Dissertation Defense

Inverse Problems in Hyperspectral Imaging

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Abstract: In hyperpsectral imaging, multiple images of the same scene are obtained over a contiguous range of wavelengths in the electromagnetic spectrum. Hyperspectral images represent observations of a scene at many different wavelengths and most importantly associate to each pixel in the imaged scene a full spectral vector or spectral signature. However, due to the presence of spectral mixtures (at different scales) in the scene and/or low spatial resolution of the hyperspectral sensor, the acquired spectral vectors of each pixel are actually a mixture of the spectra of the various materials present in the spatial coverage area of the corresponding pixel, and they also contain additional degradations caused by atmospheric blurring.We present a numerical approach for deblurring and sparse unmixing of space objects taken by ground based telescopes. A major challenge for deblurring hyperspectral images is that of estimating the overall blurring operator, taking into account the fact that the blurring operator point spread function (PSF) can be wavelength dependent and depend on the imaging system as well as the effects of atmospheric turbulence. We formulate the PSF estimation as a nonlinear least squares problem, which is solved using a variable projection Gauss-Newton method. Our analysis shows that the Jacobian can be potentially very ill-conditioned. To deal with this ill-conditioning, we use a combination of subset selection and regularization. We then incorporate the PSF estimation scheme with a preconditioned alternating direction method of multipliers to solve the deblurring and sparse unmixing problem. Experimental results illustrate the effectiveness of the resulting numerical schemes.

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