

Feature Extraction from Aerial Photos

Mesut Gündüz, Ferruh Yildiz, and Ayşe Onat

Abstract—In Geographic Information System, one of the sources of obtaining needed geographic data is digitizing analog maps and evaluation of aerial and satellite photos. In this study, a method will be discussed which can be used to extract vectorial features and creating vectorized drawing files for aerial photos. At the same time a software developed for these purpose. Converting from raster to vector is also known as vectorization and it is the most important step when creating vectorized drawing files. In the developed algorithm, first of all preprocessing on the aerial photo is done. These are; converting to grayscale if necessary, reducing noise, applying some filters and determining the edge of the objects etc. After these steps, every pixel which constitutes the photo are followed from upper left to right bottom by examining its neighborhood relationship and one pixel wide lines or polylines obtained. The obtained lines have to be erased for preventing confusion while continuing vectorization because if not erased they can be perceived as new line, but if erased it can cause discontinuity in vector drawing so the image converted from 2 bit to 8 bit and the detected pixels are expressed as a different bit. In conclusion, the aerial photo can be converted to vector form which includes lines and polylines and can be opened in any CAD application.

Keywords—Vectorization, Aerial Photos, Vectorized Drawing File.

I. INTRODUCTION

GEOGRAPHIC Information systems are knowledge systems that collect place dependent data, process these data and prepares for usage. One way of obtaining necessary information in these systems is analyzing aerial photos and satellite images. Aerial photos are in raster format when acquired by computer. Raster images are made up of pixels. A structure like raster format takes huge storage areas in computer disks. The more important thing is that when needed editing and modifying of these images are too difficult. Therefore, it is important to obtain meaningful data from these images. The same situation exists for engineering drawings. There are billions of drawings on papers in the world. Paper drawings are difficult to protect and gets older by the time. If these drawings transferred to computer environment and than the problems mentioned above are met. The difficulty of

protecting and modifying can be exceeded by converting these raster images to vector form.

Converting raster images to vector form is called vectorization. Although there are too many works in literature about this conversion, none of them gives perfect results and there are still developments on this area [1]. While converting engineering drawings or aerial photos to vector form, one must take care about the special rules of the related area. For example, if a construction engineering drawing will be converted to vector form it is necessary to take care about the drawing rules of construction engineering, the symbols used in these drawings and dimension rules about the drawings. Therefore preprocessing, processing and post processing will be different for different types of drawings. This is also true for aerial photos or satellite images. If these special approaches are not considered it is not possible to success in vectorization.

II. VECTORIZATION METHODS

There are a lot of methods used for vectorization. These methods can be classified as; Hough Transform Based Methods, Thinning Based Methods, Contour Based Methods, Run-Graph Based Methods, Mesh Pattern Based Methods and Sparse Pixel Based Methods according to Lui and Dori.[2].

a. Hough Transform Based Methods; for vectorization spatially extended parameters in binary image are transformed to shorter parameter space[3]. This transformation converts the more difficult detection problem in image space to easier local peak detection problem. The detection of the straight line in this way is to parameterize a line according to its intercept and slope.

b. Thinning Based Methods; These methods are the most widely used ones[4]. Thinning is the first step for a lot of vectorization algorithm. These methods uses thinning as a subprocess of medial axes point extraction and produce a one pixel wide skeleton. After obtaining skeleton line following subprocess is applied.

c. Contour Based Methods; first contours of the object is extracted then medial axis points between the contours are found. These vectorization methods find medial axis points while sampling the image.

d. Run-Graph Based Methods [5]; scans raster images through line or column for computing run-length encoding. After that these encodings are taken as input and analyzed for obtaining vector structures.

e. Mesh-Pattern Based Methods [6]; the aim is to divide image certain meshes and analyze the border of these meshes to obtain characteristic patterns. Each mesh only analyzed at the mesh border. The obtained mesh properties are compared

Manuscript received June 30, 2006.

M. Gündüz is with Selcuk University, Engineering and Architecture Faculty, Computer Engineering Department, Turkey (phone: +90-332-223-3721; fax: +90-332-241-0635; e-mail: mgunduz@selcuk.edu.tr).

F. Yildiz is with Selcuk University, Engineering and Architecture Faculty, Geodesy & Photogrammetry Engineering Department, Turkey (e-mail: fyildiz@selcuk.edu.tr).

A. Onat is with Selcuk University, Bozkır Vocational School of Higher Education, Computer Department, Turkey (phone: +90-332-426 1444; e-mail: aonat@selcuk.edu.tr).

equivalent label at the database and labeled according to these values. Later these labels are used for making control map.

f. Sparse Pixel Based Methods; these methods takes OZZ method as base[9]. OZZ method does not visit all the pixels in image. Instead it visits image lines sparsely. After finding the first black pixel the algorithm traverses zig-zag style in line. Sparse Pixel Method differ from OZZ that it generates a reliable starting point first and then starts the algorithm. Moreover, in OZZ two pass is necessary for vectorization, but in Sparse Pixel Method one pass is enough [11].

III. PREPROCESSING

The aim of this study is to vektörize aerial photos. Aerial photos are in raster form and in raster form images are formed by some points. These points are called picture element or shortly pixel and they are stored as numerical arrays in computer environments. For detection any object in image it is necessary to analyze these pixels.

The input image that will be used in image processing can be obtained by one of the devices of CCD (Charge Coupled Device) camera, ultrasound, MRI (Magnetic Resonance Imaging) or CT (Computed Tomography). No matter how it is obtained the image is subjected to some noise. Therefore the first step of vectorization should be minimizing the noise and preparing the image for vectorization according to area which the image belongs. The processes before the main ones are called preprocessing. Preprocessing is also necessary for Aerial photos. The preprocessing steps can change in respect of field or method developed even the image itself. For example, for a colored image and thinning based algorithm, first the image should be converted to grayscale. Then the noise should be minimized and image enhancement algorithms applied if necessary. After all of the preprocessing steps done, the main vectorization process can start.

In this study, 72 dpi (dot per inch) scanned grayscale images used. Therefore, converting to grayscale is not a necessary step. For preparing aerial photos to vectorization some preprocessing applied. First histogram equalization process is done in order to enhance the contrast of images by transforming the values in intensity image, so that the histogram of the output image approximately matches a specified histogram.

The next step is finding the edge of the aerial photos, but in aerial photos there are always to much unnecessary information which can cause problems while identifying the objects images. These unnecessary information are, trees in some area, ongoing traffic on the roads, shadows etc. Therefore this information should be removed from aerial photos. For an automatic vectorization system this process should be done without human interaction. Some filters applied to the image after histogram equalization operation done in order to reduce unnecessary information. This information can be called noise for this application. The first thing should be done to determine which filters can be applied to aerial photos. After a series of experiments, the filters determined. Therefore, first a 7x7 matrix average filter applied to the image, and then intensity adjustment is made again. After this operation a circular average filter radius 1 applied to

the result image. From now on the image is ready for edge detection. Most of the unnecessary details in the image are removed by doing these operations. The original aerial photo example and filtered image is shown in Fig. 1.



a. Aerial Photo of a Section of Selcuk University Campus



b. Filtered Image

Fig. 1 Original Aerial Photo (a), Filtered Image (b)

For edge detection operation, Canny Operator selected. The reason for choosing Canny Operator is that this operator first defines the best edge. It is a multi step operation. First the image smoothed by a Gaussian filter and then a 2nd order derivative operation (like Robert Cross) is applied to the smoothed image. Therefore the edge of the image is obtained. [10]

Some other edge detectors are also examined for proper edge detection but the best result obtained with Canny Operator. After edge detection the image edges are obtained. By inverting the image an image with black pixels foreground and white pixels background get. The image edge determined is shown in Fig. 2.

IV. APPLIED ALGORITHM

The image that is preprocessed is now ready for vectorization. In this method all the pixels are examined by their neighborhood relationship. Every pixel is in relationship with the pixels that surround it. This is shown in Fig. 3.

Aerial photo as it is preprocessed form scanned from top left to right bottom to find a black pixel that represents an edge.



Fig. 2 Canny Operator Applied Image

| | | |
|----|----|----|
| P6 | P7 | P8 |
| P5 | P | P1 |
| P4 | P3 | P2 |

Fig. 3 Pixel P and its Neighbors

The found black pixel is tracked by the help of its neighbor pixels. For doing this, the found pixel is P, and as shown in Fig. 3, from P1 to P8 every neighbor of P is examined and if there is a black neighbor the line tracked through that direction. While doing this tracking it must be cared about the other pixels than the line direction. For example if a line tracking continues through P1 direction, every pixel except P1 and P5 must be cared about the neighborhood. If there are neighbors black pixels in these neighbors it can be said that there is a junction there. The pixels that must be examined while tracking through P1 is shown as X symbol in Fig. 4.

| | | |
|----|---|----|
| X | X | X |
| P5 | P | P1 |
| X | X | X |

Fig. 4 The Pixels Except P1 And P5 Must Be Examined

After examining of these pixels, if there is no neighbor the pixel value should switched to 1 to remove it from image. Because, if examined pixel is not removed, it can be found again by the algorithm as if not examined. If there is one or more neighbor, the pixel could not be removed, because there must be some junction there. Therefore, in order to achieve continuity in junction points the pixel value should not be made 1. Instead, it can be 2 or another value that expresses there is a junction at this point. Here the image is represented as 2 bit, 0 and 1. Therefore, to represent the junction point with another bit the image should be expressed more than 2 bit e.g. 8 bit. This process is done before the start of all tracking procedure and image is converted to 8 bit structure

like grayscale image, but still the pixels are formed with 0 and 1s and in junction points 2.

There is another important control in order to obtain a good vectorized aerial photo. While tracking for every pixel it is examined that if it is the end of the line, if so it is again examined to find that is there another neighbor than the tracking way. If there is no neighbor the found primitive is a line. If there is a neighbor or more the found primitive is part of a polyline and from this point tracking of the polyline is done. The flowchart of the algorithm that describes this process is shown in Fig. 6.

After finding all lines and polylines of the image, the found primitives are saved as vector file. For this purpose DXF (Data eXchange Format) file format is used. DXF file format is defined by Autodesk Firm which is the producer of AutoCAD software. This file format is known by nearly all CAD (Computer Aided Design) software. In CAD software a drawing can be saved as DXF file format and opened. This opportunity is very useful when it is necessary to transport the drawings. [8]. The vectorized file obtained after the algorithm is shown in Fig. 5.

DXF file format actually is a text file format. Everything that can be expressed in a drawing file can also be expressed in this type of file. There are some parts that forms DXF file format. These are; Header Part that defines the file properties, Classes Part that defines classes, Tables Part, Blocks Part, Entities Part that is the most important part and the lines and polylines are expressed in this part, Objects Part and Thumbnailimage Part that can include a preview of the drawing and the last part is the File End.

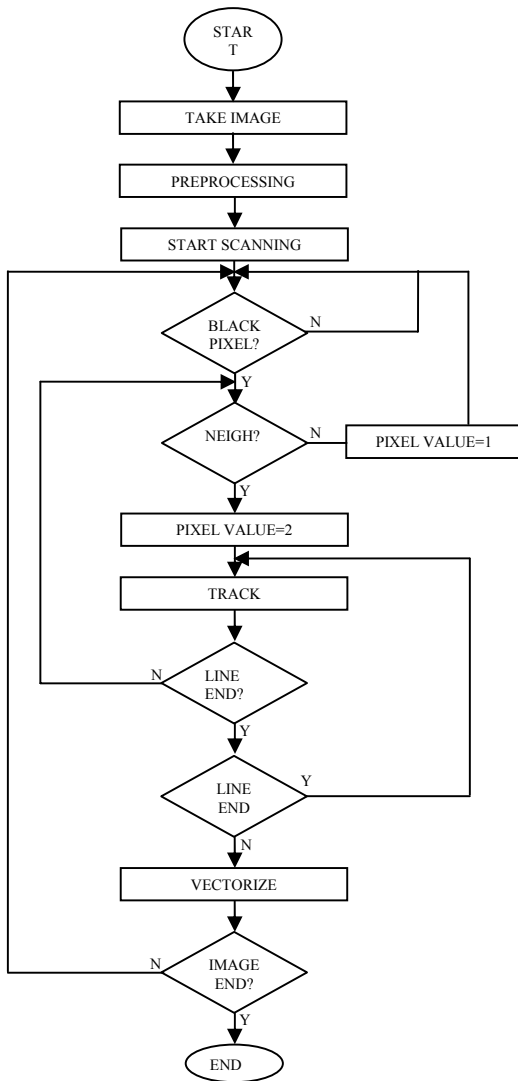
V. CONCLUSION

In this study a method and software is developed for vectorizing aerial photos. In developed method aerial photos are prepared for vectorization after some filter operations. After that vectorization procedure is applied and line and polyline primitive from aerial photos is obtained. These primitives are than saved as DXF vector file.

Aerial Photos is the most difficult image from because there are too much unnecessary details and shadows etc. on these images. Therefore, there are too much noise and noise like primitives in the obtained vector files. For this reason to increase the quality of the vector file, the images used for vectorization should be taken in sunny times. High quality cameras should be used. When acquiring images by scanner high resolution values should be referred. In order to decrease noise like primitives, an analysis of vector file can be done.



Fig. 5 CAD File Obtained



* LINE END N.* : IS THERE NEIGHBOR AT LINE END?

Fig. 6 Flowchart of algorithm

REFERENCES

[1] K. Tombre, Analysis of Engineering Drawings: State of the Art and Challenges, *Proceedings of the Graphics Recognition-Algorithms and Systems*, 257-264, 1998.
 [2] L. Wenyin, D. Dori, From Raster to Vectors: Extracting Visual Information from Line Drawing, *Pattern Analysis & Applications* (1999) 2, 10-21., 1999.

[3] P. V. C. Hough, A Method And Means For Recognizing Complex Patterns, *USA Patent* 3,096,654, 1962.
 [4] L. Louisa, L. Seong-Wan, Thinning Methodologies-A Comprehensive Survey, *IEEE (Institute of Electrical and Electronics Engineers) Transactions on Pattern Analysis and Machine Intelligence*, Vol. 14, No.9, 1992
 [5] G. Monagan, M. Roosli, Appropriate Base Representation Using a Run Graph. In *Proceedings of the 2nd International Conference on Document Analysis and Recognition*, Tsukuba, Japan, pp 623-626., 1993.
 [6] X. Lin, S. Shimotsuji, M. Minoh, T. Sakai, Efficient Diagram Understanding with, Characteristic Pattern Detection. *Computer Vision, Graphics and Image Processing*, 30:84-106, 1985.
 [7] M. S. Nixon, A. S. Aguado, Feature Extraction and Image Processing, *Newnes Pub.*, 2002
 [8] A. Yarwood, An Introduction to AutoCAD 2004: 2D and 3D Design, Newnes, 2004
 [9] D. Dori, Orthogonal Zig-Zag: an Algorithm for Vectorizing Engineering Drawings Compared with Hough Transform, *Advances in Engineering Software*, 28(1), pp11-24, 1997
 [10] URL1, <http://homepages.inf.ed.ac.uk/rbf/HIPR2/canny.htm>
 [11] D. Dori, L. Wenyin, Sparse Pixel Vectorization: An Algorithm and Its Performance Evaluation, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 21, No. 3, 202-215, 1999.