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# Technological aspects of the development of the automated method of air-photo interpretation of forest stands

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**Abstract** The article focused on one of the possible methods for the development of an automated method for interpretation Earth remote sensing data. As the basic elements for solving the problem, the practical experience from forest inventory training system was taken. Authors used the AutoCAD program to perform per-stem decoding. The article describes some features of modern air-photo interpretation system used in forest inventory and the possible transition from classical forest inventory to automated analysing methods.

#### 1. Introduction.

The development of automated data processing methods of Earth Remote Sensing (ERS) is one of the promising areas for monitoring forest resources. This method involves the use of a number of techniques based on information technology, mathematical statistics and artificial intelligence. With the receipt of a large amount of information from geostationary Earth satellites and the improvement of the quality of Earth remote sensing materials, it is necessary to constantly develop new image analysis algorithms and improve existing ones [1]. Nowadays, automated image processing methods have proven successful in agriculture. Used of the NDVI (Normalized difference vegetation index) indices based on spectral brightness coefficients reliably allows the calculation of many parameters and indicators. However, it is necessary to notice that these indices do not allow full use of them in forestry, since the main indicators of agricultural crops, on the basis of which the calculation is made, are of the same type, due to the biological and morphological characteristics of monocultures themselves. These indicators include: periods of crop ripening; the severity of certain signs in the images at each stage of ripening; clear boundaries between different types of crops and relatively short periods of growth. In forestry, on the contrary, there are the following difficulties in processing and using normalized indices: the complex; multi-tiered structure of the stand; the long period of time of growth of forest stands; the similarity of morphological features of some tree species; the lack of clear natural and geographical boundaries between forests. Moreover, the use of NDVI indices does not solve important economic problems of assessing the quantitative and qualitative characteristics of the forest component; rather, this indicator can be considered as informational and composite indicator.

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Is it possible to use automated methods for processing images obtained by remote methods to solve the above-described problems of analysis of remote sensing materials? Using software methods for processing satellite images, machine learning technologies, and geographic information technologies, with the correct combination of these methods, it is possible to solve the indicated problems with obtaining a sufficiently accurate result acceptable for the forest sector.

By automated recognition systems is meant a software-algorithmic complex that acts as a decoder with outputting the result in a form that is accessible to perception by a decision maker. As a modern scientific approach to deciphering forest stands, we consider an information model and an author's method of processing materials.

#### 2. Methods and Materials

Some researches [2, 3] indicated the possibility of using software processing of remote sensing materials to separate the composition of forests into deciduous and coniferous without separation into separate species, due to the distinctive features of the spectral coefficients of foliage and needles. The next task is to divide the stands according to their composition into separate breeds in the image. For this, it is necessary to indicate which planting features will be considered as being analyzed, as well as indicate which main indicators of forests are practically important for their determination.

The analyzed areas are remote materials obtained using an unmanned aerial vehicle and open data from web-mapping services. AutoCAD was used as a material processing tool. The method of work consists of the following steps.

1. The definition of economically significant main forest species to be decrypted in the image.

2. Contour (manual), tree-based decoding of stands.

3. Development of a database of stands features.

4. Establishing links between the created layer of individual rocks with a sign and the stands of the created base.

The definition for decoding a forest-forming species is one of the necessary conditions for the decryption process, since the actual number of recognition objects containing the rules assigned to a particular class will depend on the number of recognition breeds. This stage can be described as a machine learning process, since in this case the decoder is a teacher of system learning, and the system is filled with formal signs, based on which the trees will be distinguished, by composition (table 1). These features of the color range are typical for middle-aged forests of the Leningrad Region.

Species	Stand characteristics (The shape of the crown)	Indicators in the image (Color, shadow) in the RGB system
Norway spruce ( <i>Picea abies</i> L.)	Stellate, cone-shaped	Green in the RGB range (0, 255, 0 - 173, 255, 47)
Scots pine (Pinus sylvestris L.)	Young, middle-aged- pyramidal, mature- umbrella-shaped	Crescent-shaped own shadow, flat top of old trees Dark green (51, 102, 0 - 34, 139, 34)
Birch (Betula pubescens Ehrh.)	Round or oval ("dense" in contrast to aspen in the pictures)	Yellow (255, 255, 0 - 255, 250, 205)
Aspen (Populus tremula L.)	Egg-shaped or wide- cylindrical	Mostly orange (255, 128, 0 –255, 165, 0)

Table 1. Characteristics of signs of plantings of remote sensing materials.

To reduce the variability of recognition objects, we indicate four main forest-forming species of the Leningrad Region according to the regional Forest Plan. According to the Forest Plan, the distribution by species composition of forests as a percentage is as follows:

- 1. Pinus sylvestris L. 32%
- 2. Betula sp. 32%
- 3. Picea abies L. 27%
- 4. Populus tremula L. 8%
- 5. Other breeds 1%

According to the data [4, 5] in the European part of the taiga zone, the main forest-forming tree species are: from conifers – Scots Pine (*Pinus silvestris*) and Norway spruce (*Picea abies*), from deciduous – aspen (*Populus tremula*), birch (*Betula pendula*), gray alder (*Alnus incana*) and black alder (*Alnus glutinosa*). Each of the described breeds requires a separate database of planting features and a separate logical database of breed features. It is also necessary to take into account that the forest-forming species forms the upper canopy of the forest — the main canopy layer of the stand. The associative bases of planting features in simple, even-aged stands will differ in the content of variability of the features of this stand in the image. If the image has a multi-aged, mixed stand, then the number of formed features will be greater, due to the fact that different canopy layers are formed due to the different age structure of the forest. As the experimental part of the data analysis, we chose the territory of Yelagin Island (Saint-Petersburg, Russia) for which there are materials of both open mapping services (figure 1) and the survey obtained using unmanned aerial vehicles.



Figure 1. The investigated part of the stands of Elagin Island.

#### 2.1. Multilevel data processing

Data analysing based on the principle of system training. The principle of system training is partially based on predicate logic (first level) describing the relations of the presented formal classes, i.e. what is the concept of a tree to determine it in a satellite image. "Birch - a tree", "Spruce - a tree." The second level of definition, the semantic connectivity of each particular class and the definition of taxation parameters based on the data obtained: the shape and color of the crown, the density of the stand, the pixel characteristics of an individual element. [1] Semantic connectivity is achieved by creating a structure hierarchically ordered «stand class» of the object. That «stand class» revealing all

the attributes of planting, an identifier should be assigned to this class. An expert system for analyzing the characteristics of an individual tree was similarly demonstrated at some scientific papers [6].

An identifier in AutoCAD links an associative layer with attributes that contain the particular object. (figure 2) Each associative layer, according to the manual decryption technique, will belong to a certain class of tree species. Thus, tree-based decryption in manual mode is an important practical task, thanks to this procedure, an overclass of associative attributes belonging to a particular breed is formed. An example of the result of tree decryption using image presented on figure 2. The second level of associative attribute binding with a tree of a specific species - is the morphological characteristics of the stand on the analysed image. High-spatial images obtained from unmanned aerial vehicles have such image quality that clearly distinguishable features between different tree species are well established. [7] It should be noted that among a wide variety of web-cartographic materials, the quality of open images improves every year. For example, the Bing mapping service, the materials of which, locally, are of no worse quality than the materials received from unmanned aerial vehicles.



Figure 2. The process of subtree decryption in AutoCAD.

## 3. Results and Discussion

As the circuit level of data representation, we present the main components of the system in the diagram (figure 3). The practical task of recognition is reduced to the three most important technological aspects, on which the accuracy of the results of this method will depend.

## 3.1. The first indicator

The formation of a database of planting traits is necessary for each breed; for the Leningrad Region, the formation of 4 databases of economically significant breeds is sufficient.

## *3.2. The second indicator*

The training and qualification of the decoder, whose tasks will include the creation of an associative layer in the image associated with the decryptable species. That will determine the correctness of the correspondence of planting signs with the tree species. In order to minimize the systematic error in recognition, a large statistical sample of the standards, uniquely those decrypted rocks, which will be confirmed by a field survey and coincide 100%, is needed.

## 3.3. The third indicator

The recognition procedure should have control points for the preservation of the learning process algorithm, this is necessary so that it would be possible to apply the final procedure template, for another locality, with other types of tree species. In this case, in this technique, the operator needs to change the recognition species and color variables in the RGB system, the material processing procedure will be performed in a similar way.

To represent the main constituent components in the formalization of the tree species recognition problem, in our study we compiled a conceptual model that takes into account some characteristics and recognition features, which contains the following elements, shown in figure 3. It is necessary to take into account the possibility of expanding the model and increasing the number separately of the processes under consideration that determine the completeness of the system, in the scientific papers [8-10], geodata models, risks and landscape morphology are taken into account when using research forest properties.



Figure 3. Formalization of features of the model.

## 4. Summary

Finally, the following conclusions should be made. Decryption automation and its methods are poorly developed for practical implementation in the industry. However, the potential of this industry can make a significant contribution to distance methods for studying vegetation. As a full-scale high-precision tool for the analysis of large areas covered with forest, a high-quality software environment is required in combination with powerful computing hardware components. This concept can be described as a multifunctional software package for processing Earth remote sensing materials. The machine learning process can be improved using not only comparative analysis based on predicate logic, but also apply multichannel data processing technology based on deep learning of neural network data analysis.

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