ROAD DETECTION FROM HIGH AND LOW RESOLUTION SATELLITE IMAGES

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ABSTRACT:

Road extraction from satellite imagery has become a heated research subjects in recent years. It is especially used in the city planning, cartography and to update previously detected roads in Geographic Information Systems (GIS) environment.In this study automated road extraction technique is applied to four different satellite images (SPOT, IKONOS, QUICKBIRD, ASTER) with different resolutions that belong to Ankara city of Turkey. The aim of this study is to find out the effect of the resolution on the automatically extracted roads. In this manner the roads are extracted from these four satellite images individually. Finally, the accuracy of generated results was tested with the GIS data layer that represents the reality.

1. INTRODUCTION

Many ways of road extraction have been proposed and they are quite different due to the differences instrategies, type and resolution of input images, experiment configurations, ways of processing and general assumptions, etc. (Fortier et. al., 1999). In the previous studies roads are extracted from satellite images using automated and semi-automated methods (Gruen, et.al., 1997); (Baltsavias, et.al, 2001); (Wiedemann, C., Hinz, S., 1999). The main advantages of automated road extraction are its ability to uniform approach to different images; processing operations are performed in a short time and its ability to extract roads which are not recognized by the human eyes. In semi-automated extraction method, roads are extracted from satellite image by using visual interpretation. There are several image enhancement techniques that can contribute to semi automated road extraction as filtering, image classification, band rationing etc/. Zheng et al. (1998) detected roads from satellite images by using filtering and edge detection processes. Ruisheng Wang and Yun Zhang, (2003) extracted roads from Quickbird images using classification techniques.

Resolution of satellite images has important effect on roads or other objects to be discriminated. Images having different resolution include different types of road. In a low resolution images roads are exist as single line on the other hand in a high resolution images roads have particular width and the pixels located at two sides of road have irregular pattern because of existing of trees, cars and houses along the roads.

Aim of this study is to detect the roads in urban areas from satellite images with different resolutions by using automated and semi-automated methods and to investigate the influence of resolution on road extraction. The automated road extraction in this study was performed by the LINE module of Geomatica software. The main idea is automatically detect a line of pixels as a vector element by examining local variance of the gray level in a digital image Koike et al. (1995). For the semi-automated extraction filtering and image classification procedures were applied.

2. DATA AND METODOLOGY

Study carried on western of Ankara, capital of Turkey, including 6 km^2 area (Figure 1). Five different satellite images with different resolutions (QUICKBIRD 2.4 m, IKONOS 4 m, SPOT-PAN 10 m, ASTER 15 m and LANDSAT-ETM 30 m.) were used and roads were tried to detect by using automated and semi-automated methods from these five images having different characteristics.

Figure 1: Study area

2.1. Automated Methods

There are several different automated methods are used for extracting roads from images. Generally, automated road extraction consists of four steps; roads sharpening, roads finding, roads drawing and relating to extracted roads to each other. In this study automated road extraction carried out by using line module of PCI Geomatica software (Figure 2).

According to automated extraction results, the roads through bare rural areas could be detected more easily and accurately. This is because of basic and regular structure of roads at bare rural areas, and they are far away from settlements. In a high resolution image detecting roads by automated module is hard. Because these roads have nonlinear and nonuniform structure, also shadows of buildings around these roads lie on them. In a low resolution image the size of pixel could be bigger than the width of road so the lower the image resolution the harder to detect the roads (Figure 2).

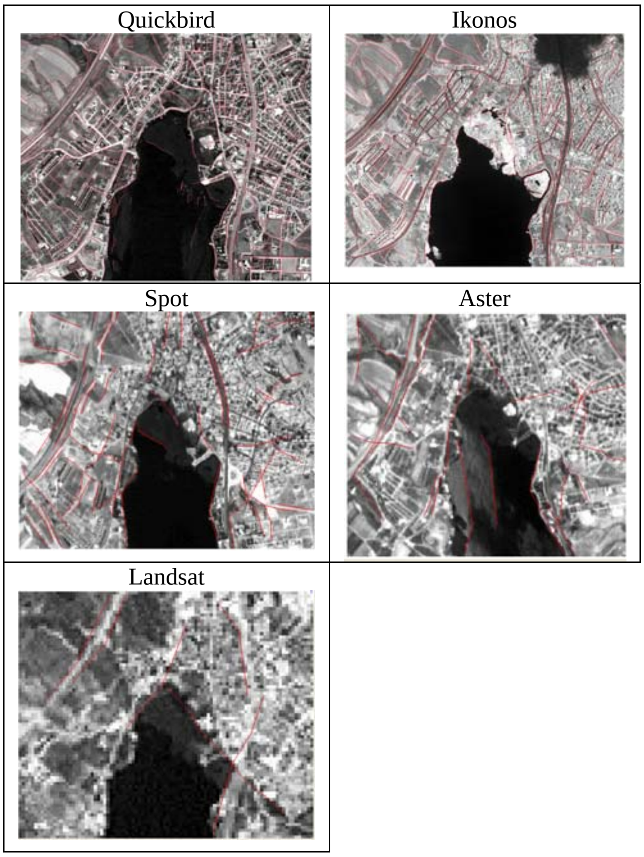

Figure 2: Roads that extracted by using automated methods.

2.2. Semi- Automated Methods

Filtering

Spatial frequency is described as the number of variations among pixels' values in a specific region over the raster dataset. If this variation is low that image can be described as low frequency image, otherwise if variation is high the image described as high frequency image.

High pass filters are used for increasing the spatial frequency of images while Low pass filters are used for reducing or suppressing the spatial frequency of images. In filtering processes each pixel evaluated with particular number of its neighbors pixels and depends on weight the new value of each pixel is computed and then assigned to each one.

In this study in order to detect the roads edge detection filters which are the types of high pass filters (Prewitt and Sobel) are conducted to each satellite images having different spatial resolution. In this way spatial frequency of each image was increased so the roads were highlighted and then extracted from each image (Figure 3). According to this processes' results, in high resolution images such as Quickbird and Ikonos the main and secondary roads are detected more accurately, however in low resolution images (Spot, Aster and Landsat-ETM) the details are reduced and detection of roads become more difficult therefore at some region only the main roads could be detected.

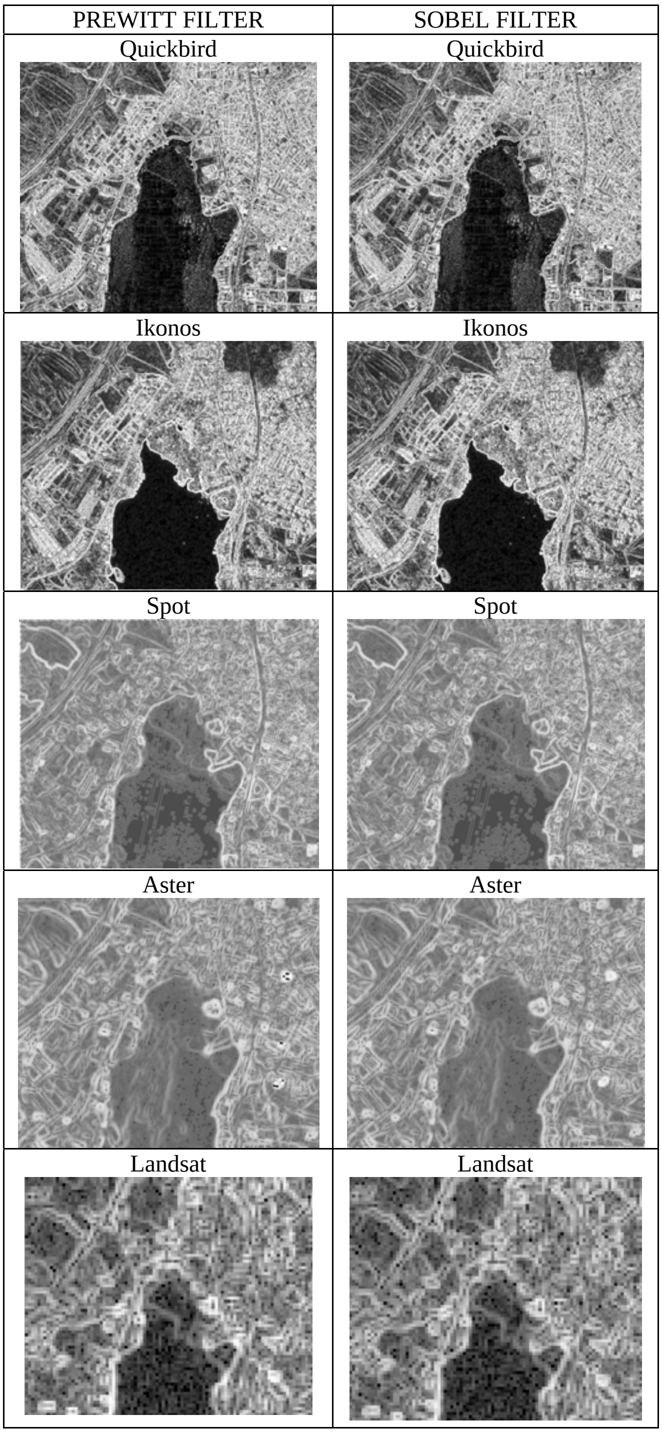

Figure 3: High pass filtered (Prewitt and Sobel) images.

Classification

Classification can be described as, grouping image pixels into categories or classes to produce a thematic representation. Classification can be used in thematic maps or can be further incorporated into digital analysis. It can be performed on single or multiple image channels to separate areas according to their different scattering or spectral characteristics. Digital image classification procedures are differentiated as being either supervised or unsupervised.

In this study Maximum Likelihood classification technique was applied four images (Quickbird, Ikonos, Aster, and Landsat) that have different resolution. Six classes were defined; and for each class training data were collected and images were classified. Then classified images were reclassed as two classes; road and nonroad by merging classes other than road and results were compared. Although the classified data of high resolution images produced better results, several problems experienced;

When the pavement of road surface changes (e.g. from asphalt to concrete) the contrast changes so the same road could be assigned different cluster label.
Due to very high resolution, vehicle, overpass, and other objects on a road could cause misclassification for that particular part.
Other objects such as house roofs, which have same spectral property as roads, are misclassified into road clusters.

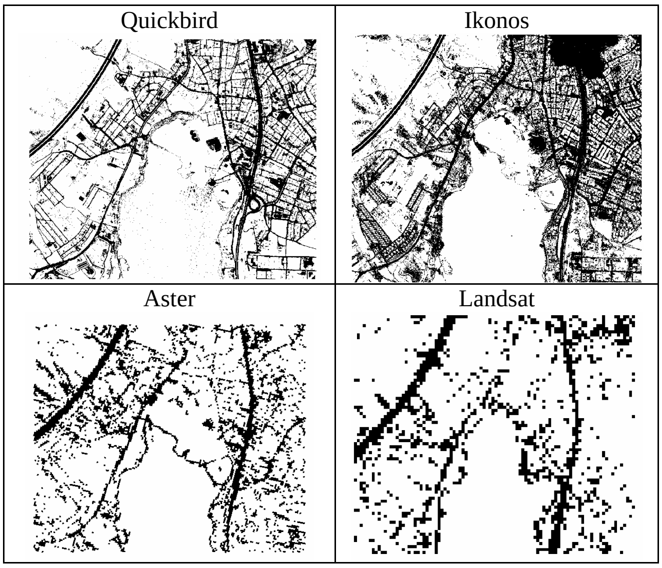

Figure 4: Classified images with two classes.

3. CONCLUSION

- Many objects which can be recognized from high resolution images can not be detected distinctly in a low resolution image.
- In a low resolution image roads can be extracted by using basic methods but the results have low accuracy.
- In a high resolution image many detail information about roads can be obtained and the roads can be detected more accurately. However complex methods are required for this process.
- Finally, the accuracy of road extraction from high resolution images is more than that one from low resolution images.

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