

# 21<sup>th</sup> International School for Computer Science Researchers

## Medical and Molecular Imaging, and Bioinformatics

Lipari, Italy: July 11-18 2009

**WEBSITE:** <http://lipari.dipmat.unict.it/LipariSchool/CS/index.php>

### **Speakers (Brief Biosketches of the speakers are given in the attached pages)**

Nicholas Ayache: <http://www.sop.inria.fr/members/Nicholas.Ayache/ayache.html>

Mike Brady: <http://www.robots.ox.ac.uk/~jmb/>

Jim Duncan: <http://www.eng.yale.edu/faculty/vita/duncan.html>

Roger Gunn: Clinical Imaging Centre, GSK, London

Richard Leahy: [http://neuroimage.usc.edu/leahy\\_home.html](http://neuroimage.usc.edu/leahy_home.html)

Gene Myers: <http://research.janelia.org/myers/>

Daniel Rueckert: <http://www.doc.ic.ac.uk/~dr/>

Julia Schnabel: <http://www.robots.ox.ac.uk/~julia/home.html>

### **Directors:**

Prof. Mike Brady, (University of Oxford), Co-Chair

Prof. Roberto Cipolla, (University of Cambridge), Co-Chair

Prof. Alfredo Ferro, (University of Catania), Co-Chair

Prof. Giovanni Gallo, (University of Catania), Co-Chair

**Registration:** <http://lipari.dipmat.unict.it/LipariSchool/CS/index.php>

Two kinds of participants are welcome. Students: Participants who are expected to do afternoon courseworks and take a final exam. Auditors: Participants who are not interested in taking the final exam. Registration fee is 350 Euros all inclusive of: course material (memory stick), bus + hydrofoil Catania airport-Lipari-Catania airport, 2 social tours (Salina and Panarea) and the social dinner on the beach of Vulcano. Deadline for application is March 31, 2009. Late registration is 450 Euros. Applicants must include a short curriculum vitae and specify two professors whom letters of recommendation will be asked to, if deemed necessary. Applicants will be notified about admission by April 15, 2009.

**Local arrangements:** <http://lipari.dipmat.unict.it/LipariSchool/CS/index.php>

Participants will be arranged in a comfortable hotel at very special rates. The conference room is air-conditioned and equipped with all conference materials. Special areas are reserved to students for the afternoon coursework and study. The island of Lipari can be easily reached from Milazzo, Palermo, Naples, Messina and Reggio Calabria by ferry or hydrofoil (50 minutes from Milazzo).

## Topics covered by the School

### Nicholas Ayache Lectures

1. Cortex Variability from sulcal lines extracted from a database of MR images
2. Tumor growth from time series of MR images and physiopathological models
3. Cardiac function from images and physiological models
4. Mosaicing of/ in vivo/ microscopic images

### Mike Brady Lectures

1. Feature detection and density estimation in medical image analysis
2. Image analysis in colorectal and liver cancer
3. Some aspects of molecular imaging: glycolysis, hypoxia, and optical image analysis

### Jim Duncan Lectures

1. Recovery of Soft Tissue Deformation from Medical Images (mainly work on the Left ventricle of the heart and brain shift in epilepsy surgery)
2. Geometric Strategies for Neuroanatomic Analysis from MRI (mostly different approaches for cortical + subcortical segmentation)
3. fMRI Analysis Using Prior Information
4. Registration and plan updating for Image Guided Intervention (primarily for Epilepsy, Neurosurgery and/or Prostate Radiotherapy).

### Roger Gunn Lectures

1. Physics, Biology and Modelling Precursors for PET Molecular Imaging
  - Physics
  - Biology
  - Modelling
    - Spatial Processing
    - Input Functions
2. Quantitative Analysis of Dynamic PET Molecular Imaging Studies
  - Tracer Compartmental Modelling
  - Reference Tissue Approaches
  - Basis Function Approaches

### 3. Development and Validation of CNS PET Molecular Imaging Probes

- What kind of properties does one need
- Experiments to do to validate probes
- Examples
- Biomathematical modelling approaches

### 4. Application of PET Molecular Imaging to CNS Drug Development

- The drug discovery and development process
- Biodistribution Studies
- Occupancy Studies

## **Richard Leahy Lectures**

1. Image Estimation for Molecular Imaging 1: Statistical and physical models and Bayesian estimation
2. Image Estimation for Molecular Imaging 2: Image analysis and detection
3. Mapping brain function with magnetoencephalography (MEG) 1: forward models and inverse methods
4. Mapping brain function with magnetoencephalography (MEG) 2: detecting and modeling cortical interactions and networks

## **Gene Myers Lectures**

Arguably the most significant contribution of the human genome project is that we can now build a recombinant construct of every gene and every promotor in *C. elegans* (worm), *D. melanogaster* (fly), *M. musculus* (mouse), and *H. sapiens* (human). These include fluorescent proteins and other markers that can be induced at controlled time points via a change in temperature, light, or chemistry. Combined with tremendous advances in light and electron microscopy in recent years, I believe we are now poised to visualize the meso-scale of the cell, and the development small organs (e.g. a fly's brain) and organisms (e.g. the worm) at the resolution of individual cells.

These advances will require new imaging and data-mining methods for what I call "imaging bioinformatics". Many of the problems resemble those that arising in medical imaging but at a different scale and resolution. Toward this end, my group is working on a number of imaging projects along these lines. These include (a) the biophysics of mitosis, (b) studies of gene expression in individual cells within the worm *C. elegans*, (c) a detailed reconstruction of a fly's brain including its developmental partitioning into lineages, and (d) a high-throughput microscope to image the volume of an entire mouse brain at 1 micro resolution (4.2 trillion voxels) in less than a week. I will

spend my lectures introducing the relevant biological background and the nature of the computational problems, as well as going into some detail on the major methods we employ to solve these problems.

### **Daniel Rueckert and Julia Schnabel Lectures**

1. Non-rigid registration I: Theory and Methods
2. Non-rigid registration II: Advanced Methods and Validation
3. Cardiac and respiratory motion modeling using registration
4. Neurological image analysis using registration

### **Reading Group**

Mike Brady will lead the session marked “Reading”, which will be based on the weekly reading seminar he has lead in Oxford for the past 20 years. The students will be assigned a paper in advance of arriving in Lipari and will be expected to have read it thoroughly. They should be prepared to explain the content, either in broad outline, or on detailed points, to all the rest of the students.

## Brief Biosketches of the speakers

### Nicholas Ayache



**Nicholas Ayache** received his Ph.D in 1983, and his "Thèse d'Etat" in 1988, both in computer science and applied mathematics. He is currently a Research Director at INRIA Sophia-Antipolis, France, where he is the scientific leader of the ASCLEPIOS research group on biomedical image analysis and simulation since November 2005. He is the author of a large number of peer-reviewed scientific publications in Computer Vision, Medical Image Analysis and Surgery Simulation, the author of the book *Artificial Vision for Mobile Robots* (MIT-Press), and the Editor of the book *Computational Models for the Human Body* (Elsevier). He is the co-Founder and co-Editor in Chief of the *Medical Image Analysis Journal* (Elsevier), Ass. Ed. of *Tr. on Medical Imaging* (IEEE), and serves on the editorial board of major conferences like MICCAI and ISBI. He chaired the 1<sup>st</sup> Int. Conf. on Computer Vision, Virtual Reality, and Robotics in Medicine (CVRMed) held in Nice in April 1995, and co-chaired the 1<sup>st</sup> Symp. on Surgery Simulation and Soft Tissue Modeling in 2003. He was the Program Chair of the MICCAI conference in 2007 (Medical Image Computing and Computer Assisted Intervention).

Nicholas Ayache received in 2006, the "Grand Prize of Information Sciences and Applications" from the EADS Foundation and French Academy of Sciences, in 2007 he was elected member of the College of Fellows of the American Institute for Medical and Biomedical Engineering (AIMBE), and in 2008 he received the "Microsoft Award for Science in Europe", jointly awarded by the Royal Society and the French Academy of Sciences.

### Mike Brady



**Professor Sir Mike Brady** FRS, FREng, FMedSci is Professor of Information Engineering at the University of Oxford. Mike is the author of over 450 articles and 24 patents in computer vision, robotics, medical image analysis, and artificial intelligence, and the author or editor of ten books, including (with Ralph Highnam)

*Mammographic Image Analysis* (Kluwer, January 1999) and (with Sue Astley, Chris Rose and Reyer Ziggelaer) the *International Workshop on Digital Mammography* (Springer 2006). Mike's research mostly concerns cancer, both clinical and preclinical, of the breast, colorectum, liver and pancreas, with image modalities that include mammography (and digital breast tomosynthesis), ultrasound, MRI, PET, and optical imaging. He has a strong commitment to **model-based image analysis**, ranging from modelling the formation of an image to (most recently) modelling cellular pathways involved in tumour hypoxia.

Mike has a strong commitment to entrepreneurial activity, and serves as a non-executive director and Deputy Chairman of Oxford Instruments plc (<http://www.oxinst.com/>), and he is a director of Isis Innovation <http://www.isis-innovation.com/> (Oxford University's intellectual property company). Mike is a founding Director of the start-up companies Guidance (<http://www.gcsLtd.co.uk>), which develops navigation systems for mobile robots and for dynamic ship positioning as well as electronic tags for offenders, and Mirada Solutions Limited (<http://www.mirada-solutions.com>) which develops medical image analysis software, in particular *Miraview* for multimodal image fusion. Mirada Solutions was acquired in 2003 by CTI Molecular Imaging Inc (NASDAQ) and CTI was acquired in turn by Siemens in April 2005, becoming Siemens Molecular Imaging. Most recently, Mike is Senior Independent Director of the start-up company <http://www.ixico.net/> which provides image analysis services to the pharmaceutical industry, is a Director of <http://www.dexela.co.uk/> which is developing a novel 3D mammography system for more reliable and early detection of breast cancer, and a recent management buyout from Siemens of Mirada Medical (again). Mike is Chairman of the Science Advisory Board of Technikos (<http://www.technikos.co.uk/>)

## Jim Duncan



**James S. Duncan** is the Ebenezer K. Hunt Professor of Biomedical Engineering, as well as a Professor of Diagnostic Radiology and Electrical Engineering at Yale University, New Haven, CT, USA. He trained in Electrical Engineering, receiving the Ph.D. from the University of Southern California, Los Angeles, in 1982. His research and teaching efforts have been in the areas of computer vision, image processing and medical imaging, with an emphasis in biomedical image analysis. Currently, he is the Director of Undergraduate Studies and the Associate Chair of Biomedical Engineering and the Vice-Chair for Bioimaging Sciences research in Diagnostic Radiology. His specific research interests include the segmentation of deformable structure from 3D image data, the tracking of non-rigid motion /deformation from spatiotemporal images and development of strategies for image-guided intervention/surgery. He has published over 180 peer-reviewed articles in these areas and has been the principal investigator on a number of peer-reviewed grants from both the National Institutes of Health and the National Science Foundation over the past 25 years. From 1973-1983, he was a member of the technical staff and Section Head at Hughes Aircraft Company, Electro- Optical and Data Systems Group, El Segundo, California, and joined the Yale faculty in 1983. Professor Duncan is a member of Eta Kappa Nu

and Sigma Xi, is a Fellow of the *IEEE* and is a Fellow of the *American Institute for Medical and Biological Engineering* (AIMBE). He was awarded the “MICCAI 2008 Significant Researcher Award,” given for his “pioneering research on Statistical and Deformable Model-Based Methods and their multi-organ-based applications.” He is on the editorial board of the *Journal of Mathematical Imaging and Vision*, is an Associate Editor for the *IEEE Transactions on Medical Imaging* and is one of the founding co-Editors-in-Chief of the journal *Medical Image Analysis* (Elsevier). He was a Fulbright Research Scholar at the Universities of Amsterdam and Utrecht in the Netherlands during part of the 1993-94 academic year. In 1997, he chaired the 15th international meeting on *Information Processing in Medical Imaging* and was the general chair for the 2005 meeting on *Medical Image Computing and Computer-Assisted Intervention* (MICCAI). From 1999 to 2003, Dr. Duncan was a charter member of the National Institutes of Health (NIH) Diagnostic Imaging Study Section, serving as its Chair from 2001-2003.

## Roger Gunn



**Roger Gunn** is Director of PET Modelling at GSK where he is leading the application of PET imaging to drug development. He did his undergraduate degree in applied mathematics at the University of Warwick before completing a PhD in the bio-mathematical modelling of PET data at the MRC Cyclotron Unit. He left the MRC to take up a faculty position at McGill University where he worked at the Montreal Neurological Institute before joining GSK in 2003. He holds Visiting Professorships at Oxford University (Dept Engineering Science) and Imperial College (Division of Neuroscience and Mental Health) and has published over 70 peer reviewed journal articles in the field of imaging.

## Richard Leahy



**Richard Leahy** is a Professor of Electrical Engineering, Biomedical Engineering and Radiology at the University of Southern California. He was Director of the USC Signal and Image Processing Institute from 1997 - 2003. Dr. Leahy is a Fellow of the Institute of Electrical and Electronic Engineers (IEEE) and was general chair of the 2004 IEEE International Symposium on Biomedical Imaging (ISBI). He has published

over 200 papers in the field of biomedical signal and image processing. His research interests lie in the application of signal and image processing theory to biomedical imaging problems. His research involves the development of methods for anatomical and functional imaging with applications in neuroimaging and molecular imaging using PET, MRI and EEG/MEG.

## Gene Myers



**Dr. Eugene W. Myers** is a Group Leader at the new Janelia Farms Research Campus of the Howard Hughes Medical Institute. He was one of the first computer scientist to enter the field of computational molecular biology in the early 80's, and was a key developer of BLAST and other similarity search tools in the 90's. In 1995 he and Jim Weber proposed the whole genome shotgun sequencing of the human genome, and in 1998 he joined the founding Celera team to accomplish that mission. At Celera his team produced reconstructions of the Drosophila, Human, Mouse, and Anopheles genomes.

Dr. Myers received his Ph.D. in Computer Science in 1981 at the University of Colorado. He has since authored more than ninety peer-reviewed articles and four patents. Dr. Myers was awarded the Newcomb Cleveland Award for best article in Science in 2001 and the ACM Paris Kanellakis Theory and Practice Award in 2002. In 2003 he was elected to the National Academy of Engineering. In 2004 he won the International Max Planck Prize and in 2006 he was elected to the German National Academy of Science, Leopoldina. His research interests have centered on the design and analysis of algorithms in discrete pattern matching, computer graphics, and computational molecular biology. His current interest is developing algorithms and software for the automatic interpretation of images produced by light and electron microscopy of stained samples with a particular emphasis on building 3D and 4D "atlases" of brains, developing organisms, and cellular processes.

## Daniel Rueckert



**Daniel Rueckert** joined the Visual Information Processing Group in the Department of Computing as a lecturer in 1999 and became senior lecturer in 2003. Since 2005 he is Professor of Visual Information Processing. He received a Diploma in Computer Science (equiv to M.Sc.) from the Technical University Berlin and a Ph.D. in Computer Science from Imperial College London. Before moving to Imperial College,

he has worked as a post-doctoral research fellow in the Division of Radiological Sciences and Medical Engineering, King's College London where he has worked on the development of non-rigid registration algorithms for the compensation of tissue motion and deformation. The developed registration techniques have been successfully used for the non-rigid registration of various anatomical structures, including in the breast, liver, heart and brain and are currently commercialized by IXICO, an Imperial College spin-out company. During his doctoral and post-doctoral research he has published more than 180 journal and conference articles. Professor Rueckert is an associate editor of IEEE Transactions on Medical Imaging and a referee for a number of international medical imaging journals and conferences.

## **Julia Schnabel**



**Julia Schnabel** joined the Department of Engineering Science as a University Lecturer in Medical Imaging in 2007, coming from the Centre of Medical Image Computing at University College London. She is a faculty member of the new Institute of Biomedical Engineering, and a Fellow of St. Hilda's College, Oxford. Julia has been working in medical image analysis for over a decade, and is renowned for her work on non-rigid image registration methodology, statistical/biomechanical deformation modelling, with applications to neurosciences and oncology. She has published over 50 international journal articles and peer-reviewed conference papers, is an Associate Editor for Medical Physics, and a referee for most major medical imaging conferences and journals.