PATTERN RECOGNITION PROCEDURES FOR AUTOMATIC DIGITIZING OF CADASTRAL MAPS

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ABSTRACT

The author reports about the necessity of pattern recognition software for automatic digitization of cadastral maps by scanners in the FRG. This software has to support the feature-tagging after the raster-vector-conversion. He describes own software developements for this purpose briefly and two examples of successful algorithms.

INTRODUCTION

The new edition of cadastral maps and the establishment of a so called "Automated Cadastral Map" are two of the main tasks of german cadastral authorities. There do exist different methods to get digital data of the features represented in the cadastral maps. Some federal states take the measurement elements to calculate point coordinates, some states digitize the maps only and transform the table coordinates with the aid of fix-points into the official coordinate system. In the case of old cadastral maps based on a bad geodectic network the authorities digitize the cartographic features in the map and mark them for the storage in a data bank as graphic data. After updating the geodectic network and the measurement elements the marked coordinates will be replaced by calculated coordinates. So for both tasks it is necessary to digitize a lot of cadastarl maps.

BRIEF EVALUATION OF ALTERNATIVE METHODS OF DIGITIZING CADASTRAL MAPS

The evaluation of the potential of certain digitizer systems for cartographic purposes depends on the data form, in which the geometry of a map has to be represented digitally. For cadastral purposes vector-data are preferred. With vector-data you can get a data structure by tagging the cartographic features with special codes and the data are stored in a feature selected way. These facts facilitate the storage, updating and selection of features in a data bank and support the application of feature related user software.
In the Federal Republik of Germany(FRG) for the digitization of cadastral maps table digitizer are used generally. This method is economic for that special purpose today/LICHTNER 1984/. In relation to semi-automatic and automatic digitizer systems the amount of investment is low and acceptable for many small engineering offices. So you can divide and distribute the work of a digitization program to several offices.
Semi-automatic systems like line-followers offer real advantages only in the case of isoline representations. Scanner systems

produce raster data. Therefore a raster-vector-conversion is necessary.For that purpose theredo exist several software systems which generally produce in a batch-process a line- and node-file first. Then in a second step the feature-tagging is realized in a very time-consuming procedure at an interactive graphic working station by an operator. This method is not economic for cadastral maps today, but author believes that new software developements will offer more capabilities with this technique in the future. So his Institute of Cartography at Hanover University is engaged in the developement of software to support the application of raster scanners and digital image processing systems for cartographic purposes. In the discussed case of digitizing cadastral maps software is desired to support the feature tagging after the raster-vector-conversion with the aid of pattern recognition procedures.

PRACTICAL APPLICATIONS OF PATTERN RECOGNITION PROCEDURES

<u>General.</u> Fig.1 demonstrates the typical graphic of a german cadstral map. Each corner of a real estate is marked by a circle feature and the building areas are structured by a system of parallel lines. The parcels are coded with parcel numbers.

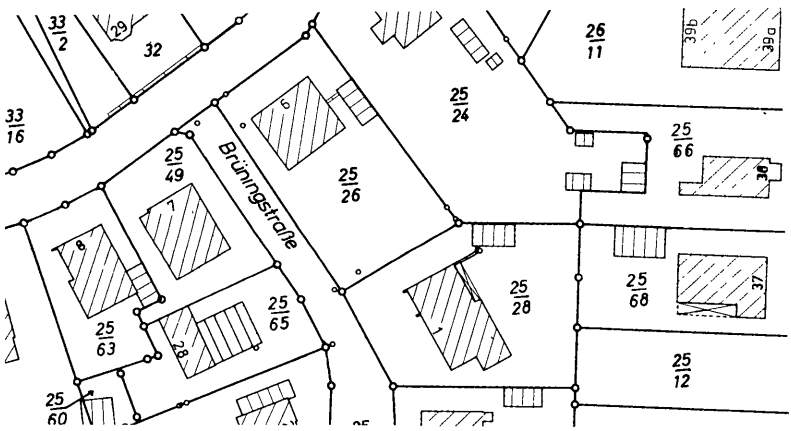

Figure 1: Typical graphic of a german cadastral map.

A handicap for pattern recognition procedures is the fact that the graphic of old cadastral maps is not of the best quality and you have to accept gaps in lines and damaged house-corner pattern.
In the first step the image(cadastral map) is scanned in order to get an image matrix. With the aid of a threshold operation the grey value matrix of the image is transformed into a binary matrix. Before starting the raster-vector-conversion it is advantageous to preprocess the binary matrix in order to reduce noise. For that purpose we use non-linear operations(mask operations)/NIEMANN 1974, PAVLIDIS 1977, PRATT 1983/ to delete noise in a binary pattern. We delete noise in a size of one pixel only.
For the raster-vector-conversion our own software developement is used. The skeletonizing is realized by the topologic method

combined with the information from a distance matrix. The result is a line-and node-file extracted from a binary skeleton matrix. At this point existing pattern recognition software generally starts with the preprocessing, the investigation of topologic and geometric characteristics of the vectors and the detection of certain cartographic features by statistical classification methods. If we scanned cadastral maps of a good graphic quality this procedure was very successful in our tests. But the reason of the new edition of cadastral maps is their bad graphic quality. That means the pattern recognition procedures have to work with damaged and destroyed topologic line structures. That is the main reason of unsatisfactory results in the case of old maps with a bad graphic quality.
So we modified the detection procedure for certain features, which have been very sensible of a damaged topologic line structure. A typical example is the circle feature, which appears in mentioned maps very often. A safe detection of this feature is very helpful for the structuring of the real estate borderlines. It is not the intension of the author to describe all pattern recognition procedures of his software system. but two examples may demonstrate two typical problems and tasks.

Example: Detection of circle features.

In the case of damaged circle features(gaps in the circle line) the pattern classification of vectors is very sensible. So we tried to get better results by the application of a correlation technique in the binary matrix before skeletonizing. With the aid of map design description you can define an ideal pattern $\underline{s}$ of a certain feature. $\underline{f}$ is an existing pattern in the binary matrix. For getting characteristics we calculate the correlation between $\underline{f}$ and the ideal pattern $\underline{s}$. If the ideal pattern $\underline{s}$ is in $\underline{f}$ we will get a top of correlation at pixel (i,j).

$$h_{i,j} = \sum_{k=0}^{k_o-1} \sum_{l=0}^{l_o-1} f_{i+k,j+l}\, s_{k,l} \qquad (1)$$

If the value h at pixel (i,j) is more than a certain threshold we can classify the pattern.
With this simple correlation technique we detected about 91% of all circle features(incl.the damaged ones) in our tested old cadastral maps. With the classification technique for vectors we got 60-65% only. The correlation technique is not so sensible to gaps in circle lines and that is very useful in our special case.
The reason of 9% non-classification was not a damaged circle pattern, but the influence of the neighbouring cartographic features. So we looked for a modification to reduce this influence. The developed method is very practical and successful. In a first step we calculate a difference mask $\underline{d}$:

$$\underline{d} = \underline{s} - \underline{f} \qquad (2)$$

The mask $\underline{d}$ is the multiplied with a special weight mask $\underline{g}$ and the weighted values of all pixels are summed up (see equ.3). The comparision if $t_{i,j}$ with a threshold decide in the classification process.

$$t_{i,j} = \sum_{m=0}^{m_o} \sum_{n=0}^{n_o} d_{i+m}\, g_{j+n} \qquad (3)$$

You need a little bit more computer time for the described modification, but with a good definition of g for a special feature this algorithm is very safe. In tests with four cadastral maps and with about 35% damaged circle features we got a 100% correct classification for this symbol. It was possible to differentiate the circle pattern from number characters like "2","3","6","8" and "9" very safe.So we got a successful support for the structuring and further classifications later on.

Example: Detection of house corners.

The classification of pattern in the binary matrix is very useful only in certain cases as mentioned before. For other features (i.e.buildings) we prefer the pattern classification with vectors.

The graphic representation of a building has two typical characteristics. There don't exist circle symbols at the corner-points of the building outline and the area of a building feature has a texture of parallel lines (see Fig.1). If the outline of a building feature is classified you have to detect the house-corners on this outline. For this task we developed the following procedure.

The extracted outline of the building is a skeleton of the representation of a polygon line. For the detection of the polygon-points(building corners) it is important and helpful to find first one corner point of the building outline. This point can be found easily by determing the line-point with the longest distance to a free selected starting point(any point of the outline). This so found line point is always a corner point of the building outline. You can repeat this procedure-if you want- and can find a second corner by using this procedure again. A repetition is impossible if the starting point was already a corner point. In this case you will find your first corner point again.

After the detection of a first corner point you can continue with a subroutine for the determination of straight lines in the building outline. Starting with the first corner point and the next point on the extracted outline the parameters of a straight line equation are computed. If the distance between the line and a new point is smaller than a threshold, this point is used to compute an updated line; otherwise a new line is introduced.

CONCLUSION

The mentioned software system is in the developement and there do exist a test version only for optimazing the used algorithms and procedures. First tests with four old cadastral maps have been very successful. The next task is the modification of the test version into a software package for users at cadastral authorities.

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