MARS HYPERSPECTRAL DATA PROCESSING USING ICA AND BAYESIAN POSITIVE SOURCE SEPARATION

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Abstract

The surface of Mars is currently being mapped with an unprecedented spatial resolution. The high spatial resolution and its spectral range give it the ability to pinpoint chemical species on Mars more accurately than before. The subject of this paper is to present a method to extract this information. The proposed method combines two approaches, Independent Component Analysis (ICA) [1] and Bayesian positive source separation (BPSS) [2]. ICA will be applied iteratively for selection of pixels in independent locations of the images, while spatial reconstruction SNR will be used to check whether all the regions are accounted for. BPSS is then applied for the estimation of the pure constituent spectra and their abundances. The hyperspectral images are collected with the OMEGA instrument (Observatoire pour la Minralogie, l'Eau, les Glaces et l'Activit), which is a spectrometer boarded on the European Space Agency Mars Express mission and collects 256 images in the infrared spectral region from 0.926 to 5.108 μm with a resolution of 0.014 μm roughly.

As solar light incident to a planetary surface is partially reflected back by interaction with the different constituents, the analysis of reflectance spectra may allow the identification and the quantification of the chemical species present at the surface of Mars. For the linear model the measured spectra is assumed to be a linear mixture of the reflectance spectra, which is the case for geographical mixture of chemical species on the surface. The actual sources are correlated and thus the fundemental assumption of independence in ICA is not satisfied and therefore ICA is not an adequate method for the unmixing. Moreover, it is important to take into account the positivity constraint of both sources and mixing coefficients. This draws attention to Bayesian approach which is able to manage priors such as positivity, but there we face the problem of high computation time when dealing with vast amount of data (more than 30.000 pixels). In this paper, we propose to combine spatial ICA and

spectral BPSS. The basic idea is to use spatial ICA yielding a rough classification of pixels, which allows selection of small, but relevant, number of pixels. Results of this method are shown and assessed by comparison with reference spectra. Spatial reconstruction error is used to valuate if the found components model all the observed region. This is then used to estimate : (1) if additional sources are present and more components are needed (2) if the linear model is relevant or not.

References:

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