Characterizing ligneous resources by using remote sensing

From trees outside forests to forest stands

04/06/2020 – Corentin Bolyn
Feel Wood

Forêt Pro Bos
Forêt Pro Bos – remote sensing as a tool for the good management of our territories

• Improve our knowledge about the distribution and evolution of timber resources located in the Interreg project area

• Three development goals related to remote sensing :
  • Mapping main timber resources forest species
  • Mapping ligneous elements outside forests
  • Characterizing the development stages of poplar stands
Ligneous elements in the landscape
From trees outside forests ...
... to forest stands
According to their development stage, forestry plantations can belong to both categories.
Mapping and characterizing trees outside forests by using the LiDAR technology

• Requires very high spatial resolution data
  • Delineating small ligneous elements
  • Differentiating immediate environment: herbaceous vegetation, man-made elements.
Mapping and characterizing trees outside forests by using the LiDAR technology

• Requires very high spatial resolution data
  • Delineating small ligneous elements
  • Differentiating immediate environment: herbaceous vegetation, man-made elements.

• Mapping method exclusively based on aerial LiDAR
4 steps methodology

1. Identify «ground» points and normalize the point cloud
4 steps methodology

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2. Identify all the points corresponding to ligneous elements
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1. Identify « ground » points and normalize the point cloud
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3. Make the distinction between forest stands and trees outside forests
Definition of a forest

• FAO definition
  • *Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ*
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3. Make the distinction between forest stands and trees outside forests
4. Classification of ligneous elements located outside forests
Typology of trees outside forests

- **Grove**: continuous and non-linear element spanning more than 400 m²
- **Agglomerated trees**: a group of ligneous elements standing less than 10 m apart and that are not aligned (e.g. orchards);
- **Aligned trees**: an alignment comprised of at least 5 ligneous elements standing less than 10 m apart;
- **Hedges**: continuous and linear element being at least 10 m long and not exceeding 20 m in width. The length/width ratio is above 3. The hedge sections standing less than 5 m apart are considered as part of the same hedge;
- **Isolated trees**: ligneous elements comprising only one tree, standing more than 5 m away from any other mapped element. The corona projected on the ground spans at least 12,6 m², corresponding to a 4 m diameter disk;
- **Shrub**: isolated ligneous elements, standing more than 5 m away from a grove, a hedge or a forest and more than 10 m away from another ligneous element. This category includes shrubs, bushes and groves not exceeding a surface of 400 m²;
- **Others**: comprises elements of over 2 m which are not meeting the above-mentioned criteria.
Classifying ligneous elements located outside the forest

- 1st step: classifying the various elements into three classes:
  - Small size ligneous elements
  - Groves (surface area > 400 m²)
  - Linear elements (minimum length: 10 m, maximum width: 20 m, (length/width) > 3)
Classifying ligneous elements located outside the forest

• 1st step : classifying the various elements into three classes :
  • Small size ligneous elements
  • Groves (surface area > 400 m²)
  • Linear elements (minimum length : 10 m, maximum width : 20 m, (length/width) > 3)

• 2d step : algorithm comprising proximity criteria in order to achieve the final classification into 6 categories
Accuracy, strengths and weaknesses

• **Strength:** automated processing chain that can be applied to any other LiDAR data set
Accuracy, strengths and weaknesses

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• Source of error: confusion between ligneous elements and non-ligneous elements exceeding 2 m
Accuracy, strengths and weaknesses

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• Using photointerpretation in order to assess the classification of ligneous elements in agricultural areas: 93% accuracy
Further analyses
Detection of changes over time

Orthophoto 2012 - spw

Orthophoto 2019 - spw
Detection of changes over time
Connectivity analysis

Ohey municipality: 55 %

Condé sur l’escaut area: 84 %
Results in young plantations ?
Sensing of poplar plantations

- Requires very high spatial resolution data
  - Accurate positioning of trees inside the plantation
  - Detecting plants that have a small crown
  - Differentiating the immediate environment: regrows
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Methodology

1. Identify «ground» points and normalize the point cloud
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3. Sensing the location of trees and per stratum clustering
   • Geographic proximity (x, y, z)
   • Proximity of texture indexes measured around the tree
Height digital model
Sensing the location of trees
Clustering for detected trees
Methodology

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3. Sensing the location of trees and per stratum clustering
4. Sensing the « plantation » pattern (8 X 8 m)
   • Algorithm comprising distance matrices
   • Tree group index representing the proportion of points laid out in a 8 X 8 m grid
Accuracy, strengths and weaknesses

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• Strength: automated processing chain that can be applied to any LiDAR data set
• Weakness: solely based on the trees layout, noise-sensitive
Accuracy, strengths and weaknesses

• **Strength:** automated processing chain that can be applied to any LiDAR data set
• **Weakness:** solely based on the trees layout, noise-sensitive
• **Accuracy analysis:** based on MNH LiDAR photointerpretation and knowledge of the ground
• Grid 100 x 100 m

• Sensing accuracy for the plantations by height categories

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Results in mature forest plants ?
Results in mature forest plants?

- Complementary approach combined with the mapping of timber species through satellite imagery
Mapping of timber species through the use of Sentinel-2 satellite imagery

• Mapping of forest stands
  • Less constraining spatial resolution
  • Work undertaken at the Interreg territory level
Mapping of timber species through the use of Sentinel-2 satellite imagery

• Mapping of forest stands
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  • Work undertaken at the Interreg territory level

• Sentinel-2 imagery
  • Available for the entire area
  • Continuous acquisition, return time: 5 days
  • High spectral resolution for 10 bands
• 10 m bands

• 20 m bands
Technical constraint related to satellite imagery

• At the Interreg project level
  • Impossible to have no clouds for a definite period
  • Use the available images without a cloud?
    • Poorly reproducible approach
Technical constraint related to satellite imagery

- Developing a S2 mosaic without a cloud for the vegetation period (from 2018-05-01 to 2018-09-30)
Technical constraint related to satellite imagery

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\[
brightness = \text{mean(bands)}
\]

\[
\text{Normalized band} = \frac{\text{Band} - \text{brightness}}{\text{Band} + \text{brightness}}
\]
Supervised per pixel classification

- Imagery: Sentinel-2 mosaic without cloud (2018-05-01 to 2018-09-30)
Supervised per pixel classification

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• Training data :
  • Geodatabase of the Department of Nature and Forests (Public Service of Wallonia)
  • Data from the Interreg Transpop project
  • Digitalized data from the project’s partners
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Method

1. Model aimed at generating a ligneous mask in the Interreg area
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2. 1 model per timber species to be mapped:
   • Deciduous trees: oak, beech, poplar, other deciduous trees
   • Softwood trees: spruce, douglas, larch, pine tree, other softwood trees
Method

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   • Deciduous trees: oak, beech, poplar, other deciduous trees
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3. Produce maps showing the presence probability according to random forest model
Mosaic S2
Nir SWIR SWIR
Result:
Presence probability of oak
Result:
Combination of the probability maps
Accuracy, strengths and weaknesses

• Strengths:
  • Reproducibility from one year to another
  • Workable for large study areas (whole Interreg area)
Accuracy, strengths and weaknesses

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  • Reproducibility from one year to another
  • Workable for large study areas (whole Interreg area)

• Weaknesses:
  • Training data for the models
  • Ligneous mask solely defined on the basis of satellite imagery
    • Possible confusion with other types of soil occupation
Accuracy, strengths and weaknesses

• Assessment of the accuracy:
  • Field inventory undertaken in the framework of the project for 5 pilot areas
  • 751 plots inventoried in the field by the task officers and forest technicians for the Pro Bos Forest project
Accuracy, strengths and weaknesses

• Detection of the most dominant species

• Detection of one of the dominant species
Accuracy, strengths and weaknesses

- Detection of the most dominant species
- Detection of one of the dominant species

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• Detection of the most dominant species

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Accuracy, strengths and weaknesses

• Detection of the most dominant species

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Conclusion

• Developments made in the framework of the Pro Bos Forest project show the potential of existing remote sensing data in order to map and characterize timber resources in all their forms.

• The acquisition of aerial LiDAR data is a major asset in order to characterize the territory and monitor the evolution of our resources in the future.

• All of the three topics addressed here show concrete ways for improvement. One of the biggest challenges is the improvement of the training database used for generating forest species mapping models.
Thank you

Bolyn Corentin
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