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PRELIMINARY DIGITAL PROCESSING METHODS IN AUTOMATED SYSTEMS  
OF VISUAL INTERPRETATION FOR SPACE  
IMAGES

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ABSTRACT: Some methodological aspects of digital image processing that realize decision information provision in the process of automated visual interpretation are considered. Methods based on increasing image interpretability, primitive image segmentation and extracting/measuring image structure elements are discussed. Some data on the estimation of automated interpretation based on the developed methods are presented.

The utilization of full-scale computerized image interpretation often does not render solution of the main tasks of interpretation of space images, because of the difficulties in steady indications' discerning. The complicacy of the problem grows if one endeavours to make up an automated multipurpose interpretational system. The universally recognized alternative is a man-computer approach, based on an interactive processing. Note that detailed investigations of correlation between heuristic and algorithmic components in operator's activity are needed. Such an analysis renders requirements to the components of the system and offers structural detalization of the automated visual interpretation.

The based on this analysis system ought to include a set of programming means providing informational monitoring of a decision, taken by an operator. Besides search for efficient algorithms one should build up an experimental system consisting of aggregate of interconnected program modules with common informational base under monitoring program control. The system is applied to the preliminary processing methods. It simulates identification methods and solves a number of important tasks, including such as

- elaboration of alternative versions of image processing and comparative investigations with different tasks and conditions of their solutions;
- raising and catalogization of indicational descriptions of natural phenomena;
- contribution of additional substantial information promoting image visual interpretational characteristics;
- methodical output of separate automated interpretational processes aimed at mapping.

Results of investigations in this field brought forward a common structure and main components of the above experimental system with a few subsystems of software. They are aimed at

- promotion of visual interpretational conditions of image processing stages;
- separation of unnoticed structural features in the image (segmentation);
- estimation of metrical and statistical characteristics, based upon study of multiplicity of picked out elements;
- conventional classification and recognition of singular objects upon a multiplicity of picked out elements;
- monitoring units for control of a complex variety of programs and systematic arrangement of extended informational base, including digital terrain models of different kinds.

Utilization of the above means in automated interpretation is based upon an appropriate and opportune performance of man-computer analysis of images. Its general scheme is shown in Fig.1.

There are two types of processing programs included into different sub-systems:

- primary processing modules with the access to digitized image elements;
- secondary processing modules of intermediate data ob-

tained at primary processing stage.

The software includes a variety of subsidiary programs as well. Among them the following are of primary importance:

- access modules to informational base of the system;
- modules of accomodation and representation of intermediate data, providing interactive functions of the system.

The diversity and the amount of subsidiary programs is defined by the availability of apparatus conformation of the system including display units and a multipurpose computer.

The basic version of such a system is used for estimation of primary processing methods' efficiency, mainly utilizing shade transformation of images, as well as data preparation for measuring interpretation.

Different kinds of shade transformation are most important for promotion of interpretational properties of images. Some of the image properties can be utilized during computer tuning. For example interpretational properties of an image are widely varied depending on contrast and spacial limits of perception with distribution of local contrasts and integral shade characteristics. These and the like features are easily accounted for while digital processing of images.

A methodical investigation of stage-by-stage operations was carried out, those operations being of quantum assessment and equalizational type, as well as a number of local processes, including optimum quantum assessment by the second order statistics, non-linear transformation of histograms and various kinds of planimetric features' discernment. A feasibility of determinated procedures, most convenient for mass processing of images was taken into consideration in program realizations.

The discernment of structural features of images widens measuring potentialities inherent in image interpretation. One of the main aspects of it is a distinction of homogeneous spatial image sections. Investigations of the appropriate methods were based on a detailed analysis of opportune approach, considering requirements for image interpretation in a certain system. Various versions of transitional estimations combined with non-linear smoothing over and degenerating image transformations were considered in the class of parallel algorithms. A conventional method of following closed boundaries was considered as an alternative one. As it is not a very reliable and efficient one, for deliniation of extended boundaries on images there are special modes of operations. In one version the algorithm of following linear features in image is used to specify the boundaries, set by a cursor, in the other version it is used to approximately follow the boundary line at the upper levels of tree-shaped data base, obtained by consistent coarsening of resolving power of the initial image.

The high-speed version of tracing of closed boundaries of a beforehand segmented image was also realized. Combined with appropriate brightness transformer it provides the catalogue of closed boundaries of homogeneous sections for contrast images.

Secondary processing units are designed to measure and identify the objects, discerned at primary processing stage. For this purpose conditions were analysed and access means of programs for secondary processing for initial image (Fig. 2) were elaborated. In this sub-system there were metric indices estimation algorithms, various first order statistic estimation modules, programs of estimation of texture based on second order statistics. It is allowed to subdivide the multiplicity of segments localised in image plate into conventional categories with subsequent interactive correction of the subdivision. An estimation of areas in images is also stipulated. Both direct measurement of homogeneous sections according to the catalogue of boundaries with utilization of local topography data and method of indirect measurements of areas by categories based on solution with restoration of mixed distribution are used.

Preliminary investigations of the main algorithms, as well as elaboration and compilation of auxiliary procedures initiated estimation of automated identification efficiency. Its aim is to obtain objective data for quantitative and qualitative correction of impact of preliminary digital processing upon visual interpretation processes.

Such investigations were carried out for map compilation utilizing remote sensing data. The multiplicity of aims, objects and characteristics of such a process, as well as subjective nature of visual interpretation inherent in it, urged to do the above estimation upon the results of conventional and automated interpretation using several objects. A conventional informativity of map compilation process was used as a criterion of estimation. The elucidation and measurement of objective indices of the efficiency was based upon wide application of modern method of expert appraisal. Experiments on qualitative estimation of potential opportunities of automated interpretation were carried out at the first stage, meanwhile at the same time the methodical problems of multipurpose processing means selection were solved. A set of versatile digital data on an object was examined as an empirical system with relations. Subjective measurements in the system were performed by the group of experts, mainly by pair comparison method with the use of order scale and relation scale. Different sets of data with relations are characterised mainly by a smooth distribution of estimates. It quantitatively testifies to a relatively high efficiency of the used preliminary processing method. The repetition of such an examination on other objects and aims and analyses of the obtained ranking by method of rank correlation renders estimate on the universality of the given processing methods. There were experiments using criteria of accuracy, productivity and conventional completeness of interpretation to substantiate the quantitative inference on increased informativity of the map compilation process. The first two indices were estimated in tasks of outline interpretation. It was proved that preliminary processing saved 30% of time and at the same time increased accuracy of section area determination on 52%, while shape and twisting of planimetric features' determination improved on 18%.

The examination of comparative estimate of relative completeness of visual and automated interpretation was based on an "object-characteristic" combination. Multiplicity of this combinations was put together basing on results of secondary processing. It was examined as an extensive empirical system which can be described by the scale of relations. It allows to measure a relative completeness of identification and conventional informativity of the resulting map-scheme. When the same methods of the preliminary processing are used, such examinations on different objects rendered 57% increase of the relative completeness of automated identification.

The results proved benefits of the automated visual identification based on preliminary processing methods. It is hoped that there will be extensive widening of the opportunities as the systems of the described type will be improved.

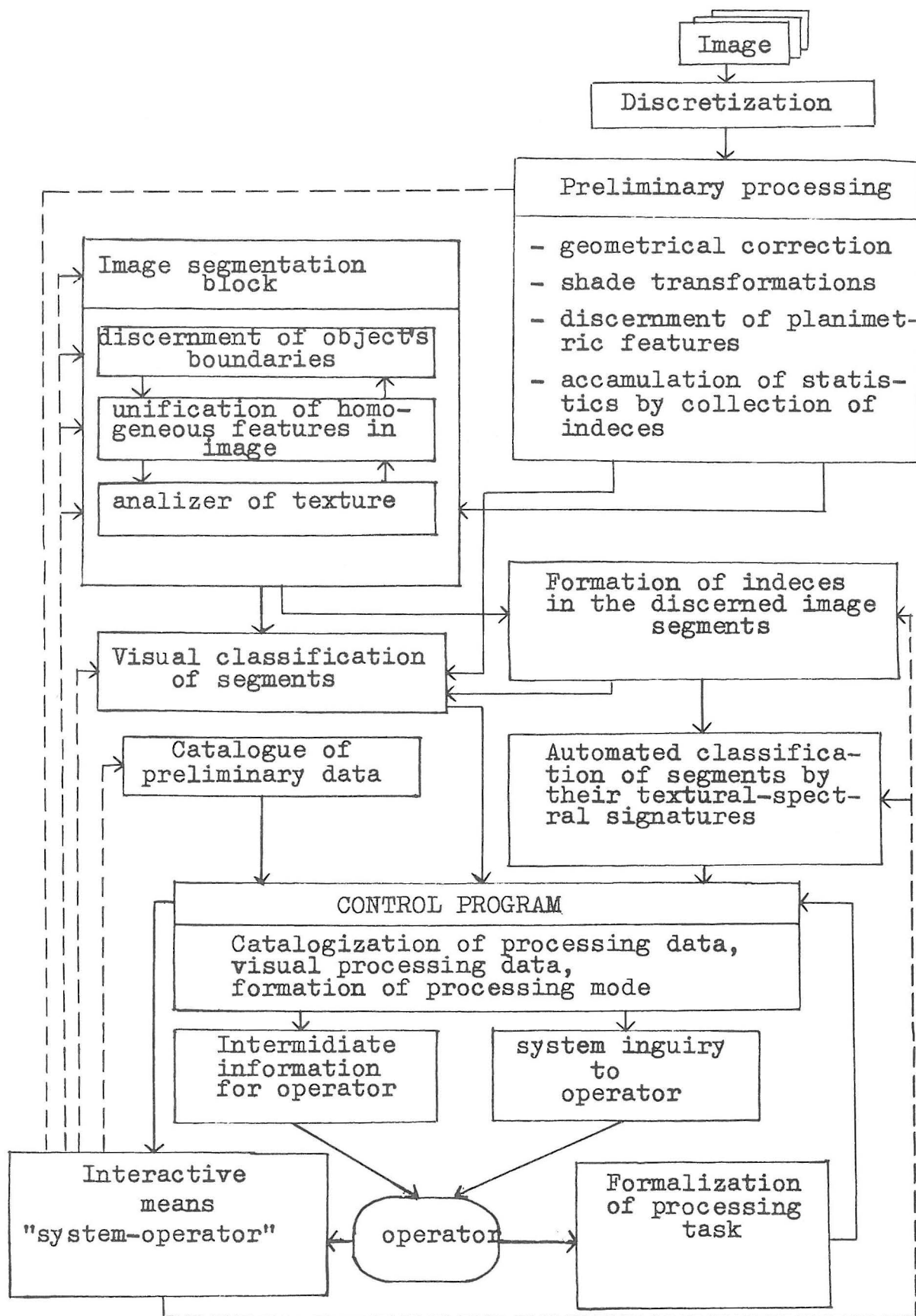


Fig.1. Man-computer image analysis in an automated visual interpretational system.



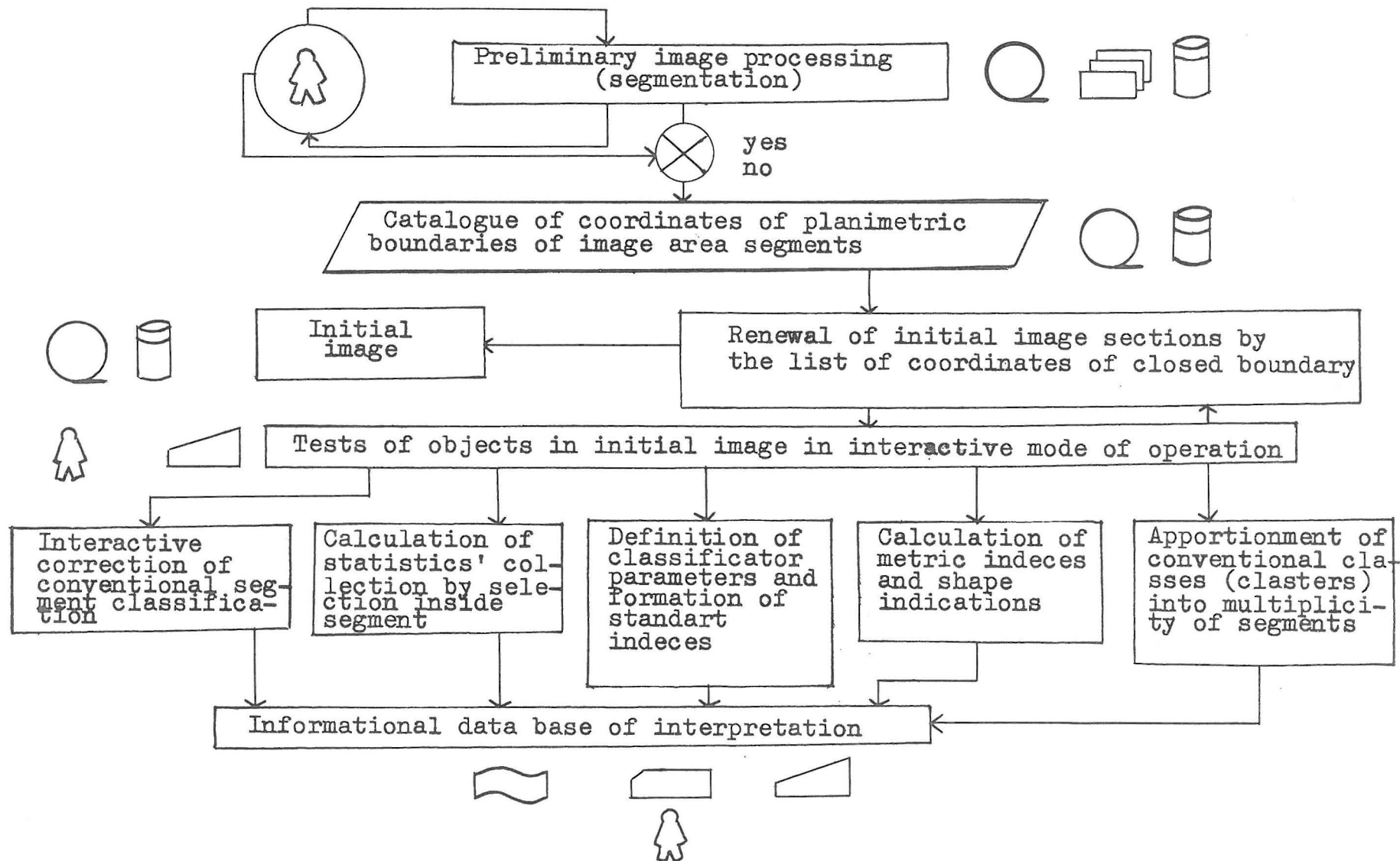


Fig.2. Secondary data processing in automated visual interpretational system.