Fuzzy Object Identification Using Texture Based Segmentation Of High-Resolution Dem And Remote Sensing Imagery Of A Coastal Area In England

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Biography

Arko Lucieer is a Ph.D. student at ITC, the Netherlands (2000-present). He obtained a M.Sc. degree in Physical Geography with a specialization in Remote Sensing and GIS at Utrecht University. His research interests are: remote sensing classification and segmentation techniques, uncertainty and (geo)visualization.

Introduction

Object-oriented approaches to remotely sensed image processing have become increasingly popular with the growing amount of high-resolution satellite and airborne imagery. Several studies have shown that segmentation techniques can help to extract spatial objects from an image. Uncertainty, however, will be present in any segmented image and can have a significant effect on further image processing. In particular, in areas where fuzzy objects dominate an indication of segmentation uncertainty is important. In this study, we present a feature extraction technique that identifies fuzzy objects from remotely sensed imagery of a coastal area in northwest England. This paper builds on work of Lucieer and Stein (2002) and further explores the generation of thematic and spatial object uncertainty in the process of image segmentation.

Study Area And Imagery

The study area is on the coast of northwest England named Ainsdale Sands. The landforms are typical of such a system, with high dune ridges and dune valleys containing slacks. Slacks are hollows that are often flooded in winter and provide the habitat for many unusual plants and animals. Mapping of this coastal area is important because the region is being designated a Site of Special Scientific Interest, as well as the general importance of the environment as a major and threatened habitat type and as a defence against coastal flooding. The Environment Agency, UK, collected a high-resolution digital elevation model (DEM) by LiDAR, and simultaneously, acquired hyper-spectral Compact Airborne Spectral Imager (CASI) imagery at a similar resolution.

A straightforward approach to identifying fuzzy objects is to apply a (supervised) fuzzy c-means classification. This classifier gives, beside the most likely class, information on the degree to which a pixel could belong to all classes. One important aspect, however, is not taken into account by this method, the spatial correlation between pixels (also known as pattern or texture). Spatial and thematic uncertainty are closely related for fuzzy objects in particular. Therefore, we should take into account the spatial component using some kind of texture descriptor.

Texture And The Local Binary Pattern Operator

A relatively new and simple texture descriptor is the local binary pattern operator (LBP) (Ojala, 2002). The method is based on recognizing that certain local binary patterns are fundamental properties of local image texture, and their occurrence histogram proves to be a very powerful texture feature. The LBP operator is an excellent measure of the spatial structure of local image texture, but by definition, it discards the other important property of local image texture, i.e. contrast. Therefore, the performance of LBP can be further enhanced by combining it with a rotation invariant variance measure that characterizes the contrast of local image texture. The joint distribution of these two complementary operators is a powerful tool for rotation invariant texture classification.

In classifying texture, we evaluate the (dis)similarity of sample and model histograms as a test of goodness-of-fit using a nonparametric statistic, the log-likelihood ratio statistic. Here, the sample is a histogram of the texture measure distribution of an image window. The model is a histogram of a reference image window of a particular class. By using a nonparametric test we avoid making any, possibly erroneous, assumptions about the feature distributions, although the window size should be appropriate for the computation of the texture features. However, as we consider windows of increased size, the probability that regions contain a mixture of textures is increased. This can bias the comparison, since the reference textures contain only features of individual patterns. On the other hand, if the window size is too small it is impossible to calculate a texture measure. Within this constraint, it is impossible to define an optimum size for segmenting the entire image. Therefore, we suggest that when the window is small, a pixel is classified mainly based on its intensity information, whilst when the size of the window is increased spatial dependence information is exploited by considering the patterns defined by surrounding pixels.

Segmentation And Uncertainty

A split-and-merge segmentation algorithm offers a very suitable framework for this concept. In the hierarchical splitting procedure, we can calculate the texture histogram for each image (sub)block to test on texture homogeneity. When we have obtained the final quadtree or subdivision of the image, we can classify the blocks according to their texture. From the histogram similarity measures of the image blocks, we can compute the confusion index and entropy. These two measures provide an excellent way for depicting thematic and spatial uncertainty of the identified objects.

References

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