Geophysical Research Abstracts
Vol. 14, EGU2012-11034, 2012
EGU General Assembly 2012

Normalisation of hyperspectral data with respect to illumination and local topography

A. Grumpe, F. Belkhir, V. Zirin, and C. Wöhler

TU Dortmund, Faculty of Electrical Engineering and Information Technology, Image Analysis Group, Otto-Hahn-Straße 4, 44227 Dortmund, {arne.grumpe | christian.wohler} @tu-dortmund.de

Unmixing the apparent reflectance into standard reflectance spectra of so-called endmembers is a common technique in remote sensing of the Moon [Mustard & Pieters 1988]. Recent approaches use distinct features in the reflectance spectrum, such as the depth and position of the minimum of an absorption trough, to estimate elemental abundances of the lunar soil [Wöhler et al. 2010]. It is well known that the apparent reflectance depends on the illumination geometry, and models of the surface reflectance, e.g. the Hapke model [Hapke 1981, 1984, 1986, 2002], were developed. Therefore, a normalisation to a reference geometry is necessary. An important factor governing the illumination geometry is the small-scale topography of the lunar surface. Unfortunately, the lateral resolution of available digital elevation models (DEM) is lower than the lateral resolution of recent spectral observations [Boardman et al. 2011]. Furthermore, the observed radiance is distorted by thermal irradiance [Clark et al. 2011] and might not be pixel-synchronous with the DEM data due to uncertain selenolocation [Boardman et al. 2011].

In this study, we present a general framework to normalise hyperspectral imagery with respect to small-scale topography and variations of illumination geometry. We describe the construction of pixel-synchronous DEMs of very high lateral resolution from single or multiple radiance images using photometric methods [Grumpe & Wöhler 2011]. After correction for thermal radiation, the radiance data are converted to reflectance and normalised to standard geometry (30° incidence angle, 0° emission angle, 30° phase angle) based on the constructed DEMs by applying the Hapke model. We found, however, that this normalisation does not eliminate all topography-related distortions of the spectra, i.e. spectra acquired under standard illumination conditions show different spectral features than spectra of the same lunar surface area acquired under more oblique illumination conditions.

Hence, in a first step we propose an empirical approach to correct the spectra with respect to small-scale topography, using the constructed DEMs of high lateral resolution. In a second step, distortions of the spectra due to deviation of the illumination geometry from standard geometry are compensated. For this purpose, a correction procedure is applied which is calibrated based on Chandrayaan-1 M3 imagery of regions for which data acquired under standard illumination conditions and under oblique illumination are available. In order to be able to generate pixel-synchronous hyperspectral data for images of the same surface region acquired under different illumination conditions, an illumination-independent registration scheme for images acquired under strongly different illumination conditions is developed, which is able to take into account complex topography-related image distortions due to changing viewpoint based on the constructed DEMs.

As a result, corrected hyperspectral data and spectral feature maps are obtained in which topographic effects are no longer apparent. The proposed normalisation approach is required for a direct comparison between the spectral properties of lunar surface regions across a broad range of selenographic latitudes. Hence, it is especially relevant for spectral mapping of the lunar polar regions, which are always observed under oblique illumination conditions.

Boardman, J. W., Pieters, C. M., Green, R. O., Lundeen, S. R., Varanasi, P., Nettles, J., Petro, N., Isaacson, P., Besse, S., Taylor L. A. (2011): Measuring moonlight: An overview of the spatial properties, lunar coverage, selenoloctation and related Level 1B products of the Moon Mineralogy Mapper. Journal of Geophysical Research, Vol. 116, E00G14

Clark, R. N., Pieters, C. M., Green, R. O., Boardman, J. W. (2011): Thermal removal from near-infrared imaging spectroscopy data of the Moon. Journal of Geophysical Research, Vol. 116, E00G16

Grumpe, A. & Wöhler, C. (2011): DEM Construction and Calibration of Hyperspectral Image Data Using Pairs of Radiance Images. Proc. Int. Symp. on Image and Signal Processing and Analysis, Vol. 7, pp 609-614.

Hapke, B. W. (1981): Bidirectional reflectance spectroscopy 1: Theory. J. Geophys. Res. 86, pp. 3039-3054.

Hapke, B. W. (1984): Bidirectional reflectance spectroscopy 3: Correction for macroscopic roughness. Icarus 59, pp. 41-59.

Hapke, B. W. (1986): Bidirectional reflectance spectroscopy 4: The extinction coefficient and the opposition effect. Icarus 67, 264-280.

Hapke, B. W. (2002): Bidirectional reflectance spectroscopy 5: The coherent backscatter opposition effect and anisotropic scattering. Icarus 157, 523-534.

Mustard, J. F. & Pieters, C. M. (1989) Photometric Phase Functions of Common Geologic Minerals and Applications to Quantitative Analysis of Mineral Mixture Reflectance Spectra. Journal of Geophysical Research, Vol. 94, pp. 13619 - 13634.

Wöhler C., Berezhnoy, A., Evans, R. (2011): Estimation of Elemental Abundances of the Lunar Regolith Using Clementine UVVIS+NIR Data. Planetary and Space Science, Vol. 59, pp 92 - 110.