FDM X-Ray

The Future System for Roughmill Optimization

The best optimization solution for your roughmill might be a combination of technologies

BY RICHARD W. CONNERS,
D. EARL KLINE, PHILIP A. ARAMAN,
AND THOMAS H. DRAYER

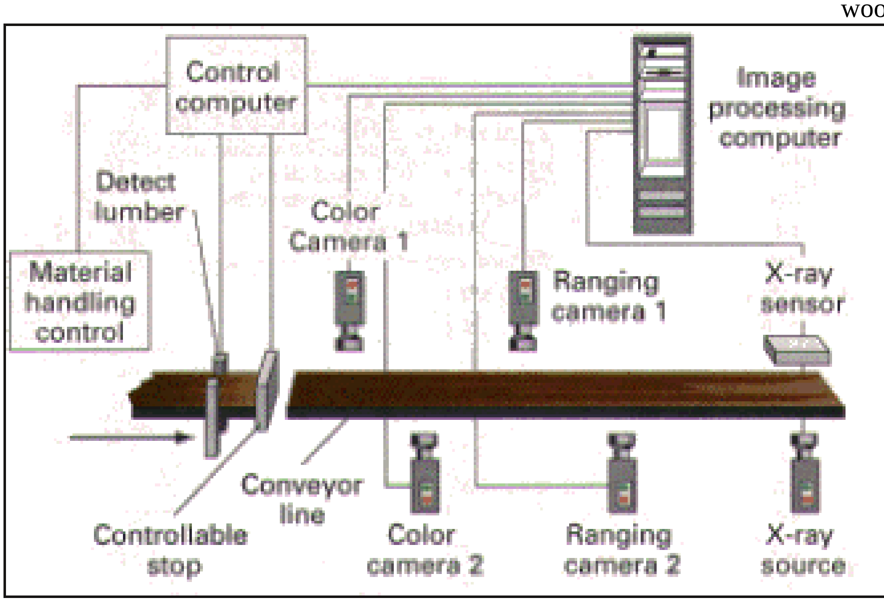

Figure 1. Researchers at Virginia Tech developed this multisensor machine vision prototype for lumber inspection. The system combines several components to analyze boards, including color imaging, laser ranging, and X-ray.

FROM FOREST to finished product, wood is moved from one processing stage to the next, subject to the decisions of individuals along the way. While this process has worked for hundreds of years, the technology exists today to provide more complete information to the decision makers. Virginia Tech has developed this technology, creating a machine vision prototype for wood products manufacturing.

To some extent, vision technology has existed in the industry since the early 1980s. Various technologies, such as laser ranging and black-and-white cameras, have been used to measure the dimensions of logs and lumber. While this has been most useful in improving efficiency, it has done little to maximize the value of the resulting products. Much research has gone into developing other technologies that can detect and plot features in the wood. A useful technology must accurately identify the three features of a board that will affect its value:

- Surface features: knots, holes, splits, decay, discoloration-coloration, slope of grain;
- Geometry features: three-dimensional shape, warp, wane, variations in thickness; and

The authors are all from Virginia Tech, Blacksburg, VA. Richard Conners is director of the Spatial Data Analysis Laboratory; D. Earl Kline is an associate professor in the Department of Wood Science and Forest Products; Philip Araman is a project leader with the USDA Forest Service, Southern Research Station, and a senior research scientist; and Thomas Drayer is a senior research associate in the Spatial Data Analysis Laboratory.

- Internal features: voids, knots, decay.

Most research has gone into optical sensing methods, including cameras and spectrometers, which measure the intensity and color of reflected light. These devices detect surface features and can be readily automated, but they will miss knots that are the same color as clear wood, or classify soil or grease on the board as a defect. They also can be confused by variations between species and by the roughness and moistness of the wood. Of course, they are of no use for detecting internal features.

Technologies that measure density of the wood can detect internal features, so much research has gone into developing machine vision systems using ultrasound, microwave, nuclear magnetic resonance, and X-ray technologies. While these systems overcome some of the problems of optical systems, they can't detect the color of the wood or defects such as stains. Also, since some defects have nearly the same density as clear wood, they can't detect all defects, nor can they accurately differentiate between defect types. It is apparent that an ideal machine vision system would incorporate various sensing technologies, analyzing the combined data to locate and plot features and defects of the wood.

Multisensor prototype

Over the past 10 years, researchers at Virginia Tech have experimented with machine vision technologies for the forest products industry. By integrating information from color cameras and other sensors, we have developed a multisensory system suitable for a variety of manufacturing applications. Figure 1 shows a simple conceptualization of this system.

Our work has resulted in a multisensory machine vision prototype. This design includes:

- A color-imaging system for locating and identifying surface defects and discolorations;
- A high-speed laser-ranging system for detecting cracks and holes in the surface and variations in the thickness of the board; and
- An X-ray imaging system for locating and identifying features associated with higher or lower density than clear wood.

The prototype integrates this sensing array with a materials handling system, an image-processing system, a control computer, and ma-

continued on page 126

chine vision software.

The prototype is a full-scale machine that can handle the typical widths, thicknesses, and lengths of lumber. It can be configured for different types of sawmill operations and handle both green and dry lumber. It was built so that other sensing devices, besides the three described, can be added and tested. The prototype has been used to test various applications, including edging and trimming, lumber grading, color sorting, and automation of sawmill operations.

The prototype uses ***two Pulnix color line-scan cameras*** — one for each face of the board. Processing speed is 2 linear feet per second. Tungsten-halogen incandescent bulbs illuminate the boards. The bulbs can be mounted in a convenient location away from the board surfaces, keeping them away from the dusty wood and allowing easy replacement when bulbs burn out.

The ***laser-based ranging system*** was designed and built at Virginia Tech. A point of laser light is swept across the board, and the image is captured by four black-and-white cameras. Through this process, the laser-based ranging system can measure board thickness and voids and indentations in the board surface to within 1/64 inch.

The ***X-ray scanning system*** is much like those used to scan luggage in airports.

Handling is key

In order for these sensing devices to work properly, boards need to pass through the prototype at a constant rate, without bouncing vertically or shifting laterally. In the ***materials handling system,*** canted drive rollers beneath the board keep it moving, while pneumatic rollers above the board keep it in place. Canting the drive rollers keeps the board sliding snugly against a fence, which is critical for accurate image registration. The positioning accuracy of the material passing through the system is +/- 0.01 inch. A dedicated computer controls the system, which has programmable speeds ranging from 0 to 6 linear feet per second.

The prototype's ***image-processing system*** is a 200-MHz Pentium PC with 64 MB of main memory, running Windows NT.

A ***286 PC*** controls the entire prototype system, sending control signals to the materials handling and image-processing computers. The PC also continuously monitors the system components to ensure that they are operating correctly. At this point the software running the system is rudimentary, but it will be developed to include an interface so that a typical employee at a mill can use it to operate the system and perform routine maintenance.

To handle the large amounts of data, the ***machine vision software*** processes data in a way that minimizes computational complexity and enhances feature-detection capabilities:

1. The segmented laser profile image is analyzed to determine which areas of the board fall above or below an acceptable thickness threshold. Areas that are too thin are then removed from consideration in subsequent analysis of X-ray and color image data.

A 286 PC continuously monitors the system components.

2. X-ray data, along with color data, is used to locate knots, voids, and decay. These areas are removed from subsequent analysis.

3. By the time the color image data is analyzed, the larger and unambiguous defect regions have already been eliminated.

Real-world application

Virginia Tech has developed two applications for its machine vision prototype, both now being patented. One addresses the growing use of edge-glued panels in the manufacture of doors, tabletops, desktops, and other wood products. Because light-colored stains are becoming more popular, it is critical that the bare-wood colors of adjoining panels match. As a manual process, color sorting of wood is labor-intensive and difficult, but this application, when used with the prototype system, can collect color data and automatically sort wood.

Another Virginia Tech project applies this technology in roughmills where defects are removed with crosscut saws. This, too, requires a good deal of human attentiveness and energy to be well done. Researchers at Virginia Tech, however, have developed the hardware and software for the prototype system that will operate a fully automatic crosscut saw in a roughmill.