

APPROACHES FOR RECOGNITION OF WOOD QUALITY OF STANDING TREES BASED ON TERRESTRIAL LASERSCANNER DATA

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ABSTRACT:

In this project the applications of terrestrial laserscanner for recording characteristics of quality of standing trees are examined. Furthermore it is investigated to what extent inhomogeneous bark structures, for example, branch scar, blind conk etc. can be recognized and so indicate the inner wood quality of a tree. The effects of the outward wood defects are explained by means of stems which were finished to sliced veneer. The interesting parameters are, for example, the expected block-, or rather, the log-length, the ovality in different heights, the volume of the log as well as brachiness, numbers and shape of the branch scars. This method of measurement hopes to contribute to the sustainability in value and enable approximate through-cut calculations of standing trees. This problem was exemplarily investigated by analyzing seven logs of the tree species European beech (*Fagus sylvatica*), oak (*Quercus spec.*) and wild cherry (*Prunus avium*). To detect the outward wood defects on the scanned trees the laserscans were unwound and analyzed. Firstly the trees were identified in the laserscanner data, and for every trunk, the diameters were calculated of the log ends. These diameters were averaged and yielded the diameter of the reference cylinder, which constitutes an ideal trunk. The scan coordinates were converted into picture coordinates by means of different transformation matrices. The result of this cylindrical unwinding is a 2D-picture for every scanned tree. These pictures were applied to another analysis software, which enabled an semiautomatic wood defect detection and classification. The software works with different image algorithms as well as with a neural network, so that the recognition rate of the software can be improved by reading of training data records, and furthermore, learn from each additional picture analysis. The result of the analysis was the corresponding classification of every wood defect as well as its location and expansion on the tree stems.

Through the combination of the results a “decision tree” is created, which later should support the cut calculation. For example, it is possible, that in the “decision tree” define how many branch scars of a specific diameter inside a specific log can be found for a defined quality, and that the result of the cut calculation’s software provides the corresponding dimension and the expected log volume.

1. INTRODUCTION

The measurement of externally visible wood defects of standing trees and their extent inside wood bodies is the theme of this work. Modern high precision laser scanner allow sound wood inventories which are based on directly measured wood defects like branch scars, curvatures or unevenness in the trunk surface. These inventory results

differ to the conventional inventory result categories (poor – satisfactory - good) quality (Mahler et al. 2001). The effects of the outward wood defects will be explained by means of sample stems which were finished to sliced veneer.

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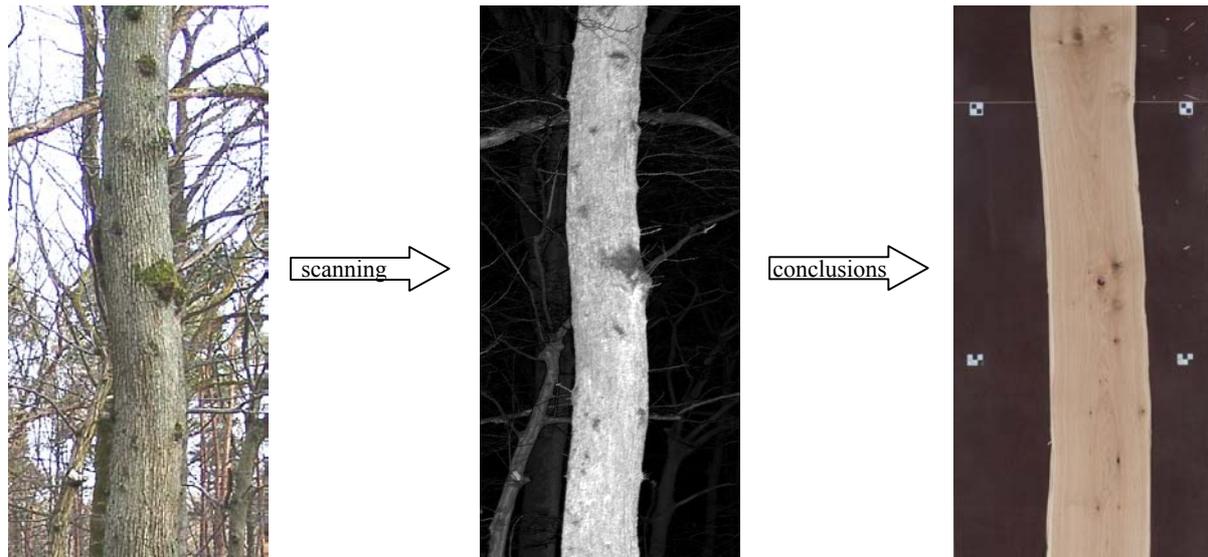


Figure 1. Clarification of the problem definition

2. INTENTIONS

In the context of this work, the applications of terrestrial laserscanner for the collection of price-determining quality characteristics of standing trees are examined. Furthermore, it is examined to what extent inhomogeneous bark structures, for example, branch scar, blind conk etc. can be recognized and so indicate the inner wood quality of a tree. The interesting parameters are, for example, the expected block-, or rather the log-length, the ovality at different heights, the volume of the logs as well brachiness, numbers and shape of branch scars. This method of measurement hopes to contribute to the sustainability in value and enable approximate through-cut calculations of standing trees. These information could help to reduce risks involved in wood quality assessment. Figure 1 demonstrates the process. On the left hand side there is an oak (*Quercus spec.*) of external bad quality. In the middle of the figure, there is a scanned oak; the picture resembles a black-and-white picture, however it's actually a three-dimensional scatter-plot in the area. Far distant points are darkly represented, and close lying points are brightly represented (Mettenleiter & Fröhlich 2000). On the right hand side of the figure, there's a sliced veneer from this oak. The aim of the study is to automatically locate the external wood defects in the laserscanner data which can be recognized directly by the human eye (see middle of the figure) and from this indicate the inner wood quality (right hand site of the figure) (Schütt et al. 2004).

This problem was exemplarily analysed on seven logs of the tree species European beech (*Fagus sylvatica*), oak (*Quercus spec.*) and wild cherry (*Prunus avium*).

3. LASERSCANNING OF STANDING TREES

First of all the single trees were scanned with the laser-measuring system IMAGER 5003 produced by Zoller + Fröhlich. A single tree would normally be scanned, from four locations, with a resolution of 10.000 x 5.000 pixels. In addition to the standard resolution, some trees were scanned with the maximum resolution of 20.000 x 10.000 pixels. The scanner points of view were selected in a distance of approx. 9-11 meters to the single tree and were aligned to the next scanner point of view at a right-angle. The orientation of the scan-recordings to each other occurred with tacheometric measured pass points, so-called targets. For each laser measuring point, the power of the reflected laser light as well as the distance or rather the position of the measuring point.

4. DETECTION OF EXTERNAL VISBLE WOOD DEFECTS

4.1 Preprocessing the scans

With the help of the software, "Scanalyser", the tree trunks, to be examined were extracted out of the laserscan data. In addition, different filters were applied to the respective laserscan data, and in doing this pixels were removed which had originated by a sharpening cut and thus were not clearly assigned in their position and intensity. Disturbing influences from neighbour trees, e.g. branches (see figure 2 at the top) were removed, so that only the trunk remains extracted (see figure2).



Figure 2. Tree trunk

4.2 Cylindrical unwinding of the laserscan data

4.2.1 Determining reference cylinder

In order to detect the external wood defects on scanned trees, the extracted tree trunks were unwound from the laserscan data over a reference cylinder.

The reference cylinder here represents an idealized tree trunk and was individually created for every tree which was to be examined. This cylinder was specified first with the help of the "Scanalyser" at the upper and the lower end of the tree trunk. In each case, a 10 cm thick layer was separated, representing a disc. A circle was adapted to the data of the layer and from this, the diameter as well as the position of the circle center were determined. This was accomplished both for the lower and upper layer. The diameter of the respective reference cylinder was determined by the mean of these two diameters.

4.2.2 Cylindrical unwinding

The data flow of a cylindrical unwinding is schematically represented in figure 3.

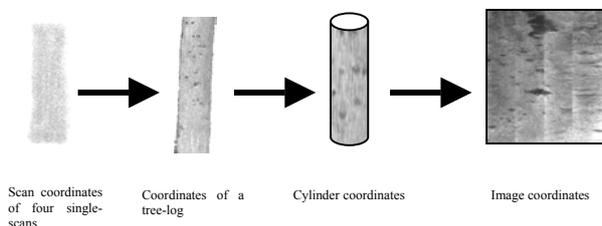


Figure 3. Data flow of a cylindrical unwinding

In a first step, the scan coordinates were transformed with the help of different transformation matrices into tree log coordinates. The tree log coordinate system here represents the fusion of the local coordinate systems of the four scans, from the respective scanned trees over the unwound trunk log.

Each scanning point of the log surface was converted from the Cartesian tree coordinate system into the cylindrical coordinate system of the respective reference cylinder.

As the stem surface is recorded from several points of view, the scatter-plots of the individual scans are overlapping. In general there is a tendency for, the quality of the scan points to decrease in the lap ranges regarding the accuracy of the position and intensity. Stripes are used to optimise scan points within the lap ranges. For each defined strip it will be determined which scan points will be used for the unwinding. The strips are defined by the bisectors of an angle of two neighbouring scanner points of view. For data collection the scanner points of view and the position of the reference cylinder are needed.

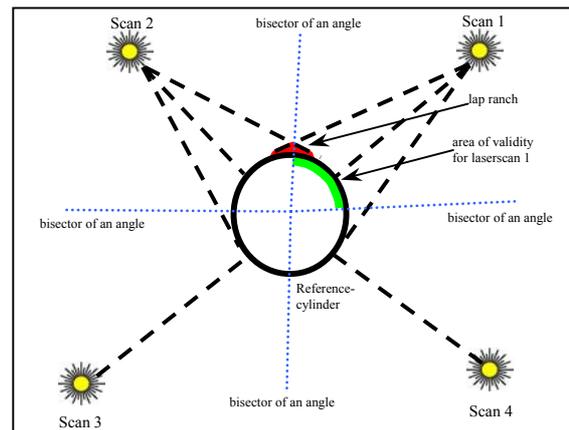


Figure 4. Area of validity of scanner point of view

For the calculation of the cylindrical coordinates, only the points (see figure 4), whose grid bearing on the reference cylinder lies between the bisector of an angle of the scanning points of view were used. In the last step of unwinding, the cylindrical coordinates are converted into image coordinates and saved onto specific format.

In the extraction of figure 5, you can see the result of an oak unwinding as an example. On the left hand side of the figure the unwound intensity image and on the right hand side the unwound range image is represented.

The intensity images are always represented as grey tone pictures and each intensity value is an assigned grey tone. Dark pixels correspond to a small intensity value and bright pixel to a high intensity value of the measuring points. Accordingly range images are also represented as grey tone pictures here, where a grey tone is assigned to each distance value, so that the measuring points with small distance are represented in black and large distance in white.

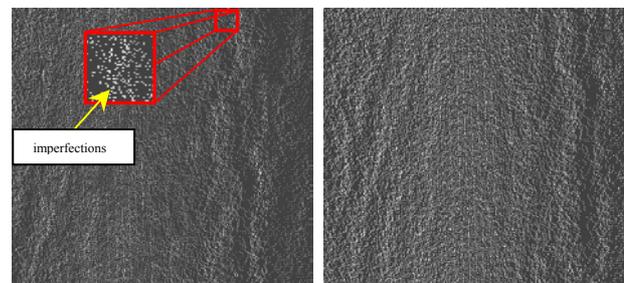


Figure 5. Cutout of an cylindrical unwinding; intensity image (left side), range image (right side)

4.2.3 Fine-tuning the unwinding results

As a result of the uneven distribution of the scan points on the stem surface, empty spaces appear in the reproduction on the reference cylinder. The value of a void is interpolated by the Inverse-Distance-Method (see figure 6). The value of a void is estimated by a weighted average of the nearest four measured grey tones neighbouring pixels.

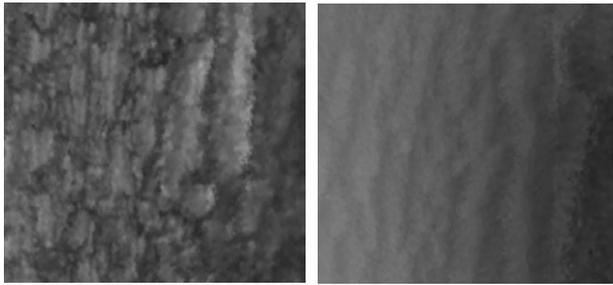


Figure 6. Result after interpolation; intensity image (left side), range image (right side)

The interpolated final results, the intensity as well as the range image of the cylindrical unwinding represent the input data for further analysis.

4.3 Detection and classification of wood defects

With the tool “WoodFlawFinder” it’s possible to do a semi-automatic wood defect detection and classification. The program takes the intensity and range image of an unwound trunk. It also minimizes high grey tone jumps at the “joints”. Which are the results of the unwinding of four scans onto one picture. With the grey tone values there is an automatic segmenting of the image in certain areas, where each represents a field of a potential wood defect (figure 7).

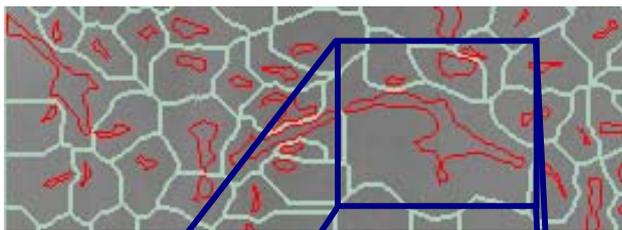


Figure 7. Result of segmentation

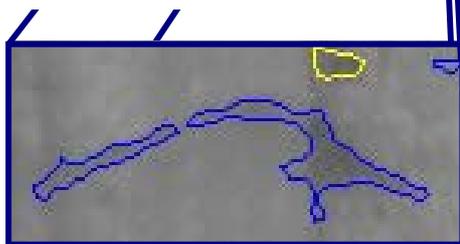


Figure 8. Detected and marked types of wood defects

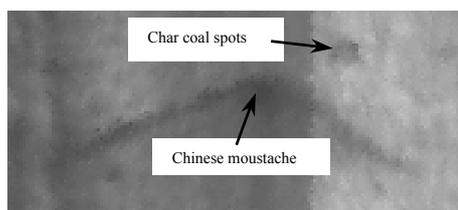


Figure 9. Types of wood defects

The fields of potential wood defects are marked red. The adjoined areas are marked green. For each field of a potential wood defect several characteristics were calculated e.g. intensity, roundness or the like. The software works with a neural network which receives the calculated characteristics as input data. The desired wood defect types were assigned to the neural network exits. It’s now possible to manually train the neural network. Potential error regions must be examined for possible wood defects types by the user and these are accordingly assigned. As soon as the training data record is applied, this can be used for the evaluation of other unwinding images allowing the evaluation of additional trees. Evaluation results stored in a data file contain the respective type of wood defect as well as expansion and position in the image. In figure 8 you can see an example of detected results. Figure 9 shows the wood defects, which are hidden behind the coloured marking from figure 8. Additionally, the system can learn by reading further training data records as well as manual corrections of the results. In the course of application, the quality of the analysis results can be improved. The data results were converted again into metric units and should go in the future into a cut calculation software.

5. CONCLUSION AND OUTLOOK

The work showed that it is possible to detect and classify wood defects in laserscans. In the near future, the results of the internal and external wood quality examination will be combined. From this study a “decision tree” will be provided which will later support a through-cut calculation. The “decision tree” is able to specify how many branch scars of a certain diameter may occur within a certain log for a defined quality. The through-cut calculation software supplies the appropriate dimensioning and the log volume results. In the future, it is conceivable the use this method in forest inventories, in order to better estimate the value of forest stands and to better guarantee sustainability of forest management. Regarding the use of value inventory, it is possible to combine these results with geographic information systems (GIS) to make market-orientated inquiries. These inquiries provide information about the specific quality and volume of a specific forest stand.

6. REFERENCES

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