NOTE TO USERS

CHARACTERIZING SCALE-DEPENDENT SPATIAL STRUCTURE IN MULTI-RESOLUTION, MULTI-TEMPORAL AND HYPERSPECTRAL REMOTELY SENSED IMAGERY

by

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Characterizing scale-dependent spatial structure in multi-resolution, multi-temporal and hyperspectral remotely sensed imagery

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Spatial structure information characterized from remotely sensed imagery can be used in various applications. Previous studies in this field were mostly concentrated on forests, grasslands or wetlands. Little attention was paid to the crop canopies, where this information is needed for remote sensing of agriculture. In this research, the scale-dependent spatial structure in remotely sensed imagery from different sources acquired over agricultural crop canopies was characterized to assess the effect on observed spatial structure stemming from changes in spatial, spectral and temporal factors. Three research questions were addressed: (1) What is the effect of spatial resolution on observed spatial structure and how good is the correspondence between measured and rescaled data sets? (2) How does the temporal development of spatial structure differ among spectral wavebands and indices? (3) How does observed spatial structure change with spectral resolution and wavelength? The study was conducted at the University of Nebraska Agricultural Research and Development Center, near Mead, Nebraska. Spatial structure characterization was carried out using lacunarity, semivariogram, and scale of fluctuation analyses. Results indicated that: (1) Due to the difference in spatial structure of fractional

vegetation cover (FVC), one crop FVC has higher lacunarity and more complicated lacunarity deviation than the other. (2) Regularization can lead to the decrease in amount of spatial variability and increase in spatial dependence, and rescaling via block averaging can overly retain original spatial structure, which may be reduced via spatial filtering operations prior to rescaling. (3) Spatio-temporal patterns are different between vegetation indices and their component bands, and vegetation indices are more sensitive to the development of crop canopies than their component bands. (4) The degree of spatial variation with wavelength is correlated to the degree of the difference in reflectance of underlying targets and increasing bandwidth may blur spatial structure that occurs at finer spectral resolution. These findings are useful for studies of rescaling, crop monitoring, sampling design, and identification of an appropriate spatial resolution for agricultural remote sensing.

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INTRODUCTION

Remote sensing has become an important tool for mapping and monitoring vegetation cover (Hobbs, 1990; Mantovani and Setzer, 1997; Young and Wang, 2001). The majority of the research work to date has concentrated on the spectral properties of the data. In contrast, the spatial domain has received considerably less attention in image analysis. Spatial domain is an important aspect of remotely sensed imagery and contains lots of useful information. Estes at al.(1983) included size, shape, texture, height, shadow, site, and association, all as inherent elements within an image that can provide an image analyst clues for interpretation. Many studies have also shown that texture is useful to improve image classification (Haralick and Shanmugam, 1973; Agbu and Nizeyimana, 1991; Barber and LeDrew, 1991; Peddle and Franklin, 1991).

Spatial pattern can be generally defined as the amount and variability of a system property in space and time (Davidson and Csillag, 2003). Spatial structure is a subset of the concept of spatial pattern and refers to the spatial components of heterogeneity (i.e., the way in which total landscape variability is partitioned across spatial scales) (Gustafson, 1998). Originally used in ecological studies, spatial structure in remote sensing pays more attention to the overall spatial arrangement of pixels across the entire image. This is different from texture, which emphasizes more on tonal repetitions within an object, or within groups of objects that are too small to be discerned individually.