMI and among the 24 first authors of oral presentations, 20 were eligible for the Erbsmann Prize.

As a tradition of IPMI, a remote location was chosen in order to intensify the participants' interchange of ideas. In the middle of Bavaria and at the foot of the mighty Alps lies the former Benedictine monastery Irsee. The Irsee Monastery, whose current buildings were constructed in the Baroque era, was founded by hermits on the Irsee Castle Mountain in 1182 and remained active until the nineteenth century. In addition to prayer and spirituality, the main focuses of monastery life at Irsee were scientific knowledge and education. In the eighteenth century, members of Irsee included renowned thinkers in the natural sciences, philosophy, and music. The monastery hosted an acclaimed mathematical museum, and this old wisdom lingered and inspired the IPMI attendees when walking the same corridors as the old monks. In addition to visiting the monastery's brewery, one afternoon was devoted to refreshing our minds and interacting informally during a hike through the beautiful surroundings of the monastery, while some attendees visited the fairy-tale castle Neuschwanstein 50 kilometers south of Irsee. We also held the traditional "US versus the Rest of the World" soccer match on Wednesday evening.

In these proceedings, IPMI 2011 papers are published in the order of their presentation at the meeting and we hope that they will remain an invaluable source of information and reminder for the participants. For those who could not attend, they provide an excellent overview of some of the best current research available in information processing in medical imaging and an encouragement to participate in the next IPMI, which will be held in the USA in 2013. Please visit www.ipmi-conference.org for up-to-date information.

July 2011

Gábor Székely
Horst K. Hahn

Acknowledgements

The organization of a meeting is always a large team effort and the Co-chairs of IPMI 2011 are grateful for the many individuals who enthusiastically supported the preparation of the meeting. First of all, we would like to thank the members of the Scientific Review Committee for the careful reviewing of a large number of manuscripts and their invaluable expert advice for the rather difficult task of identifying the best papers out of many excellent submissions. We are very grateful to the members of the Paper Selection Committee, Jerry Prince, Chris Taylor and Baba Vemuri, who spent enormous effort leading to an even-handed selection and the compilation of an outstanding final program. We also would like to thank many organizers of previous IPMI meetings, especially Jerry Prince, Chris Taylor, Nico Karssemeijer, Dzung Pham and Kyle Myers for their advice and support.

We greatly acknowledge Derek Jones taking all his time and effort to provide us with an outstanding keynote lecture on multi-spectral imaging of white matter and the challenges of quantifying connectivity.

The organization of this meeting would not have been possible without the support of many colleagues at the Computer Vision Laboratory of the ETH Zürich and Fraunhofer MEVIS. We would like to wholeheartedly thank Christoph Brachmann, Julien Egger, Ola Friman, Nils Papenberg, Bram Platel, Matthias Schneider and Christine Tanner for their enormous work and enthusiasm, spending countless hours on the numerous tasks related to all aspects of preparing IPMI 2011. We also thank our colleagues forming the IPMI Staff for spending a week at the conference venue helping to run the meeting in a smooth and effective fashion, as well as Iris Auer from the Irsee Monastery for hosting us so well.

Finally, we would like to acknowledge the following organizations for their generous financial support:

NCCR Co-Me, the Swiss National Center of Competence in Research on Computer-Aided and Image-Guided Medical Interventions

Bayer HealthCare, Diagnostic Imaging, Berlin, Germany

MeVis Medical Solutions AG, Bremen, Germany

Siemens AG, Healthcare Sector, Erlangen, Germany

CIMST, Zurich Center of Imaging Science and Technology, Switzerland

François Erbsmann Prizewinners

1987 (Utrecht, The Netherlands): **John M. Gauch**, University of North Carolina, Chapel Hill, NC, USA.
J.M. Gauch, W.R. Oliver and S.M. Pizer: Multiresolution shape descriptions and their applications in medical imaging.

1989 (Berkeley, CA, USA): **Arthur F. Gmitro**, University of Arizona, Tucson, AZ, USA.
A.F. Gmitro, V. Tresp, V. Chen, Y. Snell and G.R. Gindi: Video-rate reconstruction of CT and MR images.

1991 (Wye, Kent, UK): **H. Isil Bozma**, Yale University, New Haven, CT, USA.
H.I. Bozma and J.S. Duncan: Model-based recognition of multiple deformable objects using a game-theoretic framework.

1993 (Flagstaff, AZ, USA): **Jeffrey A. Fessler**, University of Michigan, Ann Arbor, MI, USA.
J.A. Fessler: Tomographic reconstruction using information-weighted spline smoothing.

1995 (Brest, France): **Maurits K. Konings**, University Hospital, Utrecht, The Netherlands.
M.K. Konings, W.P.T.M. Mali and M.A. Viergever: Design of a robust strategy to measure intravascular electrical impedance.

1997 (Poultney, VT, USA): **David Atkinson**, Guys Hospital, London, UK.
D. Atkinson, D.L.G. Hill, P.N.R. Stoyle, P.E. Summers and S.F. Keevil: An autofocus algorithm for the automatic correction of motion artifacts in MR images.

1999 (Visegrad, Hungary): **Liana M. Lorigo**, Massachusetts Institute of Technology, Cambridge,MA, USA.
L.M. Lorigo, O. Faugeras, W.E.L. Grimson, R. Keriven, R. Kikinis and C.-F. Westin: Codimension 2 geodesic active contours for MRA segmentation.

2001 (Davis, CA, USA): **Viktor K. Jirsa**, Florida Atlantic University, FL, USA.
V.K. Jirsa, K.J. Jantzen, A. Fuchs and J.A. Scott Kelso: Neural field dynamics on the folded three-dimensional cortical sheet and its forward EEG and MEG.

2003 (Ambleside, UK): **Guillaume Marrelec**, INSERM, France.
G. Marrelec, P. Ciuciu, M. Pelegrini-Issac and H. Benali: Estimation of the hemodyamic response function in event-related functional MRI: directed acyclic graphs for a general Bayesian inference framework.

2005 (Glenwood Springs, Colorado, USA): **Duygu Tosun**, Johns Hopkins University, Baltimore, USA.
D. Tosun and J.L. Prince: Cortical surface alignment using geometry-driven multispectral optical flow.

2007 (Kerkrade, The Netherlands): **Ben Glocker**, Technische Universität München, Garching, Germany.
B. Glocker, N. Komodakis, N. Paragios, G. Tziritas and N. Navab: Inter-and intramodal deformable registration: continuous deformations meet efficient optimal linear programming.

2009 (Williamsburg, Virginia, USA): **Maxime Descoteaux**, NeuroSpin, IFR 49 CEA Saclay, France.
M. Descoteaux, R. Deriche, D. Le Bihan, J.-F. Mangin and C. Poupon: Diffusion propagator imaging: using Laplace's equation and multiple shell acquisitions to reconstruct the diffusion propagator.

Organization

Chairs

Gábor Székely	Swiss Federal Institute of Technology Zürich, Switzerland
Horst K. Hahn	Fraunhofer MEVIS, Institute for Medical Image Computing, Bremen, Germany

Paper Selection Committee

Jerry L. Prince	Johns Hopkins University, USA
Chris Taylor	The University of Manchester, UK
Baba C. Vemuri	University of Florida, Gainesville, USA

Scientific Review Committee

Daniel C. Alexander	University College London, UK
Amir A. Amini	University of Louisville, USA
Suyash P. Awate	University of Utah, USA
Christian Barillot	IRISA/CNRS, France
Pierre-Louis Bazin	Johns Hopkins University, USA
Sylvain Bouix	Brigham and Women's Hospital, Harvard Medical School, USA
Djamal Boukerroui	Université de Technologie de Compiègne, France
Michael Brady	University of Oxford, UK
Elizabeth Bullitt	University of North Carolina, USA
Owen T. Carmichael	University of California, Davis, USA
Philippe Cattin	University of Basel, Switzerland
Gary E. Christensen	University of Iowa, USA
Ela Claridge	The University of Birmingham, UK
Christos Davatzikos	University of Pennsylvania, USA
Benoit M. Dawant	Vanderbilt University, USA
Marleen de Bruijne	Erasmus MC - University Medical Center Rotterdam, The Netherlands
James S. Duncan	Yale University, USA
Bernd Fischer	Institute of Mathematics and Image Computing, University of Lübeck, Germany
P. Thomas Fletcher	University of Utah, USA
Luc Florack	Eindhoven University of Technology, The Netherlands

Alejandro F. Frangi	Universitat Pompeu Fabra, Spain
Ola Friman	Fraunhofer MEVIS, Bremen, Germany
James C. Gee	University of Pennsylvania, USA
Guido Gerig	University of Utah, USA
Polina Golland	Massachusetts Institute of Technology, USA
Michael L. Goris	Stanford University School of Medicine, USA
Matthias Guenther	Fraunhofer MEVIS, Bremen, Germany
Jo Hajnal	Imperial College London, UK
Joachim Hornegger	University of Erlangen, Germany
Nico Karssemeijer	Radboud University Nijmegen Medical Centre, The Netherlands
Frithjof Kruggel	University of California, Irvine, USA
Jan Kybic	Czech Technical University, Czech Republic
Rasmus Larsen	Technical University of Denmark, DTU, Denmark
Richard M. Leahy	University of Southern California, USA
Boudewijn P.F. Lelieveldt	Leiden University Medical Center, The Netherlands
Gabriele Lohmann	Max Planck Institute for Human Cognitive and Brain Sciences, Germany
Frederik Maes	Katholieke Universiteit Leuven, Belgium
Jean-Francois Mangin	CEA, France
Charles R. Meyer	University of Michigan, USA
Mads Nielsen	University of Copenhagen, Denmark
Wiro Niessen	Erasmus Medical Center Rotterdam, The Netherlands
Alison Noble	University of Oxford, UK
Sebastien Ourselin	Centre for Medical Image Computing, University College London, UK
Xenophon Papademetris	Yale University, USA
Nikos Paragios	Ecole Centrale de Paris, France
Xavier Pennec	INRIA, France
Franjo Pernus	University of Ljubljana, Slovenia
Dzung L. Pham	Johns Hopkins University, USA
Stephen M. Pizer	The University of North Carolina at Chapel Hill, USA
Hill Kilian Pohl	University of Pennsylvania, USA
Jinyi Qi	University of California, Davis, USA
Anand Rangarajan	University of Florida, USA
Joseph M. Reinhardt	University of Iowa, USA
Torsten Rohlfing	SRI International, USA
Karl Rohr	DKFZ Heidelberg, Germany
Daniel Rueckert	Imperial College London, UK
Julia A. Schnabel	University of Oxford, UK

Dinggang Shen	The University of North Carolina at Chapel Hill, USA
Pengcheng Shi	Rochester Institute of Technology, USA
Lawrence H. Staib	Yale University, USA
Martin Andreas Styner	The University of North Carolina at Chapel Hill, USA
Jean-Philippe Thiran	Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland
Klaus D. Toennies	Universität Magdeburg, Germany
Carole J. Twining	The University of Manchester, UK
Bram van Ginneken	Radboud University Nijmegen Medical Centre, The Netherlands
Koen Van Leemput	Harvard Medical School, Massachusetts General Hospital, USA
Marijn van Stralen	Image Sciences Institute, The Netherlands
Dirk Vandermeulen	Katholieke Universiteit Leuven, Belgium
Stefan Wörz	DKFZ Heidelberg, Germany
Simon K. Warfield	Harvard Medical School and Children's Hospital, USA
William M. Wells	Harvard Medical School and Brigham and Women's Hospital, USA
Carl-Fredrik Westin	Harvard Medical School and Brigham and Women's Hospital, USA
Guoyan Zheng	University of Bern, Switzerland
Lilla Zollei	Massachusetts General Hospital, USA

IPMI 2011 Board

Harrison H. Barrett
Christian Barillot
Aaron B. Brill
Gary E. Christensen
Alan C.F. Colchester
James S. Duncan
Michael L. Goris
Nico Karssemeijer
Richard M. Leahy
Stephen M. Pizer
Jerry L. Prince
Gábor Székely
Chris Taylor
Andrew Todd-Pokropek

Table of Contents

Segmentation

Statistical Methods

Shape Analysis

Poster Session I (Segmentation, Shape Analysis, Statistical Methods, Image Reconstruction, Microscopic Image Analysis)

Registration

Poster Session II (Computer Aided Diagnosis, Diffusion Imaging, Functional Brain Analysis, Registration, Other)

Diffusion Imaging

Disease Progression Modeling

Computer Aided Diagnosis

Erratum