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Using Hyperspectral Images and Lidar Data to Create Models for the Classification and CAVE Visualization of Tree Species

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Abstract: - The article describes the use of artificial intelligence methods to create models for detecting and classifying tree species, using hyperspectral images and LiDAR data in the aerial photography of energy line structures. The most important output is a validated model with cloud infrastructure support for detecting and classifying objects of interest at the TRL 5 level, which is also exceptional on a global scale. The outputs of the research are also a geodatabase of reference tree characteristics, a library of spectral curves, a database of simulation of tree growth, but also a cloud infrastructure to support the development of classification models and data storage. An important output will be the visualization of the results of simulations in the "CAVE" environment.

Keywords: Tree species, Forest generator, Hyperspectral images, Cloud infrastructure.

I. Introduction

A. The use of hyperspectral data in combination with laser scanning

Based on the results obtained, it is possible to confirm the feasibility of the usability of hyperspectral data in combination with a laser aerial scan. With new approaches and methods of processing ALS, we can expect an increase in accuracy in deriving crown projections Under these assumptions, we can expect an overall improvement in accuracy in the allocation of attributes from the raster layer (output of classification) vector (crown projections of individual trees).

Our current research is focused on using hyperspectral data combined with laser scanning in the air in forestry to classify different tree species [1]. In the introduction, we deal with the technical description of the experimental material and the methodology of processing and evaluating the available data as hyperspectral images and data obtained by LiDAR technology within the framework of aerial photography of energy line structures. This is mainly an assessment of the suitability of hyperspectral materials obtained. The choice of a hyperspectral camera and its design is important [2].

When using the VNIR 1800 camera, the following outputs are required. See figure 1.

MAIN SPECIFICATIONS	
Spectral range	400 – 1000 nm
Spatial pixels	1800
Spectral channels	186
Spectral sampling	3.26 nm
FOV*	17°
Pixel FOV across/along*	0.16/0.32 mrad
Bit resolution	16 bit
Noise floor	2.4 e-
Dynamic range	20000
Peak SNR (at full resolution)	> 255
Max speed (at full resolution)	260 fps
Power consumption	30 W
Dimensions (l–w–h)	39 – 9.9 – 15 cm
Weight	5.0 kg
Camera Interface	CameraLink

Fig 1. Demonstration of the provided outputs when using the VNIR_1800 camera.

For the needs of our research, it is possible to obtain data from the so-called "ground campaign" where it is mainly to choose the appropriate ground campaign technology. For our goal, the application of the ground campaign is suitable, namely the spatial identification of crown projections of trees and subsequently the Spectral classification of the image. See figures 2. and 3.

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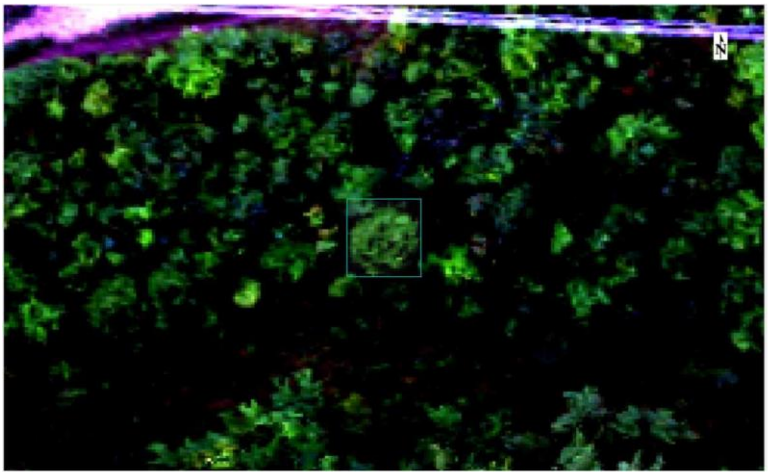

Fig. 2. Spectral image classification – examples, pixel-oriented classification VS object-oriented classified

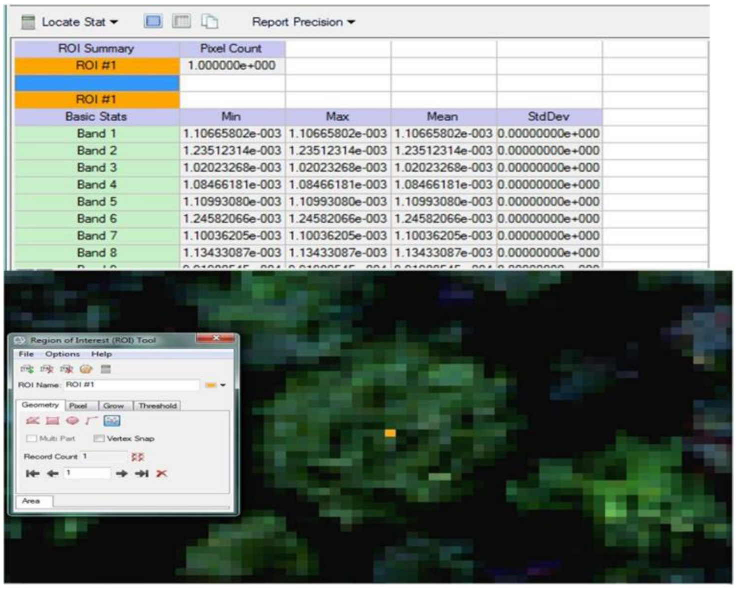

Fig. 3. Pixel-oriented classification.

The outputs from forest growth models are often very complex, and the information arranged in the tables is eloquent only for the limited community [3]. The relationships between the variables of a given model are best understood by the wider community through visualization and virtual reality. Through successive research, visualization outputs from growth simulators have proven to be suitable inputs for visualization and virtual reality. Visualization through virtual reality is the most illustrative and understandable. The development and creation of raster simulators were carried out by many researchers from the field of forestry. Such is, for example, the simulator Dentro Cloud, see figure 4.

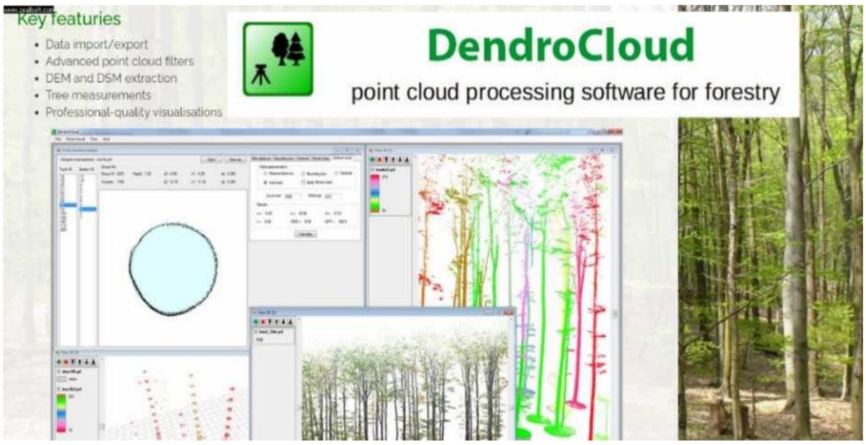

Fig. 4. Dentro cloud forest simulator.

II. Ground Campaign

The second appropriate technology is the ground campaign as data collection technology to measure tree characteristics. A Nikon camera, Forestry Pro II was used to measure tree characteristics.

A. Application of ground campaign data

For spatial identification of crown projections of tree crowns, see figure 5. and for data see figure 6.

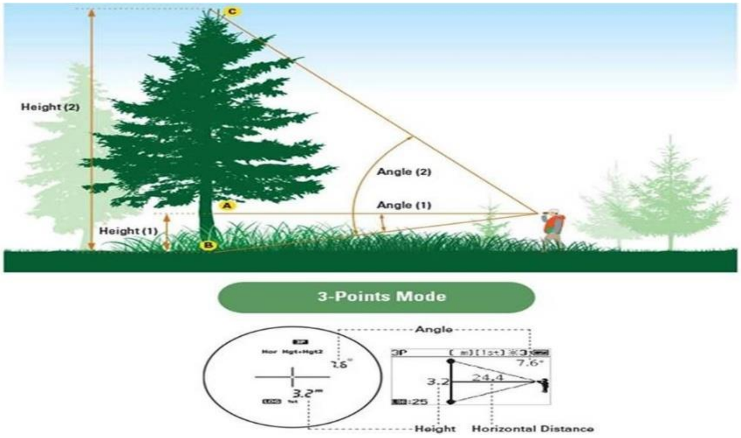

Fig. 5. Spatial identification of crown projections of tree crowns

IDPlot	ID	X_m	Y_m	Specie	Qualit	DBH_m	Crown Base_d
2	1	0,235	-2,547	SM	2	355	109
2	2	-0,058	-15,859	SM	2	99	12
2	3	1,235	-19,16	SM	3	144	60
2	4	1,438	-19,74	BK	2	105	49
2	5	2,113	-24,224	BK	2	125	13
2	6	2,302	-24,415	BK	2	111	44
2	7	3,759	-34,72	BO	1	265	104
2	8	3,374	-35,81	BK	1	108	5
2	9	-0,164	-34,909	BO	1	346	83
2	10	0,227	-32,712	BK	1	130	22
2	11	0,664	-33,073	BK	1	159	22
2	12	2,205	-32,715	BK	1	179	17
2	13	1,529	-31,783	BO	1	326	85
2	14	1,245	-31,012	SM	2	121	18
2	15	-0,928	-30,337	SM	2	69	15
2	16	-4,58	-31,49	BK	1	78	16
2	17	-5,535	-33,122	BK	2	137	17
2	18	-5,902	-33,782	BK	1	133	14
2	19	-4,827	-34,675	BO	1	370	92
2	20	-10,549	-31,379	MU	2	83	22

Fig. 6. Output data of spatial identification of projections of tree crowns.

B. Classification of Individual Types of Woody Plants by Different Machine Learning Methods.

The classification of individual types of woody plants can be realized by different methods of machine learning [4]. Consistently based on the basic mathematical models of machine learning [5], the classification task is one of the simplest derivable models

- the Support Vector Machine. Other models such as Decision Trees, Random Forest, rule-based, or many others usually provide a higher degree of accuracy of classification. In order to further increase accuracy, it is possible to group several models into one using ensemble learning methods, with individual sub-models suitably complementing and eliminating weaknesses with each other. Merged models usually use Voting or Weighting techniques. In the case of large-scale data, special methods, algorithms, and classification approaches are available that do not simultaneously require the availability of all data in memory, as well as significantly reduce the time required for training.

The deployment of deep learning methods significantly reduces the need for preprocessing inputs, as the first layers of deep neural networks carry out preprocessing directly in the neural network. Determining the appropriate method of preprocessing images is thus part of the training process.

III. Sybila Forest Generator

For our research purposes, the Sybila forest generator designed at the Faculty of Forestry Zvolen [6] has proven itself well. In the past, the Sybila generator was used for projects dealing with natural disasters such as fires and flooding in Slovakia. See figure 7, figure 8., and figure 9.

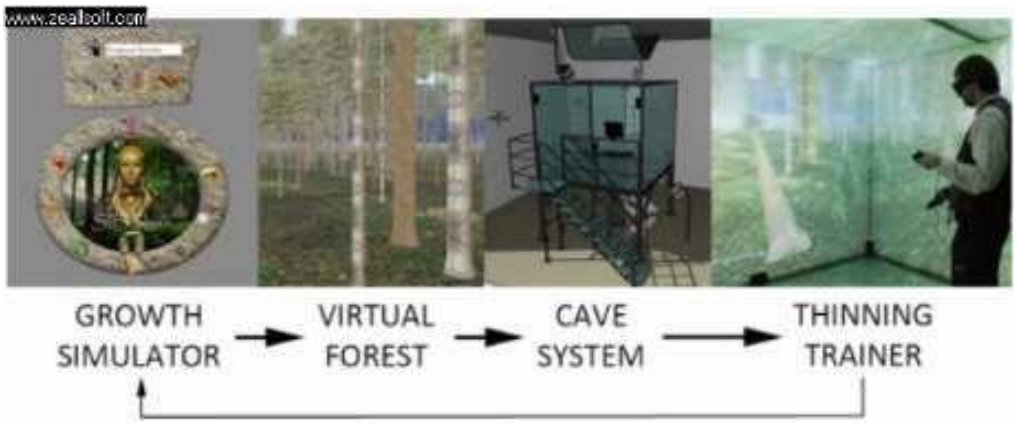

Fig. 7. Growth simulator and CAVE system.

Fig. 8. Forest from Sybila generator

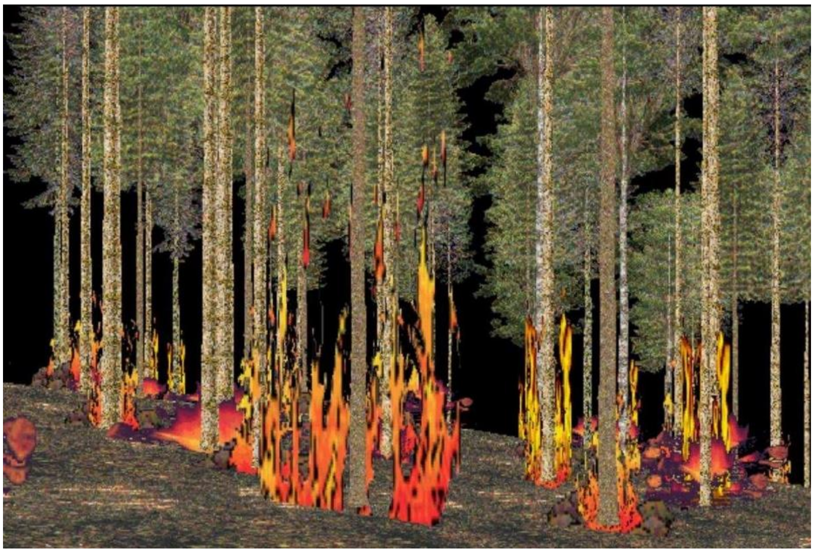

Fig. 9. Forest fire developed at Sybila grown simulator.

Virtual reality is also present in the SIBYLA growth simulator, which it not only allows the display of a virtual forest stand but also offers the opportunity to make any necessary scene in such a virtual environment. The virtual forest produced by the SIBYLA growth simulator can be displayed in a sophisticated visualized tool – the CAVE system built at the TU in Zvolen [7]. For the virtual reality of fires and floods, we have created a 3D visualization tool that can store simulation outputs in grid and cloud environments in a file that is also the input for our 3D tool. The 3D tool prepares data viewable in the Cave system in VRML – Virtual reality modeling language format.

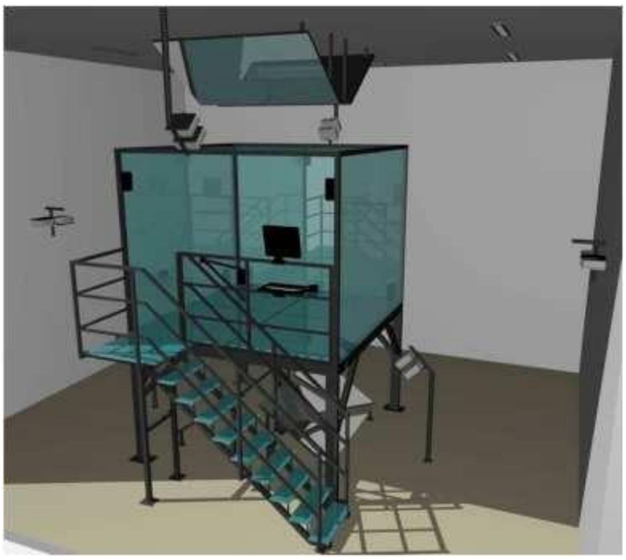

Fig. 10. CAVE system for visualization in Forest faculty in Zvolen.

New, modern software solutions, formed based on research needs and requirements, have created the requirement to connect the CAVE system with the SIBYLA growth simulator, a unique tool worldwide. This tool makes a significant contribution to science, education, and public relations through the popularization of forestry science. [8].

The interconnection of hardware, virtual reality, and the SIBYLA growth model is created using a software solution in the Cloud and Grid environments [6]. The fully automatic system provides users with the opportunity to interact and experiment with the virtual forest and, at the final stage, to visualize the scientific results. For this purpose, we also chose Sybila and the Cave system [9]. See figure 10..

The thesis is focused on using hyperspectral data in combination with airborne laser scanning in forestry concerned with the classification of various tree species. The first part of the thesis is dedicated to a brief theory related to the issue, which is characterized by the hyperspectral data, the spectral behavior of the vegetation, the spectral classification of the picture, the classification algorithm, and airborne laser scanning. The second part is dealing with a technical description of experimental material and the methodology of processing and evaluation of available data of airborne laser scanning and hyperspectral data provided by the AISA Eagle system. The result of the thesis is a percentual evaluation of classification accuracy for various tree species with the use of the classification algorithm of Gaussian maximum likelihood and spectral angle mapper with applications with various spectral ranges. The end of the thesis summarizes the results, describing the observations and acquired problems while solving the issue, as well as a proposition for the melioration of classification accuracy and enhancement of automatization level. See figure 11 and figure 12.

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Fig. 11. Spatial identification of crown projections of tree crowns

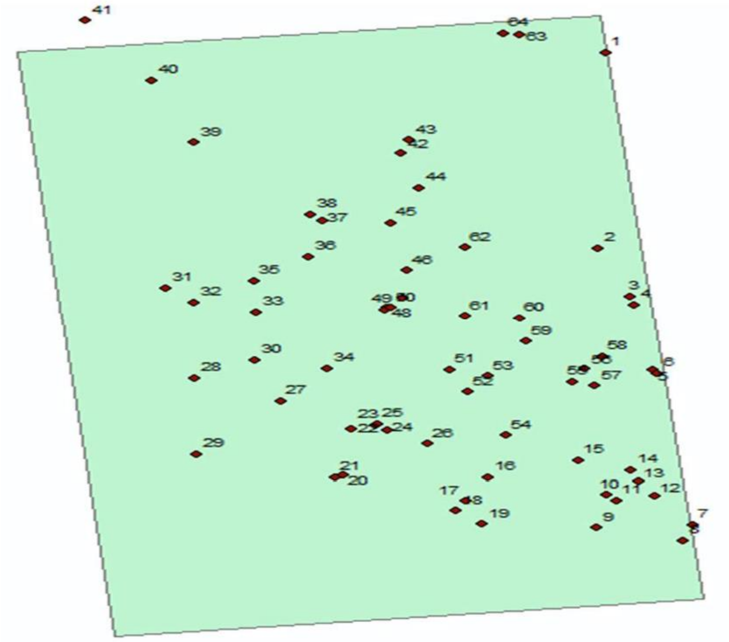

Fig. 12. Output data of spatial identification of projections of tree crowns.

IV. Conclusion

Research on the application of artificial intelligence means in the analysis and classification of hyperspectral imaging data within the framework of effective cooperation combines the activities of independent research and development provided by the Technical University in Zvolen and the Institute of Informatics of the Slovak Academy of Sciences, with industrial research provided by VUJE, as. Within the framework of the project, engineering, research, and development work will be carried out, including the implementation of repeated aerial photography of selected sections of electrical leadership, using the cutting-edge technology of individual partners. The excellence of the research is supported not only by a top team, which includes 4 guarantors from different fields but also by focusing the project on current research trends, which it combines for the needs of applications in the field of energy of the Slovak Republic. The project aims to use artificial intelligence methods to create the model. Work is in progress. We are also using the forest generator Sibyla and the system CAVE in Zvolen University for Virtual reality [10]. Work is in progress. The results of this research will have an impact on the method of conducting aerial scanning of line structures, and their application will bring a higher quality of implementation of this service in practice. The high quality of the outputs will also be reflected in the dissemination of results, as well as in the publishing activity. The implementation of the project will also contribute to an increase in the number of registered intellectual property rights due to the implementation of research activities in the Slovak Republic. Work is in progress.

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