

DETERMINATION OF OPTIMAL SCALE PARAMETER FOR ALLIANCE-LEVEL FOREST CLASSIFICATION OF MULTISPECTRAL IKONOS IMAGES

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ABSTRACT:

The automated interpretation of remotely sensed data is still performed largely on the basis of per-pixel image classification, *i.e.*, the statistical analysis of each pixel's spectral value. The conventional per-pixel classification approaches, however, may have limitations to be considered when used with very high resolution imagery because these procedures ignore spectral reflectance characteristics of neighboring pixels. Object-based classification approaches can be an alternative to overcome these problems held in conventional per-pixel classification approaches. Although object-based classification techniques appear to cast a promising light on limitations of per-pixel approaches, further research is required to assess the quality of the classification results and the sensitivity of input parameters. The scale parameter controls the size of image objects and is the most important and critical issue because the quality of classification is directly affected by segmentation quality. This scale parameter should be a crucial factor to be considered in the use of object-based classification for alliance-level forest mapping. In this study, we adopted the graphs of local variance in an attempt to anticipate the optimal scale parameter for forest classification from multispectral Ikonos images. The local variance of image objects reached a threshold approximately at the scale parameter of 21 and the highest classification accuracies occurred around the threshold of scale parameter. The graphs of local variance may be used as a methodology to anticipate the optimal scale parameter before actual image classification.

1. INTRODUCTION

Conventional per-pixel approaches may have limitations to be considered when very high resolution (VHR) imagery is utilized in image classification procedures (Fisher, 1997; Towonshend *et al.*, 2000). As an alternative, object-based classification schemes have been largely utilized in remote sensing applications in recent years, especially with VHR data.

The object-based classification approach is divided into two major steps: 1) image segmentation and 2) image classification based on image objects which are spectrally homogeneous clusters of pixels (Schowengerdt, 1997). Image segmentation is a primary step to derive primitive and meaningful image objects from remotely sensed data before actual image classification takes place.

Even though the object-based classification scheme seems to cast a promising light on those limitations of the per-pixel approach, it also has the most problematic difficulty, *i.e.*, determination of the scale parameter for image segmentation. The scale parameter, controlling image objects' size, is the most important and critical issue because the quality of classification is directly affected by segmentation quality (Blascke, 2003; Meinel and Neubert, 2004). The analysis of the scale parameter could be conducted by changing its value to produce different sizes of image objects, classifying segmented images, and evaluating classification accuracies. In doing so, it can reveal what size of image objects yields the best classification accuracy. This scheme, however, definitely needs empirically repetitive image classifications on large numbers of segmented images. Thus, it is desirable to develop methods which enable *a priori* knowledge related to the scale parameter to be acquired before actual image classification. An

experimental method based on scale/resolution-related issues was conducted with a view to demonstrating if they can be utilized as indicators to find optimal scale parameters in segmentation procedures.

The scale/resolution-related studies are mainly concerned with developing methods for determining the most appropriate scale/resolution and assessing their effects on digital image classification. As for VHR imagery, the accuracy of classification is closely associated with the relative size of feature classes under observation. Most studies related to the optimal scale and resolution have been based largely on per-pixel classification and the method of graphing local variance has been often utilized in an attempt to find the optimal scale/resolution. The graphs of local variance, proposed by Woodcock and Strahler (1987), for example, are used mainly for determining a single optimal spatial scale over an entire image. They computed variances held in 3-by-3 moving window for individual pixels and calculated average local variance on a whole scene. These average local variances are then graphed as a function of spatial resolution, *i.e.*, the aggregated levels of pixels (or upscaling). In contrast to the graphs of local variance applied to the per-pixel approach, image segmentation results in irregularly aggregated (or clustered) pixels as image objects. The variance of each image object after segmentation could be obtained and utilized in order to graph local variance. In this study, we examined the relationship between the graphs of local variance and the classification results of an object-based approach.

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2. STUDY AREA AND DATA

The study area is the Guilford Courthouse National Military Park (GUCO) located in Greensboro, North Carolina in eastern United States (Figure 1). The Park is predominantly forested and includes needle-leaf evergreen, submontane cold-deciduous, and temporarily flooded cold-deciduous forest communities. In addition, there are areas of herbaceous vegetation, shrubland, and man-made features such as former pastures and agricultural fields. The park is managed to preserve the vegetation and landscape that approximates the battle field at the time of the American Revolution and it was mapped by the Center for Remote Sensing and Mapping Science (CRMS), Department of Geography at the University of Georgia in conjunction with Nature Serve, as part of the National Park Service (NPS) and U.S. Geological Survey (USGS) National Vegetation Mapping Program. This study will employ alliance-level forest classes as a classification scheme.

They include deciduous forest, evergreen forest, deciduous dominant mixed forest, and evergreen dominant mixed forest.

A multispectral Ikonos image of 4-m resolution, conferred as a 2005 Space Imaging Award presented by Space Imaging, Inc. and the American Society of Photogrammetry and Remote Sensing (ASPRS), was utilized for object-based forest classification (Figure 2). A color infrared (CIR) aerial photograph of 1:12,000 scale and scanned and orthorectified by the CRMS at a root-mean-square-error (RMSE) of approximately ± 3 m also was used to georeference the multispectral Ikonos image. A manually interpreted vegetation map produced by CRMS from these orthorectified images provided information on community-level forest classes. These classes were collapsed to the alliance-level forest classes mentioned above. From this alliance-level forest map, two data sets were derived for image classification and accuracy evaluation; training data sets and sampling points with stratified random sampling scheme.

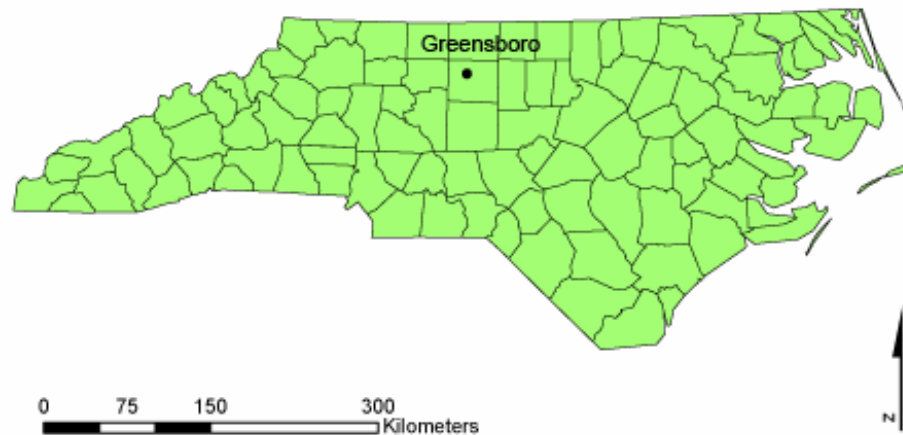


Figure 1. Locator map of Guilford Courthouse National Military Park (GUCO) in Greensboro, North Carolina.

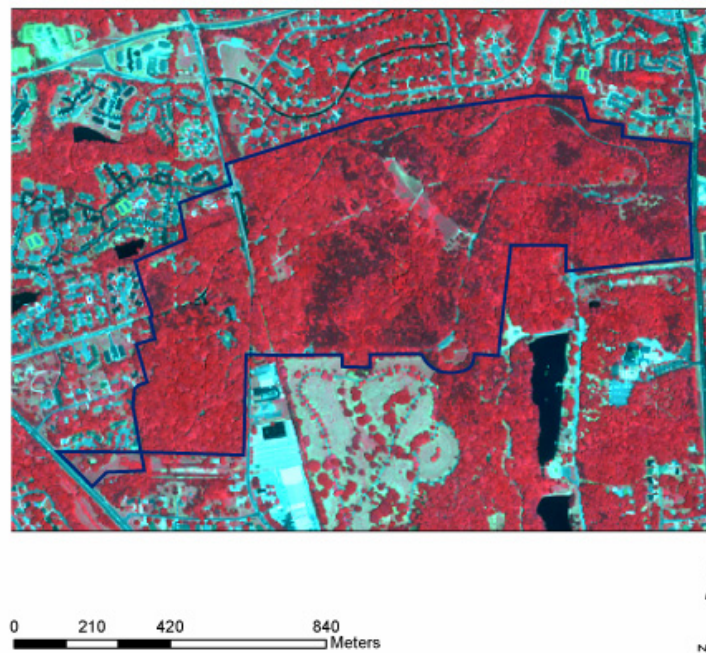


Figure 2. Multispectral Ikonos image of GUCO.
The park boundary is delineated in blue.

3. RESULTS

Multispectral Ikonos data of GUCO were segmented with various values of scale parameters in eCognition, while the ratio of shape and color was set to .1 and maintained across the whole procedure. Arbitrarily chosen values of scale parameter ranged from 2 to 24. Local variances of all image objects were computed and averaged at each scale parameter and graphed as a function of scale parameter (Figure 3). Alliance-level forest classifications were performed using supervised standard nearest neighbor classifier and mean spectral values of each image object. Overall accuracy and kappa statistics were computed and graphed as a function of scale parameters (Figures 4 and 5).

As shown in Figure 3, local variance of image objects increased with the increase of scale parameter. In particular,

the graph of local variance derived from the NIR band leveled off approximately at the scale parameter of 21. Classification accuracies reveal that the highest overall accuracy and kappa statistic occur at the scale parameters of 21 and 23 when using the NIR band alone and all spectral bands, respectively. The highest overall accuracies were 56.95 % at the scale parameter of 21 and 56.32 % at the scale parameter of 23. The kappa statistic of 0.328 was obtained at the scale parameter of 21 and that of 0.301 at the scale parameter of 23. As shown in Figures 4 and 5, classification accuracies could be increased by adding statistical texture derived from the NIR band. The overall accuracies could be enhanced to 69.44 % using only the NIR band at the scale parameter of 21 and 67.99 % using all spectral bands at the scale parameter of 23.

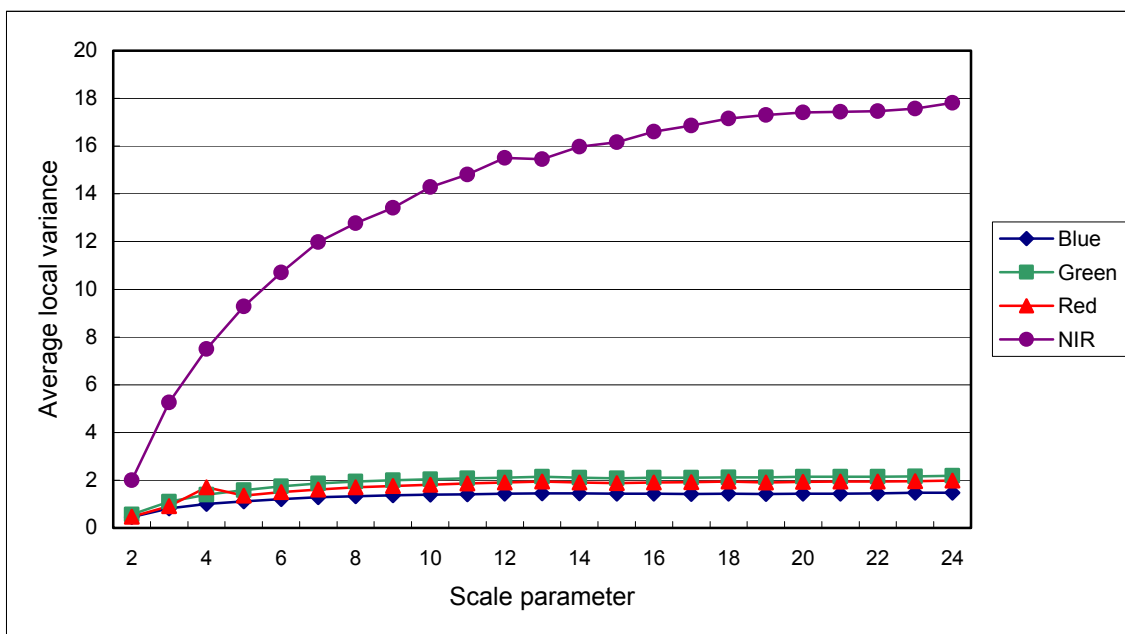


Figure 3. The graph of local variance as a function of scale parameter.

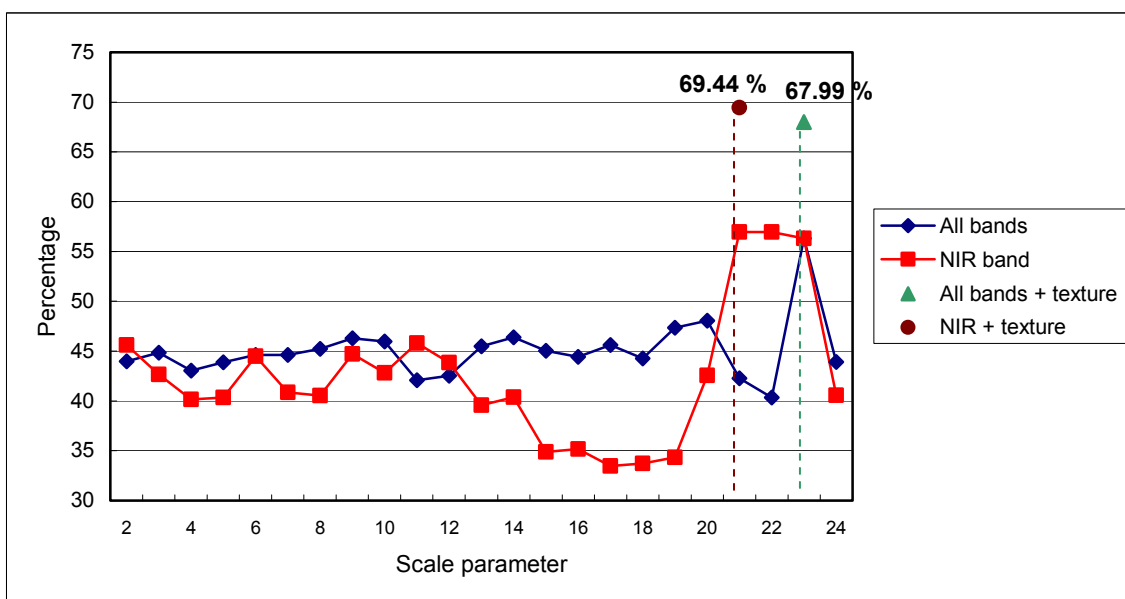


Figure 4. The graph of overall accuracy as a function of scale parameter.

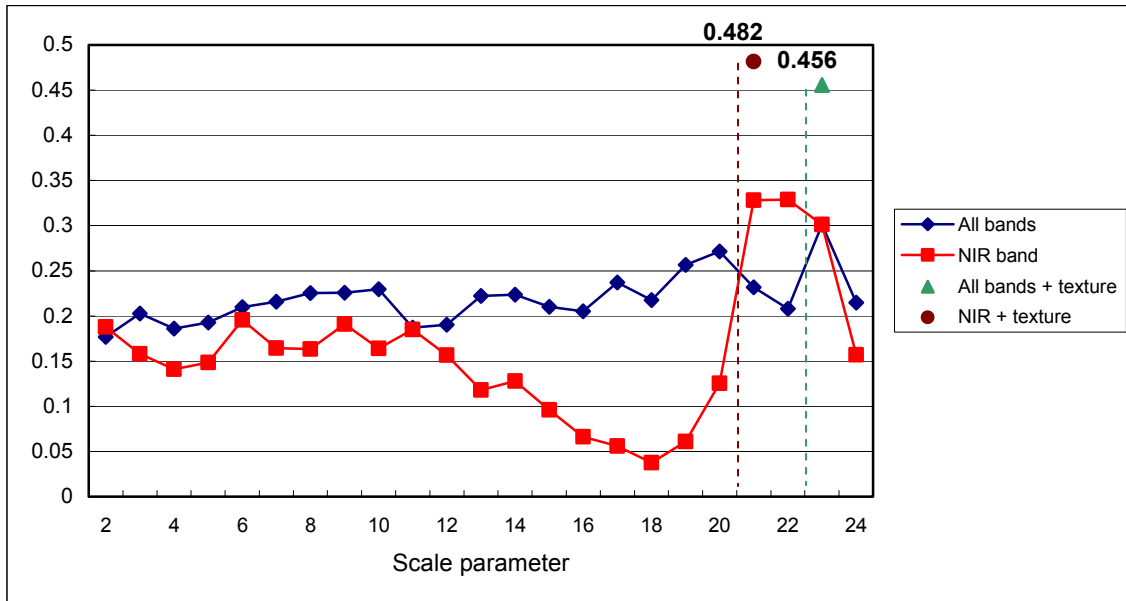


Figure 5. The graph of kappa statistic as a function of scale parameter.

4. CONCLUSIONS

The local variance, suggested by Woodcock and Strahler (1987), related the size of the objects in the scene to the spatial resolution of the peak local variance. The graph of local variance derived from this study reached a threshold and the highest classification accuracies of alliance-level forests occurred around that threshold. The quality of segmentation is important because it has a direct effect on classification accuracy (Meinel and Neubert, 2004). In using eCognition, segmentation quality could be controlled by the scale parameter which is used in a segmentation procedure. Hence, the effects of scale on segmentation procedures should be investigated before actual image classification proceeds.

Research related to the effects of scale parameter on classification accuracy is rare except that conducted by Wang *et al.* (2004) who developed a new method to choose the optimal scale parameter with the aid of a spectral separability index, Bhattacharya Distance (BD), from Ikonos imagery for mangroves mapping. However, most studies using object-based image classification procedures adopt a scale parameter determined in a rule-of-thumb way. The graph of local variance used in this study may be another methodology to anticipate the optimal scale parameter associated with classification accuracies.

5. REFERENCES

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