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Analysis of Landsat ETM+ Image Enhancement for Lithological Classification Improvement in Eagle Plain Area, Northern Yukon

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Summary

Remote sensing image enhancement techniques including principal component analysis, band ratioing and grey level co-occurrence matrix have been employed to improve the lithological classification using Landsat ETM+data in the present study. A principal component analysis (PCA) has been performed on the six Landsat ETM+ spectral bands to extract the pertinent information from the different bands and isolate the noise in its own band or bands which can then be ignored. Grey level co-occurrence matrix (GLCM) is one of the widely used approaches to perform textural feature measument. A variety of measures have extracted useful textural information from co-occurrence matrices. Band ratioing was performed on six Landsat ETM+ spectral bands to reduce the effects of environmental factors such as cast shadows in mountainous terrain with high relief. A supervised Supervised classification was performed individually on the six original multispectral ETM+ bands and six new datasets of combination of principal components, ratioing bands and GLCM-based textural parameters. The classification accuracy assessment based on the field investigation and existing geological map shows that the integration of principal component analysis, band ratioing and texture feature analysis had a great contribution in improving the lithological classification in the study area using Landsat ETM+ data.

Introduction

Remote sensing and satellite imagery have been effectively used in geology. Landsat ETM+ image data are the most widely used satellite data sets in geological application, especially, in lithological classification. Lithological classification is a process of distinguishing rock types based on the image classification. Supervised classification is one of the most commonly used approaches of image classification. However, the traditional supervised classification is mostly based on the identification of the unique or typical spectral characteristics of rocks determined by physical and chemical properties of rocks. In addition to the spectral characteristics, the textural features of rocks in satellite remote sensing images, resulting from weathering, erosion and tectonic activities can provide important and valuable information for discriminating rock types. Principal components analysis has been valuable in the analysis of multispectral remotely sensed data and widely used in geological interpretation as an image enhancement approach. Image division or spectral band ratioing, which is one of the most common mathematical operations, can be applied to a multi-spectral image to reduce the effects of such environmental factors and is considered to be an effective method to eliminate the inter-band correction of multispectral image data. The study area is located in the region between latitudes 65º45’ N and 66º00’N, longitudes138º00’ W and 139º30’W, which is a part of Eagle Plain.This study is focused on the principal components analysis, spectral band ratioing, and the textural feature extraction and analysis of the Landsat ETM+ image in the study area which is part of Eagle Plain area, northern Yukon. It is found that integration of texture analysis principal components analysis and band ratioing can be used to improve the lithological classification of the study area in the northern Yukon.

Theory and/or Method

Remotely sensed images are typically taken at a great distance from the earth's surface and electromagnetic energy must pass through a substantial atmospheric path before it reaches the sensor. Therefore, it is essential that remotely sensed imagery be accurately registered to the proposed map base. The rectified images will have geometric consistency with another georeferenced image or map by performing geometric correction. Geometric correction was performed only on the Landsat ETM+ and the scanned Ogilvie River geological map (Norris, 1982). Remotely sensed data acquired by satellite sensor system are usually interfered by atmospheric effects. Atmospheric correction is a process to retrieve the surface reflectance from remotely sensed data by removing atmospheric effects. Among various atmospheric effect removing algorithms, dark-object subtraction method described by Campbell (1993) was used in this study. With large variations in spectral response from a diverse range of object types and even variations due to different time and location for same object type, no generic radiometric correction could optimally account for and display the optimum brightness range and contrast for all object types. Thus, it is necessary to adjust the range and distribution of brightness values for each application and each image. Image enhancement is concerned with the modification of images to enhance the display of its information content or to improve the appearance of an image for human visual interpretation and digital analysis (Jensen, 2005). Image enhancement techniques used in this study include principal components analysis, band rationing and texture feature analysis. Maximum Likelihood classification was performed on the different input datasets. The classification accuracy of the classified result was assessed to evaluate if the image enhancement techiniques used in this study play a role in improvement of lithological classification using Landsat ETM+ data. The procedure of image preprocessing, image enhancement and lithological classification is outlined in Figure 1.

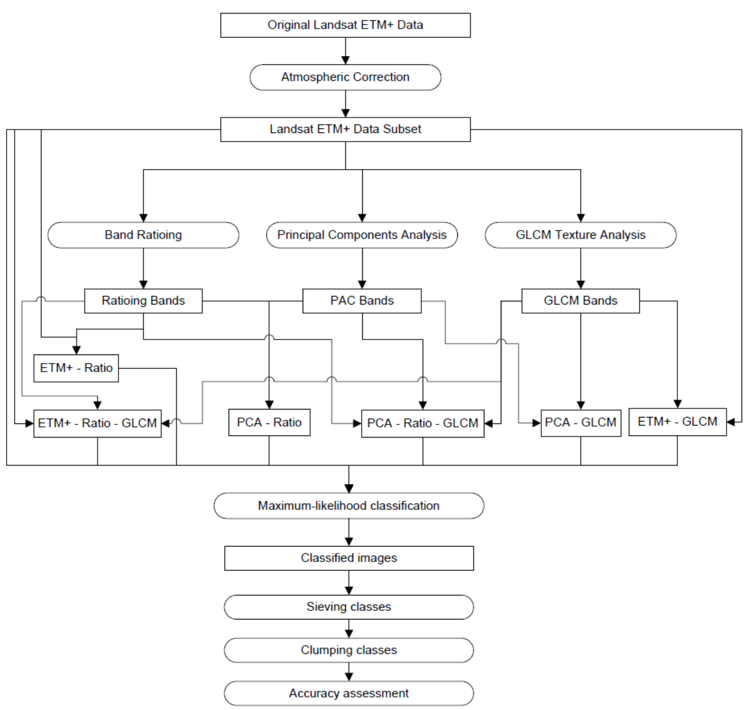

Figure 1: Overview of methodological approach for lithological classification.

Examples

Principal component analysis indicated that the first principal component bands carry the most information of ETM+ image and the other three principal component bands can be ignored based on the loadings of six original bands in principal component bands and principal components variance percentage (Figure 2). Table 1 shows the selected output principal components (PC) bands and PC eigenvalues of the ETM+ image. The four pairs of band ratioing images were visually examined. The original image and the four pairs of band ratioing images were compared. The visual examination and comparison indicated that the band ratioing of bands 7/5 and bands 4/3 worked effectively on the ETM+ image. GLCM analysis showed that three textural parameters including variance, entropy and homogeneity were the optimal textural parameters for differentiating the different rock units. Variance measures the dispersion of the grey levels. Coarse textured features are associated with a higher variance. Entropy is a measure of the disorder of an image. Homogeneity assumes higher values for smaller grey tone differences in pixel pair elements.

A total of fifteen lithological units for the study area were identified on the seven classification images. In order to evaluate the seven classification images produced from the six original multispectral bands and the data combinations of principal components, ratioing bands and GLCM-based textural parameters, the classification accuracy for classification images was assessed using the overall (OA), user's (UA) and producer's (PA) accuracies and the kappa coefficient (K) derived from a confusion matrix (Grebby et al., 2002, Congalton, 1991). The overall classification accuracies and kappa coefficient for the seven Maximum Likelihood classification images were summarized in Table 2. The classification only performed on the multispectral ETM+ data was improved with an OA value of 3.76% and a K value of 0.0284, an OA value of 6.15% and a K value of 0.0537, an OA value of 4.82% and a K value of 0.0395, an OA value of 7.13% and a K value of 0.0569, an OA value of 6.78% and a K value of 0.0545 and an OA value of 7.54% and a K value of 0.0814 by using ETM+-Ratio, ETM+-GLCM, PCA-Ratio, PCA-GLCM, ETM+-Ratio-GLCM and PCA-Ratio-GLCM as the input datasets respectively (Figure 3).

Table 1. Selected output Principal Components bands of TM image.

PC	1	2	3	4	5	6
Eigenvalue	828.190	133.678	85.819	7.047	4.963	2.459
Percentage of variability	77.97%	12.59%	08.08%	0.66%	0.47%	0.23%

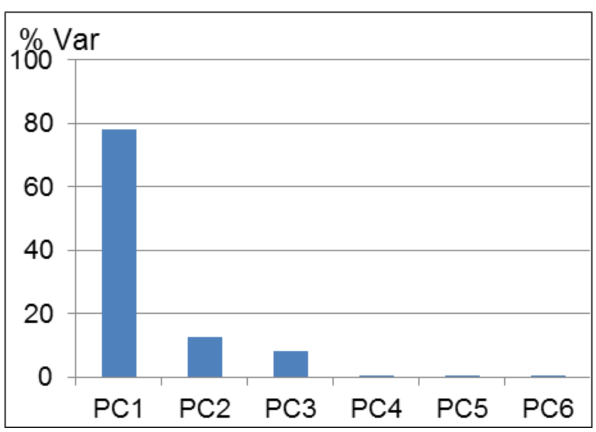

Figure 2. Principal components variance percentage.

Table 2. Classification accuracy of different input datasets of Landsat ETM+ data.

Input dataset	ETM+ multispectral	ETM+-Ratio	ETM+-GLCM	PCA-Ratio	PCA-GLCM	ETM+-ratio-GLCM	PCA-ratio-GLCM
OA	54.73%	58.49%	60.88%	59.55%	61.86%	61.51%	62.27%
K	0.5143	0.5427	0.5680	0.5538	0.5712	0.5688	0.5957

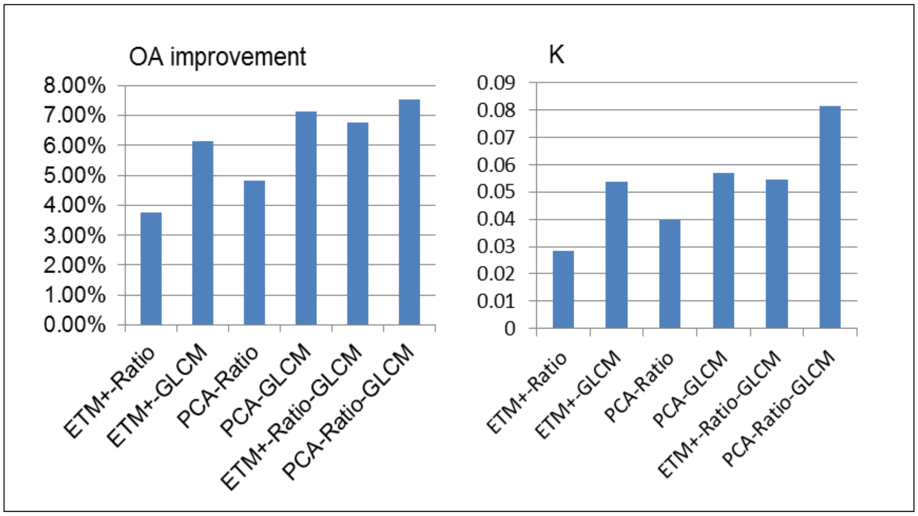

Figure 3. Classification accuracy improvement by comparing classification overall accuracy and kappa coefficient using original Landsat ETM+ data and different combinations of Landsat ETM+ data.

The lithological classification result based on PCA-Ratio-GLCM data had the highest overall accuracy and kappa coefficient (Figure 4).

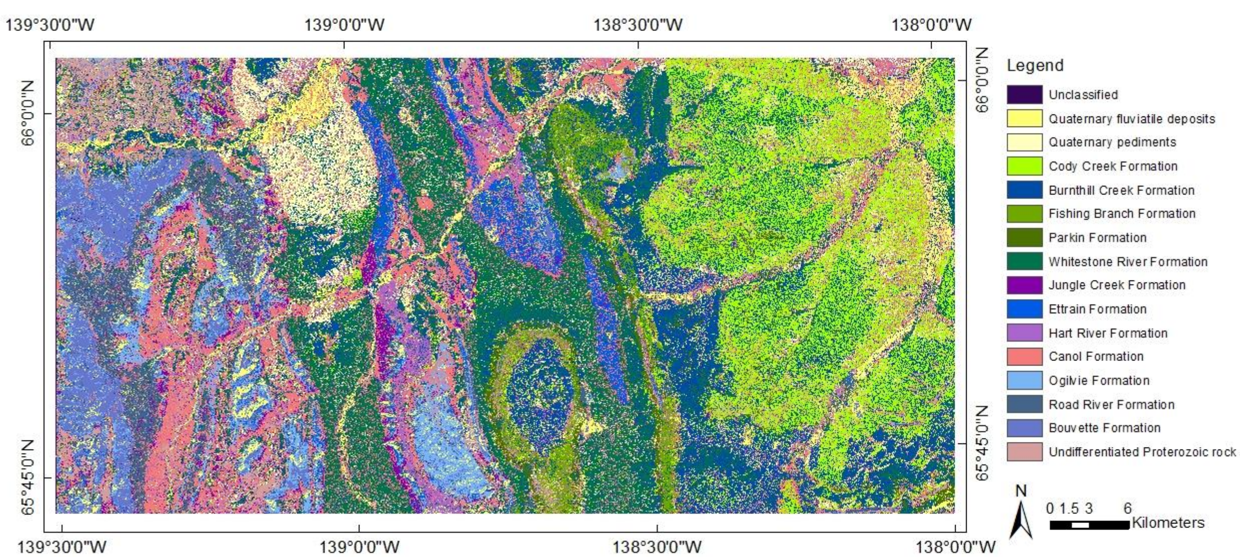

Figure 4.The lithological classification result
based on PCA-Ratio-GLCM combination of Landsat ETM+ data.

In addition to the overall accuracy and kappa coefficient, user's accuracy (UA) and producer's accuracy (PA), the commission and omission errors associated with the individual classes were also used for classification accuracy assessment (Figure 5).

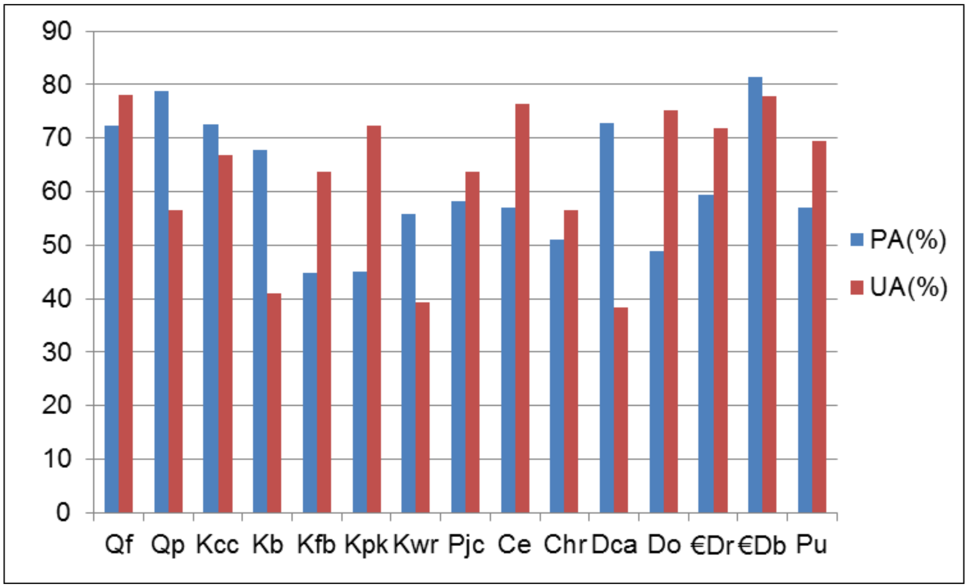

Figure 5. Individual class accuracies for the classification based on PCA-Ratio-GLCM combination of Landsat ETM+ data. (Quaternary fluviatile deposits (Qf), Quaternary pediments(Qp), Cody Creek Formation (Kcc), Burnthill Creek Formation(Kb), Fishing Branch Formation(Kfb), Parkin Formation(Kpk), Whitestone River Formation(Kwr), Jungle Creek Formation(Pjc), Ettrain Formation(Ce), Hart River Formation(Chr), Canol Formation(Dca), Ogilvie Formation (Do), Road River Formation(€Dr), Bouvette Formation(€Db), Undifferentiated Proterozoic rock (Pu)).

Conclusions

Three image enhancement techniques including principal component analysis, grey level co-occurrence matrix and band ratioing were studied. Lithological classification was performed individually on six the original multispectral ETM+ bands and six new datasets of combination of principal components, ratioing bands and GLCM-based textural parameters. It is found that the integration of principal components analysis, band rationing and texture feature analysis can be employed as a powerful tool to improve the lithological classification in the study area using Landsat ETM+ data based on one of the accuracy assessment result that PCA-Ratio-GLCM data had the highest overall accuracy and kappa coefficient.

Acknowledgements

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