27 Training

27.1 Introduction

Training is an integral component of the Center and consists of many elements. The software documentation (specifically the tutorials) and conference tutorials represent two key components of the training efforts within the Center. In this section, we specifically address the topics of student and research training within the Center and the training of collaborators and users in the operation of our software.

"...the training and support your center provides is of the utmost importance for introducing new students and fellows to your powerful technology."

- Cameron C. McIntyre, Ph.D.,
  Associate Professor,
  Cleveland Clinic,
  Lerner College of Medicine - CWRU

27.2 Student and postdoctoral training

Since its inception, the Center has served as a gathering place for expertise in Bioengineering, Medical Physics, Physiology, and Computer Science. Undergraduates, graduate students, and postdoctoral fellows are immersed in these cross-disciplinary studies. The NCRR Center Seminar Series (see Section 27.4) is a just one specific event that gives students exposure to leading figures in the biomedical research community. The Center offers great opportunities to serve the community by educating and training tomorrow’s leading scientists. As a result of this collaborative environment, we have seen many successful students and postdoctoral fellows advance through their programs and into successful careers in academia or the commercial arena. Below is a brief listing of the students and post doctoral fellows who were trained on Center projects over the past five years of the CIBC.

Postdoctoral fellows:

- Jeroen Sinstra—Research Staff Scientist, Numira Biosciences, Inc.
- Xavier Tricoche—Assistant Professor, Computer Science, Purdue University
- Jens Krueger—Research Group Leader, Multimodal Computing and Interaction, Saarbrucken

Graduate students—Ph.D.:

- Seok Lew—Massachusetts General Hospital, Dept. of Radiology
- Sarah Geneser—Post Doctoral Fellow, Stanford University
- Alireza Ghodrati—Draeger Medical
- Saeed Babaeizadeh—Phillips Medical
- Miriah Meyer—Post Doctoral Fellow, Harvard University
- Jason Shepherd—Sandia National Laboratory
- Chris Butson—Assist. Professor, University of Wisconsin
- Josh Cates—Will defend in October, 2009
Graduate students—M.S.:

- Anastasia Mironova—Conoco Phillips
- Lee Roy Myers—Instructor, Eastern Wyoming College
- P.J. Hawkes—Medical School, University of Utah
- J.R. Blackham—Apple Computer
- Andrew Keely—Nuance Communications

Undergraduate students:

- McKay Davis—Makai Ocean Engineering, Waimanalo, Hawaii
- Zachary Warnock—Medical School, University of Utah
- Lindsey Healy—Graduate Student, Bioengineering, Univ. of Utah
- Patrick Rasch
- Anatoliy Zharkikh
- Cory Shirts

27.3 User and collaborator education and training

In our efforts to train users and Center collaborators, we use a variety of strategies including: one-on-one training of collaborators; online documentation combined with email-based user groups; and software workshops and training laboratories. These training efforts are critical to many of our collaborations and help bridge the significant distance between biomedical research and computer science. Our collaborators have had direct input on our training efforts.

Direct one-on-one interaction with our collaborators:

Over the past several years, we have discovered that the most effective model to provide training is either a site visit from Center staff to the collaborator’s laboratory or a visit from the collaborator to the Center. These visits allow both the time and focus on the collaborator’s research and the Center research to provide a substantial base of shared knowledge. This base understanding is the foundation for further training efforts.

We have seen that direct Center-collaborator interactions offer bidirectional training. The collaborators are often training in the use of the Center software and the scientific computing research methods incorporated within the software (and the Center as well). The Center personnel are also effectively trained in multiple disciplines as the interaction with collaborators changes the Center software. Additionally, we directly train students and research scientists in an interdisciplinary environment, encouraging interaction between medical and computational scientists.

We have several examples of these visits that have resulted in either significant research gains, as demonstrated by publications, or in the establishment of preliminary results having led to successful proposals. Examples include:

**Collaborative Institution:** Center for Molecular Imaging Research, Massachusetts General Hospital  
**Visitor:** Dr. Damon Hyde  
This project involves work on joint fluorescence molecular tomography (FMT) and computed tomography (CT) under Vasilis Ntziachristos and Simon Warfield at Massachusetts General Hospital. A result of this collaboration is the 2009 IEEE Bioimaging Symposium lecture, “Differential equation-driven regularization for joint FMT-CT imaging.” Damon Hyde; Children’s Hospital Boston and Harvard Medical School, Eric Miller; Tufts University, Dana H. Brooks; Northeastern University, Vasilis Ntziachristos; Technical University of Munich and Helmholtz Center Munich.
Collaborative Institute: Department of Biomedical Engineering, Bucknell University
Visitor: Dr. Joseph Tranquillo
Dr. Tranquillo made progress on several projects during a sabbatical visit to the Center. This progress resulted in a number of publications with undergraduate students at Bucknell: “Quantitative Neurophysiology”, published by Morgan and Claypool, 2008, as part of the Synthesis Lectures in Biomedical Engineering; “Intrinsic Inhomogeneities and the Coexistence of Spirals with Different Periods of Rotation”, published in Physical Review E (78:051914), 2008; and “Negative Curvature as a Mechanism of Rate Acceleration in Pacing-induced Multi-wave Spirals” in review with the Biophysical Journal.

Collaborative Institution: Utah Center for Advanced Imaging Research (UCAIR)
Visitor: Graduate student Dosik Hwang
Dosik worked with several members of our Center in the area of inverse solutions for magnetoencephalography, completing his dissertation and publishing a number of articles including: “Controlled Support MEG Imaging”, Srikantan Nagarajan, Oleg Portniaguine, Dosik Hwang, Chris Johnson, and Kensuke Sekihara, NeuroImage, vol. 33, pp. 878-885, 2006.

We have allocated and will continue to allocate considerable resources to training in all forms; training is an essential aspect of our mission. Software with the complexity and power of our software simply requires extensive documentation and education. It is our intent to limit the costly one-on-one interactions, when possible, to those who are developing either new applications or new capabilities for the software. The training tools described below are largely influenced by what we learn during our one-on-one interactions with collaborators.

Online documentation combined with email-based user group: While the Center documentation and email lists are cornerstones supporting our software dissemination, we also recognize these tools as supporting the training agenda of the Center. Many of the users we encounter in our mail lists are graduate students in interdisciplinary areas; we can further the training efforts of our Center by responding to user questions in an informative manner rather than simply trying to “solve the user’s current problem.”

Workshops and training laboratories:

Software Workshops: We have had five onsite workshops, three in Salt Lake City, Utah and two in Boston, Massachusetts.

- NIH/NCRR CIBC Workshop 2009, Boston
- NIH/NCRR CIBC Workshop 2008, Salt Lake City
- An Introduction to SCIRun 2006, Salt Lake City
- NIH/NCRR CIBC Workshop 2006, Salt Lake City
- An Introduction to SCIRun 2006, Boston

The general agenda of the workshops includes a 2-day session for users with an added third day for developers. The user portion of the workshops focuses on the utilization of SCIRun and the various software systems that CIBC offers. The developers’ session involves many workshops, focusing on topics such as module design and creation in SCIRun, GUI design and guidelines, and SCIRun dataflow datatypes and I/O. Each workshop reflects the evolving state of the Center software.

Participants of these workshops come from a number of corporations and institutions including: UT–San Antonio, Cleveland Clinic, UC–San Francisco, UC–San Diego, Mass. General Hospital, Indiana University - Purdue University Indianapolis, Harvard, Indiana U., UH–Downtown Houston, and others.

We receive very positive feedback from these workshops, for example, “My self and two graduate students attended the work shop organized by the SCI Institute in Boston last January, to learn about the current capabilities and future directions of the SCIRun software. We were left very impressed with the flexibility and potential of this and other software packages developed at the SCI Institute. We plan to incorporate these tools into a customized FEA package for biomechanical analysis of the mastication system.”

- Sinan Muftu, Ph.D., Associate Professor, Department of Mechanical and Industrial Engineering, Northeastern University
**SCIRun/map3d labs for graduate Bioengineering physiology classes:** We have also created labs for graduate-level bioengineering and physiology students (*i.e.*, Bioen 6000 – CV Physiology and Bioen 6460 – Bioelectricity). These labs serve to introduce the students to the concepts and practice of simulation and three-dimensional visualization in biomedical research. Specifically, the students perform exercises in bioelectric forward problems and source localization in the heart and brain. SCIRun allows them to interactively place sources at any location within the volume conductor and immediately see the resulting ECG/EEG fields. They then start with a given body-surface potential distribution and try, first manually and then using inverse algorithms, to use SCIRun to identify the location and orientation of the associated dipolar source. The first labs were part of the 2003 edition of the course and are now part of the annual lab rotation. Using SCIRun and map3d in the student-lab environment has been very valuable to the Center. The students fill out a questionnaire at the end of the lab, providing their feedback and supplying the Center with information that helps shape improvements to the software. This information has been especially helpful in improving the user interface and overall ease of use of the software packages.

In addition to our use of Center software for the purpose of teaching our students, we are seeing the use of Center software in other institutions’ classrooms, for example,

“...In addition, I already use some of your other software (BioFEM and BioImage3D) in a core curriculum class for students pursuing a Ph.D. in Computational Biology. With your software and some of your datasets, the students are able to study the heart as a bioelectric dipole embedded in a human torso, and to visualize surface electrodes and electric field lines through the tissues.”
- Joel R. Stiles, MD, Ph.D., Director National Resource for Biomedical Supercomputing, Pittsburgh Supercomputing Center, Associate Professor, Department of Biological Sciences, Carnegie Mellon

“... Your software has also been very helpful as tutorials for our students and post doctoral fellows to learn new techniques in software development and their application. Most of your software development is written in C/C++ using well known libraries. The software is open source which allows our students and postdocs to study the code and learn techniques in code development.”
- Grant T. Gullberg, Ph.D., Senior Staff Scientist, Lawrence Berkeley National Laboratory, Adjunct Professor of Radiology, University of California San Francisco

### 27.4 Seminars

A major initiative of the training segment of our Center is the seminar series that exposes our students and scientists to other local, national, and international scientists from the biomedical computing research field. Over the last four years of the Center we have hosted over 90 seminars, a sampling of which are listed below:

#### 2009

- **Andrew Alexander** – Developments in Diffusion MRI – Improvements to Voxel-based Analysis and Hybrid Diffusion Imaging, University of Wisconsin
- **Moo Chung** – Limitations of Fourier descriptors and Spherical Harmonic Representation and Its Application to Autism Data Set, University of Wisconsin
- **Mark Pauly** – Scalable Geometry Processing, ETH Zurich
- **Samuel Gerber** – Dimensionality Reduction and Principal Surfaces via Kernel Map, University of Utah, SCI Institute
- **Ewout Vansteenkiste** – Quantitative Image Analysis of the Preterm Brain, Ghent University
- **Mario Hlawitschka** – Tensor Lines Revisited - a unified way of defining line structures, UC–Davis
- **Kyle Thomson** – The need for visualization of the next generation of neural interfaces, University of Utah, Neurosciences
• **Tom Peters** – TEA, Knots & Molecules in Animation, Simulation & Visualization, Kerner Graphics and UConn

• **Jens Krueger** – “Weird Data” - Current and Future Challenges in Scientific Visualization, University of Utah, SCI Institute

• **Jose Principe** – Co-Adaptive Brain Machine Interfaces, University of Florida

• **Frank Wood** – A Nonparametric Bayesian Alternative to Spike Sorting, University College, London

• **Daniel Silverman** – PET Imaging in Cognitive Impairment: Neurodegenerative and Hormone-Related Alterations of Brain Chemistry, UC – Los Angeles

• **Casey Goodlett** — Computation of Statistics for Populations of Diffusion Tensor Images, University of Utah, SCI Institute & Utah Center for Neuroimage Analysis (UCNIA)

• **Erik Anderson** — Data processing and visualization in an rTMS study, University of Utah, SCI Institute

• **Dennis Gannon** — The Challenges of Cloud Computing, Microsoft Research

• **Kannan UV** — Automatic Markup of Neural Cell Membranes Using Boosted Decision Stumps, University of Utah, SCI Institute

• **Stanley Durrleman** — Spatiotemporal Atlas Estimation From Longitudinal Dataset, INRIA Sophia–Antipolis

• **Sam Preston** — Processing of MRI data for Simulation and Monitoring of Drug Delivery, University of Utah, SCI Institute

• **Joana Fonseca** — Image Segmentation Techniques for Granular Materials, Imperial College London

• **Satoshi Matsuoka** — GPU Accelerated Computing from Hype to Mainstream, the Rebirth of Vector Computing, Tokyo Institute of Technology

• **Manuel Casanova** — Cortical Modularity and Autism, University of Louisville

• **Tom Fletcher** — Why averaging works great in 2D but not so great in 3D, University of Utah, SCI Institute & Utah Center for Neuroimage Analysis (UCNIA)

**2008**

• **Jong-Min Lee** — Computational NeuroImage Analysis Lab, Hanhyang University

• **Yongsheng Pan** — Image Segmentation using PDE, Variational, Morphological and Probabilistic Methods, University of Utah, SCI Institute

• **Tom Fletcher** — A Tutorial on Kendall Shape Spaces and Recent Work on Robust Shape Statistics, University of Utah, SCI Institute & Utah Center for Neuroimage Analysis (UCNIA)

• **Hans-Peter Pfister** — From Pictures to Insights, Harvard University

• **Chi-Bin Chien** — Analyzing Anatomy and Development of the Zebrafish Visual System in 3 and 4 dimensions, University of Utah, Neuroscience

• **Joel Spaltenstein** — Using the OsiriX medical image viewer for microscopy, OsiriX

• **Seok Lew** — EEG/MEG Source Analysis and Brain Tissue Conductivity, University of Utah, CIBC

• **Will Schroeder** — the NAMIC Kit, Kitware

• **Josh Cates** — A Hypothesis Testing Framework for High-Dimensional Shape Models, University of Utah, CIBC

• **Ed Di Bella** — Model-Based Reconstruction for Dynamic MRI, University of Utah, UCAIR, Radiology
• David Weinstein — Small Animal Imaging, Numira Biosciences, Inc.

• Neda Sadeghi — Automatic Classification of Alzheimer's Disease and Frontotemporal Dementia: A Decision tree Approach with FDG-PET Cortical Metabolism, University of Utah, SCI Institute & Utah Center for Neuroimage Analysis (UCNIA)

• Jacob Hinkle — 4D Tomographic Reconstruction, University of Utah, SCI Institute

• Richard King — Complexity Measures of the Cerebral Cortex in Normal Aging and Alzheimer's Disease, UT Southwestern Medical Center

• Antonio Paiva — Reproducing Kernel Hilbert Spaces for Point Processes, with Applications to Neural Activity Analysis, University of Utah, SCI Institute

• Jim Gee — Tract-specific analysis of brain white matter, University of Pennsylvania

• Bradley Greger — High channel number multi-scale electrophysiological neural data: a visualization and modeling challenge, University of Utah, Bioengineering

• Guido Gerig — Mapping Early Brain Development via Neuroimaging, University of Utah, SCI Institute & Utah Center for Neuroimage Analysis (UCNIA)

• Sarah Geneser — Computing Statistics of Radiation Dose Variation Resulting From Breathing-Induced Organ Motion, University of Utah, SCI Institute

2007

• Orly Alter — Discovery of Principles of Nature from Mathematical Modeling of DNA Microarray Data, UT–Austin

• Miriah Meyer — Particle Systems for Efficient and Accurate High-Order Finite Element Visualization, Harvard University

• Josh Cates — Entropy-Based Particle Systems for Shape Correspondence, University of Utah, CIBC

• Won-ki Jeong — A Fast Eikonal Equation Solver for Parallel Systems, University of Utah, SCI Institute

• Tom Fletcher — Quantifying Region-to-Region White Matter Connectivity in DT-MRI, University of Utah, SCI Institute & Utah Center for Neuroimage Analysis (UCNIA)

• Dmitri "Mitya" Chklovskii — Brain circuit reconstructions - a grand challenge for computer vision, Cold Spring Harbor

• Srikanth Suryanarayanan — Clinical Applications for CT & PET from GE Global Research, GE Healthcare

• Marta Mattoso — "Scientific Data Management", Federal University of Rio de Janeiro

• Andrew E. Anderson — Computational Modeling of Hip Joint Mechanics, University of Utah, SCI Institute & Musculoskeletal Research Lab (MRL)

• David Luebke — NVIDIA GPU Computing for Scientific Simulation and Visualization, NVIDIA

• Tammy Kolda — presents Tensor Decompositions, the MATLAB Tensor Toolbox, and Applications to Data Analysis, Sandia National Lab.

• Elizabeth Jurrus — Axon Tracking in Serial Block-Face Scanning Electron Microscopy, University of Utah, SCI Institute

• Vince Calhoun — The MIND Research Network, University of New Mexico

• Brian Athey — National Center for Integrative Biomedical Informatics (NCIBI) Scope and Collaborative Opportunities, University of Michigan
• **Gordon Kindlmann** — Anisotropy Creases and Geodesic-Loxodromes: Recent Developments in the Analysis and Interpolation of Diffusion Tensor Images, Harvard University and Brigham and Women's Hospital

• **Jens H. Krueger** — Real-Time Graphics, TU Munich

• **Guido Gerig** — Longitudinal Data Analysis, University of Utah, SCI Institute

• **Cleve Moler** — Evolution of MATLAB, MathWorks

• **Chris Butson** — Neuromodulation Therapy: Computational Methods & Clinical Correlates, Cleveland Clinic

• **Juliana Freire** — VisTrails: Using Provenance to Streamline Data Exploration, University of Utah, School of Computing

• **Brad Davis** — Population Shape Regression From Random Design Data, University of North Carolina and Kitware

• **Suresh Venkatasubramanian** — Shape Matching: A Computational Geometric Perspective, University of Utah, SCI Institute

• **Tobias Preusser** — "Image Based Computing for the Planning of Radio-Frequency Ablation", Fraunhofer MEVIS

• **Won-Ki Jeong** — Interactive Visualization of Volumetric White Matter Connectivity in DT-MRI using a Parallel-Hardware Hamilton-Jacobi Solver, University of Utah, SCI Institute

• **Sarah Geneser** — Applications of the Stochastic Collocation Method: Calculating the Effect of Cardiac Position on Body Surface Potentials, University of Utah, SCI Institute

• **Ross Whitaker** — Accurate and Robust Medial Axis Detection, University of Utah, CIBC

• **Norman Foster** — Alzheimer’s Disease Neuroimaging Initiative (ADNI): Status of Imaging and Analyses, University of Utah, Neurology

• **Tolga Tasdizen** — Non-linear dimensionality reduction and a new robust technique based on successive single dimensional embeddings, University of Utah, SCI Institute

• **Rob MacLeod** — Image Processing in Treating Atrial Fibrillation: One Challenging Problem After Another, University of Utah, CIBC

• **Bryan Jones** — Computational Retinal Reconstruction, University of Utah, Moran Eye Center

• **Marcel Prastawa** — A Hierarchical Segmentation Scheme for Brain Lesions in MRI, University of Utah, SCI Institute & Utah Center for Neuroimage Analysis (UCNIA)

• **Zhuowen Tu** — Auto-Context and Its Applications on Medical Imaging and Computer Vision, UC–Los Angeles

**2006**

• **Guido Gerig** — Neuroimaging: What can we learn about brain development?, UNC–Chapel Hill

• **Travis Oliphant** — Using Python with NumPy, SciPy, Matplotlib, and IPython to create a Matlab(TM)-like scientific-computing environment, Brigham Young University

• **Spencer J. Sherwin** — Arteries and Algorithms: Multi-scale Modelling of flow in the Cardiovascular system, Imperial College London

• **Russ Altman** — Challenges in Creating an Infrastructure for Physics-Based Simulation of Biological Structures, Stanford University
• Christian Renken — Cryo-Electron Tomography of Membrane Systems, New York State, Department of Health

• Ian Foster — Service-Oriented Science, University of Chicago, Argonne National Lab

• Natalia Trayanova — Virtual Reality in the Race against Sudden Cardiac Death, Tulane University

• Bart M. ter Haar Romeny — Biologically inspired algorithm development for computer-aided diagnosis, Eindhoven University

• Guido Gerig — Statistics of populations of 3-D images and its embedded objects, UNC–Chapel Hill

• Luca Pavarino — Mathematical and numerical modeling of ventricular electrical heterogeneities, University of Milano

• Han-Wei Shen — Navigating Large-Scale Multiresolution Volumes, Ohio State University

• Sarang Joshi — Statistics of Shape: Simple Statistics on Interesting Spaces, University of Utah, SCI Institute

• Kevin Montgomery — Advanced Technologies for Next Generation Medicine, Stanford University

• Michael Miller — The Emergent Discipline of Computational Anatomy, Johns Hopkins University

• TJ Jankun-Kelly — A Model and Framework for Visualization Exploration, Mississippi State University

• Larry Frank — Magnetic Resonance Imaging in Marine Biology Research, UC – San Diego

• Lee Hood — Systems Biology and Systems Medicine: Computational Challenges, Institute for Systems Biology

• Andrew Pullan — Electrical Activity of the Heart, Stomach and Skeletal Muscle, University of Auckland

The seminar series is a critical component of our training efforts. This series not only serves as a mechanism for exposing our researchers and students to world-class scientists, but also serves as a forum for faculty, students and postdoctoral fellows to present their research. Moreover, we have found the seminar series to be informative and an aid in strengthening the Center’s collaborative research and in increasing the impact of our research and software.