SUPER-RESOLUTION ANALYSIS FOR ACCURATE MAPPING OF LAND COVER AND LAND COVER PATTERN

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1. INTRODUCTION

Land cover is one of the most fundamental geographical variables. Land cover plays a major role in natural systems, not least as a driver of climate and control on biodiversity. With regard to the latter, a key issue is the pattern of land cover distribution over a landscape. The size, shape and distribution of land cover patches have, for example, considerable impact on the biodiversity of a region. Consequently, there is a need for accurate information on land cover and in many cases remote sensing is the only practical source of this information.

The accuracy with which land cover may be mapped from remote sensing is often limited by the spatial resolution of the imagery. For example, popular satellite sensor systems for large area mapping (e.g. MODIS, MERIS, AVHRR) typically provide imagery with spatial resolutions of 250m or more. This greatly limits the ability to define patch boundaries or characterize small, sub-pixel scale, land cover properties. Although this problem could be reduced through use of finer spatial resolution sensors many concerns remain (e.g. there is an increase in cost, data pre-processing needs etc.). An alternative is to apply a super-resolution technique to effectively increase the spatial resolution of a data set, enabling land cover to be mapped at a resolution finer than that of the sensor used to acquire the data. A variety of super-resolution techniques have been investigated but generally fall into one of two categories: super-resolution restitution and super-resolution mapping [1,2]. This paper will explore the value of a hybrid method that uses both restitution and mapping based approaches.

2. METHODOLOGY

In this paper, a super-resolution technique is proposed as a means to gain accurate information of land cover, and especially its spatial pattern, at sub-pixel scales. The technique is based on a combination of iterative back-projection (IBP) [3] and Hopfield neural network [4,5] methods. To illustrate the method a series of fine spatial resolution images of a Mediterranean region containing a range of different patterns was acquired. Each image was taken to represent reality and used as the reference data set in evaluation of the super-resolution analyses. All of the latter were based on spatially degraded versions of the original imagery. Although representing an imperfect means to simulate coarse resolution data this approach has many advantages, notably in that error from miss-registration of data sets is avoided.

With each image, the first step of the method was to apply IBP. This involves the generation of a set of coarse resolution images by shifting the image randomly at sub-pixel scales. IBP then allows the production of a finer spatial resolution image from the set of shifted images. Using this image, the fractional class composition was estimated. The derived sub-pixel land cover estimates for each pixel provided information on the land cover composition of the pixel, but not its location. The latter was estimated by application of a Hopfield Neural Network (HNN) super-resolution mapping technique utilising prior knowledge on spatial pattern in the form of a semi-variogram function used as a goal constraint in the analysis. The final output of the analysis is, therefore, a land cover map at a spatial resolution finer than the original imagery. The paper will include a discussion of the 'zoom factors' achievable by the method. Further analyses (e.g. without prior knowledge or based on hard classification analyses) were undertaken for comparative purposes.

3. CONCLUSION

The accuracy of the proposed technique was evaluated using site specific accuracy measures (e.g. overall accuracy from a confusion matrix) and descriptors of spatial pattern (based on comparison of semi-variograms and a set of map comparison measures). For comparative purposes the results are compared against those derived from other methods. The latter includes a basic HNN, a HNN with prior information on land cover pattern, IBP alone and conventional hard classification analyses. Figure 1 provides a sample of the results for illustrative purposes. The results show that the proposed method, utilizing a combination of IBP and HNN, was more accurate than other techniques. In particular, the approach was more accurate for each image, which represented a different land cover pattern, using each measure of accuracy. Although the differences in accuracy varied from image to image, it was apparent that the proposed method was significantly more accurate than a basic HNN (difference typically >10%) and slightly (1-4% more accurate) than a HNN with prior knowledge. The results suggest considerable potential to enhance the value of coarse spatial resolution imagery for the mapping of land cover and land cover patterns.

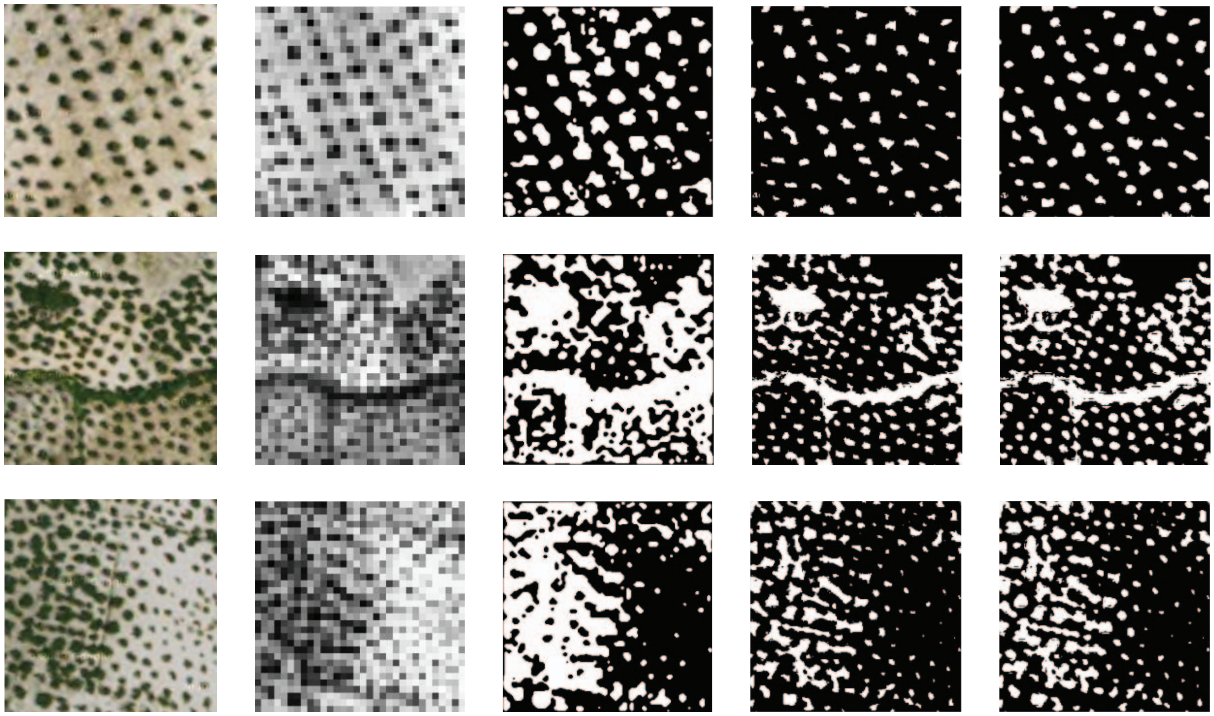

Fig. 1. Example of some results. Rows 1-3 show different land covers pattern; homogenous, heterogeneous and inter-grade. Columns show, from left to right, original images, degraded images, results from the basic HNN method, HNN with prior knowledge and the proposed method.

4. REFERENCES

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