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# SPECTRAL AND BRIGHTNESS CHARACTERISTICS OF THE MAIN FOREST-FORMING SPECIES ON IMAGES OF THE SCANNER LEICA ADS100

Until 2014 the aerial photography was carried out using analogue Leica RC30 camera. In 2014 was purchased a digital scanner Leica ADS100, which provides images of very high spatial resolution in four bands: blue, green, red and near-infrared. In connection with the transition to the new equipment it is necessary to study the variability of spectral luminance characteristics of the main tree species and on the resulting images.

The variability of change of spectral luminance characteristics of a shaded and illuminated parts of crowns of major tree species in images of very high resolution are investigated. Regularities of the change of the average value of the spectral brightness of the tree species depending on age class are described. The analysis of separability of the classes crowns is given, the classification of images of controlled and uncontrolled methods and subsequent evaluation of their accuracy was performed.

**Key words:** aerial photography, spectral brightness characteristics, regions of interest, spectral brightness, interpretation, classification.

**Introduction.** Aerial and satellite images are widely used in forest management planning and for the preparation of cartographic materials, inventory and assessment of the state of forests and current changes in the forest fund. The works of different authors show that the materials of remote sensing of forests can be used for fire risk assessment [1], and the study of patterns of relationships between interpretive signs and inventory indices will determine the basic characteristics of the taxation of the stand, and even evaluate product and assortment structure [2].

The first experience in using images obtained by the scanner on the aerial Leica ADS100 showed that the spectral signatures of trees in different images, and within one of them are different. It complicates the process and leads to significant errors when using automated image interpretation techniques. The study of patterns of variability of the spectral brightness and performance of major tree species in the ADS100 images will develop methods to improve the properties of decoding properties of the images, image alignment, which in turn will improve the quality of decoding.

The aim of this work is to study the spectral and brightness characteristics of crowns of trees of different age classes, as well as the evaluation of the accuracy of different methods of image classification.

**Main part.** Spectral reflectance properties of the objects are the basis for their decryption. Coefficients of the spectral brightness on which curves of the spectral brightness are based are obtained on the basis of the absolute or relative dimensions.

The spectral reflectance of the green vegetation with increasing wavelength varies greatly, but all species have the general shape of the curve.

The chlorophyll absorption bands, which correspond to the red and blue range of the visible area, the low reflectivity is observed. The maximum reflectivity is within the range with a wavelength of about 0.54 μm.

The effect of pigments on the reflectivity of the vegetation cover affects only the visible spectral range – 0.5–0.7 μm. Significant differences in spectral brightness indicators depending on the number and type of pigments are observed there. In the near and medium infrared the influence of pigments is insignificant.

In the transition from the visible to the infrared portion of the spectrum in the range of 0.76 μm the vegetation reflectance increases substantially.

In the mid-infrared reflecting a significant reduction in the areas of water absorption occurs. The degree of absorption of radiation by the vegetation in mid-infrared range depends on the amount of moisture contained in the leaf plate and its thickness. With the reduction of the moisture content of the leaves their reflectivity is markedly increased in the mid-infrared wavelength range.

The spectral brightness curves of objects allow you to set the laws and fulfill their classification, to determine the optimal spectral ranges and timing of the survey, to obtain images with high interpretive properties [3].

The objects of the study were the territory of Ivanovo forestry SFE “Cherven Forestry” and Ratomskoye forestry of Borovljany special forestry. The digital images the scanner Leica ADS100 2014 were used for the analysis. The statistical indicators were determined for the four channels – blue, green, red and near infrared. For a better perception of the differences between the canopy the equalization of snapshot was performed as well the combination of channels 4-2-3 (NIR – green – blue) was made.

The work consisted of the following steps.

1. Analysis of a plot database, selection of research subjects.

2. Isolation the shaded and illuminated parts of tree crowns by species and age classeson images.

3. Investigation of the spectral and brightness characteristics of the main forest-forming species.

4. Evaluation of the separability of classes.

5. The classification of images.

6. Post-classification processing.

7. Evaluation of the classification results.

The allotments of pine (II–IV age classes), spruce (II–IV), birch (III–VI), aspen (III–VI) and alder (III–VI) with an admixture of other species not more than 2–3 units within the composition were selected on the images of Cherven forestry.

By means of a geographic information system Quantum GIS in the pictures within the selected vector layers of strata with a shaded and illuminated part of the crown of each breed and for each age class have been created. With ENVI software the following statistics for the selected areas have been identified: the minimum and maximum values, mean and standard deviation of brightness.

The average values of the distribution analysis showed that the differences are clearly visible in bright and dark parts of crowns within the same species. Changing the spectral brightness age classes is observed in the green and near-infrared channels from all the analyzed crowns of trees except pines, the variation values of which are weak.

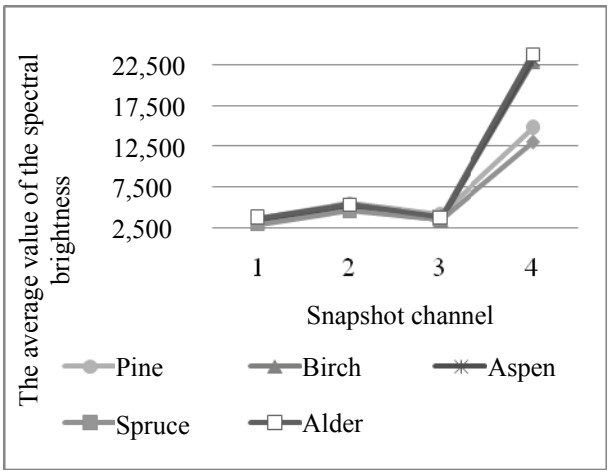
Further investigation showed that the values of the spectral brightness of a shaded and bleached (Figure) parts of crowns from softwood trees are very close, which may cause difficulty in deciphering. Spruce and pine are well separable with each other in the 4th (near infrared) snapshot channel, in the visible range (1-, 2-, 3rd channels) crowns of coniferous and broadleaved species have similar meanings.

To evaluate the separability of classes the calculation of special coefficients of separability: transformed divergence and Jeffries – Matusit was performed.

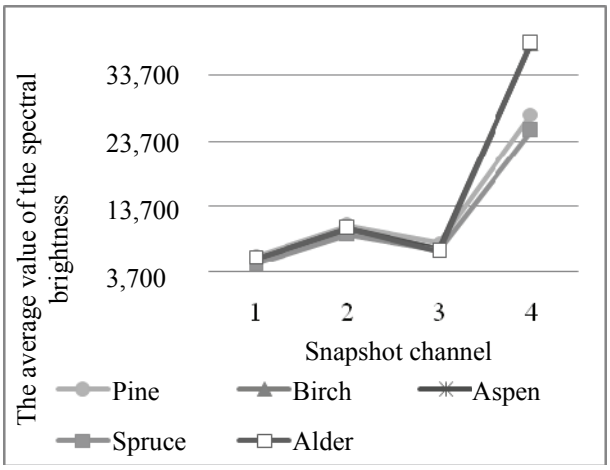
The smallest separabilityof the shaded areas of crowns are characteristic of aspen and birch (ratios of 0.3/0.3), spruce and pine (0.6/0.62), and black alder and aspen (0.69/0.72).

Low values of factors point to a possible entanglement classes at the stage of snapshot classification.

A similar pattern can also be seen to illuminate the areas of crones, but the separability values take higher values: birch, aspen – 0.86/0.93, spruce, pine – 0.89/0.91, black alder, aspen – 0.91/0.92, indicating that the tops of the trees will be classified with greater precision. In general, the crowns are characterized by a strong entanglement in classes of coniferous and broadleaved species.




*a*




*b*

The spectral brightness curves of the shaded (*a*) and illuminated (*b*) parts of crones

For the classification the regions of interest and control sites for the following species: pine, spruce, birch, aspen, black alder, oak, maple, linden were identified in the images of Borovljany special forestry.

The following classes: black alder, aspen (coefficients ofseparability are 0.45/0.53), birch, pine (0.56/0.61), oak, black alder (0.36/0.42) have the lowest separability.

Classification without learning using the ISODATA method has been implemented in several stages:

1) implementation of the algorithm;

2) manual grouping of classes;

3) analysis of the majority/minority (Majority/Minority Analysis);

4) automated grouping of classes (Clump Classes);

5) evaluation of the accuracy of the classification.

As a result, the following the matic classes could be distinguished: pine, spruce, and soft- and broad-leaved deciduous species. The classification accuracy was 55.8, 77.3, 14.3 and 82.5%, respectively.

Supervised classification was made with the help of minimum distance methods, maximum likelihood, Mahalanobis distance, spectral angle (Table 1). At the stage of thet post-classification the majority/minority analysis with a grain size of 7 × 7 pixels and grouping class size 3 rows by 3 columns was carried out.

Table 1

**The results of classification accuracy by various methods**

| Classification method | Total accuracy of classification, % | |
|---|---|---|
| | By species | By groups of species |
| Minimal distance | 45 | 70 |
| Maximum likelihood | 73 | 94 |
| Mahalanobis distance | 76 | 90 |
| Spectral angle | 54 | 84 |

The greatest accuracy in classifying separation of species was shown by Mahalanobis distance method – accuracy was 76% (Table 1). With the separation into groups of species the best result was shown by the maximum likelihood method, the overall classification accuracy – 94% (Table 2).

**Conclusion.** The study of the spectral characteristics of brightness in the images of the scanner Leica ADS100 showed that the brightness curves for all species have a similar shape, the values of the spectral brightness of the shaded part of the crown is smaller than the illuminated one. Conifers are characterized by a lower reflectivity than hard woods.

Table 2

**The accuracy of the classification by the method of maximum likelihood**

| Group of species | Coniferous | Broad-leaved deciduous | Soft-leaved deciduous |
|---|---|---|---|
| Coniferous | 94.8 | 0.1 | 1.5 |
| Broad-leaved deciduous | 0.3 | 91.1 | 2.5 |
| Soft-leaved deciduous | 4.9 | 8.0 | 96.0 |
| ***Total*** | **100** | **100** | **100** |

The crones of softwood trees are close together on brightness values in both the visible and in the mid-infrared channel, while the separability of crowns of coniferous trees is more pronounced. By the age class the greatest differences are observed in the near-infrared range, however any pattern could be detected, which may be caused by snapshot features.

The highest classification accuracy was achieved on species by the method of Mahalanobis distance (76%). After the grouping of species by classesusing the maximum likelihood method it was possible to classify a snapshot with an accuracy of within 94%, which confirms the high potential of the digital images ADS100 scanner as the materials for the automated interpretation.

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