Fingerprint traceability of sawn products using x-ray log scanning and sawn timber surface scanning

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ABSTRACT

Traceability in the sawmilling industry is a concept that could be used to more effectively control the production process and the utilization of the raw material. The fingerprint approach is a traceability concept that rests on the idea that every piece of wood is a unique individual with unique properties and hence can be identified and separated if a sufficient number of these properties are measured accurately enough. This study was hosted by a sawmill in northern Sweden and was aimed at making the fingerprint connection between logs and the center yield sawn from those logs using length and knot information. The 140 logs involved in the study were of Scots pine with top diameters spanning the range from 153 to 213 millimeters. The center yield sawn from these logs was of two dimensions. The smaller logs (153–187 mm) were sawn with a 2 ex pattern to 50 by 100 mm, and the larger logs (174–213 mm) were sawn to 50 by 125 mm with a 2 ex pattern. The data from the logs were collected at the log sorting station by an industrial one-directional x-ray log scanner in combination with a 3-D optical scanner. The data from the sawn center yield were collected by an industrial cross-fed surface scanning system situated in the sawmill's green sorting station. Both systems are used in the sawmill's normal continuous production. The results show that over 90% of all planks could be matched to the right log, which bespeaks a great potential for further development and realization of fingerprint tracing as a tool for process control and process improvement.

INTRODUCTION

Modern forestry and sawmilling companies often have sophisticated measurement equipment that generates large quantities of data at an individual level. These data are collected at certain points along the production chain, but are unfortunately almost exclusively used as a means to control the production process close to the measurement point. Most of the generated data for a specific piece of wood is therefore discarded as soon as the piece has moved past the measurement point. If the data for each specific piece were to be collected and stored in a database, the final product could then "be considered as an information intensive product" (Uusijärvi 2003). The challenge is therefore not to generate data, but to connect the generated data to each individual piece of wood. The reconnected data would make it possible to investigate and analyze both large and small sections of the production chain. A good example is the connection between the diameter classes for logs in the log sorting station and the volume recovery of sawn planks and boards. Without reconnection of data, one is reduced to comparing physical properties for a larger group of logs with the physical properties of their planks and boards. With traceability, i.e., reconnection of data, one is given the opportunity not only to analyze and find the individual logs in the group that yield high recovery, but perhaps even more importantly, to find the logs in the group that yield low recovery for a specific sawing pattern. Being able to make this distinction then makes it possible to adjust process parameters such as log class limits or sawing patterns for an overall higher recovery.

Since sawmills have a diverging flow, and modern sawmills have high production speed, the tracing and storing of data is not well suited for manual labor. A better alternative for handling the tracing and tracking is some form of automated identification (McFarlane and Sheffi 2002). One way of identifying individual pieces of wood is to use the already existing measurement data and make identification by means of the fingerprint approach (Chiorescu 2003). The fingerprint approach rests on the foundation that each piece of wood has unique individual features. These can be both outer and inner features. If these individual features could be measured accurately enough, it would then be possible to identify individual pieces in the production chain in the same way that human beings can be identified by the use of their fingerprints. The purpose of this study is to investigate whether the important individual connection between log and sawn center yield can be made by using the fingerprint approach based on length and x-ray information from the log sorting station and on length and surface scanning information from the green sorting station.

MATERIALS AND METHODS

The sawmill that hosted this study is a large-size mill situated in northern Sweden with an annual production of approximately 400,000 m^3 of sawn timber. The sawmill handles only Scots pine (*Pinus sylvestris*), which was also the only species included in this study. The 140 logs that were involved in the study were randomly chosen and had top diameters spanning the range from 153 to 213 millimeters. These logs were all sawn with a 2 ex pattern into two different center yield dimensions. The smaller logs (153–187 mm) were sawn to 50 by 100 mm, and the larger logs (174–213 mm) were sawn to 50 by 125 mm, making a total amount of 280 sawn center yield pieces. The sideboards produced were not included in the study.

The data used in this study were gathered at two points in the production chain from systems that are used in the sawmill’s daily production. The first point was the sawmill’s log sorting station where data from the logs were gathered with a one-directional x-ray log scanner from Rema Control AB in combination with a 3-D optical scanner from MPM Engineering Ltd. The data extracted from these systems were the log’s total length according to the 3-D scanner and the position and length of the log’s knot whorls according to the x-ray log scanner. The second point of data gathering was a Finscan Boardmaster surface scanning system situated at the sawmill’s green sorting station. The total length and the positions of surface knots were recorded for each of the sawn planks. The order in which the logs and planks passed the measurement systems was written down manually from the end surfaces, which had been stamped with identification information (Skog and Oja 2007).

The analysis of the gathered data was performed using MatLab 7.3 (The MathWorks 2007). The first step in the analysis was to investigate the correlation between the total length measurements from the log sorting and green sorting stations. This was done by calculating the mean and standard deviation values for all the logs’ lengths minus their corresponding planks’ lengths. Once the length correlation was known, an algorithm was constructed to perform fingerprint matching between logs and planks. The algorithm was designed to work in a three-step sequence. The first and second steps in the sequence read the data into two matrices, first from the logs and then from the planks. Each row in the log matrix contained the identification, the total length and the starting position and length of all knot whorls found in the specific log. The information in the plank matrix was setup in the same way, with the difference that it contained the lengthwise starting point and length of all surface knots found on the planks. Due to edge effects in the filter, the x-ray log scanner needs a short distance before it starts registering information. Therefore, knots that were situated within 200 mm of the top and butt ends of the planks were disregarded.

The third and final step of the sequence was the actual matching procedure. The algorithm worked iteratively by taking one plank at a time and comparing its surface knot positions with the positions of knot whorls in all logs that had passed a length filtering. The length filter only allowed logs with a total length within a span based on the length correlation mean and standard deviation. The final matching was then made between the length-filtered log and the actual plank that showed the highest agreement in knot positioning. When all planks had been iterated, the total percentage of correct matches was calculated.

In order to find well-working settings for the algorithm, different values were tested for the log length filter as well as for the distance over which knots were disregarded at the plank ends. These values were between 3 and 10 cm for the length filter and between 100 and 400 mm for plank end disregarding.

RESULTS

Figure 1 and figure 2 show how the agreement in the planks' surface knots and the logs' knot whorls can be used to pair together a certain plank with a certain log.

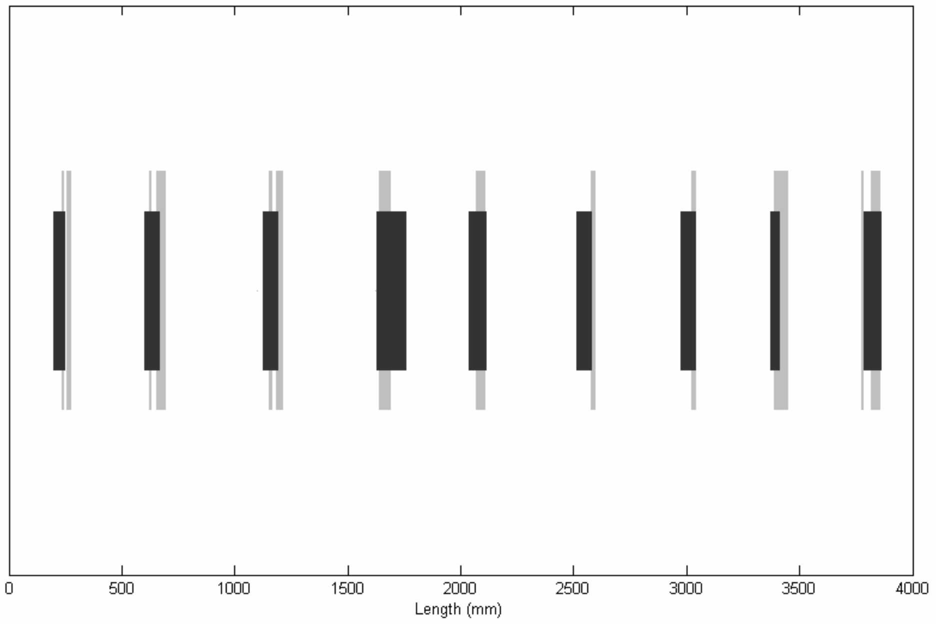

Figure 1. A correct match shows good agreement between the plank's surface knot positions (light gray) and the log's knot whorl positions (dark gray).

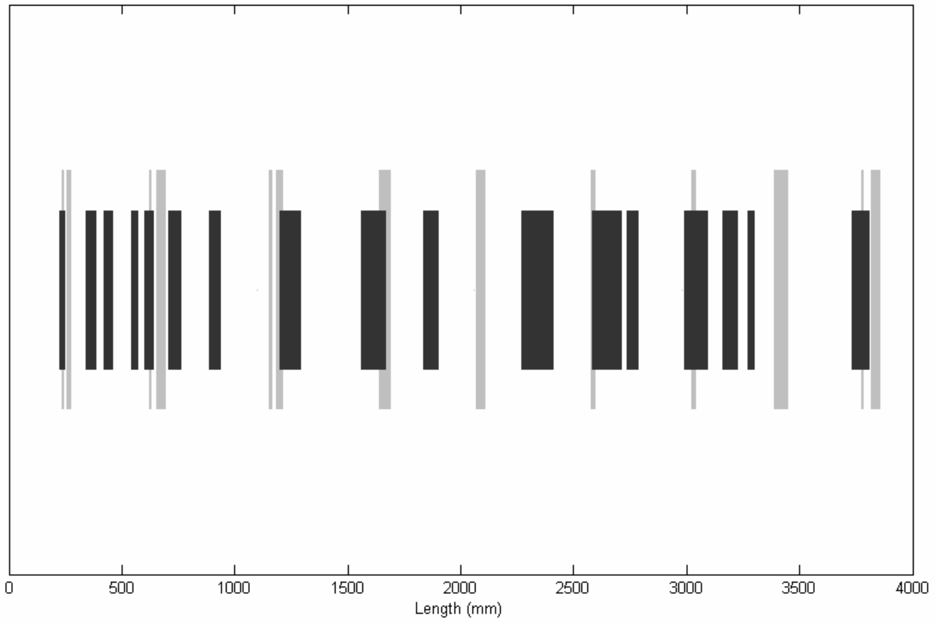

Figure 2. An incorrect match shows poor agreement between the plank's surface knot positions (light gray) and the log's knot whorl positions (dark gray).

The results from the fingerprint matching are positive, with a total correct matching percentage of approximately 90%. The length correlation between log sorting and green sorting station gave a mean value of -1.2 cm and a standard deviation of 1.6 cm. This means that the planks are in general measured slightly more than one centimeter longer than their corresponding logs and that the correct log, with very high certainty, is to be found within +/- 5 cm from the planks length minus 1.2 cm. The testing of different values for the log length filter and plank end disregarding didn't give any drastic results on the total percentage of correct matches. The percentage hovered slightly over and under 90% with the different values.

When basing the settings for the log length filter on the length correlation to +/- 5 cm (with mean correction) and using the original setting of 200 mm for plank end disregarding, a total of 92.5 % of the 280 planks were matched to the correct log.

DISCUSSION

With promising results like this, one can look forward to what might lie ahead for this method of tracing. One interesting spinoff is the ability to follow up if changes in process parameters such as, for example, log class limits have had the desired impact on the sawn product. Another idea is to use the fingerprint connected data to develop sorting models for the log sorting station, i.e., finding the outer and/or inner characteristics of the logs that yield a specific quality and/or volume recovery.

This study was conducted on Scots pine only. It's therefore hard to say how the fingerprint tracing approach would work on Norway spruce (*Picea abies*) which is the other main species of wood sawn in Sweden. Initially, it is thought that it will probably be more difficult, since Norway spruce doesn't have as clearly defined knot whorls as Scots pine because branches also grow in between the main knot whorls in the living tree. It would, however, be very interesting to investigate the possibilities of tracing Norway spruce with this method.

CONCLUSIONS

The results show a high potential for further development and realization of fingerprint tracing between log sorting and green sorting into a practical application for process control and process improvement.

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REFERENCES

1. Chiorescu, S. (2003): *The forestry-wood chain, Simulation technique-Measurement accuracy-Traceability concept*. Doctoral thesis 2003:03. Luleå University of Technology, Skellefteå, Sweden.
2. The MathWorks (2007): The MathWorks, Inc., 3 Apple Hill Drive, Natick, MA 01760-2098, United States. <www.mathworks.com>.
3. McFarlane, D. and Sheffi, Y. (2002): The impact of automatic identification on supply chain operations. *International Journal of Logistics Management*. 14(1):1–17.
4. Skog, J. and Oja J. (2007): Improved log sorting combining X-ray and 3D scanning –a preliminary study. Proceedings of the COST E53 Conference on Quality Control for Wood and Wood Products, Warsaw, 15–17 Oct. 2007.
5. Uusijärvi, R. (2003): *Linking raw material characteristics with Industrial Needs for Environmentally Sustainable and Efficient Transformation processes (LINESET)*. QLRT-1999-01476 Final Report. SP Technical Research Institute of Sweden, Wood Technology, (SP Trätek). Research Report no. P 0309034.