COMPARISON OF OBJECT ORIENTED IMAGE ANALYSIS AND MANUAL DIGITIZING FOR FEATURE EXTRACTION

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ABSTRACT:

The developments in the remote sensing technology have provided the use of high-resolution images for different purposes if possible. These images can be used for a study such as town planning where high resolution and information content are required. In this study, high resolution panchromatic KVR-1000 image has been employed for extraction of man-made structures in a metropolitan city area. The test area is a part of Zonguldak (Turkey) city. First, boundaries of buildings and road's center lines have been digitized manually. Additionally, the object oriented classification process has been implemented for the same area. In this manner, the results from manual digitizing and large-scale maps produced by photogrammetrical techniques have been compared and the success of manual digitizing has been verified. The large-scale maps have been taken as the base criteria in the comparison. The second analysis deals with tests using object oriented classification. Both methods include some disadvantages. Operator could experience some problems during manual digitizing process. The object oriented analysis is an alternative tool which uses grey values of objects in the process. Both methods have been analyzed for the orderly and disordered zones constituted by the buildings and the independent houses, respectively.

1. INTRODUCTION

One of the main objectives of geoinformatics engineering is to collect data and analyze, represent the products of these data with diverse means. Today, the reliable production of information and its rapid serve to the user community is an important task. The reliability and rapidity aspects of information provision have accelerated the progress of technology. As a result of this stormy progress data acquisition from space has been an operational concern. Data acquired from space can be used in different disciplines such as geoinformatics, forestry, agriculture and etc.

Extracting both geometric and semantic information from space images has been the main concern since the early phase of remote sensing. Qualitative analysis of images does not help the user to deduce required information. Abundance of information in both photographs and space images leads user to digitize only the interested objects. Digitized objects help user to extract information on only focused features. Map digitizing started with the invention of digitizing tablets. The graphical map to be digitized is laid on the digitizer table and coordinate values of discrete points are stored in a computer using a cursor. With the emergence of scanners on the market, graphical maps are scanned at equal intervals throughout the whole image and scanned data are stored in raster file format. The next step has consisted of vectorizing the raster image. Several methods are developed to vectorize raster images. One of those methods is called *on-screen digitizing* as a manual method, and the other one is called *object oriented image analysis* as an automatic method. The basic purpose of developing these methods aims at reducing operator's interactivity with the computer and thus speeding up the digitizing process.

Today, space images can be used for data acquisition purposes. Many vendor companies provide a wide range of images for different users. One of the high resolution space imagery is the Russian KVR-1000 system. KVR-1000 images are for example used to isolate illegal buildings in a forest environment in Greece (Karathanassi et al., 2003). Kostka (2002) uses KVR-1000 imagery together with other high resolution images in order to make inferences about climatic studies, transportation routes, water resources, conservation areas, and relicts of human land-use. Another study uses KVR-1000 images to monitor refugee camps in south-east Asia (Bjorgo, 2000).

All above studies deal primarily with semantic relating of spatial objects. Geometric accuracy potential of KVR-1000 images is not well researched. Therefore a geometric assessment should be made within the context of this study. For this goal objects in KVR-1000 images are digitized using manual and automatic methods. Both obtained results are compared to 1:1000 photogrammetrically produced digital line maps.

2. METHODS

Digitizing is a way of conversion of information from analogously produced graphical maps to machine readable vector or raster formats. Many methods are used for the vectorizing process. Two of these methods are adopted in this study. These methods are manual on-screen digitizing and object oriented approach.

2.1 Manual On-Screen Digitizing

Evolving computer technology enabled digitizing interactively which was made in the former times on digitizing tables. The

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details on graphical map are traced on the screen via proper software. The end product is a compound of many user defined layers. The topology is created and edited by the user himself.

2.2 Object Oriented Image Analysis

In object oriented image analysis the basic processing units are not only individual pixels but also image objects or segments. The classifiers in object oriented image analysis are soft classifiers that are based on fuzzy logic. Soft classifiers use membership to express an object's assignment to a defined class. The membership value lies between 0.0 and 1.0, where 0.0 expresses absolute improbability and 1.0 expresses a complete assignment to a class. The degree of membership depends on the degree to which the objects fulfill the class-describing conditions. One advantage of these soft classifiers lies in their possibility to express uncertainties about the classes' descriptions. The basic processing units in object oriented image analysis are objects or pixel clusters, with object oriented approach to analyze images, the first step is always to form the processing units by image segmentation (Yan, 2003). After all processes mentioned above the objects on the image can be recognized by software using pre-defined parameters. Thus, what at manual digitizing the user carries out is handed over to computer software. Operator intervenes in case of making essential alterations to the parameters.

3. STUDY AREA AND UTILIZED DATA

The study area, which is shown in Figure 1, is a part of Zonguldak city, located in Western Black Sea region of Turkey. It is famous with being one of the main hard coal mining field 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 forest inner regions. In the study area the elevation ranges roughly up to 400 m.

Figure 1. Study area

In this test, image part from full panoramic KVR-1000 frame with frame number of 2252 and the viewing date of October 17th, 2000 was implemented. The first phase in the production of KVR-1000 orthoimages in Sovinformsputnik (SIS) is the scanning of hardcopy KVR-1000 photographs. This task was realized by the Zeiss SCAI scanner using 7 μm pixel size. For rectification of KVR-1000 images, the PC-based digital photogrammetric system called Ortho/Z-Space developed by the cooperation of SIS and Russian Institute GosNIAS was used. In this process, generally DEM from stereo TK-350 images or by the available mapping materials can be used. In the given case, for orthoimage generation, DEM digitized from the topographic maps of 1:100000 scale (with the height accuracy of 20 m) was used (information from the SIS). The used KVR-1000 orthoimage's pixel size is 1.56 m, ellipsoid is WGS-84, projection is UTM. It is in 8-bit grayscale. For the purposes, large scale maps (1:1000) which photogrammetrically produced are used. These maps date back to 1997.

4. MANUAL AND AUTOMATIC DIGITIZING

Two methods have been used in this study. The first one is on-screen digitizing which requires user intervention at the whole digitizing process. The second method requires some settings prior to processing. Here operator plays also a crucial role but the intervention is slightly reduced compared to manual methods. The method used in this study is object oriented image analysis approach as described in the second section briefly.

The study area consists of 2 km x 1.8 km sub-image of a KVR-1000 orthoimage covering nearly 14 km x 14 km on the ground. Computer Aided Design (CAD) software has been used for on-screen digitizing. While KVR-1000 image is in WGS-84 coordinate system, the 1:1000 maps are in national coordinate system. Thus, a transformation between both systems is necessary. The transformation has been made by polynomial methods and yielded an accuracy of 4.5 m. Corresponding transformation points in both systems are chosen visually.

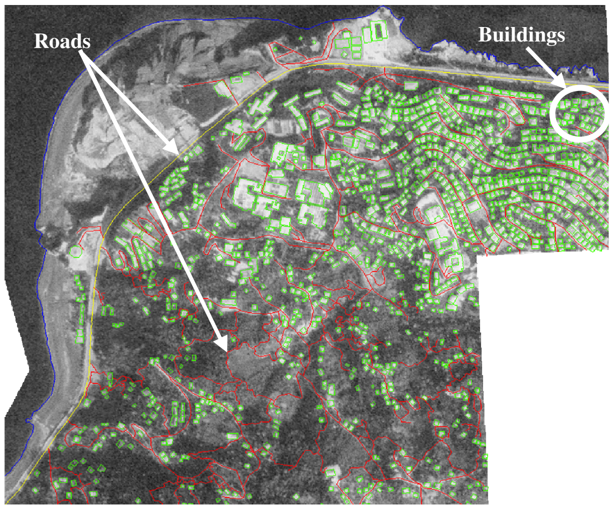


Figure 2. Digitized structures and study area

On-screen digitizing result is given in Figure 2 in green color overlapped on orthoimage. Centre lines of roads can be shown as red color in the same figure. The digitized vector results represent the area as seen from this overview image. For the quality analyses of the generated building layer the digitized structures have been compared visually with digital 1:1000 maps. There are some positional differences between the buildings which stem from digital 1:1000 maps and digitized KVR-1000 image. The discrepancies between both layers do not show systematic properties. These discrepancies are rather randomly distributed over the entire image. Some locations have been choosen for a close inspection.One can take the Figure 3 as an example. The left hand-side of the figure shows discrepancies between two layers at a location where two layers fit each other quite well. The differences lies in the range of 0.5 and 5 m. But the deviations between two layers are not homogeneous in the entire image. The right hand-side of the same figure shows two other buildings located 1 km distance from the buildings at the left hand-side. Here the disagreement between both layers vary about 6 to 13 m. Although an accuracy of ±4.5 m has been achieved after the transformation, this result is not representative in the entire study field. For the transformation, generally well-agreed points were selected in the cropped image. For more reliable interpretation, transformation, between pixel coordinates of selected points and their GPS surveyed coordinates has been made. Affine transformation has resulted in nearly ±12 m accuracy. The points used for transformation cover the whole image from which our study field has been cropped. Hence, transformation for the whole image is more representative than the transformation carried out in our study field.

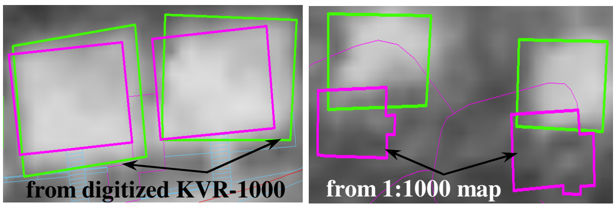


Figure 3. Discrepancies between both layers

As mentioned before, KVR-1000 orthoimage was taken in 2000 and the digital 1:1000 maps were generated in 1997. So, there are temporal differences between two materials. Although it is not possible to reach the geometric accuracy of 1:1000 maps, it is clear that determination of new buildings and roads is possible by using KVR-1000 orthoimage. For example, two centre lines of two different roads have been digitized. One of them can be seen in left hand-side of Figure 4. This line is located in both the 1:1000 map and the image. The second one is not located in the map but is detectable in the image easily (see right hand-side of Figure 4).

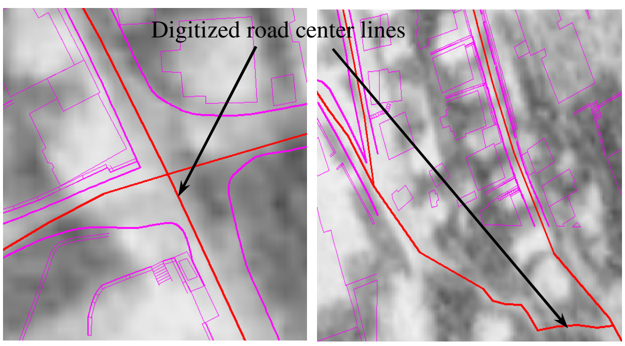
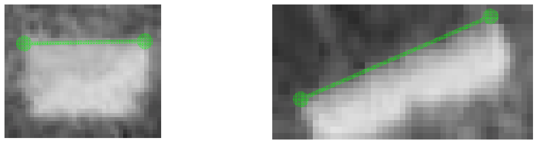


Figure 4. Digitized center lines of roads

The operator should accommodate the objects in the image during manual digitizing process using radiometric changes in the interest area. The contrast of image and effective pixel size help this achievement. So, the grey value profile analysis should be carried out in order to determine the effective pixel size of the image.



a | b

	a: Average		a: Differences		b: Average		b: Differences
1	96	1	4	1	68	1	-2
2	100	2	6	2	66	2	1
3	106	3	-1	3	67	3	2
4	105	4	-1	4	69	4	4
5	104	5	5	5	73	5	4
6	109	6	12	6	77	6	8
7	121	7	22	7	85	7	15
8	143	8	21	8	100	8	24
9	164	9	12	9	124	9	24
10	176	10	5	10	148	10	15
11	181	11	5	11	163	11	17
12	186	12	1	12	180	12	9
13	187	13	-1	13	189	13	6
14	186	14	-1	14	195	14	1
15	185			15	196		

c | d

	c: Average		c: Differences		d: Average		d: Differences
1	132	1	-1	1	130	1	-4
2	131	2	-2	2	126	2	-2
3	129	3	-5	3	124	3	0
4	124	4	-3	4	124	4	2
5	121	5	7	5	126	5	-1
6	128	6	22	6	125	6	3
7	150	7	36	7	128	7	14
8	186	8	25	8	142	8	29
9	211	9	7	9	171	9	36
10	218	10	0	10	207	10	22
11	218	11	2	11	229	11	5
12	220	12	6	12	234	12	-1
13	226	13	4	13	233	13	0
14	230	14	2	14	233	14	1
15	232			15	234		

Figure 5. Grey value profiles of different edges

Four different constructions at some selected locations can be seen in Figure 5. At the constructions the edges depicted in green are selected. The aim of the following analysis is to determine contrast of edges, especially between white and dark areas. The dark areas can be the grass, water or ground, and the white areas can be road or roof of the buildings etc. The edge analysis consists of taking profiles along the edge itself. The profiles are chosen perpendicular to the edge. For all profiles, mean values of the corresponding profile points are determined. Thus a graphic showing the trend of average values is obtained. The differences of grey values between adjacent points are built and can be seen visually. Both graphics can be seen underneath the cropped samples in Figure 5. After edge analysis, it is expected that the contrast should be very sharp like in object space (Parker, 1997). But in general, the grey value profile will not be sharp due to the imaging sensors. In Figure 5a, the edge lies in left-right direction, the edge in 5b lies in diagonal and the edge in 5c lies in upper-down direction in the image. All of them are the edges between roof (white) and grass (dark) and the grey value profiles are not sharp like in the object space. For analysis, the EDGE module of BLUH program system of Hannover University has been used. It is realized that the profiles are not so smooth. However, the profile of diagonal edge is more smooth than a and c. Figure 5d is an edge of swimming pool and the dark side is the water and the profile of diagonal edge is the sharpest among the samples. The grey value profile gives the effective pixel size from the differences. The width of point spread function at 50% height can be used as effective pixel size (Topan et al., 2004). For KVR-1000 image used in this paper, the effective pixel size is nearly 2.7 m. This means that, during the digitizing process, the operator senses approximately 2 pixels instead of 1 pixel. This situation will effect the digitization negatively.

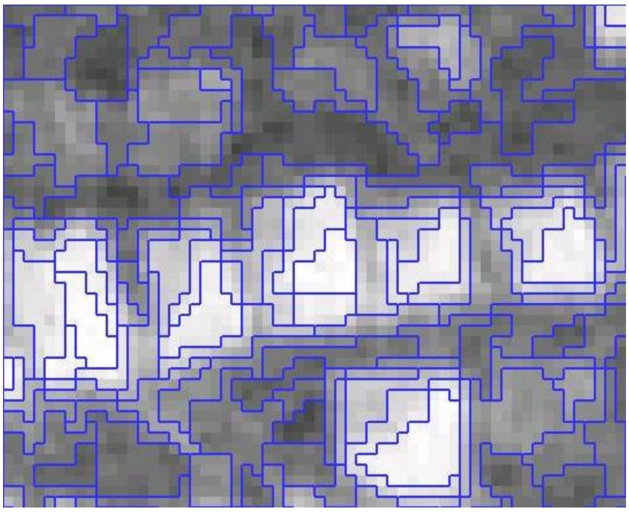


Figure 6. Created segments

Starting point of object oriented approach using the commercial software eCognition v3.0 is to create segments which are basis for building objects. The output of the segmentation step is shown in Figure 6. The boundaries show equi-characteristic cluster of pixels. The characteristics are defined by parameters before processing.

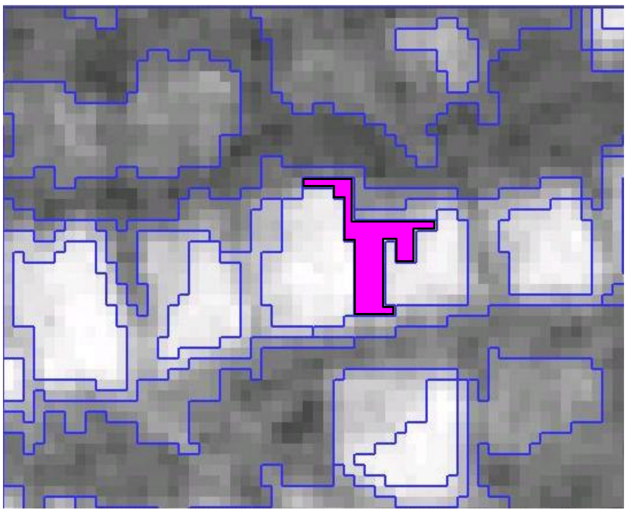


Figure 7. Mixed segments

A lot of problems occurred in the course of processing. One problem experienced is spreading of grey values over neighboring pixels due to buildings having the same characteristics would have been classified into the same class. But this is not the case because some buildings are shadowed by the adjacent buildings. The similar reflectance properties of different neighboring objects give rise to missegmentation of these different classes. This situation is shown in Figure 7.

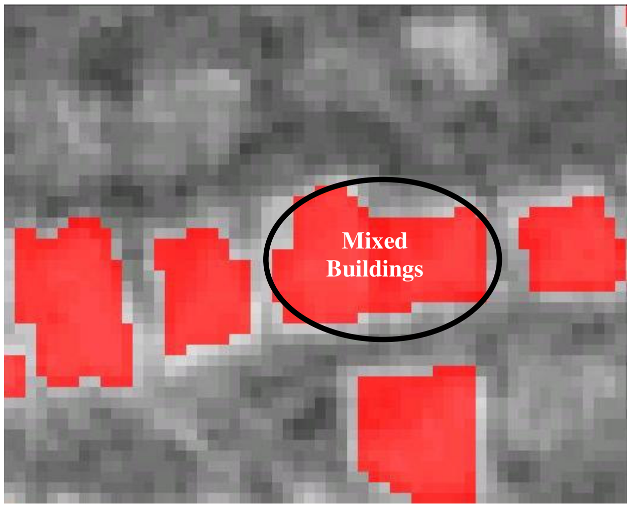


Figure 8. Objects in *buildings* class

Due to above stated problems and selecting small scale parameter the real world cannot be extracted exactly. On the contrary setting large scale parameter values leads to clutter of buildings. Several experiments are carried out with different parameters settings but the expected results are not satisfactory. The most acceptable output is obtained using mean grey value criterion. Grey values falling below 185 are disregarded and some extra setting values are used in the framework of this study. The classification results obtained hereafter are shown in Figure 9.

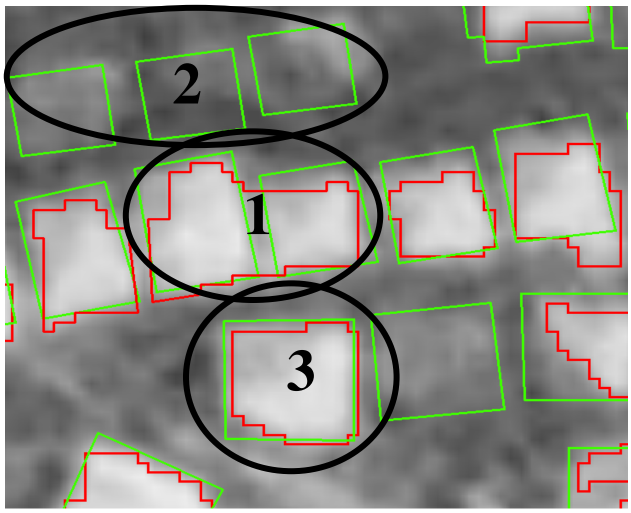


Figure 9. Overlap of manual and automatic digitized objects

Following the segmentation with small scale values as applied in Figure 6 the classification is resulted in for a series of buildings as shown in Figure 8. Although the building blocks should have been separated from each other, the buildings are classified altogether apparently. The overlapping manually and automatic digitized objects are shown in Figure 9.

It is too normal that, there can be some inconsistency between classifiers fail at separating two different buildings as one building as seen in Figure 9 marked with 1. Besides, some buildings can not be extracted from the image, although these constructions can be digitized manually. This situation can be seen in Figure 9 marked by 2. Originally these three buildings exist in the 1:1000 line maps. However, some buildings like in Figure 9 marked by 3 have the same size obtained by manual and automatic digitizing.

5. CONCLUSION

In this study, manual on-screen digitizing and the automatic object oriented image analysis methods have been compared using KVR-1000 orthoimage. By manual method, almost all building and road details that are available or not available could be derived. Although the effective pixel size of KVR-1000 orthoimage is about 2 pixel, experience and function of operator are the main factors on the success rate. However, accuracy of the coordinate transformation of about ±12 m does not provide the required position accuracy. The reason for this is that the KVR-1000 orthoimage was generated by the DEM with 20 m height accuracy. As a rule of thumb 10 times of the pixel size gives the scale factor (Jacobsen, 2002). For KVR-1000 case 10 times of the pixel size is 15.6 m and this corresponds to 1:16000 map scale. Individual structures in a forest can be located significantly due to their distinct grey values using KVR-1000 images. Such a study was made by Karathanassi et al. (2003). Their concern was not the geometric accuracy of the classification. But our study has attempted the accuracy potential of from KVR-1000 image digitized vector maps. The study comes to the conclusion that pixel size does not dictate the map scale of end product to be extracted from the satellite images such as KVR-1000.

Expected success rate could not be reached on the KVR-1000 ortho-image using eCognition 3.0 object-oriented image analysis software not enough contrast, monochromatic image, and negative influence of DEM on orthoimage generation fails the segmentation phase, then the following classification produce did not work as efficient as possible. In contrast to automatic method, manual, method produced expected success for the object extraction purpose.

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