FlexWood

Flexible Wood Supply Chain

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Annex to Del. 4.1: Description of tree and wood resources in the forest based on novel technologies

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SEVENTH FRAMEWORK PROGRAMME

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Annex

1. Results of the identification of bark features

As described in chapter 6.1. of the Deliverable points describing bark features are transformed into a coordinate system to visualize them by a height model. This bark surface model approach can also be applied to the whole stem. Figure 1.1 shows the branch-free part of a stem of one of the trees of the Karlsruhe test site.

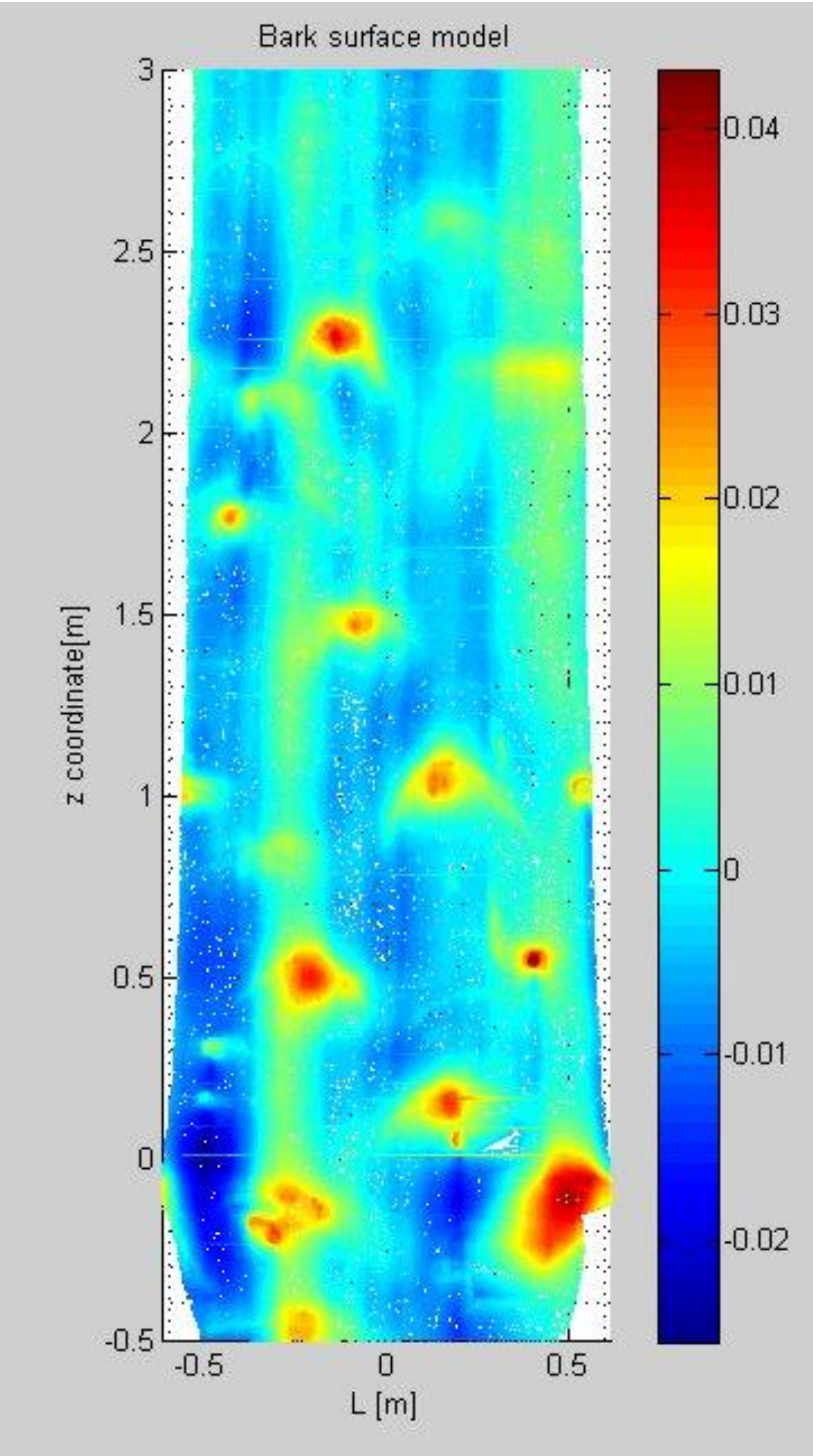

Figure 1.1: Bark surface model for part of a tree stem

The stem surface is visualized in blue. The darker the blue the lower the surface is. Elevations from the surface are visualized in yellow and then by red areas. Even this visualization presents the shape of branch seals and Chinese moustaches.

The scaling of the height is set automatically depending on the heights of the features in the section of the stem which is itself dependent on the number of cylinders visualized in the section. The quality of the model depends on the quality of the basic geometry, i.e. the cylinder approximating the stem. In our case it represents the basic geometry and no deviations. For this reason a rough approximation may deliver better results. We compared the results of the bark surface model with the intensity values of the terrestrial laser scans. The left hand side of Figure 2 shows the intensity values of a tree stem mapped on the approximating cylinders. The features which were manually measured by project partner FVA in Task 6100 are visualized with yellow crosses and numbered according to the correspondent numbering system. On the right hand side the bark surface model of nearly the same part of the tree stem is presented. It should be mentioned that the origin of the coordinate system is dependent on the transformation into the cylindrical coordinate system and does not comply here with the origin of the two-dimensional coordinate system of the mapped tree stem.

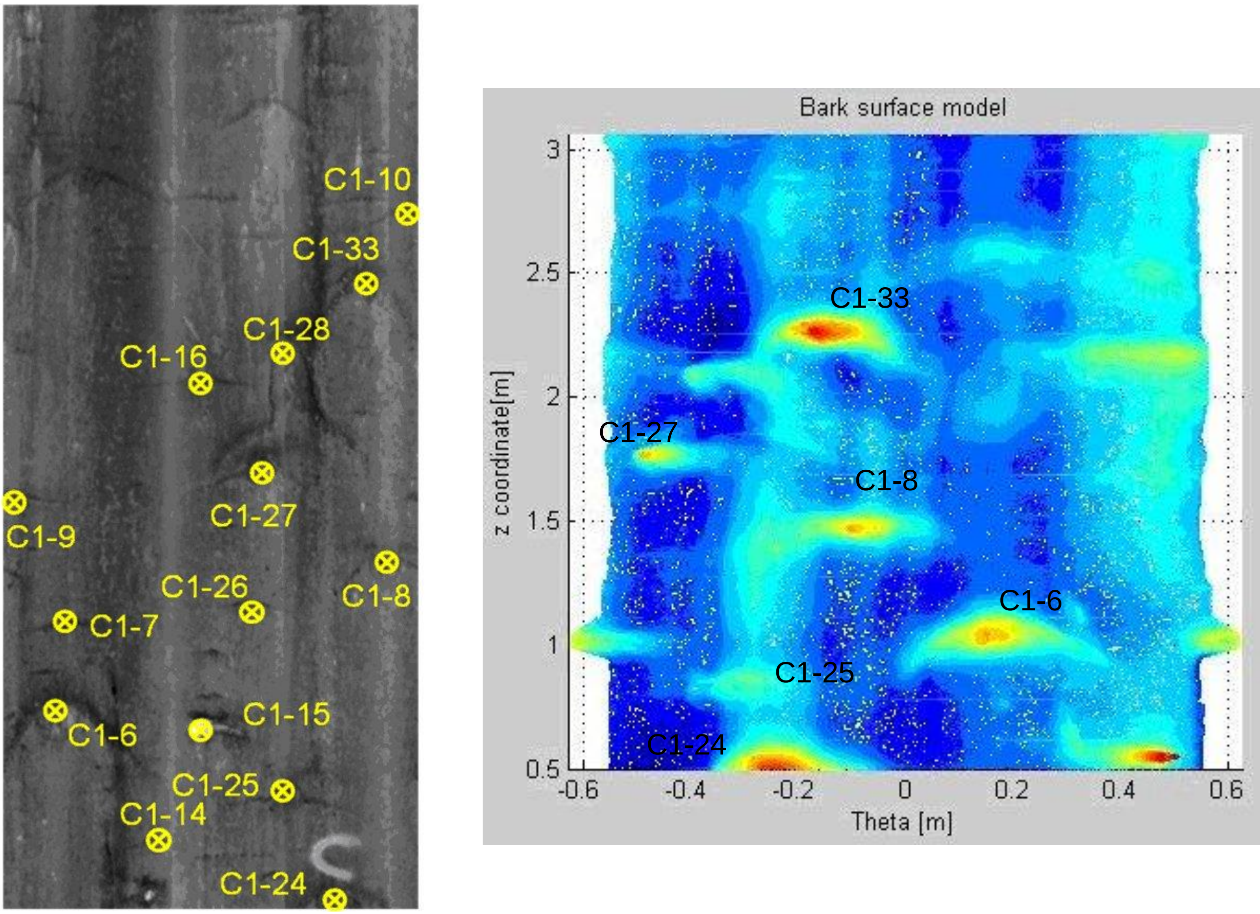

Figure 2: Mapping of the intensity values of the terrestrial laser scan data of a tree on the approximating cylinders (left) and the bark surface model (right) of nearly the same part of the tree (height of z=0.5 to z=3.06 m). The bark features are numbered according to the numbering of the manually measured features by project partner FVA in Task 6100.

This comparison shows that not all features are visible in the height model of the bark surface approach. The minimal distance above the approximated cylinder of our features identified so far is 1.2 cm. Even with double resolution in vertical and horizontal direction no further information could be gathered.

2. Measurement of the features

Based on the identification of the features height and width of branch seal and Chinese moustache were measured. These terms are explained in Figure 3 (source: FVA, Department of Forest Utilisation).

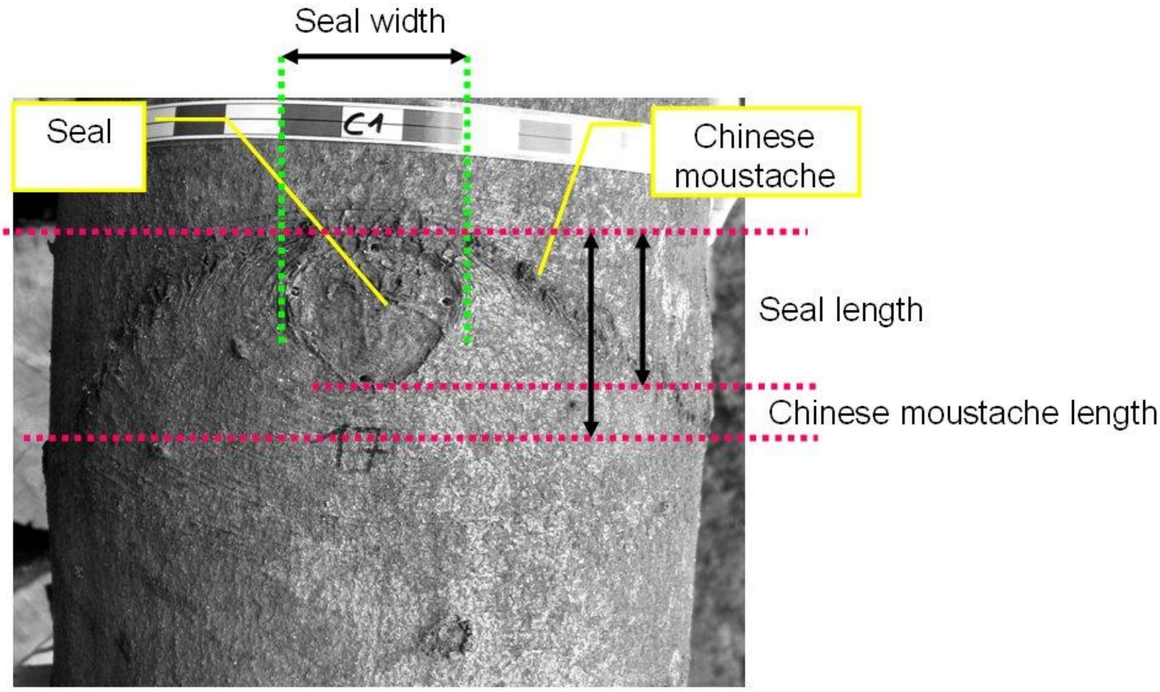

Figure 3: Definition of branch seal and Chinese moustache

The measurements of these bark features at four different trees were compared to the manual measurements of the same features done by project partner FVA in Task 6100. The differences between these measurements are visualized in Figure 4 in relation to the lengths of the measurements. Also the corresponding regression lines are presented here.

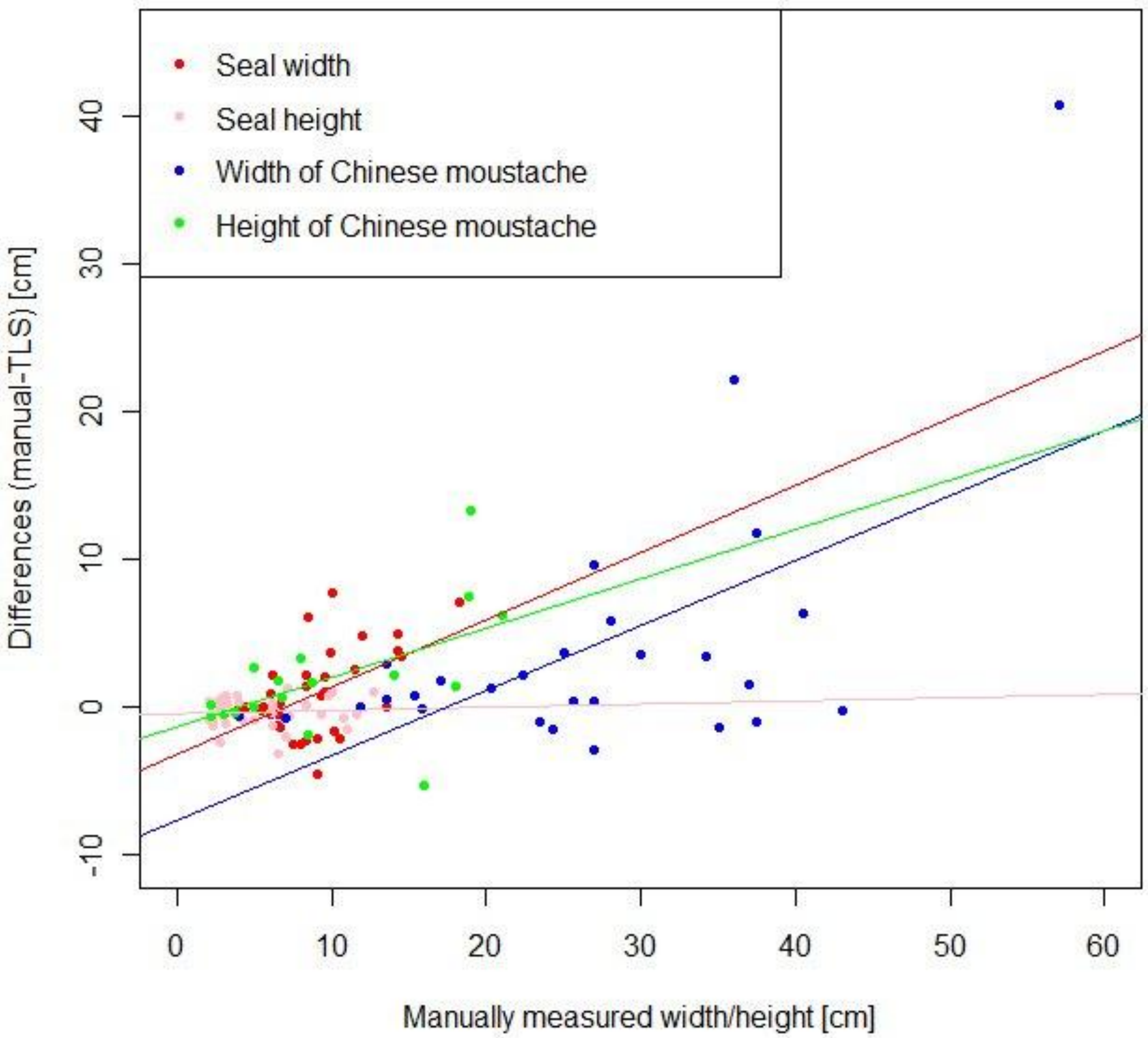

Figure 4: Differences between measurements by TLS data and manually measured values of bark features in relation to the manually measured width or height of the feature. The correspondent regression lines expressing the relationship are colored according to the color of the measurements.

It can be shown that the differences for width measurements of the Chinese moustaches are rather big (blue dots). The values for the length measurements of these feature are also the highest. It could be shown that neither the measurements in the intensity data nor in the bark surface models for these features achieve satisfying results. The reason is that the horizontal ends of Chinese moustaches are badly recognizable in both data sets, i.e. in TLS data per se. Our solution is that the easier recognition of the inner shape of a Chinese moustache should be used to extrapolate the shape on the ends of the Chinese moustaches (see chapter 3 below). Regarding the measurements of the branch seals, the slope of the regression line for height measurements is 0.02 and therefore close to the x-axis. These results are very promising. The width measurements do not match so well. The reason is that the horizontal borders while measuring them manually were identified inconsistently. Different persons in charge identified them differently so that the results do not reflect the real potential of TLS data by analyzing the width measurements of branch seals.

3. Automatic registration of the shape

To improve the measurements of the Chinese moustaches, an extrapolation of the shape by using the central points was applied to the data. To do so, the contour lines of the features are used to establish a functional model. The best results could be obtained by applying a Fourier approximation with degree 1 (for the interior run) and degree 2 for the run at the ends of the Chinese moustache.

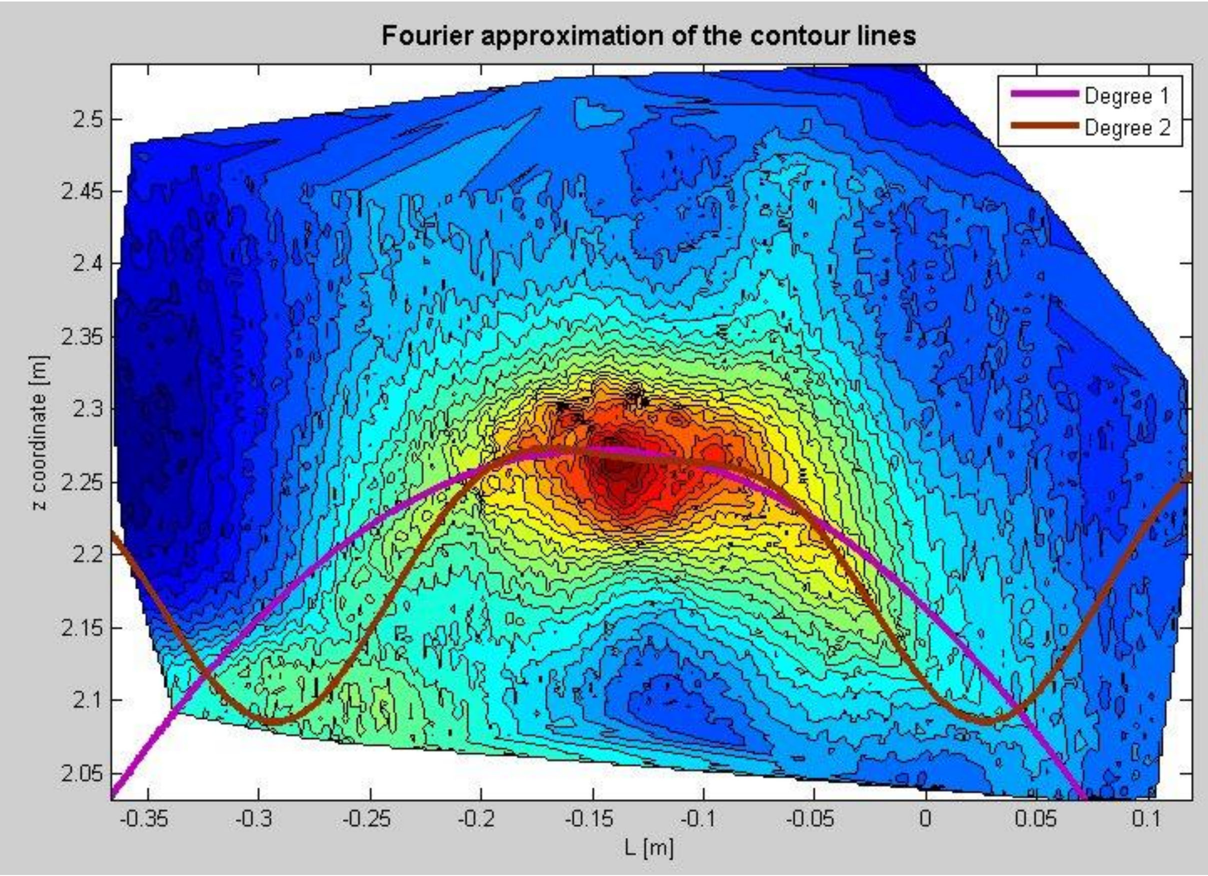

Figure 5: The shape of the Chinese moustache is interpolated by a Fourier approximation. It could be shown that the interior part is best approximated by a function with degree 1 and the outer parts by one with degree 2. The Fourier approximation of degree 2 is also used to extrapolate the end regions when no adequate information is available, e.g. the elevation of this part is not sufficient.

This automatic approach can be applied not only for the identification of the shape of the feature but also to enhance measurements (height and width).

4. Relation to inside defects

To predict inner wood quality of single trees a connection of exterior measurements of the branch seals out of TLS data with the inside quality of the log analyzed by a CT device was established. From four trees radial cuts were taken and manually measured in Task 6100. Here, the relationship between outside stem features and inside wood defects was confirmed by establishing the scar seal quotient (Stängle et al. 2012) which serves as an equation to predict inside wood defects by measuring the height and width of branch seals:

$$\frac{\text{Seal height}}{\text{Seal width}} = \frac{\text{Size of occluded knot}}{\text{Current radius}}$$

This relation was applied to the relationship between TLS and CT data (see Figure 6):

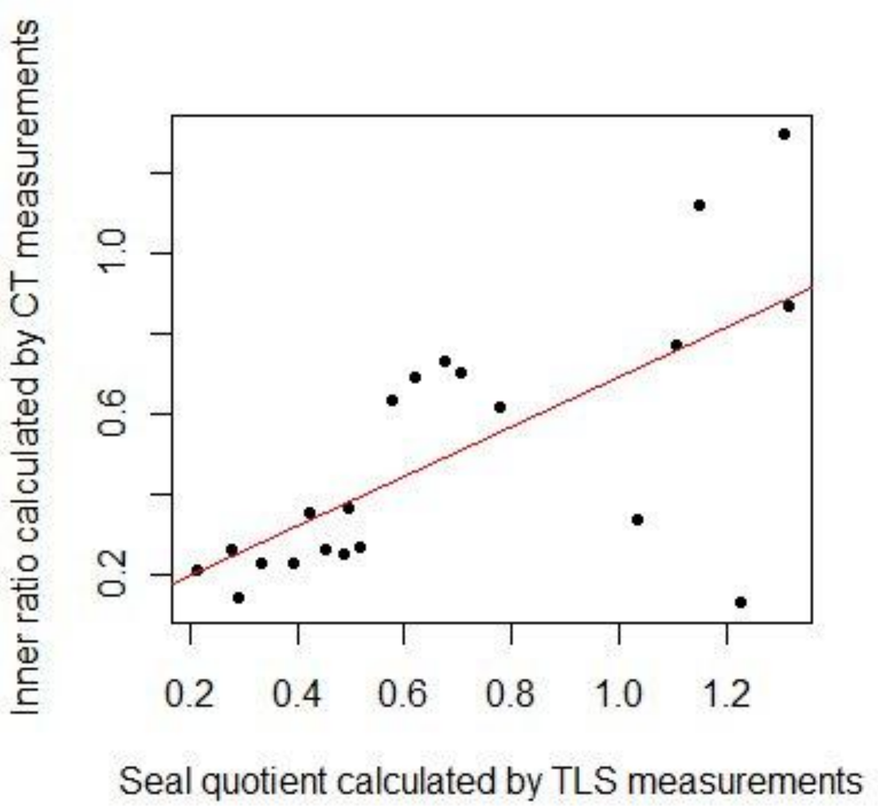

Figure 6: Relationship between the scar seal quotient calculated by measurements of TLS data and the ratio between inner knot size and log radius out of CT data

The dots represent the left and right side of the equation above. The left side is represented by seal height and width measured in TLS data whereas the right side was calculated by measurements in the CT data. A perfect result would be a regression line with a slope of 1. Here, the regression line shows an intercept of 0.07 and a slope of 0.62. This deviation is due to the quality of the digital data which does not allow identifying the borders of the exterior and the interior features as easily as by a person doing the measurements manually. Nevertheless this method does offer a starting point for a general evaluation of the inner quality of logs by analyzing TLS data.

5. References

Stefan M. Stängle, Franka Brüchert, and Udo H. Sauter (2012). Quality assessment of beech logs using CT-scanning technology. Proceedings of Hardwood Science and Technology: The 5th Conference on Hardwood Research and Utilisation in Europe 2012