Nonlinear Unmixing of Hyperspectral datasets: physical, statistical and geometrical prospectives

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I will present an overview of some of the research conducted by the "Remote Hyperspectral Observers", a group in the Electrical and Computer Engineering Department at the University of Massachusetts Amherst dedicated to the study of hyperspectral imaging systems, algorithms and applications. Our research interests include the discovery of evidence of past life in the rocks composing the surface of planets, the integration of hyperspectral imaging and robotics for opportunistic unmanned exploration with rovers and orbiters, the identification of chemical polluting or threatening agents and the investigation of composition and styles of paintings for museums and insurance companies.

In my talk I will focus on our efforts towards identifying the pure signatures in hyperspectral images of particulate media such as geological surfaces and soils. First I will get the audience acquainted with the challenges of unmixing intimately mixed materials.

I will then present a new spectral unmixing method which leverages a "semantic" spectral representation, a set of labels extracted from a statistical model of the fluctuations of wavelet transforms of spectra obtained from a library. Such model is capable of recognizing the pure components from mixed spectra by only leveraging features considered "diagnostic" of a spectral family.

A second prospective on unmixing will be offered by a second approach I will consider, a topological model that identifies pure signatures in a hyperspectral image by considering extreme points on the boundary of the data cloud obtained when considering the pixel of the image as points in a high-dimensional space. The boundary points are identified by measures of centrality on a graph constructed on the point cloud.