Curriculum Vitae

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Name

Yogesh Rathi

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Education

1992-1997	B.E	Electrical and Electronics Engineering	Birla Institute of Technology and Science, Pilani, India
1992-1997	M.Sc.	Mathematics	Birla Institute of Technology and Science, Pilani, India. (Dual-Degree Program)
2003-2006	Ph.D.	Electrical and Computer Engineering (ECE) Advisor: Prof. Allen Tannenbaum	Georgia Institute of Technology, Atlanta, GA

Postdoctoral Training

2006-2007	Research Scientist	Computer Vision Advisor: Allen Tannenbaum	Georgia Institute of Technology, Atlanta, GA
2007-2008	Research Fellow	Medical Image Analysis Advisor: M. E. Shenton	Brigham and Women's Hospital, Boston, MA

Faculty Academic Appointments

2008-2010	Instructor, Department of of Psychiatry	Harvard Medical School
2009-2016	Adjunct Assistant Professor, Department of ECE	Georgia Institute of Technology
2010-2016	Assistant Professor, Department of Psychiatry	Harvard Medical School
2016-present	Associate Professor, Department of Psychiatry and Radiology	Harvard Medical School

Appointments at Hospital/Affiliated Institutions

2007- present	Research Associate	Psychiatry Neuroimaging Laboratory, Department of Psychiatry, Brigham and Women's Hospital
2009- 2020	Research Associate	Laboratory of Neuroscience, Clinical Neuroscience Division, VA Boston Healthcare System, Brockton, MA
2015-present	Research Staff	Massachusetts General Hospital

Other Professional Positions

1997-1999	Research Engineer	Scientific Systems Inc
1999-2003	Software Engineer	Teradyne Inc
2006-2007	Scientific Research Consultant	MZA Associates

Major Administrative Leadership Positions

Local:

2012-present	Director for Image Computing	Brigham and Women's Hospital, Harvard Medical School

National and International:

2014	Challenge Organizer	Organized SPARC dMRI challenge at MICCAI, Boston, USA
2014	Workshop Organizer	Workshop on Computational diffusion MRI, Boston, USA
2015	Workshop Organizer	Workshop on Computational diffusion MRI, Munich, Germany
2016	Workshop Organizer	Workshop on Computational diffusion MRI, Athens, Greece
2020	Symposium Organizer	Symposium on MRI data harmonization, SOBP, New York, USA

Committee Service

Regional:

2021 Thesis Committee Member, Boston University

National:

2020 Thesis Committee Member, New York University

International:

2021 Thesis Committee Member, Indian Institute of Technology, Mumbai, India

Professional Societies

Institute of Electrical and Electronics Engineers (IEEE):

2005-2008	Member
2008	Program Committee member for workshop on Tensor Processing in Computer Vision

Medical Image Computing and Computer Assisted Intervention (MICCAI):

2007- present	Member
2012-2013	Session Chair for Diffusion Weighted Imaging
2012-2013	Program Committee member for workshop on Computational diffusion MRI

International society of Magnetic Resonance in Medicine (ISMRM):

2010-present	Member
2013	Diffusion Study Group Presenter

Grant Review Activities

2008	NSF Career Award	National Science Foundation (NSF) Ad-hoc member
2008	Proposal Evaluation	Army Research Office (ARO) Ad-hoc member
2014	Proposal Reviewer	Natural Sciences and Engineering Research Council of Canada (NSERC) Ad-hoc member
2017-2021	Grant Reviewer	National Institute of Health (NIH) Ad-hoc member

Editorial Activities

	Reviewer
2005-present	Medical Image Analysis
	IEEE Transactions on Medical Imaging
	IEEE Transactions on Information Technology in Biomedicine
	IEEE Transactions on Pattern Analysis and Machine Intelligence
	Pattern Recognition Letters
	SIAM Journal of Applied Mathematics
	International Conference on Medical Image Computing and Computer-Assisted Intervention
	IEEE Conference on Computer Vision and Pattern Recognition
	IEEE Transactions on Image Processing
	International Journal for Computer Vision
	Neuroimage
	Human Brain Mapping
	Associate Editor
2015- present	Frontiers In Neuroscience, Brain Imaging Methods

Honors and Prizes

1992-1997	BITS Institute Fellowship	Birla Institute of Technology and Science (BITS)
1996	Motorola Best Student Thesis Award	Joint award by Motorola and BITS
2007	O. Hugo Schuck Best Paper Award	American Automatic Control Council.
2009	Winner of Best Tractography algorithm	Fiber Cup Competition held with MICCAI 2009.
2012	NIMH's list of the "new and notable"	`http://tinyurl.com/ou6zngc`
2013	Selected to be in Harvard Medical School's "Leadership program"	
2015	Best ISMRM Abstract	ISMRM Diffusion Study Group
2019	Best Harmonization Algorithm	MUSHAC challenge
2019	Pillar award in Excellence	Brigham and Women's Hospital, Boston

Report of Funded and Unfunded Projects

Funding Information

Past

2007-2012 Investigator - NIMH P50MH080272
Vulnerability to progression in Schizophrenia.
Imaging core PI: Martha E. Shenton
The goal was to study subjects who are at various stages of progression of schizophernia - prodromal, first episode and chronic, giving us a large database on phenotypic markers and predictors of progression.

2008-2009 **Principal Investigator** - Partners Information Systems Research Council
Real-time registration of multi-modality images using graphics processor unit (GPU)
PI: **Yogesh Rathi**
The main goal of this project was to develop algorithms using CUDA language and use the GPU for real-time registration of images (affine and non-rigid) for use in the clinical workflow.

2009-2014 Investigator - VA Merit
White matter analyses in schizophrenia
PI: Martha E. Shenton
The goal of this project is to evaluate the changes in white matter diffusion measures affected in schizophrenia.

2009-2014 Investigator - VA Merit
Disease progression in schizophrenia
PI: Robert McCarley, Core PI: Martha Shenton
This project is focussed on looking at the progression of disease at various stages for various sub-types.

2009-2014 Investigator - NIMH R01 MH 082918
Computational Morphometry in Schizophrenia and Related Disorders
PI: Sylvain Bouix
The goal of the project is to develop, evaluate and apply novel computational tools for the purpose of understanding morphometric changes in neuroanatomical structures related to schizophrenia.

2012-2012 **Principal Investigator** - Bridge Funding from Brigham and Women's Hospital
Taking advanced diffusion imaging to the clinic
PI : **Yogesh Rathi**
The project involved development of compressed sensing techniques to accelerate acquisition of diffusion MRI scans.

2014-2015 **Principal Investigator** - INTRuST (DoD) Grant - W81XWH-08-2-0159
Harmonizing diffusion MRI data from multiple scanners
PI: **Yogesh Rathi**
The goal of this project is to harmonize the diffusion MRI data acquired from several MR scanners so that all subjects can be analyzed together to increase statistical power.

2012-2017 **Principal Investigator** - NIMH R01 MH097979
Taking advanced diffusion imaging to the clinic for pediatric patients with ADHD
PI: **Yogesh Rathi**
Total Direct Cost - $1.25M
The goal of this grant is to use compressed sensing based techniques for designing fast diffusion imaging techniques for applying it to study brain structure and function in ADHD.

Past

2012-2017 Investigator - NIMH R01 MH 074794
Novel DT-MRI analyses of white matter in schizophrenia
PI: C-F Westin
Total Direct Cost - $1.75M
This grant is focussed on developing new gradient acquisition schemes for imaging brain tissue microstructure not accessible with standard techniques.

2015-2017 **PI** - NIH, Supplement to R01MH097979
Fast perfusion imaging and analysis in ADHD
PI: **Yogesh Rathi**
Total Direct Cost: $120K
The goal is develop fast perfusion imaging technique for estimating cerebral blood flow and volume in ADHD

2018-2018 **PI: Yogesh Rathi** - GIAN - Teach in India
Total Direct Cost - $7K
Medical Image Processing: Advanced machine learning and MRI applications
The goal of this project is to teach a 5-day, 24 hour course to students in India at IIT Bombay.

2016-2019 Key Personnel - NIH, Supplement - R01MH 102377S1
Harmonizing diffusion MRI data from multiple scanners with different acquisition parameters
PI: Marek Kubicki
Total Direct Cost - $255K
The goal of this project is to harmonize the diffusion MRI data acquired from several MR scanners with varying acquisition parameters.

2016-2018 Investigator - NIH - R03MH111320
Computational Modeling of Deep Brain Stimulation of the Ventral Striatum
PI: Alik Widge
Total Direct Cost - $100K
The goal of this project is to fuse the standard computational modeling approach with multi-tensor tractography approach for better targeting of DBS.

2013-2018 Investigator - NIH R01 AG042512
Neural substrates of diffusion imaging in cognitively aging rhesus monkeys
PI: Marek Kubicki And Nikos Makris
Total Direct Cost - $1.1M
The goal is to study the relation between diffusion MRI based and histology based markers of aging in rhesus monkeys.

2017-2019 Site PI - NIH R21HD090549
Multi-modal neuroimaging in children with congenital hemiplegia
PI: Dr. Papadelis
Total Direct Cost - $264K
The goal is to use advanced tractography algorithm to study motor tracts in congenital hemiplegia.

2014-2019 Investigator - NIH R01MH 102377
Diffusion Imaging Biomarkers for Risk, Onset and Outcome in Schizophrenia
PI: Marek Kubicki
Total Direct Cost - $1.1M
The main goals of this project is to use diffusion MRI, along with the newest MRI acquisition and analysis methods, and to a apply them to study schizophrenia.

2017-2019 Investigator - NIH R21MH 102377
Personalized target selection for TMS therapy using functional vs. structural connectivity MRI
PI: Lipeng Ning
Total Direct Cost - $250K
The main goals of this project are to quantify and compare the reliability of current methods to identify cortical

2018-2020 Investigator - NIH R21MH116352
Multimodal brain-connectivity biomarkers for profiling heterogeneity in early psychosis
PI: Lipeng Ning
Total Direct Cost - $250K
The main goals of this project is to use diffusion MRI and functional MRI, to understand psychosis.

Current

2017-2022 **MPI: Daugherty, Rathi, Makris** - NIH - R01MH111917
Total Direct Cost - $2.148M
Patient-specific, Effective and Rational Connectivity Targeting for DBS in OCD
The goal of this project is to develop better tools to determine the best set of white matter fibers to stimulate in severe OCD patients using DBS.

2018-2023 **MPI: Setsompop, Rathi** - NIH - R01MH116173
Total Direct Cost - $2.5M
Fast diffusion imaging of brain microstructure at the submillimeter resolution
The goal of this project is to develop advanced and fast ultra-high resolution diffusion imaging protocol and reconstruction algorithms.

2019-2024 **MPI: Rathi, O'Donnell** - NIH - R01MH119222
Total Direct Cost - $2.5M
Harmonizing diffusion MRI data sets across the lifespan and brain disorders
The goal of this project is to harmonize diffusion MRI data sets across scanners and create an anatomical atlas of the brain.

2019-2024 **Site-PI: Rathi** - NIH - R01HD100009
Total Direct Cost - $2.5M
PI: Grant
Novel MRI Assessment of Placental Structure and Function Throughout Pregnancy
The goal is to develop MRI measures that can inform about abnormalities in the placenta.

2019-2024 **Core Co-PI: Rathi** - NIH P41 EB015902
Neuroimage Analysis Center (NAC)
PIs: Ron Kikinis, C-F Westin
Total Direct Cost - $3.75M
The goal of the "algorithm core" is to develop new algorithms for multidimensional MRI data and apply it to study diseases like brain tumors.

2019-2024 Investigator: Rathi - NIH R01 HD100009
Total Direct Cost - $2.5M
PIs: Grant, Robinson
Novel MRI Assessment of Placental Structure and Function Throughout Pregnancy
The goal of this project is to use dMRI for estimating placental blood flow and volume.

2019-2021 Investigator: Rathi - NIH R21 MH121704
Total Direct Cost - $250K
PI: Levitt
The Brain Wiring of Fronto-Striatal Connections in Early Psychosis
The goal of this project is to use tractography to determine fronto-striatal abnormalities.

2021-2026 **MPI: O'Donnell, Rathi** - NIH R01MH125860
Total Direct Cost - $2.5M
Mapping the SWM connectome of the human brain using ultra high resolution multi-contrast diffusion MRI
The goal of this project is to create a connectome of the superficial white matter of the human brain.

2021-2022 **Site-PI: Rathi** - DoD
Total Direct Cost - $192K
PI: Elizabeth Wilde, University of Utah
Harmonizing dMRI data from the CENC project
The goal of this project is to harmonize the data acquired from multiple scanners.

2021-2023 Investigator: Rathi - NIH R21 MH126396
Total Direct Cost - $250K
PI: Ning
Real-time visualization and precision targeting in transcranial magnetic stimulation
The goal of this project is to develop tools for real-time visualization of TMS field.

2020-2025 Investigator: Rathi - NIH - U24MH124629
Total Direct Cost - $3.24M
PIs: Shenton, Kahn
Psychosis Risk Evaluation, Data Integration and Computational Technologies (PREDICT): Data Processing, Analysis, and Coordination Center
The goal of this project is the determine biomarkers of early psychosis.

Training Grants and Mentored Trainee Grants:

2018-2023 PI: Makris, K24MH116366
Advisor
Mentoring and neuroimaging research on new targets for DBS in OCD
The goal of this project is to determine new targets for deep brain stimulation in OCD.

2017-2022 PI: Kubicki, K24MH110807
Advisor
Mentoring and Neuroimaging Research on White Matter Pathology in Schizophrenia
The goal of this project is to determine new markers of pathology in schizophrenia.

2019-2024 PI: Ning, K01MH117346
Mentor
Joint structural-and-functional MRI analysis for predicting electroconvulsive therapy response in major depressive
The goal of this project is to determine markers of major depressive disorder.

Report of Local Teaching and Training

Teaching of Students in Courses

Birla Institute of Technology and Science

1997 *Cicuits and Systems*
Undergraduate level, Teaching Assistant, 3hrs per wk for 16 wks

Georgia Institute of Technology

2006-2007 *Problem based learning*
Undergraduate level, Guest Lecturer, 2hrs per wk for 6 wks

2006-2007 *Fundamentals of Computer Vision*
Undergraduate/Graduate level, Guest Lecturer, 1.5hrs per wk for 3 wks

Formal Teaching of Residents, Clinical Fellows and Research Fellows (post-docs)

Brigham and Women's Hospital

2009-present *Tractography – do's and don'ts, A course for neuroscientists and research assistants*
Biannual training seminar, 4 hours per year

2012-present *Diffusion MRI – basics, A course for early post-doctoral fellows, research assistants, graduate students*
Biannual training seminar, 4 hours per year

2018-present *PNL MRI processing pipeline – A course on the processing of MRI images*
Annual training seminar, 2 hours per year

Research Supervisory and Training Responsibilities

2006-2007	Supervision and training of graduate students	Daily mentorship of 2 students
2008-2009	Supervision and training of one research assistant	Weekly mentorship
2008-	Supervision of 2 research assistants	Weekly mentorship (2 hours per week)
2009-	Training of two post-doctoral fellows	Weekly mentorship (4 hours per week)
2010-2014	Supervision and training of one software engineer	Weekly mentorship (1 hour per week)
2012-2019	Train 1 high school student in neuroimaging	(8-12 weeks in summer, 25 hours per year)
2012-	Train a research assistant in MR scanning procedures	Monthly mentorship (10 hours per year)
2015-	Supervise and mentor undergraduate and graduate students	Weekly mentorship (4 hours per week)

Formally Supervised Students/Fellows

2007-2010 James G Malcolm, PhD Student.
Published several peer-reviewed manuscripts.
Currently pursuing MD at Emory University.

2007-2007 Gallagher Pryor, Ph.D Student.
Designed a real-time multi-object tracking system for tracking objects in deep turbulence.
Working for Accelereyes Inc.

Formally Supervised Students/Fellows

2008-2009	Jalpa Patel, M.S. in Biomedical Engineering. Quantitative analysis of various rigid and non-rigid registration algorithms from Slicer. Validation Engineer at Q Pharma, NY.
2008-2009	Padmapriya Srinivasan, M.S. in Biomedical Engineering. Designed a software module for group registration of labeled images. Data Analyst at Quanttus Inc.
2009-2010	Hsiao Piau Ng, Post-doctoral reseacher Use multi-tensor tractography for locating abnormal fiber bundles in schizophrenia. Researcher at ASTAR Singapore.
2009-2011	Takeshi Asami, Post-doctoral researcher Use histogram analysis and two-tensor tractography for fiber tract analysis. Assistant Professor, Yokohama City University, Japan
2010-2011	Po-Chang Hsu, Graduate Student Utilizing tractography methods for analyzing thalamic connections in the brain. Master's student at Harvard University.
2010-2014	Ryan Eckbo, Software Engineer Provide supervision and training in all aspects of software engineering at the PNL. Consultant, Brigham and Women's Hospital, PNL.
2010-2011	Stefan Leinhard, Masters thesis Student False positive detection for filtered two/three tensor tractography. PhD student at EPFL, Zurich.
2011-2012	Christian Baumgartner, Graduate Student Unscented Kalman filter based estimation of free water in diffusion MRI. Currently, PhD student at King's College, London.
2011-2018	Peter Savadjiev, Instructor Mentor on several scientific projects. Brigham and Women's Hospital, PNL.
2013-2017	Lipeng Ning, Post-doctoral fellow Advisor and Mentor - Compressed sensing. Brigham and Women's Hospital, PNL.
2014-2016	Pradyumna Reddy, Under-graduate student Bachelors thesis advisor - novel diffusion MRI models. Birla Institute of Technology and Science, Goa, India.
2014-	Madhura Bakshi, Masters/PhD Student Master's thesis advisor - EPI distortion correction. Currently pursuing PhD at Boston University.
2014-2016	Hengameh Dastardi, Post-doctoral fellow Advisor and Mentor - Diffusion MRI data harmonization. Brigham and Women's Hospital, Boston.
2015-2017	Weining Wu, Post-doctoral fellow Advisor and Mentor – Microstructure in ADHD Brigham and Women's Hospital, Boston.
2015	Come Carquex, Master's Student Master's thesis advisor - Artifact detection in diffusion MRI Brigham and Women's Hospital, Boston.
2015-2016	Efe Carabeyli, Master's Student Master's thesis advisor - Multi-scale tractography for multi-value data Brigham and Women's Hospital, Boston.
2015-2018	Sarina Karmacharya, Research Assistant Mentor - Advanced diffusion imaging in neonates with congenital heart disease Brigham and Women's Hospital, Boston.
2016-2017	Samar Fouda, Medical Student Mentor - Gray matter microstructural abnormalities in ADHD Brigham and Women's Hospital, Boston.
2017-2019	Benjamin Reid, Research Assistant Mentor - Impulsivity in young adolescents Brigham and Women's Hospital, Boston.

Formally Supervised Students/Fellows

2017-2020	Suheyla Cetin, Post-doctoral fellow Advisor and Mentor – Harmonization of Diffusion MRI data Brigham and Women's Hospital, Boston.
2018-2019	Rinat Mukhometzianov, Graduate Student Advisor - Tractography using complex models Currently at University of Waterloo, Canada.
2018-2020	Gabriel Ramos Llorden, Post-doctoral fellow Advisor and Mentor – High-resolution diffusion MRI reconstruction Brigham and Women's Hospital, Boston.
2019-present	Magdalini Tsintou, Instructor Mentor – Diffusion MRI data analysis Massachusetts General Hospital, Boston.
2019-2020	Saurabh Shigwan, Graduate Student Mentor – Deep learning for uncertainty quantification in dMRI Brigham and Women's Hospital, Boston.
2020-present	Debdut Mandal, Undergraduate Student Advisor – Axon radii estimation from dMRI data Indian Institute of Technology, Kharagpur, India
2021-present	Hazhar Sufi Karimi, Post-doctoral fellow Advisor and Mentor – Deep learning for tractography Brigham and Women's Hospital, Boston.
2021-present	Arghya Pal, Post-doctoral fellow Advisor and Mentor – Deep learning methods for MR reconstruction Brigham and Women's Hospital, Boston.

Other Mentored trainees and Faculty

2017-present	Lipeng Ning, Assistant Professor Mentor - Diffusion MRI, functional MRI and Transcranial magnetic stimulation Brigham and Women's Hospital, PNL.
2021-present	Suheyla Cetin-Karayumak, Assistant Professor Mentor - Harmonization of MRI data across scanners Brigham and Women's Hospital, PNL.

Local Invited Presentations

None of the following presentations were sponsored by outside entities.

2006	*A filtering approach to tracking highly deforming objects* Air-force office of scientific research (AFOSR), Dept. of Mechanical Engineering, Georgia Institute of Technology
2007	*Affine registration of richly labeled images* Laboratory of Mathematics in Imaging (LMI)- BWH
2008	*Directional functions for fiber-orientation distribution estimation* Laboratory of Mathematics in Imaging (LMI) - BWH
2009	*Neural Tractography using a Filtering Approach* Golby Lab, Dept. of Neurosurgery - BWH
2009	*Multi-tensor tractography and its applications* Laboratory of Mathematics in Imaging (LMI) - BWH
2010	*Multi-fiber tractography and statistical analysis of first-episode schizophrenia patients* Genetics and Schizophrenia Seminar - BWH
2011	*Compressed Sensing for diffusion MRI* Martinos Center for Biomedical Imaging - MGH
2012	*Fast diffusion imaging for the clinic* Children's Hospital Boston - BCH

Local Invited Presentations

2012 *Diffusion MRI – processing and analysis*
McLean Hospital

2013 *Gray matter heterogeneity in early aging*
Laboratory of Mathematics in Imaging - BWH

2013 *Fast diffusion imaging using compressed sensing and model based techniques*
Fetal-Neonatal Neuroimaging and Development Science Center - Children's Hospital Boston

2013 *Thriving in a research hospital*
Career Research Training Program - Judge Baker Children's Center, Boston

2014 *Diffusion imaging for cancer research*
Mass. General Hospital (MGH), Boston

2014 *Career planning in a research hospital*
Career Research Training Program - Judge Baker Children's Center, Boston

2015 *Critique on orthogonal fiber crossing in the brain*
Laboratory of Mathematics in Imaging (LMI) - BWH

2016 *Revisiting the fundamental diffusion equation*
Surgical Planning Laboratory - BWH

2018 *Recent advances in diffusion imaging*
FNNDSC - Boston Children's Hospital

2020 *Retrospective and prospective diffusion MRI harmonization*
BrainMap Seminar - MGH

2021 *Removal of scanner differences in diffusion MRI*
Research Initiatives Seminar - BWH

Report of Regional, National and International Invited Presentations

Regional Presentations

None of the following presentations were sponsored by outside entities.

2010 *A unified framework for multi-fiber tractography using the unscented Kalman Filter*
CSAIL - MIT (Massachusetts Institute of Technology)

2014 *Image processing in Medical Imaging*
Northeastern University, Boston, MA

National Presentations

None of the following presentations were sponsored by outside entities.

2005 *Particle Filtering for Geometric Active Contours with Application to Tracking Moving and Deforming Objects*
IEEE Conference on Computer Vision and Pattern Recognition, San Diego, CA

2006 *Segmenting Images on the Tensor Manifold*
Harvard Journal Club, Surgical Planning Laboratory - BWH

2008 *Orientation distribution estimation using directional functions*
IEEE Workshop on Tensor computing in computer vision, Anchorage, Alaska

2008 *Orientation distribution estimation using the Watson directional function*
Minerva Research Group, Georgia Institute of Technology, Atlanta, GA

2008 *Orientation distribution estimation using directional functions in the context of Q-ball imaging*
Mathematical Biosciences Institute, Ohio State University, Columbus, OH

2011 *Compressed sensing in diffusion MRI*
NIH - Clinical Center, Bethesda, Maryland

2012 *Fast diffusion imaging using compressed sensing and model based techniques*
University of North Carolina, Chapel Hill, NC

2013 *Diffusion imaging based markers of abnormal brain tissue*
Quantitative Medical Imaging, Arlington, VA

National Presentations

2014 *A dual spherical model for multi-shell diffusion imaging*
SPIE Medical, San Diego, CA
2018 *Inter-site and inter-scanner diffusion MRI data harmonization* – **Keynote Speaker**
3D Tractography Challenge (VoTEM), Washington DC, USA
2020 *Diffusion MRI harmonization methods*
Pittsburgh BrainHack Seminar

International Presentations

None of the following presentations were sponsored by outside entities.

2006 *Comparative Analysis of Kernel Methods for Statistical Shape Learning*
Workshop on Computer Vision Approaches for Medical Image Analysis, Graz, Austria.
2008 *Registration and Segmentation of Medical Images*
GE Research, Bangalore, India
2008 *Tracking objects in deep turbulence*
IBM Research Laboratories, India
2009 *Validation on Physical Phantom: Two-Tensor Tractography*
Workshop on computational diffusion MRI, London, UK
2010 *Building an average population HARDI atlas*
Workshop on computational diffusion MRI, Beijing, China
2012 *A unified framework for comparing diffusion models on clinical scans*
Workshop on Computational diffusion MRI, Nice, France
2014 *Fast diffusion imaging using compressed sensing*
Danish Research Center for Magnetic Resonance, Copenhagen, Denmark
2014 *Results from the SPARC diffusion MRI Challenge*
Workshop on Computational diffusion MRI, Boston, MA
2015 *Compressed sensing for ultra high-resolution diffusion imaging*
Center for Addiction and Mental Health, Univ. of Toronto, Canada
2015 *Compressed sensing and Super-resolution for high-resolution diffusion imaging*
Information Processing in Medical Imaging (IPMI), Scotland, UK
2016 *Revisiting the fundamental diffusion equation*
Diffusion Workshop, Sweden
2016 *Harmonizing diffusion MRI data acquired from multiple scanners*
International Society for Magnetic Resonance in Medicine, Singapore
2018 *Retrospective and prospective diffusion MRI data harmonization* – **Keynote Speaker**
Computational Diffusion MRI workshop, MICCAI, Granada Spain
2018 *Medical Image Computing: Machine-learning methods and Advanced-MRI applications*
24 hrs of lecture series at Indian Institute of Technology, Mumbai, India
2020 *Deep brain stimulation and tractography*
Workshop on Neuromodulation, Italy
2021 *Diffusion MRI data harmonization*
Japanese Human Brain Mapping Seminar, Japan

Report of Technological and Other Scientific Innovations

Developed and distributed several software packages as part of open-source and open-science initiative.

- Lead the development of a GPU CUDA based software for affine and non-rigid registration of 3D medical imaging data.
- A module to perform curvature based affine-invariant smoothing of medical images (as part of 3D Slicer)
- An unscented Kalman filter based tractography algorithm with several different features to trace neural fibers of the brain.
- A semi-automatic method for artifact detection and correction in diffusion MRI images.
- Software for harmonization of diffusion MRI data acquired from multiple scanners.

Patents

- System and method for high resolution diffusion imaging, *US Patent:* US10302727B2
- System and methods for ultra-fast multi-dimensional diffusion-relaxation MRI using time-division multiplexing sequences, *US Patent application: PCT/US2021/035693*
- System and method for simultaneous electric field simulation and neuronavigation for transcranial magnetic stimulation, *US Patent application: PCT/US21/28644*.

Report of Scholarship

Peer-reviewed articles published in journals

1. S. Kumar, **Y. Rathi** and R. C. Jain, "An efficient lapped orthogonal transform image coding technique", *IEEE Transactions on Consumer Electronics*, 43:993–1002, 1997.
2. **Y. Rathi**, N. Vaswani and A. Tannenbaum, "A generic framework for tracking using particle filter with dynamic shape prior", *IEEE Transactions on Image Processing*, 16(5):1370, 2007.
3. T. Georgiou, O. Michailovich, **Y. Rathi**, J. Malcolm and A. Tannenbaum, "Distribution metrics and image segmentation", *Linear algebra and its applications*, 425(2-3):663–672, 2007.
4. **Y. Rathi**, N. Vaswani, A. Tannenbaum and A. Yezzi, "Tracking deforming objects using particle filtering for geometric active contours", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 29(8):1470–1475, 2007.
5. O. Michailovich, **Y. Rathi** and A. Tannenbaum, "Image segmentation using active contours driven by the bhattacharyya gradient flow", *IEEE Transactions on Image Processing*, 16(11):2787–2801, 2007.
6. S. Dambreville, **Y. Rathi** and A. Tannenbaum, "A Framework for Image Segmentation Using Shape Models and Kernel Space Shape Priors", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 30(8):1385–1399, 2008.
7. **Y. Rathi**, O. Michailovich, M. E. Shenton and S. Bouix, "Directional functions for orientation distribution estimation", *Medical Image Analysis*, 13(3):432–444, 2009.
8. N. Vaswani, **Y. Rathi**, A. Yezzi and A. Tannenbaum, "Deform PF-MT: Particle Filter with Mode Tracker for Tracking Non-Affine Contour Deformations", *IEEE Transactions on Image Processing*, 19:841–857, 2010.
9. J. Malcolm, O. Michailovich, S. Bouix, C.-F. Westin, M. E. Shenton and **Y. Rathi**, "A filtered approach to neural tractography using the Watson directional function", *Medical Image Analysis*, 14(1):58–69, 2010.
10. **Y. Rathi**, J. Malcolm, S. Bouix, A. Tannenbaum and M. E. Shenton, "Affine registration of label maps in label space", *Journal of Computing*, 2(4):1–11, 2010.
11. **Y. Rathi**, J. Malcolm, O. Michailovich, C-F Westin, M.E. Shenton and S. Bouix, "Tensor-kernels for simultaneous fiber model estimation and tractography", *Magnetic Resonance in Medicine*, 64(1):138–148, 2010.
12. O. Michailovich and **Y. Rathi**, "On approximation of orientation distributions by means of spherical ridgelets", *IEEE Transactions on Image Processing*, 19(3):1–17, March 2010.
13. J. G. Malcolm, M. E. Shenton and **Y. Rathi**, "Filtered multi-tensor tractography", *IEEE Trans. on Medical Imaging*, 29:1664–1675, 2010.
14. **Y. Rathi**, M. Kubicki, S. Bouix, C-F Westin, J. Goldstein, L. Seidman, R. Mesholam-Gately, R. W. McCarley and M.E. Shenton, "Statistical Analysis of Fiber Bundles using Multi-tensor Tractography: Application to First-episode Schizophrenia", *Magnetic Resonance Imaging*, 29(4):507–515, 2011.
15. J. G. Malcolm, **Y. Rathi** and C.-F. Westin, *Processing and Visualization of Diffusion MRI*, in: T. Deserno, (ed.), *Recent Advances in Biomedical Image Processing and Analysis*, chapter 16, pp. 387–410. Springer, 2011.
16. S. Lienhard, J. Malcolm, C-F Westin and **Y. Rathi**, "A full bi-tensor neural tractography algorithm using the unscented Kalman filter", *EURASIP journal on Advances in signal processing: Reproducible Research in Signal Processing*, 1:1–10, 2011.
17. O. Michailovich, S. Dolui and **Y. Rathi**, "Spatially Regularized Compressed Sensing for High Angular Resolution Diffusion Imaging", *IEEE Transactions on Medical Imaging*, 30:1100–1115, 2011.
18. A. Venkataraman, **Y. Rathi**, M. Kubicki, C-F Westin and P. Golland, "Joint modeling of anatomical and functional connectivity for population studies", *IEEE Transactions on Medical Imaging*, 31:164–182, 2012.
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Note: International Conferences publications presented here are full length peer-reviewed articles. International Conferences such as ICCV, ECCV, CVPR and MICCAI are viewed as important as journal publications in the computer science community.

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Narrative Report

As the Director for Image Computing at the Psychiatry Neuroimaging Laboratory (PNL), I lead (and co-lead) several scientific research projects which are at the interface of neuroscience and engineering sciences, such as: 1) Fast acquisition of diffusion MRI data at ultra-high spatial resolution, 2). Harmonization of MRI data acquired from multiple scanners, 3). Harmonization of MRI data acquisition protocols across vendors, 4). Advanced data modeling for tracing the superficial white matter of the brain (human and non-human primate), 5). Accurate placement of electrodes for deep brain stimulation in OCD, 6). Ex-vivo validation of tractography and tissue microstructure using rhesus monkey data, and 7). Detecting microstructural and functional abnormalities in diseases such as schizophrenia, depression etc.

My research focus is to design novel mathematical algorithms that enable next generation of neuroimaging and neuroscience studies. I have developed award-winning algorithms that allow to trace complex neural fiber bundles in the brain from diffusion MRI data, which plays a very important role in the field of "connectomics". While long-range white matter connections were the focus for the past two decades, I have now pushed the envelope and developed technologies that can enable study of the short-range superficial white matter in human and non-human primate brains. These connections, termed U-fibers for their shape, form a majority of the connections in the human brain, but were largely inaccessible due to technological and ground truth limitations. Working with a team of neuroanatomists, I am in process of developing the first ever atlas of the superficial white matter in monkey and human brains. Abnormalities in these fibers are reported to be present in several neurodevelopmental and neurodegenerative disorders. The technologies developed in my recent R01 grant (R01MH125860) will allow studying these disorders at a scale that was not possible before.

To comprehensively map the connectivity of the human brain, higher spatial resolution is required. However, acquisition of high resolution diffusion MRI data is plagued with several challenges, including low signal-to-noise ration (low data quality) and long scan time. My recent work has focussed on developing new technologies that can allow obtaining in-vivo human brain diffusion MRI data at an unprecedented level of detail that was not possible before (resolution of 600 micrometers compared to 1.25 millimeters) with very good data quality, in a clinically feasible scan time of about 10 minutes. This is the focus of one of my R01 grants (R01MH116173) where I develop and apply new mathematical theories to dramatically reduce diffusion MRI (dMRI) scan time by a factor of 4 or more. Another part of this work involves reducing the noise in the signal, without using any *a-priori* knowledge about the data, thereby increasing data quality. Thus, advanced scans that were impractical before (took more than an hour to scan) can now be easily done in a few minutes (about 10 minutes). This also reduces patient discomfort, while allowing quicker turnaround time for MRI scans.

I have also pioneered and developed the field of MRI data harmonization. In particular, I brought to the notice of the neuroimaging community the problems related to the bias present in data acquired from multiple scanners. While large amounts of multi-site data is being acquired across the world, little attention is paid to the significant bias present in the data that dramatically reduces the statistical power of these studies and can also lead

to spurious false positive/negative results. This is directly related to the "reproducibility crisis" in the neuroimaging community. I, along with my team developed and proposed several new algorithms to reduce the scanner bias in diffusion MRI data that has already been acquired (termed *r*etrospective harmonization). We also proposed ways to remove scanner bias in data that is going to be acquired prospectively by making use of traveling subjects between sites. This issue has since gathered a lot of attention in the community and was the basis for holding at-least two major international competitions (challenges) by the community. My team participated in these challenges, and we were the winners of the **" Best Harmonization Algorithm"** among 30+ other competing algorithms from across the world. The algorithms developed as part of this project has resulted in an R01 grant (R01MH119222) that focusses on harmonizing diffusion MRI data from 30,000 subjects across ages (neonates to 80+ years) and brain disorders. This will enable large-scale data exploration to determine brain structural changes in several mental disorders. As part of this project, we will also provide connectivity information in all these subjects using the most comprehensive long-range white matter connectivity atlas. All of the data will be made publicly available on the NIMH data archive website. I would also like to note the significant contributions we have made in promoting open-science, whereby all our algorithms and code has been shared openly with the community.

Another important focus has been the translation of these tools for clinical investigation. Specifically, I am working with my colleagues in computational psychiatry at MGH to determine if deep brain stimulation of a particular set of white matter pathways affects outcome in obsessive compulsive disorder. In this study, we looked at subjects who have already been implanted with an electrode in the deep gray matter. This is a first such study (with a large number of subjects) to look at individual predictors of response to electrical stimulation in patients who were followed over several years. The results of this work will allow for understanding the circuits involved in OCD as well as help guide future clinical investigation to better treat patients with this debilitating condition. Technologies developed by my team, such as the ability to trace white matter pathways as well as high spatial resolution diffusion MRI data acquisition will be critical to move this work forward and inform future clinical trials.

Apart from these major projects, I am involved in several other research initiatives at the Psychiatry Neuroimaging Laboratory (PNL). I am a key member involved in experimental design, data analysis and technology development for several research projects such as the large U24 grant (PI: Dr. Shenton) on developing biomarkers for early stage schizophrenia as well as a P41 technology development grant (PIs: Drs. Westin, Kikinis) on identification of markers of brain tumors from in-vivo MRI data. Apart from these projects, I am also involved in advising and mentoring several junior faculty on managing and leading research projects.

While scientific research is exciting, I also enjoy mentoring students and post-doctoral fellows on developing the right scientific acumen so that they can become good researchers. As such, I typically devote several hours everyday in mentoring undergraduate/graduate students and post-doctoral fellows. I also supervise research assistants on technical aspects of data processing and mentor them on "asking the right questions" for scientific investigation. Two of my mentees, who joined me as post-doctoral fellows have now been promoted to the position of Assistant Professor at HMS. Throughout their career, I mentored them on the nuances of grant writing, which has helped them become successful at securing funding from NIH and other foundations. For example, Dr. Lipeng Ning has been awarded 3 R21 grants and a K01 grant to-date, while Dr. Suheyla Cetin-Karayumak as secured funding from BWH as well as received a NARSAD (a prestigious international grant award) grant. Other mentees of mine have also been successful at securing jobs either in academia or in national laboratories. Apart from mentoring, I have organized educational sessions to raise awareness about the issue of data harmonization. In particular, I was invited to hold a symposium on data harmonization by SOBP (Society of Biological Psychiatry), which uses a merit based process to select researchers for holding a symposium. For this symposium, I brought together well-known researchers from around the world and from diverse backgrounds. Finally, as recognition of my contributions, I have been invited to present my work either as a Keynote Speaker or an invited guest at several well-known international conferences and venues. I am also regularly invited to review NIH and NSF grants. Along with being actively involved in peer-reviewing for major scientific journals, I am also an Associate Editor for the journal "Frontiers in Neuroscience, Brain Imaging Methods".

To summarize, my research interest spans several fields and lies at the interface of neuroscience, neurobiology, engineering and mathematics. My goal is to develop technology for transforming our understanding of the brain from the microstructure to the macrostructure. Further, developing new mathematical methods that allow for pushing the frontiers of technology, both for understanding the brain structure as well as for guiding and monitoring clinical interventions in mental disorders is my key focus. I am also deeply committed to mentoring students and fellows and providing a diverse, open and fruitful environment for them to flourish as successful researchers and scientists.