Characterization of the quality of roundwood automatically: Recent results and perspectives

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Which economic stakes about wood quality?

Log selling price depends on the presence of defects

<table>
<thead>
<tr>
<th>Classe</th>
<th>Longueur</th>
<th>Diamètre</th>
<th>Défaut</th>
<th>Prix</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3m</td>
<td>&gt;=55cm</td>
<td>Sans défaut</td>
<td>&gt;=560€</td>
</tr>
<tr>
<td>B</td>
<td>3m</td>
<td>&gt;=50cm</td>
<td>Peu défauts</td>
<td>&gt;=345€</td>
</tr>
<tr>
<td>C</td>
<td>3m</td>
<td>&gt;=35cm</td>
<td>Avec défauts</td>
<td>180€</td>
</tr>
<tr>
<td>D</td>
<td>1.5m</td>
<td></td>
<td>Beaucoup défauts</td>
<td>9€</td>
</tr>
</tbody>
</table>

From: Forêts de France (2017)

Factors
- Diameter ➔ Volume ➔ Global shape (Taper, Curvature)
- Log Ends: Ring Width, Colour, Eccentricity, Rot,....
- Number of surface defects / meter / type.
Surface defects:
Which economic stakes about Wood Quality?

To optimize from quality information the first transformation

Optimization on global shape

Optimization from shape and knots

Horns down Sawing = standard optimization

269 Logs Norway Spruce and Scots Pine

Fredriksson 2014

Recovery Value + 21%

Recovery Value + 13%

Fredriksson 2014
X-Ray scanner = Reference Method

Geometrical model of the inner structure of a Beech log coming from an X-Ray Scan.
60 -80% of Internal defects are detectable from outside
Is it possible to characterize the inner part from outside automatically?

Perhaps... but several steps must be lifted.

- To describe the bark surface with enough details:
  - T-LiDAR = Reference Method
    Providing detailed information on standing trees
  - To detect the defect on bark
  - To identify the defect type
  - To measure its characteristics
- To link external features of the defect to inner ones

3 Objectives of Van-Tho's PhD

ANR Project WoodSeer?
Detection of the defect on the bark

A tricky objective which needs a reference surface

(b) Cylindrical based method
Algorithm for segmenting defect areas

Step 1: 3D Cloud
Step 2: Meshing
Step 3: Central Line
Step 4: For each 3D Point
  Real Distance D to the Central Line
  Reference Distance Dref to the central line fitted from a neighbourhood of the point
Step 5: D-Dref
Step 6: Thresholding

Nguyen et al. 2016 a & b
Results

Elm
Wild Cherry
Silver Fir
Red Oak
Beech
Checker Tree

Expert
Algorithm
Agreement
Results about defect detection

**Metrics**

- **Precision**
  \[
  P = \frac{TP}{TP + FP}
  \]

- **Recall**
  \[
  R = \frac{TP}{TP + FN}
  \]

- **F1 value**
  \[
  F_1 = 2 \cdot \frac{PR}{P + R}
  \]

<table>
<thead>
<tr>
<th></th>
<th>Proposed method</th>
<th>Cyl.-based method[12]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log</td>
<td>Prec</td>
<td>Recall</td>
</tr>
<tr>
<td>Fir 1</td>
<td>0.747</td>
<td>0.769</td>
</tr>
<tr>
<td>Fir 2</td>
<td>0.673</td>
<td>0.775</td>
</tr>
<tr>
<td>Wild cherry 1</td>
<td>0.696</td>
<td>0.765</td>
</tr>
<tr>
<td>Wild cherry 2</td>
<td>0.846</td>
<td>0.711</td>
</tr>
<tr>
<td>Red oak 1</td>
<td>0.749</td>
<td>0.742</td>
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<tr>
<td>Red oak 2</td>
<td>0.428</td>
<td>0.833</td>
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<tr>
<td>Beech</td>
<td>0.670</td>
<td>0.604</td>
</tr>
<tr>
<td>Birch</td>
<td>0.733</td>
<td>0.756</td>
</tr>
<tr>
<td>Elm</td>
<td>0.694</td>
<td>0.755</td>
</tr>
<tr>
<td>Wst²</td>
<td>0.247</td>
<td>0.741</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td>0.685</td>
<td>0.740</td>
</tr>
</tbody>
</table>
Classification of defects

Five Classes
- Branches (sequential and epicormic)
- Branch scars
- Burl
- Small defects = (Picot, Sphéroblaste, Bud Cluster, bud)
- Bark

Shape Descriptors

Defect to be classified

Shape Descriptors

Random Forests

Defect Type

Learning Dataset
Defect + Type
N = 425

Shape Descriptors
Classification of defects

15 Shape Descriptors
- Species
- Ratio between the nb of points of the defect and the volume of its bounding box
- Hu invariant moments
- Ratio between eigenvalues
- Angle between trunk axis and 3rd eigen vector
- ......
Results about classification

- **Oak**
- **Beech**
- **Wild Cherry**
- **Norway Spruce**

Legend:
- Branch
- Branch Scar
- Burl
- Small Defect
Classification Results
Characterization of the defect

- To compare with human characterization is a difficult task
- An example about the width of the knot scar (w)

Geometrical Model

Data + Result

40% of Maximum
First local minimum

Position along the periphery

Vertical dimension
Characterization of defect

- A difficulty:
  - the definition of a defect area is not exactly the same between a human and algorithms.
Characterization of defect

141 Defects

- Overestimation of dimensions by algorithms
- Encouraging results
- Must be improved ....
**Project ANR : WoodSeer 🍁**

**Task 1**
- 4 species x 10 trees → Min 100 defects by species
- Diversification of data
- Acquisition True shape scanner
- Handheld Cameras
- To provide a dataset with outer and inner 3D data of the same defects (X-Ray scans)
- Generation of Virtual Data to feed learning dataset for Deep Learning approaches

**Task 2**
- To improve the segmentation and classification steps
  - For outer surface data
  - For inner volume data
- Deep Learning with geometrical constraints

**Task 3**
- To connect Outer and Inner part of the defect
  - By Deep Learning
  - By statistical model on characteristics
Conclusions

With respect to initial objectives:
- Description of Trunk surface: T-LiDAR relevant but time costly
- Detection of defects: Rather efficient method available
- Classification of defects: Improvement needed
  - More data for learning dataset
  - To refine the classes; Type + Size

Characterization of defects
- Human-like characterization by algorithm difficult but not necessary for IA approaches
- Connection to inner characteristics: To do
MERCI DE VOTRE ATTENTION