Detection of Urban Features From High Resolution Satellite Images

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Abstract – **One common approach to detect urban features from high resolution images is, using automatic classification methods. The purpose of this paper is to demonstrate the applicability of the developed algorithm (DA) by systematically evaluating its performances in comparison to other popular classifier, support vector machine (SVM). The detection performance of algorithms is evaluated by an object-based criterion. Considering consistency, the same set of ground truth data which is produced by labeling the building boundaries in the GIS environment is used for accuracy assessment. The method is applied to two different Quickbird images for complex urban patterns. In evaluation of object based accuracy assessment it is shown that, while, SVM provide higher rates of correct detection it provides higher rates of false alarms. DA, on the other hand, providing tolerable rates of correct detection and lower rates of false alarm.**

Key Words: Remote Sensing, urban, classification, monitoring, GIS

1. INTRODUCTION

Identification of buildings, roads, utilities, and recreational areas is crucial for urban planning, GIS updating, disaster management, and military target detection and so on. Due to the complexity and diversity of problem domain, there are various algorithms and methods developed for building extraction (i.e., detection and delineation of buildings). The most commonly used approach for information extraction is multispectral classification methods (Jensen, 1996). The SVM is one of the popular methods, which has gained extensive applications in pattern recognition over the last decades (Gualtieri and Cromp, 1999; Brown et al., 2000; Huang et al., 2002; Zhu and Blumberg, 2002; Melgani and Bruzzone, 2004; Pal and Mather, 2005; Chi et al., 2008). The SVM is a machine learning algorithm which employs optimization algorithms to locate the optimal boundaries between classes (Huang et al., 2002). Multispectral classification methods are limited by only using spectral information without considering spatial information (Yan et al., 2006). In this concept, we developed a generic algorithm for automatic extraction of buildings. The theoretical background of the developed algorithm presented in detail in the Aytekin et al., 2010. The algorithm exploits spectral properties in conjunction with spatial properties both of which actually provide complementary information to each other. In the literature there is various studies focus on comparison of pixel-based and object-oriented image classification approaches (Song et al., 2006; Yan et al., 2006; Matinfar et al., 2007; Qian et al., 2007). The purpose of this paper is to compare the performance of the SVM and the DA for detection of buildings. In order to obtain useful remote sensing derived information, it is necessary to quantitatively evaluate the classification accuracy (Meyer and Werth, 1990). Many studies in the literature simply express the classification accuracy by a pixel based error matrix (Huang et al., 2002; Matinfar et al. 2007; Otukei and Blaschke, 2010). In the building detection studies, the output maps of the algorithms are images where the pixels corresponding to each detected building are labeled with a unique integer value (Aksoy et al., 2008). These outputs can be considered as objects in the image data. Therefore, object-based evaluation of classification may be more appropriate than pixel-based evaluation techniques. As a result, an object-based criterion is used in this study for the comparison of the algorithms.

2. TEST SITE and DATA

The data is composed of medium resolution (2.4m) multi-spectral (R, G, B, NIR) bands and high resolution (0.6m) panchromatic band of Quickbird image of Ankara city. The Quickbird image of the study region is obtained in year 2002. Since, each region is formed by different properties of surface features; study is not restricted to only one region. Therefore, the study is implemented in two different small test regions which are located in the western districts of Ankara province, Turkey (Figure 1).
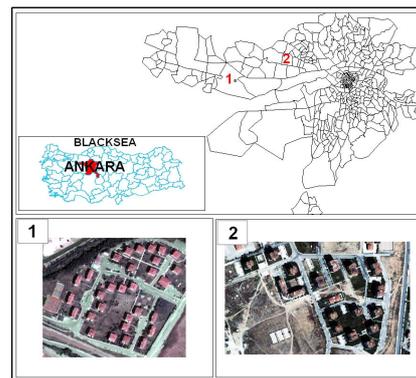

Figure 1. Test Regions used for the analysis

These regions involve Erler (1) and Mehmet Akif Ersoy (2), neighborhood respectively (see Figure 1). The regions with complex urban patterns involve almost all kinds of challenges such as dense build up areas, regions with bare soil, shadow, vegetation, wide and narrow size roads and/or paths, small and large buildings with different building rooftops such as concrete and brick.

3. IMAGE CLASSIFICATION

3.1. Support Vector Machines (SVMs)

The SVMs seeks to find the optimal separating hyperplane that separates two classes. In literature, there have been quite a few comparison studies for selecting kernel and kernel parameters for SVM classification (Scholkopf et al., 1999; Cherkassky and Ma, 2004; Dixon and Candade, 2008). It has been known that RBF works well in most cases (Huang et al., 2002; Boyd et al. 2006; Ge et al., 2008). Based on these findings, for the current study, only RBF kernels are used. The parameters that are varied are the RBF kernel radius and the regularization parameter (C). for In order to select the

kernel parameters for SVM classification a comparison study is done. As a result of these analyses, kernel radius is set to 1 and C is set to 1000 for each test region. While SVM is a binary classifier in its simplest form, it can function as a multiclass classifier by combining several binary SVM classifiers (creating a binary classifier for each possible pair of classes). In this study a pair wise classification strategy for multiclass classification is used.

Initially, appropriate region of interests are selected for different categories of land use/land cover classes present for test region 1 and 2. Once trained, the SVM algorithm is used to classify the entire subset for test regions. SVM classification algorithm is performed in ENVI 4.3 environment. After obtaining the classification results for test regions the result maps are post processed in order to aggregate the land cover classes other than building. As a result, classification maps contain two different categories namely: building class and non building class which can be compared by the DA results. The result maps obtained for test regions 1 and 2 is presented below Figure **2**:
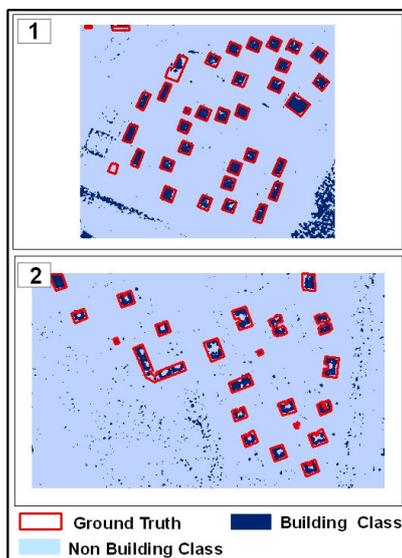

Figure 2. The SVM classification results overlaid by the ground truths for test region 1 and 2 .

3.2. Developed Algorithm (DA)

The theoretical background of the developed algorithm presented in detail in the Aytekin et al., 2010. In this algorithm first, natural and man-made regions are classified and segmented by using Normalized Difference Vegetation Index (NDVI). Then, shadow regions are detected by using chromaticity to intensity ratio in YIQ colour space. After the classification of the vegetation and the shadow areas, the rest of the image consists of man-made areas only. The manmade areas are partitioned by mean shift segmentation where some resulting segments are irrelevant to buildings in terms of shape. These artefacts are eliminated in two steps: First, each segment is thinned using morphological operations and its length is compared to a threshold which is specified according to the empirical length of the buildings. As a result, long segments which most probably represent roads are masked out. Second, the erroneous thin artefacts which are classified by principle component analysis (PCA) are

removed. In parallel to PCA, small artefacts are wiped out based on morphological processes as well. As a result of the algorithm candidate buildings are obtained. The proposed algorithm is implemented in Matlab v. 7.6 environments. Only the mean-shift segmentation is performed using a stand-alone system (EDISON) developed by Comaniciu and Meer (2002). The result maps obtained for test regions 1 and 2 is presented in Figure 3.
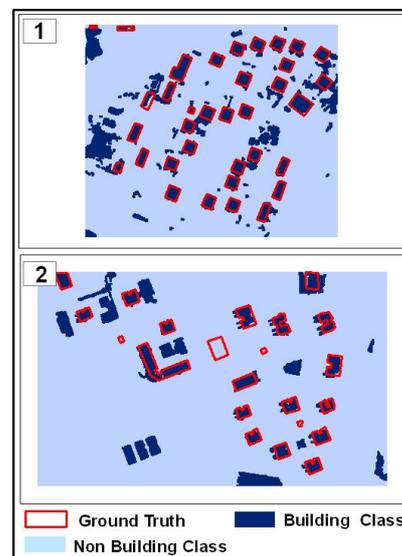

Figure 3. The DA classification results overlaid by the ground truths for test region 1 and 2 .

3.3. Accuracy Assessment

Computations of performance measures are more straightforward by the object-based error measure, the overlapping area matrix (OAM) (Beauchemin and Thomson, 1997). The details of the approach was presented in detail in the Aytekin et al., 2010. Therefore, the theoretical background information will not be provided here, just the results will be presented. In order to evaluate and compare the algorithms performance, the percent rates of measurements are computed for two different test regions. According to the OAM algorithm, the results of the OAM parameters vary depending on the selected threshold values. Therefore, to provide more rigorous evaluation of algorithms, the percent rates of OAM measurements assessed by a threshold value in a continuous range between 0 and 1. As a result of these computations, it is seen that the algorithm results don't provide any over and under detections for any test regions which might be due to distant locations of the buildings. The graphical presentation of correct detection, rates are displayed in this study.

The parameters are displayed in percent in order to provide a reasonable comparison of the algorithms. Here, it is important to indicate that, the algorithm can provide higher percents of correct detections when the percent is computed for the total number of ground truth objects. However, it is significant also to analyze the percent of correct detection to the total number of output objects obtained from the classification results. Since, the algorithm may provide significant numbers of false alarms, beside the correct detections. Therefore, in this study the correct detections are evaluated by computing the percents to the ground truths and classification outputs, respectively. Figure 4 presents the

correct detection rate in percent to the total number of ground truth objects and to the total number of classification outputs.
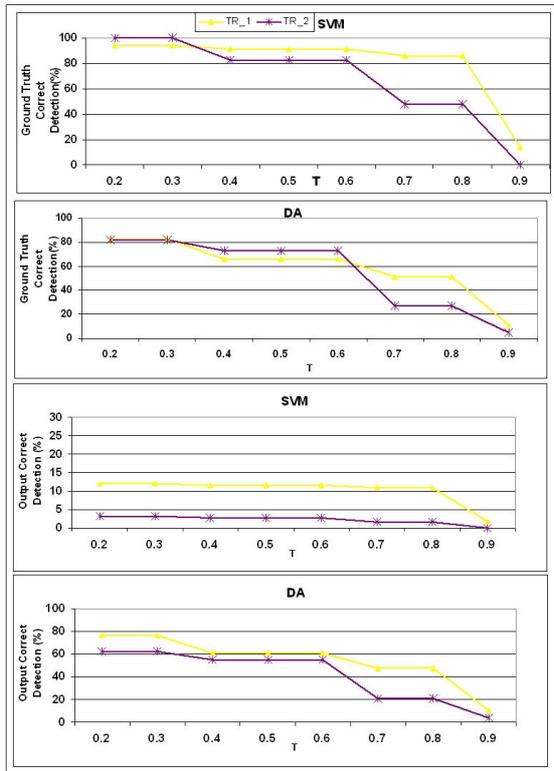

Figure 4. Correct detection percents with respect to ground truths and outputs.

This illustration clearly indicates that, the classification maps obtained by SVM provide higher numbers of false alarms besides the correct detection. Because, both test regions provide higher percents of correct detection (90% to 100%) when the ground truth is considered, however the correct detection percent decreases to lower percents (4% to 12%) when the output objects are used. On the other hand, the DA provides a tolerable correct detection percents (70% to 80%) when the ground truth and the total output objects are considered. This may be result with the lower rates of false alarms are obtained as a result of DA classification maps.

CONCLUSION

This research and resultant information is critical and provides guidance for the further studies for detection of urban features in utilization of remotely sensed data. As a result of this study it shown that SVMs have considerable potential for the classification of remotely sensed data. However, besides its ability to detect high percent of ground truths, it provides also high percents of false alarms. DA on the other hand provides tolerable results to detect the buildings and also it provides lower percents of false alarms. This is mainly due to the methodology of the DA algorithm used. It removes objects other than building. Therefore, while removing the artifacts it may also eliminate some buildings. Moreover, the segmentation used in the algorithm is very critical. Therefore, in the future studies different segmentation algorithms may also be evaluated.

REFERENCES

S. Aksoy, B. Ozdemir, S. Eckert, F. Kayitakire, M. Pesarasi, O. Aytekin, C.C. Borel, J. Cech, E. Christophe, H.S.B. Duzgun, A. Erener, K. Ertugay, E. Hussain, J. Inglada, S. Lefevre, O. Ok, D.K. San, R. Sara, J. Shan, J. Soman, I.Ulusoy, R. Witz, "Performance Evaluation of Building Detection and Digital Surface Model Extraction Algorithms: Outcomes of the PRRS 2008 Algorithm Performance Contest," Proc. of IAPR Wokshop on Pattern Recognition in Remote Sensing (PRRS 2008), 7 December, Tampa Florida, USA.

Ö. Aytekin, A. Erener, İ. Ulusoy, and H.S.B. Düzgün, "Unsupervised Building Detection in Complex Urban Environments from Multi Spectral Satellite Imagery", International Journal of Remote Sensing (Under Press), 2011

M. Brown, H.G. Lewis, and S.R. Gunn, "Linear Spectral Mixture Models and Support Vector Machines for Remote Sensing", IEEE Transactions on Geoscience and Remote Sensing, vol 38(5), p.p. 2346 - 2360, September 2000

M. Chi, R. Feng, L. Bruzzone, "Classification of hyperspectral remote-sensing data with primal SVM for small-sized training dataset problem", Advances in Space Research, vol 41, p.p. 1793-1799, 2008

J.A. Gualtieri, and R.F. Cromp, "Support vector machines for hyperspectral remote sensing classification," in Proceedings of the SPIE, vol 3584, p.p. 221–232, 1999

C. Huang, L.S. Davis, J.R.G. Townshed, "An assessment of support Vector Machines for Land cover classification", International Journal of Remote sensing, vol 23, p.p. 725–749, 2002

J.R. Jensen, "Introductory Digital Image Processing a Remote Sensing Perspective", Prentice Hall. ISBN: 0-13-205840-5, p.p.172,199, 1996

H.R. Matinfar, F. Sarmadian, , S.K. Alavi Panah, and R.J. Heck," Comparisons of Object-Oriented and Pixel-Based Classification of Land Use/Land Cover Types Based on Lansadsat7, Etm+ Spectral Bands (Case Study: Arid Region of Iran)", American-Eurasian J. Agric. & Environ. Sci., vol 2 (4), p.p. 448-456, 2007. ISSN 1818-6769, 2007

F. Melgani and L. Bruzzone, "Classification of Hyperspectral Remote Sensing Images With Support Vector Machines", IEEE Transactions on Geoscience and Remote Sensing, vol 42(8), p.p. 1778 - 1790, August 2004.

M. Meyer, and L. Werth, "Satellite Data: Management Panacea or Potential Problem?", Journal of Forestry, vol 88(9), p.p. 10-13, 1990

J.R. Otukei, T. Blaschke, "Land cover change assessment using decision trees, support vector machines and maximum likelihood classification algorithms", International Journal of

Applied Earth Observation and Geoinformation, vol 12, p.p. 27–31, 2010

M. Pal, and P. M. Mather, "Support vector machines for classification in remote sensing", International Journal of Remote Sensing, vol 26(5), p.p. 1007–1011, 2005

G.Yan, J.F. Mas, B.H.P. Maathuis, Z. Xiangmin, and P.M. Van Dijk, "Comparison of pixel-based and object-oriented image classification approaches—a case study in a coal fire area, Wuda, Inner Mongolia, China", International Journal of Remote Sensing, vol 27(18), p.p. 4039–4055, 2006

G. Zhu, and D.G. Blumberg, "Classification using ASTER data and SVM algorithms: The case study of Beer Sheva, Israel", Remote Sensing of Environment, vol 80(2), p.p. 233–240, 2002