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Towards automatic lithological classification from remote sensing data using support vector machines

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Remote sensing data can be effectively used as a mean to build geological knowledge for poorly mapped terrains. Spectral remote sensing data from space- and air-borne sensors have been widely used to geological mapping, especially in areas of high outcrop density in arid regions. However, spectral remote sensing information by itself cannot be efficiently used for a comprehensive lithological classification of an area due to (1) diagnostic spectral response of a rock within an image pixel is conditioned by several factors including the atmospheric effects, spectral and spatial resolution of the image, sub-pixel level heterogeneity in chemical and mineralogical composition of the rock, presence of soil and vegetation cover; (2) only surface information and is therefore highly sensitive to the noise due to weathering, soil cover, and vegetation. Consequently, for efficient lithological classification, spectral remote sensing data needs to be supplemented with other remote sensing datasets that provide geomorphological and subsurface geological information, such as digital topographic model (DEM) and aeromagnetic data. Each of the datasets contain significant information about geology that, in conjunction, can potentially be used for automated lithological classification using supervised machine learning algorithms.

In this study, support vector machine (SVM), which is a kernel-based supervised learning method, was applied to automated lithological classification of a study area in northwestern India using remote sensing data, namely, ASTER, DEM and aeromagnetic data. Several digital image processing techniques were used to produce derivative datasets that contained enhanced information relevant to lithological discrimination. A series of SVMs (trained using k-folder cross-validation with grid search) were tested using various combinations of input datasets selected from among 50 datasets including the original 14 ASTER bands and 36 derivative datasets (including 14 principal component bands, 14 independent component bands, 3 band ratios, 3 DEM derivatives: slope\curvature\roughness and 2 aeromagnetic derivatives: mean and variance of susceptibility) extracted from the ASTER, DEM and aeromagnetic data, in order to determine the optimal inputs that provide the highest classification accuracy. It was found that a combination of ASTER-derived independent components, principal components and band ratios, DEM-derived slope, curvature and roughness, and aeromagnetic-derived mean and variance of magnetic susceptibility provide the highest classification accuracy of 93.4% on independent test samples. A comparison of the classification results of the SVM with those of maximum likelihood (84.9%) and minimum distance (38.4%) classifiers clearly show that the SVM algorithm returns much higher classification accuracy. Therefore, the SVM method can be used to produce quick and reliable geological maps from scarce geological information, which is still the case with many under-developed frontier regions of the world.