TREE DATABASE DEVELOPMENT. USE FOR ANALYSIS OF THE DISTRIBUTION OF FOREST RESOURCES OUTSIDE THE NATIONAL FOREST INVENTORY SAMPLE PLOTS

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National forest inventory is aimed to assess amount and dynamics of resources in the whole country, and information collected is a valuable source for testing remote sensing classification on the ground by combining both orthorectified aerial images and tree database. We tested applicibility of multispectral analysis (superivised classification), image texture analysis (supervised and unsupervised classification) and LIDAR data classification. From LIDAR las files is lidar data derived materials prepared - DTM (digital terain model) with resolution 5m, DSM (digital surface model) and CHM (crown height model) for stand height, basal area classification. The classification quality of Image Texture Analysis is highly appreciated resulting Kappa coefficient of 0.83 dominant species analysis. There is also strong correlation between the results of lidar data CHM and tree height in sample plots. Comparing CHM data with Forest register data negligible higher average height values are indicating in LIDAR data. When comparing lidar data CHM height peak figures in sample plot areas, there is a strong correlation compared to the stand basal area. There are sufficient data for preparation of forest distribution maps for spatial planning document supporting data. The public lidar data should be used as a qualitative addition data source for forest classification and forest management planning.

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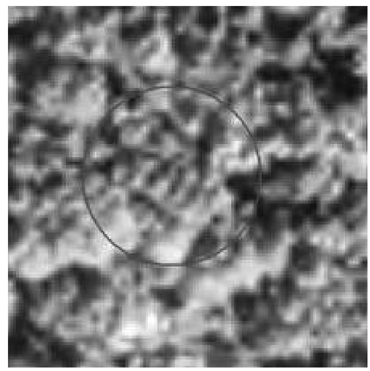
INTRODUCTION

When comparing national forest inventory (NFI) sample plot tree measurement data from the NFI database produced by calculation of the coordinate shift from sample plot center resulting tree spatial location data in LKS-92 coordinate system identified not matching to the LIDAR single tree data coordinates. It is not possible to identify individual tree in forest stand. One of the reasons – sample plot center coordinate measurement accuracy are problems associated with autonomous GPS measurement quality under the tree canopy. Previously review of public remote sensing materials has been made available for the whole country. The analysis of distribution of forest resources outside the NFI plots is based on Landsat satellite images and orthophotos of Latvian Geospatial Information Agency (LGIA). The Landsat images are useful to classify land cover types as forest, agricultural areas, grasslands, also for operational needs providing with confidence from 75 to 92% (MAF, 2007). The identified forests cover polygons later to be used as "mask" to classify other images and to distinct coniferous stands from deciduous stands. It is tested that Landsat images are useful also to detect change and calculate amount of annual carbon stock. When using LGIA images for supervised classification in areas previously estimated with the help of Landsat 'forest mask', the original image (0.5 m resolution) is not usable for individual tree species parameters estimation. However when resampling original image to 5 meter resolution, classification results show sufficient quality for microstand delineation.

Along with pixel-oriented image classification, image texture analysis is widely used worldwide (So-Ra Kim et al. 2011). There is made an image texture analysis technology suitability study using LGIA orthophoto images with support of NFI sample plot ground truth information. For stands that are identical in texture analysis results, we have used additional LIDAR data (Wen Zhang et al. 2008), which allows to fine-tuning stand's spatial structure information.

MATERIAL AND METHODS

A NFI sample plot center coordinate is adjusted by repeated GPS measurements to calculate average value. This is done during the measurements sample plot trees. Real-time correction from base stations is not used. Measurements are taken along 150 plots, which are further used as tree database material for remote sensing classification at tree level.



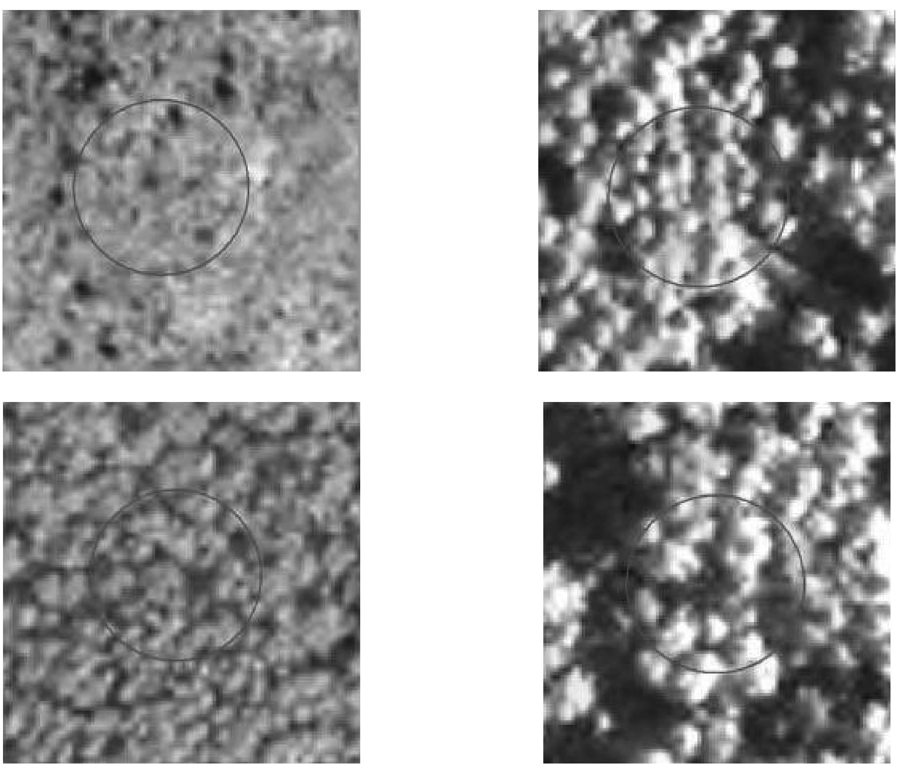


Fig.1. Texture Library example of black alder stands.

The tree data and image comparison *LGIA* infrared orthophoto spectral band composition. Preparation of various image band combinations is made virtually by pointing witch image bands participate in the classification process. Real pictures for the new combination are not produced.

Classification is performed by using LGIA orthophoto images with additional infrared (CIR) spectrum band (RGB & CIR). This is because CIR spectral band is a valuable source of information, which allows designating stands' borders more precisely. Orthophoto contains visible light red, green and blue spectrum, infrared image - additional invisible near infrared (NIR near infra-red) spectrum (800 to 2500nm). In order to assess the best classification settings, the following classification methods were used:

- unsupervised texture classification;
- simultaneous unsupervised texture and spectrum classification;
- supervised texture classification;
- simultaneous supervised texture and spectrum classification;
- LIDAR data classification.

Inside one 25x25 km orthophoto image there are about 6 NFI sample plots which do not cover all possible species and age group variations within the area. For another possible stands cases we have prepared texture library (Fig.1.) form NFI data ortophoto data that are located in other ortophoto area. Information is needed to recognize and identify the images characteristic of different species and age of trees classification.

For LIDAR data classification there were selected test areas of ca 90000 ha in Ādažu, Carnikavas, Garkalnes, Ropazu, Inčukalna, Krimulda areas.

The raw LIDAR point data is received from LGIA on *.las file format. Data is divided in 1 x 1 km data blocks. LIDAR point average accuracy is 2

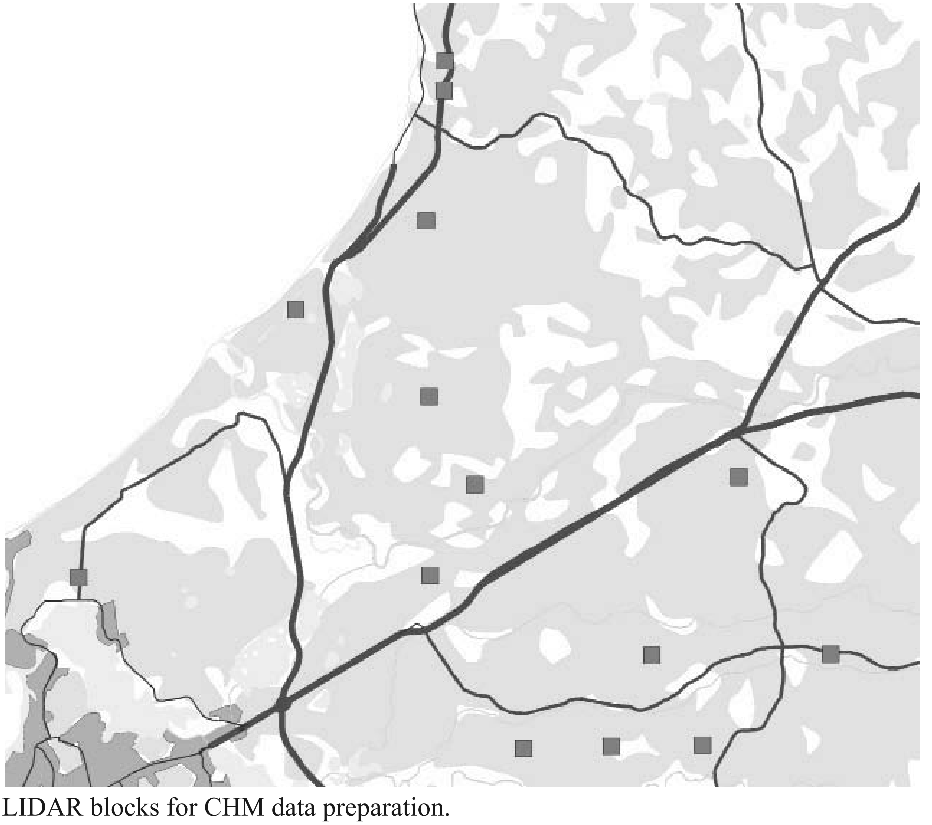


Fig.2. LIDAR blocks for CHM data preparation.

to 3 points per m^2.

According to the available NFI sample plots in test area 142 full-area (500m2) plots in 14 LIDAR data blocks (Fig.3.) are selected.

From the original *.las data the following data are prepared:

- DTM (digital terrain model) - 5m resolution;
- DSM (digital surface model) - 5m resolution;
- CHM (canopy height model) - 5m resolution.

CHM is used as additional data for stand vertical structure analysis (Ali et al. 2008). CHM could be applied to divide forested area into young, middle age and mature stands (Donis 2009).

From CHM data in NFI sample plot and forest compartment areas is identified:

- Average height values;
- Sum of height maximums.

For classification results following ground truth data are used:

- Forest compartment data layer with the average height data to compare with Lidar data classification mean values;
- NFI plot data with the average height to compare with Lidar data classification mean values;
- Forest compartment data layer with stand basal area height to compare with Lidar data classification height maximum (Korpela et al. 2010).

RESULTS AND DISCUSSION

The NFI sample plot center adjustment reported satellite geometry values - PDOP from 3 to 20, measurements per plot - from 20 to 1895. The average number of measurements was 400. Number of measurements is strongly related to particular GPS measurement conditions. Scattering of measured points in one sample plot was from 0.3 to 10 m. The average deviation was 3.86 m and STDEV was 2.31. Relative to nominal sample plot centers, new surveyed points offsets 0.08 m to 17.6 m. Average - 3.4 m and STDEV - 2,7 m. The real plot coordinates shift is small enough to use tree location for high-precision image classification.

Orthophoto images that do not contain DEM or DSM information, with unsupervised texture

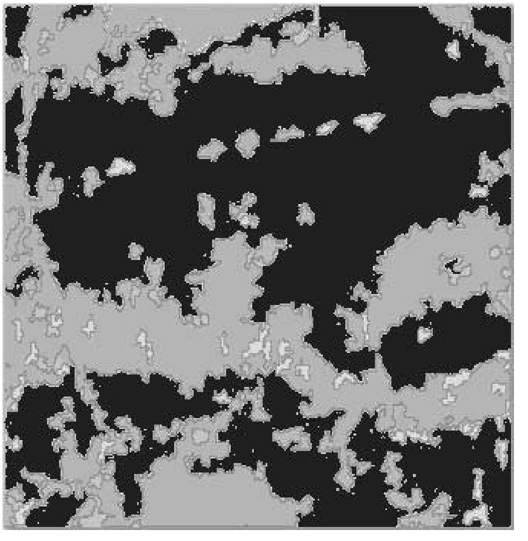


Fig.3. Supervised texture classification based on spectral information.

Table 1.Error matrix by tree species

	Scotch pine	Spruce	Birch	Black alder	Common aspen	Grey alder
Scotch pine	42					
Spruce	4	13	1			
Birch		2	31	1	2	
Black alder				3		
Common aspen			3		4	
Grey alder						6
Total	46	15	35	4	6	6
%	91,3	86,7	88,6	75,0	66,7	100,0

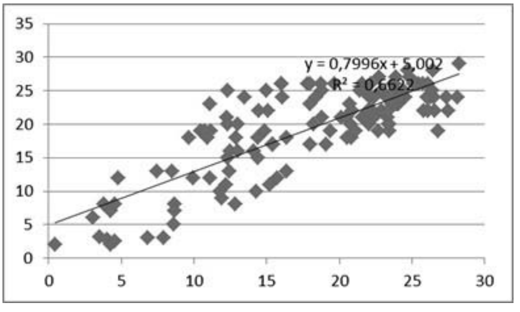


Fig.4. CHM and forest compartment average height data.

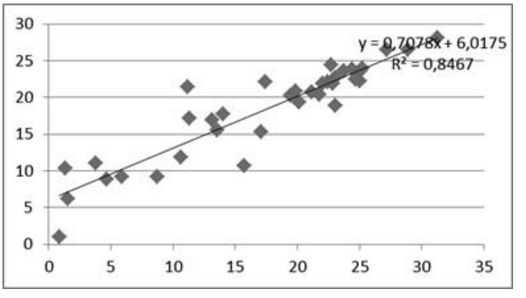


Fig.5. CHM and NFI sample plot average height data.

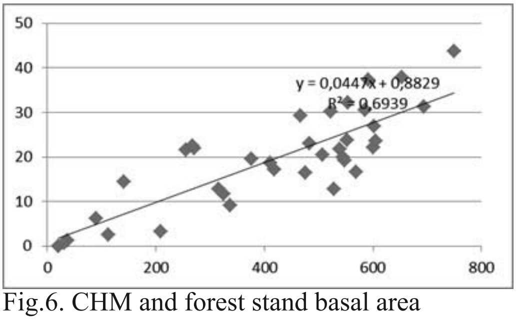


Fig.6. CHM and forest stand basal area

classification can result into image structure separation. Texture image analysis approach is used more for man-made object classification (Hayit K et all, 1992). However, the method could be used to analyze forested area images along drainage systems, to recognize tracks, and also for microstand crown structure analysis. Timber resources estimates cannot be based only on image texture analysis.

The best classification results are shown by supervised classification method which uses both image texture and spectral information (Fig.3.).

Accuracy of classification results is estimated with the help of error matrix (Table 1.). It has shown better results than only spectral classification (MAF 2007).

There is a strong correlation comparing LIDAR and CHM method medium height according to forest compartment data (Fig.4.). State forest register data with negligible higher average height values, which could be explained by the fact that Lidar measurements are obtained directly from the treetops with a small number of points per m^2 (Huang et al. 2009).

Comparing LIDAR and CHM model medium height according to NFI sample plot data, there is

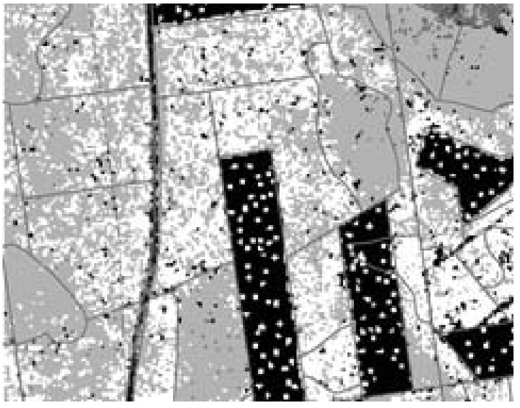
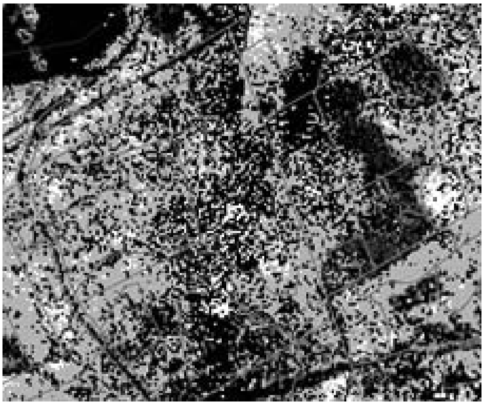



Fig.7. seed trees and scattered forest at CHM data.

a strong correlation (Fig.5.). Here are too slightly higher plot height measurements compared with LIDAR data.

Comparing LIDAR data CHM model height maximum sum, there is a strong correlation to the stand basal area (Fig.6.) (Stefan Lang et all, 2006).

CONCLUSIONS

1. Database of trees must be supplemented with a crown azimuth measuring information.

2. After sample plot center clarification, tree data can be used for image classification.

3. LGIA ortophoto can be used for forest microstand delineation with the help of NFI sample plot ground truth.

4. The public LIDAR data can be used as an additional source of data for forest classification.

5. There is a need for a wider LIDAR data acquisition in forestry because of their potential use in:
   - DTM data - logging path planning using micro relief (Johan SONESSON et all, 2012);
   - DTM data in order to reduce the impact of logging on the environment (Lindeman Harri et all, 2012);
   - DTM and DSM data used for harvester navigation (Kari Väätäinen et all, 2012);
   - CHM data are useful also to monitor ecological / seed tree status (Fig.7.);

ACKNOWLEDGMENTS

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