Canopy Height Estimation through the Use of Texture Analysis of a Very High Resolution Satellite Image

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Abstract

Vegetation height is a principal feature used in land cover and habitat mapping to discriminate among different vegetation types. Principal sources of height estimation include in situ observations or data derived from satellite or airborne active sensors (e.g. Light Detection And Ranging - LiDAR). Since such data are often unavailable and/ or cost much, a methodology is presented to discriminate among different vegetation height categories, based on texture analysis of available time- and cost-effective multispectral imagery. Various texture measures, based on local variance, entropy and local binary patterns, are proposed and evaluated in discriminating between vegetation of less and more than 2m high in a protected coastal Mediterranean site in Italy. In some cases, classification accuracies exceed 90%. In addition, to evaluate the potential of the method in parallel with removal of redundant information, dimensionality reduction is performed to the multispectral image and the proposed texture measures are calculated in the reconstructed images. Results indicate that image information can be reduced up to one half without any significant loss of performance.

Study Objective 1 : texture analysis

to propose surrogates for vegetation height discrimination, based on texture analysis of a VHR multispectral satellite image

Six texture measures are calculated for each area patch, in each band of the QB image, from the ones proposed in [4]. They are computed in a neighbourhood around each pixel of a patch. The average value of all pixels is assigned to the patch. The calculated measures are:

i) Local Variance (LE), where a 3×3 window is used,
ii) Local Entropy (LH), with a 9×9 window and 8-bin quantization in each window,
iii) Local Entropy Ratio (LHR), with 9×9 and 13×13 inner and outer windows, respectively,
iv) rotation invariant Local Binary Patterns (LBP), with radius 1,
v) rotation variant Local Ternary (LTP), and
vi) Local Binary Pattern with range (LTBP), with radii 1 and 2, respectively.

results :

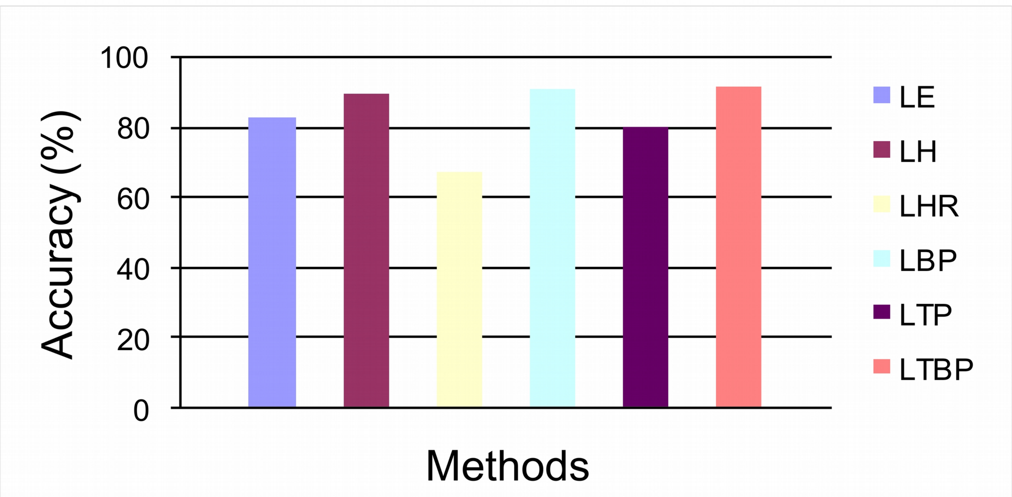

Figure 2. Classification accuracy of the texture measures applied in the green band of the Quickbird image.

Texture measures calculated in the green band presented the highest accuracies in discriminating between patches with vegetation of less and more than 2m high (Figure 2). LH, LBP and LTBP outperformed the other measures, with the latter two reaching accuracies over 90%. In addition, LE and LTP performed significantly well.

Study area

The area of interest is the Natura 2000 protected site Le Cesine, Apulia region, south-eastern Italy. It is characterized by a complex of coastal lagoons, various canals, marshes and humid grasslands. A Quickbird (QB) image of 2m spatial resolution, from July 2005, is used for the texture analysis. A habitat map of the area is used for training and validation of the method (Figure 1).

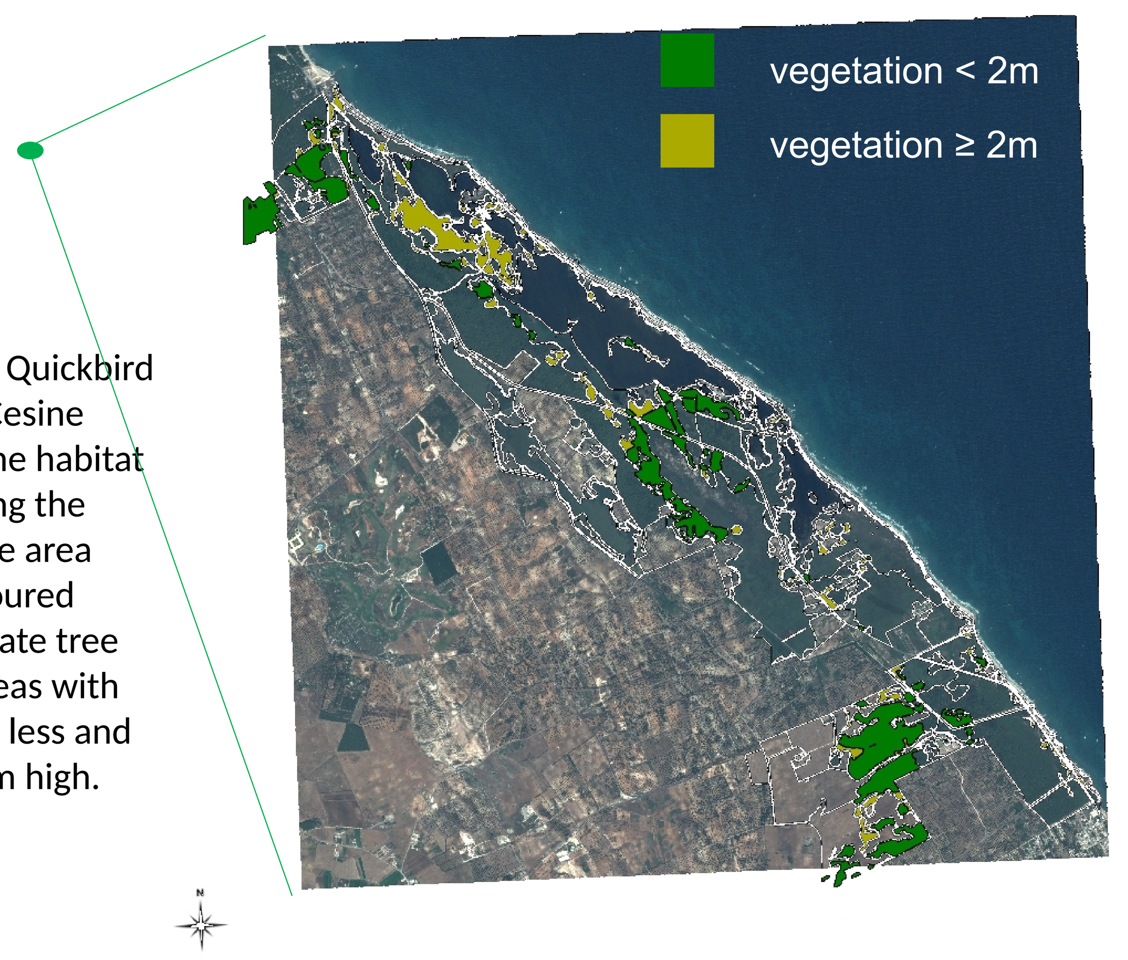

Figure 1. The Quickbird image of Le Cesine overlaid by the habitat map, depicting the borders of the area patches. Coloured patches indicate tree and shrub areas with vegetation of less and more than 2m high.

Study Objective 2 : dimensionality reduction

to remove redundant information without compromising accuracy

Principal Component Analysis (PCA) is applied in the QB image, to identify correlated features and remove redundant information. 4 principal components are created after the eigenanalysis of the image. Using the one, two and three components with the largest eigenvalues, respective reconstructions of the original QB image are created.

Figure 3 presents the classification accuracies of the texture measures for the three reconstructions of the QB image, applied in the green band. The accuracies from the original image are depicted for comparison.

results :

Using only the first principal component leads to data reduction by 75%, however significant loss in the classification performance is observed, approaching 25% for certain texture measures (Figure 3.a).

On the other hand, reconstruction using the two or three principal components, thus resulting in data reduction by 50% and 25%, respectively, causes an insignificant loss in accuracy (Figures 3.b and 3.c). Therefore, the discriminatory ability of texture measures in vegetation height is maintained under data de-correlation and reduction up to 50%.

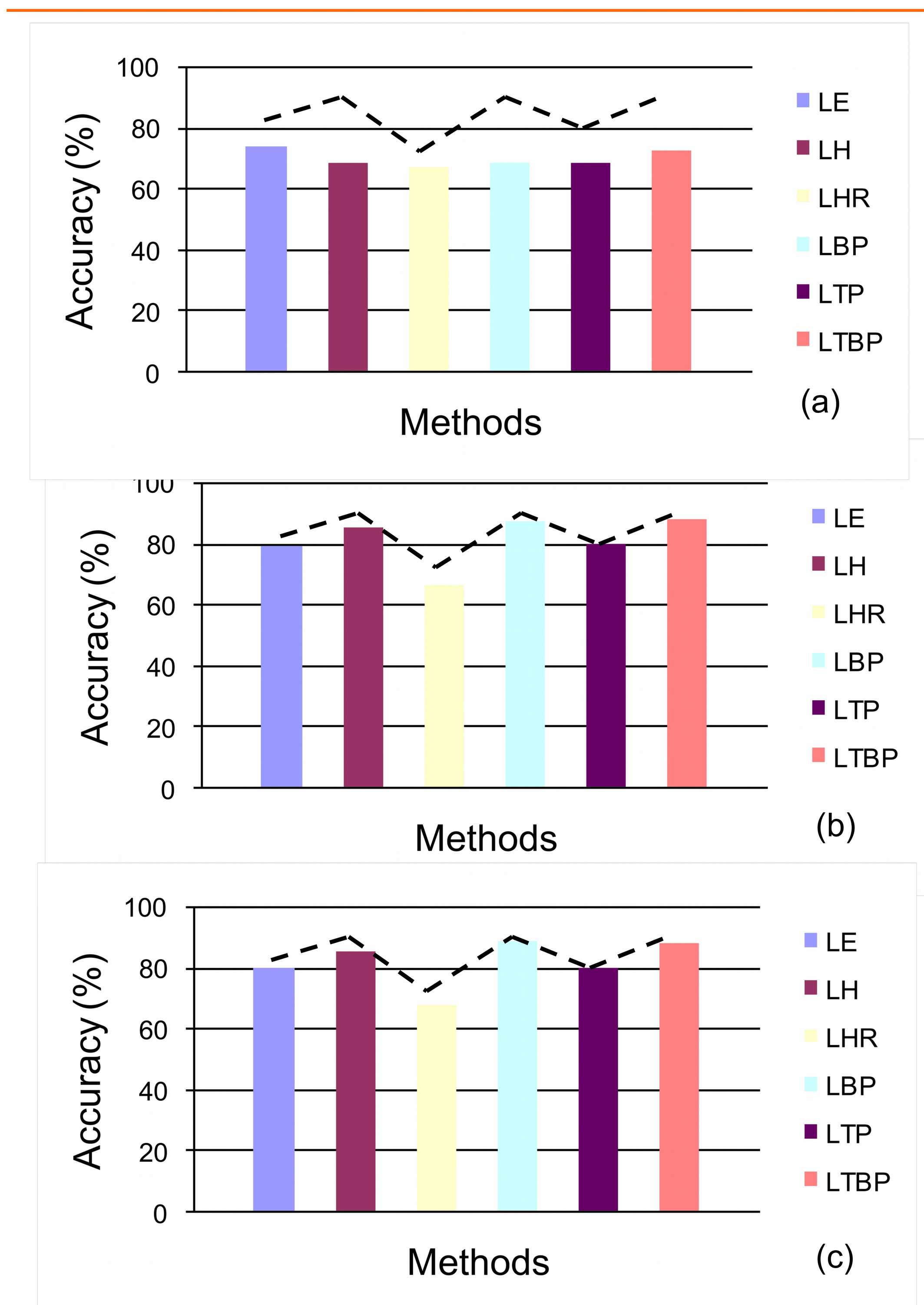

Figure 3. Classification accuracies of the texture measures for the reconstructed QB images resulting from the first (a) one, (b) two and (c) three principal components, applied in the green band. The dashed line represents the respective accuracies from the original QB image.

Conclusions

A__ Texture analysis on VHR data has been proven efficient in discriminating between tree and shrub vegetation of less and more than 2m high. Texture measures calculated locally in a per pixel and patch basis are proven promising surrogates in cases where principal information from in situ measurements or LiDAR data is unavailable.

B__ Dimensionality reduction can lead to significant removal of redundant information, thus reduction of memory requirements, up to 50%, without compromising the discriminatory power of the texture measures.

References

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