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# Estimation of point spread function for unmixing geological spectral mixtures

**Maitreya Mohan Sahoo**[1,2], Arun Pattathal Vijayakumar[3], Ittai Herrmann[2], Shibu K. Mathew[4], and Alok Porwal[1]

[1]Centre of Studies in Resources Engineering, Indian Institute of Technology, Bombay, 400076, India
[2]The Robert H. Smith Institute of Plant Sciences and Genetics in Agriculture, The Hebrew University of Jerusalem, Rehovot, 7610001, Israel
[3]Indian Institute of Information Technology, Sri City, Chittoor, 517646, India
[4]Udaipur Solar Observatory, Physical Research Laboratory, Udaipur, 313001, India

Geological materials are mixtures of different endmember constituents with most of them having particles smaller in size than the path length of incident light. The obtained spectral response (reflectance) from such mixtures is nonlinear which can be attributed to multiple scattering of light and the receiver sensor's height from the incident surface. Assuming a sensor's fixed instantaneous field of view (IFOV), variation in its field of view (FOV) by shifting its height affects the spatial resolution of acquired spectra. We propose to estimate the point spread function (PSF) for which the spectral responses of fine-resolution pixels acquired by a sensor are mixed to produce a coarse-resolution pixel obtained by the same. Our approach is based on the sensor's unchanged IFOV obtaining spectral information from a smaller ground resolution cell (GRC) at a lower FOV and a larger GRC with an increased sensor's FOV. The larger GRC producing a coarse resolution pixel can be modeled as a gaussian PSF of its corresponding center and neighboring fine-resolution subpixels with the center exerting the maximum influence. Extensive experiments performed using a point-based sensor and a push broom scanner revealed such variational effects in PSF that are dependent on the sensor's FOV, the spatial interval of acquisition, and optical properties. The coarse-resolution pixels' spectra were regressed with their corresponding fine-resolution subpixels to provide estimates of the PSF values that assumed the shape of a two-dimensional Gaussian function. Constraining these values as sum-to-one introduced sparsity and explained variability in the spectral acquisition by different sensors. The estimated PSFs were further validated through the linear spectral unmixing technique. It was observed that the fractional abundances obtained for the fine-resolution subpixels convolved with our estimated PSF to produce its corresponding coarse-resolution counterpart with minimal error. The obtained PSFs using different sensors also explained spectral mixing at different scales of observation and provided a basis for nonlinear unmixing integrating spatial as well as spectral effects and addressing endmember variability. We performed our experiments with various coarse-grained and fine-grained igneous and sedimentary rocks under laboratory conditions to validate our results which were compared with available literature.