Application of the Gaussian fitting for mineral composition mapping using airborne hyperspectral sensor data

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Mineralogical and lithological mapping by remote sensing widely used in the early stages of metals exploration to narrow down the area with high resource potential. Since clay and carbonate minerals have diagnostic absorption features in the visible to short-wavelength-infrared regions, we can know the types and chemical compositions of these minerals at a target area by determining the wavelength of absorption features observed by remote sensing. The change in absorption associated with difference in mineral types is usually larger than several tens of nanometers. Also, slight change (< 10 nm) in the absorption center can be observed depending on variation of solid solution composition of a mineral.

Today, spaceborne and airborne hyperspectral sensors with higher spectral resolution is available, but still have a spectral resolution of only 5 to 15 nm that is not high enough to detect the slight change for the purpose of mineral mapping. The objectives of this study are to develop a method that allows us to accurately detect the absorption center wavelength from a reflectance spectrum obtained by the hyperspectral sensor and to evaluated the performance of the proposed method.

In this study, it is assumed that the absorption by a single factor in the mineral could be expressed by a Gaussian function, and that the reflectance spectrum observed by the sensor could be expressed by the sum of multiple Gaussian functions. The outline of the proposed method is as follows: First, Continuum Removal (CR) is applied to the observed reflectance spectrum to enhance absorption peaks. Thereafter, the approximate wavelength of the absorption peaks is obtained from the continuous transformation, and is used as the initial value for Gaussian fitting. The number of Gaussian functions used for fitting is gradually increased, and the fitting is terminated based on the error after fitting and the fitting parameters. Each Gaussian function is regarded as an absorption caused by each absorption factor in the mineral.

The performance of the proposed method was evaluated from two viewpoint. Firstly, we evaluated how accurately the proposed method could restore the original spectrum from the convolved and noise-added spectrum, simulated to correspond to the observation by a satellite or an aircraft sensor. Secondly, we evaluated how accurately the proposed method could detect the absorption peaks. A spectrum with known peaks was prepared and convolved to a simulated spectrum with lower spectral resolution in the same manner as the first evaluation. The original spectrum was compared with the simulated spectrum processed by the proposed method. These two performance evaluations showed the effectiveness of the proposed method and the accuracy of the absorption peak detection.
Finally, the proposed method was applied to actual image data obtained by airborne hyperspectral sensors (AVIRIS and AVIRIS-NG) and we compared the results with the field survey verification. To present the result obtained by the proposed method as an image, we employed the HSV color model by assigning absorption center wavelength to H (hue), absorption depth to S (saturation) and V (lightness), respectively. The Cuprite and Goldfield areas in Nevada, USA, and the Mountain Pass area in California, USA, were selected as test sites. The target minerals are epidote in the Cuprite area, alunite in the Goldfield area, and carbonate minerals in the Mountain Pass area. It was proven that the proposed method could successfully show the gradual shifts of the absorption center wavelength of these minerals

corresponding to the variation of chemical compositions. We also confirmed that the result was consistent with the field observations.

Keywords: Remote sensing, Geological mapping, Gaussian fitting

