INCREASING PRODUCTIVITY

SCANNING SYSTEM

TECHNOLOGY WORTH A LOOK

Today's experimentation with X-ray machines and color cameras may offer tomorrow's rough mill operators an option for attaining higher yields.

Editor's note: *In an effort to help automate the inspection for lumber defects, optical scanning systems are emerging as an alternative to the human eye. Although still in its infancy, scanning technology is being explored by machine companies and universities. The following article was excerpted from "Machine Vision Systems for Grading and Processing Hardwood Lumber," by Philip A. Araman and Daniel L. Schmoldt, USDA Forest Service, Southern Research Station; Richard W. Conners, Bradley Dept. of Electrical Engineering; and D. Earl Kline, Dept. of Wood Science and Forest Products. Their report is based on scanning technology research conducted at Virginia Tech University in Blacksburg, Va.*

The manufacture of furniture, cabinets, flooring, millwork and mouldings, along with hardwood lumber exports, accounts for most high- and medium-grade hardwood lumber consumption. Systems are needed that will allow hardwood processors to automate, increase product volume and value recovery, and reduce costs when processing lumber.

Recent industrial trends are to modernize rough mills to improve yields and reduce rejects and part costs. Many would like to take the next step toward complete automation. Furthermore, in a recent survey (Bush et al. 1990), hardwood lumber customers reported several major concerns: 1) inaccurate lumber grading by producers; 2) inconsistent lumber thickness; and 3) poor quality of purchased lumber.

To keep and satisfy hardwood lumber customers, hardwood sawmillers need to improve the accuracy of their lumber grading and provide consistent, high-quality products.

Machine vision systems and computer aided processing systems hold promise for solving the problems of hardwood sawmillers and furniture, cabinet and dimension manufacturers. Automated systems could improve production, increase productivity, improve raw material utilization, reduce costs, improve marketing and accurately grade lumber. This report focuses mainly on machine vision systems for lumber grading and processing.

Automated grading and processing

Developing automated systems for grading, describing potential furniture cuttings in hardwood lumber, and providing that information to control rough mill processing are the goals of our research. A key to the success of this work is the ability to automate the detection of defects on boards. Defects must be located, properly sized and identified. For the sawmiller, value can be improved by proper edging and trimming. Software can be used to select the edging and trimming lines to maximize board value, and in many cases, produce a larger board with more furniture cuttings.

In most secondary hardwood processing mills, boards are either cut along their length (rip first) or cut across their length (crosscut first) as a first cutup operation. Both options are normally not available. The complementary cuts needed to get clear wood cuttings and to remove defects normally are made in subsequent operations. One of the biggest advantages of automated computer scanning can be realized if the choice of ripping or cross-cutting first is based on the characteristics of individual boards and their defects.

A system composed of scanning, grading and analysis would generate packages of computer-graded and barcode-marked lumber. Computer discs which would accompany shipments of lumber. Grade mix, total board footage, potential yield in cuttings, and potential distribution of cuttings would be provided.

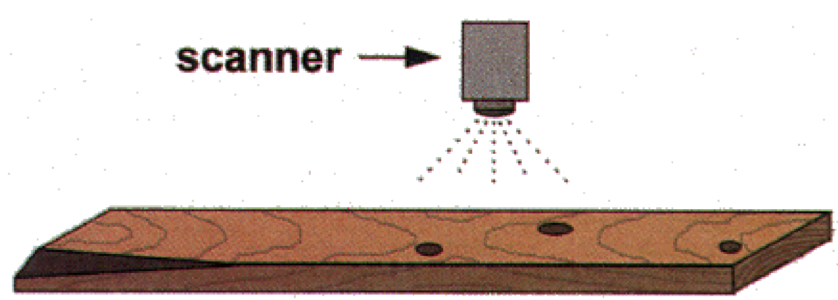
The lumber user could pull the information on each board off a supplier-provided computer disc or re-scan the lumber. Either way, this information would be used to make cutup decisions at the rough mill.

For a number of reasons, the machine vision system is the most difficult component to design and is taking the longest to develop. First, a system must be able to handle a variety of species. Hardwood species vary substantially in their appearance and in the way undesirable features manifest themselves. Further, for an automated system to be industrially useful, it must process lumber at least as fast as a skilled human grader or a cross-cut operator in a rough mill. To satisfy these needs, we have had to abandon off-the-shelf machine vision systems in favor of developing a system using special purpose methods for scanning wood.

Basic research on detecting, sizing and identifying wood defects on rough and surfaced lumber by machine vision is underway. Defect detection on rough lumber is similar to detection on surfaced lumber, but it is more complex. Surfacing lumber removes many of the visual characteristics of wood that confound the identification of surface features. Lumber changes in visual appearance as the surface dries. Outside storage and drying can cause color changes due to weathering and ultraviolet light. Handling and storage of wood can introduce dirt into its surface. Planed boards will take care of most of these problems, but hardwood is mostly graded and traded before surfacing. So we need to scan and grade rough surfaced lumber. For pickier rough mill scanning, most boards will be surfaced.

Scope and status of the hardwood lumber vision system

A machine vision system includes, in gen-



Scanning of hardwood lumber not only locates the placement of the defect but identifies the optimal cutting patterns based on the wood's characteristics.

eral, subsystems for image scanning and image interpretation. Image scanning uses one or more sensing techniques to measure spatially varying characteristics of an object. For example, optical scanning measures light intensity or color saturation and X-ray scanning measures density variations. These analog signals are converted to digital values, stored and later processed by computer.

Image interpretation uses these digital data to interpret various features in the imaging scene. Because board appearance varies due to the stage of drying and prior handling, image interpretation methods must be robust and dynamic.

Image scanning of lumber

A satisfactory computer scanning system will require several hardware and software components. First, there are the imaging subsystems used to create digital images of wood characteristics. Next, a system is needed for moving boards through the imaging subsystems. Also, a computer must collect and store information. Finally, a software system must orchestrate the operation.

Image interpretation of lumber

Image interpretation of lumber for the color camera consists of two broad tasks: image segmentation and object recognition. Segmentation distinguishes and separates aspects of the scene that are of interest. In the analysis of board images for defects, we are interested in objects such as knots, holes, splits, etc. Because segmentation only highlights areas with extreme values, it can be performed independent of species and board differences. Recognition on the other hand, requires technical knowledge of wood defects to perform domain-specific classification.

An image interpretation system for the color cameras has been created that can locate and identify four types of grading defects (knots, holes, wane, splits and checks). We have tested this vision system on more than 160 samples of rough maple, cherry, red oak and poplar, as well as surfaced oak. The system operates in a species-independent manner; that is, no parameter changes are required in changing from one hardwood species to another.

Knots have posed a problem at times for our color sensor. In each species, some knots have almost no color difference and these knots are hard for the segmentation system to locate and even harder for the recognition system to identify. Because of this difficulty, the addition of X-ray scanning is needed. Identical to those used in airports to scan luggage, the scanner's X-ray systems can locate knots, decay, mineral streak and internal defects such as honeycomb.

Multiple sensor scanning approach

Given the range and features that automated scanning systems will be required to find and label, we have decided to use a multiple sensor approach. We have previously described our three sensing systems as 1) the color imaging system, 2) the laser-based ranging system, and 3) the X-ray scanning system. Because each of these different sensing systems provides a unique type of information about the nature of the wood material, scanning systems can be designed with sensing technologies best suited for a particular application.

Color scanner test

Recently, we tested fifty boards including a mixture of FAS, 1 Face, 1 Common and 2 Common red oak boards. The scanning-optimization fixed-arbor gang-rip system increased the potential yield over 4 percent. The scanning-grader results indicated that 21 out of 50 company graded boards were graded too high. Also four boards were graded to low. Initial results results also showed that we are missing parts of defects and we are also misclassifying some clear wood as defective.

Discussions and conclusions

Cooperative research by scientists with Virginia Tech University and the USDA Forest Service has clearly shown that automated lumber scanning is possible. Serious questions whether it will be practical for typical wood processing operations, but we are optimistic. Our costs have been high because we are breaking new ground in a research-oriented operation. For example, equipment costs alone for the rough lumber vision system could be approximately $200,000. Once vision systems are perfected, however, we think that machinery manufacturers will be able to transfer our research into salable products.

As we proceed toward full scale grading and analysis of lumber, processing speed becomes increasingly important. At present we can scan at acceptable industrial speeds, but we will have to increase our computing speed substantially to process the large amounts of data gathered in the scanning. We recognize that producer and consumer preferences can influence the acceptable features in wood products, Our machine vision and automated processing systems must be flexible enough to accommodate such market realities.