Bark Measurements with X-Ray Technology

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ABSTRACT

Automatic measurement of log dimensions at the gate of medium and large scale sawmills in Germany and other countries in Central Europe is successfully established for many years. The scanner technology measures the dimensions of the logs at the debarked surface precisely. On this basis the wood volume is calculated without bark as a reference for the payment of the resource delivered by the forest owners. The use of this method in sawmills requires to debark the logs directly after the logs arrive at the wood yard of the mill due to the requested payment after short time. For some wood species and during the summer months it can be critical to store debarked logs because of fast degradation caused by discolorations due to fungi, cracks and insect damages. One possibility to overcome these problems of early debarking to date is to measure the logs over bark and subtract a bark estimate derived from a fixed table afterwards. This does not require debarking but on the other hand leads to a loss of precision with respect to the variation of bark thickness.

Application of automatic detection and measuring of the bark using x-ray technology allows to control and update the discounts in the bark tables, but more importantly to measure exactly the real volume of the wood at the mill site without prior debarking.

In this investigation, 96 logs of Norway spruce were tested to measure wood volume using x-ray technology. The logs were fully barked except for defined, exactly measured, rectangular shaped, debarked stem sections to test the system for accuracy of bark detection. Data were gathered by an industrial scanner with two x-ray sources installed in a sawmill in Austria. Algorithms extracting the bark thickness based on the form of the signal change at the edges of the logs were developed and tested. The manual reference values were obtained by measurements at four positions around the log each at the butt end, half length, and the top end of the logs. High correlations between the values computed by the algorithms and the manually measured values were found.

INTRODUCTION

Automatic measurement of log dimensions at the gate of medium and large scale sawmills in Germany and other countries in Central Europe is successfully established for many years. The scanner technology measures the dimensions of the logs at the debarked surface precisely. On this basis the wood volume is calculated without bark as a reference for the payment of the resource delivered by the forest owners. The use of this method in sawmills requires to debark the logs directly after the logs arrive at the wood yard of the mill due to the requested payment after short time. For some wood species and during the summer months it can be critical to store debarked logs because of quick degradation caused by discolorations by fungi, by cracks, and insect damages. One possibility to overcome these problems of early debarking to date is to measure the logs over bark and subtract a bark estimate derived from a fixed table afterwards. This does not require debarking but on the other hand leads to a loss of precision with respect to the variation of bark thickness.

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MATERIALS AND METHODS

Wood material

This investigation used 96 Norway spruce logs cut from 27 trees taken from two stands in the Swabian Alb in southern Germany. The logs were handled with such care to keep them in bark as much as possible during transport. After arrival at the mill each log was debarked at defined positions (small, rectangular areas) which were exactly measured in position, size, and shape. These areas were used to test the system for accuracy of bark detection. Between felling and all measurements there were at most five days in which the logs were stored to prevent them from drying, keeping moisture loss to a minimum.

Manual measurements

From each log circular shaped bark samples (Figure 1) with a diameter of 3 cm were taken at the butt end, half length, and the top end of the log. At each of these positions four samples were drawn evenly distributed around the log. The thickness of these samples was measured with a calliper immediately after extraction. From the twelve thickness values an average was calculated and used as reference value for the automatic procedures.

Figure 1. Circular shaped bark sample next to the position it was drawn

Automatic measurements

Data for the automatic procedure were gathered by a Microtec Tomolog®, an industrial scanner with two x-ray sources and corresponding detectors, installed in a sawmill in Austria.

From the raw data an attenuation image was computed and smoothed in longitudinal direction of the log. This resulted in an image where each row corresponds to the attenuation profile of the log at a certain position in longitudinal direction. The background was set to zero. A line with constant slope was fitted to the signal ascent on one side of the log and a second line to the descent on the opposite side of the log. From the length of the ascent/descent of the fitted line a first value for the bark thickness was derived. A constant offset was found during validation of the values for debarked areas. This offset was subtracted from every bark thickness value. Figure 2 shows the shape of a log with bark (continuous line) and the shape without bark (dashed line) which was calculated from the bark thickness derived by the method described.

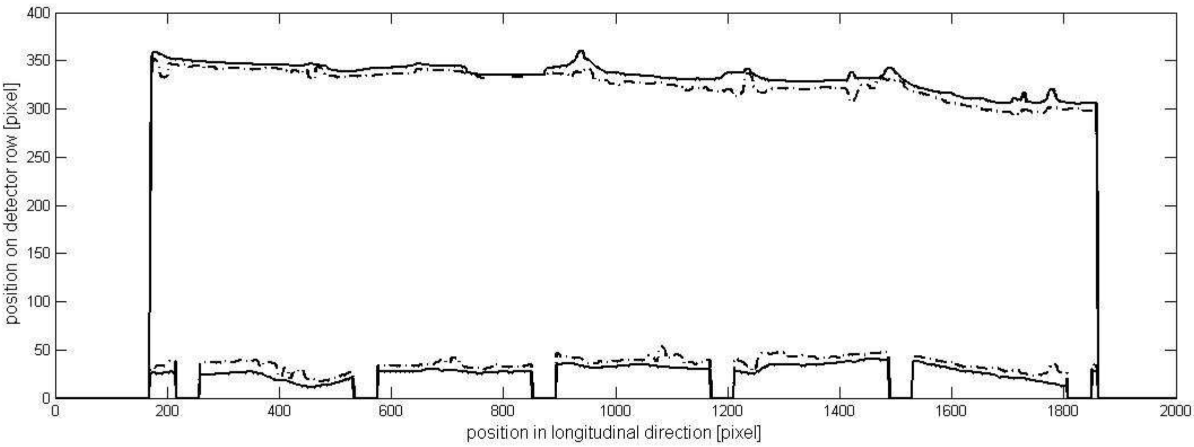

Figure 2. Shape of the log (continuous line) and of the recognized solid wood (dashed line); missing parts in the downer lines are caused by the conveyor where neither the outer shape nor the shape of solid wood can be detected

Due to knots or other defects outliers were produced in the calculation. To eliminate these outliers two methods were applied: bark thickness values over a certain threshold were eliminated, followed by the application of a median filter.

RESULTS AND DISCUSSION

With the methods described in the last chapter, the data gathered by the x-ray scanner were analysed and the results were compared to the manually derived data.

Statistical distribution of single bark measurements

The distribution of the automatically derived bark thickness for every position in every log was compared to the distribution of the 1152 (96 times twelve) manually gathered values. The main parameters are shown in table 1.

Table 1. Main parameters of the statistical distribution of the single bark measurements

	mean [mm]	std. dev. [mm]	minimum [mm]	1st quartile [mm]	median [mm]	3rd quartile [mm]	maximum [mm]
manual	6.0	1.5	3.2	4.9	5.7	6.9	14.1
automated	5.8	2.3	0.0	4.0	5.5	7.5	28.0

The mean value of all results obtained by the automatic procedure is similar to the manual one(5.8 mm compared to 6.0 mm), but the results have a higher standard deviation (2.3 mm in comparison to1.5 mm). One reason for that is that the range of the values in the automated measurements is broader which can be seen from the lower minimum and the higher maximum (0.0 mm and 28.0 mm for automated, 3.2 mm and 14.1 mm for manual measuring). But also for the central part of both distributions differences can be found. The range between first and third quartile is wider for automated measurements than for the manual measurements (between 4.0 mm and 7.5 mm compared to 4.9 mm and 6.9 mm). For the median likewise the mean a similar value for automatic and manual results could be achieved (5.5 mm / 5.7 mm).

One reason for the wider spreading of bark thickness values is that x-ray data includes errors especially in the rough conditions in a sawmill. Another reason is that in the automatic procedure every position is measured except for the conveyor positions and some eliminated values because of the threshold. This sums up to about 540’000 positions in contrast to 1152 positions of manual measurements. An increase of robustness against some wrong measurements is the consequence, but also a larger variety of values, because of the inhomogeneity of bark.

Measurements for whole logs

By averaging all values for one log, a single value (“automatic bark thickness”) was obtained for the automatic procedure. From the twelve manually gathered values per log the average was computed, too (“manual bark thickness”). Figure 3 shows the plot of manual versus automatic bark thickness.

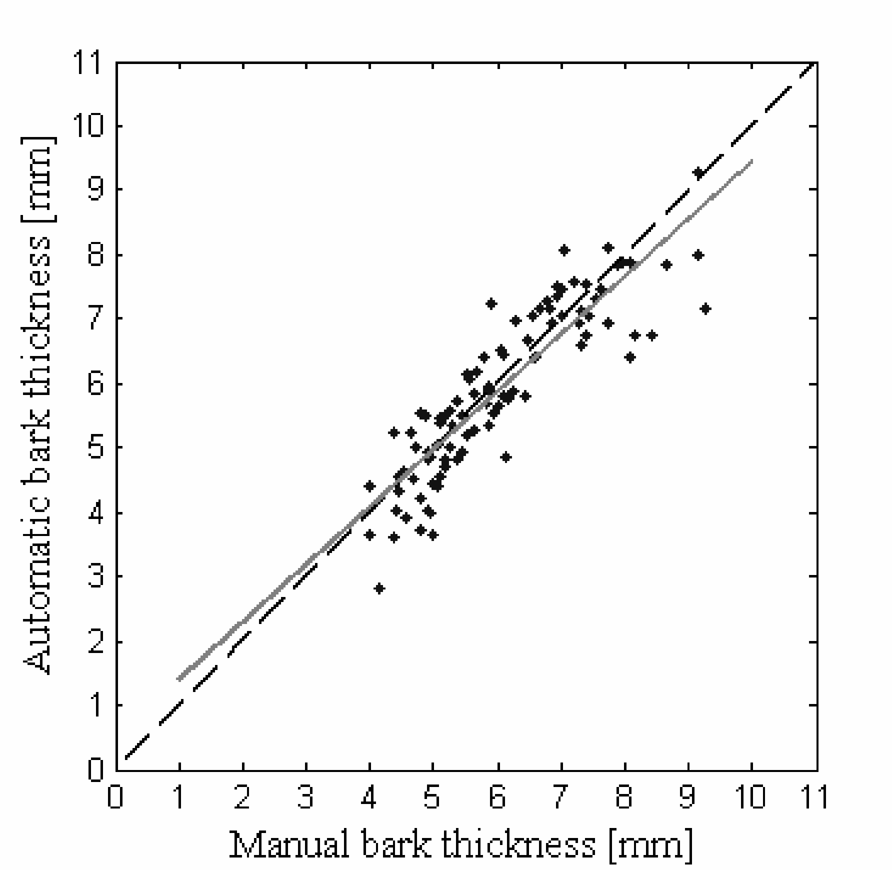

Figure 3. For each log manual versus automatic bark thickness is plotted

Each point corresponds to the average measurement for one log. The dashed black line is the optimum where manual and automatic values are equal, and the continuous grey line is the best linear fit. The quadratic mathematical correlation (R^2) between the manually and the automatically derived results is 0.78 (where total correlation leads to a value of one; no correlation to zero). The average absolute difference between manual and automatic bark thickness is 0.49 mm.

CONCLUSIONS

This investigation shows that for the observed logs with x-ray technology a bark measurement can be carried out which is on average less than half a millimetre different from the manual reference value. Up-to-now the procedure was only applied to data recorded on one day and logs from two stands. A verification with an independent test is in progress.

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