HIERARCHICAL SEGMENTATION OF VEGETATION AREAS IN HIGH SPATIAL RESOLUTION IMAGES BY FUSION OF MULTISPECTRAL INFORMATION

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1. INTRODUCTION

Improvement in classification accuracy is always a concern in the remote sensing field, and particularly, in the context of vegetation classification. High spatial resolution imagery offers new opportunities for potentially more accurate identification and area estimation than traditional satellite imagery. Space Imaging successfully launched the IKONOS satellite in 1999, the first high resolution commercial remote sensing satellite for civilian uses. IKONOS records four channels of multispectral data at 4 m resolution and one panchromatic channel at 1 m resolution. Two years later, DigitalGlobe successfully deployed the QuickBird satellite, which provides four channels of multispectral data with 2.4 m (at nadir) resolution and one panchromatic channel with 0.6 m resolution.

While high spatial resolution remote sensing provides more information than coarse-resolution imagery for detailed observation, an increasingly smaller spatial resolution does not necessarily benefit classification performance and accuracy. With the increase in spatial resolution, single pixels no longer capture the characteristics of classification targets. The increase in intra-class spectral variability causes a reduction of statistical separability between classes with traditional pixel-based classification approaches [1]. Thus, preliminary feature extraction techniques are of great importance for the success of classification methodologies when applied to high resolution imagery.

One important feature extraction approach is image segmentation. It partitions the image into a set of homogeneous regions under a certain criterion. Regions are a first level of abstraction, being more robust and semantically meaningful than pixels, especially for vegetation characterization. A large number of algorithms have been proposed for image segmentation [2] but mainly applied to grayscale images. However there has been little progress in the segmentation of multispectral imagery [3], i.e. generating a segmentation that combines the available information in each channel. In addition, the required level of detail into the segmentation of the vegetation areas depends on the final application. Hence, a general tool for vegetation analysis should provide a hierarchical representation where, instead of a unique partition, different region-based explanations at different levels of detail are given.

2. METHODOLOGY

In this context we present a new region-based methodology for the automated extraction and hierarchical segmentation of vegetation areas into high spatial resolution images. The extraction of the vegetation areas is obtained by: (i) the creation of an over-segmented (free of merging errors) partition for each spectral channel; (ii) the combination by intersection of the partitions to create a basic consensus partition; (iii) the estimation of the average NVDI index for each region of the multispectral consensus partition; (iv) the final classification into vegetation and no-vegetation regions, for instance, using a k-means clustering algorithm. The use of region-based information improves the accuracy and robustness with respect to NDVI pixel-based vegetation classification techniques (see Figure 1-(b)).

Once vegetation areas are extracted, their hierarchical segmentation is performed by the fusion of multispectral information using cooperative region merging. This technique has succeeded to the combination of different types of information at partition level, such as color and depth information [4]. Starting with a basic consensus partition, a set of new partitions (one per available channel) is independently computed. Then, the channel partitions are fused by unanimity or majority rules into a new multispectral consensus partition that improves the previous one. Using the previous agreement as a new initial partition, the process is iterated. The consensus partitions obtained at each iteration form a hierarchy of partitions. In our work, the hierarchical image segmentation technique used for single channel partitioning is an unsupervised information theoretical region merging [5], which provides a unified solution to natural and texture image segmentation, outperforming specific state-of-the-art techniques in both contexts.

In addition, the high flexibility of the proposed scheme allows different configurations depending on the final purpose. For instance, (i) if any channels are assumed more relevant, accurate, or reliable, their information can be prioritized in the fusion process; (ii) the area information can be incorporated into the partition hierarchy (as the level of detail decreases, only large areas of vegetation remain in the hierarchy); (iii) channels with different resolutions can be combined into the cooperative process; and (iv) vegetation extraction can be further refined including a classification stage at each iteration.

The potential of the proposed framework has been tested for high spatial resolution images from commercial satellites, such as IKONOS and QuickBird. The extraction and hierarchical segmentation of different areas of interest using the four channels of multispectral data with equal resolution (see an example in Figure 1-(c), (d)), or combining them with the panchromatic channel of higher resolution are presented. The quality of the vegetation characterization is also evaluated when all channels are considered equally relevant, or when more importance is given to one of the bands (for instance, to the IR channel).

3. CONCLUSIONS

The presented results show that the proposed hierarchical multichannel segmentation approach provides an unsupervised and flexible tool for the analysis and classification of vegetation into a broad range of remote sensing applications with different needs and characteristics.

4. REFERENCES

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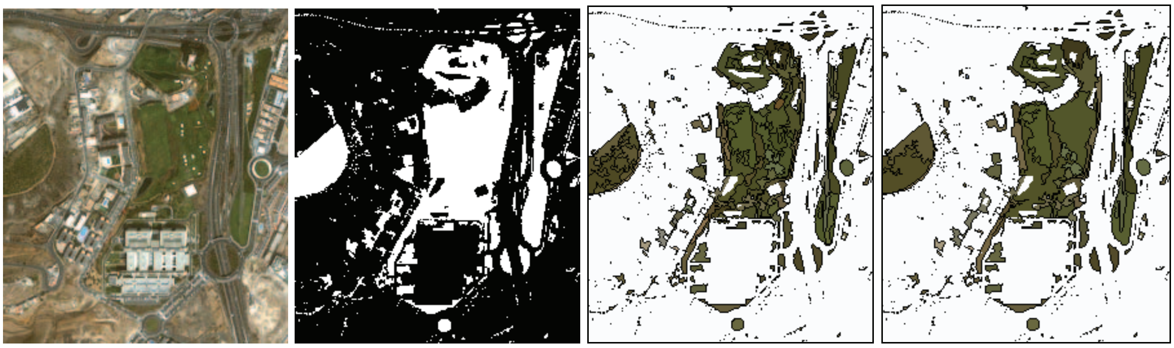

(a) (b) (c) (d)

Figure 1. Extraction and hierarchical segmentation of the vegetation areas for a QuickBird image of May, 24th 2003. (a) Area of interest of the original image (R, G, and B channels are shown). (b) Extracted vegetation areas (white). (c)-(d) Segmentation of the vegetation areas at a fine and a coarse level of detail, respectively.