DETECTION OF URBAN FEATURES AND MAP UPDATING FROM SATELLITE IMAGES USING OBJECT-BASED IMAGE CLASSIFICATION METHODS AND INTEGRATION TO GIS

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ABSTRACT:

The images having ground sampling distance of 0.6-1.0m recently regarded as the high resolution remote sensing images are widely using in recent remote sensing technologies. They are very important and required data for obtaining spatial data using their information contents. With regard to the arrangement of remote sensing images for any mapping applications, there are some existing methods, algorithms and the processes for their geometric corrections and enhancements. Additionally, new approaches of classification such as "object-based image analysis" utilize to obtain information contents of the images widely used in recent years.

In this study, the high resolution QuickBird image of 2004 and IKONOS satellite images of 2002 and 2008 covering Zonguldak City in Turkey have been used. The testfield is agro-industrial district in Zonguldak which has rolling topography along the Black Sea Coast. The urban features like buildings and roads in the images have been detected, recognized and extracted using Cognition v4.0.6 software and the object-based classification approach. The results have been compared with the reference vector maps scale of 1/5000 of testfield, and the success of object-based image analysis of final results compared and contrasted respectively with other vector products, which had been obtained by the method of on-screen digitizing results, has been tested by GIS software. Consequently, the results and discussions about the production and updating of maps at the scales of 1/5000, which are recently and widely used by local authorities and public organizations, have been presented.

1. INTRODUCTION

Developments in the satellite technologies have specifically provided the opportunity of determination of the large areas in details and in this respect, production of the reliable and extended recent data quickly. Thus, the fast developments in urban areas can be followed and strategies of directing those developments can be formed. In this respect, automatic object extraction approaches have recently become necessary for large-scale topographic mapping from the images, determining the changes of topography and revising the existing map data. For mapping from high resolution space imagery or GIS database construction and its update, automatic object-based image analysis has been generally used for remote sensing applications in recent years. Besides, as the products obtained by automatic object-based extractions are GIS-based, they can be integrated to GIS, queried and various strategic analyses can be made.

In addition, the geometric resolution and information contents of VHR space images are very important factor to get spatial information and extract objects from images. These images are now suitable for mapping purposes by technological developments comparing past. The main cause is that these images have smaller ground sampling distance (GSD) values. The GSD which is mentioned above is the distance of the centers of neighboured pixels projected to the ground (Buyuksalih et al., 2006). The pixel size on the ground is the physical size of the projected pixels. Neighboured pixels may be over-sampled (the projected pixels are overlapping) or under-sampled (there is a gap between neighboured pixels). The user will not see something about over- or under-sampling; this is only influencing the image contrast, for the user the GSD looks like the pixel size on the ground.

Topographic line maps should have a geometric accuracy of approximately 0.25mm in the map. That means with 1m GSD, corresponding also to a standard deviation of the object coordinates of 1m, a map scale 1: 4000 should be possible. This is a quite larger scale like justified by the information contents. Large scale maps do show more details like small scale maps, so a higher resolution is required for large scale mapping (Topan et al., 2004). Based on experiences, there is a rule of thumb of 0.05 up to 0.1mm GSD in the representation scale. That means with 0.6m GSD of QuickBird images a map with a scale 1/5000 can be generated approximately (0.6m / 0.1m ≈ 5000). For this scale, a horizontal accuracy of 1.3m (5000 x 0.25mm ≈ 1.3m) is required. In the same way, a map with a scale 1:10000 can be generated with 1m GSD of IKONOS images (Passini and Jacobsen, 2004).

In this study, the building and road features from georectificated QuickBird image of 2004 and IKONOS satellite images of 2002 and 2008 covering Zonguldak testfield have been obtained automatically by using eCognition v4.0.6 software and object-based image analysis. The obtained results have changed into vector format and integrated to a database. These vectors, produced automatically, have been compared

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with the reference 1/5000 scale topographic vector maps of testfield and the results obtained from on-screen manual digitizing method. Thus, information contents of QuickBird and IKONOS images were discussed from the acquired results. The capability of object-based feature extraction and was tested by GIS software; the results have been presented and commented. On the other hand, the results and discussions about the production and updating of maps at the scales of 1/5000, which are recently and widely used by local authorities and public organizations, have been presented. Therefore, making GIS-based analysis and comparisons with raster and vector data of the test area has crucial importance in terms of putting forth the recent situation.

2. TESTFIELD AND DATASETS

Zonguldak testfield is located in Western Black Sea region of Turkey. It is famous with being one of the main coal mining areas in the world. Although losing economical interest, there are several coal mines still active in Zonguldak. Area has a rolling topography, in some parts, with steep and rugged terrain. While partly built city area is located alongside the sea coast, there are some agricultural lands and forests in the inner part of the region. Fig.1 shows the testfield from QuickBird imagery of taken in May 2004. In the upper part of the testfield, Black Sea is lying down and other parts of the image includes central part of the Zonguldak city which covers nearly 15x15km area with the elevation range up to 450m.

Figure 1. Zonguldak testfield from QuickBird image

Before analyses, QuickBird and IKONOS images was enhanced by applying a pan-sharpening method (Zhang and Wang, 2004) used in PCI system. This method makes it possible to benefit from the sensors spectral capabilities simultaneously with its high spatial resolution. After the fusion, a pan-sharpened QuickBird and IKONOS images are obtained with a 0.60m and 1m resolutions and 4 MS bands (NIR/R/G/B) (Fig. 2).

In this study, a subset of pan-sharpened image which includes the buildings and road features were planning to automatically extract was tested. The characteristics of this field, shown in Fig. 2, 3 and 4, are to have a variable topography and to be more urbanized area in Zonguldak. Looking detail to image, there are lots of buildings with different shapes and road network without in order. It can be seen that, some of building roofs of are different from each other and some of the road network is shadowed by building features and vegetation (Marangoz 2009).

Figure 2. Subset of pan-sharpened image QuickBird of 2004 of Zonguldak testfield, 0.60m GSD

Figure 3. Subset of pan-sharpened image IKONOS of 2002 of Zonguldak testfield, 1m GSD

Figure 4. Subset of pan-sharpened image IKONOS of 2008 of Zonguldak testfield, 1m GSD

2.1 Results from Object-based Image Analysis

Object-based approach takes the form, textures and spectral information into account. Its classification phase starts with the crucial initial step of grouping neighboring pixels into meaningful areas, which can be handled in the later step of classification. Such segmentation and topology generation must be set according to the resolution and the scale of the expected objects. By this method, not single pixels are classified but homogenous image objects are extracted during a previous segmentation step. This segmentation can be done in multiple resolutions, thus allowing differentiating several levels of object categories (Baatz et al., 2004).

For the purpose of this study, several tests were carried out to match with the successful segmentation, then the classification by entering different parameters to eCognition software package (Fig. 5a, 5b, 5c, 5d, 5e and 5f).

Figure 5a. Vector results of object-based classification of buildings from QuickBird image of 2004

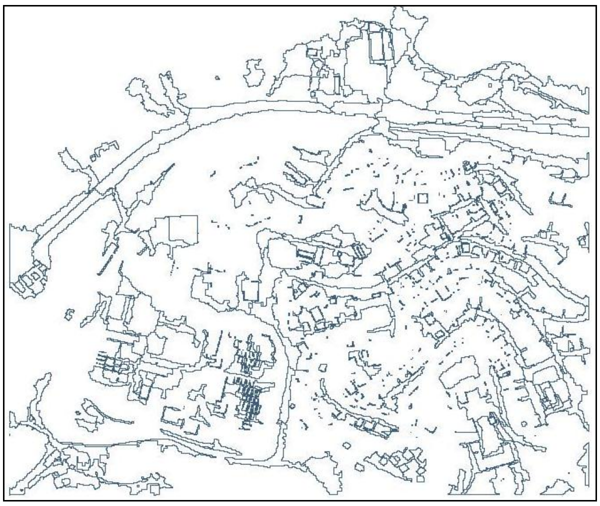


Figure 5b. Vector results of object-based classification of road network from QuickBird image of 2004

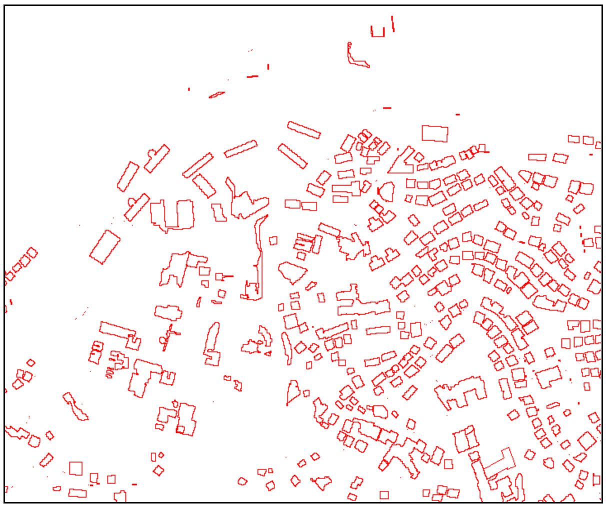


Figure 5c. Vector results of object-based classification of buildings from IKONOS image of 2002

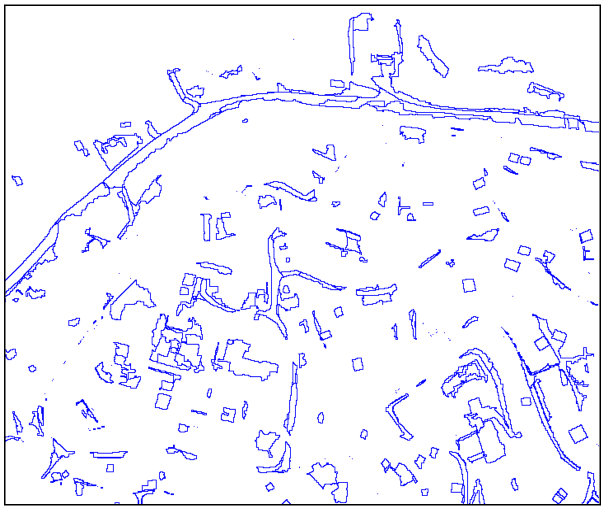


Figure 5d. Vector results of object-based classification of road network from IKONOS image of 2002

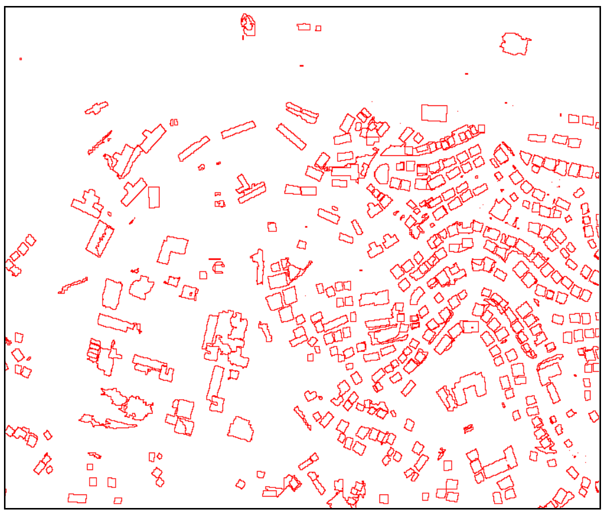


Figure 5e. Vector results of object-based classification of buildings from IKONOS image of 2008

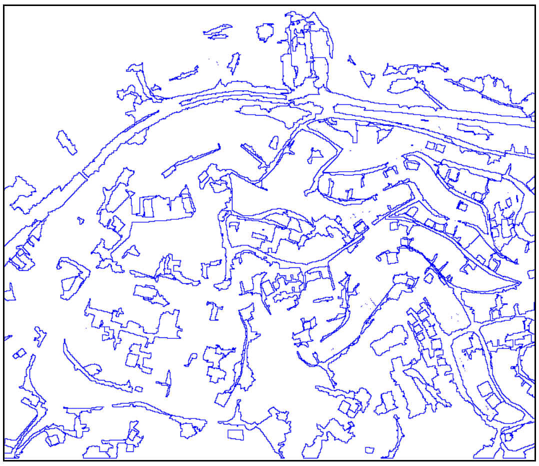


Figure 5f. Vector results of object-based classification of road network from IKONOS image of 2008

Classification accuracy in remote sensing is to determine the agreement between the selected reference materials and the classified data. For this purpose, 100 sample segments for buildings and 50 sample segments for road network in the testfield have been selected randomly from image and their agreement with ground truth were analysed. Based on these analyses, the overall accuracy was determined as %78, %73 and %75 in turn.

2.2 Results from Manual On-Screen Digitizing Method

Evolving computer technology enabled digitizing interactively which was made in the former times on digitizing tables. The features on graphical map are traced on the screen via proper software. The result data is a compound of many operator defined layers. The topology is created and edited by the operator himself.

For the purpose of this study, an operator digitized buildings and road network manually based on QuickBird and IKONOS images. The acquired results of buildings and road network vectors from manual on-screen digitizing method are shown in Figure 6a and 6b (only IKONOS image of 2008 vector results are given here).

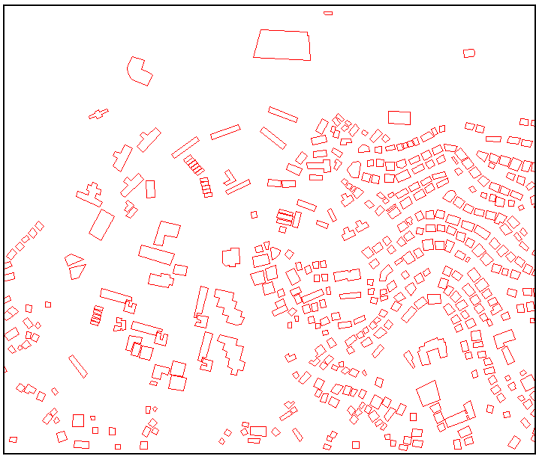


Figure 6a. Building vector results from manual on-screen digitizing method

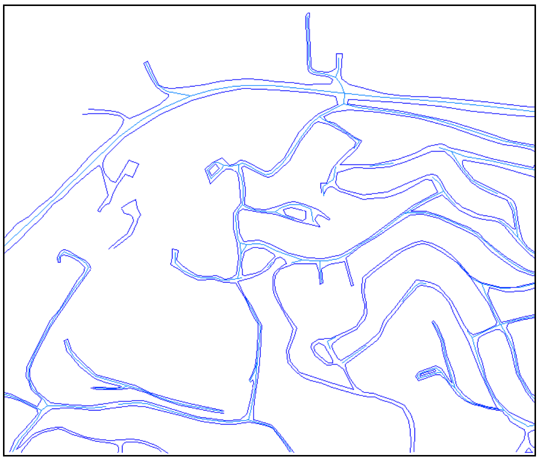
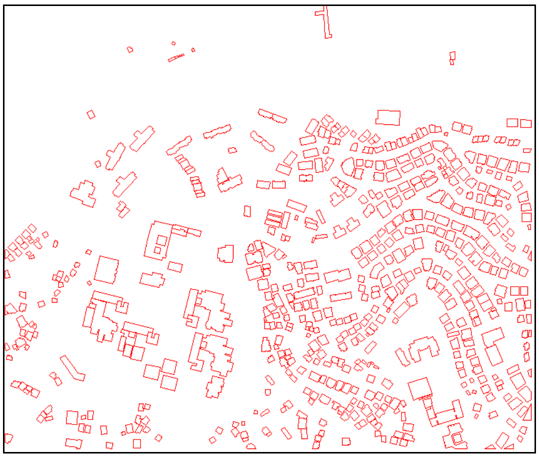


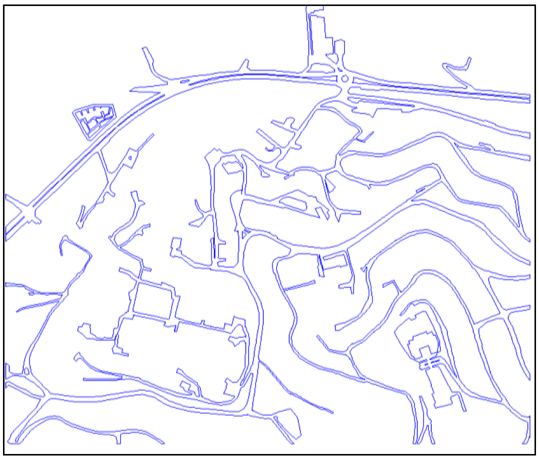
Figure 6b. Road network vector results from manual on-screen digitizing method

2.3 Vectors from 1/5000 Scale Topographic Maps

For the purpose of this study, buildings and road vectors from 1/5000 scale topographic maps were used as a reference data for comparison of two feature extraction methods (Fig. 7)



(7a)

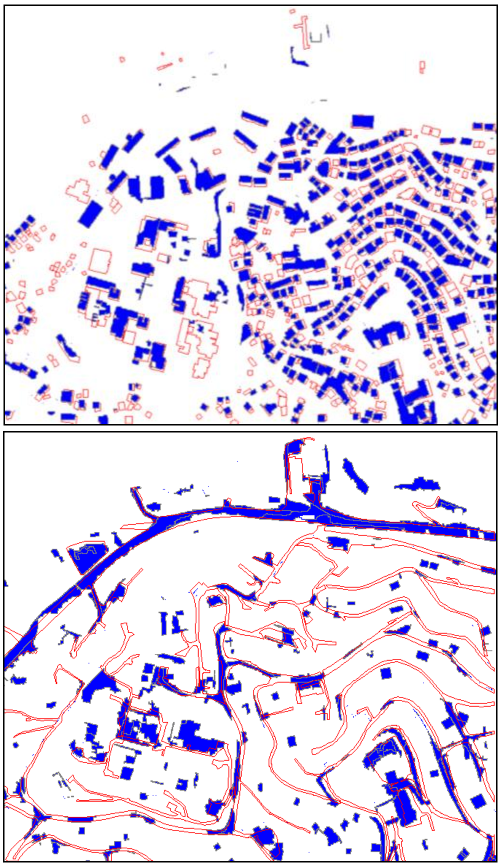


(7b)

Figure 7. Building and road network vector results from 1/5000 scale topographic maps

3. COMPARISON OF FEATURE EXTRACTION METHODS WITH REFERENCE VECTORS

Automatic object-based feature extraction results and manual on-screen digitizing results were compared with reference vectors from 1/5000 scale topographic maps using GIS software. Firstly, vector results of object-based feature extraction of buildings and road network were compared and superimposed with reference vectors (Fig. 8) (IKONOS image of 2008 results are given here).



a

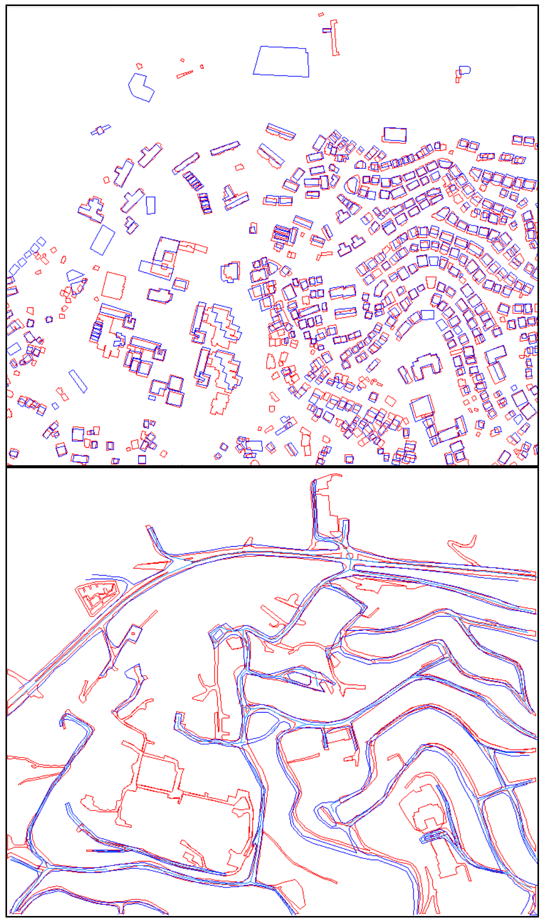
b

(Red: Reference vector, Blue: Object-based results)

Figure 8. GIS-based analysis of object-based results of buildings and road network using reference vector

In the segmentation phase of object-based feature extraction, most suitable segmentation result was selected and therefore, this situation caused more success results of buildings extractions. The extracted buildings are good shaped and similar to their real forms. Looking at Figure 8a in detail, some new buildings were constructed and some buildings were demolished. By comparing the center lines of road network of reference vector and object-based results, it was seen that, road network was extracted automatically but occurred with unsuitable results. The reason of this situation is shadow problems caused from buildings in this image and the proximity of the buildings. The other reason is low extraction capability of linear objects of eCognition (Marangoz, 2009).

Secondly, on-screen manual digitizing vector results of buildings were compared and superimposed with reference vectors (Fig. 9) (IKONOS image of 2008 results are given here).



(Red: Reference vector, Blue: Manual digitizing)

Figure 9. GIS-based analysis of on-screen manual digitizing results of buildings and road network using reference vector

Manual digitizing of buildings from QuickBird and IKONOS images were extracted with correct shape by using the advantage of 0.60m and 1m GSD. Therefore, small buildings and the street lines located in shadows could be identified easily. By counting the digitized buildings in testfield using GIS software, it was seen that, almost whole buildings were digitized manually from the images. Main problem of the road extraction from pan-sharpened QuickBird imagery is the threes which prevent extracting the objects under them. Some of the roads could not be extracted because of the blur, operator errors, operator ignorance and shadow effects. They are the other important obstacles in extraction of roads.

4. CONCLUSION

In this study, information contents and feature extraction methods were tested using very high resolution images for the production and updating of maps at the scales of 1/5000. For these purpose, these items mentioned above were compared using automatic object-based extraction and manual on-screen digitizing results from VHR images and reference 1/5000 scale topographic maps in testfield (Table 1). Firstly, object-based image analysis results of buildings and road network were derived using eCognition v4.0.6 software. Then features mentioned above were digitized manually to compare with reference vector data. For this comparison, on-screen digitizing method was used without field check of extracted objects from the images.

Data / Features		Building (piece)	Building (area – m^2)	Road (length - m)	Road (area m^2)
Reference 1/5000 scale topographic maps		596 (%100)	143100.45 (%100)	14570.31 (%100)	165037.52 (%100)
Pan-sharpened QuickBird image of 2004	Manual Vector	422 (%71)	114198.67 (%79)	13285.57 (%91)	-
	Object - Based	520 (%87)	130123.91 (%91)	-	188729.34 (%114)
Pan-sharpened IKONOS image of 2002	Manual Vector	404 (%68)	96814.44 (%68)	8063.66 (%55)	-
	Object - Based	530 (%89)	123534.14 (%86)	-	220481.00 (%133)
Pan-sharpened IKONOS image of 2008	Manual Vector	431 (%72)	112504.76 (%79)	10096.23 (%69)	-
	Object - Based	451 (%76)	138748.31 (%97)	-	243216.13 (%147)

Table 1. Capability of feature extractions using manual on-screen digitizing and OBIA (Marangoz 2009)

Based on the results, following conclusions could be drawn:

- Although QuickBird and IKONOS pan-sharpened images are suitable for production and updating of maps at the scales of 1/5000, these images does not contain whole information contents in maps at the scales of 1/5000.
- Object-based feature extraction process is very fast and feasible on building extraction, because it has close results as manual digitizing.
- Manual on-screen digitizing method process is slower than the automatic one but it has more close results as the real feature forms.
- Based on the object-based results, it was seen that, %79-97 of buildings and %115-147 of road network was extracted automatically. The reason of this low value (%79) are the situations of features in this image (unplanned urbanization) and detail contrast, shadow problems caused from buildings in the image, the proximity of the buildings and topography of testfield.
- On the other hand, eCognition software has low extraction capability of linear objects. Therefore, wrong extracted results were occurred about road features. Some of road features had same spectral reflectance with the non-roof buildings; therefore, unsuitable results were formed in the segmentation and classification phase, at the end, wrong extracted results were occurred like %115-147.
- Operator knowledge was used for manual digitizing. On the other hand, fuzzy membership functions were used to extract features in the object-based image analysis.
- Making GIS-based analysis and comparisons with raster and vector data of the test area has crucial importance in terms of putting forth the recent situation.

5. REFERENCES

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