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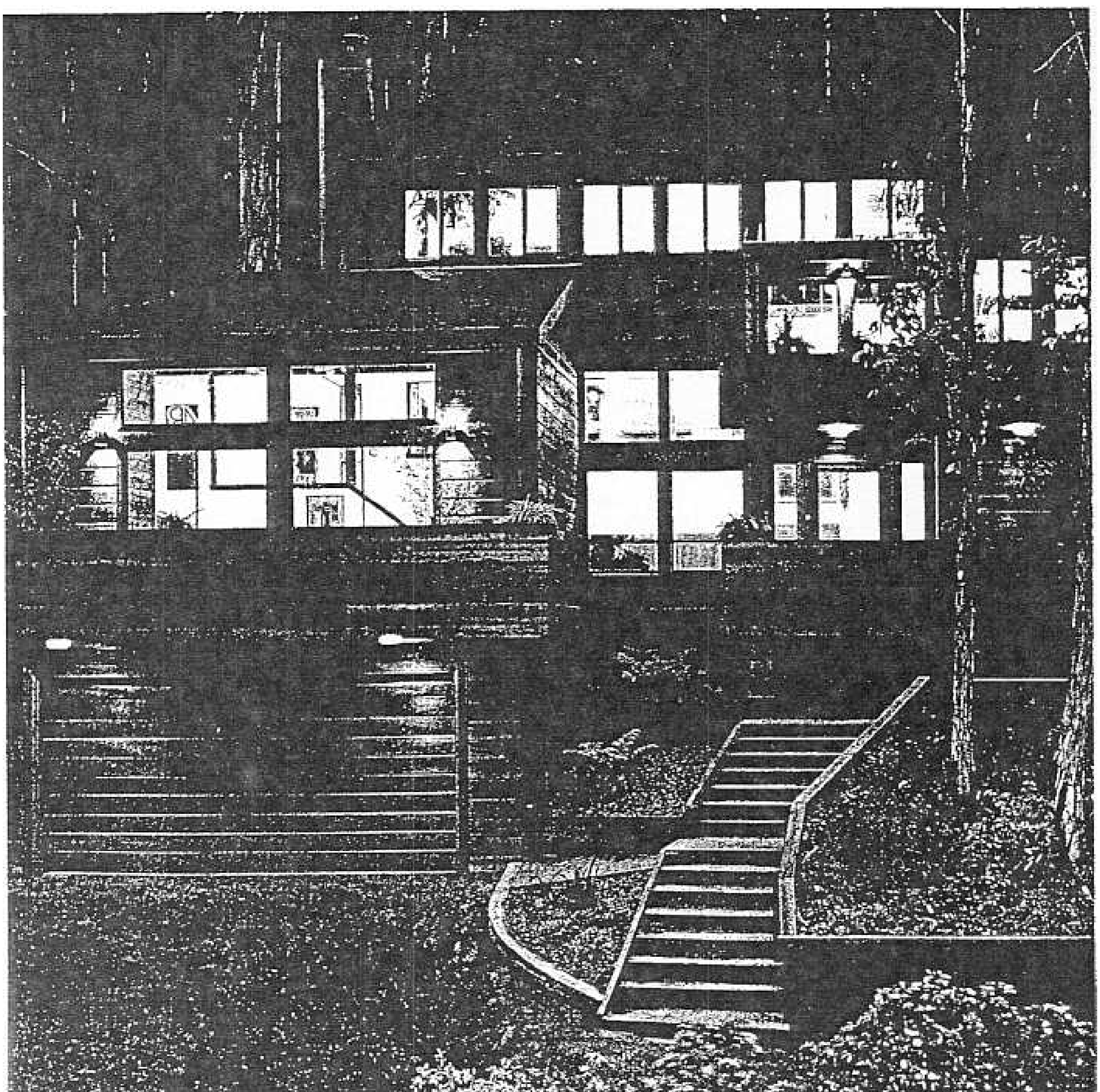

Ultrafast CT scanning of an oak log for internal defects

Technical Note

Francis G. Wagner
Fred W. Taylor
Douglas S. Ladd
Charles W. McMillin
Fredrick L. Roder

Abstract

Detecting internal defects in sawlogs and veneer logs with computerized tomographic (CT) scanning is possible, but has been impractical due to the long scanning time required. This research investigated a new scanner able to acquire 34 cross-sectional log scans per second. This scanning rate translates to a linear log feed rate of 85 feet (25.91 m) per minute at one scan each 0.5 inch (1.27 cm). This speed approaches that required at commercial sawmills and veneer plants.

In modern sawmills and veneer plants, scanners are used to determine the size and shape of logs. This information is processed by computer to select the sawing or slicing pattern and sometimes the log orientation that will maximize volume recovery (7). However, such systems do not have the capability of maximizing lumber or veneer grade.

Evidence, based on assumed knot location or on actual location of knots in a few logs, shows that knowledge of defect locations can be used to increase the grade of lumber sawn from logs (12,13,15,17). These studies have shown that the average value of lumber sawn from both hardwood and pine logs may be increased by as much as 7 to 21 percent by selecting the optimum log orientation and sawing pattern.

The technology for scanning logs for internal defects exists, and industrial scanners can be developed (1,3,11). A new ultrafast computerized tomographic (CT) medical scanner that can acquire 34 cross-sectional log scans per second is operational. This project evaluated the potential of this scanner for detecting defects within hardwood logs.

Previous work

The CT technique has become widely recognized because of its use in medical imaging (10). Since its commercial introduction just 16 years ago, CT has become the most widely used method of obtaining three-dimensional information on patients and is used in every major hospital within the United States (6).

The first commercial CT scanner (developed in 1973) was quite slow, requiring about 4 minutes per scan. Multiple detectors in second-generation translate-rotate geometry scanners reduced scan times to around 20 seconds. Third and fourth generation (rotate only) machines eliminated source-detector translation and reduced scan times to about 1 second. This speed approaches the minimum attainable in rotating scanners. Centrifugal stress resulting from rotating significant mass around an object as large as a log limits rotation speed and resulting scan time. Despite its slow speed, a number of researchers have investigated various CT scanning techniques to detect defects in logs and other wood products (2,4,5,8,9,14).

More rapid scanning is now possible because of a scanning electron beam CT scanner developed by Imatron, Inc., South San Francisco, Calif. (1,3,11). In the ultrafast mode, the Imatron C-100 scanner acquires a pair of anatomically contiguous slices at the rate of 34 images per second.

The scanner achieves fast scan times by eliminating all moving parts. It generates a moving x-ray fan by scanning a highly focused electron beam along semicircular

The authors are, respectively, Associate Professor, Professor, and Research Assistant, Mississippi Forest Prod. Util. Lab., P.O. Drawer FP, Mississippi State, MS 39762; Principal Wood Scientist, USDA Forest Serv., Southern Forest Expt. Sta., P.O. Box 5500, 2500 Shreveport Hwy., Pineville, LA 71360; and Director of New Product Development, Imatron, Inc., 389 Oyster Point Blvd., South San Francisco, CA 94080. This paper was received for publication in October 1988.

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Figure 1. — A 2-foot (0.61-m) log section being prepared for scanning in a C-100 ultrafast CT scanner. Cross-sectional scans were made at the rate of 34 scans per second.

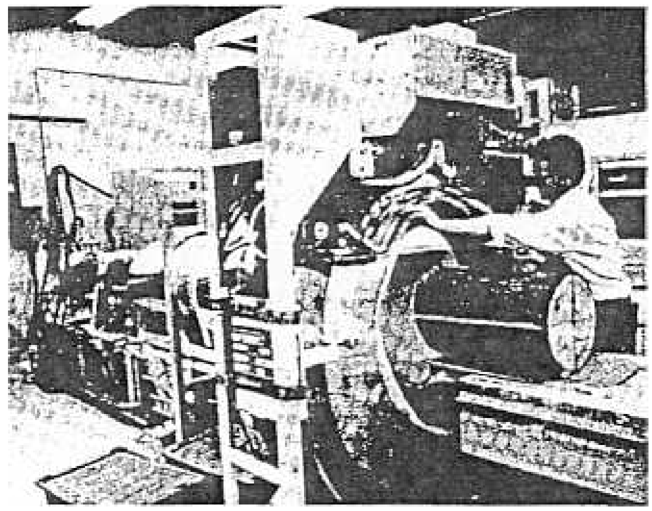

Figure 2. — An ultrafast CT image of a typical cross-sectional slice of the study log. The location of knots, holes, and pith can be seen in the image.

(210 degree) tungsten targets that partially surround the object to be scanned. The scanner acquires data with a solid-state detector system, converts it to digital form, and sends it via fiber optic cables to a 32 megabyte dual-ported high speed bulk memory. An array processor and back-projector reconstruct the images in approximately 5 seconds.

The ultrafast image matrix is 256 by 256 with an 18.9-inch (48-cm) diameter reconstruction circle. Modification of the C-100 system to function in a commercial sawmill environment would be relatively straightforward. In order to reconstruct images at the image acquisition rate of 34 images per second, the resolution would have to be decreased by a factor of 2 and a 128 by 128 reconstruction matrix utilized. Thus configured, the scanner would be capable of handling logs up to 15 inches (38.1 cm) in diameter.

Procedure

A grade 2 (USDA Forest Service hardwood log grade (16)), 15-inch (38.1-cm) diameter, 12-foot (3.66-m) water oak (*Quercus nigra*) log was selected for the study. The log was crosscut into six 2-foot (0.61-m) sections and shipped to the laboratories of Imatron, Inc., in South San Francisco, Calif. The log sections were scanned at 0.31-inch (8-mm) intervals (Fig. 1). A total of 456 cross-sectional scans were made in the ultrafast mode. Ultrafast scan images (tomograms) were produced on an imaging workstation.

After scanning, the six log sections were shipped to the Mississippi Forest Products Utilization Laboratory. The log sections were physically crosscut into 0.31-inch (8-mm) disks (includes sawkerf) near the tomographic slice planes for validation of the CT images.

Results and discussion

Figure 2 shows an ultrafast CT image of a typical slice of the study log. Note that defects such as knots, holes, and pith can be seen in the CT image. Defects appear as light or dark patches or as breaks in normal growth rings of the log. Quantifying the accuracy of the CT images was not attempted. However, visual inspection of the 456 ultrafast CT images and the log slices showed that literally all log defects could be seen.

The eventual goal of this research is to develop a commercial scanning system that distinguishes defects from clear wood within logs and uses this information to improve lumber or veneer grade yield at the headrig and resaw or at the veneer slicer. This study has shown that defects can be seen in ultrafast scan images of logs and that scan data can be collected at commercial speeds. Because defects can be seen, the development of image analysis techniques to automatically distinguish defects from clear wood should be possible. Some image analysis work has already been done (5,14). However, additional work is necessary to improve both the speed and accuracy of these image-analysis procedures before the commercial application of ultrafast CT scanning of logs will be possible. Incorporation of internal log defect information into process control algorithms to optimize lumber or veneer value is also needed.

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