APPLICATION OF QUICKBIRD DATA FOR URBAN LAND COVER CLASSIFICATION

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ABSTRACT: In recent years, (very) high resolution satellite images have been successfully used for a urban land cover mapping and for the information extraction from such images, diverse methods are being applied. The aim of this study is to extract land use information from a high resolution Quickbird image. For this purpose, a knowledge-based classification technique based on a rule-based approach has been constructed. The method uses an initial image segmentation procedure based on a Mahalanobis distance classifier as well as the constraints on spectral and spatial thresholds. Overall, the study indicated that the information extracted from a high resolution satellite image is very reliable and can be successfully used for urban spatial decision-making.

KEY WORDS: High resolution, Urban land cover, Knowledge-based classification

1. INTRODUCTION

In recent years, high resolution satellite images such as Ikonos and Quickbird have been successfully used for a urban land cover mapping as well as for a mapping at a local scale. However, until the launch of these high resolution satellites, space data sets had been mainly used for a land cover mapping at regional or smaller scales, because the available moderate resolution satellite images could fulfill the mapping conditions of only regional level. The utilization of these satellite data sets allow the mapping specialists to map the natural and man made features usually at a class level and it is very difficult to define the individual objects on such images. However, using high resolution RS images it is possible to map any features at object as well as class levels.

Over the years, for the extraction of thematic information from remote sensing (RS) images at national and regional levels, different image processing techniques have been used. Most of these techniques were based on digital methods of classification which mainly included statistical and non-statistical methods, neural networks as well as other knowledge-based classifications. In recent years, for identification of the individual objects different object-oriented classification techniques have been used. However, it is still very difficult to extract the objects themselves as they are positioned in the real world.

The aim of this study is to classify urban land cover types using Quickbird image. For identification of urban land-cover types a knowledge-based classification technique based on a rule-based approach has been constructed. The constructed method uses an initial image segmentation procedure based on a Mahalanobis distance classifier as well as the constraints on spectral and spatial thresholds. The result of the knowledge-based method was compared with

results of a statistical maximum likelihood classification (MLC) and it demonstrated higher accuracy.

2. TEST SITE AND DATA SOURCES

As a test site, Baga toiruu area situated in central part of Ulaanbaatar, the capital city of Mongolia has been selected. The Baga toiruu is the city business district of Ulaanbaatar city where different government, educational, cultural and commercial organizations are located. Besides the Central Government, Parliament and headquarters of major political parties, the Baga toiruu contains approximately two third of ministries, one third of major government organizations, half of bank headquarters, one fifth of all state universities, half of diplomatic and international organizations, and many theatres and museums (Chinbat *et al.* 2006). The location of the Baga toiruu area represented in a panchromatic Quickbird image of 2002 is shown in figure 1.

Figure 1. The test area represented in a Quickbird image of 2002.

As the RS data sources, multispectral and panchromatic Quickbird images of 2002 have been used. The Quickbird data has four multispectral bands (B1: 0.45–0.52μm, B2: 0.52–0.60μm, B3: 0.63–0.69μm, B4: 0.76–0.90μm) and one panchromatic band (Pan: 0.45-0.9μm). The spatial resolution is 0.61 m for the panchromatic image, while it is 2.4 m for the multispectral bands. The high spatial resolution of the panchromatic image can distinguish most small elements at an object level which multispectral bands cannot fully resolve. Therefore, a combination of panchromatic and multispectral bands gives a real colour view of a scene. In the current study, a pan-sharpened image has been used (Pohl and van Genderen,1998). In addition, a topographic map of 2000, scale 1:5000 as well as GIS layers created on the basis of the topographic maps, were available.

3. KNOWLEDGE-BASED CLASSIFICATION OF THE QUICKBIRD IMAGE

Over the past years, knowledge-based techniques have been widely used for the classification of RS images. The knowledge in image classification can be represented in different forms depending on the type of knowledge and necessity of its usage (Amarsaikhan and Douglas 2004). The most commonly used techniques for knowledge representation are a rule-based approach and neural network classification (Amarsaikhan *et al.* 2007). In the present study, for discrimination of the urban land-cover types a rule-based approach has been applied.

As we had data sets with different spatial and spectral resolutions, they should be merged for conducting further analyses. In this study, to merge the images, Brovey transform and PCA (Vrabel 1996 and Gonzalez and Woods 2002) have been applied and the results were compared. For the Brovey transform, the bands of 2,3 and 4 were considered as the multispectral bands, while the panchromatic Quickbird image was considered as the higher spatial resolution band. The PCA has been performed using the available panchromatic and multispectral bands. As it was seen from the PCA, the first three PCs contained almost 98.6% of the total variance. The inspection of the last PC indicated that it contained noise from the total dataset. Therefore, it was excluded from the analysis.

In order to obtain a reliable image that can illustrate the spectral and spatial variations in the selected classes of objects, different band combinations have been compared. Although, the image created by the Brovey transform contained some shadows that were present on the panchromatic image, it still illustrated good result in terms of separation of the available land use classes and individual objects. The image created by the PCA method contained less shadows, however, it was very difficult to analyze the final image, because it contained too much color variation of objects belonging to the same class. Therefore, for further analysis the image created by the Brovey transform has been used. As seen from the Brovey transformed image shown in figure 2, all details are clearly seen. For creation of urban GIS layer, the selected classes of objects were screen digitized from the topographic map of 2000.

Figure 2. The Brovey transformed image of the test area.

To extract the urban land cover information, a rule-based approach which consists of a set of rules, that contains the initial image segmentation procedure based on a Mahalanobis distance classifier (Mather 1999) and the constraints on spectral parameters and spatial thresholds, has been constructed. The Mahalanobis distance classifier is a parametric method, in which the criterion to determine the class membership of a pixel is the minimum Mahalanobis distance between the pixel and the class centre.

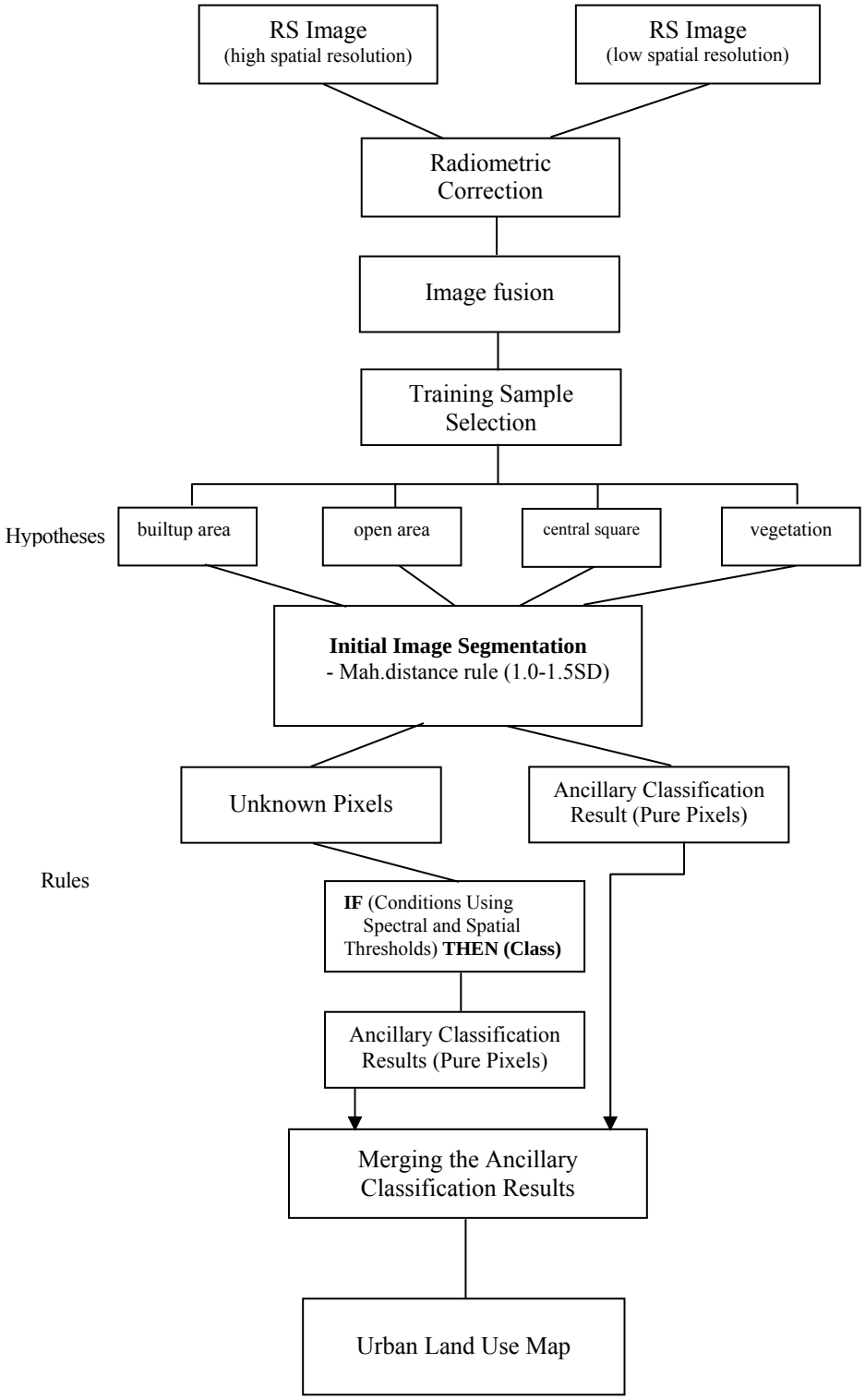

Figure 3. A general diagram of the knowledge-based classification.

In the Mahalanobis distance estimation, for the initial separation of the classes, only pixels falling within 1.0-1.5 standard deviation (SD) and the Brovey transformed features were used. The pixels falling outside of 1.0-1.5 SD were temporarily identified as unknown classes and further classified using the rules in which different spectral and spatial thresholds were used. The spectral thresholds were determined based on the knowledge about spectral characteristics of the selected classes, whereas the spatial thresholds were determined based on polygon boundaries of the created GIS layer. The flowchart for the constructed rule-based approach can be drawn as shown in figure 3 and the image classified by this method is shown in figure 4b. As seen from the classified image, the rule-based approach could very well separate all individual objects. For the accuracy assessment of the classification result, the overall performance has been used. As ground truth information, for each class several regions containing the total of 3268 purest pixels have been selected. The confusion matrix indicated an overall accuracy of 98.26%.

Figure 4. a) The result of the MLC, b) The result of the rule-based method.
(1-Vegetation, 2-Builtup area, 3-Central square, 4-Open area).

To compare the performances of the developed algorithm and a standard method, the same set of features and training signatures used for the rule-based classification, were classified using the statistical MLC. The image classified by the MLC method is shown in figure 4a. The confusion matrix indicated an overall accuracy of 86.34%. As seen from the classification results shown in figure 4a-b, the result of the rule-based method looks much better than that of the standard method and the extracted objects are very accurately delineated forming the classes of objects. The comparison of the extracted objects with the existing GIS layer (figure 5b) shows that there had occurred some changes within a two year period. Therefore, the obtained result could be successfully used for update of the GIS layer after making some corrections.

4. CONCLUSIONS

The aim of this study was to extract the information from the high resolution satellite images of Ulaanbaatar, the capital city of Mongolia. For the extraction of land cover information from the selected RS data sets, a knowledge-based classification technique based on a rule-based

approach was constructed. The constructed method uses an initial image segmentation procedure based on a Mahalanobis distance classifier as well as the constraints on spectral and spatial thresholds. The result of the knowledge-based method waswere compared with result of a statistical MLC and it demonstrated higher accuracy. Overall, the study indicated that the information extracted from very high resolution satellite images are very reliable and can be successfully used for update of a GIS layer specifically in urban context.

5. REFERENCES

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