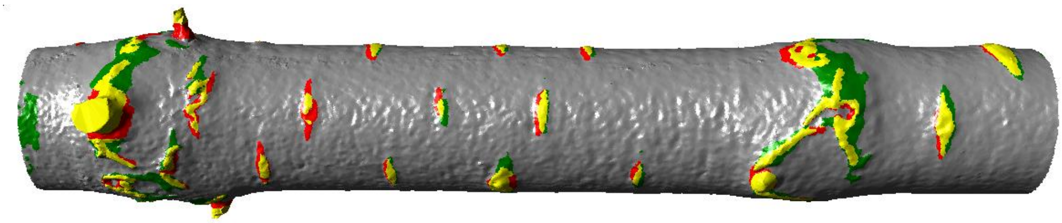
# QUALIDAR



**Estimation de la qualité des bois ronds et des troncs d'arbre par LiDAR terrestre**

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**Context** — The ground-based LiDAR (Light Detection And Ranging) technology allows the description of complex scenes with an unrivalled level of detail : by scanning its environment by a laser beam until some tenths of meters, the device measures the distances to the closest obstacle in millions of directions, with an accuracy of some millimetres. In forest, important issues lay on this technique which upsets the ability for scientists, inventorists or managers to describe trees at a plot level. A lot of scientific works prove the worldwide interest in the use of this technology eventually associated to other sensors, and especially on the data processing for extracting relevant variables. Thus, this project aims to provide variables characterizing the roundwood and trunk quality and valuable for grading or transformation processes by seeking to harness the description of their outer surface.

To reach such objectives, skills in discrete geometry, tree development and wood quality are needed. Another important context feature helping development, testing and diffusion of the methods is the open-source software platform Computree (http://computree.onf.fr/).

**Objectives** — The objective of this project is to extract from T-LiDAR data, not only the shape characteristics impacting the quality (volume, curvature, inclination, …), but also the characteristics of the defects located on the bark surface modifying its rugosity, which are often markers of inner defects and correspond to branches, sound knots until branch scars or small epicormics.

**Approach** — Starting from a 3D point cloud describing a piece of trunk, the developed approach was broken down into 3 successive steps. Each of which requires the development of algorithms and specific methods to reach the final objective of characterizing the defects for using them in grading, for instance. Thus, the partial objectives are (i) to detect the areas prone to correspond to a defect by an analysis of the local roughness, then for each zone (ii) to identify the type of defect by using machine learning methods and (iii) to determine the dimensional characteristics of the defect.

The relevance of the automated processing was evaluated from ground truths established on a subsample of logs by using the following metrics:

- The precision is the quotient of the number of detected and real elements divided by the number of detected elements.
- The recall is the quotient of detected and real elements divided by the number of real element.
- F-Measure is the harmonic mean of both previous metrics.

**Key results** — The method for detecting the surface defects was rather insensitive to the possible complex shape of a trunk, and was auto-adaptative to the roughness of the bark which impede the detection of small defects when it is high.

- Concerning the number of 3D points belonging to a defect area, the ratios were close to 0.7 : precision 0.685, recall 0.74, F-measure 0.71.
- About the defect types, their identification made use of machine learning methods. Following a first test phase, for all defect types and for oak the ratios were close to 0.8 (Precision 0.767, Recall 0.861, F-measure 0.810) and respectively for beech (precision 0.440, recall 0.785, F-measure 0.533).
- For the dimensional characteristics of the defects, for instance the horizontal length occupied by the defect along the periphery and leading to a 115mm mean value resulting from manual protocol, the root mean square error (RMSE) resulting from the automated method was 106 mm.

Software developments linked to this work were integrated into the Computree platform, and have taken advantage of the library DGtal l http://dgtal.org.

**Main conclusions including key points of discussion** — The sensitivity of the method to the small defects is very dependent on the initial quality of the 3D point cloud, and in particular on the density of 3D points. In case of plot inventory, added to the problem of occlusion, it will be very difficult to ensure the results unless a minimal point density is guaranteed with respect to the defect size. However, these difficulties will vanish in case of grading roundwood in sawmill with a well suited trueshape scanner.

The detection method seems satisfactory, but it faces to the recurrent difficulty of the definition of the ground truth built from different measurements probably less controlled or less accurate.

The lower precision obtained for beech is paradoxically due to the higher sensitivity of the method resulting from the very low roughness of the beech bark, and which leads to the detections of irregularities on the surface like wrinkles of the bark which are not real defects.

**Future perspectives** — The improvement of the current results will require the improvement of the classifier in order to better identify the defects and to reject false positives. To reach that aim it will be necessary to enlarge the learning database in terms of number of defects by type and in terms of tested species.

The following stage should be to establish relationships between the external characteristics of the defects and the internal ones in order to go further in the quality assessment and to get closer to information delivered by X-Ray CT scanners.

**Valorisation** —

**Oral communication**

Van-Tho NGUYEN, Thiéry CONSTANT, Bertrand KERAUTRET, Isabelle DEBLED-RENNESSON, Bruno GARNIER, Alexandre PIBOULE, Francis COLIN. Oak epicormics: feasibility of detection by terrestrial Lidar. EPIC-IUFRO, 15-16 Septembre 2017, Nancy, France

V-T. Nguyen, B. Kerautret, I. Debled-Rennesson, F. Colin, A. Piboule, T. Constant. De la description 3D des bois ronds à la caractérisation des défauts internes: nouveaux savoir-faire et perspectives. Caqsis, 30 Mars 2017, Bordeaux, France

V-T Nguyen, T. Constant, D. Elhareth, A. Piboule, F. Colin. Grading of roundwood: Roughness analysis from T-Lidar data for detecting defects. Journée des Doctorants et Post-doctorants du LabEx ARBRE, 16 novembre 2015, Champenoux, France

V-T. Nguyen, B. Kerautret, I. Debled-Rennesson, F. Colin, A. Piboule, T. Constant. Détection de défauts à la surface du tronc d'arbres à partir de données T-Lidar. Atelier Lidar, 23-24 novembre 2016, Avignon, France

**Posters**

V-T. Nguyen, B. Kerautret, I. Debled-Rennesson, F. Colin, A. Piboule, T. Constant. Segmentation of defects on log surface from terrestrial Lidar data. Pattern Recognition (ICPR) "23rd International Conference on Pattern Recognition", 4-8 décembre 2016, Cancun, Mexique

V-T. Nguyen, B. Kerautret, I. Debled-Rennesson, F. Colin, A. Piboule, T. Constant. Algorithms and Implementation for Segmenting Tree Log Surface Defects. 1st Workshop on Reproducible Research in Pattern Recognition, 4 décembre 2016, Cancun, Mexique

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V-T Nguyen, T. Constant, D. Elhareth, A. Piboule, F. Colin. Analysis of roundwood surface for detection of inner defects. Silvilaser, 28-30 septembre 2015, La Grande Motte, France

**Publications**

Nguyen, V. T., Kerautret, B., Debled-Rennesson, I., Colin, F., Piboule, A., & Constant, T. (2016, December). Segmentation of defects on log surface from terrestrial lidar data. In Pattern Recognition (ICPR), 2016 23rd International Conference on (pp. 3168-3173). IEEE.

Nguyen, V. T., Kerautret, B., Debled-Rennesson, I., Colin, F., Piboule, A., & Constant, T. (2016, December). Algorithms and Implementation for Segmenting Tree Log Surface Defects. In International Workshop on Reproducible Research in Pattern Recognition (pp. 150-166). Springer, Cham.