JOINT AUTOMATED PROCESSING OF AERIAL SPACE AND CARTOGRAPHIC INFORMATION ABOUT FORESTS

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1. Introduction

The development of remote sensing methods for the Earth's natural resources study based on the use of aerial space photography materials has put forward a number of new requirements to the methods of these materials processing. One of such requirements is the necessity of the joint processing of aerial space information extracted from photography materials and cartographic information read from maps and other sources. These two types of information come through independent channels, mutually augment each other and favour the quicker, more accurate and effective solution of a number of forestry tasks.

The technical basis of the joint processing is the automated system containing the technological lines of forest mapping and interpretation of aerial and space photographs and resting upon the united base of forest mensuration and cartographic data. One can give a whole set of examples of the joint use of aerial space and cartographic information in the automated methods of forestry task solution. Thus in the compilation of planning-cartographic materials of forest management two flows of information are jointly processed: one of them comes from topographic maps (administrative boundaries, hydrography, road network, relief) and makes up the topo-basis of the future forest map, and the other takes information about contours and forest mensuration characteristics of forest plots from aerial or space photographs. The joining of the flows is done by the control points at the automated working place in the interactive mode. The joint processing of two information flows ensures the improvement of the accuracy of the output documents. The second example is the timely registration of the current changes on the forest fund areas caused by fires, natural calamities and economic activities. Space photographs contribute to quicker determination of the forest fund changes relative to the control state at the definite instant of time. This state is set by the cartographic information contained in the data base. In order to implement this idea the joint processing of both information types is carried out. There are some other examples.

In the All-Union Association "Lesproject" (Moscow) automated system of forest interpretation and mapping (ASFIM) which makes it possible to process aerial and space photography materials of forests together with the cartographic information in the automated solution of forestry tasks has been developed. The

system is being applied in science and in practical work.

2. Technical Means of the System

The following tasks are solved with the help of ASFIM:
- input of the source information from different carriers: aerial and space photographs, topographic maps, geodetic data tables, digital magnetic tapes;
- preprocessing of the entered information including the error search and correction, extraction of the contour information read from photographs and control points, and contour transformation from the raster into the vector format;
- further processing including the analytical rectification of information fragments, their coordination, mutual adjustment and reduction of contours, correction and area calculation;
- development and management of cartographic and forest mensuration data base in the form of the relational tables complex;
- joint interactive processing of aerial space and cartographic information;
- information output by requests (including cartographic information).

In order to solve the above mentioned tasks the systems should have the following technical characteristics.

Input devices allow to read information from aerial and space photographs of different kinds and scales, black-and-white, color, multispectral photos, negatives and positives, written on the photo film, paper and magnetic tape. The frame format is 300x300 mm, and the reading apertures make up 25 and 50 microns.

Information from outlines and photo-outlines is read by the television input device. Information from maps is read with the help of the digitizer of the format A0. Image discretization on the color raster display makes up 256 x 256 and 512 x 512 elements. For the correction of the graphical information a vector display is used. Map plotting is done with the plotter of the format A0 in four colors at speed 800 mm/sec. All peripheral devices are united into automated working places controled by mini-computers. For the data base storage magnetic disks with the capacity of 96 Mbytes are used.

3.1 Framing Method of Forest Cartographic Materials Compilation

We shall call planning-cartographic materials of forest management and thematic forest maps forest cartographic materials. To planning-cartographic forest management materials we refer forest management schematic maps, forest stands plans and plans of forest management units. Thematic forest maps include non-traditional cartographic documents containing information about forests of interest for planning organs, forest management bodies, etc. Forest management schematic maps are compiled at the largest scale (from 1 : 10000 to 1: 25000 depending on the forest management category) thus they are most accurate forest maps. The requirements to the accuracy of forest cartographic materials are the same as in case of topographic maps of corresponding

scales. However one must bear in mind that requirements to the accuracy of drawing various elements on maps are different.

All the lines (showing boundaries of various area units and linear objects, and determining trajectories of legend plotting) and points (fixing the location of control points and symbols) may be divided into three classes according to the requirements set towards the accuracy of their description and plotting. To the first class we refer those elements which determine the metric accuracy of the document. These are control points, district boundaries of the State forest fund lands and other administrative boundaries, hydrography, road network, compartment openings, etc. In the use of the vector format coordinates of these lines and points must be known with the accuracy of fractions of mm at scale of the output document. The totality of elements of the first class accuracy makes up the frame of the cartographic document. Boundaries of forest mensuration plots (especially those established by way of contour interpretation of aerial space photographs) and other "washed away" ground objects refer to the second class contours which form the filling of the frame cells. Their coordinates must be known with the accuracy of units of mm at scale of the output document. The third class includes lines the main requirement to the accuracy of the description of which is the observance of their correct location and orientation towards other area and linear objects. These are shading lines, lines determining the legend positions, frame contours, etc. To this class also points determining the location of some symbols and legends having the predetermined orientation are referred.

The frame elements are entered into the computer either by means of presenting information in the digital form (for example data obtained in the process of the geodetic survey of the district boundaries of the State forest fund lands) or with the help of the precision input devices (for example schematic map digitizer) from highly accurate cartographic materials (road network, hydrography, control points, etc.).

Information about objects of the second class (for instance about forest mensuration plot boundaries) is entered into the computer with the help of television input devices in combination with raster display systems of a low resolution (512 x 512) from aerial space photographs, outlines or old corrected maps, and coordinated to the axes of the frame by means of different transformations (flat-parallel transfer, avertence, linear stretching, projecting transformation) chosen in accordance with the type of a document with source data by control points.

Coordinates of the third class elements are usually determined automatically or with programming means with the minimal interference of the operator. Thus through the detailization of requirements to the map accuracy it is possible to get an access to the information of different accuracy and to reduce the time of information input while increasing the automation degree of the procedure of entering the source data and reducing the requirements to their accuracy.

3.2 Photointerpretation with the Use of Data about Relief

Interpretation of space photographs showing mountain forests requires the knowledge of the relief characteristics of the photographed terrain. The use of the relief data in the process of interpretation increases the range of the tasks solved and improves the results accuracy. For the determination of the forest mensuration indices of stands growing under mountain conditions additional features (slope, exposition, point height, etc.) which can be extracted from the digital relief model (DRM) are required. Contour interpretation of photos with the determination of the relief elements (watersheds, valley lines) is done more accurately and in more detail. Land category extraction by space photographs is also done with the increased accuracy if the relief data is available.

It is necessary that each space photograph be supplied with the local DRM which is related to the photograph in scale and coordinates, and the photograph should be processed together with the DRM.

In the data base of ASFIM the division in which isolinear relief models in the vector format are stored has been created. There is another division in which data about control points is concentrated.

In the joint processing of a space photograph and DRM a number of control points which are stored in the cartographic data base is marked. The fragment of the DRM covering the photograph is called from the base and rectified into the photograph plane by the selected control points. In the raster display system superposed composite terrain images read from the space photograph, and the isolinear DRM transformed into the raster format are shown. Then by the isolinear model the hypsometric relief model defined on the same raster as the terrain image and combined with it is built.

After the mentioned preparatory operations in the memory of the raster display system we have the local hypsometric DRM each pixel of which contains information about the height of the terrain point defined on the image with the pixel with the same coordinates. Then the joint processing of the image and DRM is carried out. Data about height extracted from the relief model is used as additional features in the automated photointerpretation.

3.3 Determination and Registration of the Current Changes on the Forest Fund Areas

In order to reveal and register current forest fund changes caused by natural calamities (burns, windthrows, forest pathology, etc.) and economic activities (cuttings and other anthropogenic influence) automated comparison of planning-cartographic materials of forest management (for example forest management map schemes or forest stands plans) and other forest maps with aerial space photographs and scanner images is provided for in

ASFIM. Into it forest mensuration characteristics and cartographic information including boundaries of plots and objects (burns, cuts, etc.) which emerged after the latest forest management operations took place are entered. With the help of the television device or just from the magnetic tape an aerial space photograph is entered into the raster display system and visualized on the screen. Interactive procedures of the automated extraction of contours showing burns, cutting areas, etc. have been developed. In order to reveal and register the current changes contours obtained in the interactive mode should be compared with the contour network determining the forest state at the time of the last revision. To this end the geometric correction of contours stored in the cartographic data base of ASFIM is carried out by the control points, as a result of which they are coordinated by the photograph axes. The coordination by the photograph is done with the help of the projection transformation, and by the scanner image - through the account and compensation of the cylindrical distortions and the earth's revolution with further affine transformations. After the geometric correction contours from the cartographic data base are shown on the screen of the display system together with the photo image. Sometimes this procedure is done before the automated interpretation of a photograph takes place.

The possibility of combining on the display system screen the planning-cartographic materials and photographs makes it possible not only to determine the quantitative characteristics of changes (for example the volume of the burnt timber, violation of the major cutting regulations, etc.), but in some cases also gives the interpreter additional information which helps to considerably improve the reliability of the interpretation process (for example the degree of forest combustibility, land categories, etc.).

The experience of work with ASFIM has shown that the joint processing of the digital cartographic and aerial space information makes it possible to solve a number of tasks dealing with the processing of photographs in a new manner and with the additional effect.