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Approximation Techniques in Data Analysis

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Program

Morning Session, September 2, 2010 Chairman: Rong-Qing Jia

9:00–9:50: *Qianshun Chang*

A Robust and Fast Combination Algorithms of Split Bregman Method for Deblurring and Denoising

9:50–10:40: *Jianzhong Wang*

Construction of Local Nonlinear Kernel in Image Restoration

10:40–11:30: *Jianfeng Cai*

Singular Value Thresholding Algorithms for Low-rank Matrix Completion

Afternoon Session, September 2, 2010 Chairman: Jianzhong Wang

2:00–2:50: *Bin Han*

Nonhomogeneous Wavelet Systems and Frequency-based Framelets

2:50–3:40: *Jun Xian*

Local Sampling and Reconstruction in Shift-invariant Spaces and Their Applications in Spline Subspaces

Morning Session, September 3, 2010 Chairman: Bin Han

9:00–9:50: *Rong-Qing Jia*

Relaxation Methods for Image Denoising Based on Difference Schemes

9:50–10:40: *Song Li*

Some Results of ℓ_p Minimization Problems for $0 \leq p \leq 1$ in Compressive Sampling

Abstracts

Singular Value Thresholding Algorithms for Low-rank Matrix Completion

Jianfeng Cai, University of California at Los Angles, USA

Low-rank matrix completion refers to recovering a low-rank matrix from a sampling of its entries. It routinely comes up whenever one collects partially filled out surveys, and one would like to infer the many missing entries. Matrix completion is a natural extension of compressed sensing. Candes and his co-authors proved that one can solve the low-rank matrix completion problem exactly by minimizing a nuclear norm (the L_1-norm of the vector of singular values) function subject to linear constraints. In this talk, I will present singular value thresholding algorithms for the nuclear norm minimization arising from low-rank matrix completion.

A Robust and Fast Combination Algorithms of Split Bregman Method for Deblurring and Denoising

Qianshun Chang, Chinese Academy of Sciences, China

In this paper, we propose two efficient algorithms for split Bregman method for deblurring and denoising. The split Bregman method is used to convert nonlinear TV model into linear systems. Then, the FFT method is applied to solve the linear system with the blurring operator. Another method is to combine algorithm of algebraic multigrid method and Krylov acceleration method for deblurring and denoising.

For the linear system, we have deduced convergence analysis to determine an auxiliary linear term that significantly stabilizes and accelerates the outer iteration of the linear system. The inclusion of the linear stabilizing term plays a crucial role in our combination algorithm. The iterative convergence is proved.

The two algorithms are efficient and robust. Our algorithms also prove to work efficiently over a wide range of parameters. We have conducted extensive numerical experiments. The result shows that our algorithms are efficient and robust for μ ranging from $O(1)$ to the pure blurring limit $\mu = 100$ and various strong blur operators such as the out of focus and truncated Gaussian. The results of numerical experiments are given and compared with some published papers.

Nonhomogeneous Wavelet Systems and Frequency-based Framelets

Bin Han, University of Alberta, Canada

Linked with discretization of continuous wavelet transforms, most wavelets (including framelets) studied in the literature are homogeneous wavelet systems generated by square integrable functions. However, in this talk, we show that nonhomogeneous wavelet systems, in particular with wavelet generators being distributions in the frequency domain, play a fundamental role by naturally linking many aspects of wavelet analysis together. For example, we show that every dual framelet filter bank is naturally associated with a pair of frequency-based nonhomogeneous dual framelets in the distribution space, for which we have a complete and simple characterization. Directional framelets in high dimensions will be also mentioned in this talk.

Relaxation Methods for Image Denoising Based on Difference Schemes

Rong-Qing Jia, University of Alberta, Canada

In this talk, we propose some relaxation methods that can be used to design very fast iteration schemes for image denoising based on the total variation model. By using certain techniques from convex optimization, we establish the convergence of the iteration schemes based on these relaxation methods. Furthermore, we provide some empirical formulas for the parameters needed in the denoising model. As a result, we are able to construct automatic algorithms for image denoising that produce nearly optimal results. Finally, we apply the relaxation methods to image denoising based on high-order difference schemes. The resulting iteration scheme is fast and yields significantly better image quality than the numerical schemes based on the total variation model.

Some Results of ℓ_p Minimization Problems for $0 \leq p \leq 1$ in Compressive Sampling

Song Li, Zhejiang University, China

In this talk we shall investigate some problems in compressive sampling. We give a new bound on the restricted isometry constant δ_{2k} to guarantee the equivalence of (P_0) problem and (P_1) problem. This improves some earlier results of Candes, Lai, and Cai. We also study the ℓ_p minimization problem for $0 < p < 1$ and obtain some interesting results.

Construction of Local Nonlinear Kernel in Image Restoration

Jianzhong Wang, Sam Huston University, USA

This paper introduces an innovative approach to the construction of a local nonlinear kernel in image processing, which has no staircase effect. A local nonlinear kernel changes its characters depending on the image content within a local area. Hence, it may preserve the image features. Due to its local property, the filtering algorithm has simple structure and fast performance. Two well-known local nonlinear kernels are Yoroslavsky's neighborhood filter (also called sigma filter) and the bilateral filter (also called SUSAN filter). These filters produce very fast and effective denoising algorithms. But, unfortunately, they show staircase effect. To overcome their drawback, in this paper we construct a new local nonlinear kernel, called directly diffusion filter (DDF). DDF preserves image features and does not show a staircase effect. We also study the DDF's properties and reveal the relation between DDF and Rudin-Osher-Fatemi's TV model. Since the DDF denoising algorithm is very fast and use very few memories, it can be applied in the real-time processing for the devices without many memories, such as cell-phones, security cameras, and multi-spectral imagery sensors.

Local Sampling and Reconstruction in Shift-invariant Spaces and Their Applications in Spline Subspaces

Jun Xian, Sun Yat-sen University, China

The local reconstruction from samples is one of the most desirable properties for many applications in signal processing. Local sampling is practically useful since we need only

to consider a signal on a bounded interval and computer can only process finite samples. However, the local sampling and reconstruction problem has not been given as much attention. Most of known results concern global sampling and reconstruction. There are only a few results about local sampling and reconstruction in spline subspaces. In this paper, we study local sampling and reconstruction in general shift-invariant spaces and finitely generated shift-invariant spaces with compactly supported generators. Then we give several applications in spline subspaces and finitely generated spline subspaces.