PROCEDURES AND STRUCTURES FOR EXTRACTION AND SAMPLING GEO-INFORMATION FROM IMAGES

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ABSTRACT

A general framework is outlined for structuring information from a functional perspective. A distinction is made between the basic information and the control data, and further between the semantic and metric deomains. The information can be structured accordingly for each process stage. Attention is given to interrelationships between information extraction, sampling, and structuring. The proposed structural schemes are general; more specific schemes, e.g. for the user oriented data bases, can be drawn up accordingly.

I. INTRODUCTION

Extraction and sampling from images of terrain concern those features and phenomena which contribute to further processes which will be carried out by the users of such information. The value of information depends on the way it is used and thus differs from one use to another and from one item to another. Different items of information can portray terrain from different perspectives and to different degrees of fidelity. Information not contained in images can be added by humans, e.g., during sampling or later in the editing stage.

Extraction and sampling are commonly carried out in a combined single process stage. If the complexity of information exceeds a certain degree, it is preferable to extract features in a separate phase before sampling. For mapping, however, a mixed approach is often most appropriate, i.e., to extract first only the critical features whereas simple extraction is combined with sampling.

Extraction of more complex features requires expertise in a specific field. The corresponding interpretation is more involved and time consuming than a straightforward recognition of features. Manual extraction is subjective and therefore to some degree inconsistent. Inconsistency is greater if the information content in images is low; missing information needs be supplemented by the interpreter's knowledge and/or information from other sources (e.g., the ground truth).

Closely associated with extraction and sampling is the structuring of information. The interrelationships between a data base, its structure and the corresponding procedures (including algorithms) are shown, simplified, in figure 1.

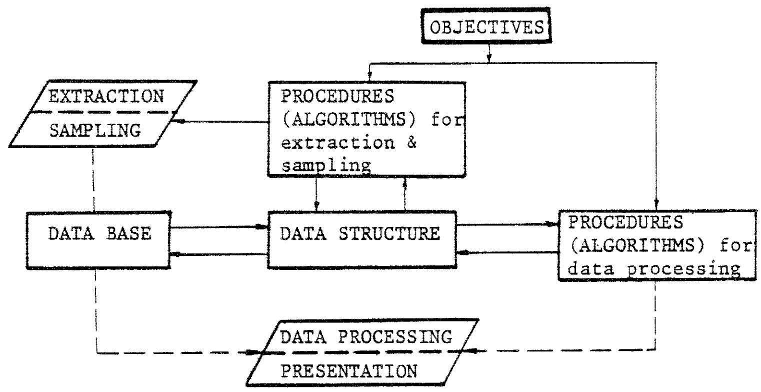

Fig. 1: Data structuring linking data base with procedures

Information should be structured in the extraction stage and coding and indexing of features should reflect this structure. A well established structural framework for information and procedures tends to provide a reference for all process stages.

For structuring, a distinction can be made between the basic information and the control data. Basic information has semantic and metric components, whereas control data refer to information and processes in the semantic and metric domains.

After reviewing some basic issues concerning extraction, sampling and structuring, an outline will be presented of the four main structural schemes.

II. BASIC ISSUES

To provide background which is helpful for conceiving the structural schemes, attention is given first to the relationships among information extraction, sampling, processing and data structuring, and then to the information structures related to process stages and functional classification of information.

1. Extraction versus structure

Extraction concerns isolation of the relevant features in images and the corresponding structuring. The process involves image perception and recognition or interpretation. The latter applies image analysis and synthesis with the interpreter's (a priori) knowledge. The extracted features need be encoded and indexed systematically, e.g., by using an "index chart". Extraction procedure and information structure are inter- dependent (Figure 2). The structure tends to dominate the procedure.

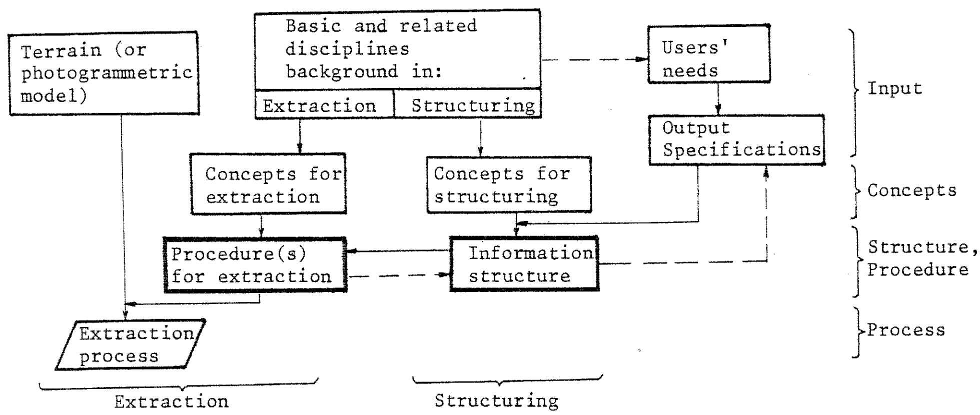

Fig. 2: Extraction procedure versus structure

The extraction procedure and information structure should be optimised jointly (figure 3). Optimisation is based on the (changing) state-of-the-art, users' specifications, and on the insight gained from experience.

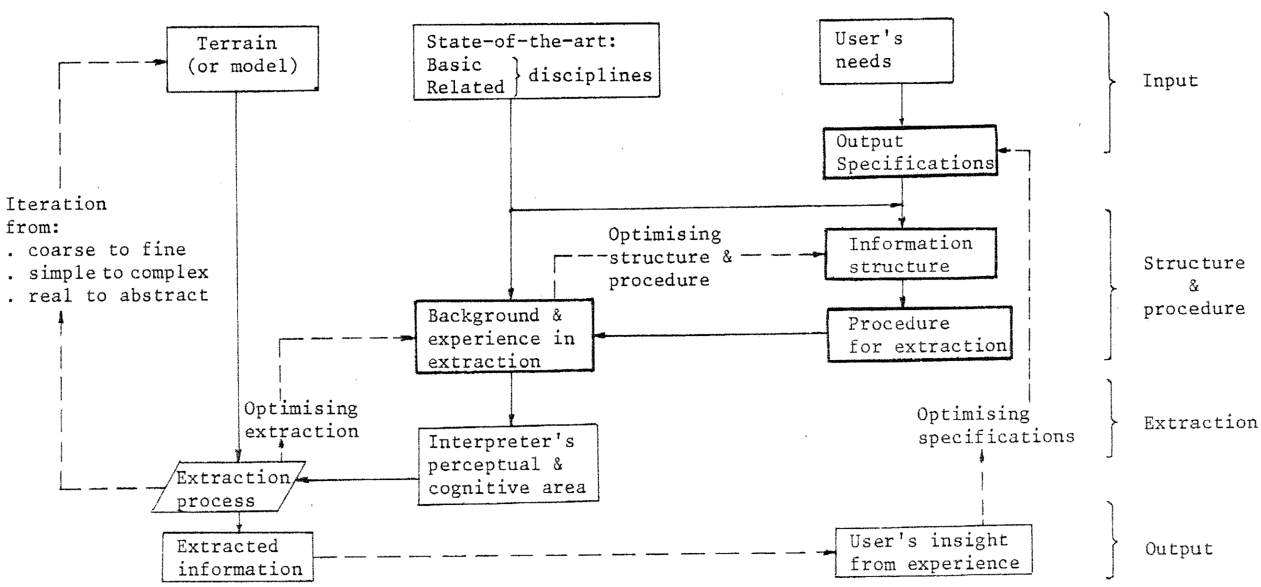

Fig. 3: Optimising data extraction

2. Sampling versus processing

Sampling consists of identification and measurement of the extracted items; it produces raw information (figure 4). The procedures for sampling and subsequent processing depend on the state-of-the-art and the users' specifications.
The structure of the raw information should reflect the procedures (including algorithms) for sampling and subsequent processing. The latter may, however, include conversion(s) of structure. Figure 4 shows, in addition to interrelationships among sampling and processing, the corresponding optimising loops.

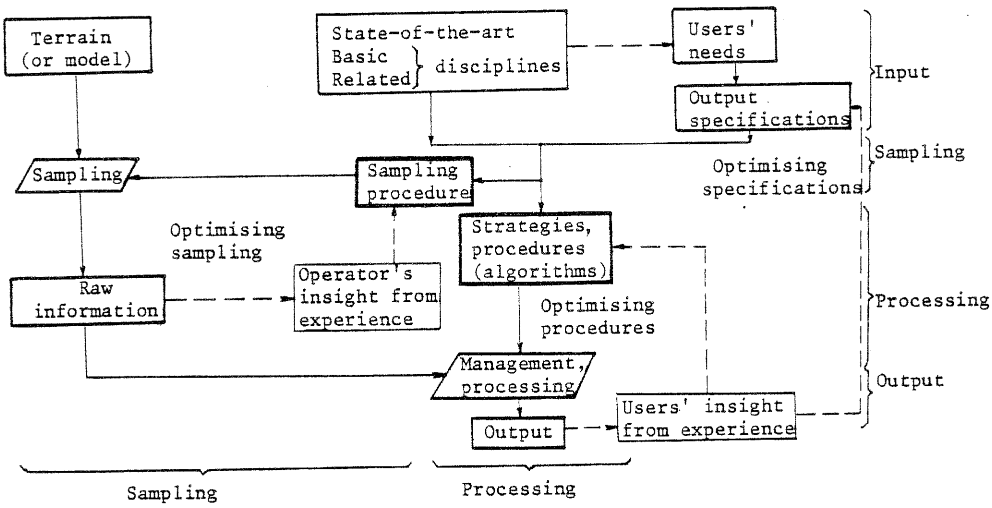

Fig. 4: Optimising sampling and processing

Because operations in the processing stage are very diverse the structure of information can differ accordingly.

3. Process stages versus information structures

Between the primary data source (images or the real world) and the information end-products, the information structure can change several times. The structures of input and output of each process stage or operation may differ. After some (pre-) processing, the raw information can be entered in a master data base or in a user-specific data base. The latter can serve different groups of users with similar requirements for information.

Figure 5 shows symbolically the main process stages and corresponding information structures; these can be differentiated further.

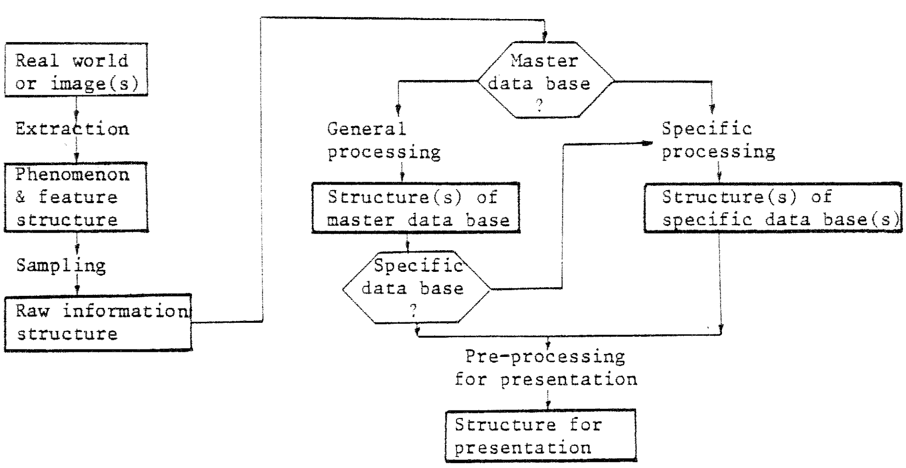

Fig. 5: Information structures related to process stages

4. Functional classification of information

As stated before, there is a distinction between basic information and control data. The basic information is problem oriented, i.e., it concerns features or phenomena in which the end-user is interested. The control data on the other hand, are solution oriented; they enable the information system to function. Control data comprise specifications for basic information (input and output), and for processes. The users of basic information are usually not interested in control data - unless they need such data for further processing. In some operations (e.g. graphic display) basic information also provides control for positioning; thus it has a double role.

A general classification of geo-information is presented in figure 6. The four levels concern the function, domain, characteristic, and category of information.

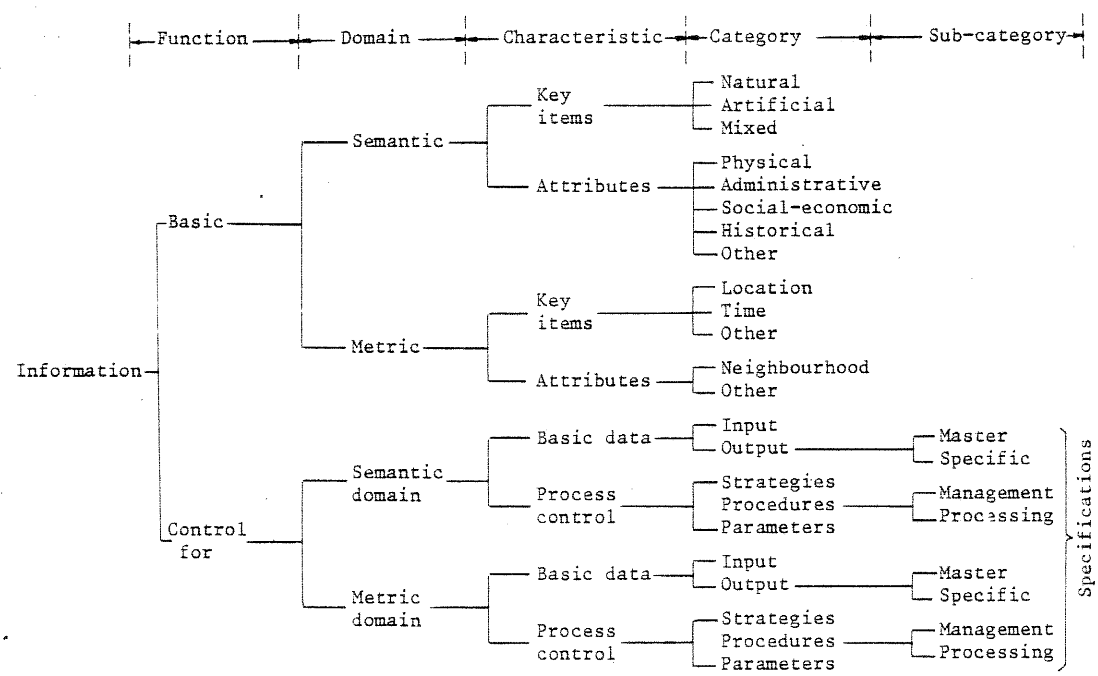

Fig. 6: Functional classification of information

Basic information contains semantic and metric components; each can be regarded as primary or secondary. In "vector format", the semantic component is primary and metric data (locations) are allotted to elements of semantic information. In "raster format", however, the situation is reverse: items of semantic information are assigned to increments of space (grid cells).

The main categories of semantic information are natural features (and phenomena), artificial objects, and mixed features (e.g., cultivated areas). The corresponding metric information refers to spatial location, time, neighbourhood, etc. Other metric information can be derived from these.

Control data are needed for execution of any operation in the semantic and/or metric domain. In each domain, control data can be further differentiated according to specifications for the basic information and those for the process control. The latter concern control strategies, the procedures (and algorithms), and the corresponding parameter values.

The main categories of information, indicated in figure 6 need to be further differentiated.

III. MAIN STRUCTURES

According to the functional classification of the information (figure 6), four main entries should be used for structuring. These entries are indicated in figure 7; such structuring can be applied to all process stages between extraction and sampling, and representation and communication.

Process stages

Domain / Function	Semantic	Metric
Basic (contents)	Key-items Attributes	Key-items Attributes
Control (specifications)	Inputs/Outputs Process control	Inputs/Outputs Process control

Fig. 7: Main entries for information structuring

Attention is given to each of these four structural schemes and some other related issued in the following.

1. Basic semantic information

Such information is feature (or phenomenon) oriented and comprises key-items and corresponding attributes. A structural scheme provides a frame of reference for systematic extraction and sampling. Figure 8 shows such a scheme for structuring key-items, which can be further subdivided.

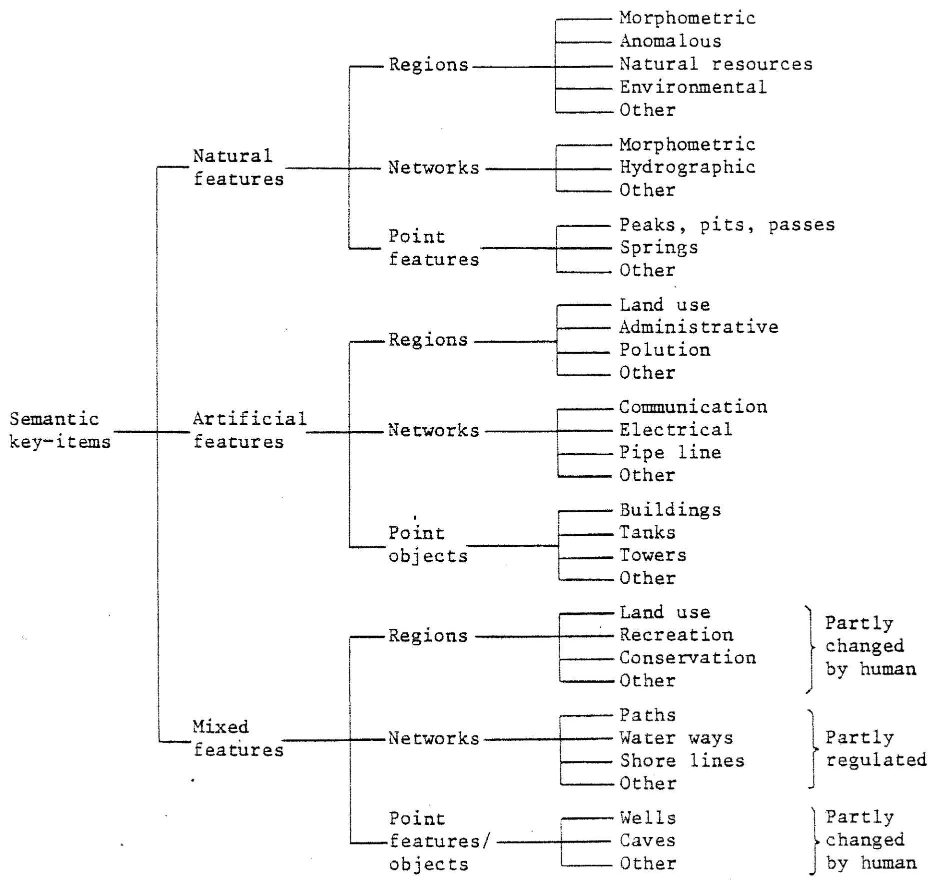

Fig. 8: Structural scheme for semantic key-items

The list of corresponding attributes is open-ended. Examples of attributes are source and type of information, value of objects, proprietary status, type and quality of material, historial information, etc.
The structure of basic semantic information provides a frame of reference for coding (and indexing) key-items in the extraction stage. Features extracted from the real world (or images) are abstracted to idealized entities suitable for sampling. Figure 9 shows a hierarchical structure of such entities.

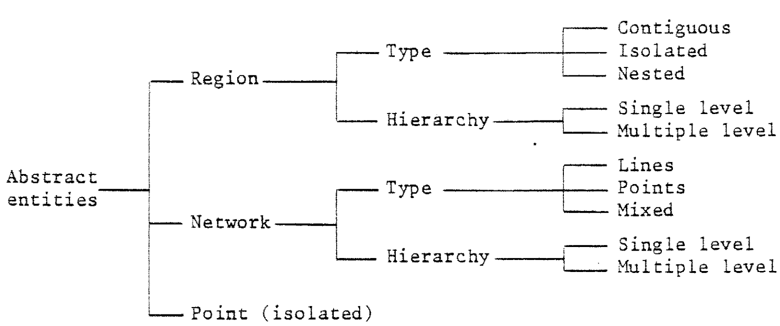

Fig. 9: Abstract entities of extraction

2. Basic metric information

Metric information has one or more dimensions, such as spatial location, time, gray level, colour, etc. Key-items can be supplemented by attributes, e.g., neighbourhood description, units of measurement, constraints, etc. These main categories can be further differentiated as shown in figure 10.

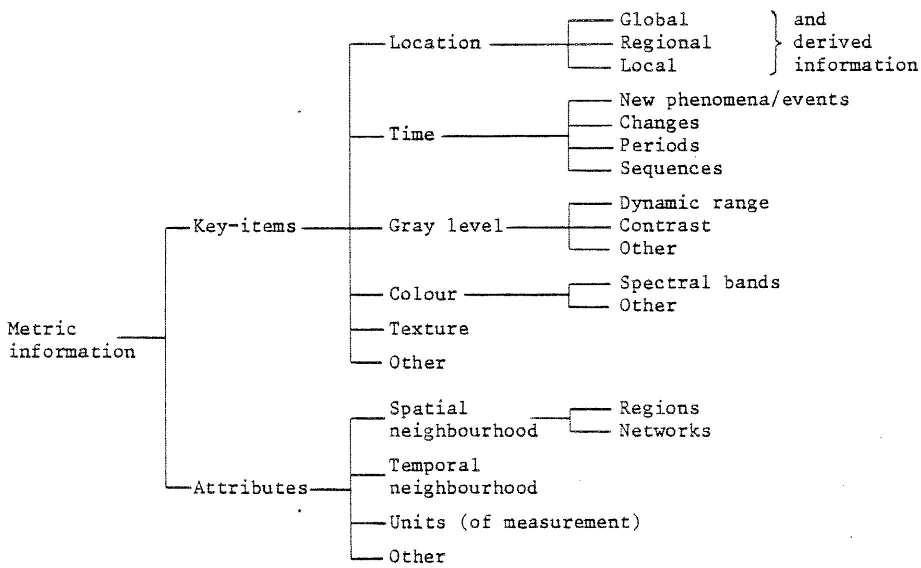

Fig. 10: Structural scheme for basic metric information

Associated with sampling, differentiation can be made among chains of line segments, continuous strings of points, grids, isolated points and different combinations thereoff. Figure 11 shows these sampling entities combined with the abstract information entities (fig. 9).

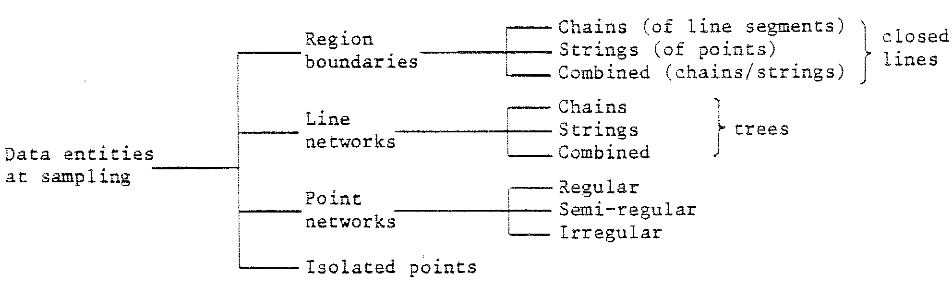

Fig. 11: Entities at sampling

3. Control data in semantic domain

The control data in the semantic domain comprise specifications for the basic input and output (semantic) and the processes involved. Thus they can be differentiated accordingly into two main categories: semantic information oriented and process control oriented (figure 12).

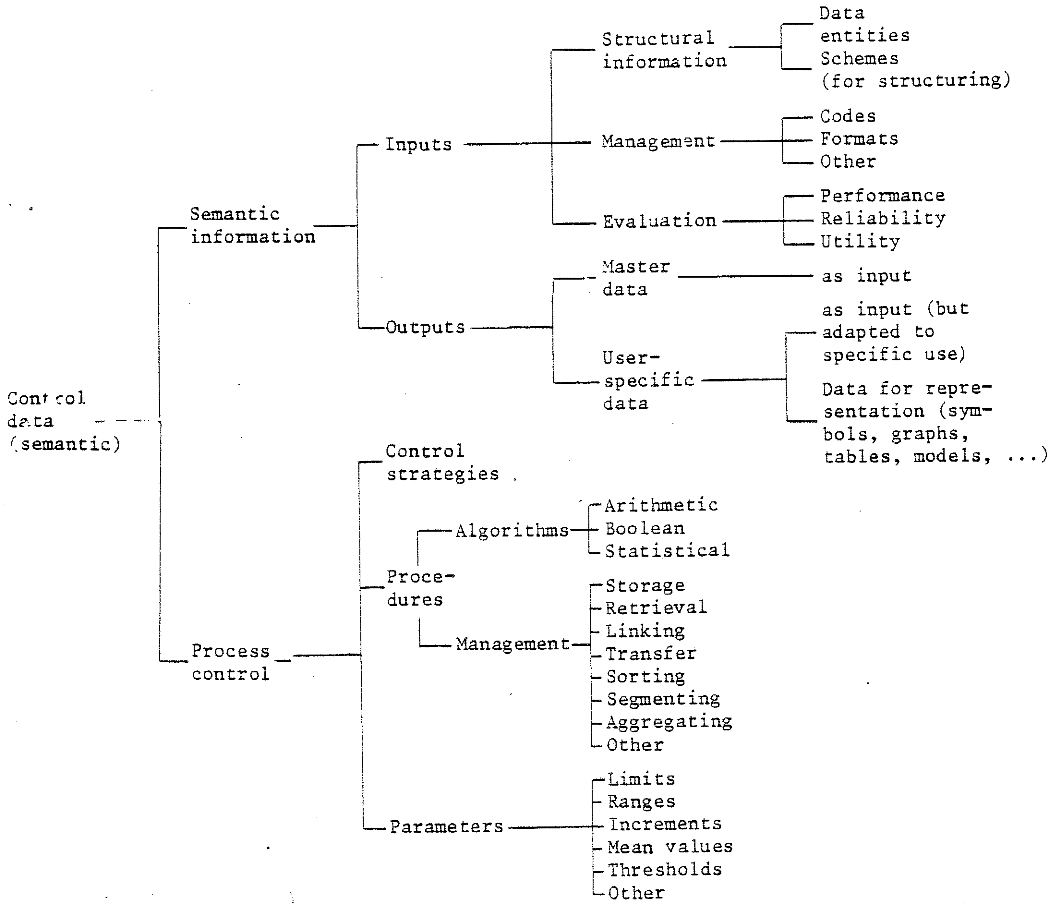

Fig. 12: Structural scheme for control data in semantic domain

Fig. 12: Structural scheme for control data in semantic domain

Specifications for the input and output can be differentiated according to the structural data, management data, and the data needed for evaluation. Output refers to either a master data base or a user-specific data base; the specifications differ accordingly.

Specifications for process control concern all process stages (figure 12). They comprise the control strategies, procedures (with algorithms and routines for data management) and parameter values.

As stated above, several operations involve both semantic and metric domains. Hence, the corresponding process control is mixed.

4. Control data in metric domain

The structural scheme for these control data is similar to that shown in figure 12, but, obviously the data content differs. It seems useful, however, to consider the basic metric data (input and output) differentiated according to key-items and attributes as shown in figure 13.

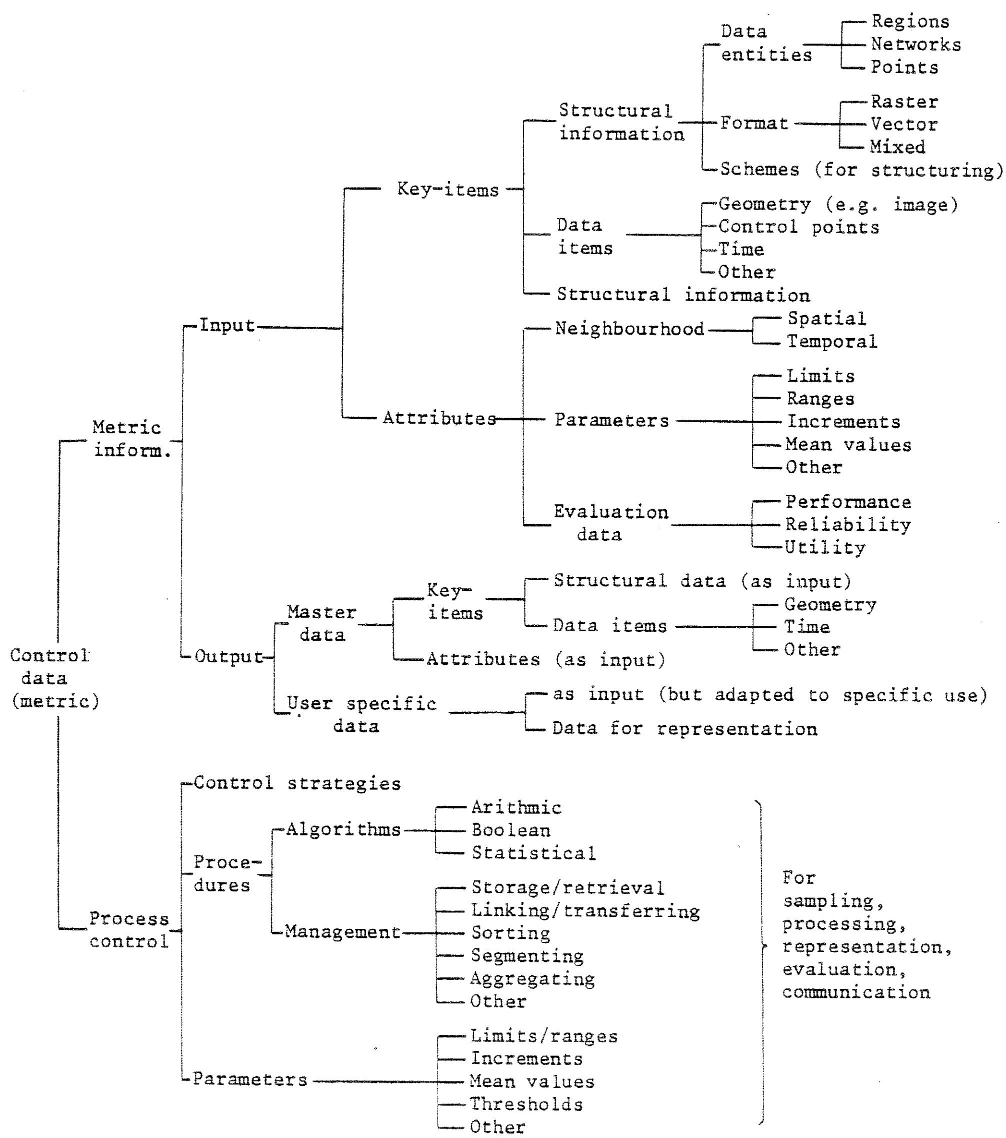

Fig. 13: Structural scheme for control data in metric domain

The metric domain is usually restricted to spatial location and some other information derived from locations. Time is not involved explicitely. In graphical and image data bases, however, gray level, colour and other metric information can also be involved. Specifications should be drawn up for all process stages.

IV. CONCLUSION

Procedures and data structures in geo-information systems are interrelated and should therefore be mutually adjusted. For photogrammetrists, the procedures for feature extraction and sampling are of special interest. The data base thus obtained, however, should also be compatible with the procedures for subsequent process stages. In each main process stage, data structure may change; thus in the whole process, which links source data with the end products, the data structure can be converted several times.

From a functional viewpoint, it is useful to differentiate between the basic information and the control data and, further, between the semantic and metric domains. Information can be structured accordingly for each process stage. These four main structural schemes are interrelated and to some extent flexible. At different hierarchical levels, the lists of data items are more or less tentative and open-ended. The schemes do not refer to physical storage structures, but to functional information structures. They tend to provide a framework for more systematic collection and processing of geoinformation.