Background Image: Node degrees in a brain network

Workshop on Mathematical Methods in Medical Image Analysis

International Conference Hall, Bldg. 25-1, Seoul National University, Korea

September 26-27, 2011

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Jang-Yeon Park, Konkuk University, Korea

Session 2: Brain Connectivity and Networks

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Session 3: Machine Learning in Medical Images

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Michelle Liou, Academia Sinica
Young Jo Lee, Seoul National University
Sungho Tak, KAIST
Seung-Goo Kim, Seoul National University

Please contact Moo K. Chung
email: mkchung@wisc.edu
까까오: NIGHTSKY
for additional information.

Session 1:
Image Acquisition and Reconstruction
September 26, 10:00am-12:00pm

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

Compressed Sensing for Biomedical Imaging of Time Varying Objects

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, such as beating hearts or brain neuro/hemodynamics, in which we can further achieve significant reduction of the data acquisition time by exploiting temporal redundancy. 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 a novel dynamic compressed sensing approach for EEG/MEG or DOT source localization applications, which overcomes the classical "coherent source" problems in array signal processing by exploiting joint sparsity.

Bio: Jong Chul Ye, Ph.D, is an Associate Prof. Dept. of Bio/Brain Engineering, 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. Before he joined KAIST as an assistant professor in 2004, he worked as research scientist at GE Global Research Center, NY, Philips Research, NY, University of Illinois at Urbana-Champaign. His current research interests include compressed sensing, statistical signal processing for various imaging modalities such as MRI, NIRS, etc. He received various awards including Guerbet Paper Award from Korean Society for Magnetic Resonance in Medicine (2010), best paper award from Korean Human Brain Mapping Society (2009), etc. He was the winner of 2009 ISMRM Recon Challenge at ISMRM Workshop.

Jang-Yeon Park, Ph.D.
School of Biomedical Engineering
Konkuk University, Korea

New Frontier of Magnetic Resonance Imaging: Ultrashort Echo-time 3D Projection Acquisition Imaging

Abstract:_Ultrashort echo-time (UTE) imaging is a powerful technique for imaging very short T_2 species. Recently, two new ultrashort TE 3D projection acquisition techniques were developed: SWIFT (SWeep Imaging with Fourier Transform) and CODE (COncurrent Dephasing and Excitation). In SWIFT, spin excitation and data acquisition occur in a time-shared manner. In other words, data acquisition is performed during spin excitation at the same time, which ideally allows SWIFT to achieve almost zero TE. CODE is basically a 3D radial gradient-echo (GRE) imaging technique. In CODE, the pre-dephasing gradient for readout is performed during RF excitation. CODE can effectively achieve TE on the order of ~0.2 ms and larger. CODE can easily be implemented on a clinical scanner with no strong hardware requirements when compared to conventional UTE and SWIFT. In this talk, SWIFT and CODE imaging will be introduced with the demonstration of interesting results obtained from several applications. Some challenging issues related to them will also be discussed in image analysis and image reconstruction.

Bio: Jang-Yeon Park, Ph.D., is an Assistant Professor in the Department of Biomedical Engineering at Konkuk University, Korea. Dr. Park received his Ph.D. in Medical Physics from University of Minnesota under the guidance of Michael Garwood, the Associate Director of the Center for Magnetic Resonance Research, in 2006. For his Ph.D. dissertation, he worked on the analytical description of the physical mechanism of spins in gradient-echo and spin-echo pulse sequences in terms of phase behavior when using a frequency-modulation RF pulse, specifically focusing on the use of a hyperbolic secant pulse (sech/tanh). Besides, he was involved in the development of a new ultrashort TE 3D projection acquisition pulse sequence, which is called SWIFT (Sweep Imaging with Fourier Transform). In SWIFT, data acquisition occurs during RF excitation in a time shared manner unlike conventional MRI applying RF excitation followed by data acquisition. SWIFT is really booming in MR community now. He also developed a new short TE 3D radial gradient-echo pulse sequence called CODE (COncurrent Dephasing and Excitation), where the pre-dephasing gradient for readout is applied during RF excitation. Currently his main research interests are in nanoparticle imaging of cancer and musculoskeletal imaging using short TE pulse sequences he developed.

Session 2:
Brain Connectivity and Networks
September 26, 1:30-3:30pm

James Gee, Ph.D.
Penn Image Computing and Science Laboratory (PICSL)
University of Pennsylvania

Integrative Analysis of Cortico-Connective Patterns of Network Degeneration

Abstract: We describe a new, unsupervised strategy for multivariate imaging and analysis, and demonstrate its application to identify related patterns of reduced white matter integrity and decreases in cortical thickness in Alzheimer's disease (AD) and frontotemporal dementia (FTD). This process is based on a novel computational model derived from sparse canonical correlation analysis (SCCA) that allows us to automatically identify mutually predictive, distributed neuroanatomical regions from different imaging modalities. SCCA shows that the FTD-related frontal and temporal degeneration pattern is correlated across modalities; whereas, in AD, we find significant association between cortical thinning and reduction in white matter integrity within a distributed parietal and temporal network. Furthermore, we show that within SCCA-identified regions significant differences exist between FTD and AD cortical-connective degeneration patterns, and validate these distinct, multimodal imaging patterns by showing unique relationships with cognitive measures in AD and FTD.

Bio: James Gee, Ph.D., is Associate Professor of Radiologic Science and Computer and Information Science, Director of the the HHMI-NIBIB (Howard Hughes Medical Institute – National Institutes of Biomedical Imaging and Bioengineering) Interfaces Program in Biomedical Imaging and Informational Sciences, and Co-Director of the Translational Biomedical Imaging Center of the Institute for Translational Medicine and Therapeutics, all at the University of Pennsylvania, Philadelphia. Dr. Gee works broadly in the field of biomedical image analysis, and his group, the Penn Image Computing and Science Laboratory (PICSL), is renown for basic and applied research in mathematical, computational and statistical methods for detecting, quantifying and modeling the ways in which anatomy and physiology can vary in nature, over time, or as a consequence of disease or therapy. A major goal of this research is its translation into practical tools, made freely and publicly available through the group's open-source ITK-SNAP, ANTS, DTI-TK and ITK software, which have consistently ranked as the best performing and most widely used applications in segmentation, registration, diffusion tensor imaging and morphometry. The group's diverse portfolio of interdisciplinary collaborations spans various body and animal systems and the major modalities in biological and medical imaging, and includes integrative studies of structure-function relationships of the brain, breast, lung, heart and musculoskeletal system in health and disease.

Hyekyoung Lee, Ph.D.
Department of Nuclear Medicine, Brain and Cognitive Sciences
Seoul National University

Extraction of Brain Network Using Graph Filtration

Abstract: The differences between brain networks have often been assessed by the difference of global topological measures such as the clustering coefficient, degree distribution and modularity. In this talk, we introduce a new framework for measuring the network differences using the Gromov-Hausdorff (GH) distance, which is often used in shape analysis. In order to apply the GH distance, we need to define the shape of the brain network by piecing together the patches of locally connected nearest neighbors using the concept of graph filtration. The shape of the network is then transformed into an algebraic form called the single linkage matrix. The single linkage matrix is subsequently used in measuring network differences using the GH distance. As an illustration, we apply the proposed framework to compare the FDG-PET based functional brain networks out of 24 attention deficit hyperactivity disorder (ADHD) children, 26 autism spectrum disorder (ASD) children and 11 pediatric control subjects.

Bio: Hyekyoung Lee, Ph.D. is a post doctoral Researcher in the Department of Nuclear Medicine and the Department of Brain and Cognitive Sciences at Seoul National University in South Korea. H. Lee received her B.Sc. in Electrical and Computer Engineering from Hanyang University and M.Sc. and Ph.D. degrees in Computer Science and Engineering from Pohang University of Science and Technology in 2009. During her Ph.D study, she worked on the field of machine learning and its application, EEG-based brain computer interface (BCI). Her dissertation focused on the feature extraction based on nonnegative matrix/tensor factorization to improve the performance of BCI system. Since 2009, she has focused her research in medical image analysis, especially, functional brain connectivity on PET. Her recent MICCAI 2011 paper, which was selected for oral representation, was the first paper to introduced the persistent homological framework in brain network modeling. The method was applied in finding the multi-scale connected network structures of brain in clinical populaitons.

Moo K. Chung, Ph.D.
Department of Statistics, Biostatistics and Medical Informatics
University of Wisconsin-Madison
Department of Brain and Cognitive Sciences, Seoul National University

Fiedler's Vector, Spectral Embedding and Hot Spots Conjecture in Networks

Abstract: The second eigenfunction of the Laplace-Beltrami operator follows the pattern of the overall shape of an object. This geometric property is well known and used for various applications including mesh processing, feature extraction, manifold learning, spectral embedding and the minimum linear arrangement problem. Surprisingly, this geometric property has not been mathematically formulated yet. This problem is directly related to the somewhat obscure hot spots conjecture in differential geometry. The aim of the talk is to raise the awareness of this nontrivial issue and formulate the problem more concretely. As an application, we show how the second eigenfunction alone can be used for shape modeling of tubular structures such as the human mandible obtained from CT images and determining the diameter of biological networks.

Bio: Moo K. Chung, Ph.D. (http://www.stat.wisc.edu/~mchung), is an Associate Professor in the Department of Statistics, Biostatistics and Medical Informatics at the University of Wisconsin-Madison. Also affiliated with the Waisman Laboratory for Brain Imaging and Behavior and the Vocal Tract Laboratory. As a part of the World Class University (WCU) project, he is also affiliated with the Department of Brain and Cognitive Sciences, Seoul National University. Dr. Chung received Ph.D. in Statistics from McGill University under Keith J. Worsley and James O. Ramsay in 2001. Dr. Chung's main research area is computational neuroanatomy, where noninvasive brain imaging modalities such as magnetic resonance imaging (MRI) and diffusion tensor imaging (DTI) are used to map the spatiotemporal dynamics of the human brain. His research concentrates on the methodological development required for quantifying and contrasting anatomical shape variations in both normal and clinical populations at the macroscopic level using various statistical and computational techniques. He is currently writing a 400-page research monograph on computational neuroanatomy, scheduled to be published in 2012. Recently, Dr. Chung received the Editor's Award for best paper published in Journal of Speech, Language, and Hearing Research in year 2010 for the paper that analyzed vocal tract CT images.

Session 3:
Machine Learning in Medical Images
September 26, 4:00-6:00pm

Chris Hinrichs
Department of Computer Science
University of Wisconsin-Madison

A Novel Clinical Trial Methodology for Neuroimaging Data

Abstract: Traditional clinical trial models use a scalar outcome measure to quantify a pathological condition of interest in each subject, and a t-statistic to test the hypothesis that a treatment is effective in modifying the disease. In this ongoing work, we re-examine the central question itself – how can we best use neuroimaging data to judge the efficacy of a treatment? Our proposed method is to use a Support Vector Machines (SVM) learning algorithm to train a pattern classifier to distinguish between treatment and placebo groups. We can then use the classifier's cross-validated classification accuracy as the test-statistic. This gives us a new Null hypothesis: that the classifier will not classify the trial subjects better than chance, which is given by the Binomial distribution. Monte-Carlo simulations demonstrate that this method can outperform a t-test on voxel means, suggesting that current neuroimaging based trial methodologies are under-powered. The next step is to characterize the relation between sample sizes and statistical power in this framework, using results from Gaussian Process theory.

Bio: Chris Hinrichs is a Ph.D. dissertater at the University of Wisconsin-Madison in the departments of Computer Sciences, and Biostatistics and Medical Informatics. (Expected graduation in 2012.) Chris's dissertation research explores the topic of adapting machine learning methods to prediction and other inference tasks in the neuroimaging setting, with a particular emphasis on Alzheimer's Disease (AD). Primary contributions include novel learning methods for leveraging 3-D imaging properties, as well as for combining disparate imaging modalities for predicting progression to AD, and development of novel clinical trial concepts. He is supported by an NLM Fellowship, and was selected to represent the Wisconsin CIBM program with a plenary talk at the 2011 NLM training program meeting. Chris has served as a reviewer for NeuroImage, IJBDM, and several computer vision and machine learning conferences.

Joon-Kyung Seong, Ph.D
School of Computer Science and Engineering
Soongsil University, Korea

Individual Subject Classification for Alzheimer's Disease based on Incremental Learning Using a Spatial Frequency Representation of Cortical Thickness Data

Abstract: In this talk, I propose an incremental method for AD classification using cortical thickness data. We represent the cortical thickness data of a subject in terms of their spatial frequency components, employing the manifold harmonic transform. The basis functions for this transform are obtained from the eigenfunctions of the Laplace-Beltrami operator, which are dependent only on the geometry of a cortical surface but not on the cortical thickness defined on it. This facilitates individual subject classification based on incremental learning. We utilized MR volumes provided by Alzheimer's Disease Neuroimaging Initiative (ADNI) to validate the performance of the method. Our method discriminated AD patients from Healthy Control (HC) subjects with 82% sensitivity and 93% specificity. It also discriminated Mild Cognitive Impairment (MCI) patients, who converted to AD within 18 month, from non-converted MCI subjects with 63% sensitivity and 76% specificity. In comparison with other classification methods, our method demonstrated high classification performance in the both categories, which supports the discriminative power of our method in both AD diagnosis and AD prediction.

Bio: Joon-Kyung Seong is an assitant professor in the school of computer science and engineering at Soongsil University, Korea. His research interests include computer graphics, geometric modeling, and computational neuroimage analysis. Prof. Seong received a B.S. and a Ph.D. degrees from Seoul National University in 2000 and 2005, respectively. After his graduation, he conducted his postdoctoral research in the School of Computing at the University of Utah. In 2008, he joined the department of computer science at Korea Advanced Institute of Science and Technology (KAIST) as a research professor, while he is working in the school of computer science and engineering at Soongsil University from fall 2010.

Session 4:
Multimodal Imaging and DTI
September 27, 9:00am-12:00pm

Hae-Jeong Park, Ph.D.
Yonsei University College of Medicine, Korea

Noise Reduction Methods in Neuroimaging Data

Abstract: Functional MRI and diffusion weighted imaging (DWI) using EPI sequence are vulnerable to artifacts such as MRI noise, physiological noise, and macro motions. The current presentation will cover two different image processing methods for artifact reduction in the fMRI and high angular resolution diffusion imaging (HARDI). In the fMRI analysis, spatial smoothing using isotropic Gaussian kernels reduces spatial resolution and increases the partial volume effect of fMRI, thereby reducing localization power. To minimize these limitations, we propose a novel anisotropic smoothing method for fMRI data. To extract an anisotropic tensor for each voxel of the functional data, we derived an intensity gradient using the distance transformation of the segmented gray matter of the fMRI-coregistered T1-weighted image. The intensity gradient was then used to determine the anisotropic smoothing kernel at each voxel of the fMRI data. In the HARDI analysis, high b-valued DWI, which was designed to solve fiber-crossing problems, are susceptible to many artifacts and distortions. Since DWIs with different diffusion gradients produce dissimilar intensity contrasts, and since the distortion is nonlinear when multiple artifactual sources are intermixed, the mutual information-based affine registration may not be adequate for precise correction of distortions in DWIs. To overcome these problems, we designed an iterative image registration technique through which simulated DWIs are generated, driven from a diffusion tensor estimate, as targets for measured DWIs in the registration.These noise reduction techniques would improve the accuracy of the image analysis results, which is essential for advanced neuroscience research.

Bio: Hae-Jeong Park, Ph.D. is an Associate Professor in the Department of Radiology and division of Nuclear Medicine, Adjunct Professors of Department of Psychiatry, Severance Biomedical Science Institute, and Biomedical Science & Engineering major, the Brain Korea 21 Project for Medical Science, Yonsei University College of Medicine. Dr. Park received his BS degree in Electrical Engineering and his MS and PhD degrees in Biomedical Engineering from Seoul National University, Seoul, KOREA, in 1993, 1995, and 2000. In 2001, he developed a novel statistical parametric mapping method of distributed current densities of high resolution event-related potential (ERP), and firstly proposed independent component analysis for cross-sectional positron emission tomography (PET) images. In the late 2001, Dr. Park joined the Laboratory of Neuroscience, Department of Psychiatry, and Surgical Planning Laboratory, Department of Radiology, Brigham and Women's Hospital, Harvard Medical School. As a research fellow of Harvard, he researched fiber tracking and quantification of diffusion tensor imaging for basic and clinical neuroscience. He firstly introduced a whole-brain fiber tractography, which was very new at that time and was chosen as cover pages of Neuroimage and Human Brain Mapping, in 2003 and 2008. He is the author of a diffusion tensor software tool, DoDTI, dated back to 2004. His research interests include brain connectome for understanding the brain mechanism, methods for multimodal neuroimaging (MRI, PET, TMS, and EEG/MEG), reading mind using real-time fMRI and brain decoding, medical image processing for surgical planning, and understanding linguistic, communicative and aesthetic brains (http://neuroimage.yonsei.ac.kr).

Tianzi Jiang, Ph.D.
LIAMA Center for Computational Medicine, National Laboratory of Pattern Recognition, Institute of Automation, The Chinese Academy of Sciences

Brainnetome Based on Multimodal Magnetic Resonance Imaging

Abstract: Convergent evidence has shown that the psychiatric disorders are faulty brain networks. In order to understand the pathophysiological mechanism of psychiatric disorders, it is necessary to integrate the multi-level network features obtained with various functional and anatomical brain imaging technologies on different scales. On macroscale, such features can be obtained from networks based on illness special region of interest, networks related to specific cognitive function, and whole brain networks. We have proposed a new concept of “brainnetome” to represent such integration framework. We define the essential components of brainnetome as network topological structure (connectome), performance, dynamics, manifestation of functions and malfunctions of brain on different scales, and genetic basis of brain networks. In fact, a big project (973 program) has been approved in China to conduct studies of brainnetome for four different diseases with focal lesion (stoke and glioma) and diffusion lesions (schizophrenia and AD). The Brainnetome Consortium has been established (www.brainnetome.org). This presentation will cover the above aspects of brainnetome. We first give a brief review about the brainnetome. Then functional brain networks based on the resting-state functional MRI will be presented. After that, brain networks based on diffusion MRI will be presented. We will also present some new findings on abnormalities of functional connectivity and networks of human brain with neurological and psychiatric diseases, especially Alzheimer's Diseases, Schizophrenia. Finally, some perspective and future research directions will be touched. It envisions that brainnetome will become an emerging co-frontier of brain imaging, information technology, neurology and psychiatry. Some long-standing issues in neuropsychiatry may be solved by combining brainnetome with genome.

Bio: Dr. Tianzi Jiang is Professor of Brain Imaging and Cognitive Disorders, Institute Automation, Chinese Academy of Sciences, and Professor of Queensland Brain Institute, University of Queensland. He received his Ph.D. degree in computational mathematics from Zhejiang University in1994. After he graduated, he worked as a postdoctoral research fellow (1994-1996) and an Associate Professor (1996-1999), and full professor (1999-present) at his current institution. During that time, he worked as a Vice-Chancellor's postdoctoral fellow at the University of New South Wales, a visiting scientist at Max Planck Institute for Human Cognitive and Brain Sciences, a research fellow at the Queen's University of Belfast, and a visiting professor at University of Houston. He is the Chinese Director of the Sino-French Laboratory in Computer Science, Automation and Applied Mathematics (LIAMA), one National Center for International Research, since 2006. His research interests include anatomical and functional brain imaging, complex brain networks, imaging genetics, and their clinical applications in brain disorders and development. He is the author or co-author of over 150 reviewed journal papers in these fields and the co-editor of six issues of the Lecture Notes in Computer Sciences.

Dr. Jiang is Associate Editor of both IEEE Transactions on Medical Imaging and IEEE Transactions on Autonomous Mental Development, and an Academic Editor of PLoS One. He was/is also on editorial boards of several international journals, including NeuroImage, Cognitive Neurodynamics, International Journal of Computer mathematics, Genomics, Proteomics & Bioinformatics. He served and is serving as the Chairs and Program Committee members of a number of international conferences, including General Chair of MICCAI'2010. He was awarded the National Distinguished Youth Foundations by Chinese Government (2004), the Natural Science Award of China (2004), and the Natural Science Award of the Chinese Academy of Sciences (1996).

Anqi Qiu, Ph.D.
Division of Bioengineering
University of Singapore

Diffeomorphic Metric Mapping of High Angular Resolution Diffusion Imaging based on Riemannian Structure of Orientation Distribution Functions

Abstract: We present a novel large deformation diffeomorphic registration algorithm to align high angular resolution diffusion images (HARDI) characterized by orientation distribution functions (ODFs). Our proposed algorithm seeks an optimal diffeomorphism of large deformation between two ODF fields in a spatial volume domain and at the same time, locally reorients an ODF in a manner such that it remains consistent with the surrounding anatomical structure. To this end, we first review the Riemannian manifold of ODFs. We then define the reorientation of an ODF when an affine transformation is applied and subsequently, define the diffeomorphic group action to be applied on the ODF based on this reorientation. We incorporate the Riemannian metric of ODFs for quantifying the similarity of two HARDI images into a variational problem defined under the large deformation diffeomorphic metric mapping (LDDMM) framework. We finally derive the gradient of the cost function in both Riemannian spaces of diffeomorphisms and the ODFs, and present its numerical implementation. Both synthetic and real brain HARDI data are used to illustrate the performance of our registration algorithm.

Bio: Qiu Anqi received her BS in Biomedical Engineering from Tsinghua University in 1999 and MS degrees in Biomedical Engineering and Applied Mathematics and Statistics from University of Connecticut in 2002 and from Johns Hopkins University in 2005, respectively. Since her Ph. D study, she has worked on the field of medical image analysis. In particularly, she has been interested in extracting anatomical and functional information from MRI images in order to identify neuroimaging biomarkers associated with neurodegenerative and neuropsychiatric diseases (e.g. schizophrenia, bipolar disorder, depression, Autism, dementia). After the graduation from Johns Hopkins University in 2006, she joined Kirby research center for functional brain imaging at Kennedy Krieger Institute as postdoctoral fellow and learned medical physics. Since the summer of 2007, she moved to Singapore and became an assistant professor of Division of Bioengineering at National University of Singapore. She started her own computational functional anatomy laboratory on the campus of the faculty of engineering. Her research focuses on the translation of mathematical modeling to quantitative medicine.

Session 5:
Statistical Methods in Functional Images
September 27, 1:30-6:00pm

Michelle Liou, Ph.D.
Institute of Statistical Science
Academia Sinica, Taiwan

Persistency in fMRI BOLD Responses

Abstract: We propose a procedure for studying the persistency of BOLD responses in the experimental session without a prior specification of a design contrast in event-related fMRI studies. The procedure includes preprocessing the fMRI data by removing major trends, computing the persistency index and its sample variance, and testing the significance of the index with FDR control over the familywise error rate. We have theoretically proved the asymptotic normality and derived sample variance of the persistency index. For illustration, we have shown the use of the procedure in three event-related fMRI experiments, involving eyes closed/open, spatial cueing, and change detection tasks. Empirical results suggest that the criterion of persistency is more sensitive to temporal activity in the grey matter in contrast to that in the white matter. (This study has been collaborated with the functional neuroimaging group in the Institute).

Bio: Michelle Liou is a research fellow in the Institute of Statistical Science, Academia Sinica. She received Ph.D. in applied statistics and psychometric theory from University of Pittsburgh in 1984. She was Associate Professor in the Department of Psychology at National Taiwan University, Visiting Assistant Professor in the Program in Educational Statistics at University of California (Berkeley), and NAEP scholar at the Educational Testing Service. She received distinguished research awards from the National Science Council (Taiwan) in 1999 and 2003, and New Perspective in fMRI Research Award from the US fMRI Data Center (Dartmouth College) in 2003. She was Co-Editor of Statistica Sinica, and Associate editors of Journal of Educational Behavioral Statistics and Journal of Educational Measurement. She is currently a Review Editor of Applied Psychological Measurement. Her research interests include statistical analysis of fMRI and EEG/MEG data, and modeling multivariate mutual information in behavior science.

Young Jo Lee, Ph.D.
Department of Statistics
Seoul National University

Likelihood Approach to Large-scale Multiple Testing

Abstract: To date, only frequentistic, Bayesian and empirical Bayes approaches have been studied for the large-scale inference problem of testing simultaneously hundreds or thousands of hypotheses. Consequences have been the development of the testing procedures without necessarily checking model assumptions and the need to consider an empirical null distribution in order to avoid the problem of rejection of all null hypotheses when sample sizes are large. In this talk, we present the multiple testing problem as a multiple prediction problem of whether a null hypothesis is true or not. We introduce a hierarchical random-effect models and show how the extended likelihood is build. It is shown that the maximum likelihood prediction has a certain oracle property. The extended likelihood leads to new testing procedures, which are optimal for the usual loss function in hypothesis testing. The new tests control the local probability of false discovery for individual tests to maintain the global frequentistic false discovery rate and have no need to consider an empirical null distribution. We show conditions when such false rates vanish. Three examples illustrate how to use the likelihood method in practice. A numerical study shows that finding the best fitting model is crucial for the behavior of test procedures.

Bio: Youngjo Lee, Ph.D., is a Professor in the Department of Statistics at Seoul National University. He received his Ph.D. in statistics from Iowa state university in 1983. His research interests include extension, application, and software development for hierarchical generalized linear models (HGLMs). He contributed a wide range of applications, including combining information over trials, analysis for multi-level models, genetics, spatial and temporal models. In 2006, with two coauthors (John Nelder and Yudi Pawitan), he wrote a book (Generalized linear models with random effects: Unified analysis via H-likelihood) which contains all the latest research of him. With Professor John Nelder he has advocated the use of HGLMs for the statistical analysis of data and developed the updating of the statistical software package GenStat. Recently, he contributed to the development of R-package such as hglm, HGLMMM and frailtyHL.

Sungho Tak, Ph.D.
Department of Bio and Brain Engineering
Korea Advanced Institute of Science and Technology (KAIST), Korea

Statistical Signal Processing for Functional Near-Infrared Spectroscopy

Abstract: Functional near-infrared spectroscopy (fNIRS) is an emerging modality for measuring brain activity via blood-oxygenation changes. A new public domain statistical parametric mapping (SPM) toolbox for fNIRS (NIRS-SPM) has been developed, which enables the statistical analysis of fNIRS signal based on the general linear model (GLM) and Sun's tube formula. In this paper, we describe further advances in NIRS-SPM. First, we show that an inference using by Sun's tube formula is equivalent to that by Lipschitz-Killing curvature (LKC)-based expected Euler characteristic (EC) method, when we consider channel-wise least-square residual correlation. Moreover, we show that LKC-based expected EC can be used for general statistics such as F-map. Second, we develop a simple two step approach for spatio-temporal diffuse optical tomography using minimum norm constraint, which allows inferences on a 3D SPM. Third, we propose a method for estimating oxygen supply and consumption using simultaneous measurements of fNIRS and fMRI. Then, we apply this method to patients with subcortical vascular dementia. Finally, we present a method for removing fNIRS-measured skin blood flow from hemodynamic response to provide more accurate inference. Experimental results from finger tapping task showed that the activated region after physiological noise removal is more localized on the primary motor cortex for a given p-value. The new developments will be included in the next release of NIRS-SPM.

Bio: Sungho Tak, Ph.D. received the B.S. degree in Biomedical Engineering from Kyung Hee University, Korea, in 2006. He received the M.S. and Ph.D. degree in Bio and Brain Engineering from KAIST, Korea, in 2008 and 2011, respectively. He is currently a postdoctoral researcher at Dept. of Bio and Brain Engineering of KAIST. His current research interests include functional near-infrared spectroscopy, biophysical models for neurovascular coupling, and computational statistics.

Seung-Goo Kim, M.Sc.
Department of Brain and Cognitive Science
Seoul National University

Sparse Shape Representation using the Laplace-Beltrami Eigenfunctions and Its Application to Correlating Functional Signal to Subcortical Structures

Abstract: We present a new sparse shape modeling framework using 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 on surface coordinates. 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 by imposing $l1$-penalty. The new sparse framework can further avoids additional surface-based smoothing often used in the field. The proposed framework is applied in investigating the influence of age (38-79 years) and gender on amygdala and hippocampus shapes in the normal population. In addition, we show how the emotional response is related to the anatomy of the subcortical structures.

Bio: Seung-Goo Kim is a Ph.D. student at Seoul National University in the department of Brain and Cognitive Science. He received his B.A. in Psychology and Economics from Yonsei University and M.Sc. in Cognitive Science from Seoul National University. For the M.Sc. research, he worked on the MEG experiments on the cognitive processing on the musical chord progression in human brains, which was published in PLoS ONE. Since 2010, he has been working on problems in computational anatomy with Dr. Moo K. Chung.