Grant B. Harris

Details of my work as an *Scientific Informatics Analyst* in the *Cellular Dynamics Program* at the

Marine Biological Laboratory, Woods Hole, Mass. (2001 to the present)

The laboratory develops novel polarize d light microscopy techniques for imaging live cells. The Lab engages in interdisciplinary collaborations to conduct research in physical optics for the interpretation of image content and of computational methods for image enhancement and restoration. These physical and engineering projects are stimulated and guided by biological inquiries into the structural basis of cell function primarily for Dr. Rudolf Oldenbourg, while also assisting Dr. Shinya Inoué and Dr. Michael Shribak. Work involved software design and development, microscopy and optics, engineering, and multimedia production

OpenPolScope.org

Contributed to marketing and sales, training, business development, product design and documentation of OpenPolScope.org. Maintained technical and business relationships with collaborators, customers and manufactures (Meadowlark Optics, CRI) of system components.

Software Design & Development

Designed and developed software systems for software for instrument control and data acquisition for biological microscopy. Performed all aspects of software systems design and development in the Lab, including testing, debugging, documentation and support. Using primarily *Java* in the programming of various projects with many aspects of object-oriented programming, including concurrency/multi-threading, polymorphism, generics, annotations, dependency injection, etc. Extensively incorporated open source libraries in the construction of systems and components. Used C/C++ wrappers, having built them for cameras, an X-Y stage controller and other devices. Used the *Netbeans* integrated development environment, as well as other development tools including ANT, SWIG, Maven and Git. Utilized other programming languages, including C++, C#, and Python. Drew from and contributed to the open source bioimaging informatics community.

ImageJ2 *Project Co-Leader*

From 2010 – 2012, supported by the ImageJ2 project - an NIH funded project to redesign the open source *ImageJ* image processing application to accommodate a broader range of needs in the scientific community. The project was based at the *Laboratory for Optical and Computational Instrumentation* (LOCI) at the University of Wisconsin, Madison, in collaboration with the *CellProfiler* team at the Broad Institute, the *Fiji* project, and our lab at the MBL. Contributed to the architecture of application framework emphasizing interface (API) design for backward-compatibility, modularity, interoperability, and extensibility. This paper, IjX: ImageJ refactored to interfaces for eXtensibility authored in 2009, helped inspire the LOCI group to apply for the grant. Participated in 'Hackathons' at Madison, Heidelberg (EMBL). and Janelia Farms (HHMI).

Software Projects

Designed the application architecture, user interface, configuration, data management, and application programming interfaces (API) for a series of projects, including:

PSj / LC-PolScope: PSj is a complete birefringence imaging system based on the LC-Polscope technology that allows us to visualize molecular order directly in living cells with unprecedented sensitivity, resolution and speed. Based on polarization measurements, this mode of microscopy allows us to gain insight into submicroscopic structural parameters and non-invasively create contrast where structures are otherwise invisible. This software was provided with research instruments sold by CRI, and is in use in laboratories around the globe.

JIF: Java Instrument Framework: JIF is an Instrument Control and Image Acquisition Components Library that I designed and developed consisting of open source components for image display and analysis, image data and metadata management, and hardware interfacing for instrument control and image

acquisition using asynchronous serial I/O and low-level interfacing with C++/JNI. It provides integration with the open-source imaging system from the NIH, *ImageJ*, and incorporates a number of third-party libraries. I presented a poster (and received third place award) at the ImageJ 2008 Conference in Luxembourg, entitled *Instrument Control and Image Acquisition Tools for Live-Cell Imaging* (see ImageJ Conference Poster.)

CamAcqJ: a generalized instrument control and image acquisition application built on the described components library. This application is currently used in our lab for running experiments. It provides both user interface and script driven control of variable (LC) retarders, focus, shutters, XY-stage movement, and laser ablation while acquiring images.

Scanning Aperture LCPolscope: Software for controlling and calibrating a segmented light modulator for 3D birefringence imaging. (In collaboration with *CRI, Inc.*)

Real-time LC-PolScope: System for operation of high speed multi-camera LC-PolScope system using C# programming language. (In collaboration with *CRI, Inc.*)

Lightfield Microscope: Lightfield viewer, in collaboration with Marc Levoy, Stanford Univ.

Diattenuation Imaging System: set of MicroManager plugins for diattenuation imaging.

Image Navigator: a data viewer with special handling of multidimensional images and metadata as generated by MicroManager, for instance.

Microscopy & Optics

Through the use of and reconfiguration of microscope and optical systems in support of our lab and our numerous collaborating investigators, gained a strong practical understanding of optical microscopes, especially using polarized light. I have worked with upright and inverted microscopes from various manufacturers, as well as several custom systems, including the Centrifuge Polarizing Microscope (CPM) and Universal Light Microscopes. Continuously researched new and evolving microscopy technologies, including lightfield (4D, microlens array), structured illumination, super-resolution, and SPIM.

Analytical & Quantitative Light Microscopy Course: In May, 2005, completed the AQLM course at the Marine Biological Laboratory. Lectures and laboratory work on geometrical and physical optics of microscope image formation including Abbe's theory of the microscope and Fourier optics; interaction of light and matter; phase contrast polarization and interference microscopy for the nondestructive analysis of molecular and fine- structural organization in living cells; fluorescence microscopy, quantification of fluorescence, and GFP; principles and application of digital video imaging, high sensitivity image sensors, recording, analysis, and display; digital image processing and quantitative digital image deconvolution; ratiometric measurement of intracellular ion concentrations; confocal microscopy; and new advances in light microscopy such as FRET, FLIM, TIRF, and pattern illumination.

Engineering

Mechanical Design and Fabrication of components for experiments including a camera/transfer lens mounting, arc-lamp mounting; and various optical test rigs and adapters. CAD design (PTC Creo) and 3D-printing of optical and microscopy components.

Network and Systems Support, management and maintenance of computers and network systems for the lab.

Diagnostics & Repairs on a variety of instruments and tools, including the Centrifuge Polarizing Microscope (CPM), cameras, optical components.

Teaching

Delivered workshop on Instrument Control and Image Acquisition Using Micromanager at ImageJ Developers Conference, Luxemburg., 2012.

Lead workshop on Object Tracking using open source software for AQLM, 2011, 2012.

Provided general support and workshops on open source software and birefringence imaging techniques to the AQLM.

Multimedia Production

Video Production & Editing; DVD Production: Produced video of Polarized Light Microscopy Demonstration for Dr. Inoue; Video codec conversions & testing. Produced a companion DVD for the book *The Collected Works of Shinya Inoue*, integrating video, PowerPoint presentations, instructions, a DVD/CD auto-run & menu system.

Video Microscopy Archive Project: Organized and managed the digitization/conversion of 400+ hours of material from Dr. Shinya Inoue's library of video microscopy experiments going back to 1980. Transfers from *UMatic*, *ED-Beta*, *VHS*, and *Hi-8*, and optical disk recorders to DVD, as well as time-lapse video conversations.

PowerPoint: Extensive work with *PowerPoint*, designing templates, embedding multimedia, and graphical design work. I trained Dr. Inoue on *PowerPoint* and have assisted him extensively on the design of presentations and preparation of images, illustrations and video materials.

Website Design: Designed websites for support of the *PSj* and *CamAcqJ* systems.

Publications

Polarized Fluorescence Microscopy to Study Cytoskeleton Assembly and Organization in Live Cells., McQuilken, M., Mehta, S.B., Harris, G., Oldenbourg, R., and Gladfelter, A.S. 2015. Curr. Protoc. Cell Biol. 67:4.29.1-4.29.13.

Massive Bioaccumulation and Self-Assembly of Phenazine Compounds in Live Cells Min K. A., Rajeswaran W. G., Oldenbourg R., Harris G., Keswani R. K., Chiang M., Rzeczycki P., Talattof A., Hafeez M., Horobin R. W., Larsen S. D., Stringer K. A., Rosania G. R.. Adv. Sci., 2, 2015.

Algorithms for Measuring Orientation of Single and Ensemble of Molecules with Real-Time Fluorescence Polarization Microscope. Verma, A., S. Mehta, A. Verma, G. Harris. R. Oldenbourg, T. Tani. IEEE International Symposium on Biomedical Imaging 2013.

Shs1 is required for an organized septin higher order structure in vivo., M McQuilken, S Abrahamsson, S Mehta, G Harris… Molecular Biology Of The Cell, 2014

Polarized Light Microscopy Publications my work supported:

Polarized light imaging of birefringence and diattenuation at high resolution and high sensitivity, Shalin B. Mehta, Michael Shribak, and Rudolf Oldenbourg, Journal of Optics, Volume 15, Number 9, 2013.

Polarized light field microscopy: an analytical method using a microlens array to simultaneously capture both conoscopic and orthoscopic views of birefringent …

Quantitative orientation-independent differential interference contrast (DIC) microscopy

Septin filaments exhibit a dynamic, paired organization that ...

A Global, Myosin Light Chain Kinase-dependent Increase in ...

Orientation-Independent Differential Interference Contrast ...

Microtubule Dynamics in Cell Division: Exploring Living Cells with Polarized Light Microscopy, Annual Review of Cell and Developmental Biology, Vol. 24: 1-28 (November 2008)

Notes

NIH Image to ImageJ: 25 years of image analysis : Nature Methods