constructed on the basis of several neighboring shots of one scene of a video sequence can be estimated visually by means of an expert estimation. In fig. 1 the result of work of an algorithm after processing a scene of test video sequence as well as the found field of movement vectors are presented.

The result of research work is the algorithm of scene image formation on the basis of the neighboring frames of a video sequence scene. The offered algorithm is applicable for the solution of many important problems, for example, for construction of a panoramic image, video sequence stabilization and compression, video sequence reconstruction in systems of video editing and electronic video archives.

References

1. Damov M. V. Restoration of background in parts of a frame with small-size objects in videosequence // Vestnik. Scientific Journal of Siberian state aerospace university named after academician M. F. Reshetnev. Issue 1(27). 2010. P. 52–56.

2. Mowler K., Forsyte G., Malcolm M. Machine methods of mathematical calculations, transl : from English. Mosckov : World (Mir), 1980.

3. Making good features to track better / T. Tommasini [et al.] // Proc. IEEE Computer Society Conference on Computer Vision Pattern Recognition. 1998. P. 145–149.

4. Litvin A., Konrad J., Karl W. C. Probabilistic Video Stabilization Using Kalman Filtering and Mosaicking // Proc. of SPIE Conference on Electronic Imaging. 2003.

5. Soldatov S. A., Strelnikov K. N., Vatolin D. S. Quick and reliable definition of global motion in videosequences. // Materials of 16-th International conf. on computer graphics and its applications. 2006. P. 430 – 437.

I. M. Danilin
Siberian State Aerospace University named after academician M. F. Reshetnev, Russia, Krasnoyarsk

A. I. Danilin
Institute of Forest named after V. N. Sukachev, Siberian department of Russian Academy of Sciences, Russia, Krasnoyarsk

D. I. Svischev
Krasnoyarsk State Agrarian University, Russia, Krasnoyarsk

LASER LOCATION AND DIGITAL AERIAL SURVEY AS A SUBSATELLITE COMPONENT IN THE SYSTEM OF INFORMATION SUPPORT OF INVENTORY, MONITORING AND CADASTRE OF FOREST LANDS

Approaches and solutions in the area of forest remote sensing methods for the purposes of information support of inventory, monitoring and cadastre of forest lands with the use of innovation methods and high-end technologies of laser location, digital aerial survey and global satellite positioning are considered in the paper.

Keywords: laser location, digital aerial survey, satellite positioning, inventory, monitoring and cadastre of forest lands.

In the contemporary practice of forest use, monitoring and cadastre to receive reliable and efficient information about state and dynamics of forest lands is an urgent problem concerning both natural resources and environment and nature protection.

Nowadays laser location and digital aerial survey, which are major constituents of geomatics – the newest integral direction in the development of remote sensing methods of the Earth (aerial- and space survey), geoinformation technologies, digital photogrammetry and cartography, satellite geopositioning and telecommunications are more and more widely used in the solution of this problem in many countries of the world as well as in Russia.

Those advanced and highly effective methods today find wide application in many branches of economy. In fact they are an information basis of natural resources cadastres, land- and forest planning, ecological monitoring, systems of data gathering, processing and analysis. Judging by their accuracy and economical efficiency they exceed other methods of studying and measuring parameters of the Earth cover and natural systems [1–7].

Modern high-end aviation laser location systems develop quickly and today they have a scanning frequency of more than 200 thousand pulses (measurements) per second (fig. 1).

The highest density of scanning pulses is 1 pulse per 5–7 cm of the surface, the accuracy of measuring geometric parameters of the ground objects and vegetation morphostructural elements in plan and profile projections is about ± (5–10) cm. The accuracy of satellite positioning of forest line contours and boundaries, sample plots, separate trees and morphostructural elements of their stems and crowns, including under crown space, is practically unlimited and is determined by technical parameters of the GPS instruments [1; 4].

a *b* *c*

Fig. 1. Instrument and technological components of a laser location method:
a – universal aerial surveying laser topographic system Optech ALTM 3100 supplies laser-location data (purpose: Digital Terrain Models, contours allocation, data decoding); *b* – large-format digital photogrammetric aerial camera Vexcel UltraCamXp supplies digital aerial photographs of ultrahigh (centimeter) resolution (purpose: traditional); *c* – system of direct geopositioning and orientation of aerial photography sensors Applanix POSAV supplies elements of external orientation of digital aerial photographs and laser-location data (purpose: direct geopositioning (geoaffixment))

Satellite snapshots got by modern optical-electronic systems such as Landsat, Resurs-DK, Ikonos, OrbView-3, WorldView-2, GeoEye-1 or other systems of high- and ultrahigh resolution and decoded by main parameters and characteristics of vegetation cover [5] may also be both the tools of spatial and detailed display of contours and relief of the Earth surface together with its vegetation and the base for preliminary routes tracing for laser and digital aerial survey.

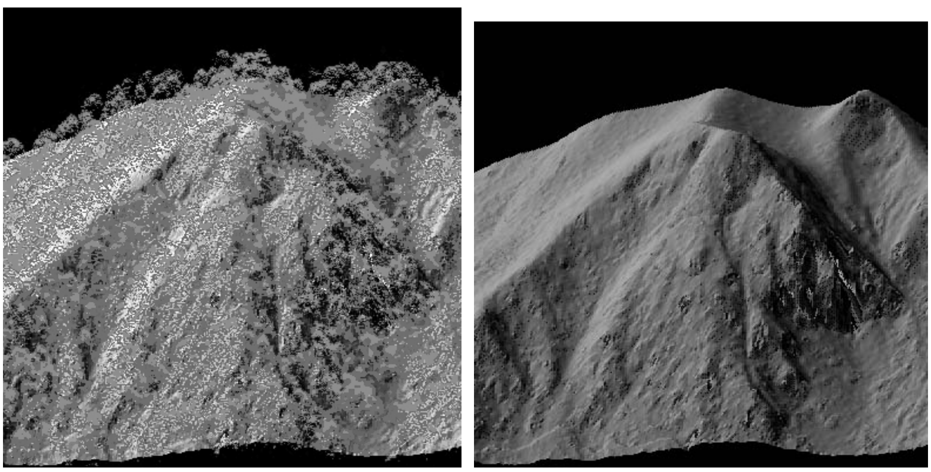
Therewith the structure, volumetric trees and tree stands indices, their phytomass are determined more reliably and precisely by laser-location data ("laser portraits"), integrated with digital geotransformed aerial photographs on the basis of DTM and forest canopy distribution field, which are generated from the initial laser location data by filtering (separating) laser pulses, reflected from the Earth surface and vegetation, by means of the ground pulses interpolation with the following triangulation of pulses reflected from vegetation in systems of differential satellite positioning GPS, GLONASS [3; 5].

Mathematic morphology methods operating with the concept of set and fuzzy set theory [8] are used in processing and analyzing laser-location data and digital aerial photographs.

Digital (laser-location) terrain and vegetation model allows to get detailed coordinates and morphostructural characteristics of relief and tree stands by means of three-dimensional computer graphics and visualization with the use of Altexis 2,0, ArcView Spatial & 3D Analyst software, or other known software [5] (fig. 2–4).

In some works implemented earlier in Russia and in other countries [1; 2; 5–7], it had been shown that accuracy of timber stock and forest biomass estimation, as well as by aviation sensing methods, can be increased up to 5–7 % with the use of morphological classification and allometric correlations among tree sizes.

Our research conducted in Krasnoyarsk region shows that the structure of the Earth's surface and vegetation cover elements with the use of DTM, generated by laser location and digital aerial photography are more adequately and effectively determined by characteristics of trees distribution lines according to the main morphometric indices – diameter and height, vertical and horizontal crown extent, which in their turn are closely intercorrelated. Therewith volumetric and weight trees and tree stands parameters are approximated with high accuracy by allometric functions through their morphometric indices (fig. 5, 6; table) [1].



a *b*

Fig. 2. Three-dimensional visualization of forest vegetation
(*a*) and land relief in under crown space; (*b*) by laser-location data

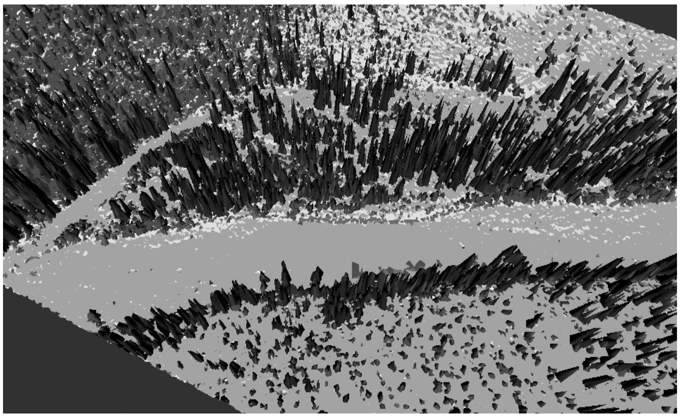


Fig. 3. Digital polygonal model of a larch stand, generated by laser-location data

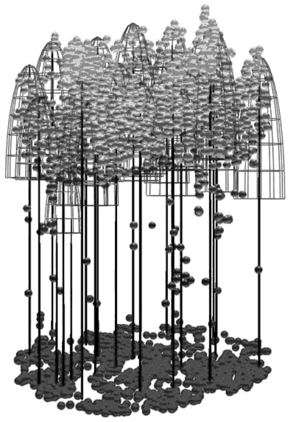
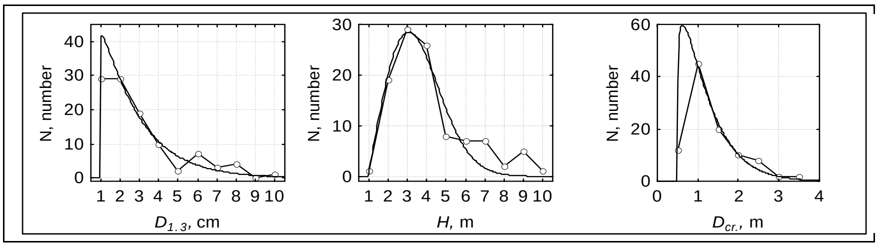
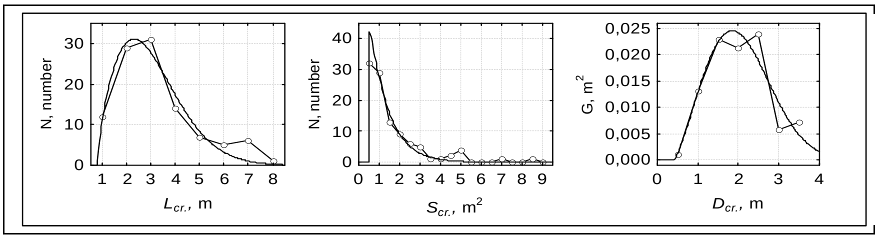


Fig. 4. Digital reconstruction of a larch stand morphological structure, implemented by laser location data



a *b* *c*



d *e* *f*

Fig. 5. Distribution of larch trees (*N*) by morphometric indices of stems and crowns, approximated by Weibull function: *a* – $D_{1.3}$ is a tree stem diameter 1,3 m above its base, cm; *b* – *H* is a tree height, m; *c* – D_{cr} is a crown diameter, m; *d* – L_{cr} is a crown length, m; *e* – S_{cr} is a crown area, m^2; *f* – *G* is a sum of tree stems cross sectional areas 1.3 m above their bases, m^2 ($G\,f\,(D_{cr})$)

Regression coefficients of morphometric indices and phytomass of larch trees

Model of approximation	$P = aD^2_{1.3}H$*			$P = aD^2_{cr}H$		
Parameters of the equation:	*a**	*S**	R^2*	*a**	*S**	R^2*
Above ground part of a tree	0.029	0.505	0.996	0.266	2.122	0.964
Stem	0.0203	0.055	0.999	0.187	1.750	0.951
Timber	0.017	0.037	0.999	0.153	1.452	0.950
Bark	0.004	0.008	0.996	0.034	0.307	0.951
Crown	0.008	0.258	0.976	0.079	0.427	0.983
Branches ∅ > 1 cm	0.003	0.068	0.940	0.024	0.217	0.959
Branches ∅ < 1 cm	0.002	0.021	0.969	0.020	0.272	0.892
Shoots of a current year	0.0001	0.000	0.873	0.0001	0.005	0.966
Needle	0.003	0.089	0.917	0.024	0.074	0.995
Dead branches	0.001	0.002	0.987	0.009	0.110	0.918

**P* is a weight of a tree fraction in absolutely dry state, kg; $D_{1.3}$ is a tree stem diameter 1.3 m above its base, cm; *H* is a tree height, m; D_{cr} is a crown diameter, m; *a* is a constant of the equation; *S* is a standard error of the equation; R^2 is an index of determination.

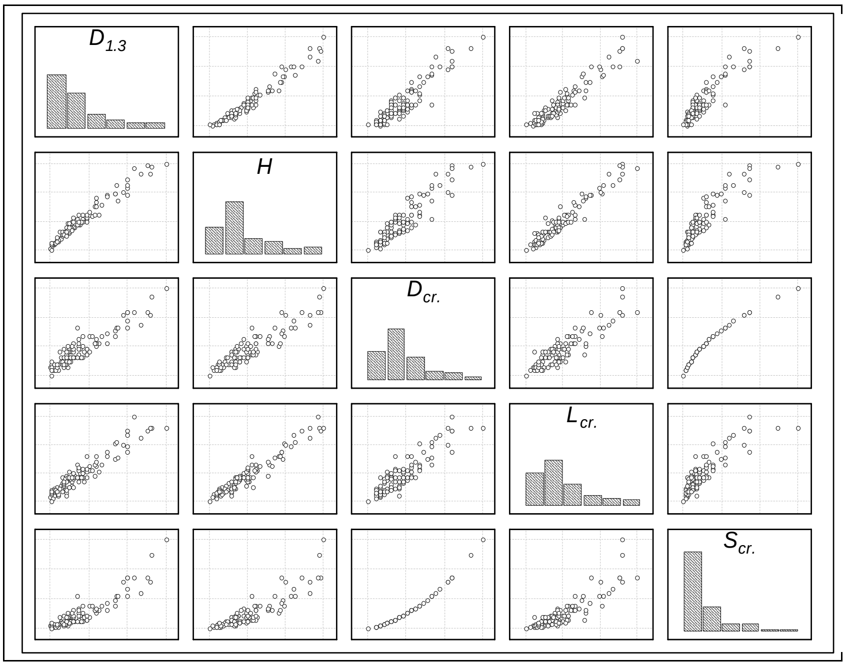


Fig. 6. An overlap matrix of distribution histograms and correlated scattering fields of the main morphometric indices of a larch tree stand (Central Evenkia)

It's generally known, that the construction of trees distribution lines by their morphometric indices traditionally supposes completing time- and labor-consuming ground biometric procedures, measuring operations and trees recalculations (continuous or selective), which require substantial financial expenditures. At the same time laser location method integrated with digital high- and ultrahigh (centimeter) resolution aerial survey allows to perform pixel instrumental-measuring forest inventory on the basis of precision satellite geodesy and detailed topographic survey, to study forest cover dynamics, horizontal and vertical structure of tree stands, to reconstruct trees distribution lines by any morphometric indicator, and to calculate required forest inventory parameters and forest biomass automatically, with high accuracy and on sufficiently large areas (up to 500–600 square km per one working day).

Assessment of timber stock and forest phytomass by laser location and digital aerial survey data in every case is reduced to identification of basic regulations of an investigated object and to determination of correlations between tree stems volumes, tree and crown heights and diameters, and phytomass, which in their turn constitute 87–99 % of explained variability of different phytomass fractions – stems, crowns skeletons and needles [1].

The results of practical approbation of an aviation laser location method combined with digital aerial survey and satellite geopositioning, integrated into geoinformation systems, give us an evidence of its high potential in use for the purposes of forest cover and disturbance analysis and simulation, inventory, on-line ecological monitoring, information support of forest lands cadastre and forest use control. This highly effective method provides remote sensing evaluation of forest resources, their state and dynamics, with minimum field works and significant saving of time and financial resources.

Cost efficiency of this method is ensured by principal increase of accuracy of the measurement results and possibility of their repetition (verification), as well as by significant reduction of labour-intensiveness and work complexity (of both field and laboratory kinds of work), at the expense of high level of automation in getting and processing laser location and digital aerial survey data. Thanks to this method the amount of field works is minimized and is necessary only for calibration of laser location results and support of aerial survey data interactive decoding.

References

1. Danilin I. M. Morphological structure, productivity and remote methods of inventory of Siberian forest stands : abstract of a thesis. … Doctor of agricultural sciences: 06.03.02. Krasnoyarsk : Institute of forest named after V. N. Sukhachev, Russian Academy of sciences, 2003.

2. High technology of XXI century for aerospace monitoring and forest inventory. Purposes of investigation and perspectives of usage / I. M. Danilin, E. M. Medvedev, N. I. Abe [et. al.] // Forest inventory and forest management. 2005. № 1 (34). P. 28–38.

3. Danilin I. M., Sveda T. Laser profiling of forest canopy // Silvics. 2001. № 6. P. 64–69.

4. Medvedev, E. M., Grigoryev A. V. Laser scanning forever // Geoprofi. 2003. № 1. P. 5–10.

5. Medvedev E. M., Danilin I. M., Melnikov S. R. Laser location of ground and forest // Tutorial, 2-nd revised and corrected edition. M. : Geocosmos.

Krasnoyarsk : Institute of forest named after V. N. Sukhachev, Russian Academy of sciences, 2007.

6. Holmgren J., Persson A. Identifying species of individual trees using airborne laser scanner // Rem. Sens. Environ. 2004. Vol. 90. № 4. P. 415–423.

7. Laser scanning of forest resources: the Nordic experience / E. Nasset [et al.] // Scand. J. For. Res. 2004. Vol. 19. № 6. P. 482–499.

8. Soille P. Morphological Image Analysis: Principles and Applications. 2nd ed. Berlin : Springer-Verlag, 2003.

M. N. Favorskaya, A. M. Popov
Siberian State Aerospace University named after academician M. F. Reshetnev, Russia, Krasnoyarsk

CONTEXT-DEPENDENT GRAMMAR DESIGN FOR DESCRIBING COMLEX SCENES WITH MULTI-LEVEL OBJECT MOTION

The problems of context-dependent grammars formation which describes structural information about patterns and pattern interaction in complex scenes are discussed in this article. The application of three-level grammar based on the task of an image sequences syntactic analysis (with extended contents of main and auxiliary dictionaries) and the task of scene syntactic analysis with multi-level object motion is suggested.

Keywords: context-dependent grammar, syntactic analysis, multi-level motion.

Initially, the structural or linguistic approach had been based upon using different linguistic structures, consisting of a dictionary and rules of sentence building from a specified dictionary. Such structural description of images permits to make an analogy between image structure and language syntax of formal grammars. Notice that this line of development appeared in the 1960's as one of the first approaches for image describing and recognition. Structural approaches not only permit the reference of supervise static objects to a definite pattern, but also describe some object properties that exclude its referring to another pattern.

Traditional methods of structural approach are based on syntax description of complex image sets with limited sets of primitives and grammatical rules. It is considered that these images are formed from elements which are connected in a variety of ways just as phrases and sentences of languages are built by connecting words, and the words are composed from letters. The simplest elements, from which words and then sentences are built, are called primitives. Designing rules of composing primitives are usually assigned with special grammars of images description. Grammar rules (rules of substitution) may be applied any number of times, which allows for a compact and sufficient definition of primary structural characteristics for a sentences infinite set. The language for image structural description in terms of primitives sets and designs such element compositions; it is called the image description language. During identification, the recognition of primitives and image description in terms of special language is realized. Essentially, pattern recognition consists of a syntax analysis (or grammar analysis) and a "sentence" which describes some image. Recognition maintains the syntax correspondence between the analyzable "sentence" or image description and special grammar [1].

The system of pattern syntax recognition includes three main modules: the pre-processing module, the description module, and the syntax analysis module. The pre-processing module realizes coding, approximation, filtration, reconstruction, and the improvement of the image. The description module includes the primitives' segmentation and allocation based on predetermined syntax operations. Each allocated part of the image is identified relatively to a special primitives set, and the whole image is characterized by a set of primitives' sequences as the structures of language types. The syntax analysis module checks the accuracy of the sets in the context of predetermined grammars. The predetermined grammar corresponds to each pattern, and if the description of analyzable image is syntactically correct in the context of such grammar, then the image is related to the pattern for which this grammar corresponds.

The development of grammar describing both structural pattern information and patterns interaction is connected to the necessity of designing grammar reconstruction (or conclusion) algorithms according to a defined set of dynamic images that present the learning sampling. Such algorithms accomplish the learning of the recognition system. In result, pattern structural descriptions and their relationship descriptions are formed; then they are used for a syntax analysis of events and the genre of a complex scene. Basically the learning process isn't executed; the choice of grammar and primitives set are realized by a tutor. Since the dynamic scene with multi-level motion has a very complicated and time-dependent structure, it's necessary to use context grammar rules, which form a multi-level context grammar.

Let's consider some main regulations which are peculiar to the structural methods of scene describing or recognition. The generative grammar is a well-ordered set of parameters **GR** = (V_T, V_N, P, S), where V_T – is a finite