New Program Proposal
Doctor of Philosophy in Biomedical Imaging
Medical University of South Carolina

Summary

The Medical University of South Carolina requests approval to offer a program leading to the Doctor of Philosophy in Biomedical Imaging to be implemented in Fall 2014. The proposed program is to be offered through traditional and blended instruction. The following chart outlines the stages for approval of the proposal; the Advisory Committee on Academic Programs (ACAP) voted to recommend approval of the proposal to the Committee on Academic Affairs and Licensing (CAAL). The full program proposal is attached.

Stages of Consideration	Date	Comments
Program Planning Summary received and posted for comment	10/15/2013	The Program Planning Summary was revised and resubmitted based on feedback from CHE staff.
Program Planning Summary considered by ACAP through electronic review	12/2/2013	ACAP members expressed support for the proposed program.
Program Proposal Received	1/10/2014	
ACAP Consideration	2/20/2014	One ACAP member questioned whether the estimated costs of the program were too low. The representative from MUSC assured the Committee that the estimated costs were accurate because faculty are already in place and the main costs of implementing any new program are faculty salaries and new course development.
Comments and suggestions from CHE staff to the institution	2/21/2014	Staff requested the proposal be revised to include the following: • more information about employment opportunities. • a description of the options in place for students who do not complete the Ph.D. program since the proposal states that the need for a M.S. degree in Biomedical Imaging will be addressed independently in the future • the identification of new courses that will need to be developed and the plan and timeline to develop these courses; and • a corrected "Estimated Costs and Sources of Financing" chart showing total costs, not just new costs.
Revised Program Proposal Received	3/21/2014	

Recommendation

The staff recommends that the Committee on Academic Affairs and Licensing commend favorably to the Commission the program leading to the Doctor of Philosophy in Biomedical Imaging at the Medical University of South Carolina to be implemented in Fall 2014.

Medical University of South Carolina

College of Graduate Studies &
Center for Biomedical Imaging

Proposed New Program

Ph.D. in Biomedical Imaging

Submitted January 15th, 2014

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Mark Sothmann, Ph.D. Date
Interim President
Medical University of South Carolina

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New Program Proposal: Ph.D. in Biomedical Imaging

Program title:	Ph.D. in Biomedical Imaging
Concentrations, options, and tracks:	Post-Baccalaureate
Academic Unit:	College of Graduate Studies
Designation, type, and level of degree:	Entry-level doctoral degree
Proposed date of implementation:	Fall 2015
CIP code:	26.1103
Site:	Medical University of South Carolina (MUSC)
Qualifies for Palmetto Fellows or Life Scholarship awards:	No
Delivery mode:	Traditional

INSTITUTIONAL APPROVAL

This proposal has been reviewed and approved by the following internal review bodies at MUSC:
College of Graduate Studies (CGS) Graduate Council – August 30th, 2013
MUSC Dean's Council –September 16th, 2013
MUSC Board of Trustees –February 14th , 2014

PURPOSE

Mission

> The **MUSC Biomedical Imaging Ph.D. Program** proposes to provide a comprehensive and integrated graduate training program with a curriculum covering imaging science and biomedical applications leading to a Ph.D. in Biomedical Imaging. Our faculty has identified a basic core of knowledge and skills which will prepare our graduates to become leaders in basic and/or clinical research in biomedical imaging and its applications. This core consists of a strong foundation in the fundamentals of image acquisition technologies and data analysis methods. The students will also receive training in research practice, experimental design, and the application of specific imaging modalities through a series of individual electives in their chosen area of interest.

Although many biomedical imaging-related doctoral programs train students to be experts in specific techniques, there is a growing need for expertise in the application of these imaging technologies to solve important biomedical problems. The Bureau of Labor Statistics estimates that nationally, "Employment of biomedical engineers is projected to grow by 62% from 2010 to 2020, much faster than the average for all occupations" (http://www.bls.gov/ooh/architecture-and-engineering/biomedical-engineers.htm). Further, the South Carolina Department of Employment and Workforces estimates that by 2020 employment of biomedical engineers will grow in South Carolina by 75%.
(http://lmi.dew.sc.gov/lmi%20site/Documents/CommunityProfiles/01000000.pdf) These employment opportunities will create demand for a wide variety of engineering skills including digital imaging, an increasing component of all aspects of modern technology. Thus, as healthcare, biomedical research, and biotechnology industries become increasingly invested in using imaging technologies, the demand for individuals with expertise in the appropriate applications of these tools and skills to develop their novel use will necessarily grow.

No university in South Carolina currently offers a graduate degree in Biomedical Imaging at either the M.S. or Ph.D. level. Although both M.S. and Ph.D. programs are ultimately needed, we propose to initially establish a new program for a Ph.D. in Biomedical Imaging and will independently address the need for an M.S. degree in Biomedical Imaging in the future. While both degrees would enable a graduate to work in industry and academia at advanced levels, the Ph.D. is specifically designed to establish its graduates as independent, creative scientists able to drive innovation in the field. Establishing this program falls within the mission of MUSC to "educate students to become creative biomedical scientists" and addresses its strategic initiative area of innovation.

The objectives of the program are to:

1. Provide a broad-based educational program for our students with both didactic and practical research experience with sufficient instruction in advanced technology, and analysis methods to enable them to become independent research scientists, application innovators, and bioimaging experts.
2. Prepare students with the skills and expertise to meet the increasing need for individuals in biomedical imaging who have a broad background in both theory and application.
3. Prepare our graduates for productive and successful careers in the imaging related aspects of biomedical research and development by developing their independent research skills.
4. Provide appropriate employment opportunities for our graduates by developing industrial and academic connections to organizations using imaging in their products and research. We expect that our graduates will have the education and skills to assume leadership roles in their future employment.

JUSTIFICATION

Program Description

The **MUSC Biomedical Imaging Ph.D. Program** will provide a comprehensive and integrated graduate training program combining biomedical sciences through the College of Graduate Studies' core curriculum, with a strong curriculum in imaging science and its biomedical applications leading to a Ph.D. in Biomedical Imaging. This degree will provide students with the education and training needed to pursue careers applying cutting edge developments in biomedical imaging to solving scientific and healthcare problems within academia or industry. It is intended for students with Bachelor's degrees or advanced pre-doctoral students who wish to master biomedical imaging and research methods to enhance or broaden their application-oriented investigations.

The core curriculum is designed to provide a strong foundation in the fundamentals of imaging acquisition technologies, data analysis methods, and research design, all within the context of applying these techniques in clinical and basic research projects in academic and industrial medical and research settings. Through this program, students will be able to gain hands-on experience with advanced imaging systems dedicated to both preclinical (bioluminescence, fluorescence, Micro-CT/PET, 7T MRI) and human (3T MRI) research. The students will have

opportunities to rotate as research assistants in laboratories of professors who actively conduct research within many departments throughout the university, such as Neurosciences, Psychiatry, Radiology, Rehabilitation, Cardiology, Pediatrics, Surgery, and Oncology. The students will be required to demonstrate scientific proficiency in the area of biomedical sciences, with an emphasis on biomedical imaging through the completion of a qualifying examination and an individual doctoral dissertation.

Upon the completion of this degree, graduates will have the foundation on which they can build careers as independent investigators or key collaborators who possess a unique combination of skills: a fund of technical knowledge of imaging sciences and its most critical innovations as well as a distinct perspective that is focused on applying these advances in biomedical imaging to a breadth of preclinical and human research areas, from basic physiological processes to phenotypically complex diseases.

Need for the Proposed Program

Biomedical imaging is an inherently multidisciplinary field requiring the expertise of clinicians, medical physicists, computer scientists, biomedical engineers, chemists, pharmacologists, and biologists. This interdisciplinary group has and will continue to revolutionize healthcare by developing new technological tools and techniques to use in the detection, diagnosis, and treatment of human disease (1).

The utilization of imaging across multiple biomedical disciplines will drive the development of a well-educated and highly trained work force using new biomedical imaging tools and techniques. This growing work force will apply these tools and techniques in different applications from the organ level to the cellular level in manufacturing, laboratory, and clinical domains. MUSC recognized the need to strengthen the biomedical imaging research community at MUSC and in 2011 the Board of Trustees established the Center for Biomedical Imaging (CBI). The mission of the CBI is to provide state-of-the art imaging resources, train and mentor young investigators, and provide opportunities for basic and clinical scientists to collaborate on new biomedical imaging discoveries (1).

The development of a Ph.D. program in Biomedical Imaging at MUSC will capitalize upon a structured group of faculty, graduate students, post-docs and research staff who focus on the application of biomedical imaging tools in laboratory and/or clinical settings in Neuroscience, Radiology, Pathology, and Psychiatry. MUSC has active clinical and basic science research programs in these departments so advanced image acquisition and image analysis skills will provide a strong complementary component to the MUSC research and educational mission. With graduate students, medical students, faculty and staff trained in biomedical imaging tools and techniques and exposed to industrial and other academic research institutional partners, the biomedical imaging-based laboratories at MUSC have a pool of talented individuals that will lead in the development of novel biomedical imaging tools and techniques. A formal Ph.D. program will strengthen the research competitiveness of MUSC across these disciplines and lead to more technological innovation in the State ultimately contributing to the creation of more knowledge-based companies and employment opportunities in South Carolina. In Science Technology Engineering Math (STEM) specific jobs, it is anticipated that in the state of South

Carolina there will be a 13% increase in STEM jobs from 71,990 to 81,140 by 2018(2), an increase of nearly 10,000 jobs.

The multidisciplinary nature of biomedical imaging results in a variety of career path options for holders of these degrees. While many will seek employment as medical scientists, biomedical engineers, biophysicists, medical physicists, or biochemists in academia, government, or industry, there are also many biomedical imaging Ph.D.s who will work in industry or manufacturing in product development, venture capital, and marketing; as well as in legal fields such as regulatory, technology transfer, and patent law. According to the Bureau of Labor Statistics 2012-2013 Occupational Outlook Handbook these are professions that can expect better than average increases in employment through 2020 across the nation (3).

	Employment 2012	Projected Employment 2022	Job growth
medical scientist(4)(5)	103,100	116,800	13,700
biomedical engineer(5)	19,400	24,600	5,200
biochemist/biophysicist(6)	29,200	34,600	5,400
medical physicist(7)	20,600	22,700	2,100

Centrality of the Program to the Institutional Mission

The proposed **MUSC Biomedical Imaging Ph.D. Program** supports the mission of MUSC in several ways: 1) fostering an inter-professional educational experience; 2) advancing economic development through the introduction of new biomedical imaging technology; and 3) building collaborations with industry and other academic institutions (8).

The **Biomedical Imaging Ph.D. Program** will be offered through the MUSC College of Graduate Studies and will include the core coursework of the Biomedical Sciences Program. The core classes will expose these students to the scientific skills necessary to function in laboratory settings. The mathematical and statistical classes contained in the program's curriculum will expose students to the fundamentals of image formation, acquisition, and analysis techniques and a multiplicity of clinical and laboratory based applications. Together these skill sets will create well-rounded graduate students uniquely prepared to apply state-of-the-art, cutting-edge imaging and analysis techniques to important biomedical questions.

Relationship of the Proposed Program to Other Related Programs with the Institution

The proposed **MUSC Biomedical Imaging Ph.D. Program** will unite faculty in the Departments of Radiology, Neuroscience, Psychiatry, Pediatrics, Surgery, and Pathology and Laboratory Science, many of whom are faculty in the Center of Biomedical Imaging. The Departments of Radiology and Psychiatry currently have only residency training programs for MDs, but no graduate student programs. The Departments of Neuroscience and Pathology have residency programs for MDs and well-established M.S. and Ph.D. programs for graduate students through the MUSC College of Graduate Studies. Students graduating through these programs receive their doctorates in Biomedical Sciences with Departmental specializations. All doctorate programs in the Biomedical Sciences require a common first year curriculum focused on providing a foundation across all Biomedical Sciences areas on campus including, fundamental coverage of Neuroscience, Cell and Molecular Pharmacology, Pathology and

Laboratory Medicine, Microbiology and Immunology, Public Health Sciences, Drug Discovery, Molecular and Cellular Biology, Pathobiology, and Bioengineering. In addition to a common first year curriculum, these students are required to participate in laboratory rotations in order to broaden students' scientific training and to assist the students in identifying an appropriate Ph.D. track and Ph.D. mentor. Students pursuing a Ph.D. in Biomedical Imaging would take the first semester core curriculum from the College of Graduate Studies to provide appropriate biomedical background. Further specific didactic course work, laboratory experience with Biomedical Imaging faculty, and an approved dissertation would complete their program of study.

Comparisons and Relationships with other Programs in the State, Region, and Nation

There are currently no Biomedical Imaging Ph.D. programs in South Carolina. Nationally, there are 25 biomedical imaging tracks associated with Biomedical Engineering Ph.D. programs but no programs solely offering a Biomedical Imaging Ph.D. (9).

The University of South Carolina (USC) offers a Biomedical Engineering Ph.D. but does not have a specialization in biomedical imaging. Likewise, Clemson University offers a Ph.D. in Bioengineering, but also has a strong focus in the area of biomaterials and not imaging. Currently, Clemson and MUSC have a Cooperative Agreement which permits MUSC dental and medical students to pursue joint degree programs, DMD or MD respectively, with a Ph.D. in Bioengineering from Clemson. The courses in the proposed Biomedical Imaging Ph.D. Program will be open to students in the joint program. If there is sufficient interest from Clemson students we will also arrange for remote classes at Clemson for the courses.

There are no other regional Biomedical Imaging Ph.D. programs with the training emphasis described in this proposal. There are specialized biomedical imaging training specializations imbedded within various Biomedical Engineering programs within adjacent states. In North Carolina, there are three Ph.D. programs in Biomedical Engineering with a biomedical imaging track at 1) Duke University and 2) a joint program between the University of North Carolina at Chapel Hill and North Carolina State University, and 3) a joint program between Wake Forest University and the Virginia Polytechnic Institute and State University. In Georgia, there is a joint Biomedical Engineering program between the Georgia Institute of Technology and Emory University.

ADMISSION CRITERIA

Individual applicants will be evaluated on undergraduate/graduate records, GRE scores and letters of recommendation. In addition, the department will consider current project, lab, and research area availability when evaluating applicants. Previous research experience or employment in areas relevant to bioengineering will carry significant weight.

Generally, applicants will require:

- an undergraduate GPA of 3.3/4.0 or higher
- GRE verbal score: 70th percentile or higher
- GRE quantitative score: 70th percentile or higher

- GRE analytical writing score: 70th percentile or higher
- Either TOEFL score: 100 or higher OR IELTS of 7.0 or higher (international students only)

Specific Biomedical Imaging Entrance Requirements

The basic requirement for admission to the **MUSC Biomedical Imaging Ph.D. Program** is a Bachelor's degree from an accredited undergraduate science program. Students will most commonly be trained in engineering, physics, or life sciences. However, due to the interdisciplinary nature of biomedical imaging, it is to be expected that some students may need to take additional courses to supplement their first year of graduate work. It is expected that all Biomedical Imaging Ph.D. students will have adequate prerequisites for acquiring additional knowledge in biochemistry, physiology and statistics.

Students can enter the program prior to meeting all the prerequisites if approved by the admissions committee. These students must plan to complete the prerequisites during their enrollment in addition to the requirements stipulated for the Ph.D. Credits from prerequisites are not applied toward a graduate degree, and students can be restricted to a minimum assistantship until undergraduate prerequisites are completed. Under special circumstances, a petition to the Biomedical Imaging Ph.D. program director may allow certain of these prerequisites to be waived.

ENROLLMENT

The **MUSC Biomedical Imaging Ph.D. Program** is proposed to start in the Fall semester of 2015. The program will recruit U.S. and international students who have STEM undergraduate degrees. However, due to proximity, the program will primarily recruit students from 4-year institutions in South Carolina. Students will be a part of the incoming graduate class and have a minimum of a Bachelor's degree and meet the requirements for admission described in the previous section. It is expected that some students may transfer from existing programs at MUSC. New students will start in the Fall semester each year.

It is estimated that 3-4 students will enroll in the first year. The number of new students is expected to increase during the first few years of the program. It is assumed that all students will take a full academic load of five 3-credit courses or 15 credits per semester and that all Ph.D. students will conduct full-time research during the summer. The typical student will complete the Ph.D. program in approximately 4-5 years. After 5 years, the anticipated average total enrollment will be 15 students although the long term steady state will be 22 students (5/yr x 4.5 years). (see Table A).

Table A – Projected Total Enrollment

Year	Fall		Spring		Summer	
	Headcount	Credit Hours	Headcount	Credit Hours	Headcount	Credit Hours
2014-2015	3	45	3	45	3	45
2015-2016	6	90	6	90	6	90
2016-2017	10	150	10	150	10	150
2017-2018	12	180	12	180	12	180
2018-2019	15	225	16	225	16	225

Assumptions:

1. Students will take a full academic load (5 courses/15 credits per semester).
2. Students will complete the Ph.D. program in an average of 4-5 years.
3. All students will take summer courses (i.e. research credit).
4. New students will enter in the fall semester.

CURRICULUM

The course requirements and program structure are designed to provide the needed foundational knowledge, primarily during the first two years of didactic courses. These are listed below. An average grade of B or higher (in graded classes) is required to continue in the program. This course work is followed by a qualifying exam in the early summer semester of the second year and the completion of 6 more credit hours of electives and a doctoral dissertation.

The 7 new required courses to be taken during the student's first two years of study are listed below together with their scheduling. A total of 15 credit hours per semester is required so that the students will have taken 60 hours of didactic study before taking their qualifying exam and formally starting their dissertation which must be approved by a 5 member dissertation review committee chaired by a member of the Biomedical Imaging faculty other than their advisor.

New Required Courses

Year One

First Semester

None – Existing standard first-year, first-semester Graduate School requirements

Second Semester

Quantitative Human Physiology with imaging specific examples
Mathematical Methods
Introduction to Biomedical Imaging Modalities

Year Two

First Semester

Probability and Statistics
Methods in Molecular Imaging

Second Semester

Methods in MRI
Signal processing/Image analysis

Summer Semester

Qualifying exam for Ph.D. candidates

Year Three plus (Two electives must be taken before graduation)
First Semester
Elective
Second Semester
Elective

A typical Course of Study

	Year 1	Year 2	Year 3 +
Fall Semester	• Foundations of Biomedical Sciences (10) • Essential Scientific Practices (1) • Diversity in Science (1) • Important Unanswered Questions(1) • Laboratory Rotation (2)	• Methods of Molecular Imaging (3) • Probability and Statistics (3) • Seminar (1) • Journal Club (1) • Research (7)	• Research (10) • Elective as needed (3) • Seminar (1) • Journal Club (1)
Spring Semester	• Quantitative Physiology using Imaging (3) • Mathematical Methods (3) • Intro to Biomedical Imaging methods (3) • Elective (3) • Laboratory Rotations (2) • Important Unanswered Questions (1)	• Methods of MRI (3) • Signal & Image Processing (3) • Seminar (1) • Journal Club (1) • Research (7)	• Research (10) • Elective as needed (3) • Seminar (1) • Journal Club (1)
Summer Semester	• Research (13) • Essential Scientific Practices III (2)	• Qualifying Exam (5) • Research (10)	• Research (15)

In addition to the core course requirements described above, several new imaging- related electives are being designed to emphasize the practical applications of imaging to biomedical research. These will be fully developed during the first years of the program.

Functional neuroimaging
Techniques for observing regional neural activity, e.g. functional MRI, PET
Cancer imaging
Techniques for imaging tumors, particularly with molecular probes
Cardiovascular imaging
Specific techniques for cardiovascular imaging using CT, MRI, PET
Two-photon imaging
Non-linear optical methods to probe neural activity at the cellular level
Chemical shift imaging of the brain
Metabolic studies of *in vivo* brain metabolism using spectroscopy
Brain stimulation
Methods of direct neural stimulation, e.g. transcranial magnetic or electric stimulation
Computational neuroscience
Mathematical models of neural systems at multiple scales
Medical imaging device development and bioscience entrepreneurship

Case studies of new instrumentation development and commercialization

Advanced clinical imaging

Applying new technical developments in clinical practice

STATUS OF PROPOSED NEW COURSES

All core courses have been planned and submitted to the MUSC curriculum committee for approval with three approved and the remaining to be reviewed at the committee's next meeting. The elective courses are planned for development over the next several years as presented the table below

Approved?	**YEAR 1**	Credits
	Fall	
Yes	**Foundations of Biomedical Sciences**	10
Yes	**Essential Scientific Practices**	1
Yes	**Diversity in Science**	1
Yes	**Important Unanswered Questions**	1
	Laboratory Rotation	2
	Fall Credits	15
	Spring	
Fall 2014	**Quantitative Human Physiology w/ Im. Apps.**	3
Yes	**Mathematical Methods**	3
Yes	**Intro. to Biomedical Imaging Modalities**	3
	Elective	3
	Laboratory Rotations	2
Yes	**Important Unanswered Questions**	1
	Spring Credits	15
	Summer	
	Research	13
Yes	**Essential Scientific Practices-III**	2
	Summer Credits	15

Approved?	**YEAR 2**	Credits
	Fall	
Fall 2014	**Methods of Molecular Imaging**	3
Fall 2014	**Probability and Statistics**	3
	Seminar	1
	Journal Club	1
	Research	7
	Fall Credits	15
	Spring	
Spring 2015	**Methods in MRI**	3

YEAR 3+	Credits
Fall	
Research	10
Elective (as needed)	3
Seminar	1
Journal Club	1
Fall Credits	15
Spring	
Research	10

Yes	**Signal Process./Image Analysis**	3		**Elective (as needed)**	3
	Seminar	1		Seminar	1
	Journal Club	1		Journal Club	1
	Research	7			
	Spring Credits	15		*Spring Credits*	15
	Summer			**Summer**	
	Qualifying Exam	5		Research	15
	Research	10			
	Summer Credits	15		*Summer Credits*	15

Courses to be Developed (in order):	
Fall 2014	**Quantitative Human Physiology w/ Im. Apps.**
Fall 2014	**Methods of Molecular Imaging**
Fall 2014	**Probability and Statistics**
Spring 2015	**Methods in MRI**
Spring 2015	**Cardiovascular imaging**
Spring 2015	**Functional neuroimaging**
Fall 2015	**Cancer imaging**
Fall 2015	**Chemical shift imaging (brain)**
Fall 2015	**Two-photon imaging**
Spring 2016	**Advanced clinical imaging**
Spring 2016	**Brain stimulation**
Spring 2016	**Computational neuroscience**
Spring 2016	**Medical imaging device development and bioscience entrepreneurship**

ASSESSMENT

The **MUSC Biomedical Imaging Ph.D. Program** will prepare students for careers in academic research and in the healthcare industry. The students will develop the skills needed to become leaders in both basic and clinical biomedical imaging research. Core concepts to be taught include biomedical imaging technology, applications of biomedical imaging, data analysis and research design. Concepts presented in the course curriculum are reinforced and applied in students' original dissertation research projects. The program will assess both program outcomes and student learning outcomes.

Program Outcomes

Assessment of program outcomes will consist of both metrics to measure student perceptions of program quality and objective measures of success of our graduates. The following metrics will be monitored:

1. Percent of students who graduate on time.
2. Percent of graduating students who agreed that they made the right choice in selecting MUSC for their education.
3. Percent of graduating students who agreed that they would recommend the program to other prospective students.
4. Percent of graduating students who rated the quality of their education as satisfactory to excellent.
5. Percent of employers who indicated graduates have demonstrated competency.
6. Percent of students who obtain full-time employment in a biomedical imaging field within one year of graduating.
7. Percent of students who obtain tenure-track faculty positions within 7 years of graduating.
8. Number of publications while students are attending MUSC.
9. Percent of graduates who successfully obtain a grant within 7 years of graduating.

Data for these measures will be collected through surveys conducted by the University at time of graduation and subsequent annual surveys of graduates of the program.

Student Competencies

Specific measures of the competencies related to the program objectives will be developed by the program faculty. In addition to maintaining a B average in their course work achievement of these competencies will be assessed using a combination of the following metrics:

1. Student self-assessments performed at the beginning of the program and at the end of the program. This will demonstrate the students' perception of their progress through the program.
2. Faculty evaluation of satisfactory demonstration of competencies for each individual core curriculum course.
3. Evaluation by faculty of the key competencies demonstrated by students during their written and oral qualifying exams.
4. Annual evaluation by faculty mentors of the student mentees' performance during their dissertation research.
5. Reports from thesis committees of the quality of final dissertations.

Program faculty will establish target values for all measures of program outcomes and student competencies. All program outcomes and summaries of student competency achievement will be presented to the program faculty annually. The faculty will review the measures and make recommendations to program administration for adjustments in program content and delivery where indicated.

Students not maintaining a B average in their course work will be given a semester to restore their grade point average. If they are unsuccessful they will be asked to withdraw from the

program. Students who have successfully completed the didactic part of the program and are unable to pass the qualifying examination or complete a dissertation will be offered a terminal Master's degree. Since the earliest this could happen is 2 years after the start of the Ph.D. program, the M.S. program in Biomedical Imaging we propose to establish (which will have considerable didactic overlap with this program) will be available for those students in this category.

FACULTY

The program faculty are predominantly members of the Center for Biomedical Imaging, a new MUSC-wide Center established by the Board of Trustees in 2011. The remainder of the faculty are recruited from the Departments of Radiology, Neuroscience, Psychiatry, Pediatrics, Surgery, Medicine and the College of Health Professions with projects in the application of imaging techniques to their research activities (see Table B). New faculty hires are not anticipated as the teaching requirements of the new program will be fulfilled by existing faculty.

Table B– Faculty List

Rank	Highest Degree Earned	Field of Study	Teaching in Field (Yes/No)
Professor #1	Ph.D.	Physics	YES
Professor #2	Ph.D.	Physics	YES
Professor #3	Ph.D.	Physics	YES
Associate Professor #1	Ph.D.	Biomedical Engineering	YES
Associate Professor #2	Ph.D.	Psychology	YES
Associate Professor #3	Ph.D.	Psychology	YES
Assistant Professor #1	Ph.D.	Electrical Engineering	YES
Assistant Professor #2	Ph.D.	Psychology	YES
Assistant Professor #3	Ph.D.	Physics	YES
Assistant Professor #4	Ph.D.	Biomedical Engineering	YES

One FTE represents a full-time faculty member who has been appointed to the MUSC faculty by the Vice President for Academic Affairs and Provost and who receives 100% of compensation through MUSC or though MUSC authorized activities. The faculty member engages in clinical practice, instruction, research, and/or administrative activities on the MUSC Campus or any of its affiliated locations. All junior faculty have a career development plan monitored by senior faculty. The faculty position may be tenured, tenure eligible, or non-tenured.

Table C – Unit Administration, Faculty & Staff Support

UNIT ADMINISTRATION, FACULTY, AND STAFF SUPPORT						
YEAR	**NEW**		**EXISTING**		**TOTAL**	
	Headcount	FTE	Headcount	FTE	Headcount	FTE
Administration						
2017 – 18			1	0.05	1	0.05
Faculty						
2014 – 2015			3	.3	3	.3
2015 – 2016			7	.7	.7	.7
2016 – 2017			8	.8	.8	.8
2017 – 2019			9	.9	.9	.9
2018 – 2019			9	.9	.9	.9
Staff						
2014 – 2018			1	0.1	1	0.1

PHYSICAL PLANT

Given that anticipated annual enrollment in this program is small relative to the total annual enrollment in the College of Graduate Studies at MUSC, the current physical plant will be adequate to meet the educational needs of the students. The core classes taught to students in this program will be conducted in existing classrooms in the basic science building, bioengineering building, and drug discovery building as needed. These classrooms are all equipped with SmartBoard technology, high definition cameras, high-fidelity projection systems, and all necessary audiovisual equipment.

EQUIPMENT

It is not anticipated that additional equipment will be necessary. The current audiovisual equipment and imaging equipment will be updated and replaced using the normal acquisition process.

LIBRARY RESOURCES

The proposed program modification will require library resources pertinent to both the ***biomedical*** and ***imaging*** sciences.

In the ***biomedical sciences***, current library resources are adequate to support the proposed program. The MUSC Library serves as a database and knowledge center, academic computing support unit, electronic education center, and leader in information planning. Pertinent online resources include the full catalog as well as major biomedical databases (e.g., MEDLINE, CINAHL, PsycINFO, SciFinder, and PubMED). A wealth of worldwide information is provided, including online catalogs of other libraries, drug information (MicroMedex, Mosby's Drug Consult), consumer health (Hands on Health, MEDLINEPLUS, Health Reference Center), clinical decision support systems (eMedicine, UpToDate, InfoPOEMS), Clinical Practice Guidelines and alerts, reviews of clinical trials, evidence-based practice (Cochrane database, INFOPOEMS), government resources (Toxnet, Federal Register, Code of Federal Regulations), electronic books (MD Consult, Harrison's Online, Access Medicine) and e-journal packages with literature search capabilities (ScienceDirect, ejournals@MUSC, Journals@Ovid, American Chemical Society), and statewide shared academic databases (Collegiate DISCUS, DISCUS)

In the ***imaging sciences***, consultation with Dr. Thomas Basler, Director of Libraries and Learning Resource Centers, has shown that any additional resources needed (the engineering, physics and mathematics references and electronic journals) are available through Inter-library loan and the existing MUSC Clemson Joint Bioengineering program.

ACCREDITATION, APPROVAL, LICENSURE, or CERTIFICATION

Not applicable for this program.

ARTICULATION

The proposed Ph.D. program is a terminal degree and, as stated elsewhere, it is the only program of its kind in South Carolina. MUSC does not generally participate in the South Carolina Transfer and Articulation (SC TRAC) program and is not a receiving school for transfer students (see: http://www.sctrac.org/MedicalUniversityofSouthCarolina-/Transfer-Profile/tabid/476/Default.aspx), as MUSC does not offer general undergraduate education coursework. However, with permission, individuals from other in- and out-of-state intuitions will be allowed to register for courses on a non-degree basis.

In 2003, MUSC and Clemson University established an active collaborative relationship in bioengineering. The CU-MUSC Bioengineering Program is on the MUSC campus in Charleston. Faculty from Clemson University and their staff have laboratories and office space on the MUSC campus. Students from Clemson, with the approval of their institution, will be allowed and encouraged to take courses offered in MUSC's Biomedical Imaging program. In the future, we will work closely with other area universities and colleges to provide similar access to courses offered through the Biomedical Imaging Ph.D. program.

ESTIMATED COSTS AND SOURCES OF FINANCING

The implementation of this program will not incur any unique costs or special state appropriations. Tuition and research grants to the faculty will be the primary source of funding along with the anticipated typical funding the College of Graduate Studies receives from state appropriations provided to MUSC. It is anticipated that this proposal will result in a total of $25,000 of additional expenses for course instruction and staff support over the first 5 years.

The percentage of in-state students who matriculated into the MUSC College of Graduate Studies varied from 50% to 60% over the last three years. It is expected that the cohort of students matriculated into the proposed Ph.D. program will follow a similar profile. However, if the number of national programs offering a similar degree is still limited at the time of implementation of this proposed program, the percent of out-of-state applicants may be higher.

This program will be a new addition to the College of Graduate Studies' existing doctoral programs in biomedical sciences so the program will be administered through the same general process. The total costs of the program will depend on the number of students accepted and are expected to be approximately the same per student as in other programs. Much of the necessary infrastructure is pre-existing, so there will be few new costs directly associated with the program administration (see Table D). Faculty for the program (primarily from MUSC's Center for Biomedical Imaging, see http://academicdepartments.musc.edu/cbi/), are supported by research grants that will also support projects that the Biomedical Imaging Ph.D. students will engage in as part of their independent research and experiential learning.

Table D – Estimated Costs and Sources of Financing by Year

ESTIMATED COSTS BY YEAR						
CATEGORY	**1st**	**2nd**	**3rd**	**4th**	**5th**	**TOTALS**
Program Administration	0	0	0	2000	2000	4000
Faculty Salaries**	38,860	81,340	92,960	104,580	104,580	422,320
Graduate Assistants	0	0	0	0	0	0
Clerical/Support Personnel	1000	1000	1000	2000	3000	8000
Supplies and Materials	1000	1000	1000	1000	1000	5000
Library Resources*	900	1800	3000	3600	4500	13,800
Equipment	0	0	0	0	0	0
Facilities	0	0	0	0	0	0
Other (Identify)	0	0	0	0	0	0
TOTALS	41,760	85,140	97,960	113,180	115,080	453,120
SOURCES OF FINANCING BY YEAR						
Tuition Funding	70,932	141,864	236,440	283,728	354,660	1,087,624
Program-Specific Fees	0	0	0	0	0	0
State Funding	0	0	0	0	0	0
Reallocation of Existing Funds	0	0	0	0	0	0
Federal Funding	0	0	0	0	0	0
Other Funding (Specify)	0	0	0	0	0	0
TOTALS	70932	141864	236440	283728	354660	1087624

** Faculty salary costs were calculated by multiplying a weighted average of the mean salaries of the faculty involved in the program times the fractional FTE's in Table C.
* Library costs were estimated at $300/student/year.

References

1. Center for biomedical imaging [Internet].; 2013. Available from: http://academicdepartments.musc.edu/cbi/.

2. STEM state-level analysis [Internet]. Available from: https://georgetown.app.box.com/s/t2fv2ydz37nqzfkhlwyj.

3. Occupational outlook handbook - healthcare occupations [Internet].; 2012. Available from: http://www.bls.gov/ooh/healthcare/home.htm.

4. Medical scientists : Occupational outlook handbook : U.S. bureau of labor statistics [Internet].; cited 3/11/2014]. Available from: http://www.bls.gov/ooh/life-physical-and-social-science/medical-scientists.htm#tab-6.

5. Biomedical engineers : Occupational outlook handbook : U.S. bureau of labor statistics [Internet].; cited 3/11/2014]. Available from: http://www.bls.gov/ooh/architecture-and-engineering/biomedical-engineers.htm#tab-6.

6. Biochemists and biophysicists : Occupational outlook handbook : U.S. bureau of labor statistics [Internet].; cited 3/11/2014]. Available from: http://www.bls.gov/ooh/life-physical-and-social-science/biochemists-and-biophysicists.htm#tab-6.

7. Physicists and astronomers : Occupational outlook handbook : U.S. bureau of labor statistics [Internet].; cited 3/11/2014]. Available from: http://www.bls.gov/ooh/life-physical-and-social-science/physicists-and-astronomers.htm#tab-6.

8. MUSC strategic plan 2010-2015 [Internet].; 2010. Available from: http://etl2.library.musc.edu/strategicplan/.

9. Biomedical imaging graduation programs imaging curricula and imaging courses [Internet]. Available from: http://www.bmesphotos.org/WhitakerArchives/academic/ferrara.pdf.

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

DEPARTMENT OF BIOMEDICAL ENGINEERING

March 5, 2014

Truman R. Brown, Ph.D.
Stephen Schabel Professor of Radiology and Radiological Science
Professor of Neuroscience
Scientific Director, Center for Biomedical Imaging
Bioengineering Building, Rm 205
68 President Street
Medical University of South Carolina
Charleston, SC 29425

Dear Prof. Brown,

Attached please find my written assessment of your proposed Ph.D. program in Biomedical Imaging at the Medical University of South Carolina. In summary I found the proposal to be outstanding. The curriculum is well thought out, taking full advantage of the resources at MUSC, as well as other Universities/Colleges in SC. Given the proposed program's careful attention to admission criteria and a willingness to provide supplemental courses to bring applicants from the behavioral sciences into the program, it will provide a good basis for the development of scientists with a range of technical and research skills needed in industry and academia in South Carolina and nationwide. I commend you on the quality of your proposal and fully support you and your colleagues in this effort.

Sincerely,

Paul Sajda, Ph.D.
Professor
Departments of Biomedical Engineering,
Electrical Engineering and Radiology

Assessment of Proposed Ph.D. in Biomedical Imaging at

the Medical University of South Carolina

Paul Sajda, Ph.D.

Professor of Biomedical Engineering and Radiology

Columbia University

New York, NY

This assessment evaluates four aspects of the proposed Ph.D. Program in Biomedical Imaging at the Medical University of South Carolina (MUSC). These are 1) The Merit of the proposed program, 2) its potential effect on existing programs at MUSC, 3) its relationship to similar programs in South Carolina and 4) the ability and readiness of MUSC to support the proposed program. To summarize the comments below, I believe the proposed program has great merit; fits very well into the existing imaging, neuroscience and other graduate programs at MUSC; and will have a beneficial effect on STEM graduate programs in South Carolina thus helping to develop the needed technical infrastructure. It can be readily supported by MUSC with few added resources needed. I believe these points are also well laid out in the proposal itself.

I. Merit

The Ph.D. program in Biomedical Imaging at MUSC will prepare graduates to become leaders in basic and/or clinical research involving the application of biomedical imaging tools. MUSC specifically, and South Carolina generally, has the need for scientists with advanced image acquisition and image analysis skills to achieve the state's research and educational missions. This program will expose students to industrial and other academic research institutional partners, providing them with career opportunities in the development of novel biomedical imaging tools and techniques. A formal Ph.D. program will strengthen the research competitiveness of MUSC across a broad range of disciplines. This will lead to more technological innovation in the State, ultimately contributing to the creation of more knowledge-based companies and employment opportunities in South Carolina and the nation.

II. Effect on existing graduate programs at MUSC

There is no doubt the proposed new program will have a positive effect on numerous research programs in the Departments of Radiology, Neuroscience, Psychiatry, Pediatrics, Surgery, and Pathology and Laboratory Science. The Departments of Neuroscience and Pathology have well-established M.S. and Ph.D. programs for graduate students through the MUSC College of Graduate Studies (CGS) which are using imaging methods in increasingly complex research protocols. The addition of an interactive pool of researchers who can both develop and use imaging techniques should significantly improve their research productivity. In addition many clinical Departments are interested in research involving imaging methods but have no direct connection to the CGS. The new program will provide the basis for many new collaborations in

these areas and the collaborations will, in turn, provide employment opportunities for students following graduation.

III. Relationship to similar programs in South Carolina

There appear to be no other Biomedical Imaging Ph.D. programs in South Carolina. Nationally, there are a number of biomedical imaging tracks in Biomedical Engineering Departments but no programs solely offering a Biomedical Imaging Ph.D. Both the University of South Carolina (USC) and Clemson University offer a Ph.D. in Biomedical Engineering and Bioengineering, respectively. Neither offers a specialization in biomedical imaging. Currently, Clemson and MUSC have a Cooperative Agreement which permits MUSC dental and medical students to pursue joint degree programs, DMD or MD respectively, with a Ph.D. in Bioengineering from Clemson. The courses in this program will be open to students in the joint program.

IV. Readiness of MUSC to support proposed program

The proposed Biomedical Imaging Ph.D. Program builds on the existing College of Graduate Studies (CGS) at MUSC. Its students will be recruited through the CGS and take a substantial fraction of its standard first year course work. The core curriculum proposed will be taught by faculty members of Center for Biomedical Imaging, all of whom have already been recruited and have existing individual research programs able to support the students entering the program. Thus the majority of the resources necessary to create and maintain the program are present. Additional anticipated needs are small and can apparently be rebudgeted without difficulty.

General Comments:

This appears to be an excellent program well suited to the resources available at MUSC. The curriculum is well thought out, taking full advantage of the recently recruited faculty at the Center for Biomedical Imaging as well as other existing faculty who depend on a variety of imaging tools for their research. Given its careful attention to admission criteria and a willingness to provide supplemental courses to bring applicants from the behavioral sciences into the program, it will provide a good basis for the development of scientists with a range of technical and research skills needed in industry and academia in South Carolina and nationwide.

MUSC
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March 6, 2014

Dr. MaryAnn Janosik
Director of Academic Affairs
SC Commission on Higher Education
1122 Lady Street, Suite 300
Columbia, SC 29201

Dear Dr. Janosik:

Please find attached Dr. Paul Sajda's evaluation of the Ph.D. in Biomedical Imaging program we are proposing to develop at MUSC. We chose Dr. Sajda to evaluate our proposed program due to his subspecialized expertise in the imaging track of the biomedical engineering program at Columbia University, New York, NY, where he is a Professor of Biomedical Engineering and Radiology. Dr. Sajda played a key role in developing the graduate curriculum in the imaging track at Columbia University in 2003, and is well suited to evaluate the merits of our proposed biomedical imaging curriculum and speak to the employment opportunities of its graduates. Dr. Sajda's CV is attached.

Based on his considerable experience supervising biomedical engineering graduate students, Dr. Sajda provided us helpful advice regarding the admission criteria for future matriculants at MUSC. He also provided valuable suggestions about the course content and syllabus for our core course in signal processing/image analysis.

I trust you will find the information contained in Dr. Sajda's report helpful in documenting the positive effects the Ph.D. in Biomedical Imaging will have on existing programs at MUSC and that his testament of MUSC's ability to support the program will prove helpful in your review.

Best regards,

Mark S. Sothmann, PhD
Interim President
Vice President for Academic Affairs and Provost

CURRICULUM VITAE

Paul Sajda, B.S., M.S.E., Ph.D.
Professor of Biomedical Engineering, Electrical Engineering and Radiology
Columbia University
351 Engineering Terrace, MC8904, 1210 Amsterdam Avenue, New York, NY 10027
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webpage: http://liinc.bme.columbia.edu

A. Field of Specialization

Neural Engineering: Computational modeling of visual processing, neuroimaging of visual function and decision making, image and signal processing in cluttered and noisy environments, brain computer interfaces which synergistically couple biological and computer vision systems, biological and machine learning.

B. Academic Training

Colleges and Universities Attended

1985-1989 Undergraduate study in Bioelectrical Engineering,
Department of Electrical Engineering and Computer Science
Massachusetts Institute of Technology**,** Cambridge, MA
B.S. in Electrical Engineering
Bachelors Thesis: “Machine Implementation of a Human Motor Task: The Yo-Yo Robot” (Sponsor: Prof. Christopher Atkeson)
Awarded Best Undergraduate Thesis in Electrical Engineering (Adler award)

1989-1994 Doctoral graduate study in Bioengineering and Computational Neuroscience,
Department of Bioengineering
University of Pennsylvania, Philadelphia, PA
M.S.E. in Bioengineering
Ph.D**.** in Bioengineering
Doctoral Thesis: “Reverse Engineering of Intermediate-level Vision: Surface Segmentation and Depth-from-Occlusion" (Thesis Supervisor: Prof. Leif Finkel)
Awarded Best Doctorial Thesis in Bioengineering (Pollack award) and Neuroscience (Flexner award)

Fellowships and Honors

1988 Eta Kappa Nu
1989 David Adler Memorial Thesis Prize for Outstanding Undergraduate Thesis Research in Electrical Engineering, MIT
1989 University Fellow, University of Pennsylvania
1991 Graduate Fellow, Office of Naval Research National Defense Science and Engineering
1993 Louis and Josepha B. Flexner Award for the Outstanding Ph.D. Dissertation in the Neurosciences, University of Pennsylvania
1994 Solomon R. Pollack Award for the Outstanding Ph.D. Dissertation Bioengineering, University of Pennsylvania

1996	Sarnoff Technical Achievement Award for “Computer Aided Diagnosis"
2002	National Science Foundation CAREER Award
2006	Elevated to Senior Member of the IEEE
2008	Awarded Japan Society for the Promotion of Science (JSPS) Fellowship
2009	Elected Fellow of the American Institute for Medical and Biological Engineering (AIMBE)
2011	Elected Editor in Chief of IEEE Transactions on Neural Systems and Rehabilitation Engineering
2012	Elected Fellow of the IEEE
2012	Invited Participant for National Academies Keck’s Future Initiative (NAKFI) “The Informed Brain in a Digital World”

Society Membership

Fellow	American Institute for Medical and Biological Engineering, since 2009
Fellow	Institute of Electrical and Electronic Engineers, since 1994
Member	Engineering in Medicine and Biology Society, since 2000
Member	American Association for the Advancement of Science, since 2000
Member	Association for Research in Vision and Ophthalmology, since 1992
Member	Association for Computing Machinery, since 2010
Member	Society for Neuroscience, since 2002

Offices Held in Professional Societies

Member	Non-voting member of IEEE Administrative Committee (2011-present)
Member	Publications Committee of IEEE EMBS (2011-present)
Member	IEEE Defense & Engineering R&D Committee (2006-2007)
Member	IEEE EMBS Technical Committee on Medical Imaging and Image Processing (2007-present)
Member	IEEE EMBS Technical Committee on Neuroengineering (2008-present)

Editorships of Journals or Other Scholarly Publications

Editor in Chief	IEEE Transactions on Neural Systems and Rehabilitation Engineering (2012-2014)
Assoc. Ed.	IEEE Transactions on Biomedical Engineering, since 2002
Assoc. Ed	IEEE Transactions on Neural Systems and Rehabilitation Engineering
Assoc. Ed	Frontiers in Perceptual Science, since 2009
Assoc. Ed.	IEEE EMBC Annual Meeting Neural Engineering Theme (3 year appt, 2008-2011)
Review Ed.	Frontiers in Decision Sciences, since 2010
Co-Editor	Special issue on “Blind Signal Separation and Deconvolution” in International Journal of Imaging Systems and Technology, 2005
Co-Editor	Special issue on “Brain Computer Interfaces”, IEEE Signal Processing Magazine, January 2008
Co-Editor	Special issue on “Single-trial analyses of behavioural and neuroimaging data in perception and decision-making”, Frontiers in Perceptual Science 2011

Conference Chairmanships and Program Committees

Session Chairman	IEEE Workshop on Neural Networks for Signal Processing, 1997
Co-organizer and Co-chair	Workshop "Directions in Brain-Computer Interface Research", Neural Information Processing Systems 2001, Whistler CANADA
Program Committee	IEEE Workshop on Learning in Computer Vision and Pattern Recognition, 2003
Program Committee	IEEE EMBS Conference on Neural Engineering, 2003 Chair, Biological Control Systems Session
Co-chair	Neural Circuits and Networks Session, IEEE EMBS, 2004
Program Committee	2005 IEEE Workshop on Learning in Computer Vision and Pattern Recognition
Program Committee	2nd International Conference on Neural Engineering, Washington D.C., 2005
Organizing Committee and Theme Chair	2006 IEEE Conference on Engineering in Medicine and Biology, New York
Co-organizer and Co-chair	Workshop on Applied Neural Computing, (August 2006), New York
Program Committee	IAPR Workshop on Cognitive Information Processing (CIP-2008), Santorini Greece
Program Committee	European Signal Processing Conference (EUSIPCO08), Lausanne, Switzerland
Steering Committtee	IEEE EMBS Conference on Neural Engineering, 2009, Antalya, TURKEY
Organizing Committee and Theme Chair	2010 IEEE Conference on Engineering in Medicine and Biology, Buenos Aires ARGENTINA
Program Committee	2011 International Conference on Machine Learning (ICML), Seattle WA
Program Committee	2011 IEEE International Conference on Neural Engineering, Cancun MEXICO
Technical Program co-Chair	2011 IEEE CAS-FEST Workshop on Brain Machine Interfaces, Rio de Janerio, BRAZIL
Organizing Committee	2011 IEEE Conference on Engineering in Medicine and Biology, Boston MA

and Theme Chair	
Co-Organizer	NSF Workshop on Mapping the Brain, Arlington, VA.
Program Committee	2013 IEEE International Conference on Neural Engineering, San Diego, CA

Review Panels

Panelist	NIH Review Panel Member (NCRR, CVP) (2003-Present)
Panelist	NSF Review Panel Member (BES, IIS, CRCNS) (2002-,Present)
Reviewer	Department of Defense (2005)
Reviewer	SERC Singapore (Mar, 2004)
Reviewer	FWF (Austria Science Foundation) Reviewer
Reviewer	Yorkshire Cancer Institute
Reviewer	CCNY University Committee on Research Awards
Reviewer	British MRC (2011)

Publications Reviewed

Annals of Biomedical Engineering, Brain Research, Cerebral Cortex, Computer Vision and Image Understanding, Current Biology, European Conference on Computer Vision, EURASIP Journal of Applied Signal Processing, Frontiers in Decision Sciences, Frontiers in Neuroscience, Frontiers in Perceptual Science, Handbook of Brain Theory and Neural Networks (editor M. Arbib), IEEE Signal Processing Letters, IEEE Transactions on Biomedical Engineering, IEEE Transactions on Medical Imaging, IEEE Transactions on Neural Systems and Rehabilitation Engineering, IEEE Transactions on Neural Networks, IEEE Transaction on Pattern Analysis and Machine Intelligence, IEEE Transactions on Systems, Man and Cybernetics, Journal of Neural Engineering, Journal of the Optical Society of America, Journal of Neurophysiology, Journal of Neuroscience Methods, Journal of Neuroscience, Journal of Vision, Journal of Visual Communication and Image Representation, Neural Network Simulation Environments (editor J. Skrzypek), Neural Computation, Neural Information Processing Systems (NIPS), Neuroscience Letters, Psychophysiology, PLOS Computational Biology, Proceedings of the National Academy of Science (PNAS), Signal Processing Journal, Trends in Cognitive Science, Vision Research

External Invited Seminars, Colloquia & Conference Talks

June 1992	"The NEXUS Neural Simulation Environment", McDonnell Summer Program in Cognitive Neuroscience, Dartmouth, NH
May 1993	"Reverse Engineering of Intermediate-level Vision: Surface Segmentation and Depth-from-Occlusion", Army Research Laboratory, Aberdeen, MD
November 1993	"Surface Segmentation and Depth-from-Occlusion", NEC Research Institute, Princeton, NJ
November 1993	"Reverse Engineering of Intermediate-level Vision: Surface Segmentation and Depth-from-Occlusion", David Sarnoff Research Center, Princeton, NJ
November 1993	"Intermediate-level Vision: Surface Segmentation and Depth-from-Occlusion", Rutgers University, NJ

March 1994	"Intermediate-level Vision: Surface Segmentation and Depth-from Occlusion", Massachusetts Institute of Technology (Media Lab), MA
September 1994	"Construction of illusory Surfaces by Intermediate-level Visual Cortical Networks ", Massachusetts Institute of Technology (Center for Biological and Computational Learning), MA
September 1994	"Data Fusion with a Hierarchical Neural Network", ONR Workshop on Sensor Fusion, Woods Hole, MA
October 1994	"A Hierarchical Image Probability Model for Mammographic Mass Detection", United States Senate, Washington, D.C.
November 1994	"A Hierarchical Image Probability Model for Mammographic Mass Detection", Neural Networks in Medicine, Denver, CO
April 1995	"A Hierarchical Image Probability Model for Mammographic Mass Detection", Rossmann Laboratories, Department of Radiology, Univ. of Chicago, IL
June 1996	"Training Neural Networks for Computer-aided Diagnosis: Experience in the Intelligence Community", United States Congress, Washington, D.C.
April 1997	Training Neural Networks for Computer-aided Diagnosis: Experience in the Intelligence Community", Office of Women's Health (DHHS), Washington, D.C.
July 1997	"Hierarchical Neural Networks for Object Recognition: Applications to Mammographic Computer-aided Diagnosis", Princeton University, NJ
October 1997	"Hierarchical Neural Networks for Object Recognition: Applications to Mammographic Computer-aided Diagnosis, University of Pennsylvania, PA
April 1998	"Neuroscience-inspired Assisted Target Recognition", National Reconnaissance Office, Washington, D.C.
August 1998	"Training Neural Networks for Computer-Aided Diagnosis: Experience in the Intelligence Community", Pacific Medical Technology Symposium, Honolulu, HI
March 1999	"Neurocomputational Models for Exploiting Context in Visual Scene Analysis" SRI, Menlo Park, CA
May 1999	"Hierarchical Neural Networks for Object Recognition: Applications to Mammographic Computer-aided Diagnosis", School of Engineering, Harvard University, MA
December 2000	"Neurocomputational Models for Exploiting Context in Visual Scene Analysis", Biologically-based Computer Vision Invited Workshop, NIMA, Washington, D.C.
September 2002	"A Multi-scale Probabilistic Network Model for Detection, Synthesis and Compression in Mammographic Image Analysis", Department of Radiology, Medical Image Processing Group, University of Pennsylvania
December 2002	"Multi-scale Probabilistic Models of Natural Images Applications to Medical Image Analysis", Siemens Corporate Research, Princeton, NJ
April 2003	"Single-trial Detection of Visual Recognition and Discrimination Events in EEG: Enabling Cognitive Interfaces", Brain Signal Processing Group, RIKEN, JAPAN
April 2003	"Bayesian Network Models for Inferring Intermediate-level Visual Representations" University of Tsukuba, JAPAN
July 2003	"Single-Trial Detection of Visual Recognition and Discrimination Events in EEG: Enabling Cognitive Interfaces "Siemens Corporate Research, Princeton, NJ

August 2003	"Scene Construction and Recognition: A Probabilistic Framework for Integration within and between Cortical Hypercolumns", NIMA Neuroscience Enabled Computer Vision Symposium, Washington, D.C.
August 2003	"Recovery of Constituent Spectra Using Non-negative Matrix Factorization", SPIE Wavelets X, San Diego, CA
September 2003	"Spatial Signatures of Visual Object Recognition Events Learned from Single-trial Analysis of EEG", IEEE Engineering in Medicine and Biology Annual Meeting, Cancun, MEXICO
February 2004	"Mechanisms of Spatial Summation in a Single Layer Spiking Neuron Model of Macaque Striate Cortex", Department of Biomedical Engineering, City College of New York
June 2004	"Single-Trial Detection of Visual Recognition and Discrimination Events in EEG", Departments of Psychology and Cognitive Neuroscience, Princeton University
July 2004	"Mechanisms of Spatial Summation in a Single Layer Spiking Neuron Model of Macaque Striate Cortex", SJTU University, Shanghai CHINA
July 2004	"Blind Recovery of Biochemical Markers of Brain Cancer in MRSI", Sichuan University, Chengdu CHINA
July 2004	"Identifying the Cortical Origins of Response Time Variability: Single-Trial Detection of Visual Recognition and Discrimination Events in EEG", Tsinghau University, Beijing CHINA
September 2004	"Inferring Direction of Figure Using a Recurrent Integrate-and-Fire Neural Circuit", IEEE Engineering in Medicine and Biology Annual Meeting, San Fransisco, CA
October 2004	"Linear Spatial Weighting for Single Trial Discrimination in Electromagnetic Brain Imaging", NIPS Workshop on Brain Computer Interfaces, Whistler & Vancouver CANADA
October 2004	"Single-trial Detection of Visual Recognition and Discrimination Events in EEG", Department of Biomedical Engineering, Oregon Graduate Institute, Portland, OR
October 2004	"Mechanisms of Spatial Summation in a Single Layer Spiking Neuron Model of Macaque Striate Cortex", Neurosciences Institute, Oregon Health Sciences University, Portland, OR
April 2005	"Bayesian Cortical Networks for Contextual Integration", National Geospatial-Intelligence Agency, Washington, D.C.
April 2005	"Single-trial Detection of Visual Recognition and Discrimination Events in EEG and fMRI" Emerging Technologies in Medical Imaging, Istanbul TURKEY
October 2005	"Cortically-coupled Computer Vision", DARPA Neurotechnology for Intelligence Analysis, Washington, D.C.
February 2006	"Single-trial Neuroimaging: Identifying Neural Correlates of Trial-to-Trial Behavioral Variability", Annual Interdisciplinary Conference, Jackson Hole, WY
May 2006	"Cortically-coupled Computer Vision", DARPA Neurotechnology for Intelligence Analysis, Santa Fe, NM
August 2006	"Cortically-coupled Computer Vision", IEEE Workshop on Applied Neural Computing, New York, NY

September 2006	“Contextual Integration in Cortical Networks”, NGA Academic Research Partnership Annual Meeting, National Academy of Sciences, Washington, D.C.
October 2006	“Linear Multivariate Analysis of EEG for Uncovering Neural Signatures of Perceptual Decision Making”, Society for Neuroscience Satellite Workshop on Network Analyses for the Cognitive and Clinical Neurosciences: Surveys and Critiques of fMRI, PET, and MEG/EEG Applications, Atlanta, GA
December 2006	“Cortically-coupled Computer Vision”, Workshop on Current Trends in Brain-Computer Interfacing, Whistler & Vancouver, CANADA
February 2007	“Circuitry & Classification of V1 Simple & Complex Cells”, Annual Interdisciplinary Conference, Jackson Hole, WY
March 2007	"Single-trial Neuroimaging: Identifying Neural Correlates of Trial-to-Trial Behavioral Variability", Department of Biomedical Engineering, University of California, Irvine. Irvine, CA
March 2007	"Single-trial Neuroimaging: Identifying Neural Correlates of Trial-to-Trial Behavioral Variability", Department of Psychology, University of Glasgow, SCOTLAND
April 2007	“Machine Learning for the Detection and Diagnosis of Disease”, New York Academy of Sciences, New York, NY
April 2007	"Single-trial Neuroimaging: Identifying Neural Correlates of Trial-to-Trial Behavioral Variability", Department of Computer Science, University of Hawaii, Honolulu, HI
June 2007	"When Does the Brain Know That a Decision is Difficult to Make?", Human Brain Mapping Symposium on Perceptual Decision Making, Chicago, IL
August 2007	“Spatio-temporal Linear Filters for Decoding Brain State: Application to Performance Augmentation in High-throughput Tasks”, Workshop on Innovation in Computational Approaches for Brain-Machine Interfaces, Inter. Joint. Conf. on Neural Networks, Orlando FL.
August 2007	“Spatio-temporal Linear Filters for Decoding Brain States”, 2nd APCTP Summer School for Brain Dynamics, Daejeon, KOREA
September 2007	“Using EEG and fMRI to Characterize the Cortical Networks Underlying Perceptual Decision Making in the Human Brain”, Ohio State University, Columbus OH.
February 2008	“EEG-Informed fMRI Reveals Spatiotemporal Characteristics of Perceptual Decision Making”, Annual Interdisciplinary Conference, Jackson Hole, WY.
April 2008	“Spatio-temporal Linear Filters for Decoding Brain States” DARPA Workshop on Foundations of Neurally Enabled Human Machine Interfaces, Arlington VA.
May 2008	"Integrating EEG and fMRI for inferring Cortical Networks Underlying Rapid Decision Making", Max Planck Institute, Berlin Germany
July 2008	“Decoding Neural Activity at Multiple Spatial and Temporal Scales: The Science and Engineering of Mind Reading”, Neuromorphic Engineering Workshop, Telluride CO.
July 2008	“Perceptual Decision Making via Sparse Decoding of Neural Activity from a Spiking Neuron Model of V1”, Methods of Information Theory in Computational Neuroscience, Portland OR.
September 2008	"Integrating EEG and fMRI for inferring Cortical Networks Underlying Rapid Decision Making” Center for Mind and Brain Studies, Princeton University, NJ.

September 2008	“Cortical Processing Underlying Rapid Decision Making”, Intelligence Science Board, Washington DC.
September 2008	“A Large-scale Spiking Neuron Model of Visual Cortex as a Substrate for Optimizing Visual Perception”, NGA Academic Research Partnership Annual Meeting, National Academy of Sciences, Washington, D.C.
October 2008	"Integrating EEG and fMRI for inferring Cortical Networks Underlying Rapid Decision Making”, RIKEN-BSI Forum, Tokyo, Japan
October 2008	“Perceptual Decision Making via Sparse Decoding of Neural Activity from a Spiking Neuron Model of V1”, Dept. of Computer Science, Tsukuba University, Japan
November 2008	“Decoding Neural Activity at Multiple Spatial and Temporal Scales: The Science and Engineering of Mind Reading”, Institute of Statistical Mathematics, Tokyo, Japan
April 2009	“Visually-driven Rapid Decision Making: Neuroscientific Findings and Applications to Brain Computer Interfaces”, Schnurmacher Institute for Vision Research Colloquia, SUNY State College of Optometry, New York, NY
June 2009	“Single trial analysis of simultaneously acquired fMRI and EEG”, Bernstein Center for Computation Neuroscience, Berlin, GERMANY
June 2009	“Single trial analysis of simultaneously acquired fMRI and EEG”, Centre for Cognitive Neuroimaging, Glasgow SCOTLAND
February 2010	“Sparse decoding of neurodynamics generated by a large-scale model of V1”, Annual Interdisciplinary Conference, Jackson Hole, WY.
February 2010	“Cortically-coupled Computer Vision”. Invited Keynote Address at 2010 International Conference in Intelligent User Interfaces, Hong Kong CHINA.
May 2010	“Cortically-coupled Computer Vision”. Translational Neuroscience Branch, Army Research Laboratory, Aberdeen, MD.
June 2010	“Finding the Needle in the Haystack with BCI", Invited speaker, Beyond Brain Machine Interface Workshop: From Senses to Cognition, Long Beach, CA.
September 2010	“Working with DARPA as an Academic”, invited keynote speaker at DARPA Young Faculty Award Ceremonies. Arlington VA.
October 2010	“Single-trial Analysis of Simultaneously Acquired fMRI and EEG: A Window Into Latent Brain States”, Psychology Colloquium, Princeton University.
December 2010	“Single-trial Analysis of Simultaneously Acquired fMRI and EEG: A Window Into Latent Brain States”, Bioengineering Seminar Series, University of Pennsylvania
February 2011	“Cortically-Coupled Computer Vision: A Closed-loop BCI for Image Search”, Annual Interdisciplinary Conference, Jackson Hole, WY.
March 2011	“Single-trial Analysis of Simultaneously Acquired fMRI and EEG: A Window Into Latent Brain States”, Biomedical Engineering Seminar Series, University of Minnesota.
June 2011	“Cortically-Coupled Cognitive Navigation”, DARPA BioNav Workshop, Washington DC.
July 2011	“Cortically-Coupled Computing: A Paradigm for Mutually-Derived Situational Awareness “Army Research Laboratory, Aberdeen Maryland.
October 2011	“Cortically-coupled Computer Vision”, ARO Workshop on Decision Making, Evanston, IL.

October 2011	"Single-trial Analysis of Simultaneously Acquired fMRI and EEG: A Window into Latent Brain States", Department of Biomedical Engineering, Johns Hopkins University
June 2012	"Cortically-Coupled Computing for Media Retrieval", Keynote talk at *ACM International Conference on Multimedia Retrieval*, Hong Kong, CHINA
June 2012	"Cortically-Coupled Computing for Image Search", Invited Plenary 2nd Beijing BCI Symposium, Tsinghau University, CHINA.
October 2012	"Cortically-Coupled Computing for Image Search", Bioengineering Seminar Series, Georgia Tech, GA
March 2013	"Using Simultaneous EEG/fMRI to Elucidate the Cortical Networks Underlying Rapid Decision Making and Perceptual Discrimination", Workshop on Multimodal Neuroimaging, Institute for Pure & Applied Mathematics UCLA
June 2013	"Multimodal Neuroimaging of Perceptual Decision Making", Workshop on Neuroimaging Data Analysis, Statistical and Applied Mathematical Sciences Institute, NC.
September 2013	"Neurally and ocularly informed graph-based models for searching 3D environments" Mathematical Biosciences Institute Colloquium, Ohio State University, OH.
November 2013	"Neurally and ocularly informed graph-based models for searching 3D environments" Plenary Speaker, IEEE Neural Engineering Conference, San Diego 2013,

Internal Invited Seminars and Colloquia

April 2001	"Predicting Motor Commands Using Magnetoencephalograhy (MEG)", Neurobiology Seminar Series, Columbia University
February 2002	"Neurocomputational Models for Medical Image Analysis: Capturing Contextual Cues for Improved Classification", Department of Ophthalmology Research Seminar, Columbia University
September 2002	"Linear Spatial Weighting for Single-trial Discrimination in Encephalography", Department of Medical Informatics, Columbia University
October 2002	"Multi-scale Probabilistic Models of Natural Images Applications to Medical Image Analysis", Department of Applied Mathematics, Columbia University
February 2006	"Single-trial Neuroimaging for Identifying Neural Correlates of Trial-to-Trial Behavioral Variability", Sergievsky Center and the Taub Institute, Columbia University
March 2006	"Single-trial Neuroimaging: Identifying Neural Correlates of Trial-to-Trial Behavioral Variability", Department of Psychology, Columbia University
October 2009	"Signal processing challenges for analysis of simultaneously acquired fMRI and EEG", Department of Electrical Engineering, Columbia University
November 2011	"Single-trial Analysis of Simultaneously Acquired fMRI and EEG: A Window into Latent Brain States", New York State Psychiatric Institute
March 2013	"Multimodal Neuroimaging of Perceptual Decision Making", University Seminar, Cognitive and Behavioral Neuroscience

Popular Press

May 1999	“Sensory Licenses Sarnoff Speech Enhancement Algorithms”, EE Times
Oct 1999	“Spies in the Sky vs. Breast Cancer: High Tech Wizards Spotting Tumors Missed by Doctors”, New York Daily News
Dec 2001	“Eyesight to the Blind”, CIO Magazine
Jul 2006	"This Is a Computer on Your Brain", Wired News
Jul 2006	“Man and Machine Vision in Perfect Harmony", New Scientist
Jul 2006	“Subliminal Search”, MIT Technology Review
Aug 2006	“Aha! Someday, image analysis may take place at the speed of thought”, HSToday
Jan 2007	“Brain-Computer Interfaces: Where Human and Machine Meet”, IEEE Computer Magazine
Dec 2007	“Mind-Reading Machines”, Biztech
Apr 2008	“A Brainy Approach to Image Sorting”, IEEE Spectrum
Aug 2008	“Hacking Our Vision System” (video), IEEE Spectrum on-line
Oct 2008	“Brain-machine interfaces charge ahead”, Biosciences Technology
Nov 2008	“The Brain”, History Channel documentary
Feb 2010	“Your Brain’s Search Engine”, Forbes Video Breakout
Nov 2010	“Computers Get Help from the Human Brain”, MIT Technology Review
Dec 2010	“Computer Vision”, Radio Interview, WTOP and National Academy of Engineering
Oct 2011	“Ailment: Too Much InformationCure: Mind-Reading Machines”, Discover Magazine
Nov 2011	“Black Friday, and Happy Christmas Shopping from your neurons!”, Significance Magazine
Mar 2012	BBC Documentary “Out of Control”, highlighted research on brain computer interfaces for image search
Jul 2012	“From Bench to Bunker How a 1960s discovery in neuroscience spawned a military project”, The Chronicle of Higher Education
Mar 2013	“This is Your Brain on Baseball”, Psychology Today
Dec 2013	“The Power of the Unconscious”, BBC World Radio
Dec 2013	“Five Mysteries of the Brain”, BBC News

Research Appointments

1987-1989	Research Assistant, MIT Artificial Intelligence Laboratory, MIT
1989-1994	Research Assistant, Neuroengineering Laboratory, University of Pennsylvania
2000-2012	Associate Professor, Biomedical Engineering and Radiology, Columbia University
2012-present	Professor, Biomedical Engineering and Radiology, Columbia University
2000-present	Director, Laboratory for Intelligent Imaging and Neural Engineering (LIINC), Columbia University
2008-present	Member, Graduate Group, Neurobiology and Behavior, Columbia University
2008	Visiting Scientist, RIKEN Brain Sciences Institute, JAPAN

Departmental and University Committees

2000-2001	Engineering School Library Committee
2000-2005	Biomedical Engineering Imaging Search Committee

2000	Inaugural Symposium Hospitality Committee
2000-2007	Biomedical Engineering Undergraduate Committee
2000-2003	BME Sophomore Advising
2001-2006	Chair, Laboratory Committee
2003	Speaker, SEAS Family Weekend
2003	Speaker, SEAS Engineering Invitationals
2005-2006	Faculty Mediator
2005-2007	Member of University Task Force on Diversity (chaired by Jean Howard and Norma Graham)
2005-2007	DBME ABET Committee
2005-2007	Chair, Undergraduate Curriculum Committee
2006-present	Member DBME Administrative Committee
2007	Chair, BME Faculty Search Committee (Neural Engineering)
2007	Chair, ABET Committee
2008	Member, SEAS Global Development Team
2008	Member Faculty Advisor Committee NWC Science Building
2008	Member Provost Committee on the Future of Science and Engineering at Columbia
2009	University Tenure Ad-hoc
2010	SEAS Tenure Ad-hoc
2011-2012	Chair, Neuroengineering Faculty Search Committee
2013	Co-Director, Center for Neural Engineering and Computation (CNEC)
2013	Executive Committee, Institute for Data Science and Engineering (IDSE)

C. Teaching Experience

Courses Taught

{Number in brackets for Columbia courses is the mean score of the overall instructor evaluation (from 1.0-lowest to 5.0-highest). Scores for individual faculty members are not available for team-taught courses. These courses are identified by [N/A].}

1989	Teaching Assistant for seminar Motor Control and Motor Learning, Massachusetts Institute of Technology
1992	Course Assistant for McDonnell Foundation Summer Institute in Cognitive Neuroscience, Dartmouth Medical School
1992	Teaching Assistant for the Introduction to Bioengineering, University of Pennsylvania
1993	Teaching Assistant for graduate course Computational Neuroscience and Neuroengineering, University of Pennsylvania
2001	Instructor, BMEN E4894, Biomedical Image Analysis (Enrollment 5 students) [4.0]
2001	Instructor, BMEN E6480, Computational Neural Modeling and Neuroengineering (Enrollment 5 students) [5.0]
2001	Director, BMEN E3810, Biomedical Engineering Laboratory I (Enrollment 40 students) [N/A]
2002	Instructor, BMEN E6480, Computational Neural Modeling and Neuroengineering (Enrollment 9 students) [4.5]
2002	Instructor, BMEN E3910, Biomedical Engineering Design (Enrollment 35 students) [4.0]
2002	Section Instructor, BME E3810, Biomedical Engineering Laboratory I

(Enrollment 38 students) [N/A]
2003 Section Instructor, BMEN 6001, Advanced Quantitative Physiology
(Enrollment 34 students) [N/A]
2003 Instructor, BMEN 3910, Biomedical Engineering Design
(Enrollment 39 students) [3.5]
2003 Instructor, BMEN 3820, Quantitative Physiology II
(Enrollment 48 students) [3.8]
2003 Section Instructor, BMEN 6001, Advanced Quantitative Physiology
(Enrollment 42 students) [N/A]
2003 Section Instructor, BME E3810, Biomedical Engineering Laboratory I
(Enrollment 63 students) [N/A]
2004 Instructor, BMEN 3910, Biomedical Engineering Design
(Enrollment 43 students) [4.0]
2004 Instructor, BMEN E6480, Computational Neural Modeling and Neuroengineering
(Enrollment 24 students) [3.9]
2004 Section Instructor, BME E3810, Biomedical Engineering Laboratory I
(Enrollment 72 students) [N/A]
2004 Section Instructor, BMEN 6001, Advanced Quantitative Physiology
(Enrollment 42 students) [N/A]
2005 Instructor, BMEN E3910, Biomedical Engineering Design
(Enrollment 59 students) [4.1]
2005 Instructor, BMEN E4420, Biomedical Signal Processing and Signal Modeling
(Enrollment 17 students) [4.0]
2005 Instructor, BMEN E3910, Biomedical Engineering Design
(Enrollment 69 students) [3.3]
2005 Section Instructor, BMEN 6001, Advanced Quantitative Physiology
(Enrollment 32 students) [N/A]
2005 Section Instructor, BME E3810, Biomedical Engineering Laboratory I
(Enrollment 56 students)
2006 Instructor, BMEN E4420, Biomedical Signal Processing and Signal Modeling
(Enrollment 13 students) [4.6]
2007 Instructor, BMEN E4420, Biomedical Signal Processing and Signal Modeling
(Enrollment 8 students) [4.5]
2007 Instructor, BMEN E6480, Computational Neural Modeling and Neuroengineering
(Enrollment 9 students) [4.4]
2007 Instructor, BMEN E4894, Biomedical Imaging
(Enrollment 22 students) [3.6]
2008 Instructor, BMEN E4420, Biomedical Signal Processing and Signal Modeling
(Enrollment 21 students) [4.1]
2008 Module Instructor BMEN E 3810, Biomedical Engineering Lab 1
(Enrollment 58 students)
2010 Instructor, BMEN E4420, Biomedical Signal Processing and Signal Modeling
(Enrollment 14 students) [4.3]
2010 Instructor, BMEE E6030, Neural Modeling and Neuroengineering
(Enrollment 6 students) [4.7]
2011 Instructor, BMEN E4420, Biomedical Signal Processing and Signal Modeling
(Enrollment 15 students) [3.8]
2011 Instructor: EEBM E6099: Topics in Computational Neuroscience and Neuroengineering: Brain Computer Interfaces

(Enrollment 16 students) [3.7]
2013 Instructor, BMEN E4420, Biomedical Signal Processing and Signal Modeling (Enrollment 26 students) [4.6]
2013 Instructor, BMEE E6030, Neural Modeling and Neuroengineering (Enrollment 5 students) [4.5]
2013 Instructor, BMEN E4420, Biomedical Signal Processing and Signal Modeling (Enrollment 23 students)

Graduate Students and Postdoctoral Fellows Supervised

*Postdoctoral Fellow**s***

- Jim Wielaard, Ph.D. Postdoctoral Fellow (2001-2005). Large-scale conductance based neuronal models of primary visual cortex. Current position: Associate Research Scientist, Columbia University.

- Kyungim Baek, Ph.D. Postdoctoral Fellow (2002-2005). Bayesian models of cortical integration. Current position: Assistant Professor, University of Hawaii.

- Robin Goldman, Ph.D. (2004-2005, co-mentor with T. R. Brown). Simultaneous recordings of fMRI and EEG to assess cognition and perception. Current position: Associate Research Scientist, Columbia University.

- Mads Dyrholm, Ph.D. (2006-2008). Multivariate methods for analysis of EEG and fMRI. Current position: President of Machlea Engineering.

- Eric Pohlmeyer, Ph.D. (2008-2010). Real-time, closed-loop brain computer interfaces for monitoring visual attention. Current position: Postdoctotal Fellow, University of Miami Medical School

- Jason Sherwin, Ph.D. (2010-Present). Situational awareness and the human brain.

- Bryan Conroy, Ph.D. (2010-Present). Mathematical models for fusing simultaneous EEG and fMRI.

Doctoral Students

- Adam Gerson, Ph.D. (Thesis defended June 2006. Ph.D. conferred October 2006.) Currently in Medical School at University of South Florida. Dissertation title: “A System for Single-trial Spatiotemporal Analysis of the Electroencephalogram based on Linear Discrimination”. Masters Thesis: "Unsupervised Unmixing Methods for Brain Signal Analysis".

- Shuyan Du, Ph.D. (Thesis defended June 2006. Ph.D. conferred October 2006) Currently Member of Research Staff, Bristol-Meyers Squibb. Dissertation title: “Machine Learning for Recovering Spectral Signatures of Disease”. Awarded the Michael Merickel Award for Best Student Paper in Medical Imaging. SPIE Medical Imaging Conference (2004).

- Marios Philiastides, Ph.D. (Thesis defended May 2007, conferred October 2007.) Currently Currently Associate Professor, University of Glasgow. Dissertation Title: “Spatiotemporal Characteristics of the Neural Correlates of Perceptual Decision Making in the Human Brain”. (Thesis Awarded Distinction).

- An Luo, Ph.D. (Thesis defended, May 2008, conferred October 2008) Currently Director of Research, Neurosky Inc. Thesis title “Spatio-temporal EEG Analysis for Tracking Brain State during Complex Visual Tasks”

- Xiaowei Li, Ph.D.(Thesis defended May 2007, conferred October 2007). (co-mentor with X.E. Guo) Currently Assistant Professor, UPenn. Thesis title “Topological Modeling of Trabecular Bone Imaged via CT and MRI.”

- Jianing Shi, (Thesis defended February 2010, conferred May 2010). Currently Postdoctoral Fellow, Rice University. Thesis title “Linking Neural Activity with Perceptual Decision Making via Sparse Decoding”

- Jennifer Walz (Candidate May 2012). Simultaneous EEG and fMRI for Characterizing Perceptual Decision Making

- Dave Jangraw (Candidate May 2013). Using TMS to Identify Cortical Networks Involved in Perceptual Decision Making

- Bin Lou (Candidate May 2014). Brain-computer Interfaces for Image Retrieval

- Jordan Muraskin (Candidate 2014). Prospective Active Marker Motion Correction for Increasing Sensitivity in BOLD fMRI,

- Linbi Hong (candidate May 2015): Correlations Between Trial-to-trial Variations in EEG and Pupil Size Reveals Neural Correlates of the Locus Coeruleus.

Masters Students (selected)

- Won-Young (Jason) Lee, May 2008, Perturbing cortical networks underlying perceptual decision making using transcranial magnetic stimulation.

- Sudhin Thomas M.S. May 2005, Image analysis using matrix decompositions (current position: Ph.D. candidate at Cornell).

- Michael Prerau M.S. May 2003, EEG correlates of perfect pitch (current position: Ph.D. candidate at Boston University).

- Feng Han M.S. May 2002, Probabilistic Inference in Visual Salience (current position: Ph.D. candidate at Berkeley).

- Sakellarios Zairis May 2009. Brain Computer Interfaces for Image Triage. (current position: M.D./Ph.D. candidate at Columbia Medical School).

- Atin Saha May 2011: Neural signals of solvable versus unsolvable visual puzzles.

Undergraduate Students Supervised (selected)

- Jeremy Lewi B.S. May 2004, Machine Learning for Visual Processing, *SEAS Valedictorian* (current position: Research Engineer at Intellisis Corporation).

- Gaurav Singal, May 2005, Cue Integration for Visual Tracking (current position: M.D./Ph.D. candidate at Harvard/MIT HST).

- Megan deBettencourt, May 2010, Statistical methods for improving EEG/fMRI sensitivity

Doctoral Dissertation Committees (selected)

- Elsa D. Angelini (Advisor, A. Laine) Quantification of Cardiac Function with Real-time Three-dimensional Ultrasound

- Yinpeng Jin (Advisor, A. Laine) Multi-scale Processing for 3D Tomographic Images

- Dong-Qing Zhang (Advisor: Shih-Fu Chang, EE) Statistical Part-based Model for Object/Scene Detection

- Volodymyr Nikolenko (Advisor: Rafael Yuste, Biological Sciences) Two-photon Uncaging for Inferring Intracortical Connectivity

- Etay Ziv (Administrative Advisor: Paul Sajda; Research Advisor: Chris Wiggens, Applied Physics and Applied Math) Quantitative, Predictive Modeling of Biochemical Networks: A Machine Learning and Information-theoretic Approach

- Ting Song (Advisor: Andrew Laine) Optimization of MR Protocols for Spatial-Temporal Analysis of 4D Dynamic Renal Images

- Sandhitsu Das (Advisor: Leif Finkel, University of Pennsylvania, Dept. of Bioengineering) Cortical Mechanisms for Spatiotemporal Integration and Biological Motion Recognition

- Yingli Yang (Advisor: T.R. Brown, Chair of Thesis Committee: P. Sajda) Sequence Development and Data Processing of Echo Planar Chemical Shift Imaging

- Christoforos Christoforou (Advisors: R. Haralick and L. Parra, CCNY) The Bilinear Brain: Bilinear Methods for EEG Analysis and Brain Computer Interfaces.

- X. Henry Zhang (Advisor: X.E. Guo) High Resolution Imaging Based Patient Specific Biomechanical Assessment of Bone Quality.

- Amin Katouzian (Advisor: A.F. Laine) Quantifying Atherosclerosis: IVUS Imaging For Lumen Border Detection And Plaque Characterization

- Noah Lee (Advisor: A.F. Laine) Synergizing Human-machine Intelligence: Visualizing, Labeling, and Mining the Electronic Health Record

D. Employment Record

1989-1994	Research Assistant, Neuroengineering Laboratory, University of Pennsylvania
1994-1996	Member of Technical Staff, Sarnoff Research Center
1996-1997	Technology Leader, Adaptive Image & Signal Processing, Sarnoff Research Center
1997-2000	Head, Adaptive Image & Signal Processing Group, Sarnoff Research Center
2000-2012	Associate Professor, Biomedical Engineering and Radiology, Columbia University
2012-present	Professor, Biomedical Engineering, Electrical Engineering and Radiology, Columbia University

Patents

4,892,405	Method and apparatus for providing quality assurance and calibration assurance in a spectrophotometer, January 1990
6,018,728,	Method and apparatus for training a neural network to learn hierarchical representations of objects and to detect and classify objects with uncertain training data, January 2000
6,208,983	Method and apparatus for training and operating a neural network for detecting breast cancer, March 2001
6,324,532	Method and apparatus for training a neural network to detect objects in an image, November 2001
6,454,410	Mosaicing and enhancement of images for ophthalmic diagnosis and documentation, September 2002
7,013,283	System and method for providing programming content in response to an audio signal, March 2006
7,835,787	Single trial detection in encephalography, November 2010
Pending	Rapid Image Annotation Via Brain State Decoding And Visual Pattern Mining, File docket no. 070050.3944
Pending	Neural correlates of baseball pitch classification: File docket no. 070050.4745
Pending	Mind Reading Personal Assistant; Col. IR #CU13178; File docket no. 070050.4800

Consulting

2000-2001	Sarnoff Corporation, Princeton, NJ. Worked with technical staff and program managers to develop strategies for commercialization of several medical imaging technologies.
2001-2004	Biofield Corporation, Alpharetta, GA. Assisted with the development and evaluation of pattern classification techniques for a new class of breast cancer diagnostic tool. Assisting in FDA Pre-Market (PMA) Approval Process for the company's products.
2007-present	Neuromatters LLC, New York, NY. Founder and Chairman of the Board. Design and development of Cortically-Coupled Computer Vision systems for multimedia search and retrieval.

E. Publications
Journal Publications

1. **P. Sajda** and L.H. Finkel (1992) NEXUS: A simulation environment for large-scale neural systems. *Simulation*:59(6), pp. 358-364.
2. **P. Sajda** and L.H. Finkel (1992) Simulating biological vision with hybrid neural networks. *Simulation*:59(1), pp. 47-55.
3. L.H. Finkel and **P. Sajda** (1992) Object discrimination based on depth-from-occlusion. *Neural Computation*: 4(6), pp. 901-921.
4. L.H. Finkel and **P. Sajda** (1994) Constructing visual perception. *American Scientist*: 82, pp. 224-237.
5. **P. Sajda** and L. H. Finkel (1995) Intermediate-level visual representations and the construction of surface perception, *Journal of Cognitive Neuroscience* 7(2), pp. 267-291.
6. **P. Sajda**, C. Spence, S. Hsu and J. Pearson (1995) Integrating neural networks with image pyramids to learn target context, *Neural Networks* 8(7/8), pp. 1143-1152.
7. K. Sakai, **P. Sajda**, S.C. Yen and L. Finkel (1997) Coarse-grain parallel computing for very large scale neural simulations in the NEXUS simulation environment, *Computers in Biology and Medicine* 27(4), pp. 257-266.
8. J. Asmuth, B. Madjarov, **P. Sajda** and J. Berger, (2001) Mosaicking and enhancement of slitlamp biomicroscope fundus images, *British Journal of Ophthalmology*, 85, pp. 563-565.
9. L. Parra, C. Alvino, A. Tang, B Pearlmutter, N. Yeung, A. Osman, and **P. Sajda**, (2002) Linear spatial integration for single trial detection in encephelography, *NeuroImage*, 17, pp. 223-230.
10. **P. Sajda**, C. Spence and J. Pearson (2002) Learning contextual relationships in mammograms using a hierarchical pyramid neural network, *IEEE Transactions on Medical Imaging*. 21 (3) pp. 239-250.
11. **P. Sajda**, A. Laine and Y. Zeevi (2002) Multi-resolution and wavelet representations for identifying signatures of disease, *Disease Markers.* invited submission, 18, pp. 339-363.
12. L. Parra and **P. Sajda** (2003) Blind source separation via generalized eigenvalue decomposition*, Journal of Machine Learning Research:* Special issue on ICA, 4(Dec), pp. 1261-1269.
13. L. Parra, C. Spence, A. Gerson and **P. Sajda** (2003). Response error correction: A demonstration of improved human-machine performance using real-time EEG monitoring, *IEEE Transactions on Neural Systems and Rehabilitation Engineering* 11, pp. 173-177.
14. **P. Sajda**, A. Gerson, K-R Mueller, B. Blankertz and L. Parra (2003) A data analysis competition to evaluate machine learning algorithms for use in brain-computer interfaces, *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 11, pp. 184-185.
15. L. Parra, C. Alvino, A. Tang, B. Pearlmutter, N. Yeung, A. Osman, and **P. Sajda**, (2003) Single-trial detection in EEG and MEG: Keeping it linear, *Neurocomputing*. (52-54), pp. 177-183.
16. **P. Sajda**, C. Spence and L. Parra (2003) A multi-scale probabilistic network model for detection, synthesis and compression in mammographic image analysis, (invited submission) *Medical Image Analysis*, 7(2) pp. 187-204.
17. **P. Sajda** and K. Baek (2004) Integration of form and motion within a generative model of visual cortex, (invited submission) *Neural Networks*: Special Issue on Vision and Brain, 17 (5/6) 809-821. Also in *Vision and Brain: How the Brain Sees / New Approaches to Computer Vision*, edited by S. Grossberg, L. Finkel and D. Field. Elsevier, 2004.
18. **P. Sajda**, S. Du, T.R. Brown, R. Stoyanova, D.C. Shungu, X. Mao, and L.C. Parra (2004) Non-negative matrix factorization for rapid recovery of constituent spectra in magnetic

resonance chemical shift imaging of the brain, *IEEE Transactions on Medical Imaging,* 23(12): 1453-1465.
19. K. Baek, and **P. Sajda** (2005) Inferring figure-ground using a recurrent integrate-and-fire neural circuit. *Neural Systems and Rehabilitation Engineering, IEEE Transactions on.* 13 (2), 125 -130.
20. L.C. Parra, C.D. Spence, A.D. Gerson and **P. Sajda** (2005) Recipes for the linear analysis of EEG, *NeuroImage* 28(2): 326-41.
21. A.D. Gerson, L.C. Parra, and **P. Sajda** (2005) Cortical origins of response time variability during rapid discrimination of visual objects, *NeuroImage*. 28(2): 342-53.
22. M.G. Philiastides and **P. Sajda** (2006) Temporal characterization of the neural correlates of perceptual decision making in the human brain, Cerebral Cortex. 16(4): 509-518, Apr. 2006. (cover article)
23. C. Spence, L. Parra and **P. Sajda** (2006) Varying complexity in tree structured distribution models, *IEEE Transactions on Image Processing*, 15(2): 319- 330.
24. A. Luo and **P. Sajda** (2006) Learning discrimination trajectories in EEG sensor space: Application to inferring task difficulty*, Journal of Neural Engineering*, 3(1):L1-L6.
25. M.G. Philiastides, R. Ratcliff and **P. Sajda** (2006) Neural representation of task difficulty and decision making during perceptual categorization: a timing diagram, *Journal of Neuroscience*, 26(35): 8965-75. (cover article)
26. **P. Sajda** (2006) Machine learning for detection and diagnosis of disease, *Annual Review of Biomedical Engineering*, (invited). Vol 8, 537-565.
27. A.D. Gerson, L.C. Parra and **P. Sajda** (2006) Cortically-coupled computer vision for rapid image search, *Neural Systems and Rehabilitation Engineering, IEEE Transactions on.* 14(2) 174-179.
28. J. Wielaard and **P. Sajda** (2006) Circuitry and the classification of simple and complex cells in V1, Journal of Neurophysiology, 96(5) 2739-2749.
29. J. Wielaard and **P. Sajda** (2006) Extraclassical receptive field phenomena & short-range connectivity in V1. *Cerebral Cortex*, published online Dec 22, 2005. vol 16:11, 1531-1545. (cover article)
30. Q. Zhao, R. Stoyanova, S. Du, **P. Sajda**, T.R. Brown (2006) HiRes - A Tool for Comprehensive Assessment and Interpretation of Metabolomic Data, *Bioinformatics* 22:20, 2552-2554.
31. M.G. Philiastides and **P. Sajda** (2006) Causal influences in the human brain during face discrimination: a short-window directed transfer function approach, *IEEE Transactions on Biomedical Engineering*, 53(12), 2602-2605.
32. J. Wielaard and **P. Sajda** (2007) Dependence of response properties on sparse connectivity in a spiking neuron model of the lateral geniculate nucleus, *Journal of Neurophysiology*, 2007 Dec;98(6):3292-308.
33. M.G. Philiastides and **P. Sajda** (2007) EEG-Informed fMRI Reveals Spatiotemporal Characteristics of Perceptual Decision Making, *Journal of Neuroscience*, Nov 28; 27(48):13082-91.
34. S. Du, X. Mao, **P. Sajda** and D. Shungu (2008) Automated Tissue Segmentation and Blind Recovery of 1H MRSI Spectral Patterns of Normal and Diseased Human Brain, *NMR in Biomedicine* Jan;21(1):33-41.
35. L.C. Parra, C. Christoforou, A. D. Gerson, M. Dyrholm, A. Luo, M. Wagner, M. G. Philiastides, **P. Sajda** (2008) Spatio-temporal linear decoding of brain state: Application to performance augmentation in high-throughput tasks, *IEEE Signal Processing Magazine*, vol. 25, no. 1, pp. 95-115.
36. Y. Su, S. Thakur, K. Sasan, S, Du, **P. Sajda**, W, Huang, L.C. Parra, (2008) Spectrum

Separation Resolves Partial Volume Effect of MRSI as Demonstrated on Brain Tumor, *NMR in Biomedicine*, Nov;21(10):1030-42.

37. M. Dyrholm, R. Goldman, **P. Sajda**, T.R. Brown (2009) "Removal of BCG artifacts using a non-Kirchhoffian overcomplete representation", *IEEE Transactions on Biomedical Engineering*, 56(2): 200-204.
38. A. Luo and **P. Sajda** (2009) Comparing neural correlates of visual target detection in serial visual presentations having different temporal correlations. *Front. Hum. Neurosci.* 3:5. Epub 2009 Apr 21
39. R. Ratcliff, M.G. Philiastides , **P. Sajda**, (2009). Quality of Evidence for Perceptual Decision Making is Indexed by Trial-to-Trial Variability of the EEG. *Proceedings of the National Academy of Sciences*, 106(16):6539-44
40. R.I. Goldman, C-Y Wei, M.G. Philiastides, A.D. Gerson, D. Friedman, T.R. Brown, **P. Sajda** (2009) Single-trial discrimination for integrating simultaneous EEG and fMRI: Identifying cortical areas contributing to trial-to-trial variability in the auditory oddball task, *Neuroimage*, Aug 1;47(1):136-47
41. **P. Sajda**, M. G. Philiastides, L. C. Parra (2009) Single-trial Analysis of Neuroimaging Data: Inferring Neural Networks Underlying Perceptual, Decision Making in the Human Brain, *IEEE Reviews In Biomedical Engineering*, (invited) Vol 2, 97-109.
42. C. Christoforou, R. Haralick, **P. Sajda**, L. C. Parra (2010) Second-Order Bilinear Discriminant Analysis, *Journal of Machine Learning Research*, 11(Feb):665–685.
43. **P. Sajda**, L.C. Parra, C. Christoforou, B. Hanna, C. Bahlmann, J. Wang, E. Pohlmeyer, J. Dmochowski, -Fu Chang (2010) In a Blink of an Eye and a Switch of a Transistor: Cortically-coupled Computer Vision", *Proceedings of the IEEE* vol 98(3): 462-478.
44. J. Shi, W. Yin, S. Osher and **P. Sajda** (2010) A Fast Hybrid Algorithm for Large Scale l1-Regularized Logistic Regression, *Journal of Machine Learning Research*, 11(Feb):713–741.
45. J. Dmochoski, **P. Sajda**, L.C. Parra (2010) Weighted Maximum Likelihood is a Nearly Optimal Solution to the Cost-Sensitive Learning Problem, *Journal of Machine Learning Research*, vol. 11: 3313-3332.
46. E.A. Pohlmeyer, J. Wang, D.C. Jangraw, B. Lou, S-F Chang and **P. Sajda** (2011) Closing the loop in cortically-coupled computer vision: a BCI for searching image databases, *Journal of Neural Engineering* 8: 036025
47. M. deBettencourt, R.I. Goldman, T.R. Brown and **P.Sajda** (2011) Adaptive Thresholding for Improving Sensitivity in Single-Trial Simultaneous EEG/fMRI, *Front. Psychology* 2:91. doi: 10.3389/fpsyg.2011.00091
48. C.R. Pernet, **P. Sajda** and G.A. Rousselet (2011) Single-trial analyses: why bother? *Frontiers in Psychology*: 2 (00322) doi: 10.3389/fpsyg.2011.00322
49. J.V. Shi, J. Wielaard, R.T. Smith and **P. Sajda** (2011) Decoding of simulated neurodynamics predicts the perceptual consequences of age-related macular degeneration, *Journal of Vision*. Dec 5;11(14):4. doi: 10.1167/11.14.4.
50. J.P. Dmochowski, **P. Sajda**, J. Dias Joao and L.C. Parra (2012) Components of ongoing EEG with high correlation point to emotionally-laden attention -- a possible marker of engagement? *Frontiers in Human Neuroscience,* 6 (00112), doi: 10.3389/fnhum.2012.00112
51. **P. Sajda** (2012) Neural correlates of the time course of the waxing and waning of attention *Front Psychol*. 2012;3:377. doi: 10.3389/fpsyg.2012.00377.
52. M. Worring, **P. Sajda**, S. Santini, D.A. Shamma, A.F. Smeaton and Q. Yang (2012) Where Is the User in Multimedia Retrieval? *MultiMedia, IEEE* 19(4): 6-10
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63. J. Shi, J. Wielaard and **P. Sajda** (2009) Modeling attention via conductance changes in LGN and primary visual cortex, *Society for Neuroscience Annual Meeting, Chicago IL, Oct 17-22.* Abstract#804.6
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68. J Shi, J Wielaard, RT Smith and **P Sajda** (2010) A modeling approach for assessing the cortical and perceptual consequences of age-related macular degeneration *Society for Neuroscience, 37th Annual Meeting, San Diego CA, Nov 13-17,* 393.5/III16
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81. B. Lou, Y. Li, J.M. Walz, and **P. Sajda** (2012) "Post-stimulus Trial-by-trial EEG Variability Indexes Mean and Variance of Pre-stimulus α Power," *18th Annual Meeting of the Organization for Human Brain Mapping*, June 10-14, Beijing, China. # 1080
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85. Y. Li, B. Lou, X. Gao and **P. Sajda** (2012) Exogenous oscillations index task difficulty in perceptual decisions, *Society for Neuroscience, 39th Annual Meeting, New Orleans LA, Oct 13-17,* 494.08/CCC25
86. J.S. Sherwin, J. Muraskin and **P. Sajda** (2012) Neural signatures of rapid recognition of a baseball pitch: Spatio-temporal evidence accumulation under time pressure, *Society for Neuroscience, 39th Annual Meeting, New Orleans LA, Oct 13-17,*804.02/CCC73
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90. B. Conroy, J, Walz and **P. Sajda** (2012) Fast Simultaneous Training of Generalized Linear Models (FaSTGLZ) for Multi-voxel Pattern Analysis in fMRI*, 2nd NIPS 2012 Workshop on Machine Learning and Interpretation in NeuroImaging (MLINI 2012).*
91. J.M. Walz, M. Carapezza, B. Lou, R.I. Goldman, T.R. Brown and **P. Sajda** (2013) Variability in distribution of fMRI BOLD response linked to prestimulus alpha power in simultaneously acquired EEG**.***, ISMRM 2013*, Salt Lake City, UT, #0756
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94. B. Conroy, J.M. Walz and P. Sajda (2013) Fast validation testing of sparse classification and regression models for multi-voxel fMRI analysis *Annual Meeting of the Organization for Human Brain Mapping,* Seattle, WA, #1644
95. B. Luber, D. Jangraw, A. Harrison, **P. Sajda**, S.H Lisanby (2013) Using Transcranial Magnetic Stimulation to Elucidate Interactions Between Top-Down and Bottom-up Brain Networks in Visual Decision Making, Annual Cog. Neuro Meet. *J. Cog. Neuro (Suppl)* , p 206.

Publications outside primary research area

1. X.E. Guo, L. Wei, **P. Sajda** and A.F. Laine (2003) New finite element modeling technique of trabecular bone based on digital topological analysis. In *Medical Imaging 2003: Image Processing*, Kenneth M. Hanson, Editor, Proceedings of SPIE Vol. 5032
2. L. Wei, **P. Sajda**, A.F. Laine, X.E. Guo (2003) A novel approach to model trabecular bone using topological image analysis, *49th Annual Meeting of the Orthopaedic Research Society.*
3. X.S. Liu, **P. Sajda**, P.K. Saha, F. Wehrli and X.E. Guo (2004) Skeleton micro-architecture predicts elastic modulus of trabecular bone*, 2004 BMES Annual Meeting*, Abstract# 447.
4. X.S. Liu, P.K. Saha, F. Wehrli, **P. Sajda**, X.E, Guo (2005) Contribution of micro-architecture to the elastic modulus of trabecular bone. *Transactions of the 51th Annual Meeting of the Orthopaedic Research Society*, Washington, D.C., February 20-23, Abstract #192.
5. X.S. Liu**, P. Sajda**, P.K. Saha, F. Wehrli and X.E. Guo (2005) A 3D morphological analysis based on individual trabeculae segmentation for human trabecular bone*, Biomedical Engineering Society Annual Meeting*, Baltimore, MD, September 28-October 1, Abstract# 952.
6. X.S. Liu, A.H. Huang, **P. Sajda**, X.E. Guo (2006) Simulating 3D architectural and mechanical changes in human trabecular bone during menopause, *Transactions of the 51st Annual Meeting of the Orthopaedic Research Society*, Chicago, IL March 19-22.
7. X.S. Liu, **P. Sajda**, P.K. Saha, F.W. Wehrli, X.E. Guo (2006) A 3D morphological analysis of trabecular bone based on individual trabeculae segmentation, *Transactions of the 51st Annual Meeting of the Orthopaedic Research Society*, Chicago, IL March 19-22, 2006

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9. X.S. Liu, A.H. Huang, **P. Sajda**, X.E. Guo (2006) Realistic simulation of 3D architectural and mechanical alterations in human trabecular bone during menopause, *ASME Summer Bioengineering Conference*, Amelia Island, FL, June 22-26.
10. X.S. Liu, A. Gupta, G. Bevill, **P. Sajda**, K.M. Keaveny, X.E. Guo (2006) Micromechanical analysis of human vertebral trabecular bone at individual trabecula level, *ASME Summer Bioengineering Conference*, Amelia Island, FL, June 22-26, 2006.
11. X.S. Liu, **P. Sajda**, P.K Saha, F.W Wehrli, X.E. Guo (2006) Quantification of the roles of trabecular micro-architecture and trabecular type in determining the elastic modulus of human trabecular bone, *Journal of Bone and Mineral Research,* 21(10) 1608-1617.
12. X.S. Liu, A.H. Huang, **P. Sajda**, X.E. Guo (2006) Realistic simulation of 3D architectural and mechanical alterations in human trabecular bone during menopause, 5th World Congress of Biomechanics, Munich GERMANY, July 29-August 4, 2006.
13. X.E. Guo, X.S. Liu**, P. Sajda** (2006) Simulation of 3D architectural and mechanical changes in human trabecular bone during menopause, *2006 Biomedical Engineering Society Annual Meeting*, Chicago, IL, October 11-14, 2006.
14. X.S. Liu, **P. Sajda**, X.E. Guo (2006) Simulating microstructural and mineralization changes during the treatment of postmenopausal osteoporosis by bisphosphonate, *53rd Annual Meeting of the Orthopaedic Research Society*, San Diego, CA, February 11-14, 2007.
15. X.H. Zhang, X.S. Liu, **P. Sajda**, P.K. Saha, F.W. Wehrli, X.E. Guo (2007) Roles of trabecular rods in determining elastic moduli of human vertebral trabecular bone, *53rd Annual Meeting of the Orthopaedic Research Society*, San Diego, CA, February 11-14, 2007.
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20. X.S. Liu, X.H. Zhang, C.S. Rajapakse, M.J. Wald, J. Magland, K.K. Sekhon, M.F. Adam, **P.Sajda**, F.W. Wehrli, X.E. Guo (2010) Accuracy of high-resolution in vivo micro magnetic resonance imaging for measurements of microstructural and mechanical properties of human distal tibial bone, *J. Bone Miner Res.* 25(9):2039-50
21. D. Jing, X.L. Lu, E. Luo, **P. Sajda**, P.L. Leong, X.E. Guo (2013) Spatiotemporal properties of intracellular calcium signaling in osteocytic and osteoblastic cell networks under fluid flow, *Bone*, 53(2) 531-540

F. Research Grants and Contracts Awarded

Active Grants

Those in which Principal Investigator or co-Principal Investigator

Title	Sponsor/Agency	Amount (total cost)	Dates
Multimodal Neuroimaging for Mapping Decision Making in the Human Brain R01- MH085092-01A1 (Sajda, PI)	NIH/NIMH	$1,772,320	8/09-7/14
Cortical Networks Underlying Rapid Decision Making W911NF-11-1-0219 PI: P. Sajda	Army Research Office (ARO)	$591,325	5/11-6/14
Constructing Mutually-derived Situational Awareness via EEG –Informed Graph-based Transductive Inference Under prime contract W911NF-10-2-0022 PI: P. Sajda	Army Research Laboratory (ARL)	$345,784	5/11-9/14
Image Database and Neuroimaging Data Collection for Rapid Visual Decision Making Co-PIs: P. Sajda and S-F Chang	Army Research Laboratory (ARL)	$544,000	6/12-9/14

Those in which co-Investigator

Hyperspectral Imaging of the Normal and Age-related Macular Degeneration Fundus PI: PI: R.T. Smith, Co-I: P. Sajda	NIH/NEI	$4,000,000 (Sajda share: $150K)	4/11-3/15

Training Grants and Conference Grants

Title	Agency	Amount	Dates
Columbia University Vision Training Grant 5T32EY013933-09 (Mason, PI; Sajda, Mentor)	NIH/NEI	$2,500,000	01-present
Core Support for Vision Research 1P30EY019007-01A2 Goldberg, PI; Sajda, Co-I	NIH/NEI	$4,000,000	7/10-6/15

Past Grants

Cortically-Coupled Computer Vision Phase 3 N10PC20050 (Sajda, PI)	DARPA[1]	$1,668,763	2/10-1/12
A Large-Scale Spiking Neuron Model of Visual Cortex as a Substrate for Optimizing Visual Perception HM1582-07-1-2002 (Sajda, PI)	NGA	$513,627	3/07-10/10
Cortically-Coupled Computer Vision Phase 2 NBCHC080029 (Sajda, PI)	DARPA[1]	$2,885,252	10/07-04/10
A Non-invasive Single-trial In Vivo Neuroimaging System (R21/R33 EB004730) (Sajda, PI)	NIH/NIBIB[2]	$1,470,000	8/04-7/09
Biomedical Image Engineering of Macular Images 1R01EY015520-01A2 (Smith, PI; Sajda, Co-I)	NIH/NEI	$2,551,292	9/05-9/10
Implicit Learning In Osteocyte Network Under Mechanical Loading 1RC1AR058453-01 (Guo, PI: Sajda, Co-I)	NIH/NIAMS	$1,000,000	9/9-8/11
Micro-Mechanical Modeling of Trabecular Bone 1R01AR051376-01A1 (Guo, PI: Sajda, Co-I)	NIH/NIAMS	$2,265,826	5/06-5/11
Cortically-Coupled Computer Vision HM1582-05-C-0043 (Sajda, PI)	DARPA[3]/NGA	$1,064,288	10/05-9/07

[1] DARPA: Defense Advanced Project Agency
[2] NIH/NIBIB: National Institutes of Health/National Institute for Biomedical Imaging and Bioengineering
[3] DARPA: Defense Advanced Project Agency

Workshop on Hybrid Neuro-Computer Vision Systems IIS- 0958402 Chang and Sajda (co-PIs)	NSF	$50,000	10/09-7/10
CAREER: Probabilistic Models for Integrating Biochemical and Morphological Markers for Cancer (BES-01-3380) (Sajda, PI)	NSF[4]	$367,257	6/02-5/07
Bayesian Cortical Networks for Contextual Integration HM1582-05-C-0008 (Sajda, PI)	NGA[5]	$977,000	10/04-9/07
Bayesian Hypercolumns for Intelligent Image Analysis (N00014-01-1-0625) (Sajda, Co-PI)	ONR/MURI	$917,010	5/01-4/07
Metabolic Patterns in 1H NMR Spectra of Biofluids, R33 (DK070301-01) (Brown, PI. Sajda, Co-PI)	NIH/NIDDK	$1,900,000	9/04-7/08
Augmented Visual Search with Real-Time EEG Analysis *(Sajda, PI)*	DARPA	$174,000	5/03-12/04
Scene Construction and Recognition: A Probabilistic Framework for Integration Within and Between Cortical Hypercolumns (NMA201-02-C-0012) (*Sajda, PI*)	NIMA	$313,375	10/01-10/04
Neural Models for Perceptual Salience for Augmented Cognition (#4900000156) (*Sajda, PI*)	DARPA	$22,926	3/03-12/03
Adaptive Brain-Computer Interfaces for Augmented Cognition and Action (*Sajda, Co-PI*)	DARPA	$325,151	4/02-12/03
Development of an MEG	NIMA/Sarnoff	$75,498	9/00-6/01

[4] NSF: National Science Foundation
[5] NGA: National Geospatial-Intelligence Agency

Brain-Computer Interface (*Sajda, PI*)			
Information Theory for Computer-Aided Diagnosis (DAMD17-98-1-8061) (*Sajda, PI*)	U.S. Army Medical Command	$475,000	8/98-8/01
Medical Technology Transfer and Development (*Sajda, PI*)	NIMA/DARPA	$2,000,000	3/00-7/01
Perceptually Optimized Workstation for Image Analysts (*Sajda, PI*)	NIMA	$275,000	8/99-7/00
Neuroscience Inspired Image Analysis (*Sajda, PI*)	NIMA	$300,000	4/98-6/99
Pattern Analysis Algorithms for Breast Cancer Detection (*Sajda, PI*)	Biofield Corporation	$750,000	6/97-2/99
Breast Cancer Technology Transfer (*Sajda, Co-PI*)	NRO[6]	$1,000,000	10/96-12/98
Clinical Evaluation of Intelligence Community Computer-Aided Diagnosis Technologies (DHHS no. 282-96-0026) (*Sajda, Co-PI*)	DHHS[7]	$150,000	9/96-12/98

[6] NRO: National Reconnaissance Office
[7] DHHS: Department of Health and Human Services (DHHS)