Increasing hardwood lumber recovery and value at the edger and trimmer

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Increasing Hardwood Lumber Recovery and Value at the Edger and Trimmer

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There are over 3500 sawmills producing hardwood lumber in the Southeastern portion of the United States for the household furniture, cabinet, millwork, dimension, and flooring industries as well as for the export market. To stay in business, these sawmills must be able to produce the highest possible value lumber from any given saw log. In these mills, about 20 percent of hardwood lumber produced must be edged and nearly all lumber must be trimmed. Decisions on where to edge and trim boards can have a major effect on the resulting dollar value of the lumber produced. Previous studies have shown that there is a potential to increase lumber value by over 20 percent through ideal edging and trimming (Bousquet, 1989). Such a large potential can translate into millions of dollars for hardwood lumber manufacturers.

Making ideal edging and trimming decisions are difficult because of the complexities of hardwood grading rules, the inability of an operator to include the effect of lumber prices and grading rules into the decision process, operator fatigue, and operator skill. We are presently conducting studies that will improve the performance of edging and trimming operations. The first phase of our research has focused on finding potential sawmill increases, in both lumber volume and value, through optimal edging and trimming. Based on these findings, a training tool is being developed to improve the skills of edger and trimmer operators. In the second phase of our research, we have initiated the development of a computer-aided edging and trimming system for hardwood lumber manufacturing. This paper discusses our current progress and future plans of these research activities.

Optimal vs. Actual Edging and Trimming Results

Figure 1 shows the difference between actual lumber value obtained at three different sawmills in southwest Virginia to the potential optimal solutions. These lumber values are based on 40 red oak boards for each mill studied (Regalado, 1991). It was found that the mills studied had the potential of increasing their final lumber **value** by at least 25

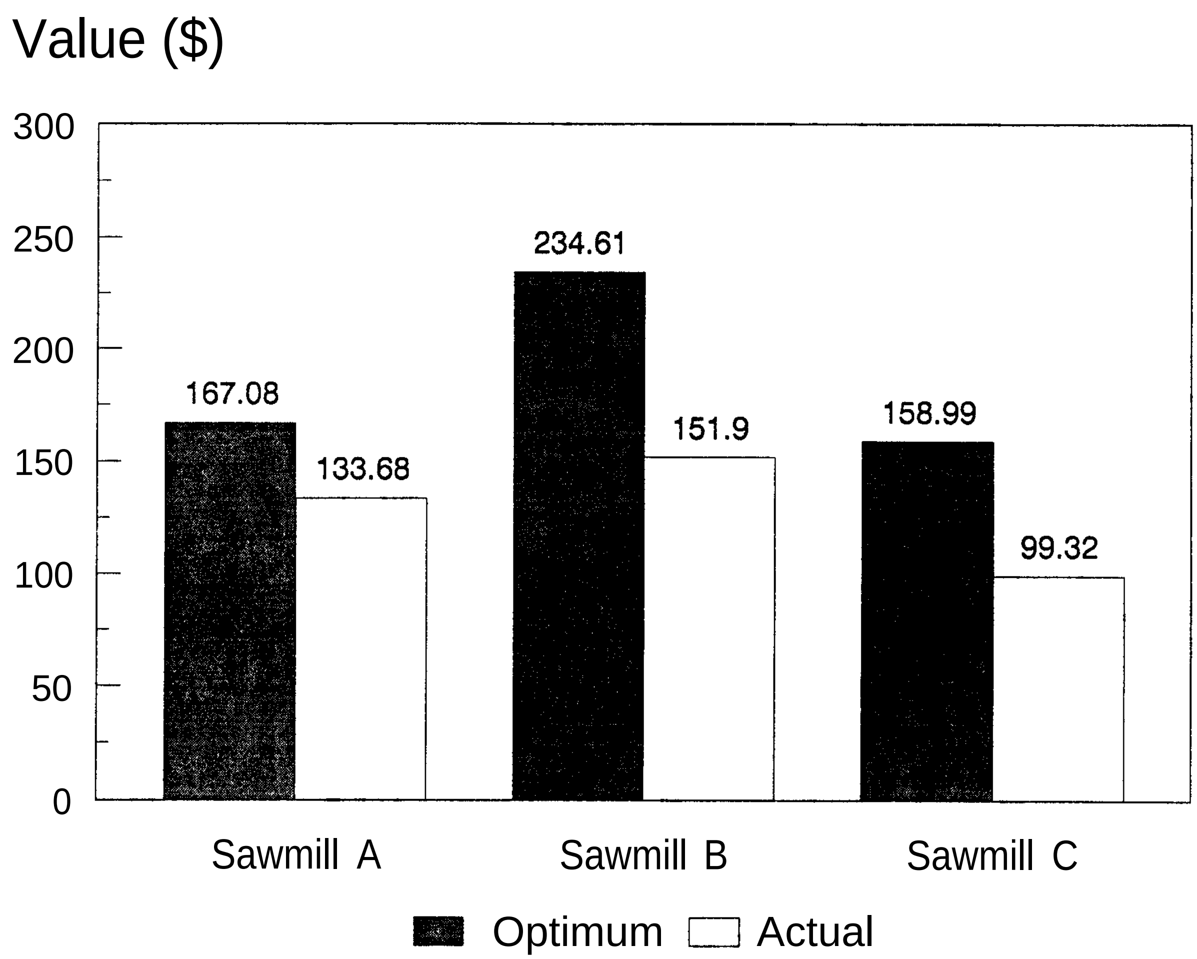

Figure 1. Actual red oak lumber value vs. optimal lumber value for three different sawmills in southwest Virginia.

percent through optimal edging and trimming. Two of the three mills studied had the potential of increasing lumber value by at least 54 percent. Let's translate these percentages into dollars. If in a particular mill the current average value of lumber produced is priced at 50 cents per board foot and one million board feet go through both the edging and trimming process annually, the potential gain in lumber value alone could be as high as $270,000 per year.

For all three sawmills, Regalado (1991) found that the biggest losses in opportunities were with boards which should have been FAS l-face or No. 1 Common grade lumber. For example, the greatest loss in value occurred when potential FAS l-face boards are dropped to a Common grade through non-optimal edging and trimming. This outcome is due to the large price gaps between successive grades for red oak lumber and because FAS l-face and No.1 Common board grades constituted a majority of all boards going through the edger and trimmer.

Another noteworthy loss in opportunity involved excessive edging of boards. A significant number of boards were actually down-graded by excessive volume loss. Figure 2 shows that two of the mills studied could improve their recovery of lumber **volume** between 17 and 23 percent even though edging and trimming optimization is based on lumber value. It was found that for these two mills much of the loss in dollar value was due to severe cutting which not only reduced volume, but also lowered the grade for a significant number of boards.

Figure 3 illustrates a typical edging and trimming mistake and exemplifies how excessive cutting reduces both the grade and volume of the board. Observed edging and trimming lines produced a board with a surface measure of 3. According to National Hardwood Lumber Association (NHLA) grading rules, this board grades as a No.2 Common. With optimal edging and trimming, a No.1 Common grade board with a surface measure of 5 can be obtained. This grade and volume increase will increase the value of the board over 200 percent.

It is also important to study how much improvement in lumber value can be achieved if only edging is optimized or if only trimming is optimized. For each of the mills studied, Table 1 compares the percent value increase for optimal edging and trimming both, optimal edging and manual trimming, and optimal trimming and manual edging. These results indicate that edging has more effect on lumber value and that trimming optimization cannot substantially improve upon lumber value once an erroneous edging decision has been made.

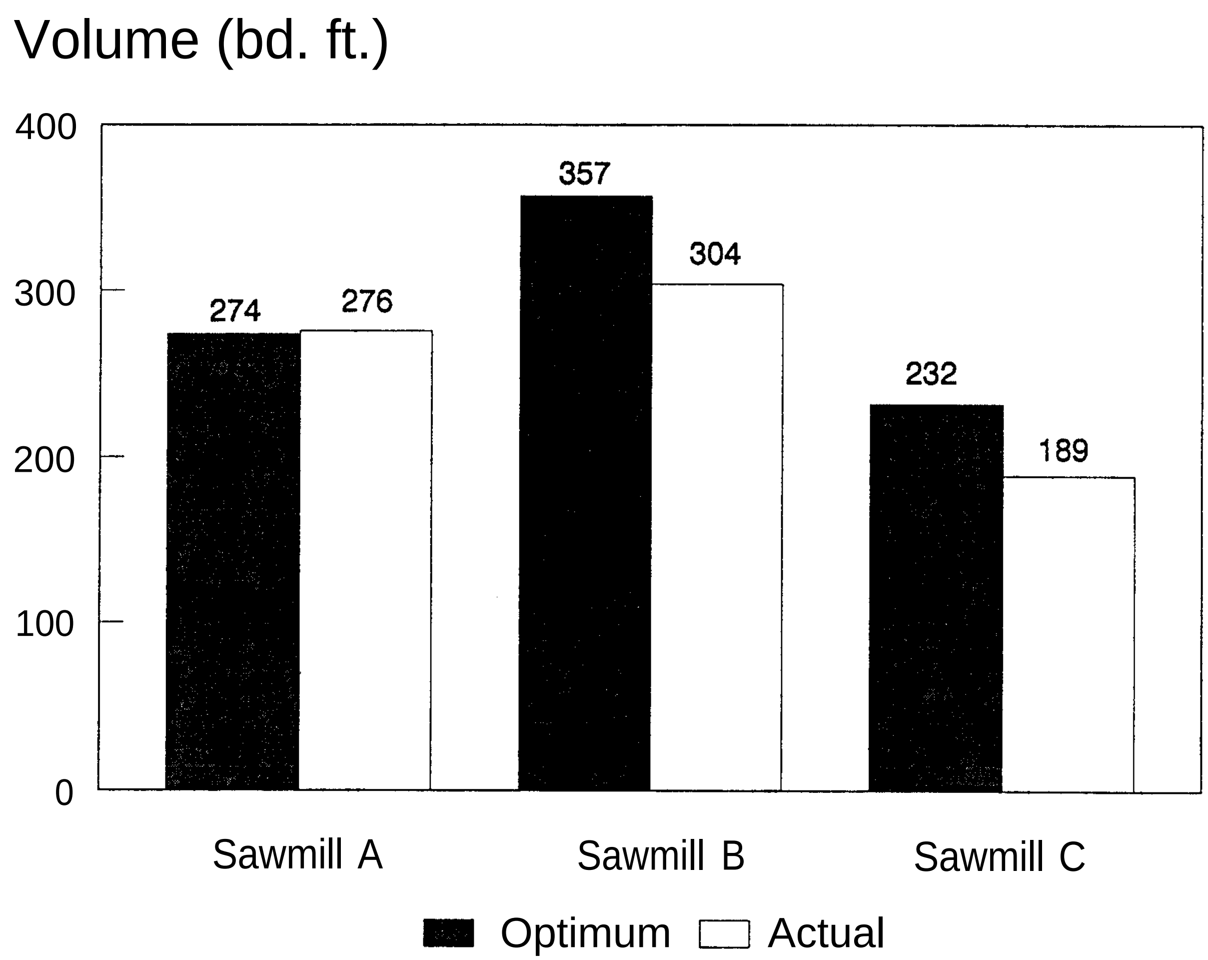

Figure 2. Actual red oak lumber volume vs. optimal lumber volume for the three different sawmills.

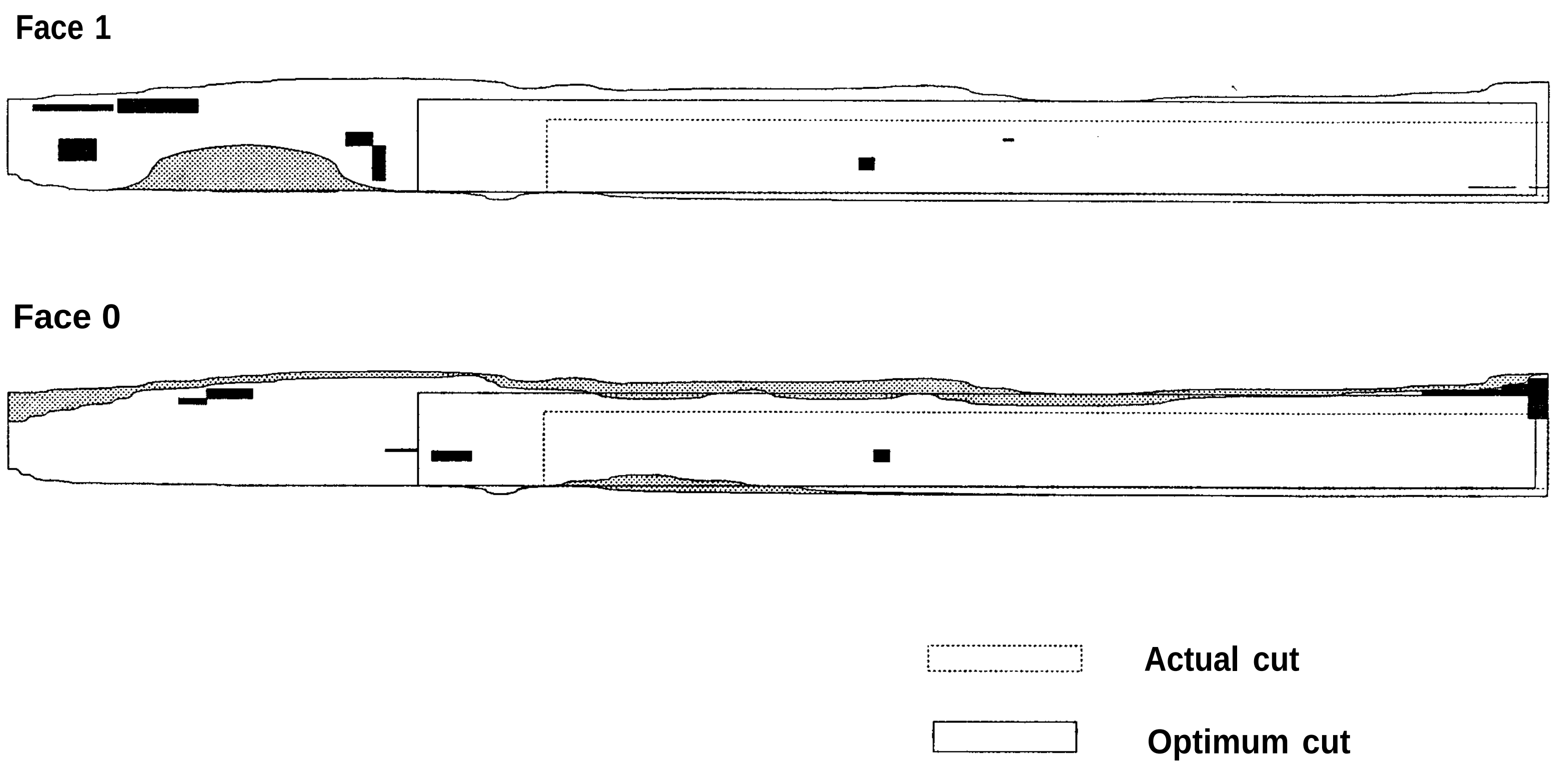

Figure 3. Illustration of severe edging and trimming at the sawmill.

Table 1. Comparison of potential increase in lumber **value** for various levels of optimization for the three sawmills.

Optimization Level	Sawmill A	Sawmill B	Sawmill C
Edging and Trimming	25 %	54 %	60 %
Edging only	13 %	47 %	50 %
Trimming only	12 %	9 %	4 %
Edging and Trimming Based on Geometry	2 %	30 %	20 %

Similar comparisons with lumber volume recovery in Table 2 show greater volume increases with edging optimization than with trimming optimization. Therefore, edging decisions have a greater impact on both lumber value and lumber volume recovery than trimming decisions.

Complete edging and trimming optimization for hardwood lumber ideally requires complete board defect information such as wane, knots, splits, decay, etc. Assuming that such complete board information is available, the above analysis shows that large increases in lumber value are possible by optimizing edging and trimming operations. However, present scanning technology can not yet provide total board information. Therefore, edging and trimming optimization was also studied based solely on geometry information (i.e. length, width, and wane). This optimization study was done because present scanning technology is currently available to detect board geometry information. Tables 1 and 2 also show the results of this optimization study based on geometry information. Increases in both lumber value and volume recovery were found to be as great as 30 and 35 percent, respectively. These results indicate that substantial increases in lumber value can still be realized by using currently available technology to automate edger and trimmer operations. The results also reveal that more complete board data is needed for true optimal solutions.

Currently, research is underway to help the industry effectively increase lumber volume and value recovery such that their overall competitiveness and profitability will be improved. The above results show that great opportunities exists in creating systems to improve edging and trimming operations. To help, we are developing a training tool for edger and trimmer operators and hopefully a low-cost computer-aided edger and trimmer system to be used in sawmills.

Training System for Edger and Trimmer Operators

On present manually operated edger and trimmers, optimum cutting decisions are difficult because of the inability of an operator to combine lumber prices, board measure, and lumber grading rules in the decision making process. The operator must be able to recognize the highest potential value of a board and then be able to edge or trim the board such that this value is attained. Therefore, proper understanding of hardwood grading rules and their restrictions along with resulting board values corresponding to board measure and lumber prices are essential if operator skills are to be improved.

We are working to develop a computer training system for edger and trimmer operators. The system simulates edger and trimmer operations. An unedged and

Table 2. Comparison of potential increase in lumber **volume** for various levels of optimization for the three sawmills.

Optimization Level	Sawmill A	Sawmill B	Sawmill C
Edging and Trimming	-1 %	17 %	23 %
Edging only	3 %	15 %	23 %
Trimming only	-4 %	1 %	0 %
Edging and Trimming Based on Geometry	6 %	27 %	35 %

untrimmed board is displayed on the computer monitor. The board is enhanced using color codes for the most common hardwood features affecting lumber grade. These features include: stains, checks, sound knots, unsound knots, wane, splits, pith, holes, and decay. The user can position both the edger and trimmer saw kerfs on the display. Once the saw kerfs are selected, the computer can then measure and grade the resulting board and assign it a value according to updated lumber prices. The user then has the opportunity to compare the selected edger and trimmer solution to a predetermined optimal solution.

After practicing on this training system, the user will soon become aware of how the interaction between grading rules, board measure, and lumber prices affect the edging and trimming decision. If edger and trimmer operators are properly trained to recognize and capture the highest potential board value, substantial lumber value recoveries can be made with no physical mill changes. However, based on data from the mills studied, we feel that manual edgers and trimmers at their best can only recover approximately 80 percent of the maximum theoretical lumber value.

Computer-Aided Hardwood Edging and Trimming

Optimal edging and trimming involves making many tedious calculations such as board measure, grade, and value. Making these calculations manually will seldom be accurate. These inaccuracies are the primary reason that a manual edging and trimming operation will never achieve 100 percent of the maximum theoretical lumber value. Therefore, edger and trimmer optimizers must involve some degree of computer automation.

For various reasons, advanced computer and automation technology for the hardwood lumber industry has been difficult to develop. One reason is that automated systems for hardwood lumber processing must be able to reliably detect many hardwood lumber features that affect its value such as size, wane, knots, stain, splits, etc. Automatic detection of these random features is a very unique and complex problem. As research in scanning technologies such as computer vision expands, edger and trimmer optimizers may be totally operated by computer. However, it should be realized that most hardwood sawmills are very small operations and expensive automation equipment will be difficult to justify. Therefore, semi-automatic or computer-aided edging and trimming decision making systems will be more effective for immediate industry adoption.

We have initiated the design and development of a computer-aided edging and trimming system. Figure 4 shows a conceptualization of this system. The present scanning

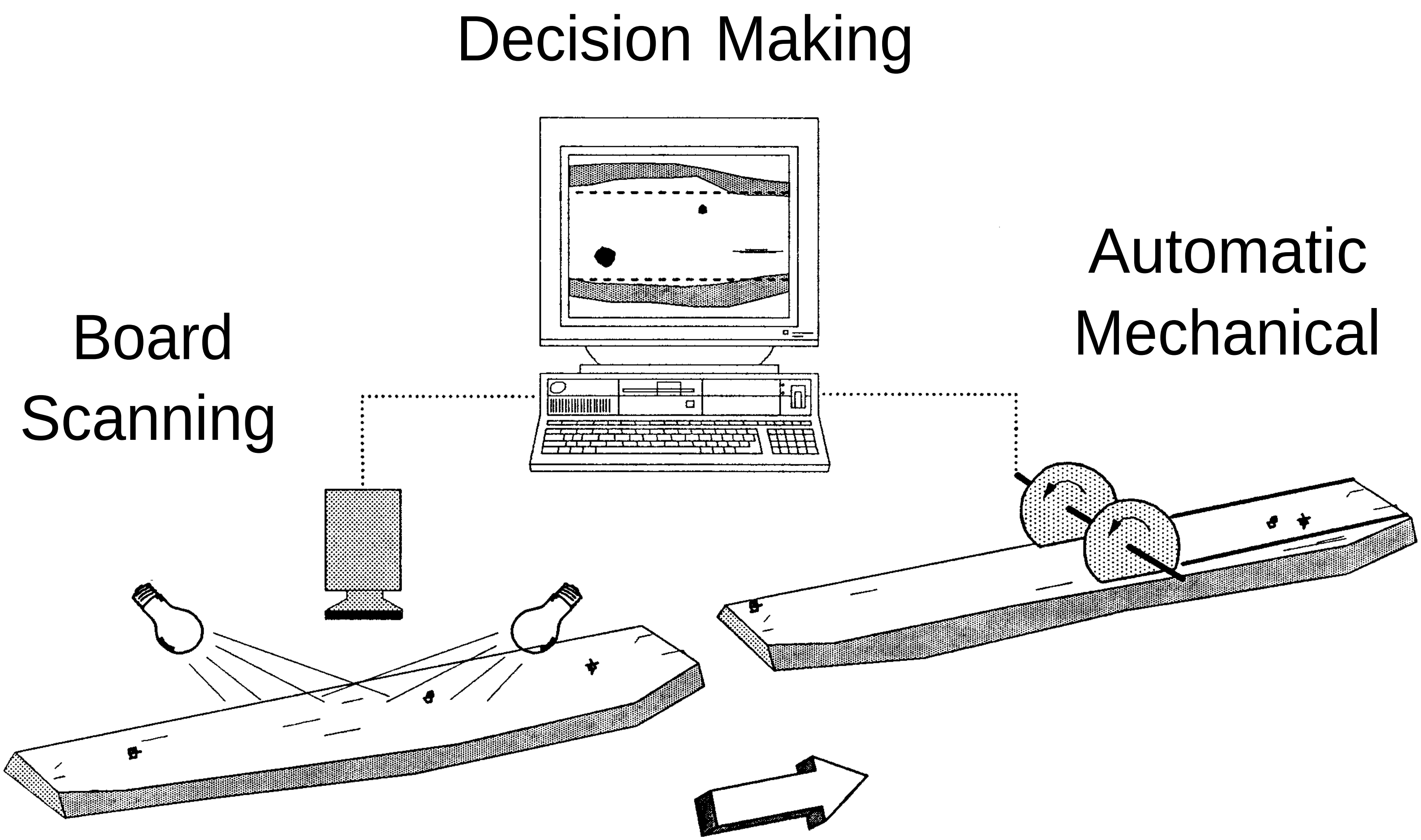

Figure 4. Conceptualization of a computer-aided edging system.

system of the computer-aided edger involves taking a “live” video picture of the board. Using a similar display layout as in the training system, a picture of the lumber to be processed is displayed on a computer monitor. The operator would then provide an estimate of the maximum potential lumber grade. For the indicated grade, hardwood lumber grading rules for wane and lumber size would be applied to position the saw kerfs that maximize lumber value. The computer would also give accurate information such as board footage, lumber value, and alternate kerf positions that can upgrade the lumber or increase volume. The operator can then use this information to make better decisions. Once the operator decides what cut is to be made, laser lights and the corresponding sawblades would be automatically positioned for the corresponding edger cuts. Furthermore, the board would also be marked to show the corresponding optimal trimming lines for later processing at the trim saws.

Our present effort in this design includes developing an interface that will allow the operator to input information and make decisions as quickly as possible. This involves properly adjusting the camera and lighting configuration. It also involves computer work to developed enhanced computer images and display information. Since entering information in the computer via a standard keyboard can be cumbersome and slow, a simplified input keypad is being developed.

We are designing this computer-aided system initially to be semi-automatic so that it will be as low-cost as possible. As mentioned earlier, when technology expands and becomes more affordable in the area of computer vision and image processing, the ultimate system will be fully automatic and fully computer controlled.

Computer Automated Hardwood Edging and Trimming

A fully automatic edging and trimming system must be able to reliably detect and recognize hardwood features that are important in determining lumber value. As indicated earlier, scanning systems already exist in accurately obtaining board geometry information such as length, width, thickness, and wane. With such a scanning system, our research has shown that an automated edging and trimming system can increase lumber value recovery as much as 30 percent when compared to manual systems. However, an automatic system that only senses board geometry can only recover approximately 80 percent of the maximum potential lumber value (Regalado, 1991).

To recover all of the maximum potential lumber value, an automatic system of the future will involve sophisticated computer vision and image processing techniques. We are making significant progress in developing computer vision software to locate and identify most features on hardwood lumber. Figures 5 and 6 show an example of applying this software on a sample image of red oak lumber (Conners et al., 1989a; Conners et al., 1989b). Figure 5 is a black and white image of the seamed lumber sample. Figure 6 is the result of applying the software to locate and identify objectionable features.

Currently, the software can recognize four important features: wane, knots, holes, and splits/checks. Also, by selecting the appropriate background color, the software system can easily determine the overall board dimensions. The same computer vision software have performed equally well on many hardwood species including white oak, red oak, walnut, cherry, maple, poplar, and hickory without the need for any parameter changes. They have also been tested successfully on both rough and surfaced lumber.

While significant progress has been made, the recognition accuracies are not yet good enough to achieve 100 percent accuracy. One problem concerns knots since many have the same color as clear wood. Also, when debarkers remove both the bark and the cambium, a tissue that is dark in hardwood species, detecting wane can also be a problem. Although we are continuing to improve the accuracy of the computer vision system, these problems suggest that an operator will need to be monitoring an automated edging or trimming system to override a computer decision when such problems occur or we need to include more reliable scanning systems so that they can better locate and identify the problem defects.

Summary and Conclusions

Studies have shown that there is a potential to increase hardwood lumber value by more than 25 percent through optimum edging and trimming. This potential was found to be as high as 60 percent in one mill case study. Studies have also shown that lumber volume recovery can be as high as 23 percent, significantly improving the utilization of our hardwood resources. These results show that a great opportunity exists to develop computer-aided edger and trimmer systems to optimize lumber value. The primary thrust of our research has been to capitalize on this opportunity and develop systems which would assist in correct edging and trimming.

Since most hardwood sawmills are small, they could not readily adopt sophisticated “high-cost” automation systems. Therefore, our research has concentrated on designing low-cost computer-aided systems to assist edger and trimmer operators make better decisions. As the cost of computers and the results of automation technologies become more proven,

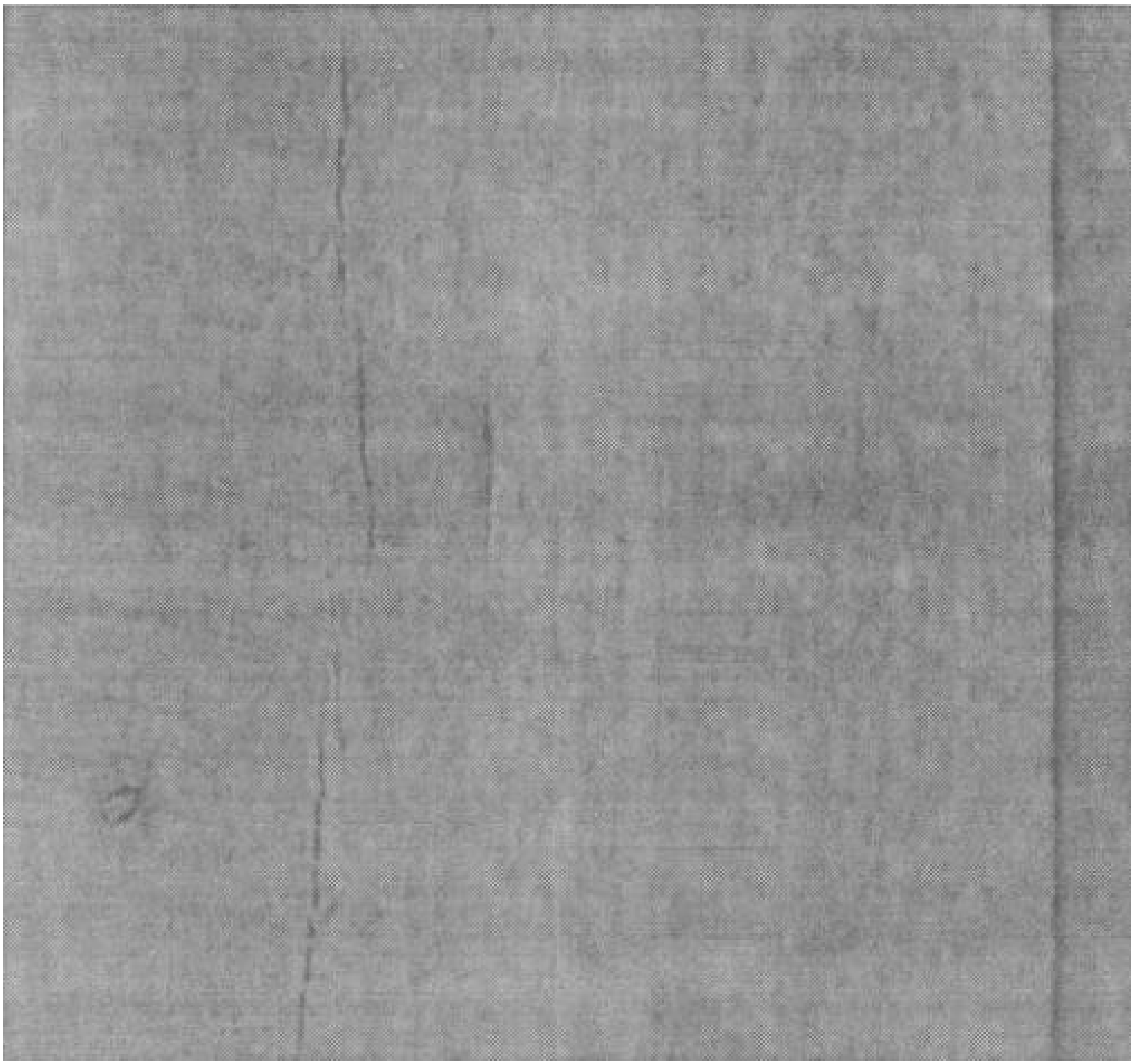

Figure 5. Black and white image of a scanned red oak lumber sample.

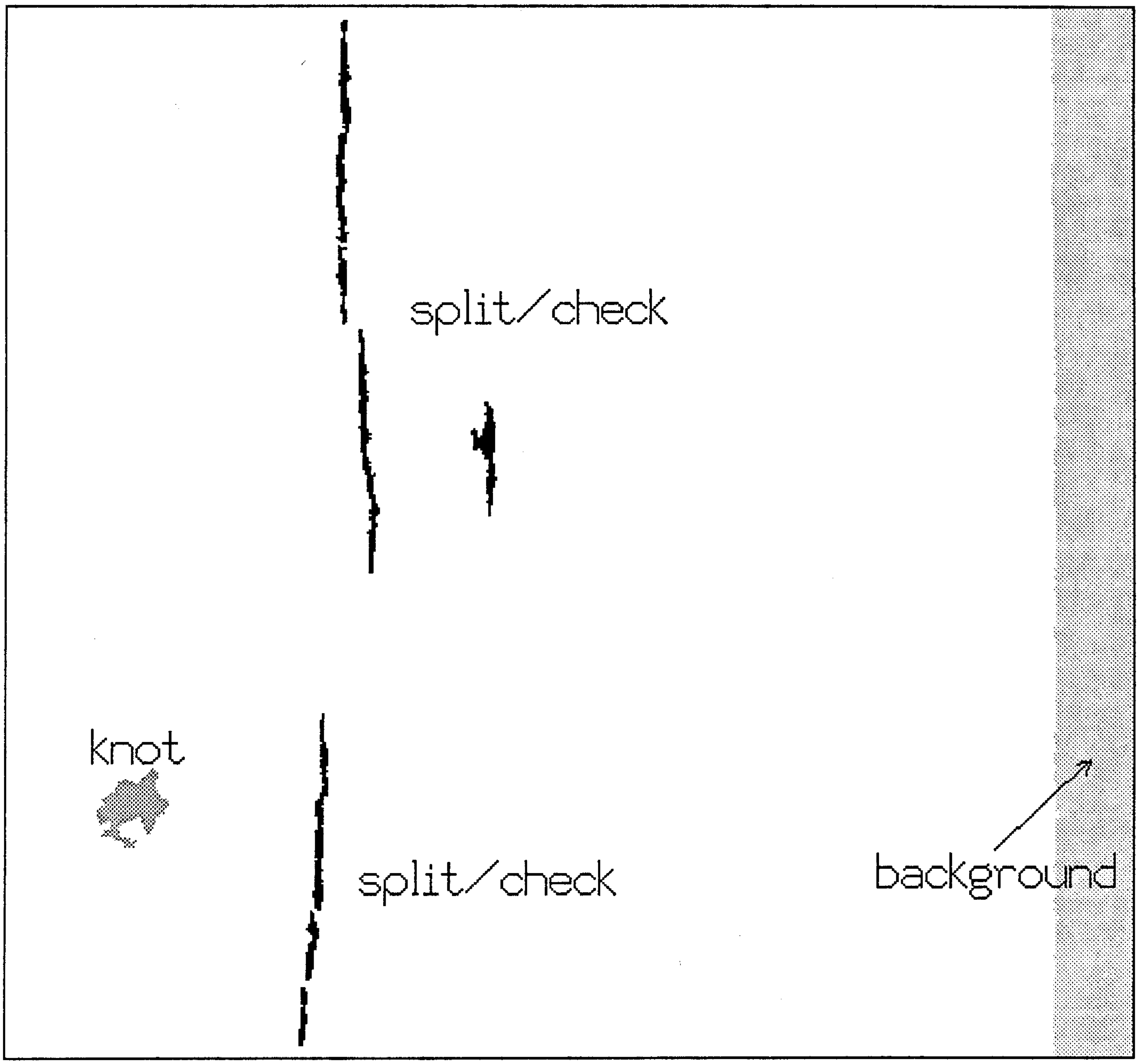

Figure 6. Features in the image of Figure 5 that are recognized by the computer.

the computer-aided edging and trimming system will ultimately evolve into a fully automated system that can be readily adopted by some of the larger sawmills.

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