MAN/MACHINE INTERACTION DURING FOREST IMAGE PROCESSING

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Abstract

The experience of air-space digital forest image processing shows, that the hardware constraints do not allow fully automated processing. At the same time, the traditional manual photointerpretation is somehow worse than the automated one, as far as the productivity and other indications are concerned. Rational organization of man/machine interaction, when solving practical tasks of forest image processing is mostly efficient. Two modes are considered: the mode of cooperative execution (interactive) and the mode of separate execution (man-machine). The functions executed by man and in the interactive mode are given. Three variations of image processing systems, differing by the degree of automation are considered, taking as the example the task of automated determination of forest resources. Depending on hardware and software available each operation of task solution technology can be executed either by man, or by machine or by their combination. Our experience shows, that the majority of contour photointerpretation operations are executed in the interactive mode, using raster, digital, display systems, and estimation of volume, density, diameter etc. are fully automated. The interactive and automatic modes are used, when preparing cartographic documents as well. Lists of operations for each mode are presented. They were developed during the productive use of technology. Brief characteristic of hardware, providing man-machine interaction during forest image processing is given.

The problem of obtaining and imaging of forest data by aerial space photographs with the use of computers is quite actual nowadays. In the All-Union Association "Lesprojekt" when solving this problem much attention is given to the rational combination of traditional visual methods and computer methods. As investigations show, these methods taken separately do not meet modern requirements of operativeness, accuracy and objectivity of processing.

Limitations of visual methods in solving new tasks are caused by the following main reasons:

a) Assimilation of space photography has led to the considerable increase in the processing volumes, which with traditional methods requires additional labour expenditures that are limited.

b) The results of photo visual interpretation are to a great extent subjective as they depend on the level of training, personal qualities and physical state of the interpreter.

c) Materials of new types of photography (small-scale, multi-band, multi-temporal, thermal and so on) are complicated for visual interpretation which leads to the decreasing of not very high labour productivity of interpreters.

d) Communication with peripheral automatized systems requires the highest possible elimination of manual labour in the subsystem of aerial space information processing.

Because of this the use of automatized means in the channels of photo materials processing is extremely necessary. However the

complete exclusion of man by automatized means is impossible now because of a number of objective reasons. The main of these are the following:

a) A lot of aspects of the physical activities of man during photo interpretation can not be submitted to formalization, and till now it's impossible to find equivalent algorithms, substituting for nonformalized processes.

b) Some of the object signs used by man in the interpretation can not be formed during the automatized photo analysis.

c) Modern technical means of photo material processing have considerable limitations of resolution, colour separation and other characteristics which do not allow to use certain parts of photo information.

d) There is always a lag of the algorithmic base from the required as to the readiness to solve new tasks of singling out and imaging of data is concerned.

Objective reasons hampering the use of visual and automatized processing lead to the solution of combining these two kinds of processing. Thus in the automation of data obtaining and imaging by photographs the search for the rational combination of man and machine efforts in the course of processing becomes important.

One can single out two types of photo processing regimes in which man and machine actions in the solution of one task are characterized by different levels of interrelations:

- a regime of separate (stage) processing;
- a regime of combined processing (interactive regime).

For the realization of the first regime the whole of the process is divided into sequential stages, one part of which is fulfilled more effectively by man and the other one - by machine. The results of the preceeding stage are considered initial for the subsequent stage. In this regime the work of man and machine can be done separately, not coinciding in place and time. This type of interaction is simple but in a number of cases more effective.

In the second regime man and machine work jointly exchanging information in the course of the dialogue. Here is a permanent possibility for man to control the processing, to interfere with the process and change its trajectory if necessary.

In Table 1 there is an example of function distribution between man and machine in the solution of one of the practical forestry tasks: inventory of reserve forests. The table is made up for three variants of man/machine interaction (A, B and C) according to the intensification of machine participation. Here System A corresponds to the traditional technology of visual photo interpretation and manual preparation of cartographic materials; System B - to automatized man/machine interpretation with separate participation; and System C - to automatized processing including the interactive regime. Symbol Mn means operations performed by man, symbol M - machine processing, and symbols MnM - interactive regime.

It can be seen from the table that in the traditional photo processing (System A) computers are used only for calculations. In automatized processing with function separation (System B) computers are used also for determination of forest estimation indices by photographs, but the preparation of photographs for such processing (contour interpretation, visual determination of a number of signs) and the formation of output cartographic materials is done by man. Investigations have shown (1-4) that the results of work of System B are more objective and in some cases more accurate than the results of System A, and the productivity

is higher. A further increase of effectiveness can be achieved by means of passing from System B to System C by introducing the interactive processing regime at those stages at which the work was done manually. It works because manual procedures can be divided into elementary operations, part of which can be done by machine. But because of the fact that these operations are closely interrelated they can not be performed separately. Thus the transition to mutual man/machine processing in the interactive regime seems quite natural.

It can also be seen from the table that with the use of the interactive regime most of the stages can be automatized.

The experience of organization of dialogue photo processing is not enough by now; however one can point out a number of definite functions which are advisable for use by man in the interactive regime. These functions are the following:

CONTROL - selection of the dialogue "trajectory" and processing by means of control transfer to the preferred programs out of the suggested list ("menu") depending on the current state of processing.

INFORMATION DELIVERY - information reports from the display panel to the machine by its inquiry.

TARGET INDICATION - cursor indication on the display screen of points and regions for machine processing.

TRAINING - indication on the screen of objects from the training set and reports to the machine about class codes to which these objects refer.

CORRECTION - introduction of corrections to the image, addition of the missing elements and elimination of unnecessary elements.

VERIFICATION - checking of the processing procedure according to the changes in the image and imaging parameters.

Man performs these functions in any sequence he likes interchanging his work with operations done by machine. The latter are diverse and based on the algorithms of geometric and photogrammetric image transformation, filtration, recognition, measurements, statistical processing, etc. The better the library of application programs of interactive processing is developed, the more operations can machine perform including those functions which were previously done by man.

The complex of technical means including the base computer ES-1033, several mini-computers, Pericolor display systems (Numelec, Sein), devices for image input into machines, Benson coordinatographs allows to master methods of man/machine interaction when solving practical tasks of obtaining and imaging of forest data by aerial space photographs. Several application program packages are used now for photo determination of forest stand estimation indices and formation of output documents. The programs included in these packages allow to carry out the following main types of processing:

a) In the interactive regime:

- input into the display memory and synthesizing in reference colours of multiband images;
- cursor representation of image plots for their subsequent machine processing;
- selection of contours of homogeneous plots on the image;
- colour selection of land categories and forest plots with different dominant species;

- processing of contours of the selected plots and their translation into the form convenient for transformations with the aim of mapping;
- correction and marking of contours;

b) In the automatic regime:

- image filtration;
- formation of texture sign vectors for each forest stand;
- determination (estimation) of values of forest stand estimation indices by sign vectors and support data;
- correction of forest estimation indices by the tables of stand development and other known regularities;
- estimate of derivative indices and formation of the obtained data in the given form;
- scaling, orientation, rectification and referencing of contour information;
- plan compilation with contour correlation;
- calculation of forest stand areas;
- input of additional contours and frame presentation;
- formation of a cartographic file;
- machine plotting of a cartographic document.

The results of the practical realization of man/machine methods for forest aerial-space photography material processing allow to determine their place among the existing technologies of interpretational and mapping work.

Table 1

Distribution of Functions Between Man and Machine in the Processing of Forest Resources Information

Processing Stages	System A	System B	System C
Division of the territory into districts			
Landscape division into districts	Mn	Mn	Mn
Stratification	Mn	Mn	MnM
Division by dominant species	Mn	Mn	MnM
Contour interpretation of photographs			
Determination of forest boundaries	Mn	Mn	MnM
Determination of land categories	Mn	Mn	MnM
Marking of compartment and block boundaries	Mn	Mn	Mn
Contouring of forest estimation stands	Mn	Mn	MnM
Visual determination of signs	Mn	Mn	Mn
Determination of forest estimation indices			
Composition	Mn	Mn	MnM
Age	Mn	M	M
Height	Mn	M	M

Table 1 (continued)

Processing Stages	System A	System B	System C
Diameter	Mn	M	M
Growing stock	Mn	M	M
Volume	M	M	M
Site class	M	M	M
Marketability class	M	M	M
Forest type	Mn	Mn	Mn
Interpretation of areas non-covered with forest			
Clearances	Mn	Mn	MnM
Cutting areas	Mn	Mn	MnM
Burns	Mn	M	M
Windthrow	Mn	Mn	MnM
Other types	Mn	Mn	MnM
Preparation of output documents			
Summary tables of forest fund data	MnM	M	M
Diagrams, map-cases, forest stand plans	Mn	Mn	MnM
Thematic maps	Mn	Mn	MnM
Schematic documents	Mn	Mn	Mn

Note: Mn - man, M - machine, MnM - man/machine.
System A - visual photo interpretation, computer calculations.
System B - pre-machine visual interpretation with subsequent machine photo processing and computer calculations.
System C - interactive photo interpretation, interactive map compilation, computer calculations, machine map drawing.

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