Measuring wood quality of logs from low-cost sensors at the sawmill or at the road side

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1 Context

X-ray computer tomography (CT) is a technology that was proved to be very efficient for measuring non-destructively external and internal characteristics of logs (e.g., knottiness, sapwood, cracks, wood density) and therefore it was planed that the CT scanners would be largely installed in the sawmills on the production lines for the estimation of wood quality with two main applications: the grading of logs into log quality classes and the sawing optimization. The application of CT to wood analysis was largely investigated during the last 30 years and still recently (Wei et al., 2011; Longuetaud et al., 2012; Roussel et al., 2014; Krähenbühl et al., 2014). However, this technology is still very expensive and a few sawmills in the world can invest in such a device. In France, only one big softwood sawmill is equipped with a CT-scanner and a second one has planned to invest in such a device.

The main idea of the present project is to go back to low-cost sensors to extract wood quality features from more accessible technologies, which potentially could be used everywhere, at wood allocation centres (as described in the European WoodWisdom project VARMA), at the sawmill stocking area, in the forest on the harvester, or at the road side for wood sells. The possibility to use a mobile-phone could be investigated to make possible quality measurements everywhere (Figure 1, 2). The sawmills targeted by this project are small and medium-sized sawmills.

In the literature, very few developments were done for the processing of rough log end images. The few available publications come from Scandinavian countries and we can mention in particular the PhD thesis of Norell (Norell, 2010).

This PhD work will be realised in the framework of the PRCI ANR project *TreeTrace*, which is a bilateral research project involving France (funded by the ANR) and Austria (funded by the FWF) for a duration of three years 2018-2020.

Figure 1: Truck transporting logs (on the left) and pile of logs (on the right). Two places where log quality estimation could be required directly on the site.

Figure 2: Log ends at different places: in the forest on the harvester and later at the sawmill on the production line.

2 Objective

One objective of this project is to develop image analysis tool, able to process rough log end images (Figure 3), in order to assist the expert at the sawmill for the grading of logs in the different quality classes. Such a tool could help small and medium-sized sawmills to become more competitive by using more accessible technologies than CT scanners.

The wood characteristics that could be automatically detected on rough log end images are:

- the pith
- ellipticity
- eccentricity
- compression wood
- mean annual ring width or radial variation from pith to bark of locally computed mean annual ring widths
- amount of sapwood for some species
- cracks
- rot
- heterogeneity criterion (colour, texture...)
- bark thickness

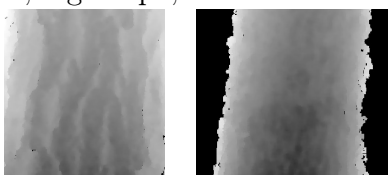
More broadly, the idea is to develop a tool that could be used easily everywhere from the forest to the sawmill. Similar approaches as the ones presented in Kerautret et al. (2016) or in Nguyen et al. (2016) could be used to detect features.

In addition to the wood quality estimation of logs, there is a parallel demand to improve wood traceability from the forest to the sawmill and within the sawmill up to the end products. This is another aspect that will be investigated in the same time by Austrian colleagues and a PhD student. This task will be done by using biometric analysis on cross-section images. Materials, methods and results will be shared between the PhD students located in France and in Austria. Biometric criteria could contribute to the estimation of wood quality and inversely wood quality characteristics automatically detected could help to the identification of cross-sections.

Figure 3: Log end images showing eccentricity and compression wood. Annual rings are visible for the estimation of mean annual ring width. Sawing marks and knots must not disturb the detection of other characteristics.

3 Data acquisition

In the project we will focus on softwood species and wood quality features related to these species (see list above) + species identification, log shape, knottiness.



Possible sensors to consider could be: RGB camera, optical scanner ("true-shape"), terrestrial LiDAR, TrueDepth scanner on mobile devices (like with *Iphone X*, see the figure on the right), vibration analyser ("BING"), GPR...

In the present work, regular digital RGB camera will be used as well as hyper-spectral and multi-spectral sensors (HMS). But it will be possible to test other technologies from the list above.

In the frame of the TreeTrace project, we will use a regular digital camera to acquire log end images at the sawmill (and potentially also in the forest when trees will be harvested). Thousands of images will be acquired. Since the log ends will be untreated like in the PhD thesis of Norell (2010) (with possibly dirt, sawing marks...), the most classical algorithms developed for RGB images of prepared cross-sections (i.e., sanded, oiled) or for CT images will probably not be able to process these images.

For the common work with the Austrian researchers, hyper-spectral and multi-spectral sensors (HMS) will also be tested, as well as CT images. The added value of such sensors will be evaluated in comparison with classical RGB camera both for the traceability and for the wood quality estimation.

The PhD student will be in charge of the installation of a digital camera (CCD or CMOS) and will lead the experimentations at the sawmill. His main task during the PhD will be the development of image analysis algorithms for wood quality estimation.

4 Collaborations

Since the project is a bilateral project between France and Austria, a strong collaboration with the Austrian colleagues of *Salzburg University of Applied Sciences* and *Paris Lodron University of Salzburg* is expected all along.

At the French side, a strong collaboration between *INRA* (wood sciences), *Loria* (computer sciences) and *Arts et Métiers ParisTech (AMPT)* (wood sciences and industrial aspects) is expected.

5 Skills

The PhD candidate could be either a student in computer science very interested by wood, wood quality and wood industry, or a student in forest or wood sciences very motivated and interested in software programming and image analysis, and ready to invest massively in this discipline applied to the study of wood material.

Editorial skills and a good organisation are required, as well as a great autonomy.

6 Host laboratory, contacts and modalities to apply

The PhD student will be mainly based in Nancy, North-East of France. The main location will be at *INRA*, centre Grand Est - Nancy, with the possibility to spend time at *Loria (Université de Lorraine, UL)*, to discuss depending on the profile of the candidate.

The PhD thesis will be co-supervised by *Loria* and *AMPT*.

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The beginning of the PhD is planned for March 2018 but if a Master student would be interested to apply, it could eventually be possible to postpone the start of the PhD contract. Deadline for the application: 28/02/2018.

References

Kerautret, B., A. Krähenbühl, I. Debled-Rennesson et J. Lachaud. 2016, «Centerline detection on partial mesh scans by confidence vote in accumulation map», dans *23rd International Conference on Pattern Recognition, ICPR*, p. 1376–1381.

Krähenbühl, A., B. Kerautret, I. Debled-Rennesson, F. Mothe et F. Longuetaud. 2014, «Knot segmentation in 3d ct images of wet wood», *Pattern Recognition*, vol. 47, n° 12, p. 3852–3869.

Longuetaud, F., F. Mothe, B. Kerautret, A. Krähenbühl, L. Hory, J. M. Leban et I. Debled-Rennesson. 2012, «Automatic knot detection and measurements from x-ray ct images of wood: a review and validation of an improved algorithm on softwood samples», *Computers and Electronics in Agriculture*, vol. 85, p. 77–89.

Nguyen, V., B. Kerautret, I. Debled-Rennesson, F. Colin, A. Piboule et T. Constant. 2016, «Segmentation of defects on log surface from terrestrial lidar data», dans *23rd International Conference on Pattern Recognition, ICPR*, p. 3168–3173.

Norell, K. 2010, *Automatic analysis of log end face images in the sawmill industry*, thèse de doctorat, Swedish University of Agricultural Sciences.

Roussel, J.-R., F. Mothe, A. Krähenbühl, B. Kerautret, I. Debled-Rennesson et F. Longuetaud. 2014, «Automatic knot segmentation in ct images of wet softwood logs using a tangential approach», *Computers and electronics in agriculture*, vol. 104, p. 46–56.

Wei, Q., B. Leblon et A. La Rocque. 2011, «On the use of x-ray computed tomography for determining wood properties: a review», *Canadian journal of forest research*, vol. 41, n° 11, p. 2120–2140.