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Texture Analysis of Tropical Rain Forest Infrared Satellite Images

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Abstract

This paper describes a new application of the Fourier transform for texture analysis of low reflectance, rain forest satellite images. After correction of edge effects, angular power spectra have been analyzed on windows of 64 by 64 pixels in size. Results of spectra analysis are compared to visually extracted linear features of near infrared SPOT images from South Cameroon forested areas. This method allows for the detection of low-contrast, periodic luminance variations and the extraction of lineament direction with an accuracy of 10°. An algorithm of processing of the whole image aimed at regional studies of texture networks is proposed. Applications to structural geology, forest-type discrimination, and soil studies in the tropics are briefly evaluated.

Introduction

Infrared spectral bands are often used in texture analysis and pattern recognition of forested areas. Remote sensing and photo-interpretation techniques are based on the low near in-

ing are usually divided into statistical and structural methods (Wang and He, 1990).

For the statistical methods, texture is considered to reflect the spatial distribution of grey levels in an image, and textural information can be extracted by co-occurrence-matrix (Haralick, 1979) or texture-spectrum operators (He *et al.*, 1987; Wang and He, 1990; He and Wang, 1991).

For the structural methods, texture is the repetition of a basic primitive pattern with a rule of placement that can be analyzed by Fourier analysis (Haralick, 1979; He *et al.*, 1987; Matsuyama *et al.*, 1980; D'Astous and Jernigan, 1984).

Existing texture operators, however, are not suitable for the extraction of fine-scale textural data from low-reflectance, low-contrast images. Methods involving digital filtering prior to texture analysis (Wang *et al.*, 1981; Drury, 1986; Blusson *et al.*, 1985) induce a degradation of image resolution and alteration of textural patterns. Methods based on Fourier analysis, although of great potential interest, are limited by the small size of the analyzing window necessary to match direction changes at the hectometric scale.

Conventional Angular Power Spectrum

On a 0 to 180° frequency versus amplitude plot obtained by the Fourier transform of a NIR SPOT subscene of homogeneous rain forest (Figures 1A to 1E), prominent peaks located

South Cameroon forested plateaus. Details concerning dates of acquisition, recording parameters, and vegetation cover can be found in Riou and Seyler (1995). Several types of comparisons between forested and cultivated areas or be-

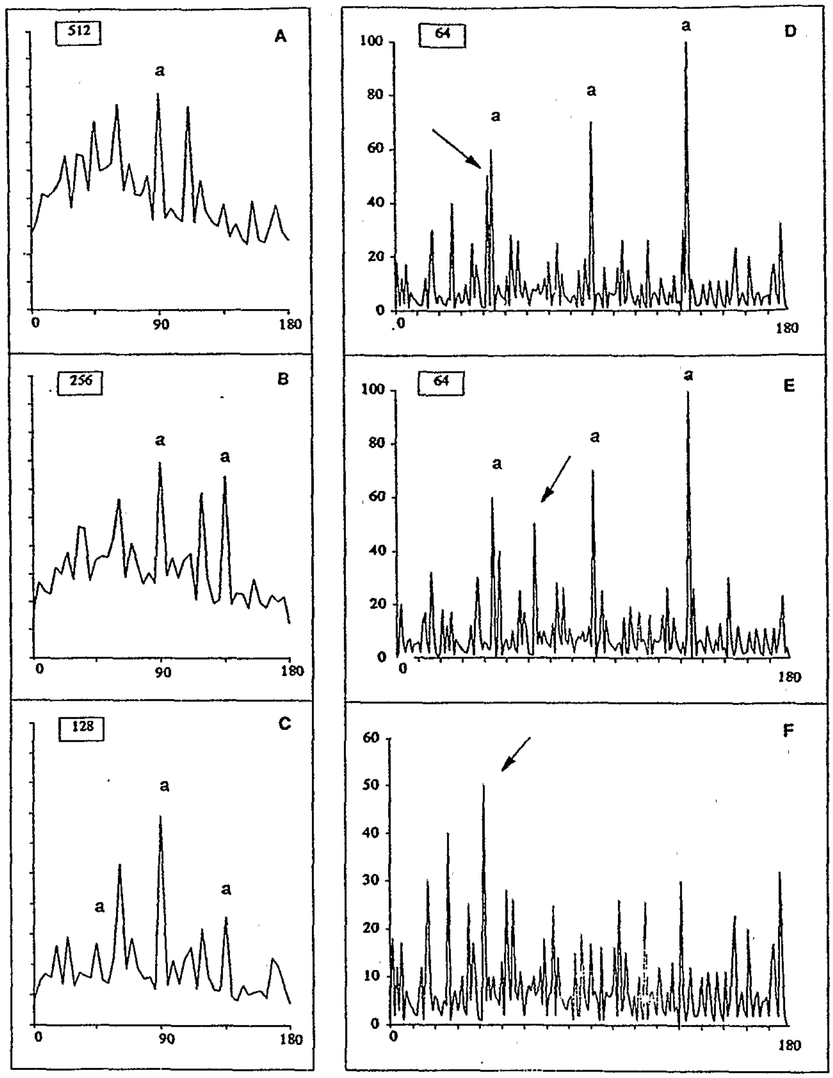


Figure 1. Edge effects on image frequency distribution and Synthetic Angular Power (SAP) spectrum (XS3 subscenes of rain forest from SPOT scene K,J: 86-344 of 07-01-1992, © CNES, 1992). (A to D) Standard angular power spectra obtained by Fourier tranform on subscenes of 512, 256, 128, and 64 pixels in size, respectively. Subscript "a" indicates frequency peaks related to edge transitions. (E) Standard angular power spectrum identical to D after a clockwise rotation of 20 °. Arrow indicates the position of the main frequency peak of the image. (F) SAP spectrum identical to D after elimination of edge frequency peaks.

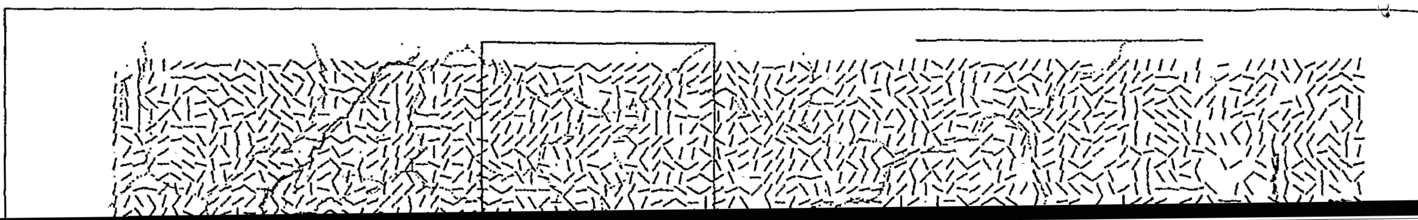
hedral network delineated by N80°E to N100°E and N140°E low reflectance zones.

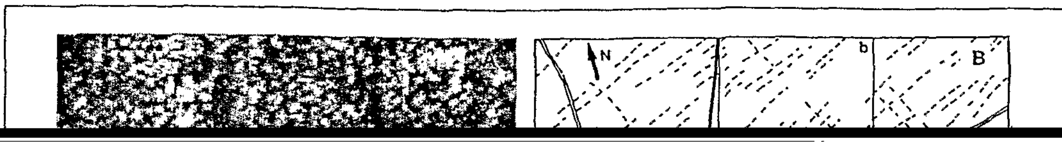
SAP spectra show a unimodal frequency distribution with a dominant peak at 50° for migmatites (Figure 4D) and a bimodal distribution with a dominant 130° peak and three second-order peaks between 70° and 95° for granite (Figure 4C). Angular values are referenced from the border of the image and, thus, are shifted from 10° relative to the north direction (SPOT images have been processed at the 1B level). After correction, angular values extracted from SAP spectra analysis match those of the lineament orientations derived from the visual interpretation of the images. Moreover, the presence of a significative frequency peak at 170 to 180° on both spectra can possibly be related to the proximity of a meridian strike-slip fault, close to the western limit of the analyzing windows. Although not visible on the image, the high-frequency components recorded by the SAP spectra could be induced by shearing discontinuities that are more or less parallel to the direction of the strike on both sides of the fault axis. This interpretation is strongly supported by field observation of multi-scale (centimetric to decametric) left-lateral ductile zones with deformation pattern consistent with strike-slip tectonics.

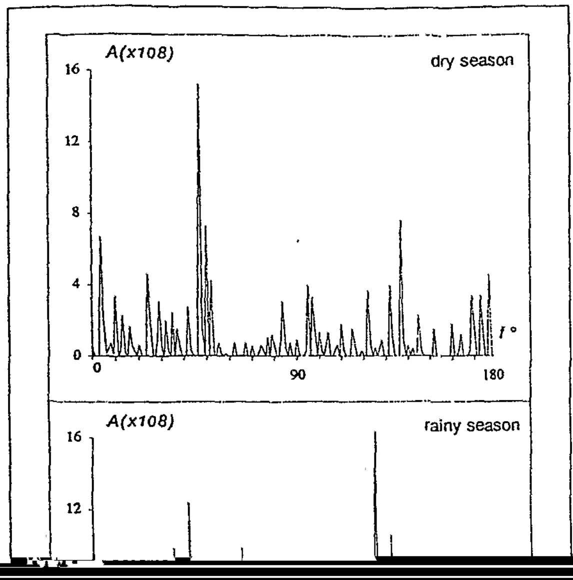
These results demonstrate the good discriminating performance of the method in lineament analysis and its potential interest in structural geology of forested areas.

Application to Forest Change Detection

Traditional agricultural and pastoral activities have induced major changes within forested areas in the tropics. These ef-




A
N
b
B



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