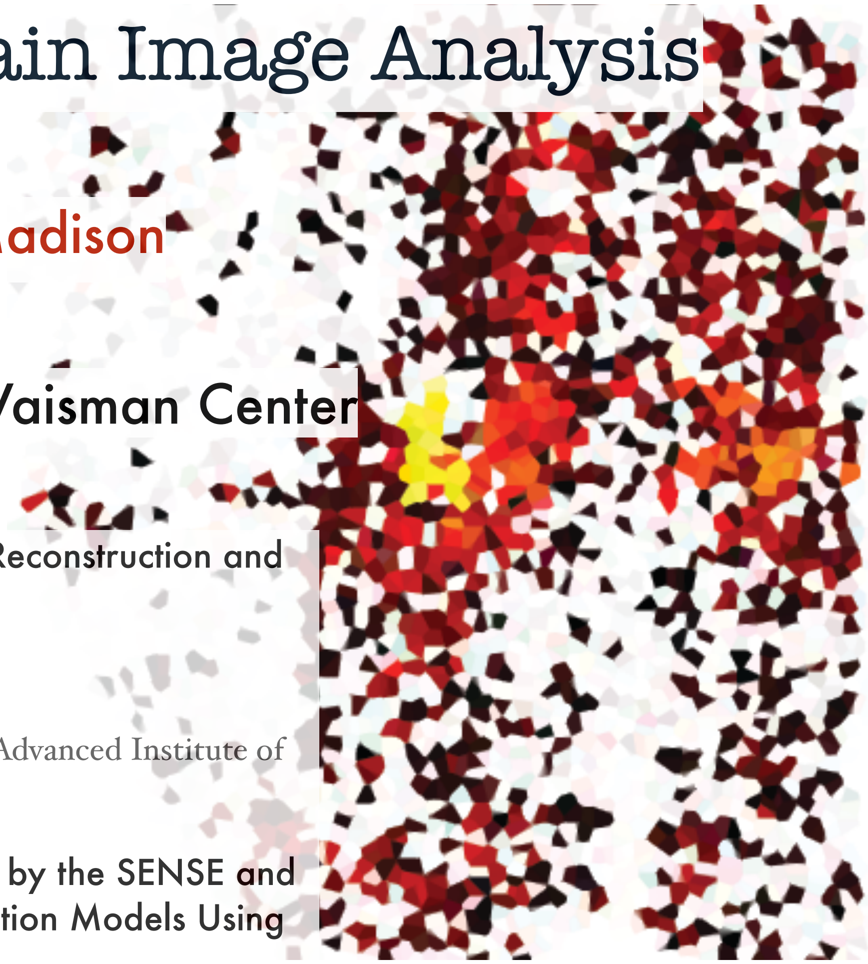
Workshop on Brain Image Analysis



University of Wisconsin, Madison

April 20, 2012

Ziemann B, 8th Floor of Waisman Center

Compressed Sensing for Dynamic MRI Reconstruction and fMRI Analysis

2:00-3:00PM

Jong Chul Ye
Department of Bio/Brain Engineering, Korea Advanced Institute of Science and Technology (KAIST), Korea

Observing Spatial Correlations Induced by the SENSE and GRAPPA Parallel MRI Image Reconstruction Models Using an Isomorphic Framework

3:00-3:30PM

Ian P. Bruce and Daniel B. Rowe
Department of Mathematics, Statistics and Computer Science, Marquette University, Milwaukee

Coffee Break

3:30-4:00PM

Extracting Quantitative Measures from EAP: a Small Clinical Study Using BFOR

4:00-4:30PM

Ameer Pasha Hosseinbor
Department of Medical Physics
Waisman Laboratory for Brain Imaging and Behavior
University of Wisconsin-Madison

Sparse Shape Recovery and Its Statistical Power Computation under Multiple Comparisons

4:30–5:00PM

Moo K. Chung
Department of Biostatistics and Medical Informatics
Waisman Laboratory for Brain Imaging and Behavior
University of Wisconsin-Madison

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Abstracts

Jong Chul Ye, Ph.D.
Department of Bio/Brain Engineering, Korea Advanced Institute of Science and Technology (KAIST), Korea

Compressed Sensing for Dynamic MRI Reconstruction and fMRI Analysis

Abstract:
Compressed sensing has become one of the important topics in signal processing area. According to compressed sensing theory, accurate reconstruction is possible even from a sampling rate dramatically smaller than the Nyquist sampling limit if the unknown signal is sparse and the sensing matrix is sufficiently incoherent to the modeling basis. From the biomedical imaging perspective, compressed sensing can become an important technique to overcome resolution limits of existing biomedical imaging systems, as well as to give an opportunity to design new types of systems.

In this talk, I will review our compressed sensing research activities at KAIST on dynamic imaging of time-varying objects, and fMRI analysis. Specifically, I will first describe our compressive sensing dynamic MRI framework called k-t FOCUSS and its variations that can overcome the many of the limitation of the existing methods. Then, I will describe sparse dictionary learning techniques for resting state fMRI analysis.

Short Bio:
Jong Chul Ye, Ph.D, Associate Professor. Dept. of Bio/Brain Engineering, Korea Advanced Inst. Of Science and Technology (KAIST), Korea.

Jong Chul Ye received the B.Sc. and M.Sc. degrees with honors from Seoul National University, Korea, and the Ph.D. degree from the School of Electrical and Computer Engineering, Purdue University, West Lafayette. After performing researches as a postdoc at UIUC, he worked as research scientist at GE Global Research Center, NY (2003-2004), Philips Research, NY (2001-2003), and then joined KAIST in 2004. His current research interests include compressed sensing and statistical signal processing for various imaging modalities such as MRI, NIRS, etc. He received various awards including 2011 Outstanding Research Award from KAIST, 2010 Guerbet Outstanding Paper Award from Korean Society for Magnetic Resonance in Medicine, 2009 Best Paper award from Korean Human Brain Mapping Society, etc. He was the winner of 2009 ISMRM Recon Challenge at ISMRM Workshop. He is currently visiting Univ of Illinois as a Beckman Senior Fellow.

Ian P. Bruce and Daniel B. Rowe
Department of Mathematics, Statistics and Computer Science,
Marquette University, Milwaukee

Observing Spatial Correlations Induced by the SENSE and GRAPPA Parallel MRI Image Reconstruction Models Using an Isomorphic Framework

Abstract:
In parallel MRI, exploiting the overlap in the sensitivity profiles of multiple receiver coils placed around an object results in a decrease in data acquisition time through the concurrent acquisition of sub-sampled spatial frequencies by multiple receiver coils. While there are multiple techniques available to perform parallel image reconstruction, SENSitivity Encoding (SENSE) and Generalized Auto-calibrating Partially Parallel Acquisition (GRAPPA) are the most commonly used in medical MRI scanners. In this study, the linear mathematical framework derived in Rowe et al. [J Neurosci Meth 159(2007) 361–369] is expanded upon to reconstruct sub-sampled data acquired from multiple receiver coils using a real-valued isomorphic representation of the complex-valued SENSE and GRAPPA models. A statistical analysis is performed of the various operators utilized in the SENSE and GRAPPA reconstruction models, with an emphasis placed on the effects each operator has on voxel means, variances, and correlations. It is shown that the unfolding of aliased voxels in the SENSE model and the interpolation of missing spatial frequencies in the GRAPPA model induce spatial correlations between voxels in the reconstructed images that could result in misleading functional connectivity conclusions.

Ameer Pasha Hosseinbor
Department of Medical Physics
University of Wisconsin-Madison

Extracting Quantitative Measures from EAP: a Small Clinical Study Using BFOR

Abstract:
The ensemble average propagator (EAP) describes the 3D average diffusion process of water molecules, capturing both its radial and angular contents, and hence providing rich information about complex tissue microstructure properties. Bessel Fourier orientation reconstruction (BFOR) is one of several analytical, non-Cartesian EAP reconstruction schemes employing multiple shell acquisitions that have recently been proposed. Such modeling bases have not yet been fully exploited in the extraction of rotationally invariant q-space indices that describe the degree of diffusion anisotropy/restrictivity. Such quantitative measures include the zero-displacement probability (*Po*), mean squared displacement (MSD), and generalized fractional anisotropy (GFA), and all three are simply scalar features of the EAP. In this study, a general relationship between MSD and q-space diffusion signal is derived and an EAP-based definition of GFA is introduced. A significant part of the paper is dedicated to utilizing BFOR in a clinical dataset, comprised of 5 multiple sclerosis (MS) patients and 4 controls, to estimate *Po*, MSD, and GFA of corpus callosum, and specifically, to see if such indices can differentiate between normal appearing white matter (NAWM) and healthy white matter (WM). Although the sample size is small, this study is a proof of concept that can be extended to larger sample sizes in the

Moo K. Chung, Ph.D.
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Sparse Shape Recovery and Its Statistical Power Computation under Multiple Comparisons

Abstract:
We present a new sparse shape modeling framework on the Laplace-Beltrami (LB) eigenfunctions. Traditionally, the LB-eigenfunctions are used as a basis for intrinsically representing surface shapes by forming a Fourier series expansion. To reduce high frequency noise, only the first few terms are used in the expansion and higher frequency terms are simply thrown away. However, some lower frequency terms may not necessarily contribute significantly in reconstructing the surfaces. Motivated by this idea, we propose to filter out only the significant eigenfunctions using sparse regression. The new sparse framework can avoid surface-based smoothing often used in the field. The main advantage of the new shape modeling framework would be the increased statistical power while achieving a more compact representation. The method is applied to MIDUS (Midlife in the United States) MRI data set collected in Wisconsin in determining the aging effect on amygdala and hippocampus structures.