DIGITAL PHOTOGRAMMETRY USED TO MODEL BIOCENOSES AND SURROUNDING OBJECTS

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Для изучения биоценозов и других объектов окружающей среды необходим большой объем разнообразной информации, в том числе пространственной, источниками которой являются материалы аэрокосмических макро и микросъемок. В докладе приводятся особенности математических методов обработки стереоизображений для изучения различных биологических объектов, а также примеры реализации цифровых фотограмметрических технологий для моделирования различных объектов.

INTRODUCTION

Promotion of the methods of digital treatment of images enlarges the range of possible applications of photogrammetric methods. The use of digital cameras and photogrammetric stations has qualitatively changed the process of production and treatment of images, increased the operative potentialities and degree of automatization of photogrammetric technologies. This made them available not only for specialists in image treatment but also for those specialized in concrete applied areas studying environment. To practically realize the applications of digital photogrammetry for solving nonstandard problems it is necessary to develop additional techniques taking into account the peculiarities of the different types of studied objects which are rather simple for a user without special photogrammetric background. In this report, our main concern is with the adaptation of digital photogrammetric technologies to the collection and treatment of spatial information during complex study of the different objects composing biocenoses. The advantage of photogrammetric methods is the possibility of forming volumetric models of objects by their stereoscopic digital images. In photogrammetric treatment, a stereoscopic model is used to measure the spatial coordinates of the points of photographed objects showing their morphometric characteristics (length, width, configuration, form) and to visualize objects almost adequate to the studied ones, in the form of three-dimensional models preserving their metric characteristics.

MATHEMATICAL METHODS AND MODEL PARAMETERS

Mathematical models of different objects can be obtained by measuring and mathematically treating a stereopair or several stereopairs of the images of photographed objects for the objects of great extension. A classical mathematical model of treatment of a stereopair of images resulting from central projecting of object points is based on conditions of collinearity and complanarity of projecting rays [1, 4]. Let us write down a functional dependence of model parameters in the general form

$$F(C_n, A_e x_n, y_n, X, Y, Z) = 0$$

where n=1,2 which corresponds to the left and right images of the stereopair.

C_n are the coordinates and angles of the orientation of a surveying system and the parameters characterizing its geometry, A_r are the support data, x, y, are the coordinates of the corresponding points of the left and right images, X, Y, Z are the spatial coordinates of the determined object points.

In a particular case, parameters determining position of the surveying system can be measured by shooting to within sufficient accuracy. However, for the general case, they should be determined, i.e., one must solve the problem of calibration. This requires a set of image points with the known coordinates in the object space or the linear dimensions of objects which can be known with the necessary degree of accuracy. These values form a basis for the support A_r data. Coordinates of the corresponding points x_n, y_n of the stereopair are measured at a digital photogrammetric station in the stereoscopic regime and the spatial coordinates of the points of XYZ object are calculated using the basic modules of the digital photogrammetric station. Thus, treating stereopair at the digital photogrammetric station provides primary data for a subsequent formation of mathematical models of photographed objects which can be solved using the programmed graphic products. Thus, the general problem of the modeling of different objects by image stereopair includes a series of subproblems each having its own peculiarities depending on the shooting scale and characteristics of the object studied (Table 1).

Table 1.

Composition of each subproblem	Output data
Determination of shooting parameters (calibration).	Focus distance of pictures, coordinates of a shooting point and angles of inclination of pictures.
Formation of volumetric model by stereoscopic pair of digital images, collection of information on the object studied.	Primary data: spatial coordinates of characteristic points, boundaries of objects, digital height model.
Realization of functions of determination of object characteristics by their coordinates.	Secondary data: geometric characteristics of object form and configuration.
Reflection of the results obtained.	Tree-dimensional visualization of object models.

Different algorithms for realizing each problem have been developed. The choice of optimum algorithm with respect to the available technical and programmed means providing the necessary accuracy of reflection of a concrete object is a very important problem which should be solved for each type of studied objects. In addition to the mathematical aspects of the choice of the best solution, there is a series of technological problems. In particular, to provide good stereoscopic plastics of a stereomodel, it is necessary to carefully choose shooting parameters and conditions for object lighting to work up the surface of studied objects. The necessary accuracy can be reached with a correct choice of either the method for determining support data or the preparation of special test-objects.

MAIN TECHNOLOGICAL PROCESSES

The following operations should be realized to create the mathematical models of separate biocenosis objects by their stereoimages:

1. The choice of optimum shooting parameters on a basis of calculation experiments on model pictures and their correction during experimental shooting of real objects.
2. The preparation of test-objects corresponding, in their size, to each group of studied objects.
3. The shooting of studied objects, i.e., the production of qualitative digital stereopairs. In this case, the shooting should be performed with the help of both digital and photographic cameras with subsequent scanning.
4. The mathematical treatment of digital images with the help of a digital photographic station for collecting primary data. It includes two stages: calibration and measurement of a stereoscopic model.
5. The reflection of results in the form of three-dimensional mathematical models.

During experiments, we used a digital photogrammetric station Siberian Digital Stereoplotter (SDS) developed at the Faculty of photogrammetry and distant sounding SGGA [3]. SDS makes it possible to extract information from aerophotographs and other pictures on a local scale for solving a wide range of problems. The main SDS module allows the treatment of stereopair with stereoscopic examination of initial images and the results of the gathering of graphic information. Besides, there are additional modules of the treatment of different images. The files of digital and graphic data obtained at the digital photogrammetric station can be exported to GIS and other graphic programmed products for further treatment. The three-dimensional visualization of results was realized with the help of such packets as MatLab and Surfer. Initial data were collected by a stereopair using SDS means either automatically or interactively. In this case, the different forms of their representation were used according to the peculiarities of the photographed object: for studying relief - Grid, and for microobjects - a matrix of three-dimensional coordinates of object points. The point wise description of surface is necessary because of the complex and unusual form of biological objects photographed by electron microscopes. A detailed representation of their numerous geometric characteristics is possible only with the help of this approach. Requirements on the density of point distribution on the surface depend on the peculiarities of the form of photographed objects. They should be determined correctly for the model to be not distorted.

RESULTS OF EXPERIMENTAL WORKS

The digital photogrammetric method for collecting spatial data for modeling the different objects of biocenosis and other objects of the environment has been realized in the form of technologies developed in detail for solving the following problems [2,5,6].

- The study of anthropogenic landscape disturbance using aerophotographs.
- The determination of morphological relief characteristics.
- The study of morphometry of pollen grains.

- The recovery of the spatial form of seeds (using pink family as an example).

Below, each technology is illustrated. A digital relief model (DRM) (one of the variants of its visualization is given in Fig. 1), was created in the framework of the complex problem of estimation of the ecological state of the national forest Kusnetzky Alatau for the area of the national forest near town Chemodan. A series of experiments was carried out to study the shape of seeds and pollen grains by their microscopic images. The method was developed to get stereoimages using both optical and electron microscopes. The images were treated at a digital photogrammetric station which allows one to determine for the first time, the parameters characterizing the spatial form of pollen grains and seeds of some plants. Fig. 2 shows the larch pollen placed on the test-object (the distance between dashes being 100 mkm). During photogrammetric treatment, in the process of stereoscopic observation, the isolines of the same height were traced each 5 mkm. The plane of the test-object was taken as the initial (zero) plane. The spatial model was restored (Fig. 3). These data made it possible to determine the volume of the surface of the visible part of pollen grains necessary for modeling aerodynamic properties of pollen. A similar technique was used to obtain spatial characteristics for studying the seeds of complex structure. This technique was worked out using the seeds of pink family characterized by particular elements of surface structure (hills or papillae of different height and form (Fig. 4)). The number of hills, their form and height on dorsal and lateral surfaces are of importance for morpho-functional analysis and are readily identified by their stereoscopic model. In addition, during expedition to Kusnetzky Alatau the stereoshooting was performed for some plants and their three-dimensional images were constructed.

The authors are grateful to N.V.Vlasova for her assistance in performing experiments.

CONCLUSIONS

Digital photogrammetric technologies are one of the means of informational supply of various problems on the study of biocenoses and biodiversity. Stereoscopic images provide additional information on various biological objects necessary for determining phenological features and systematics as the objects of plant and animal world and allow one to study the spatial structure of biocenoses. The application of digital photogrammetric technologies for treating images of different scale provides a three-dimensional conjugate modeling of the objects studied and the space-time continuity of the analysis of different objects composing biocenosis.

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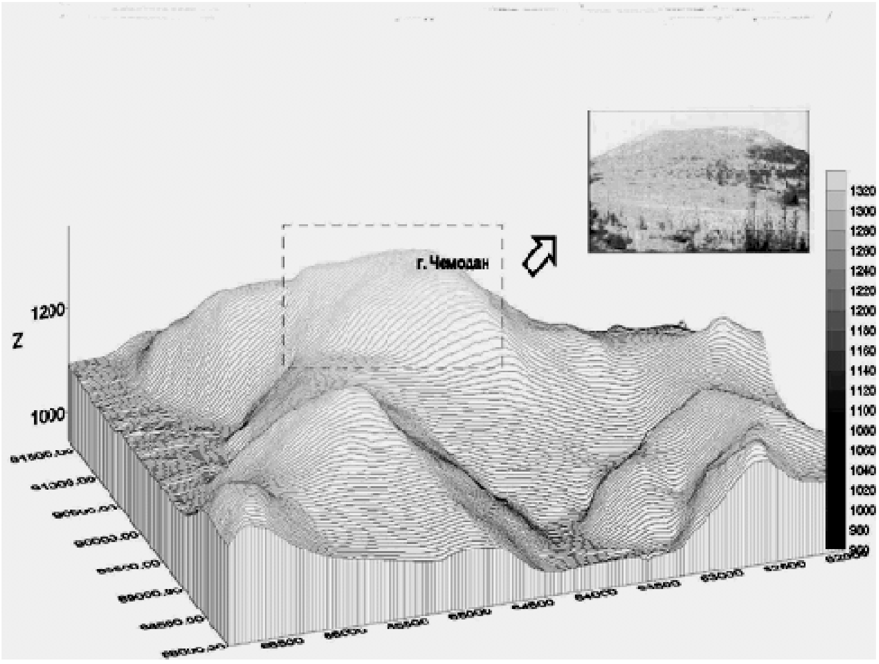

Fig.1. Three dimension surface of regionof the national forest Kusnetzky Alatau.

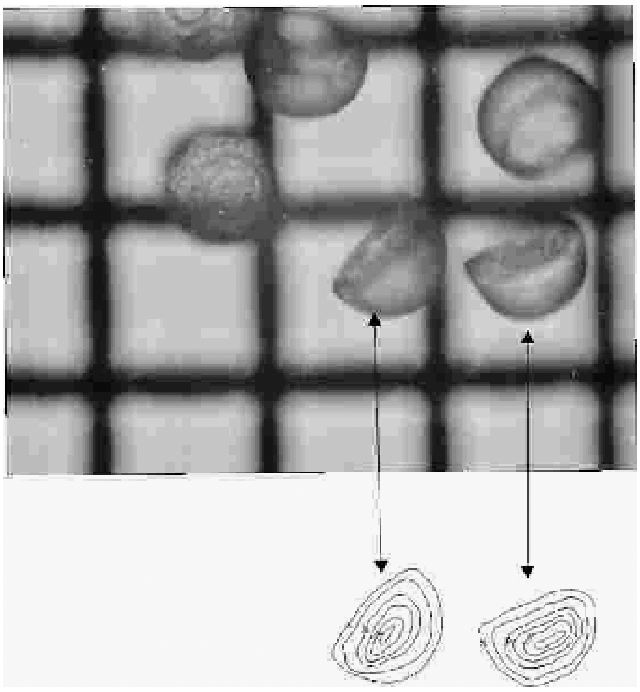

Fig.2. The larch pollen placed on the test-object.

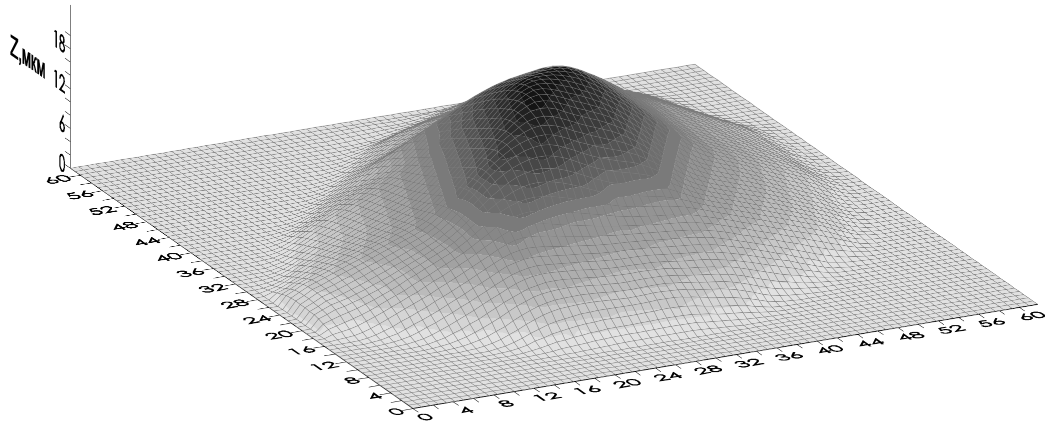

Fig.3. The spatial model of larch pollen.

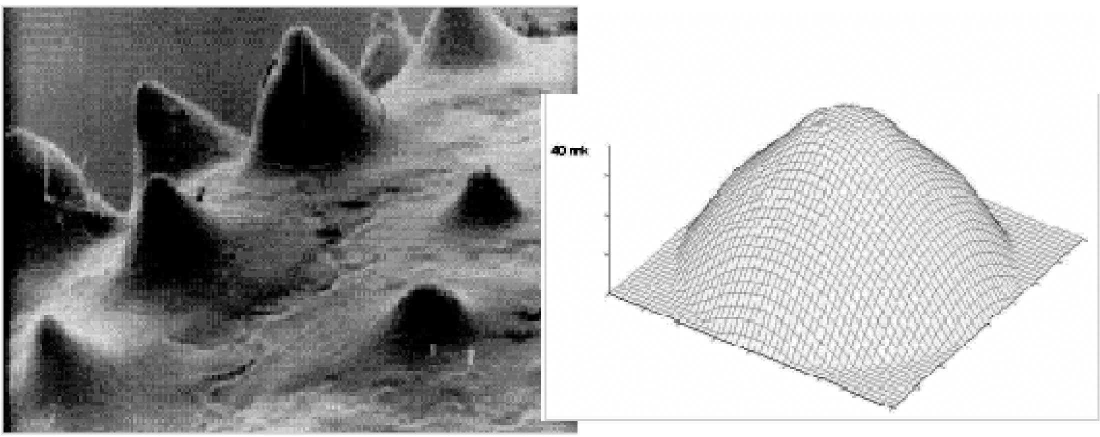

Fig. 4. The electronmicrophotography of papillae of different height and form on the seed surface. The computer model of single papilla.