Multiband Image Restoration in Remote Sensing

José Manuel Bioucas Dias

Abstract

Remote sensing images of the earth, oceans, atmosphere, and space acquired by onboard imaging instruments are at the heart of Earth monitoring and understanding. Fostered by technological advances in various fronts, the wealth and quality of the remotely sensed images from diverse regions of the electromagnetic spectrum have increased at a huge rate, enabling the extraction of vital information for various remote sensing purposes.

However, several degradation mechanisms prevent the direct extraction of useful information from the images, calling for sophisticated restoration methods. The degradation mechanisms include, namely, low spatial resolution, undersampling, noise of various types, and atmospheric effects. Tackling these difficulties corresponds to a suite of inverse problems that are currently on the remote sensing research agenda, namely denoising, deconvolution, super-resolution, and fusion. Compressive acquisition is a related theme which, although not originated in a degradation mechanism, can also be interpreted as a restoration problem.

The talk is focused on the following multiband imaging restoration problems, appearing namely in hyperspectral and multispectral imaging: denoising, deconvolution, super- resolution, fusion, and compressive acquisition. Although these four problems are different in their details, they share a common objective: to restore original images from degraded versions. For each restoration problem, the underlying mathematical problem is formulated under variational and Bayesian frameworks, and the available solutions, ranging from classical to state-of-the-art, are summarized, characterized, and compared. Image restoration examples applied to simulated and real data will be provided.

The presentation can be tuned to specific audiences (e.g., students or remote sensing scientists).

Unmixing of Remotely Sensed Hyperspectral Images

José Manuel Bioucas Dias

Abstract

Hyperspectral cameras (HSCs) acquire spectral vectors with hundreds or thousands of components from each pixel in a remotely sensed surface or scene. The wide spectral coverage and high spectral resolution of these instruments enable fine material identification via spectroscopic analysis, which facilitates countless applications that require identifying materials in scenarios unsuitable for classical spectroscopic analysis.

However, the spectra acquired by HSCs are often mixtures of the spectra of the materials present in the scene (termed endmembers) under analysis. The spectral mixing is due to, namely, low spatial resolution of HSCs, microscopic material mixing, and multiple scattering. Hyperspectral

unmixing (HU) is a blind source separation problem that aims at estimating the number of endmembers, their spectral signatures, and the material abundances at each pixel. HU is a challenging ill-posed inverse problem, owing to model inaccuracies, highly correlated spectral signatures, mixing nonlinearities, observation noise, atmospheric perturbations, and endmember variability.

In this talk, I will review the blind HU inverse problem, which appears not only in remote sensing applications but also, namely, in chemometrics, topic modeling, and audio. I will address key developments, which include mixing models, pure pixel search, convex geometry, dictionary-based sparse regression, and nonnegative matrix factorization. Mathematical problems and potential solutions are described from the viewpoint of signal processing theory and methods. Algorithm characteristics are illustrated. Examples of different HU approaches applied to simulated and real data will be provided.

The presentation can be tuned to specific audiences (e.g., students or remote sensing scientists).

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José Bioucas-Dias (S'87–M'95–SM'15–F'17) received the EE, MSc, PhD, and Habilitation degrees in electrical and computer engineering from Instituto Superior Técnico (IST), Universidade Técnica de Lisboa (now Universidade de Lisboa), Portugal, in 1985, 1991, 1995, and 2007, respectively. Since 1995, he has been with the Department of Electrical and Computer Engineering, IST, where he is an Associate Professor and teaches inverse problems in imaging and electric communications. He is also a Senior Researcher with the Pattern and Image Analysis group of the Instituto de Telecomunicações, which is a private non-profit research institution.

His research interests include inverse problems, signal and image processing, pattern recognition, optimization, and remote sensing. Dr. Bioucas-Dias has authored or co-authored more than 300 scientific publications including more than 90 journal papers (78 of which published in IEEE journals) and 210 peer-reviewed international conference papers and book chapters. He is included in Thomson Reuters' Highly Cited Researchers 2015 list.

Dr. Bioucas-Dias was an Associate Editor for the IEEE Transactions on Circuits and Systems (1997-2000) and IEEE Transactions on Image Processing (2010-2014) and he is a Senior Area Editor for the IEEE Transactions on Image Processing and an Associate Editor for the IEEE Transactions on Geoscience and Remote Sensing. He was a Guest Editor for 6 special issues of IEEE journals (IEEE Transactions on Geoscience and Re- mote Sensing, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing (2), IEEE Signal Processing, IEEE Journal of Selected Topics in Signal Processing, IEEE Geoscience and Remote Sensing Magazine). He was the General Co-Chair of the 3rd IEEE GRSS Workshop on Hyperspectral

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