SPATIAL AND TEMPORAL GIS ANALYSIS OF CHANGE DETECTION USING IKONOS IMAGES: A CASE STUDY OF ZONGULDAK

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ABSTRACT

Nowadays, remotely sensed images are used for various purposes in different applications. One of them is the change detection using high resolution satellite imagery which is city areas. Urbanization rapid land use and land cover change has taken place in many cities of Turkey as well as in the world in the last 50 years. In this context, comparison of extraction results from these images and existing vector data is the most important issue. The goal here is to show the advantages and disadvantages of the two IKONOS images for creating road and building database and also updating to the database. In this study, high resolution IKONOS 2002 and IKONOS 2008 have been chosen for the test area of the Zonguldak city. Firstly, pan-sharpened IKONOS images have been produced by fusion of high resolution PAN and MS images using PCI Geomatica v9.1 software package. The parcel, building and road network objects from these datasets have been extracted automatically by initially dividing it into the segments and then, they have been classified by using the spectral, spatial and contextual information using eCognition v4.0.6 software package. On the other hand, these objects have been manually digitized from high resolution images using ArcGIS v9.3 software package. These vectors produced automatically and manually have been compared with the existing digital cadastral maps and reference vector maps of scale 1/5000 of test area. The success of object-oriented image analysis results was tested by GIS software; the results have been presented and commented. 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.

KEY WORDS: IKONOS imagery, classification, temporal analysis, GIS.

1. INTRODUCTION

The availability of high resolution optical imagery appears to be interesting for geo-spatial database applications, namely for the capturing and maintenance of geodata. Recent works show that the geometry of IKONOS imagery are accurate enough for mapping purpose up to scale of 1:5000 (Büyüksalih and Jacobsen, 2005). High resolution satellite imagery data has a lot of advantages and they can be used for updating the available maps. This can be applied specifically to follow the road networks and verify them in the topographing database.

Nowadays, developments in remote sensing and image processing 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 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 this study, automatic object-based classification of buildings in the Zonguldak study area of Turkey has been realized by eCognition v4.0.6 software. And also manual object extraction of buildings in the Zonguldak study area has been realized ArcGIS 9.3. software package. Classification procedure has been implemented using pan-sharpened IKONOS-2002 and IKONOS-2008 imageries of the interest area. Such an image can be easily formed by the pan-sharpening module of PCI Geomatica 9.1.1 system. Several tests have been carried out to match with the successful segmentation, then the classification by entering different parameters to the used software. Aim of this study is to test feature extraction capacity of this high resolution images using for CIS. The results obtained have changed into vector format and integrated to a database. These vectors, produced automatically, have been compared with the reference vector maps of scale 1/5000 of study area and the results acquired from on-screen manual digitizing method. The success of object-oriented image analysis was tested by GIS software; the results have been presented and commented. 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. TEST FIELDS 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 IKONOS imagery of the testfield taken in May 2002.

In the upper part of the IKONOS-2002 IKONOS-2008 images, 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. When the images first received, they were analyzed for selecting suitable GCPs distributed on them uniformly. As a result of this determination, 43 distinct GCPs were measured by GPS survey with an accuracy of about 3cm. Since those points can be seen very well on the images, they were selected as building corners, crossings, etc. Because of the fine resolution of IKONOS imagery, many cultural features can be identified and used as GCPs. The manual measurements of GCPs' image coordinates were carried out by GCP Collection Tool under PCI Geomatica-OrthoEngine software package.

After geometric correction of IKONOS imageries (Jacobsen et al., 2005), it was enhanced by applying a pan-sharpening method (Wang and Zhang, 2004) used in PCI system. This method makes it possible to benefit from the sensors spectral capabilities simultaneously with its high spatial resolution.

Figure 1. Ikonos images of Zonguldak test area

In this study, a subset of pan-sharpened images which includes the buildings and road features were planning to automatically and manually extract was used. The characteristics of this area, shown in Figure 2, 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. For the purpose of this study, an operator digitized road network manually based on two of IKONOS imageries. And also automatic extraction which is using eCognition software packages.

Figure 2. Subset of Pan-sharpened IKONOS-2008 Image of Zonguldak Study Area

3. RESULTS and DISCUSSION

In this study manual and automatic object extraction has been used. For the automatic extraction object-based approach has been selected of test area. 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. 3).

| (a) | (b) |

Figure 3. Vector results of object-based classification of building (a) and road network (b) from IKONOS image

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 study area have been selected randomly from each image and their agreement with ground truth were analysed. Based on these analyses, the overall accuracy was determined as % 78 for QuickBird image (Alkan et.all, 2008 ; Marangoz, et al., 2007).

Manual extraction has been executed on ArcGIS software packages. All of the object details can be extracted for this manual methods. All of the extraction results will be compare of 1/5000 scale topographic maps in the subsection. IKONOS-2002, IKONOS-2008 and 1/5000 scale topographic map data (2005) should be compare depends on the buildings number and road distance.

3.1. Comparison Of Results

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. This comparisons will be given subsections.

3.1.1. Comparison of Object-based Feature Extraction Results with Reference Vector

In this section vector results of object-based feature extraction of building and road network from IKONOS images were compared and superimposed on GIS software with reference vectors (Fig. 4a and 4b).
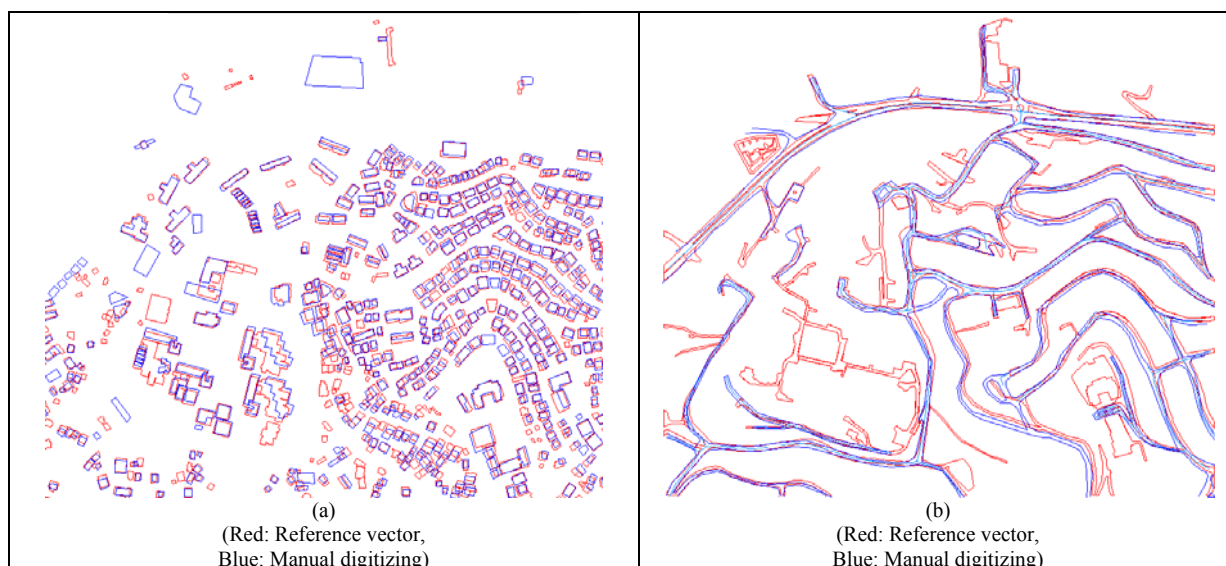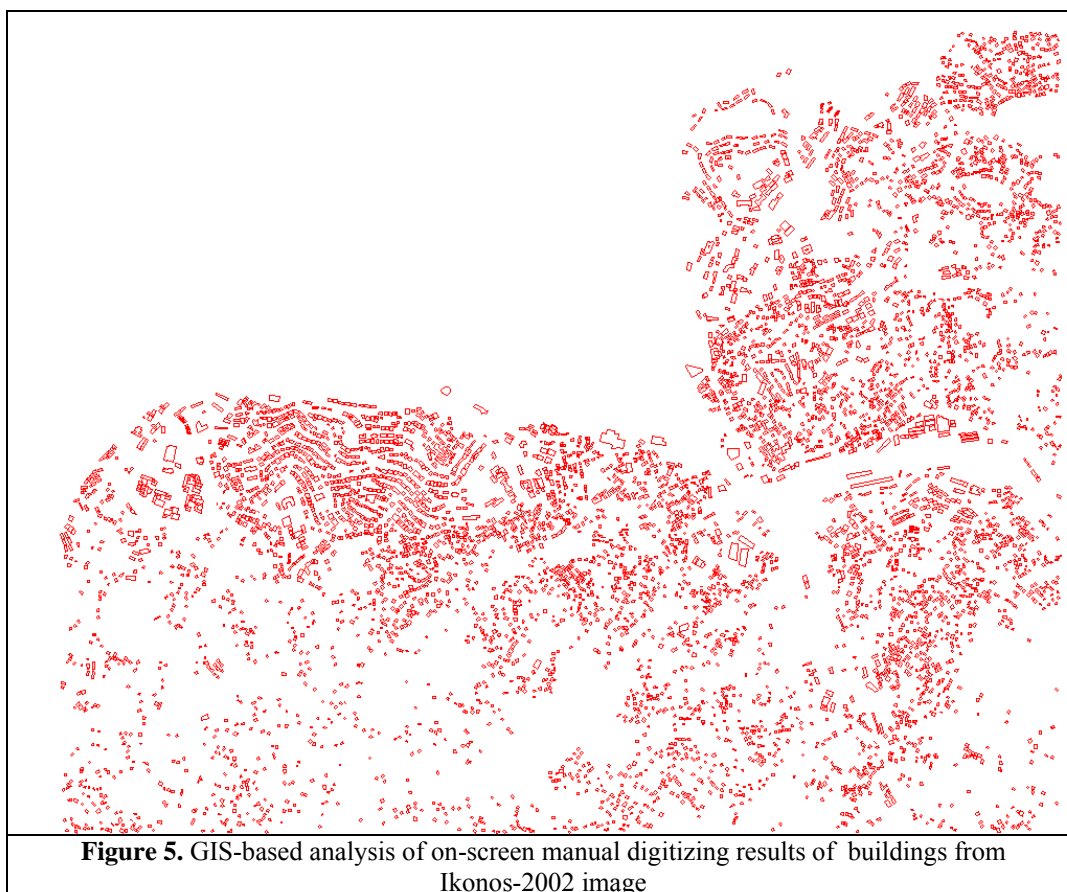

(a)
(Red: Reference vector,
Blue: Manual digitizing)

(b)
(Red: Reference vector,
Blue: Manual digitizing)

Figure 4. GIS-based analysis of on-screen manual digitizing results of building and road network from Ikonos-2008 image using reference vector

In this study, automatic extraction results is from IKONOS images approximately %75 percent for buildings. But, bad results from IKONOS images for the roads. For this reason IKONOS results of road automatic extraction is not enough for the comparison.

We were selected manual extraction results from IKONOS images for comparing with topograghing map. These comparison consist of not only buildings but also road analysis depends on the GIS functions. Figure 5. shows manual extractions results from IKONOS-2002 and Figure 6. shows manual extractions results from IKONOS-2008. And also Figure7. shows 1/5000 scale topographing map buildings data respectively.

Figure 5. GIS-based analysis of on-screen manual digitizing results of buildings from Ikonos-2002 image

Depends on the GIS analysis, IKONOS-2002 images have a 6524 numbers of buildings. IKONOS-2008 images have a 7592 buildings and finally 1/5000 scale maps have a 6937 buildings. For the GIS analysis, it is very easy to trace of the comparison and also changes of the building database. On the other hand, it is very important component is ratio of the manual extraction results from the High resolution imageries. In this study, building extraction capability is %76 , road extraction capability is %73 from IKONOS imageries.

Other results from imageries and 1/5000 scale maps road extraction. As a results of this, IKONOS-2002 have a 52003 m, IKONOS-2008 113.021 m and 1/5000 scale map have a 75203 m road distance. It is possible to seen on figure 8. and figure 9. of road database for IKONOS imageries on the ArcGIS interface.
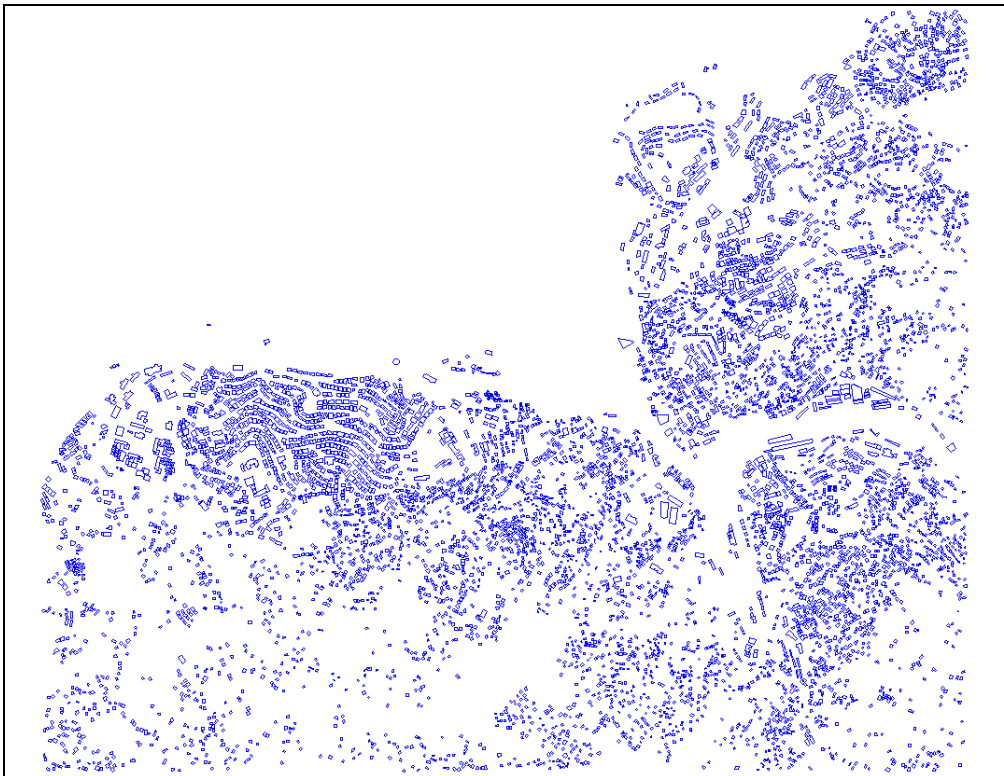
Figure 6. GIS-based analysis of on-screen manual digitizing results of buildings from Ikonos-2008 image
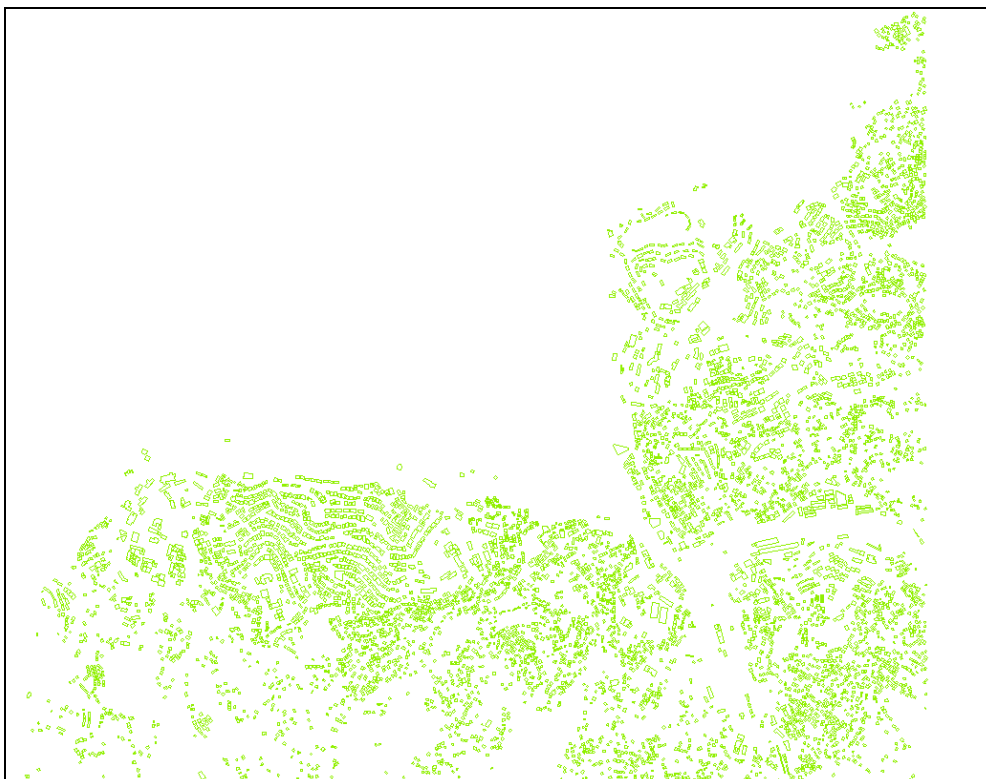

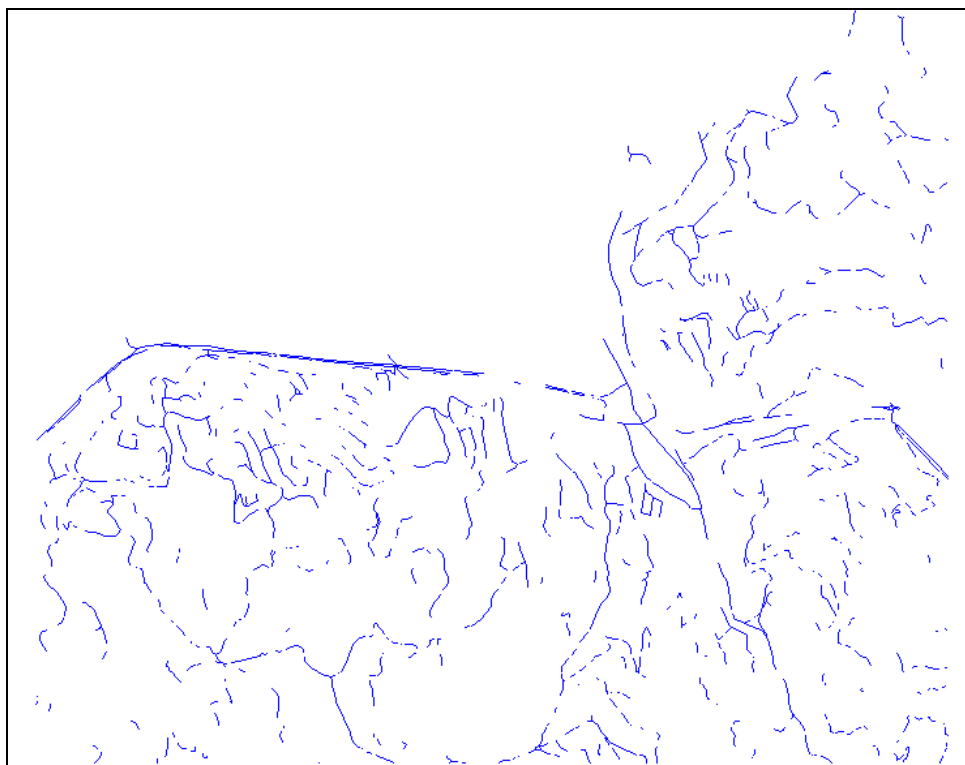**Figure 7.** GIS-based analysis of 1/5000 map results of buildings (2005)

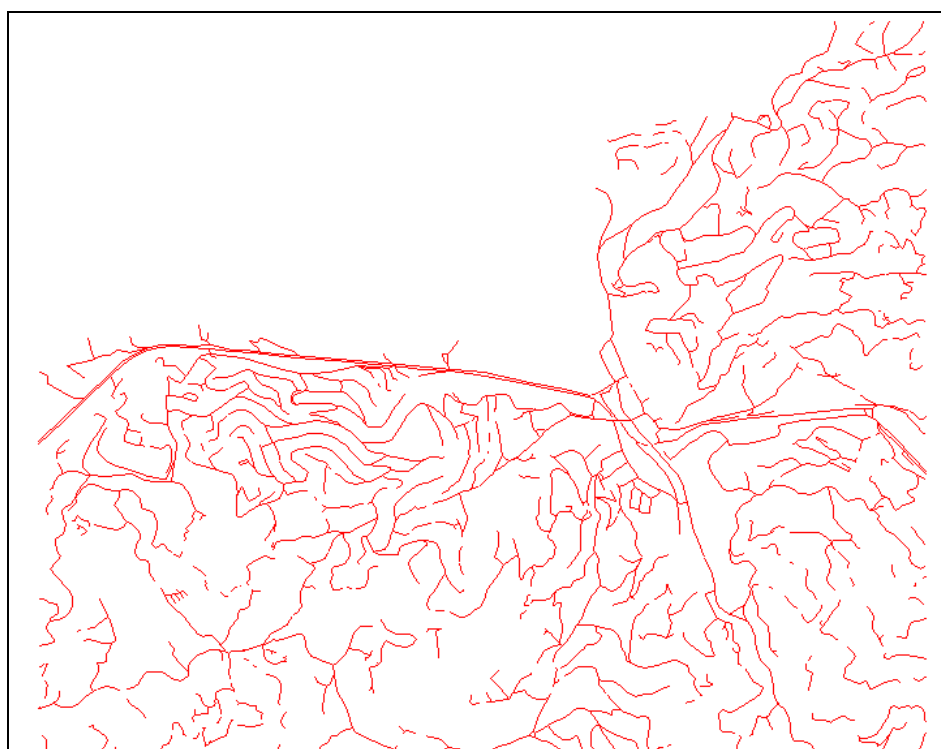**Figure 8.** GIS-based analysis of on-screen manual digitizing results of roads from Ikonos-2002 image

Figure 9. GIS-based analysis of on-screen manual digitizing results of roads from Ikonos-2008 image

Conclusion

Nowadays digital photogrammetry and remote sensing data are very important every applications of the GIS. One of the important issue is updating procedure for the GIS applications. If updating procedure is not well design, GIS application is finished as soon as possible. For this reason, digital raster data very important to updating components. It have to investigate of the digital raster data depends on the accuracy for the application. The other issue is extraction capacity of the digital imageries.

In this study, feature extraction approaches and using for updating for GIS were discussed using high resolution images for generation of topographic line mapping. Thus, it can be able to decide which data is applicable for which database updating. Features mentioned above were compared using automatic object-based extraction and manual on-screen digitizing results from IKONOS imageries and reference 1:5000 scale topographic maps in study area (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.

Table 1. Capability of manual on-screen digitizing and object-based extraction approaches using reference 1:5000 scale topographic maps

Feature in Study Area	Manual Digitizing (Ikonos-2002)	Automatic Extraction (Ikonos-2002)	Manual Digitizing (Ikonos-2008)	Automatic Extraction (Ikonos-2008)
Buildings	% 74	% 72	% 72	% 76
Road Network	% 74	-	% 69	-

Based on the results, following conclusions could be drawn:

- IKONOS imageries are not suitable for automatic feature extraction on this study area especially road features.
- Some items e.g. atmospheric conditions, sun elevation and incidence angle and detail contrast of the images affects the information contents to identify the objects.
- 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.
- 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.
- Results based on new imagery with 50cm or better GSD could be compared with the results derived from this study for GIS updating.
- Using digital photogrammetry data would produce more suitable results for GIS applications which require more accuracy.

- High resolution imageries very important for the change detection. Because it is possible to trace every six months or one year. And also faster than the other measurement methods. For instance, water supply area for the cities.

REFERENCES

Alkan M., Marangoz M.A., and Karakış S., 2008. Feature Extractions From High Resolution Imagery And Using For City Information System. 4th Workshop on Remote Sensing for Developing Countries / GISDECO 8, Istanbul, Türkiye, 04-07 Haziran 2008.

Baatz, M., Benz, U., Dehghani, S., Heynen, M., Höltje, A., Hofmann, P., Lingenfelder, I., Mimler, M., Sohlbach, M., Weber, M. and Willhauck, G., eCognition Professional: User Guide 5, Munich: Definiens-Imaging, 2004.

Büyüksalih G. and Jacobsen K., 2005: Optimized Geometric Handling of High Resolution Space Images. In: ASPRS annual convention, Baltimore, p.9

Jacobsen, K., Büyüksalih, G., Marangoz, A., Sefercik, U.G. and Büyüksalih, İ., *Recent Advances in Space Technologies (RAST)*. Istanbul, 2005.

Marangoz, A. M., Alkış, Z., Karakış, S., Evaluation of Information Content and Feature Extraction Capability Of Very High Resolution Pan-Sharpened QuickBird Image, *Conference on Information Extraction from SAR and Optical Data, with emphasis on Developing Countries*, 16-18 May, ISTANBUL, 2007.

Zhang and Wang, Multi-Resolution and Multi-Spectral Image Fusion for Urban Object Extraction, *ISPRS XXth Congress*, Istanbul, 2004.