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On the unmixing of MEx/OMEGA hyperspectral data using a MAP estimator

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Visible and infrared imaging spectroscopy is a key remote sensing technique used to study and monitor planets. It allows the detection, mapping and characterization of minerals, as well as volatile species, whose presence often provide clues for the resolution of Martian key climatic and geological issues. The OMEGA imaging spectrometer onboard Mars Express comprises 352 spectral channels from 0.3 to 5.1 μm at a spatial resolution ranging from 300 m to 4 km and provides the opportunity to investigate the mineralogy of the very top surface of Mars by looking at diagnostic spectral features in the visible and near infrared domains. The subject of this paper is to present a method of supervised unmixing applied on an OMEGA hyperspectral data cube. Data were obtained by looking to the South Polar Cap of Mars during local summer, where CO2 ice, water ice and dust were previously detected. This kind of prior knowledge on the above constituents (image endmembers) was obtained by using an unsupervised approach for hyperspectral data unmixing, namely the recently proposed Bayesian positive source separation (BSS) with positivity constraints [1]. We propose an efficient estimation for the endmembers' corresponding fractions in the pixels of the image, based on a recently proposed maximum a posteriori probability (MAP) method. This method is properly adjusted for hyperspectral data processing, and in particular for abundance estimation problems. To ensure the physical interpretation of the estimation results, the necessary properties of positivity and full additivity of the abundance fractions are both imposed. Closed form expressions are then derived for the statistical parameters required by the MAP estimator. Experimental results consisting of images of estimated abundance fractions are presented and compared to the corresponding existing results of the BSS algorithm. Simulated data are also used to demonstrate the performance and reliability of the proposed method. The proposed method offers significant computational savings as compared to Monte Carlo simulations or quadratic programming methods. This makes the algorithm suitable for (near) real-time processing of large hyperspectral data volumes including significant number of endmembers. First results show that the proposed approach can be a useful tool for providing efficient processing of hyperspectral data.

[1] S. Moussaoui et al, "On the decomposition of Mars hyperspectral data by ICA and Bayesian positive source separation", Neurocomputing, vol. 71, pp. 2194-2208, June 2008.