Primitive Feature Extraction via a Combined ICA-Wavelet Method for Image Information Mining

Vijay P. Shah, Nicolas H. Younan, Surya S. Durbha, Roger L. King
Department of Electrical and Computer Engineering
GeoResources Institute (GRI)
Mississippi State University, Mississippi State, MS 39762-9571, USA
vps1@ece.msstate.edu, younan@ece.msstate.edu, suryad@gri.msstate.edu,
rking@engr.msstate.edu

Summary

Content- and semantic-based interactive image mining systems describe remote sensing images by means of relevant features. Region-based retrieval systems have been proposed to capture the local properties of an image. Existing systems use computationally extensive methods to extract primitive features based on color, texture (spatial gray level dependency - SGLD matrices), and shape from the segmented homogenous region. Recently, the wavelet transform has been effectively used for feature extraction and region-based segmentation in a semantics-enabled framework to expedite the retrieval process for knowledge discovery in geospatial data archives gained momentum in multimedia image archives to expedite the retrieval process.

Previous research makes color components perceptually independent and uniform by converting the RGB space into the HSV space in order to capture the color information for image segmentation. Thus, this method uses only three bands for image information mining at a time: true color (RGB) or false color (NIR, R, G). Hence, while performing image segmentation, this approach fails to capture the complete spectral pattern – an important characteristic available in remote sensing imagery. Furthermore, the HSV space is statistically correlated. An independent component analysis (ICA)-based approach is used in this study to help capturing the complete spectral information during image segmentation.

ICA, a variant of principal component analysis (PCA), provides a linear transformation that minimizes statistical dependence. ICA removes the rotational invariance of PCA and also provides components that are uncorrelated and statistically independent. ICA has been successfully used to solve object recognition and classification problems. ICA is also gaining popularity in the remote sensing field. In particular, ICA has been successfully applied for unsupervised classification of hyperspectral imagery.

The image segmentation process can be performed speedily by reducing the amount of raw pixel data used for unsupervised classification. The wavelet transform decomposes an image into multiple sub-bands with different frequencies. The coefficients at a coarse level (LL sub-band) can be used for coarse-scale image segmentation, which results in reduction of raw pixel data used for unsupervised
Region identification coefficients from different frequency sub-bands are used to capture the texture detail of the region.

This study provides a comprehensive description of the methodologies used. This includes the followings:

- A general discussion about feature extraction approach using the spatial and spectral transformation.
- Clustering algorithms k-mean and kernel k-means used for image segmentation.
- A general discussion on region identification using SVM after performing feature-level fusion.
- Various evaluation criteria used for the evaluation of image segmentation and performance of image mining system.