Photogrammetrische Woche 1989
Institut für Photogrammetrie
Schriftenreihe, Heft 13, 1989

ACQUISITION, TOPOLOGY AND STRUCTURING OF SPATIAL DATA

D. Fritsch, Munich

1. INTRODUCTION

With the availability and completion of Geographic Information Systems (GIS) photogrammetric data acquisition becomes an important data source to fill the databases of these systems (Ref. /28,37/). This makes photogrammetry once more attractive because it is able to deliver vectorial informations (points, lines, objects) as well as digital images to be used in superimpositions with available (stored) map data. Although the concepts at present in use are valid furthermore it is necessary to link data acquisition techniques with data models used in GIS. As a matter of fact this results into efficient data editing systems to be used during data acquisition, data management techniques of arbitrary extension and data conversion to name only three important aspects in spatial data handling. Furthermore it helps to contribute considerably to the development of hybrid graphic systems (Ref. /16/) which are capable to manage map data, image data and non-graphical data simultaneously.

2. TOPOLOGICAL CONSIDERATIONS

The history of topology dates back to the 17th century when at that time the "analysis situs" - the analysis of space - was introduced. This analysis dealt already with geometric properties not tied to distance or coordinate measures also being called coordinate-free or interior geometry (Ref./31/). Today topology is considering the characteristics of geometry in any dimensions that are invariant under continuous transformations (Ref. /35/). Especially algebraic topology manipulates symbols representing geometric configurations and their relationships to one another. It is this symbolic geometry that is used in Geographic Information Systems (GIS) today (Ref. /27/).

When looking into the concepts of symbolic geometry to describe spatial objects one can differentiate between

- primitive instancing (PI), that means the object is represented by a fixed number of parameters (example: a cube can be described by its edge length a)
- spatial occupancy enumeration (SOE) in which the object is given by spatial cells of fixed size mostly used in computer tomography
- cell decomposition (CD) represents objects of arbitrary dimension to be composed of simple spatial elements. In the contrary to SOE the space is not subdivided into uniform spatial cells but cells of different size and shape are allowed. For example a house may be composed of a solid cube and a solid tetrahedron
- boundary representation (BR) where a spatial object is represented by its boundary elements e.g. surfaces (blocks), edges (lines) and nodes (points).

A comparison with mapping, in which objects within R^3 are mapped onto a plane shows direct connections with the boundary representation method. But mapping is not only a decomposition of the object into its boundary primitives; it is also feature-oriented in the way that it characterizes different feature symbols. This means that symbolic geometry in mapping has to deal with a topological model (interior geometry model) as well as a feature model (object model).

2.1 Boundary Representation of Spatial Data

Spatial objects to be managed by GIS should be bounded on the R^3-space (Euclidean-space). The following models may then be used describing the boundaries.

(i) the edge model in which the object is given by the connection of nodes n. This means that the edges e are functionally to describe by $e = e(n)$.

(ii) the block model which consists of constrained surfaces and approximating surfaces, respectively. While constrained surfaces are explicitely given by the connection of nodes or the composition of edges (e.g. parcels) the latter ones must be determined using reference points, edges, tangent vectors or curvatures. A functionality between the blocks b, edges e and nodes n looks like $b = b(e,n)$.

For the block model two important definitions must be given because they are leading to the theorem of Euler (Ref./35/).

Definition 2.1: A block is called flattened, if it can be drawn in plane such that no intersections of edges e_i, e_j exist which are not simultaneously nodes n_k of the block model.

Definition 2.2: A map consists of a flattened block model. The edges of the block model are called boundaries, the areas in between the edges are called surfaces (parcels, regions, countries). The map is called contiguous if the corresponding block model is contiguous.

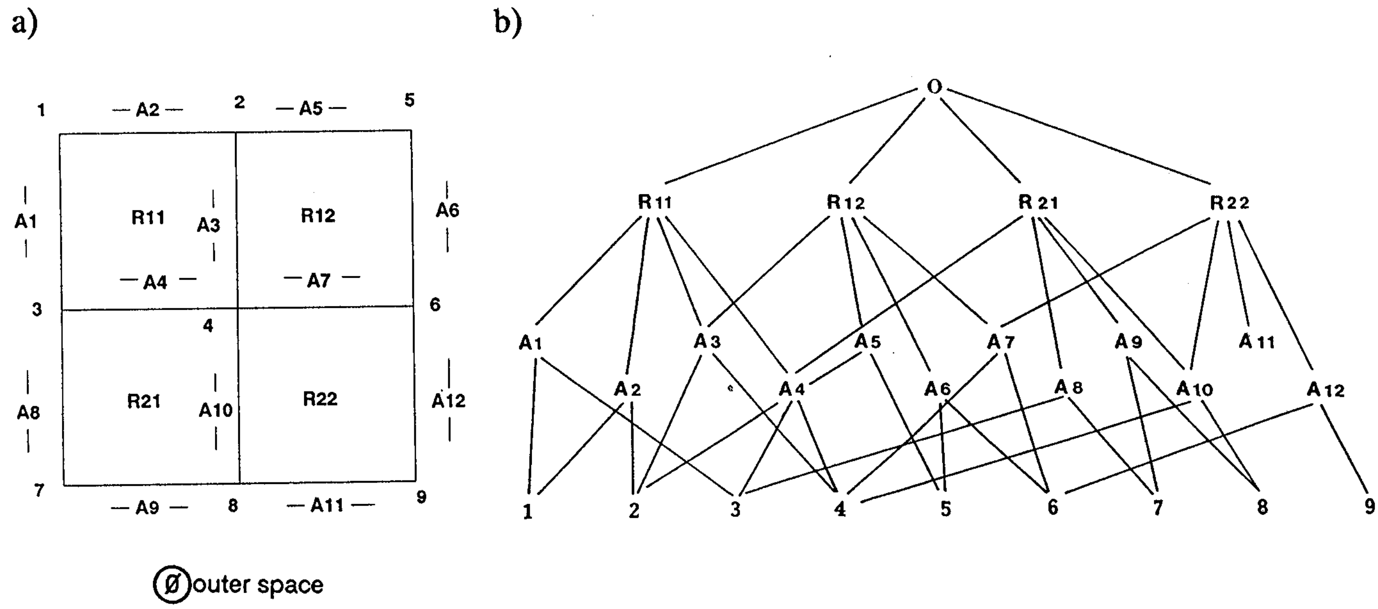
Having these two definitions in mind the theorem of Euler can be given.

Theorem 2.3: For every contiguous map with n nodes, e edges and b blocks it holds

$$C = n - e + b = 2 \qquad (1)$$

The proof of this theorem is given in /35/. The number C is called characteristic of the map. This theorem is a very important topological relation and must be proven in consistency checks of spatial data.

The boundary representation of a contiguous object can be seen in Fig. 1. The object consists of a regular grid with 4 meshes. Its topological decomposition uses the nodes, edges and blocks to describe the object completely. The metrical information e.g. the coordinates x,y,z is arranged at the lowest level in this hierarchy.



Euler proof: 9-12+5=2

Fig. 1: Boundary representation of a simple object
a) object b) topological decomposition

As said before the object can be embedded in a more complex object and the more complex object is part of a most complex object and so on. This leads to the definition of hyper-objects or super objects (Ref. /40,41/) to be handled by feature based models (Ref. /26,27/).

Today there is no discussion on the benefits of the first topological decomposition using edge models and block models, but there are controversies on the feature model building and handling.

2.2 Object Oriented Models

In order to set up feature based models different strategies can be found in GIS-practice. Most of GIS available use object oriented management techniques (Ref. /19,32,41/) in which a hierarchy consisting of complex objects (complex features), object classes (feature classes), objects (features) and object items (feature items) is used (see Fig. 2). Another philosophy dealing with main emphasis on the objects itself is demonstrated by Herring (Ref. /26,27/) and Schek (Ref. /36/).

The discussion on object oriented data models and in consequence object oriented databases is controvers such that a more complicated feature model than Fig. 1 leads to slow response times of the GIS. There is unfortunately no definition for object oriented data bases, but the aim common to most strategies is a stronger consideration of operations and functions of database objects rather than their topological structures (Ref. /36/).

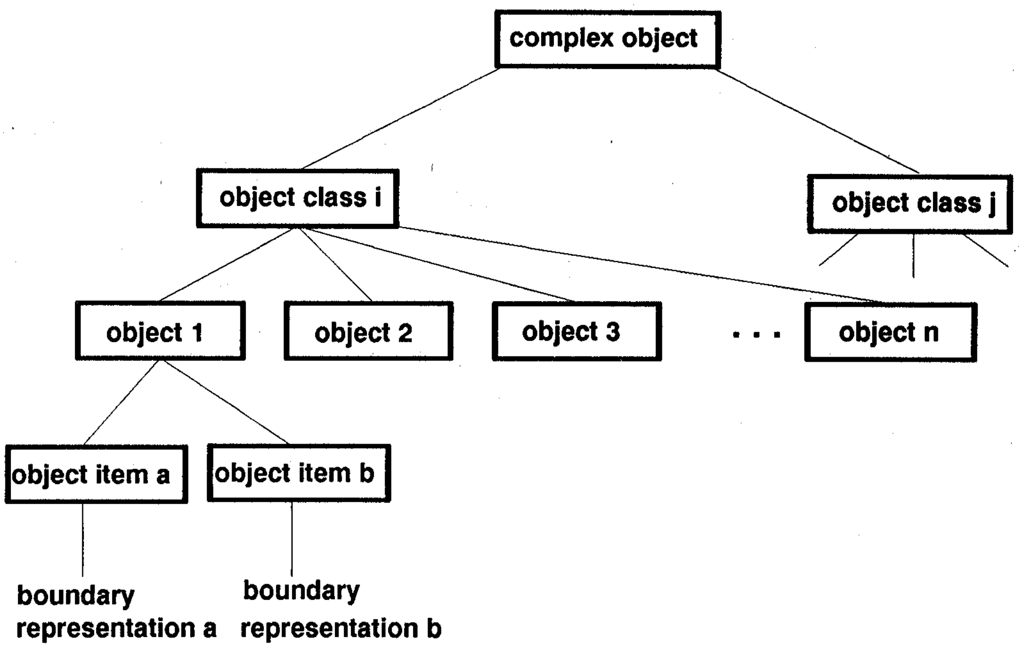


Fig. 2: Object oriented management

3. PHOTOGRAMMETRIC DATA ACQUISITION

With regard to the topological considerations given before photogrammetric data acquisition has to be differentiated according to vectorial data acquisiton and digital image data acquisition. While vectorial data can completely be described by topological decompositions (Ref. /2,34,35/) using edge models and block models respectively to be organized in an object oriented management, a topological treatment for digital image data is still subject of research (Ref. /15,18,22,29,43/).

3.1 Vectorial Data Acquisition

The data acquisition by means of an analytical plotter (AP) is point-oriented or line-oriented depending on the object which has to be discretized in the stereo model. For example the geomorphology of terrain can be captured point-oriented by profiling or the progressive sampling technique (Ref./1O,3O /), whereas contour capturing corresponds to a line-oriented mode. While a point-oriented data mode is mostly postprocessed to derive a block model - e.g. a digital terrain model (DTM) - the line-oriented approach must include more or less real-time processing such as best-fit right angles, best-fit straight lines, interpolating splines, circles etc. This leads to a bottom-up strategy for point-oriented data and a pull-down strategy for line-oriented data (see Fig.3).

For that reason the AP must at least be equipped with an editing system to care for the processing of line-oriented data. This editing system contains a graphic kernel system for the generation of the graphical elements necessary to adjust to raw line data (Ref. /7,9,25,32/). Moreover, the editing system can include also some methods of an application system to provide for interactive data modelling.

But data editing includes not only software to process the captured data it uses superimposition techniques as well for an on-line quality control of the data. This implies the solution of inverse

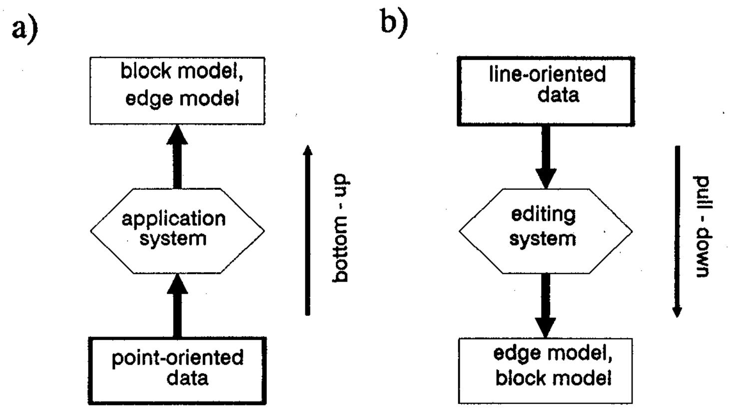


Fig. 3: Strategies for processing photogrammetric data
a) bottom-up b) pull-down

photogrammetry what means the mapping of object space onto the image space. Its visualisation within the stereo model can use only one synthesized image (sufficient quality check) or a stereo superimposition for a necessary and sufficient quality control (Ref. /3,4/). The principle of stereo superimposition is given in Fig. 4.

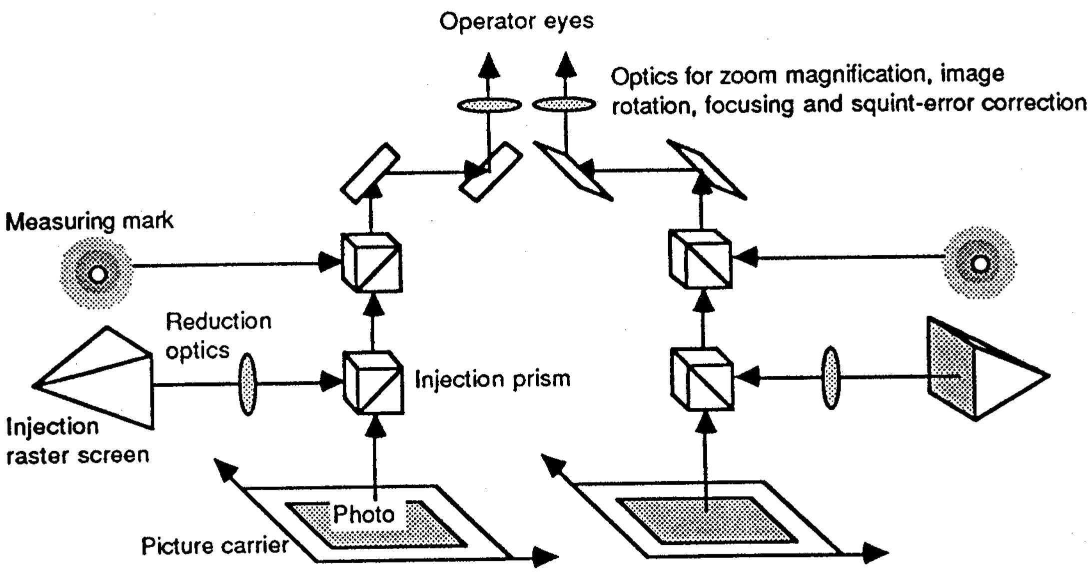


Fig. 4: Stereo superimposition optics of an AP (taken from /4/)

During photogrammetric evaluation the operator does some object building, which means that he classifies the geometrical elements (streets, waters, parcels, houses etc.). This classification must also have access to the data being stored. On the one hand it should be as simple as possible, and on the other hand it is the basis for object oriented management. This led to the introduction of object code tables (OCT) (Ref. /21,32/) in which the objects are alphanumerically coded.

From a photogrammetric point of view we have further informations to be stored in a GIS. This information is of non-graphical nature; it characterizes for example the image material, exposure and evaluation (see Fig. 5)

exposure data			
image no.(ID)	date of exposure	image scale	camera . . . .
1	1.4.1978	1:5000	RMK 15/23
2	1.4.1978	1:5000	RMK 15/23
.			
.			
.			
65	6.4.1981	1:7500	RMK 15/23
.			
.			
.			

evaluation data			
image no.(ID)	date of evaluation	evaluation instrument	operator . .
1	12.5.1978	Planicomp C100	Mueller
2	12.5.1978	Planicomp C100	Mueller
.			
.			
.			
65	29.4.1981	Planicomp C100	Meier
.			
.			
.			

Fig. 5: Non-graphical informations

This data does not have any topological structure but it can be connected in between by means of identifiers (ID)to be explained later on in more detail.

3.2 Acquisition of Image Data

Digital image data acquisition can take place within the AP by means of CCD-cameras (Charged Coupled Device-cameras) (Ref. /5,9/) which need additional equipment such as signal processors, frame buffers and video screens (Ref. /24/). Recent developments integrate transputers into the processing hardware to provide for fast image processing.

While digital photogrammetry started with point-oriented data acquisition - for example to automate the measurement of terrain points (Ref. /1,6,11,13,23,34/) which is still under research - the topic of most recent research work is concentrated as well on the extraction of line (edge) information (Ref. /14,18,22/). In the new development section the extraction of vectorial information from digital images is demonstrated by an example.

4. DATA STRUCTURING

Within data structuring mainly three methods exist

- the sequential method
- the direct access method
- the lists (pointer lists)

which use the following elements

(i) the data element - stored and processed single information

(ii) the records - composition of a number of data elements

(iii) the file - composition of records

Photogrammetrische Woche 1989
Institut für Photogrammetrie
Schriftenreihe, Heft 13, 1989

The expression 'data structure' is generally refered to the composition of records and its interrelations within the file(s). It is dependent on the operations which are carried out with the files.

Within spatial data structuring two main questions are of special interest: (i) how many data has to be stored (maximum)? and (ii) How fast should the access be on single or groups of elements? This results into constraints on the corresponding data structures

- objects with common characteristics should be arranged in arrays → object classes
- objects with a hierarchic structure should be organized in a tree structure
- dynamic growing and changing
- access on arbitrary elements

While the sequential method differentiates in simple sequential, ordered sequential and index-sequential (Ref. /8/) the list method - also commonly used in GIS- classifies to (Ref. /12,20/)

- linear lists
- pointer lists
- circle lists with single connection
- circle lists with header and single connection
- circle lists with doubled connections
- ring lists

The schemes of the different list structures can be seen in Fig. 6.

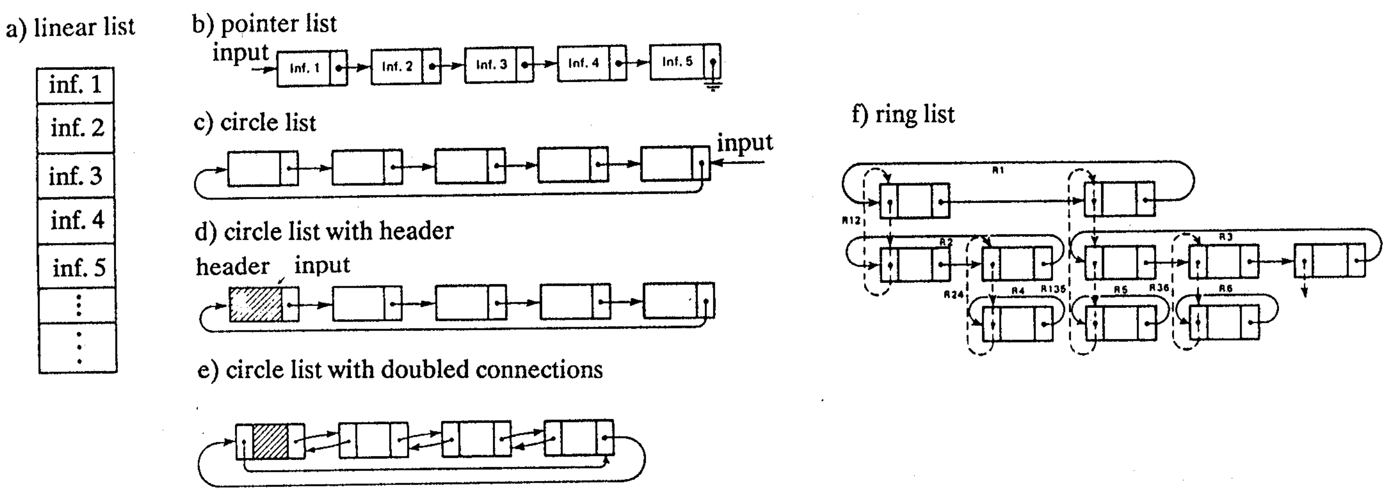
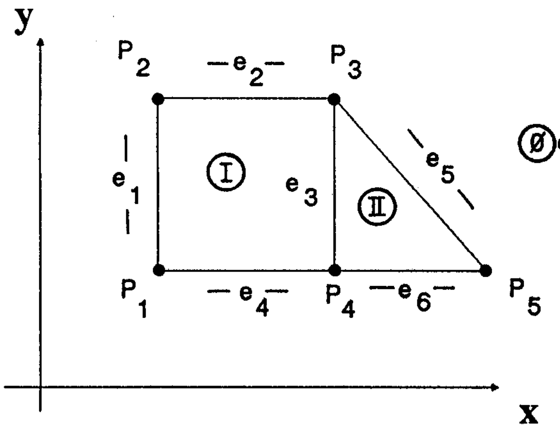


Fig. 6: Structures of lists (Ref./12/)

4.1 Topological Data Structuring

According to the boundary representation by means of edge models and block models topological data structuring is demonstrated by the following example.

Example:



Euler proof: 5 - 6 + 3 = 2

Fig. 7: A map consisting of two parcels

(i) edge model in linear lists

node list		
node	x	y
1	3	1
2	3	4
3	6	4
4	6	1
5	8	1
-999	-999	-999

edge list				
edge	start node	end node	left block	right block
1	1	2	0	I
2	2	3	0	I
3	3	4	II	I
4	4	1	0	I
5	3	5	0	II
6	4	5	II	0
-999	-999	-999	-999	-999

The Euler proof extracts from these two lists 5 nodes, 6 edges and 3 blocks (I, II and outer space O).

(ii) block model in linear lists

node list		
node	x	y
1	3	1
2	3	4
3	6	4
4	6	1
5	8	1
-999	-999	-999

edge list					
block	start end	further nodes			
I	1	2	3	4	
II	3	4	5		
0	1	2	3	5	4

block list		
block	neighbours	
I	II	0
II	I	0
0	I	II

The Euler proof in this model has to search for the number of edges in the edge list, which is not given explicitely. The edge list of the outer space R_{00} (0) is also called the 'hull' of the map.

(iii) combined model in linear lists

The combined model consists of supplementary descriptions of the edge model by parts of the block model. In some cases the block model is associated with the feature model (Ref. /19/) so that the edge model is called 'topological' model and the further descriptions belong to the 'thematic' model. But we have also topologically redundant data structures in which special interest is directed to fast data access. For our example such a combined model might be:

edge list		
edge ID	numb.of nodes	coodinates x,y
1	2	3,1 ; 3,4
2	2	3,4 ; 6,4
3	2	6,4 ; 6,1
4	2	3,1 ; 6,1
5	2	6,4 ; 8,1
6	2	6,1 ; 8,1

block list		
block ID	numb.of chains	edges
I	4	1, 2, 3, -4
II	3	3, 6, -5
0	5	1, 2, 5, -6, -4

list of connections		
edge ID	start node	end node
1	1	2
2	2	3
3	3	4
4	4	1
5	3	5
6	4	5

list of neighbours		
edge ID	block left	block right
1	0	I
2	0	I
3	II	I
4	0	I
5	0	II
6	II	0

It can also be associated with the edge model because the edges are the 'forcing' elements.

(iv) combined model in ring lists

node list						
address	node	x	y	pointer	pointer	pointer
400	1	3	1	402		402
402	2	3	4	404		404
404	3	6	4	406	406	408
406	4	6	1	500	408	0
408	5	8	1		505	406

block list			
address	block	node pointer	edge pointer
500	I	400	350
505	II	404	354
0	0	400	350

edge list						
address	edge	start node	end node	pointer	pointer	pointer
350	1	1	2	352		352
352	2	2	3	354		358
354	3	3	4	356	358	
356	4	4	1	500		0
358	5	3	5		360	360
360	6	4	5		505	356

The first data structure using ring lists was CORAL (class oriented ring associative language) developed by Sutherland at the MIT during 1964-1966, other more complex structures followed (LEAP-MLT 67, ASP, APL, DATAS).

The advantage of ring lists is that they are very fast. Because of the connection in between by means of pointers they are looking like a 'network'.

Their main disadvantage are the pointers, it means that during growing of the data all the pointers must be up-dated.

4.2 Non-graphical Data Structures

Besides the topological data structure which cares mainly for the geometry of the graphical elements (automated mapping, AM) we have the non-graphical data describing the semantics (attributes) of the data (facility management, FM). This data can be ordered in a relational structure which means that there is no hierarchy within the data (see Fig.8). According to the lists introduced before it can be classified in node features, edge features and block features for boundary representations.

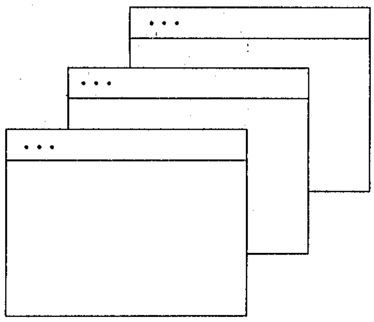


Fig. 8: Disposition of non-graphical data

The connection with the graphical data is solved by means of identifiers (ID) in the case that linear lists are used, or by using pointers as well if ring lists contain topology.

For demonstration of the link to non-graphical data the following attribute tables are introduced for our example:

utilization table		
block ID	block size	utilization
I	9	agricultural
II	3	agricultural
0	infinity	not defined

owner table	
block ID	owner
I	Maier, Hans, xcity
II	Smith, Frank, ycity
0	not defined

These tables can be linked with the graphical data by means of the block identifiers (block numbers). The strength of a GIS is mainly given to provide for a deep facility data management.

4.3 Boundary Cell Decompositions

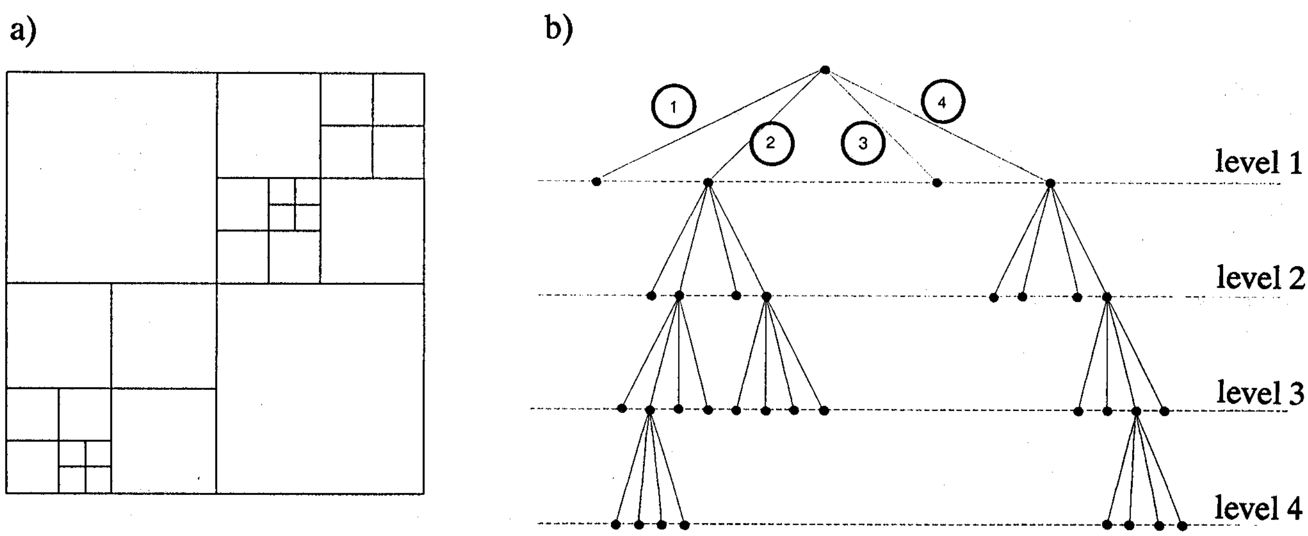


Fig. 9: Quadtree principle
a) cell decomposition b) tree structure

Photogrammetrische Woche 1989
Institut für Photogrammetrie
Schriftenreihe, Heft 13, 1989

In order to care for large areas it is appropriate to subdivide the whole region being stored into subregions. These subregions are 'cells' of the whole region and can be of quadrangular or rectangular shape. Using a quadrangular decomposition the result of the so-called 'boundary cell decomposition' is a quadtree-structure (see Fig.9).

The data management of a quadtree can be done with simple sequential files. According to the quadtree topology of Fig. 9 the elements of these files are the nodes of the quadtree.

hierarchy	nodes	data file
level 0	1 2 3 4	0
level 1	2 1 2 3 4 4 1 2 3 4	1 2 4
level 2	2 2 1 2 3 4 2 4 1 2 3 4 4 4 1 2 3 4	2 2 2 2 4 4 4
level 3	2 2 2 1 2 3 4 4 4 3 1 2 3 4	3 2 2 2 4 4 3

Thus, the cell size of the quadtree is dependent on the amount of graphical information. If the region needs a small cell size to manage parcels with buildings the lowest level contains the boundary representations of the graphical data, and all other levels are the path for data access.

But in the contrary, for example to manage agricultural areas, a medium quadtree level may contain the graphical data.

In connection with the use of rectangular elements the subdivision of a region is also called 'dynamic cell decomposition' (Ref./2,18,40/).

4.4 The Layer Principle

The layer principle results directly from the object oriented management. It is generally understood as a superimposition of object classes, in which every object class is managed in an own layer (see Fig.1O).

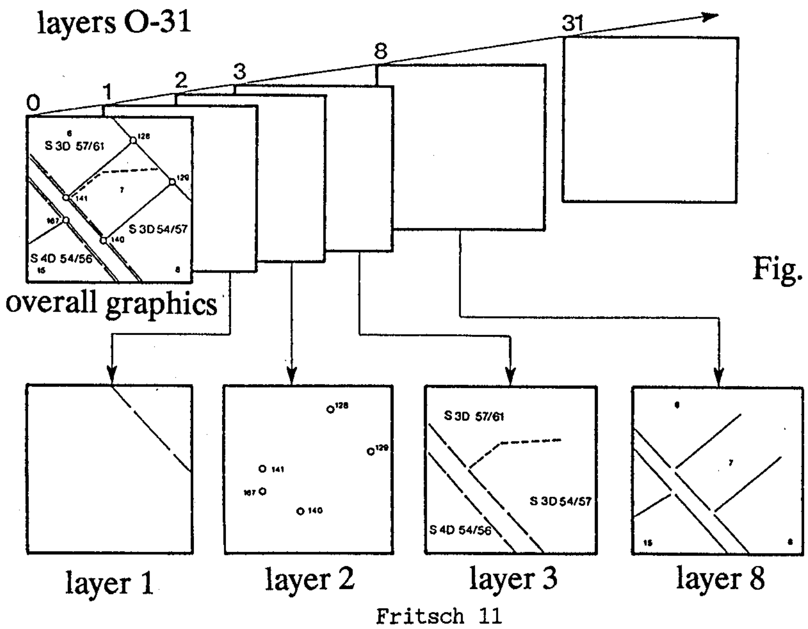


Fig. 1O: The layer principle

The connection of the object classes can be done using metric information (e.g. coordinates) and identifiers respectively.

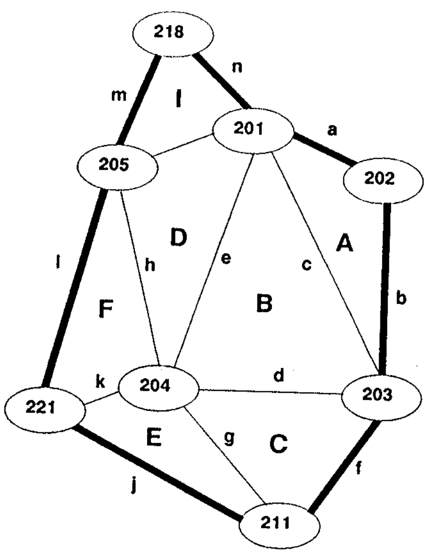
4.5 Integration of Terrain Data

The data structures of terrain data make also use of the boundary description given before. Here we have to differentiate between three structures in use (Ref./17/).

- the raster model
- the triangulation
- the hybrid model consisting of raster and triangles

While the raster model and the hybrid model can be managed easily in a hierarchy according to the quadtree principle the triangulation should also be organized in a regular structure at a higher level. This means that additional trtiangles must be set up to constrain the triangulation into a data management technique of regular cell size.

For demonstration of the management of triangles the contiguous triangles of Fig.11 are managed by a block model using linear lists



Euler proof: 8 - 14 + 8 = 2

Fig. 11: Triangulation

node list			
node	x	y	z
201	...	...	...
202	...	...	...
203	...	...	...
204	...	...	...
205	...	...	...
211	...	...	...
218	...	...	...
221	...	...	...

edge list	
triangle	nodes
A	201, 202, 203
B	201, 203, 204
C	203, 204, 211
D	201, 204, 205
E	204, 211, 221
F	204, 205, 221
I	201, 205, 218

block list	
triangle	neighbours
A	B
B	A, C, D
C	B, E
D	B, F, I
E	C, F
F	E, D
I	D

hull list
nodes
201
202
203
211
221
205
218

It is recommended and also done in practice to have a separate management for situation data and terrain data as far as boundary representations are used. The data must be connected in between by means of the layer principle.

4.5 Data Models for Database Management Systems

With regard to the data structures introduced before we are now able to define data models for database management systems. Here one can differentiate between three fundamental models

- the hierarchical data model (HDM)
- the network-oriented data model (NDM)
- the relational data model (RDM)

The three data models can be seen in Fig. 12.

a) b) c)

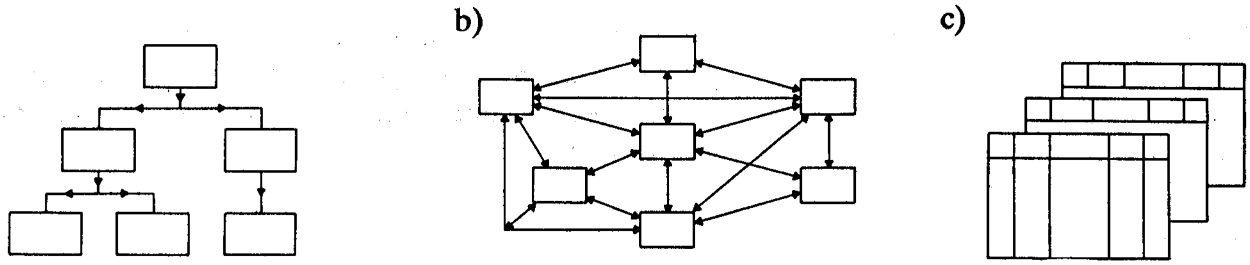


Fig. 12: Fundamental data models
a) hierarchic b) network c) relational

5. NEW DEVELOPMENTS

Data structures and resulting databases for image data are in research and under development. As far as the integration of digital images into vector-oriented GIS is concerned a three-level approach is appropriate (Ref./18/).

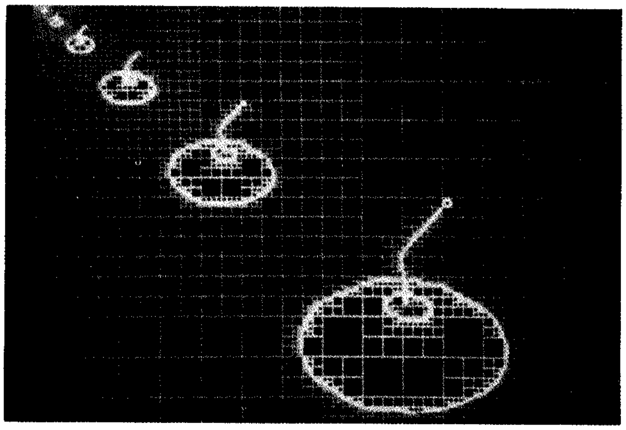
- the raster / vector superimposition
- the raster object / vector superimposition
- the vector / vector superimposition

The lowest level uses the digital image information as background, in which the graphical primitive of the image is the pixel. Using objects in a digital image the image must be classified. This has the advantage that the individual objects can be managed object-oriented with a quadtree as underlying boundary representation (Ref. /15/). Following this idea the lowest quadtree level contains a skeleton representation of the object (see Fig.13).

Photogrammetrische Woche 1989
Institut für Photogrammetrie
Schriftenreihe, Heft 13, 1989

This skeleton representation can be the starting point for a vectorisation and topological structuring to arrive finally at the third level: the vector / vector superimposition.

a)



b)

Fig. 13: Quadtree representation of image objects
a) simple object b) complex object

But to extract line information from digital images also another strategy is important and under research. Automatic vectorisation can be performed only by using image processing techniques. For demonstration of different algorithmic steps to extract line information the digital image of Fig. 14a was processed by the following algorithmization

- lowpass filtering
- edge detection
- median filtering for a homogenisation of the image gradient
- line following by windowing
- spline approximation

The results can be seen in Fig. 14b - c.

a) digital image

b) image gradient

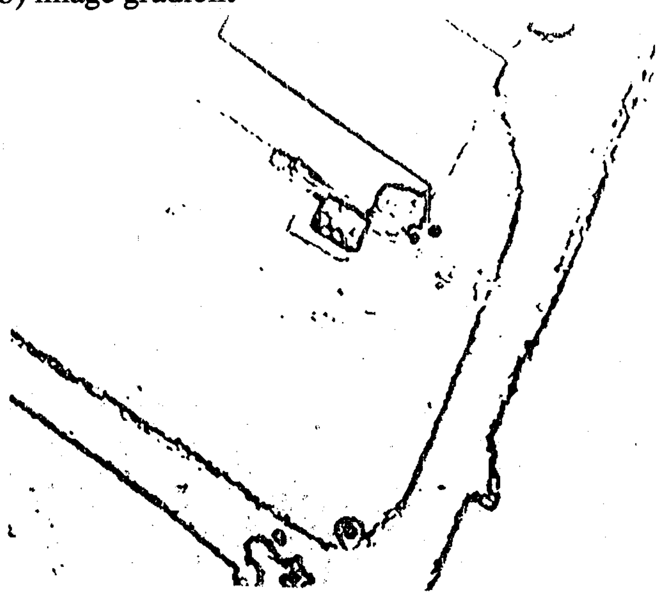


Fig. 14: Raster / vector conversion in a digital image

This result may also help the operator for computer aided evaluation. Although Fig. 14b delivers only a 'spaghetti' graphics a further topological treatment can identify points, lines and blocks. Using attributes already stored in a GIS the object identification is much simpler than to work with image understanding strategies. Therefore the problem of feature extraction in hybrid graphic systems in which all types of data are available is a further subject of intensive research.

6. CONCLUSIONS

The aim of the paper was to show up topological descriptions which are important to structure the data for storage in a GIS. As far as photogrammetric data are concerned it was differentiated between three types of data: the vector data, the semantic data and the digital image data. The new development section showed how these data should be interrelated with each other to solve problems of digital photogrammetry.

The essence of all the statements given before is the following one: photogrammetric data acquisiton is not only a data source to fill the GIS-databases; it helps also to contribute a lot to automated map updating, to complete 3D-descriptions as well as for better interpretations of the available data. Therefore photogrammetry plays an important role in the further development of GIS.

REFERENCES

/1/ ACKERMANN, F. (1984): High Precision Image Correlation. Proceed. 39. Photogr. Week, Inst. Photogr., Univ. Stuttgart, No. 9, Stuttgart.

/2/ BARTELME, N. (1989): GIS-Technologie, Springer, Berlin.

/3/ BEERENWINKEL, R. / J.-D. BONJOUR / R.D. HERSCH / O. KÖLBL (1986): Real-Time Stereo Image Injection for Photogrammetric Plotting. Int. Arch. Phot. Rem. Sens., 26, 4, pp. 99-1O9.

/4/ BONJOUR, J.-D. / G. EITEL / O. KÖLBL (1988): Experiences with the WILD System 9-AP and Its Stereo Image Injection System. Int. Arch. Phot. Rem. Sens., 27, Kyoto.

/5/ BONJOUR, J.-D. (1989): Architecture et composants des stations de travail photogrammétriques. In: Photogrammétrie et SIG, Ed. O. Kölbl, Presses Polytechniques Romandes, EPFL Lausanne, Lausanne.

/6/ BOOCHS, F. (1984): Ein Verfahren zur Herstellung digitaler Höhenmodelle aus photogrammetrischen Stereomodellen mit Hilfe der flächenhaften Korrelation in digitalen Bildern. Deutsche Geod. Komm., Reihe C, Nr. 299, München.

/7/ BURGERMEISTER, W. / T. BÄNZINGER (1989): Die Photogrammetrische Arbeitsstation WILD S9-AP als Bestandteil einer generellen GIS-Lösung. In: Photogrammétrie et SIG, Ed. O. Kölbl, Presses Polytechniques Romandes, EPFL Lausanne, Lausanne.

/8/ BURROUGH, P.A. (1986): Principles of Geographical Information Systems for Land Ressources Assessment. Clarendon Press, Oxford.

/9/ CHAPUIS, A. (1989): New Photogrammetric Systems from Kern. In: Photogrammétrie et SIG, Ed. O. Kölbl, Presses Polytechniques Romandes, EPFL Lausanne, Lausanne.

/10/ EBNER, H. / W. REINHARDT (1984): Progressive Sampling and DEM Interpolation by Finite Elements. Bildmess., Luftbildwes. (BuL), 3a, pp. 177-182.

/11/ EBNER, H. / D. FRITSCH / W. GILLESSEN / Ch. HEIPKE (1987): Integration von Bildzuordnung und Objektrekonstruktion innerhalb der Digitalen Photogrammetrie. Bildmess., Luftbildwes. (BuL), 55, S. 194-2O3.

/12/ ENCARNACAO, J.L. (1975): Computer-Graphics, Oldenbourg.

/13/ FÖRSTNER, W. (1986): On Automatic Measurement of Digital Surface Models. Proceed. 4O. Photogr. Week, Inst. Photogr., Stuttgart Univ., Stuttgart.

/14/ FÖRSTNER, W. (1988): Model Based Detection and Location of Houses as Topographic Control Points in Digital Images. Int. Arch. Phot. Rem. Sens., 27, B11, pp. III-5O5-517, Kyoto.

/15/ FRITSCH, D. / M. SCHILCHER / H. YANG (1988): Object Oriented Management of Raster Data in Geographic Information Systems. Int. Arch. Phot. Rem. Sens., 27, B4, pp. 538-546, Kyoto.

/16/ FRITSCH, D. (1988): Hybride graphische Systeme - Eine neue Generation von raumbezogenen Informationssystemen. Geo-Informations-Systeme (GIS), 1, S.12-19.

/17/ FRITSCH, D. (1989a): Digitale Geländemodelle und Raumbezogene Informationssysteme. Habilitationsschrift Techn. Univ. München, München.

/18/ FRITSCH, D. (1989b): On Raster to Vector Conversion in Hybrid Graphic Systems. Proceed. AM/FM Int. Conference, Montreux (in print).

/19/ GAUFROID, F. (1989): KERN INFOCAM - A Geographical Information System for Computer Aided Management. In: Photogrammétrie et SIG, Ed. O. Kölbl, Presses Polytechniques Romandes, EPFL Lausanne, Lausanne.

/2O/ GEISSELHARDT, W. (1989): Computergrafik in Wissenschaft und Forschung. Pres. Pap. Geo-Informations-Systeme in Wirtschaft, Wissenschaft und Verwaltung, Univ. Duisburg, Duisburg.

/21/ GÖPFERT, W. (1987): Raumbezogene Informationssysteme. Wichmann, Karlsruhe.

/22/ GREENLEE, D.D. (1987): Raster and Vector Processing for Scanned Linework. Phot. Eng. Rem. Sens., 53, pp. 1383-1387.

/23/ GRÜN, A. / E. BALTSAVIAS (1984): Geometrically Constrained Multiphoto Matching. Proceed. ISPRS Int. Com. Conf. Fast Process. Photogr. Data, pp. 2O4-23O, Interlaken.

/24/ GRÜN, A. (1987): Towards Real-Time Photogrammetry. Photogrammetria, 42, pp. 209-245.

/25/ HASSANI, M. (1989): A Photogrammetry Workshop: INTERGRAPH's Intermap Analytic. Pres. Report, Sem. Photogrammétrie et SIG, EPFL Lausanne, Lausanne.

/26/ HERRING, J.R. (1987): TIGRIS: Topologically Integrated Geographic Information System. Proceed. AutoCarto 8, pp.282-291, Baltimore.

/27/ HERRING, J.R. (1989): The Definition and Development of a Topological Spatial Data System. In: Photogrammétrie et SIG, Ed. O. Kölbl, Presses Polytechniques Romandes, EPFL Lausanne, Lausanne.

/28/ KONECNY, G. (1989): *Photogrammetry and Land Information Systems. AM/FM News, European Division.*

/29/ LICHTNER, W. / A. ILLERT (1989): *Entwicklungen zur kartographischen Mustererkennung. In: Geo-Informationssysteme, Anwendungen - Neue Entwicklungen, Ed. M. Schilcher / D. Fritsch, S. 283-291, Wichmann, Karlsruhe.*

/30/ MAKAROVIC, B. (1977): *Composite Sampling for Digital Terrain Models. ITC Journal 1977, pp. 406-433.*

/31/ MEIER, A. (1986): *Methoden der grafischen und geometrischen Datenverarbeitung. Teubner, Stuttgart.*

/32/ MENKE, K. (1989): *Presentation of the ZEISS PHOCUS System. In: Photogrammétrie et SIG, Ed. O. Kölbl, Presses Polytechniques Romandes, EPFL Lausanne, Lausanne.*

/33/ MOLENAAR, M. (1989b): *Single Valued Vector Maps. Geo-Informations-Systeme (GIS), 2, pp. 18-26.*

/34/ MOLENAAR, M. (1989a): *Knowledge Representation in Vector Structured Data Bases. In: Geo-Informationssysteme, Anwendungen - Neue Entwicklungen, Ed. M. Schilcher / D. Fritsch, pp. 311-321, Wichmann, Karlsruhe.*

/35/ MÜLLER, K.P. / H. WÖLPERT (1976): *Anschauliche Topologie. Teubner, Stuttgart.*

/36/ SCHEK, H.J. (1988): *Perspektiven zukünftiger Datenbanksysteme - Erweiterbarkeit und Objektorientierung. Tagungsband AM/FM Regionalkonferenz Siegen, Nachtrag, Siegen.*

/37/ SCHENK, T. (1989): *Towards Automated Data Collection for GIS. Geo-Informations-Systeme (GIS), 2, S. 8-16.*

/38/ SCHILCHER, M. (1985): *CAD-Kartographie, Wichmann, Karlsruhe.*

/39/ SCHÜLLER, K. (1987): *Über den Einsatz relationaler Datenbanken bei der Katasterdigitalisierung. Zeitschr. Verm. Wes. (ZfV), 112, S. 592-603.*

/40/ SPÄNI, B. / N. BARTELME (1988): *Vom Modell der Daten zur Anwenderschale eines raumbezogenen Informationssystems. In: Ingenieurvermessung 88, Ed. K. Schnädelbach / H. Ebner, B9, Dümmler, Bonn.*

/41/ SPOONER, R. (1989): *Advantages and Problems in the Creation and Use of a Topologically Structured Database. In: Photogrammétrie et SIG, Ed. O. Kölbl, Presses Polytechniques Romandes, EPFL Lausanne, Lausanne.*

/42/ WROBEL, B. (1987): *Digitale Bildzuordnung durch Facetten mit Hilfe von Objektraummodellen. Bildmess., Luftbildwes., 55, S. 93-101.*

/43/ YANG, H. / D. FRITSCH (1989): *A Raster Oriented Approach for Spatial Data in Geographic Information Systems. In: Geo-Informationssysteme, Anwendungen - Neue Entwicklungen, Ed. M. Schilcher / D. Fritsch, pp. 323-330, Wichmann, Karlsruhe.*

ABSTRACT

Spatial data handling in photogrammetry today must be solved twofold: on the one hand data acquisition should be as easy as possible using analytical plotters, and on the other hand the data have to be structured in terms of efficient storage techniques used in geographic information systems (GIS).

The paper starts with topological considerations demonstrating procedures to structure spatial data. These structures can have an object-oriented approach in common but are different mainly with regard to data access and data recundancy. Also the integration of terrain data is described to complete descriptions within R^3.

In the new development section management techniques for image data are given; also structuring of image data by means of raster/vector conversion is exhibited.

Photogrammetrische Woche 1989
Institut für Photogrammetrie
Schriftenreihe, Heft 13, 1989

ZUSAMMENFASSUNG

ERFASSUNG, TOPOLOGIE UND STRUKTURIERUNG VON RAUMBEZOGENEN DATEN

Der Umgang mit räumlichen Daten in der Photogrammetrie wird heutzutage hauptsächlich durch zwei Prämissen vorgegeben: zum einen sollte die Datenerfassung so einfach und komfortabel als möglich sein, was durchaus vermittels analytischer Plotter zu gewährleisten ist, und zum anderen sind die Daten so zu strukturieren, daß sie in der Datenbank eines Geo-Informationssystems effizient gespeichert werden können.

Der Beitrag demonstriert innerhalb der anfänglichen topologischen Betrachtungen Verfahren, um daraus Datenstrukturen abzuleiten. Diese Datenstrukturen können durchaus eine objektorientierte Vorgehensweise gemeinsam haben, unterscheiden sich aber hauptsächlich im Datenzugriff und der Redundanz. Zur Vervollständigung einer Datenbeschreibung des R^3 *werden ebenso Höhendaten integriert.*

Innerhalb des Abschnitts, der über neue Entwicklungen berichtet, werden Techniken zur Verwaltung von Bilddaten angegeben. Des weiteren wird auf die Raster/Vektorkonvertierung zur vollständigen topologischen Strukturierung von Bilddaten eingegangen.

Dr.-Ing. D. Fritsch

Lehrstuhl für Photogrammetrie
Technische Universität München
Arcisstrasse 21
D-8OOO München 2