Faculty of Forestry and Wood Technology

29. 5. 2007, Zvolen

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Development of models for forest stand attributes estimation from ALS data using ABA

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Introduction

- Immense potential of ALS
- Two major methods of forest attributes estimation, depending on the unit to be estimated
  - ITD – Individual Tree detection
    - tree level
  - ABA – Area Base Approach
    - area of a certain fixed size
    - usage of point cloud metrics
- Higher precision than inventory based on visual assesment

Materals and methods – LiDAR data

- LiDAR data were collected in September 2014
- Scanner Leica ALS70-CM
- Average pulse density 7,8 pulse/m^2
- Filtering and classification was performed in TerraSolid TerraScan
- Point cloud metrics calculated in FUSION software

Materals and methods – Field plot data

- Spruce dominated stands
- 10 circular plots with a radius of 12,62 m were established so far
- Centres of plots were measured using GNSS receiver Topcon Hiper Pro with applied RTK corrections
- Dbh was measured for all trees with Dbh > 7 cm

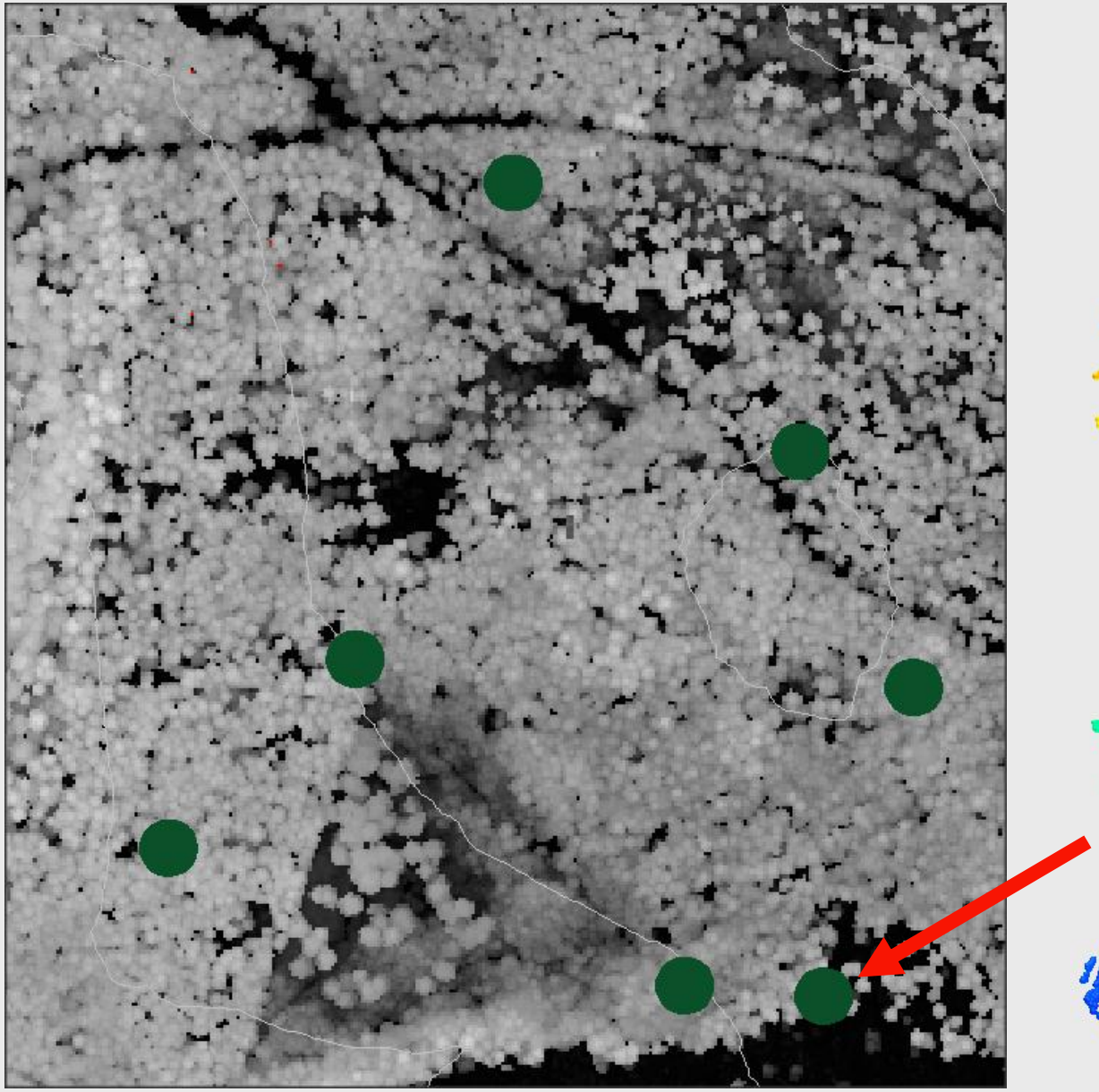
Materals and methods – Field plot data

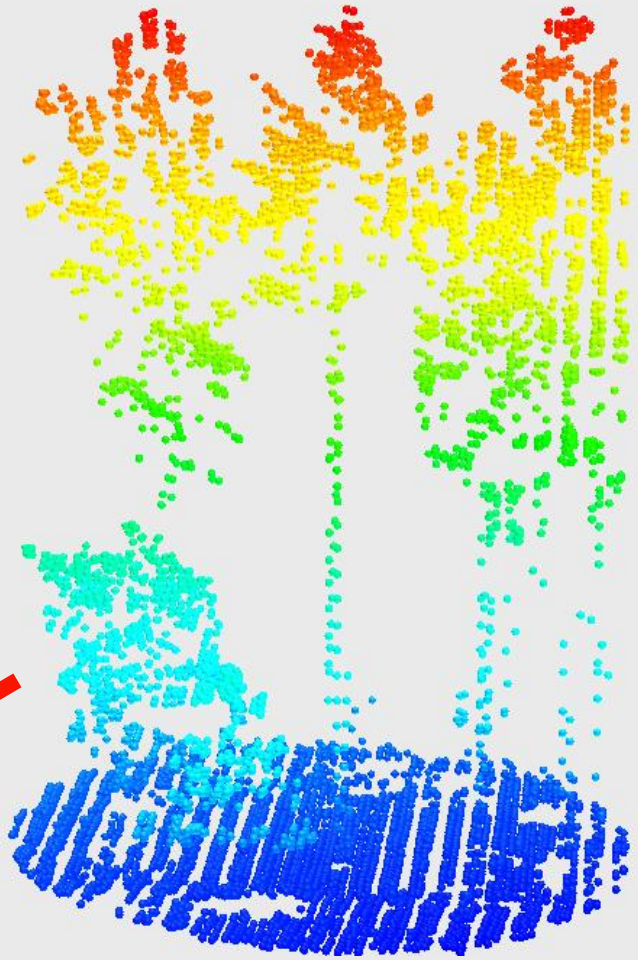
- Several heights were measured for each tree species oresponding approximately to mean stem
- Stem count
- Volume and basal area were estimated for each plot using volume tables

Materals and methods – Point cloud metrics

- Subsetting the LiDAR data that correspond to each field plot
- LiDAR data were normalized to the ground surface during the subsetting process → returns are expressed in terms of height above the ground
- Non-canopy returns were excluded from calculation – 2m height threshold

Materals and methods – Point cloud metrics





Materals and methods – Point cloud metrics

- Calculating a set of point cloud metrics variables for each plot was performed
- Output was formatted as a CSV file
- Each record in the output CSV table had a set of variables that describe the vertical distribution of the LiDAR points within the plot
- Computed point cloud metrics were used as predictor variables in the linear regression modelling

Implementation

- Linear regression used as a modeling technique
- OLS regression were widely used for forest inventory variables estimations and reliable results
- OLS regression is considered as the approach of choice for practical forest inventories

Implementation

- General principles of model building were met according to McGaughey (2013).
  - As few parameters as possible
  - Simple explanations
  - Rely in few assumtions instead on many
  - Less than three independent variables
    - Height
    - Canopy cover
    - Descriptive category

Implementation

- Solution was performed through developing an object-oriented script using Python
- Interactive computational environment Ipython notebook
- Opensource libraries and modules
  - Pandas – data manipulation and handling
  - Statsmodels – statistical analyses
  - Matplotlib – plotting

python

IP[y]: IPython
Interactive Computing

Results

- Several regression models for forest inventory variables were developed and regression diagnostics was performed

- The following formulas may be used for further modelling of forest inventory variables on the whole inventory area by using ArcGIS software

Results – Model for volume (V)

$$y = -40{,}6011 + 1{,}7392\beta_1 - 1{,}6053\beta_2 + 1{,}9580\beta_3$$

$\beta_1 \ldots All\ returns\ above\ mean\ /\ Total\ \ first\ returns * 100$

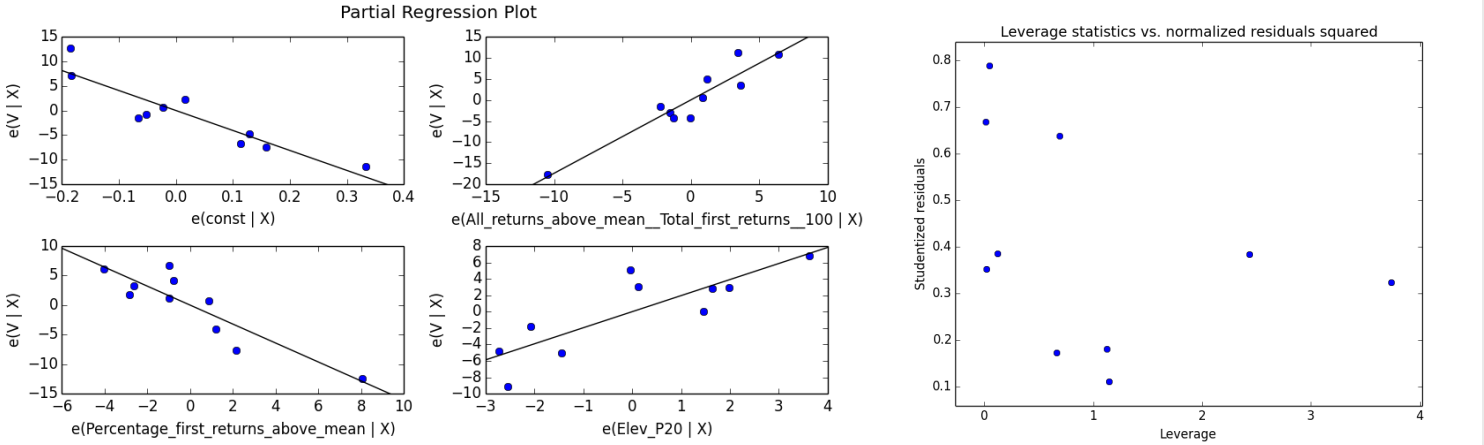
$\beta_1 \ldots Percentage\ \ first\ returns\ above\ mean$

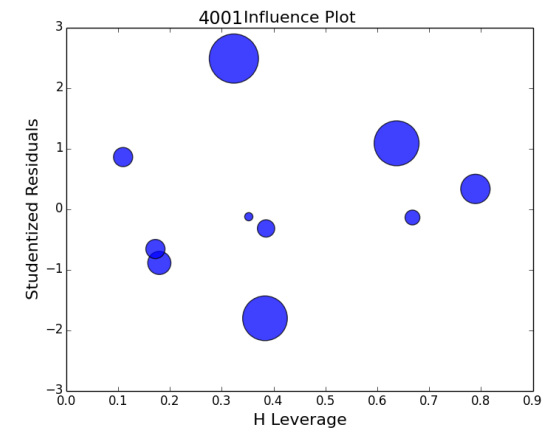
$\beta_1 \ldots Elev\ P20$

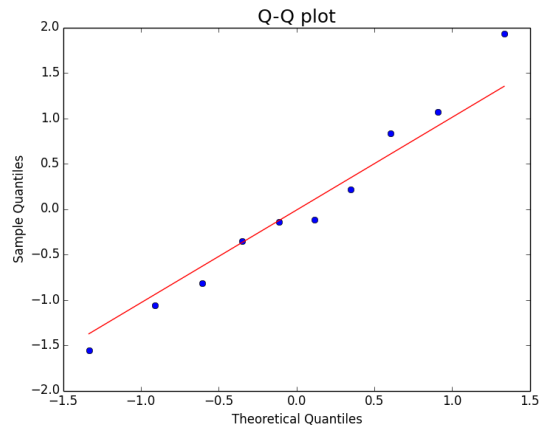
$R^2 = 0{,}94$

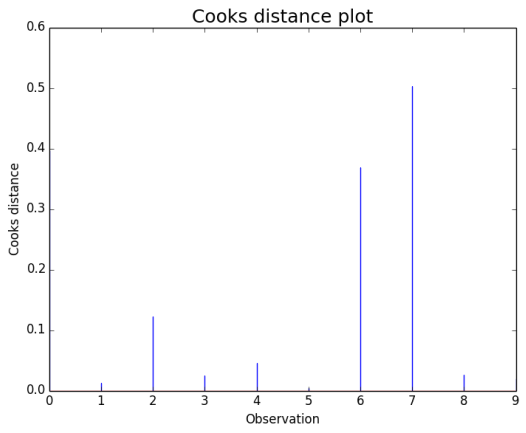
$RMSE = 6{,}83$

$bias = 25{,}82$









Results – Model for basal area (G)

$$y = -4{,}6202 - 2{,}0041\beta_1 + 1{,}3706\beta_2 + 0{,}7849\beta_3$$

$\beta_1 \ldots Elev\ mean$

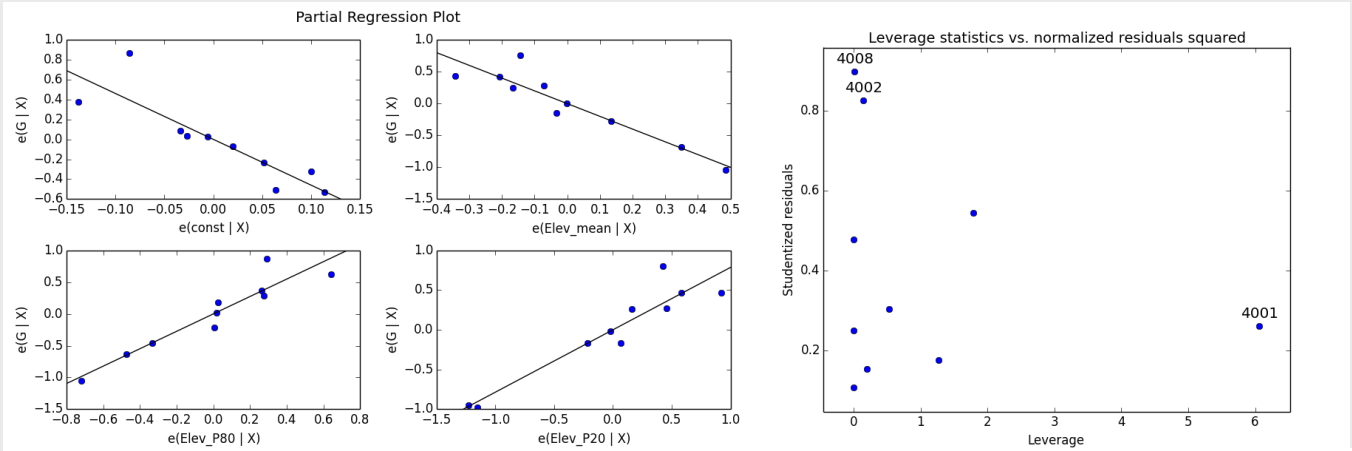
$\beta_1 \ldots Elev\ P80$

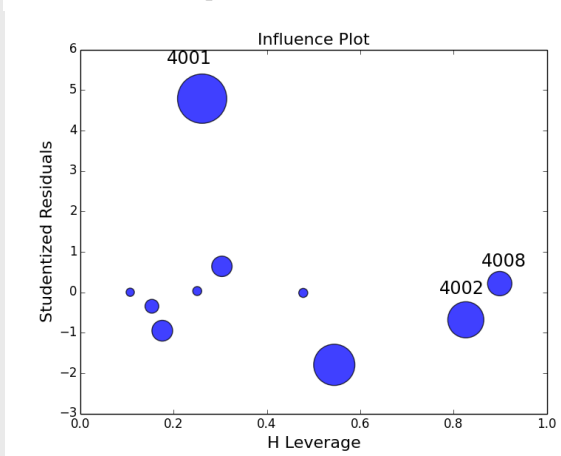
$\beta_1 \ldots Elev\ P20$

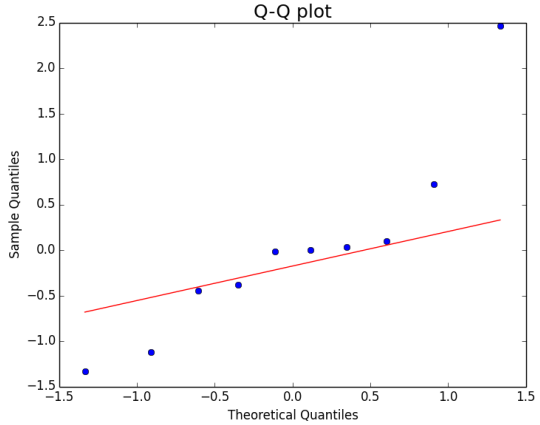
$R^2 = 0{,}93$

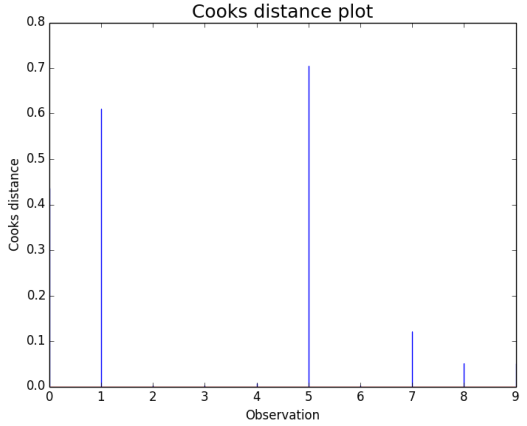
$RMSE = 0{,}40$

$bias = 19{,}92$









Conclusion – drawbacks and pitfalls

- Over-fitting the model
- Multicollinearity among independent variables
- Extrapolation of modelled relationship
- Field work

Thank you for attention.