CREATING CADASTRAL MAPS IN RURAL AND URBAN AREAS OF USING HIGH RESOLUTION SATELLITE IMAGERY

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ABSTRACT

Nowadays, remotely sensed images are used for various purposes in different applications. One of them is the cadastral application using high resolution satellite imagery. In this context, a 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 QuickBird and IKONOS imagery for making cadastral maps. In this study, high resolution IKONOS and QuickBird images of rural and urban test areas in Zonguldak and Bartın have been chosen. Firstly, pan-sharpened IKONOS and QuickBird 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 segments and then being classified by using the spectral, spatial and contextual information in eCognition v4.0.6 software package. On the other hand, these objects have been manually digitized from high resolution images using ArcGIS v9.2 software package.

These vectors produced automatically and manually have been compared with the existing digital cadastral maps and reference vector maps (scale 1/5000) of the 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.

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 QuickBird or IKONOS imagery are accurate enough for mapping purpose up to scale 1:5000 (Büyüksalih and Jacobsen, 2005). High resolution satellite imagery data has a lot of advantages and 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 large areas in detail and in this respect, production of reliable, extended and 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 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 updates, automatic object-based image analysis have 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. In this way, queries and various strategic analyses can be made.

In this study, automatic object-based classification of buildings, parcels and roads in the Zonguldak and Bartın study area of Turkey has been realized by eCognition v4.0.6 software. The Classification procedure has been implemented using pan-sharpened QuickBird images 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 is done by entering different parameters to the used software. In addition, based on the previous studies, road networks from pan-sharpened IKONOS images of the same area
have been extracted using Halcon v7.0 software and the extraction results have been interpreted. Aim of this study is to test feature extraction capacity of these high resolution images for using in GIS. The results obtained have been changed into vector format and integrated to a database. These vectors, produced automatically, have been compared with the reference vector maps (scale 1/5000) of the study area and with the results acquired from on-screen manual digitizing method. The success of object-oriented image analysis was tested by GIS software.

2 Zonguldak, Bartin Testfield and Datasets

The Zonguldak testfield is located in the 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. The 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. Figure 1 shows the QuickBird imagery of the testfield taken in May 2004. Bartin testfield is located in close of Zonguldak, but Bartin topography is smooth. Bartin test area was selected from the city center and its close vicinity of Bartin. The different structures and densities of vegetation also will be practiced approach of object-based classification.

![Figure 1: QuickBird image of Zonguldak testfield.](image)

In the upper part of the image, the Black Sea is lying down and other parts of the image include central parts of the Zonguldak city, which covers nearly 15x15km area with the elevation range up to 450m. When the images have been received, they were analyzed for selecting suitable Ground Control Points (GCPs). As a result of this determination, 43 distinct GCPs were measured by GPS survey with an accuracy of about 3cm. Since those natural GCPs can be seen very well on the images, they were selected as building corners, crossings, etc. Because of the fine resolution of QuickBird 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 QuickBird imagery (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.

In this study, a subset of pan-sharpened images which include the buildings and road features were planned to be used for the automatical extraction. The characteristics of this area, shown in Fig. 2, are a variable topography and a more urbanized area in Zonguldak. Fig. 3, is a Ikonos image, which shows urban areas and the city center of Bartin. Besides, figure 3 shows after classification of Bartin testfield. Looking at the image in detail, there are lots of buildings with different shapes and road network without any order. It can be seen that some of the building roofs are different from each other and some of the road network is shadowed by building features and vegetation. Depending on this reasons, determining parcels is not useful for Zonguldak city area. Besides, in the
urban area the determination of parcels, roads and buildings is much easier than in city areas. This situation is
given in figure 3.

![Subset of Pan-sharpened QuickBird Image of Zonguldak Study Area](image)

**Figure 2: Subset of Pan-sharpened QuickBird Image of Zonguldak Study Area**

### 3 Object-Based Feature Extraction

Object-based image analysis comprises an image segmentation and object-based classification phase in
eCognition v4.0.6 software. This software offers a segmentation technique called Multiresolution Segmentation
(MS). Because of the MS is a bottom-up region-merging technique, it is regarded as a region-based algorithm.
MS starts by considering each pixel as a separate object. Subsequently, pairs of image objects are merged to
form bigger segments (Darwish at all., 2003).

The merging decision is based on local homogeneity criteria, describing the similarity between adjacent image
objects. The pair of image objects with the smallest increase in the defined criterion is merged. The process
terminates when the smallest increase of homogeneity exceeds a user-defined threshold (the so called Scale
Parameter – SP). Therefore a higher SP will allow more merging and consequently larger objects, and vice versa.
The homogeneity criterion is a combination of color (spectral values) and shape properties (smoothness and
compactness). Applying different SPs and color/shape combinations, the user is able to create a hierarchical
network of image objects (e-Cognition, 2004).

Image segmentation phase is followed by the classification of the images. eCognition software offers two basic
classifiers: a nearest neighbour classifier and fuzzy membership functions. Both act as class descriptors. While
the nearest neighbour classifier describes the classes to detect by sample objects for each class which the user has
to determine, fuzzy membership functions describe intervals of feature characteristics wherein the objects do
belong to a certain class or not by a certain degree. Thereby each feature offered by eCognition can be used
either to describe fuzzy membership functions or to determine the feature space for the nearest neighbour
classifier. A class then is described by combining one or more class descriptors by means of fuzzy-logic
operators or by means of inheritance or a combination of both. As the class hierarchy should reflect the image
content with respect to scale the creation of level classes is very useful. These classes represent the generated
levels derived from the image segmentation and are simply described by formulating their belonging to a certain
level. Classes which only occur within these levels inherit this property from the level classes. This technique
usually helps to clearly structure the class hierarchy (Marangoz at al., 2006).
4 Comparison of Feature Extractions 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.

4.1 Comparison of Object-based Feature Extraction Results with Reference Vector

Firstly, vector results of object-based feature extraction of buildings and road network from images were compared and superimposed with reference vectors (Fig. 4a and 4b).
By counting the extracted buildings in the study area using GIS software, it was seen that 85% of buildings were extracted automatically. In the segmentation phase of object-based feature extraction, most suitable segmentation results were 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 4a in detail, it can be recognized the 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, 70% of road network was extracted automatically. The reason of this low value 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 software package (Marangoz, et al., 2007).

4.2 Comparison of On-screen Manual Digitizing Results with Reference Vector

Secondly, on-screen manual digitizing vector results of buildings and road network were compared and superimposed with reference vectors (Fig. 5a and 5b).

Figure 5: GIS-based analysis of on-screen manual digitizing results of building and road network from QuickBird image using reference vector (Red: Reference vector, blue: Manual digitizing)
Manual digitizing of buildings from QuickBird image were extracted with correct shape by using the advantage of 0.60m GSD. This image has a sun elevation angle of 65° and a sun azimuth angle of 139°, therefore, small buildings and the street lines located in shadows could be identified easily. By counting the digitized buildings in study area using GIS software, it was seen that, 90% of buildings were digitized manually. Looking at Figure 5a in detail, some new buildings were constructed and some buildings were demolished as automatic method.

Main problem of the road extraction from pan-sharpened QuickBird imagery are the trees 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. However, it was seen that, 85% of the road network of study area was digitized manually (Marangoz, et al., 2007).

5 Conclusions

In this study, the capacity of object-based classification approach to identify parcels, buildings and road networks of city and urban test areas from Ikonos and Quickbird imageries was examined. In the urban area buildings and road networks can be detected with a high percentage. However, parcel objects are not extracted very good from high resolution imagery. Besides, urban area gives a good result at all of the objects. Based on the acquired results, the following conclusions were reached.

- For extraction of parcels from the high resolution images, object-based algorithm was used. By using this algorithm parcel objects were extracted successfully which above 85% in urban area. But city area results are not good enough for creating cadastral maps (figure 3., figure 6., table.2.).
- IKONOS imagery is not suitable for automatic feature extraction on this study area especially parcel features.
- QuickBird image produced suitable mapping results. The main problems in the study area are the shadows of neighboured buildings. Besides, QuickBird image produced non-suitable mapping results for parcels objects in city area.
- 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.
- All six classes were created which contains Base_building class for Ikonos imagery. Base_building class was created to separate Buildings and Agricultural classes in city center which can not contain Agricultural objects. For this purpose, homogeneous distributed building objects were selected to create a buffer zone by 250m radius which specifies the agricultural objects out of city center. In classification phase, an inverted membership function was created to separate agricultural objects from city center which can not be in this buffer zone produced from the Base_building objects (figure 3.).
- Manual on-screen digitizing method process is slower than the automatic one but it has more close results as the real feature forms.

Figure 6: Results of Object-Based Classification of Ikonos Image in Bartın city center
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<table>
<thead>
<tr>
<th>Class Name</th>
<th>Producer's Accuracy %</th>
<th>User's Accuracy %</th>
<th>Kappa Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural</td>
<td>83</td>
<td>86</td>
<td>0.78</td>
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<tr>
<td>Buildings</td>
<td>84</td>
<td>89</td>
<td>0.75</td>
</tr>
<tr>
<td>Vegetation</td>
<td>100</td>
<td>100</td>
<td>1.00</td>
</tr>
<tr>
<td>River</td>
<td>100</td>
<td>100</td>
<td>1.00</td>
</tr>
<tr>
<td>Road</td>
<td>100</td>
<td>73</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 1: Accuracy results for classified pan-sharpened ikonos from object-based image analysis

<table>
<thead>
<tr>
<th>Feature in Study Area</th>
<th>Manual Digitizing</th>
<th>Automatic Extraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parcel (city)</td>
<td>%15</td>
<td>%10</td>
</tr>
<tr>
<td>Parcel (Urban)</td>
<td>%90</td>
<td>%85</td>
</tr>
<tr>
<td>Buildings</td>
<td>%90</td>
<td>%85</td>
</tr>
<tr>
<td>Road Network</td>
<td>%85</td>
<td>%70</td>
</tr>
</tbody>
</table>

Table 2: Capability of manual on-screen digitizing and object-based extraction approaches using reference 1:5000 scale topographic maps

References