MARCH 5TH: MEDICAL IMAGING / SIGNAL PROCESSING

Dr. Yunmei Chen, *University of Florida*

Deformable Multi-modal Image Registration by Maximizing Renyi's Statistical Dependence Measure.

We present a novel variational framework for deformable multi-modal image registration. Our approach is based on Renyi's statistical dependence measure of two random variables with the use of reproducing kernel Hilbert spaces associated with Gaussian kernels to simplify the computation. The popularly used method of maximizing mutual information based optimization algorithms are complex and sensitive to the quantization of the intensities, because it requires the estimation of continuous joint probability density function (pdf). The proposed model does not deal with joint pdf but instead observed independent samples. Experimental results with comparisons are provided to show the effectiveness of the model.

Ning Zhang, *Rensselaer Polytechnic Institute*

Log Elastographic Algorithm For Shear Stiffness Recovery Using 2D Elastic System.

Elastography is a newly developed promising medical imaging technique, which detects or characterizes tissue abnormalities by imaging the elastic properties of the tissue. In elastography, tissue is excited mechanically from initial rest status, and then the interior displacement of the propagating wave is measured as a function of time and space. In this talk, we focus on the reconstruction of tissue elastic parameters where we assume the propagating wave data is modeled by a 2D linear elastic system. We present a nonlinear Log-Elastographic algorithm to recover the shear modulus or shear wave speed together with the pressure from single frequency elastographic displacement data. This algorithm effectively controls potential exponential growth in the error, which can occur when solving first order linear partial differential equation systems when the coefficient of the zeroth order term in shear stiffness has the wrong sign or when all coefficients of the zeroth and first order terms are complex. We compare images obtained with this new algorithm and images obtained with the locally constant assumption algorithm and exhibit examples to show that this full inversion algorithm improves the quality of the recovered images. We also show images of stiffness variations in a human liver; the images are created with *in vivo* data. If time permits, our stability and accuracy results for the Log Elastographic method will be discussed.

Fuhua Chen, *University of Florida*

A New Framework of Multiphase Segmentation and Application to Partial Volume Segmentation.

An important task of image segmentation is to distinguish objects from background without affected by noise. But for brain MR image segmentation, there is another big challenge, i.e., to find partial volume caused by limited resolution and overlapping. In this paper, we proposed a framework of multiphase segmentation based on statistics and phase transition theory. Different from previous works, the framework supposes that each phase i is a family of random samples from a population fi(x) which is the PDF of a Gaussian distribution. Compared with most piecewise constant Mumford-Shah kind models, the proposed framework is robust in restraining noise. Moreover, the partial volumes can then be naturally taken as mixed Gaussian distributions, and by properly choosing an approximation function for phase characteristic function, the framework will lead to a soft segmentation. The framework is therefore applied to partial volume segmentation. Although the partial volume segmentation in this paper is focused on brain MR image, the proposed framework can be applied to any segmentation containing partial volume caused by limited resolution and overlapping.

Sadeq Damrah, *University of Alabama, Tuscaloosa*

Application of Patch Local Correlation as an Image Denoising Technique

Image denoising is a major concept in preprocessing images to obtain clean images for further analysis. Many denoising techniques have been proposed to solve such problems some of which are explained and analyzed. In this work, we present many tools for denoising images including our proposed method The Local Correlation Denoiser Method. The main idea is to find a linear combination of two images of the same object with similar, yet complementary characteristics. So we choose a blurry image and a noisy image (with streaks but no blur). We let I be the noisy image and J the blurry image then K the resulting image is defined as the linear combination of I and J. The model has been applied to both phantom and in vivo human brain data. Using the normalized correlation function, we obtained the weights of I and J and obtained comparable results in a relatively short processing time.

Prashant Athavale, *University of Maryland, College Park*

A novel integro-differential model for multiscale image decomposition

Since the early days of the field of image analysis, multiscale image decomposition has been one of its important aspects. We introduce here a novel integro-differential equation that emerges from the hierarchical (BV z;L2) multiscale image decomposition methods introduced by Tadmor, Nezzar and Vese. Viewed as a function $f \in L2(\Omega)$ the given image is decomposed into sums of simpler ”atoms" uk , where uk extracts more re_ned information from the previous scale uk-1. In this paper we note that the iterative scheme of Tadmor et. al. gives rise to an integro-differential equation $\int_0^t w(x; s)ds = f(x) + 1/2 \lambda(t)$ div (gradw(x;t)/abs(grad w(x;t)) in Ω , where $\lambda(t)$ is an increasing, non-negative, unbounded, real-valued function. We show here that if we let $\epsilon(t) = \int_0^t w(x; s)ds - f(x)$, then its star-norm $||\epsilon(t)||_* = 1/2 \lambda(t)$. We also discuss here the effect of blurring and propose a deblurring method along with a new approach.

Xiaojing Ye, *University of Florida*

MR Image Reconstruction via Sparse Representation: Modeling and Algorithm.

To reduce acquisition time in magnetic resonance (MR) imaging, compressive sensing and spares representation techniques have been developed to reconstruct MR image with partially acquired data. Although this has been a hot research topic in the field, it has not been used clinically due to three inherent problems of its current framework: potential to damage fine structures, difficulty to predefine model parameters, and long reconstruction time. The aim of this work is to tackle these problems. We propose to minimize the total variation of the underlying image, together with the l1 norm of the coefficients in its representation using a trained dictionary, as well as a fidelity term. Using a trained dictionary can take the advantage of prior knowledge and hence improve accuracy in reconstruction. Our data fidelity constraint is derived from the likelihood estimator of the recovering error in partial k-space to improve the robustness of the model to parameter selection. Moreover, a simple and efficient numerical scheme is provided to solve this model faster. The consequent experiments on both synthetic and in vivo data indicate the improvement of the proposed model in preserving fine structure, reducing computational cost, and flexibility of parameter decision.

Ryan A. Hass, *Oregon State University*

2D and 3D CT Reconstructions From Shifted Data.

A major development in 3D computed tomography in recent years has been the emergence of theoretically exact reconstruction algorithms. This talk reports on ongoing investigations with regard to errors introduced by measured x-ray data with an unknown center of rotation. We will study the sensitivity to the center of rotation of the filtered back-projection type algorithm based on Katsevich's exact reconstruction formula for 3D helical computed tomography and its counterpart in fanbeam computed tomography.

Ouyang, Yuyuan, *University of Florida*

A Total Variation Framework in Image Reconstruction and Denoising for Partial Parallel Image.

In this work, a total variation based denoising method for partial parallel imaging (PPI) is proposed. In PPI, there are multichannel receiver coils implemented to reduce scan time in various applications. Current PPI methods such as SENSE, GRAPPA, hpGRAPPA may yield artifacts or high noise level in the reconstructed image. To reduce the noise level and removing artifacts while keeping the important features in the image, a total variation plus L1 sparsity regularization method is developed, where regularization parameters are adaptively changing according to the regularization energy. The proposed method is based on the SENSE approach, while the sensitivity maps are reconstructed iteratively along with the images. The experimental results show lower noise level and fewer artifacts, while the detailed information in the image is still preserved.