IDENTIFYING STRUCTURAL CHARACTERISTICS OF TREE SPECIES FROM LIDAR DATA

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Abstract

In Bohemian Switzerland National Park, located in the north-western part of the Czech Republic, lidar data is acquired for DTM estimation. Major part of the park is covered with trees, mostly Fagus sylvatica L., Pinus strobus L., Pinus sylvestris L. and Picea abies L. Detection of specific species can be estimated by using high-resolution satellite images but the research team had an idea that spatial distribution of points in tree crowns is close correlated to tree species. Output laser scanning points form an accurate picture of the tree canopy; their height distribution relates to its vertical structure. This paper describes basic statistical parameters that can be derived from lidar data based on the analysis of the first and last pulses. We can determine characteristics of individual tree species from these parameters.

Key words:

Lidar, Laser scanning, Crown characteristics, Forestry, Tree recognition

1 Introduction

Thanks to SISTEMaPARC project (Interreg IIIB CADSES), data for Czech-Saxon Switzerland border region was acquired. Laser scanning data covering German and Czech National parks as well as neighboring protected areas is also included. Figure 1 shows a general map of the area of interest.

Figure 1: Area of interest in SISTEMaPARC project

2 Methodology

Within the scope of the INTERREG project, procedures for survey of the surface of the whole area were specified. Aerial laser scanning was one of the chosen technologies. This “SlePo” project measurement was supplemented with terrestrial laser scanning of selected localities examining forest cover in details.

2.1 Aerial laser scanning

Contemporarily, laser scanning systems undertake the most rapid growth. The measuring instrument is a laser rangefinder with passive reflection, whose beam of rays is transmitted in very short impulses with very frequent repetition. This beam of rays gets sent via optical-mechanical device over the whole profile in explicit step. Point cloud with constant or uncertain angular distance is generated. Principle of laser scanner for aerial (referred to as lidar) and ground application is analogous, it mainly differs only in accessories for determination of actual position and orientation of scanner in the space. On the board of airplanes, GPS and IMU /INS devices are installed for this purpose. GPS measurement is carried out using differential method, when at least one station is placed at base point. This way absolute position (while using more devices and orientation) of airborne platform is obtained with measurement frequency of 1 – 2 Hz. IMU/INS unit determines relative vectors of position and orientation of platform in space with measurement frequency of 10 – 1000 Hz. Some laser scanners are able to measure detailed points with frequency up to 80 kHz. After flight, measured data are corrected using calibration data and rectification. Resulting georeferenced point cloud is further processed using filtration techniques.

Figure 2: TopoSys Laser scanner

Laser scanners are designed either like profiled or matrix. In aerial systems in general, profiled constructions are used, in which all directions of transmitted impulses of beam of rays positioned with optical-mechanical device of scanner form a surface (level or cone). Hence, movements with the scanner are necessary for surveying the whole object. All kinds of types of scanners can be equipped with other accessories such as a digital camera or RGB scanner to obtain full colored information. The value of reflectance, and at multiple reflections even more measured reflections for each impulse, is information that can be added to the measured detailed points.

Specified area was scanned by TopoSys scanner, which employs a system of optical fibers to direct the beam of laser rays. On board laser scanner was used with a multispectral camera acquiring image of scanned area with final resolution of 1 M.

Area showed in figure 1 was completely measured with laser scanner and colleagues from TU in Dresden effected data filtration, thus creating detailed digital terrain model. In order to get correct georeferencing of point cloud data, several control points were measured on both German and Czech side. Points were selected in set of localities – characteristic features (road, building, forest, etc ...) were chosen. In December 2004 on the whole 40 points with horizontal RMS 50 mm and 40 mm height RMS were measured with geodetic methods to verify the accuracy [1]. To verify the accuracy of filtration 10 localities, each covering an area of several tens square meters, were measured in details using tacheometry. Average RMS error of final terrain model is ± 0, 16 m, but in rocky regions height RMS error is up to 4 m [2].

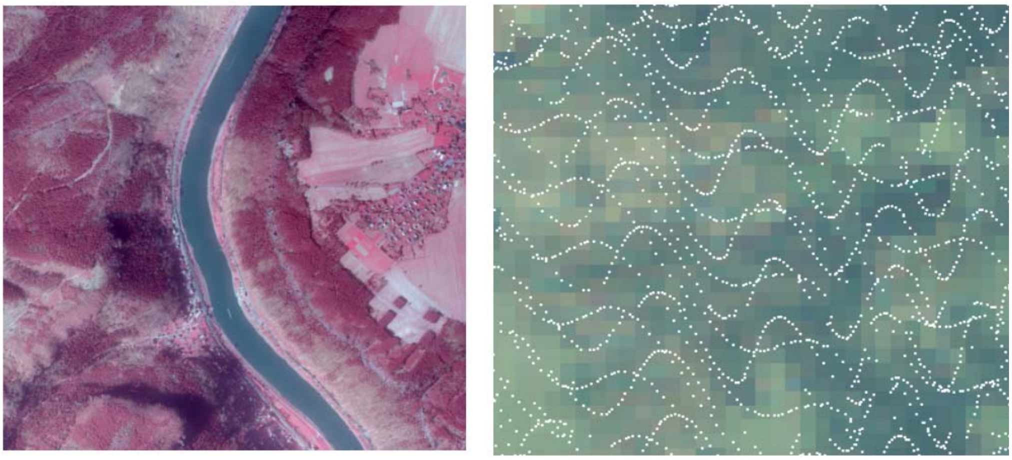

Figure 3: Illustration of multispectrál image and detail of point cloud

2.2 Terrestrial laser scanning

In order to acquire reference data and to carry out check measurement to obtain spatial forest characteristics, the HDS 3000 system was chosen. This system, made by Leica Company, is considerably different from aerial scanner systems. Nevertheless, its very narrow beam of rays of 6 mm footprint size allows the accurate scanning. It uses green laser light for scanning. Its scan range is up to 300 m, which is sufficient for an application. Scanning at a distance greater than 100 m is not expected. The system suits our purposes as it allows verification of data acquired from aerial scanning.

. During April 2007 two locations were scanned using this terrestrial scanner. First the monumental tree (mountain oak) in Krásná Lípa was scanned with its close surroundings, where noticeable similarity was expected between the derived digital model of terrain and the filtration effected on data from aerial scanning, as this surroundings was not coated with any higher vegetation. In vicinity, there is an expressive terrain cutting made by a stream. Next a part of beech forest, located in slope of Rose hill where maple is partly disseminated, was selected. Here, a slope area in proximity of small rocky formations is concerned and the objective is to verify the accuracy inside a deciduous forest. Within the scope of project, further localities will be tested and successively scanned.

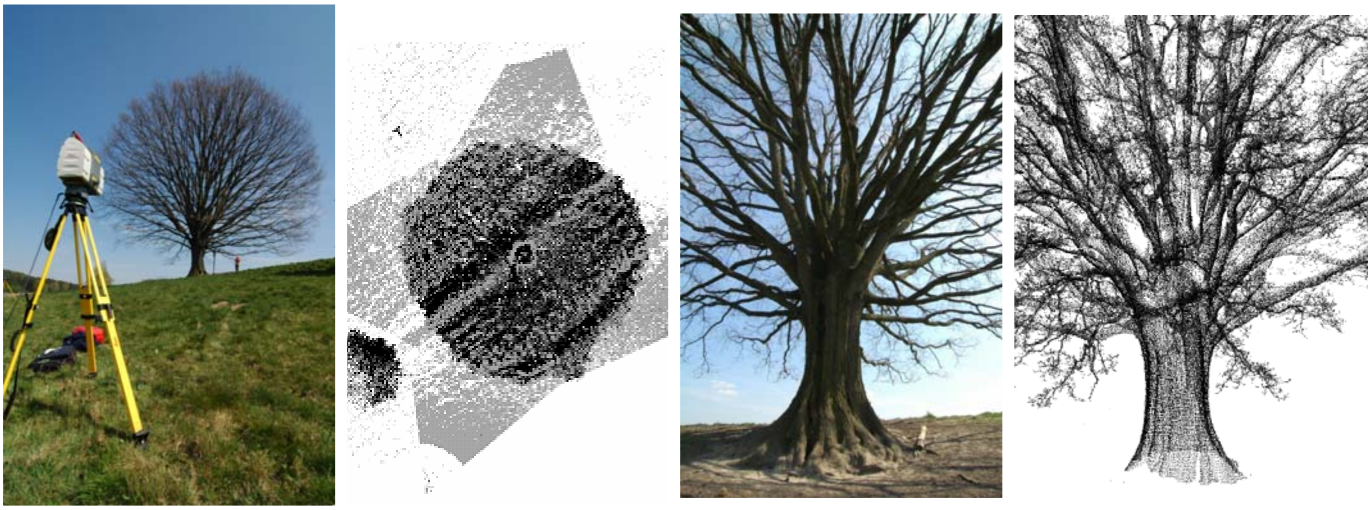

Figure 4: Terrestrial scanning of oak tree and digital model by the cloud of points

3 Application

Scanning in Krásná Lípa locality took place in April during the same period as the aerial scanning. The reason was to ensure similar conditions independent of year season. The scanning was performed from four positions equally sited around the tree in average distance of 20 m from the tree shaft. Regarding spatial composition of the crown, scanning density is heterogeneous and equals to 5cm/50m. To union individual point clouds obtained from each scanning position, standard reflective targets were used, and their identication as well as the whole model spatially referenced into Czech coordinate system S-JTSK. Surveying of the targets was accomplished using a total station connected to two near trigonometric points.

Second phase of scanning took place in July, when trees were fully leaved. Thus, data were acquired for analyses of both, leaf mass and wood volume. An example of scan data is shown in Figure 4.

From the joint point clouds, points lying on the ground and points lying on the tree were filtered out. From such prepared point cloud, individual characteristics of the tree - height of the tree, crown width, first branch height, and spatial distribution of branches and density of branches and leaves in both, vertical and horizontal direction – were analyzed. Evident difference in mass volume can be seen in figure 5, where the sectional plan of the tree in leaf and leafless state is displayed (thickness of 1m). In diagram representing the histogram of point's density in dependence on the distance from the tree trunk, the inner distribution of mass

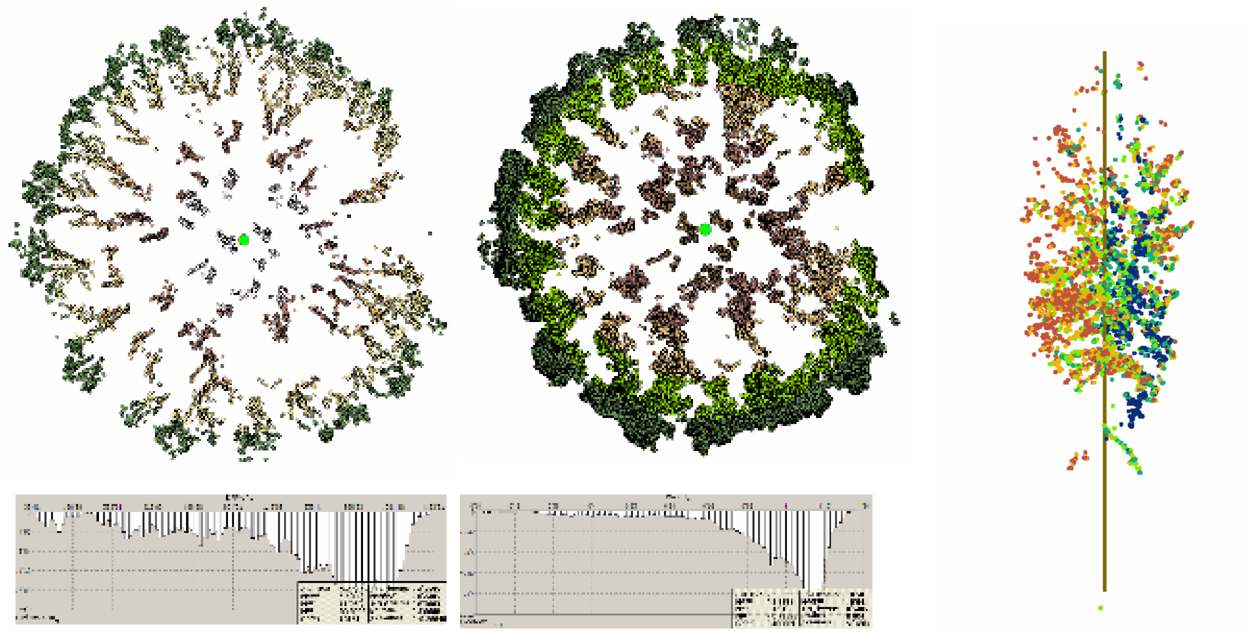

Figure 5: Left side - sectional plan of an oak tree crown. Graphs present density of mass dependent on the distance from the tree trunk. Right side- schematic spatial model of a spruce by voxel model.

inside the crown can be seen.

4 Conclusion

A precise determination of spatial features of different tree species is the result of particular procedures. These characteristics are subsequently used for creation of schematic models of actual forest covers, which may serve to study interactions and processes inside forest systems. Schematic 3D model of spruce is displayed on the right side of figure 6 using a voxel model with 0.1 m edge. Colour scale of the voxels refers to the density of leaf mass in given place, and shows space distribution of leaf mass inside a fully grown spruce crown.

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