SOFTWARE-DEVELOPMENTS FOR COMPUTER-ASSISTED GENERALIZATION

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ABSTRACT

Automated data processing has meanwhile been introduced to most of the branches of cartography. Only few institutions are engaged with the problem of computer-assisted cartographic generalization. Members of the Institute of Cartography of Hanover University (IfK) are working on several research projects dealing with developments of algorithms and computer programs for cartographic generalization. These programs are the elements for creating of cartographic information systems. Base of such information systems are Digital Landscape Models (DLM), which are derived from large-scale topographic survey by digital data flow and its processing. An essential process for creating of Digital Landscape Models of a lower resolution from those of a higher one is the computer-assisted generalization. Developments on this topic which have already been made at the IfK can succed in a system for complex model generalization. The emphasis of these investigations is the generalization of the German Basic Map at the scale of 1 : 5,000 (DGK5) and the Topographic Map at the scale of 1 : 25,000 (TK25). This paper shows the development of an expert system for complex cartographic generalization which is composed of the a.m. components.

INTRODUCTION

To be able to meet the demand of the different special disciplines (geoscientists, environmental scientists, military, a.s.o.) for digital information related to location, the official surveying and mapping has been entrusted with drawing up a computer-assisted topographic-cartographic information system. It consists of different information sources and methods of information gaining, a cartographic data base as well as methods of information disposition of digital models and cartographic descriptions (see fig. 1).

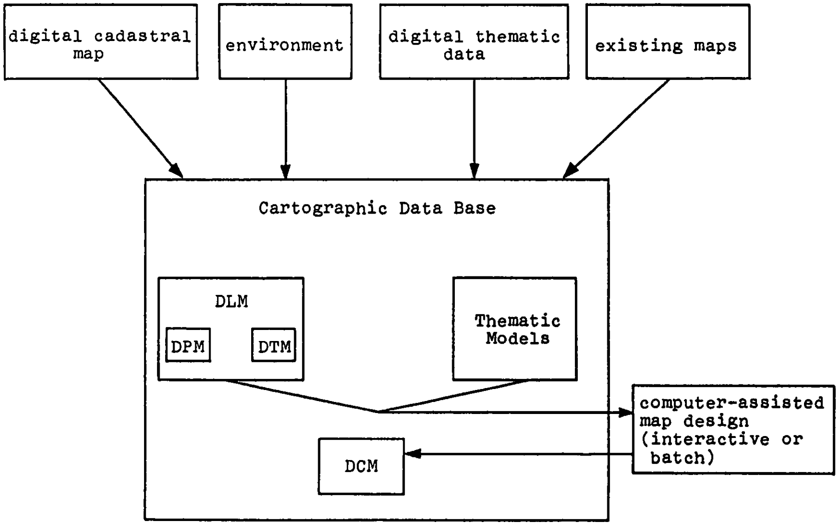


Fig. 1: Cartographic information system

The cartographic data base shall be drawn up by taking over data from different sources (e.g. digital cadastral map, digitized maps or remote sensing data). The Digital Landscape Model (DLM) and Thematic Models will be created by model generalization. In the first mentioned, Digital Landscape Models, there are the visible and non visible objects of the surface of the earth in their area relation in quality and quantity. They consist of the Digital Planimetric Models (DPM) and the Digital Terrain Models (DTM). The information of the DLM are prepared for the cartographic representation in a Digital Cartographic Model (DCM), which is also a part of the cartographic data base. As an example the object "street" should be mentioned, which is stored in the DLM with its axis and its quality characteristics, in the DCM it is stored with its symbols. The process of displacement is just only used in the DCM.

Investigations of the IfK deal with the development of an expert system for all generalization procedures, which are necessary for deriving a DLM of lower resolution from one of higher resolution in a first step and a corresponding DCM in a second one. This expert system named GENEX (GENeralization EXpert system) consits of the entire special knowledge of a cartographer.

Fig. 2 demonstrates a possible model configuration corresponding to existing topographic map series in the FRG.

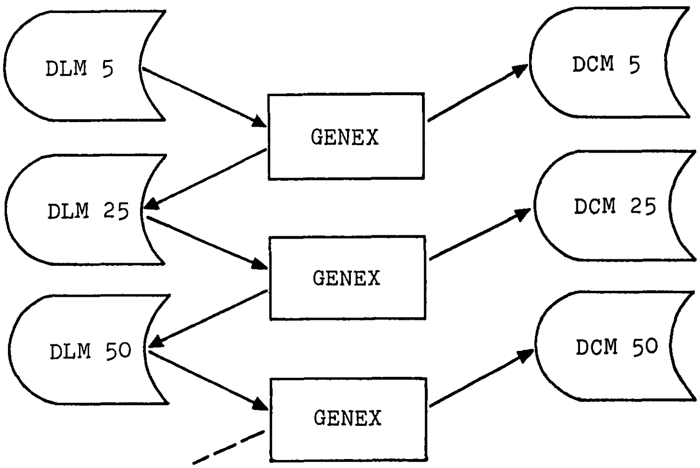


Fig. 2: Possible system of models corresponding to existing topographic map series in FRG

Essential components for the model generalization are the moduls GEBGEN and ACHSE for the generalization of areal features (e.g. buildings) and linear features (e.g. streets). They will be presented in the next chapter with their statements and efficiency.

GEBGEN - A PROGRAM FOR GENERALIZATION OF BUILDINGS

STAUFENBIEL (1973) has developed a procedure for the scale transition from 1 : 5,000 to 1 : 25,000, which has been transformed into programs by HOFFMEISTER (1978).

GRÜNREICH (1985) has extended this program for the generalization from 1 : 1,000 to 1 : 5,000 using graph-theoretic algorithms. Thus an initial step for the automatic data flow from the large scale topographic land survey to the Digital Landscape Model 1 : 25,000 or 1 : 50,000 has been undertaken.

In the following the individual program steps for a generalization of scale 1 : 5,000 to 1 : 25,000 will be shown. During this generalization procedure data will be taken from a digital data stock which could have been originated from a data flow from a basic data file 1 : 1,000 using the geometrical conceptual generalization according to GRÜNREICH or also from a manual digitalization of the German Basic Map 1 : 5,000.

Data preparation

- Conceptual generalization by feature codes (OSKA)
- Determination of outline contours of building standing closely together

Data processing

- Parameter input (e.g.threshold values for minimum lengths, - areas and - distances)
- Individual steps of generalization:
  - typification according to the offical style sheets (e.g. churches, chapels)
  - selection and enlargement: omission of buildings the area of which is smaller than the minimum dimension or enlargement of objects of extraordinary importance
  - recognition and compilation of typical parts of a building (e.g. circular arches, pillars of a church - see fig. 3), whose geometrical structure does not clearly come out of the digital data stock (generalization steps see fig. 4)

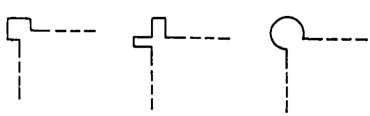


Fig. 3: Typical parts of buildings needing preprocessing

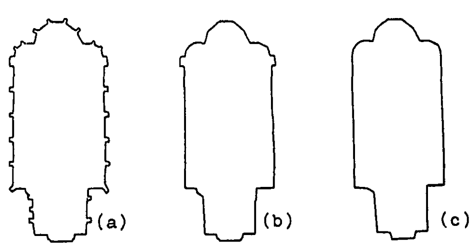
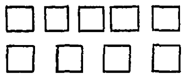


Fig. 4: Digitized data (a), first generalization step (b), generalization result (c)

- simplification of building contours
- combining of buildings whose distance inbetween is smaller than the minimum distance (see fig. 5)
- simplification of those objects having originated from combination



Forming of minimum sizes by leaving out the smallest object and equidistant distribution of the others

Fig. 5. Combining of serial objects (generalization result bottom row)

The generalization products resulting from this program may form the object classification "building" of a Digital Planimetric Model (e.g. DPM50) while choosing the corresponding minimum dimension for the requested resolution.

The following figures illustrate the generalization result for the scale 1 : 25,000 from the manually digitized German Basic Map 1 : 5,000 in an example from the city of Hannover.

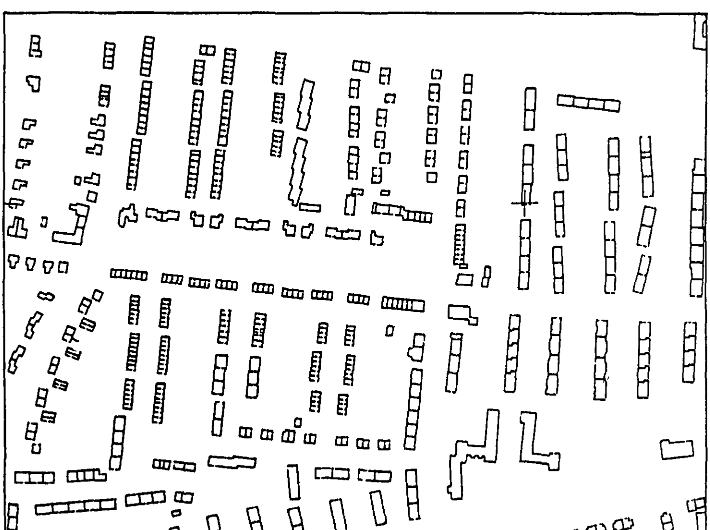


Fig. 6: Digitized data (buildings) of the German Basic Map 1 : 5,000

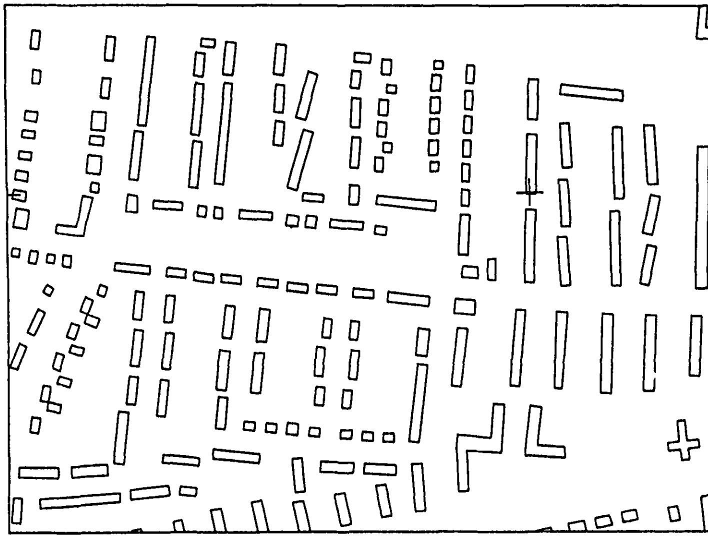


Fig. 7: Generalization result for the Topographic Map 1 : 25,000

ACHSE (AXIS) - A PROGRAM FOR GENERALIZATION OF TRAFFIC WAYS AND RIVERS

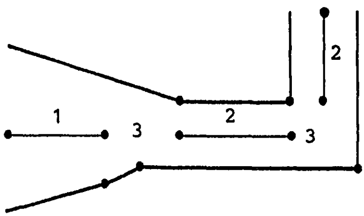
Besides the buildings and other individual features which are defined in a DPM by their individual point coordinate and an attribute there are more large groups of features - the traffic ways and the rivers, i.e. linear features, which are often symbolized in a map by double-line signatures.

While storing this group of features and also processing (generalization) the determination of their middle axis is very important. The essential factor of a procedure which has been developed by MENKE (1983) is the geometric construction of the axis elements "middle parallel", "angle divisor" and "intermediate piece".

The program ACHSE deals with digital information about the both sides of a street or a river. Also in this case the information may originate from a topographic survey as well as from digitizing of the original map.

Steps of processing

- Section by section determination of the elements of the middle axis of the type "middle parallel" and "angle" divisor" (fig. 8)
- Determination of the missing intermediate pieces (fig. 8)
- Simplification of the middle axis (polygone) with an element of the program GEBGEN



1 angle divisor element

2 middle parallel element

3 intermediate piece

Fig. 8: Elements of the middle axis

For the graphic edition of the features dealed with symbolizing is possible by a feature code:

- widening or narrowing along the supposed relation lines
- emphasis of especially broad roads if there are information about the original feature widths according to the relation lines
- objects whose widths exceed a supposed minimum width within certain sections, remain unchanged within these sections
- clearing of junctions and smoothing of irregularities of the object border lines arisen from the widening algorithm:
  - vector-raster-conversion and window building
  - area filling
  - raster-clearing of details
  - raster-vector conversion
  - filtration of the "stair"-effects arisen from the raster-vector-conversion

The introduced method of clearing of junctions and elimination of loops as a consequence of the widening furnishes results which could also have been obtained by methods of vector data processing. It is, however, evident that optimal results for the whole tested area can be achieved by relatively simple raster operations.

Fig. 9: Digitized data (street boundaries in the German Basic Map 1 . 5,000)

Fig. 10. Program results from ACHSE (street axis)

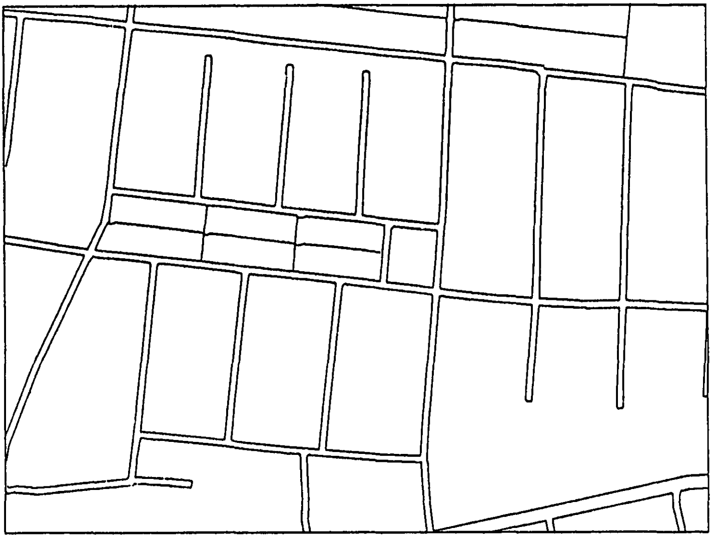


Fig. 11: Symbolized streets for DCM

COMPILATION

The moduls present elements of a complex system, which is at the moment still in the state of development. Data processing is done by hybride methods; as the final result in the DLM's of high and medium resolution the storage of geometric object information in vector-format is being planned.

An algorithm for realization has also been installed (LICHTNER 1976) and has been realized in a computer program. The further development of GEBGEN and ACHSE assists at the installation of a DLM25 or DLM50 and therefore this paper is especially devoted to this problem. The statement of displacement will be put on an existing DLM and will be an element for forming the Digital Cartographic Model (DCM) to match.

The realization of this plan, the installation of Digital Landscape Models with an automatic data flow from the topographic survey up to models of different resolution and the derivation of the resulting Digital Cartographic Models will probably need some more years of developing and will only be possible step by step with provisional solutions.

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