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Evaluation of a Feature Subset Selection method to find informative spectral bands of Hyperion hyperspectral data for hydrothermal alteration mapping: A case study from the Darrehzar porphyry copper mine, Kerman, Iran

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Introduction

In the regional prospecting of ore minerals, geologists usually utilize remote sensing images for hydrothermal alteration mineral mapping as a kind of lithological anomaly, which may be linked to mineral deposits (Carranza, 2002).

Compared to the multispectral remote sensing images, composed of few spectral bands, the hyperspectral data prepare much more spectral details of the surface materials in many bands. These high spectral resolution images provide subtle spectral data for identifying similar materials of the surface (Camps-Valls et al., 2014). This ability could greatly promote the potential of hyperspectral based mineral mapping (Wang and Zheng, 2010). As in the two last decades, hyperspectral remote sensing has been an important tool for studying earth's minerals and rocks (Zhang and Peijun, 2014).

Although, the high number of spectral bands is an important advantage for hyperspectral images, many of those bands are usually irrelevant and redundant and, therefore, cause just the size and complexity of the band space to be increased. This complexity can lead to an ill-posed problem in supervised classification, namely the curse of dimensionality and the Hughes phenomenon, which negatively affect the accuracy of the classification (Camps-Valls, 2014).

Feature reduction methods can be applied to overcome these problems and to eliminate those spectral bands in the classification of hyperspectral images that provide no further useful information. These methods produce an efficient subset of features (spectral bands in remote sensing field) from the original feature space. The decrease in complexity obtained as a result of the feature space reduction can increase the ability of classifiers to efficiently capture the classification rules. Consequently, the speed, generalization, and predictive classification accuracy are increased (Gheyas and Smith, 2010; Camps-Valls et al., 2014).

This study is aimed at evaluation and management of the curse of dimensionality risk in hyper spectral data classification by means of a feature reduction method. The method is utilized to select more informative spectral bands of Hyperion hyperspectral data, which are more effective for the classification of hydrothermal alteration zones. The well-known study area here is the Darrehzar

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porphyry copper mine located 8 km from the southeast of the giant Sarcheshmeh mine.

Materials and methods

1. Hyperion data

The Hyperion hyperspectral image with 242 spectral bands acquired on July 26, 2004 was available and it was used in this study.

2. Train and test datasets

Two datasets were utilized. The first dataset that resulted from the Mixture Tuned Matched Filtering (MTMF) method was applied to feed the feature reduction method and the second dataset containing 17 rock samples collected from the study area was used to carry out the classification by SVM.

3. The feature reduction method

In this study, we applied a hybrid Feature Subset Selection (FSS) method to reduce the number of spectral bands of Hyperion data. Extensive details may be found in Moradkhani et al. (2015).

Discussion and results

The Feature Subset Selection (FSS) algorithm was applied to reduce the size of the spectral bands of Hyperion data. The implementation of this algorithm resulted in the selection of 9 bands among all 165 spectral bands (i.e. 5% of all useable spectral bands of Hyperion) as the more influential bands for the identification of clay minerals. These bands belong to the two spectral ranges, 2125-2250 nm and 2250-2400 nm, respectively. On the other hand, it is believed that the Short-Wave Infrared (SWIR) electromagnetic range (2000-2500 nm) is an important spectral range for distinguishing clay minerals of the hydrothermal alteration systems (Hosseinjani Zadeh et al., 2014). This implies that two ranges introduced by FSS were accurately selected, because both of them coincide with the SWIR range. Clearly speaking, bands 201, 202, 204, and 205 in the range of 2125-2250 nm are used for muskovit, kaolinit and alunit enhancement. Moreover, bands 217, 220, 222, 223, and 224 in the 2250-2400 nm are appropriate for chlorite classification.

A comparison between the maps of SVM based classification of the alteration zones using 9 (selected by feature selection method) and 165 (all useable bands of Hyperion data) spectral bands confirmed a significant improvement in the output results when 9 more informative bands are utilized for classification instead of all 165 bands. In fact, the classification based on 9 selected bands is comparable and even more effective than the full band classification. This is because the decrease in spectral bands makes SVM learn the rules of classification more accurately.

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