Abstracts: Image Processing and Computational Methods

Auditorium, Young Library
University of Kentucky
Lexington, Kentucky

March 21-23 (Fri-Sun), 2003
www.ms.uky.edu/∼skim/IPCM03

Mar.21 (Fri)

9:00 - 9:45; Yunmei Chen

Using prior shape and intensity profile in medical image segmentation

In this talk we will present a novel variational framework for boundary determination that incorporates information about the expected shape and local intensity profile in geometric active contours. The basic idea of this model is to minimize an energy functional which depends on the image gradients, the shape of interest, and the intensity profile across the shape. The variational level set formulation of the proposed model is also provided. Experimental results on cardiac ultrasound images are presented. These results indicate that the proposed model provides close agreement with expert traced borders. The existence of the solution to the proposed minimization problem is also discussed.

9:50 - 10:35; Shaun Love

Stochastic Methods in Image Rendering

Rendering an image to print comprises steps that include Scaling, Color Conversion and Halftoning. Traditional methods for performing these steps are often computationally complex or yield suboptimal results. Stochastic alternatives to these rendering steps are presented. The computational efficiency of these methods and resulting image quality are considered.

11:00 - 11:45; Tony Chan

A fast algorithm for variational level set image segmentation

I'll first give an overview of a family of variational image segmentation models based on using level set representation of segment boundaries. The distinctive feature is use of regional information without using edge detection explicitly. The methodology can handle scalar and multi-valued images, multiple level sets, and logical combinations of information from different channels. In the 2nd part of the talk, I'll present a fast computational algorithm for computing the solution of these variational segmentation models. Instead of the typical PDE-based gradient descent algorithms, the new algorithm is optimization-based and make use of the objective function directly, without the need for any gradient information. The new algorithm speeds up the traditional algorithms dramatically. For 2-phase images, we prove that the algorithm finds the correct segmentation with only one sweep over the pixels of the image, regardless of the ordering of the pixels or the initial level set.

(2nd part joint work with Bing Song, UCLA)

1:30 - 2:15; **Ross Whitaker**
A PDE-Based Framework for Processing Surfaces

This talk presents some recent work on using PDEs to process surfaces. It addresses some questions in using higher order methods for surface denoising, reconstruction, and enhancement. It also addresses some computational issues and presents new results on solving level-set surface deformations at interactive rates.

2:20 - 3:05; **HongKai Zhao**
Imaging both the location and size of an extended target using an active array

An active array of transducers can both send out and record signals. In this talk I will talk about how to probe a medium and image extended targets using the response matrix of an active array. The response matrix is formed by recording the inter-element response. I will first talk about the relation between the response matrix and iterated time reversal. I will then analyze the leading eigenvalues and eigenvectors of the response matrix in terms of the location and geometry of the target. Finally I will present an algorithm that can imagine both the location and size of an extended target.

3:30 - 4:15; **Sung Ha Kang**
An error analysis on image inpainting problems

Image inpainting is to restore an image with missing information. In recent five years, there have been many developments on these image inpainting problems, including works by Bertalmio, Sapiro, Caselles and Ballester, Masnou and Morel, Chan, Kang and Shen. This talk will be on curvature based inpainting method, followed by some works on mathematical error bound for these inpainting problems.

Mar.22 (Sat)

9:00 - 9:45; **Daniel L. Lau**
Spatial and Spectral Characterization of Stochastic Halftones

Digital halftoning is the process of converting a continuous-tone image to black and white dots for the purpose of display on binary devices. Stochastic halftoning refers to algorithms that reproduce this tone using a random distribution of dots, and such halftones have been shown to produce the highest apparent resolution in the printed image, but only when these halftones ad here to certain spatial and spectral traits. In this paper, we review some of those traits that have, for the past 15 years, shaped the research being done in this area of image processing, while also reviewing some of the problems that remain to be addressed.

9:50 - 10:35; **Xiaobing Feng**

On total variational flow and its finite element approximations

In this talk, I will present some recent results on the gradient flow of the total variation functional (TV flow), which arises from image processing, materials science and geometric applications. First, I will present an L^2 theory for the TV flow, in which the well-posedness of the TV flow is established using the energy method. The main idea for obtaining these results is to exploit the relationship between a well-known regularized gradient flow, characterized by a small positive parameter ε, and the minimal surface flow as well as the prescribed mean curvature flow. Since this approach is constructive and variational, so numerical methods (such as finite element, finite volume and spectral methods) can be naturally formulated for approximating the weak solutions of the TV flow. Second, I will present the convergence results on some fully discrete finite element approximations for the TV flow. Numerical results will also be given to show efficiency of the proposed numerical methods. This is a joint work with Andreas Prohl of ETH Zürich, Switzerland.

11:00 - 11:45; **Aly A. Farag**

Stochastic models in image analysis: Parameter estimations and case studies in image segmentation

Stochastic models of images are commonly represented in terms of three random processes (random fields) defined on the region of support of the image. The observed image process G is considered as a composite of two random process: a high level process G^h , which represents the regions (or classes) that form the observed image; and a low level process G^l, which describes the statistical characteristics of each region (or class). The representation $G = (G^h, G^l)$ has been widely used in the image processing literature in the past two decades. Various statistical and algorithmic problems have been dealt with in the context of the particular application. The main problems associated with this representation include the selection of appropriate models for the processes G^h and G^l and estimation of the parameters of these models. It is often the case that only a few observations (sometimes only one image) from the process G are the only available information. The maximum a posterior estimation (MAP) has been very popular in the study of parameter estimation.

In this paper, we consider the low level process G^l as mixture of normal distributions and we will use the Expectation-Maximization (EM) algorithm to estimate the mean, the variance, and proportion for each distribution. A popular model for the high level process G^h has been the Gibbs-Markov random field (GMRF) model. We introduce two novel unsupervised approaches to estimate the parameters of a GMRF model. In the first approach we use a genetic algorithm to minimize the error between the original image and a regenerated image, obtained by the parameters estimated in the previous step. In the second approach, we estimate the model parameters that maximize the posterior probability of each pixel in a given image. The MAP estimate is obtained using a combination of genetic search and deterministic optimization using the iterated conditional mode (ICM) approach of Besag. The desired estimate of the GMRF parameters is the one corresponding to the MAP estimate.

We apply these parameters estimation approaches to various synthetic and practical images, in order to assess their robustness and computational performance. We show that these novel methods for parameter estimation do indeed work on various image processing applications including CT scans and aerial hyperspectral images. We also discuss the quality of the estimates and their computational requirements on various images.

1:30 - 2:15; **Shouhong Wang**

Structure and Motion Based on Incompressible Fluid Flows

In this talk, I shall a recently developed theory on the structure and its evolution in the physical space for 2-D incompressible fluid flows. The main philosophy is to classify the structure of the instantaneous velocity field, and to study its motion under the solutions of Navier-Stokes or the Euler equations. This philosophy is in the same spirit as that in the studies for geometrically based motion. To demonstrate the idea, I shall focus on a rigorous characterization of boundary layer separation, a long standing problem in fluid mechanics. Numerical simulations supporting the theory will be presented as well.

2:20 - 3:05; **Kevin Donohue**

Parametric imaging for ultrasonic breast scans using the generalized spectrum

A technique is presented for creating parametric images of radio frequency (rf) ultrasonic breast scans from parameters based on the general spectrum (GS). A three component model is used to describe small regions of breast tissue (on the order of 2mm by 4 mm) in terms of general scattering structures, which include regions dominated by either diffuse, specular or duct scatterers. The GS parameters related to these structures are computed to transform the image into an intensity image showing the likelihood of each region containing a certain structure type. Three types of normalization techniques are used in the GS estimation, including the energy normalization, system normalization, and regional normalization. The spatial resolution of the parameters computed over the rf scan is sufficient for a visual comparison between the parametric images and the original (echo intensity) images. The complexity of breast tissue structures results in nonstationarities that complicate tissue scatterer modeling for consistent applications of appropriate signal processing methods. The methods presented in this work can be useful for segmenting tissue into statistically homogeneous regions and greatly enhancing the performance of signal processing methods that use assumptions of stationarity or general assumptions on the scatterer structures. The performances of parametric imaging based on 3 types of normalization techniques for GS estimation are presented and compared.

This work is supported by the National Cancer Institute and the National Institutes of health Grant PO1-CA52823.

3:30 - 4:15; **Lothar Reichel**
Iterative methods for Tikhonov regularization

The solution of large-scale ill-posed problems that arise in image restoration problems has recently received considerable attention. Many of the available solution methods are based on Tikhonov regularization. This talk presents new iterative methods for Tikhonov regularization that explore the connection between orthogonal polynomials, Gauss quadrature and Lanczos bidiagonalization. Methods for unconstrained and constrained regularization problems will be discussed and comparisons with other available iterative methods will be presented.

4:20 - 5:05; **Seongjai Kim**
Efficient and reliable numerical methods for PDE-based image restoration

As image processing applications require higher levels of *reliability* and *efficiency* for the last two decades, mathematical image processing, particularly the PDE-based approach, has become an important component. Designing appropriate *numerical* techniques for the PDE models is another important component of PDE-based approaches, because roughly-developed numerical schemes can easily mislead characteristics of the model and may not perform satisfactorily in image processing. In this talk, we introduce (a) *efficient and reliable numerical algorithms for nonlinear PDEs* and (b) *their applications to noise removal and enhancement*, for images in either gray-scale or color.