Dissertation Defense

Practical Image Deblurring — with Synthetic Boundary Conditions, with GPUs, and with Multiple Frames

Ying Wai (Daniel) Fan
Emory University

Abstract: Researchers usually use several assumptions when they tackle the image deblurring problem. In particular, it is usually assumed that the blur is known exactly, and that the true image scene outside the field of view is approximated well by periodic boundary conditions. These assumptions are certainly not true in most realistic situations.

In this thesis we develop a new method to derive adaptive synthetic boundary conditions directly from the blurred images. Compared with classical boundary conditions, our approach gives better deblurring results, especially for motion blurred images. To speed up the deblurring algorithms, we also develop a new regularized DCT preconditioner.

We have written two new software packages to facilitate research in image deblurring. The first one PYRET is a serial CPU implementation in Python. With the object-oriented paradigm, we implement numerical algorithms for the general linear problem, and then specialize them for deblurring problems with a new matrix class. A web user interface for PYRET is also provided.

The second software package PARRET is a parallel implementation on NVIDIA CUDA GPU architecture. GPUs provide an economical way to obtain parallel processing power. On a consumer laptop equipped with a GPU, we can attain orders of magnitude speedup with PARRET.

Finally, we consider a blind deconvolution problem in which the involved atmospheric blurs are not known in advance. We first reduce the number of variables using a variable projection technique, then solve the reduced problem by the Gauss-Newton algorithm. With careful mathematical manipulation, the Jacobian matrix is decomposed into a series of diagonal and Fourier matrices for inexpensive multiplication. To further improve the deblurring quality, we use more than one blurred image from the same object. We use a new decoupling approach for the sparsity of the Jacobian matrix in this multi-frame case. Experiments show that the deblurring result improves when more images are used.

Monday, July 26, 2010, 4:00 pm
Mathematics and Science Center: W301

Advisor: James Nagy

Mathematics and Computer Science
Emory University