Hardwood lumber edger and trimmer training system

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Abstract

This paper describes a computerized hardwood lumber edger and trimming training system. The purpose of the training system is to help edger and trimmer operators and sawmill managers better understand how hardwood lumber grade, surface measure, and price interact to affect lumber value. The training system can be used both as a training tool and as a testing tool. As a training tool, the user can observe how the placement of edging and trimming lines can affect lumber value. As a testing tool, the user's learning progress after various training sessions can be tested. To maximize ease-of-use as well as programming flexibility, the training program was developed under Microsoft Windows 3.0. Various aspects and features of the computer program are described in this paper and an example session with the program is provided.

Previous studies have shown that lumber value can be increased by over 20 percent through ideal edging and trimming (1,2). Such lumber value increases can be translated into an increase of millions of dollars for hardwood lumber manufacturers. A recent edging and trimming study (8) found that the lumber value recovery at the edger and trimmer ranged from 62 to 78 percent of the optimum for several sawmills producing red oak lumber. These percentages indicate there is a great potential to increase mill profitability by improving edging and trimming practices.

It is difficult to make ideal edging and trimming decisions because of problems associated with the complexities of National Hardwood Lumber Association (NHLA) grading rules (7), the inability of an operator to include the effect of lumber prices and grading rules into the decision process, inadequate machine feedback (e.g. board width when edging), and the range in operator skill. Realizing that a primary factor affecting lumber value is hardwood lumber grade, computerized training programs have been developed to help lumber manufacturers (3,5). These programs have been designed primarily to train hardwood lumber graders. To further assist the hardwood lumber manufacturers, training tools are needed that are specifically designed to help the edger and trimmer operator better understand all the factors that influence lumber value.

A research effort is presently being conducted to help improve the performance of edging and trimming operations. The research has focused on developing tools to improve the skills and on-line performance of edger and trimmer operators. This paper describes a computer program that was developed to simulate an actual edging and trimming operation for training and testing purposes. The aim of the computer program is to help edger and trimmer operators better understand how hardwood lumber grade, surface measure, and price interact to affect lumber value.

Program description

System components

The hardwood lumber edger and trimmer training program consists of four main components: 1) board display; 2) edging and trimming simulator; 3) hardwood lumber grader; and 4) performance feedback.

Board display. – The board display component of the program selects a "board (i.e. an unedged and untrimmed lumber specimen) from a library of boards and displays the board on the computer display. Each board is represented by an image file consisting of the coordinates that define the outline of the board edges and the size, location, and type of all features on each face. Feature types represented in the image file include wane, sound and unsound knots, stain, decay, pith, holes, checks, and splits. An encoding system was used to represent the board features and was based on the coding system used in Klinkhachorn's (4) hardwood lumber grading program.

The primary function of the board display is to translate the coordinates contained in a board image file to a bit-mapped image on the computer display. Different contrasting colors are used for each board feature so the user can easily distinguish between the various feature types. Displayed images can also be "flipped to compare the opposite faces of the board. In addition to the displayed image, the board display presents and maintains useful information such as the overall length, width, and surface measure of the un-edged and untrimmed piece of lumber.

Edging and trimming simulator. – The edging and trimming simulator is used to place the edger and trimmer sawlines on the board display and to generate the corresponding piece of lumber to be graded. This simulator allows the user to independently move the edger sawlines and the trimmer sawlines any number of times. The present resolution of the simulator is 1/4-inch increments for both the edger and trimmer sawlines. Every time an edger or trimmer sawline is moved, the board display is updated to show where the sawkerfs are to be placed and the resulting lumber length, width, and surface measure. When the user is satisfied with the placement of the sawkerfs, the simulator generates an image file of the resulting piece of lumber. The lumber image file is generated by redefining the board outline coordinates and excluding all features that fall outside of the sawlines. The lumber image file is then processed by the hardwood lumber grader.

Hardwood lumber grader. – The lumber grading component of the program employs Klinkhachorn's (4) hardwood lumber grading routine to establish the NHLA lumber grade. Potential grades used in the current version are FAS, FAS 1-Face, 1 Common, 2A Common, and 3A Common. The grading routine uses the lumber image file generated from the edging and trimming simulator as input. After the lumber grade is established by the grading routine, information is presented by the board display, including the resulting lumber grade and lumber value. A database of unit prices for the various grades of hardwood lumber is used to established lumber value, and it can be updated whenever necessary.

Performance feedback. – To allow the user to explore how different edging and trimming lines can affect lumber value, a mechanism is provided in the program for performance feedback. The primary method of giving performance feedback is by visually comparing the user's edging and trimming solution to an optimum (i.e., maximum lumber value) solution. Therefore, the optimum edging and trimming solution is also included in the original board image file. Determined *a priori* using a separate optimization program, the optimum edging and trimming solution includes the grade, surface measure, and the outline coordinates for the maximum lumber value. Hence, the optimum solution can be graphically overlain onto the user's solution so any differences can be seen.

The separate optimization program determines optimum edging and trimming solutions by iteratively generating combinations of edging and trimming lines, comparing lumber values from the different edging and trimming line combinations, and selecting a solution that gives the highest value. Lumber values are computed based on volume and grade according to NHLA rules. The optimization algorithm is discussed in more detail by Regalado et al. (8).

Other measures are also included to provide performance feedback. The edging and trimming simulator and the hardwood lumber grader can be used any number of times on a given board so the user can observe how incremental changes in the edging or trimming lines affect the lumber value. Useful statistics can be enabled in the display, such as the percent recovery in lumber value. Also, a clock can be enabled so the user can observe how much time it takes to make a decision or how the time factor affects decision making.

Modes of operation

The training program was designed to run in one of two modes of operation, a training mode and a testing mode. In the training mode, full access to all the program functions is allowed so the user can better learn proper edging and trimming techniques. In general, the training mode allows the user to explore "what-if" type questions. For example, the user can observe how the placement of edging and trimming lines can affect lumber value. Questions can be investigated such as, "How does the value change if I increase the board width by 1/4-inch?" or, "How much wane can the board have before there is a drop in grade?" Also, the optimum edging and trimming solution can be overlain onto the board at any point in the training session so the user can observe the sensitivity in lumber value. Relative to the optimum solution, questions can be answered such as, "How much does lumber value change if I slightly overedge the lumber?" Finally, changes in lumber prices and how they affect lumber value can be explored in the training mode.

The program testing mode is designed to test a user's performance under a more realistic edging and trimming operation. Unlike the training mode, the sequence of events that occur in the testing mode are fixed and occur in the following order 1) load a board to be processed; 2) select the edge and trim lines; 3) grade the board; and 4) display performance feedback. After a board is displayed within the testing mode, the user has only one opportunity to grade the
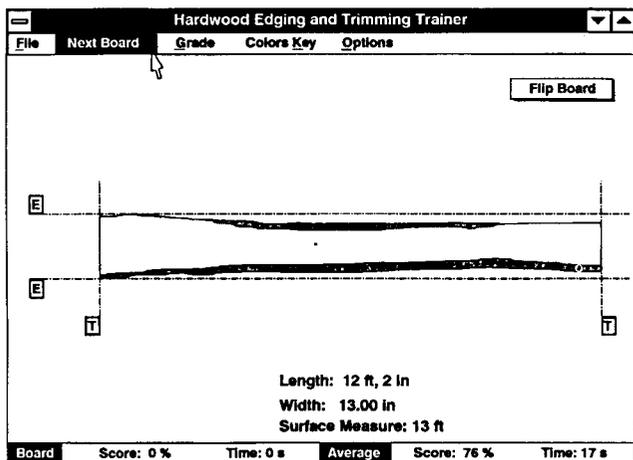
Figure 1. — Loading a board into the hardwood lumber edger an-d trimmer training system.

Figure 2. — Viewing the opposite face of the board by pressing the Flip Board button.

lumber after the edge and trim lines are placed. After the lumber is graded, the user's edging and trimming decision cannot be revised and regraded on a given board. However, before the lumber is graded, the individual edger and trimmer sawlines can be moved any number of times. Displayed performance feedback includes percent lumber value recovery, processing time, and, if desired, the optimum edging and trimming solution. The testing mode can be used to test a user's overall performance relative to the optimum edging and trimming solution and to test a user's learning progress after various training sessions.

Programming features

To maximize ease-of-use as well as programming flexibility, the training program was developed under Microsoft Windows 3.0 (6). Therefore, the program takes advantage of the Windows graphical user interface features. Since all system features can be accessed by mouse, all functions that apply at a particular time during program execution are graphically displayed on the screen in the form of icons, buttons, or menu items. This graphical user interface was designed to be "intuitive" and minimize the amount of user instruction required to operate the system.

The edger and trimmer training system was developed to run on IBM AT compatible microcomputers. Minimum hardware requirements include a math coprocessor, 640 KB of system memory, a hard disk drive with at least 8 MB free, VGA color display, and a mouse. Software requirements include MS-DOS or PC-DOS version 3.1 or later and Microsoft Windows 3.0. A 386 microcomputer is recommended to insure that the operation of the training system is smooth and fast.

Present limitations

Presently, the main limitation of the hardwood lumber edger and trimmer training system is that the board library is limited to 100 red oak 4/4 lumber specimens. Also, the FAS l-Face grade is used in the program instead of the alternate grade of Selects. However, w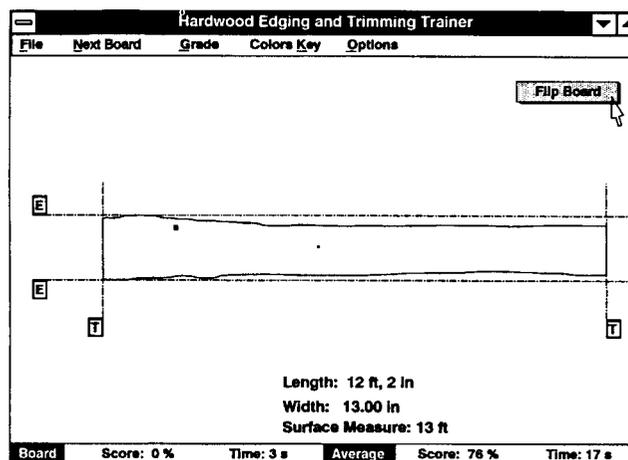ork is continuing to expand the board library in size and in the number of species available and to expand the program's capability to include the Selects grade. As mentioned earlier, the optimum edging and trimming solution was determined in an optimization program separate from the training program. Therefore, another limitation is that the optimum edging and trimming solution for a given board is based on a default lumber price schedule and may become invalid when the price schedule is changed. This limitation was necessitated since recalculating an optimum solution for a given board is time consuming. Although this limitation somewhat restricts the use of the optimum solution, the lumber price schedule can still be changed to investigate various price changes on lumber value.

In terms of lumber processing, the training system is limited to processing one piece of lumber from each board (i.e. only two edger sawkerfs and two trimmer sawkerfs). For example, it is not directly possible to split a wide board into two or three acceptable pieces of lumber to maximize value. However, in the program training mode, the same board can be processed more than once to split it into several separate pieces of lumber. The total value of the board can then be obtained by manually summing the value of each piece of lumber.

Example session

Figure 1 shows the screen layout of the edging and trimming trainer running in the testing mode. The main menu is located at the top portion of the screen. Each menu item can be easily selected by using the mouse to move the pointer (i.e. the arrow) over the desired item and then depressing the left mouse button. Menu item **File** allows the user to select individual board image files or exit the program. Item **Next Board** randomly selects and displays aboard from the library of stored board images. After the user processes the displayed board, **Grade** is selected to grade the resulting lumber or display the optimum lumber grade. Features on the board are displayed using various colors and the key of colors used can be shown using the **Colors Key** menu item. Finally, the **Options** item

allows the user to change various aspects of the program such as the mode of operation, various board display characteristics, or the lumber prices used.

When the user selects the **Next Board** function, a new board is displayed in the central portion of the screen (Fig. 1). The edging **(E)** and trimming **(T)** sawlines are displayed along with the board. Initially, the sawlines are set to the outermost edges of the board and the overall board length, width, and surface measure are displayed. For example, the board length, width, and surface measure as defined by the sawlines in Figure 1 are 12 feet, 2 inches, 13 inches, and 13 feet, respectively. In the testing mode, the **Next Board** function is disabled until the displayed board is processed and graded. Also at the bottom of the screen, performance information is provided in the testing mode. For example, the average lumber value recovery and average time to edge and trim lumber up to this point in the session is 76 percent and 17 seconds, respectively.

The user can view the opposite side of the displayed board by "pushing" the **Flip Board** button (Fig. 2). The board is not truly "flipped in the sense that the board

is actually turned over. Rather, a "transparent flip" is used, where alternate faces are displayed as if the board is transparent. The board can be repeatedly flipped at any time so the user can establish the poor or grading face of the lumber.

Processing the board involves moving the edger and trimmer sawlines on the board where the user believes the highest value lumber will result. For example, the top (Fig. 3) and bottom (Fig. 4) sawlines are moved by "dragging" them on the display to the desired location. Dragging a sawline is accomplished by moving the pointer onto one of the sawline buttons (**E** for edger and **T** for trimmer) and then holding down the left mouse button. The edger sawlines, as shown in Figures 3 and 4, will move up or down until the left mouse button is released. During the dragging of the sawlines, a number will appear on the screen to show the change in distance between sawlines (i.e., width or length) as they are moved and the corresponding change in surface measure. For example, the number in the parentheses on Figure 3 shows that if the top sawline is moved to the present position, then the lumber width and sur-
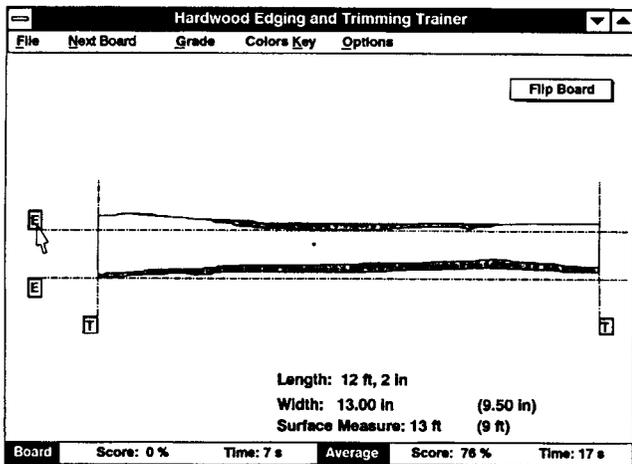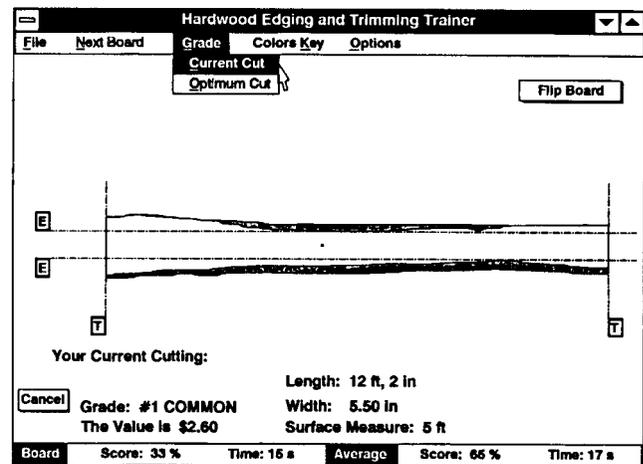

Figure 3. — Positioning the top edger sawline.

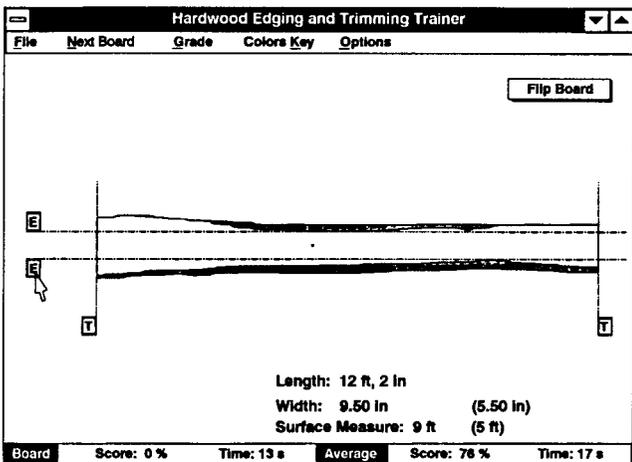Figure 5. — Grading the lumber defined within the edger and trimmer sawlines.

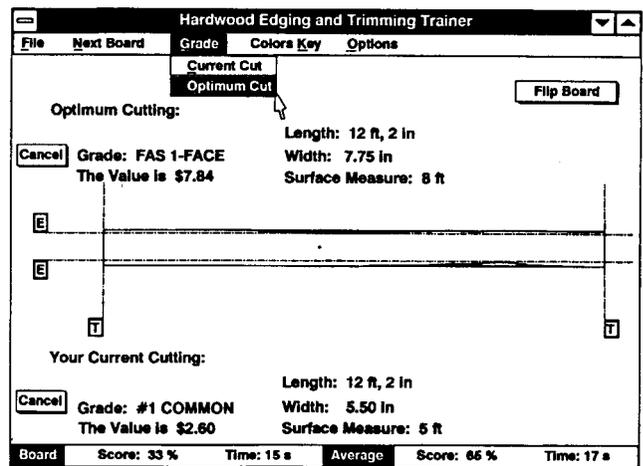Figure 4. — Positioning the bottom edger sawline.

Figure 6. — Comparing the user's edging and trimming solution to the optimum edging and trimming solution.

face measure would be 9.5 inches and 9 feet, respectively. Likewise, if the bottom sawline is moved to the position shown in Figure 4, then the lumber width and surface measure would be 5.5 inches and 5 feet, respectively. Positioning the trimmer sawlines is accomplished in the same manner as positioning the edger sawlines. After the user positions a sawline to a desired location, the appropriate lumber width, length, and surface measure values are updated.

When the user is satisfied with the positioning of all sawlines, the resulting lumber can be graded by selecting the **Grade** menu item as shown in Figures 5 and 6. Two grading choices are available when **Grade** is selected: **Current Cut** and **Optimum Cut.** These grading choices allow the user to grade the current displayed edging and trimming solution or display the optimum edging and trimming solution, respectively. In the testing mode, **Optimum Cut** cannot be chosen until after **Current Cut** is selected. Also, after **Current Cut** is selected, the user cannot go back and make any adjustments to the selected edger and trimmer sawlines in the testing mode. Different solutions are allowed in the training mode.

When evaluating the user's edging and trimming solution by selecting **Current Cut,** more information is displayed on the screen. For example, in Figure 5, the grade and value of the current cut are No. 1 Common and $2.60, respectively. Performance information provided at the bottom of the screen in Figure 5 shows that only 33 percent of the potential lumber value was obtained and 15 seconds were needed to process this particular board. Also, the average lumber processing statistics are updated, indicating that the average lumber value recovery is now 65 percent and the average time to process a board is 17 seconds.

Figure 6 shows the information that is displayed when the **Optimum Cut** grading choice is selected. Lumber grade, surface measure, length, width, and value corresponding to the optimum edging and trimming solution are displayed. In this example, the maximum board value is $7.84, which is substantially greater than the value of $2.60 obtained by the user. Additionally, the maximum value lumber is displayed graphically on the screen. Comparing the user's cutting solution to the maximum value lumber (Fig. 6), it can be seen that the low lumber value recovery of 33 percent resulted from overedging. The user can utilize this performance feedback information to make adjustments in subsequent edging and trimming decisions.

By again selecting **Next Board,** another board is displayed for the user to begin processing. AS noted earlier, the examples shown in Figures 1 through 6

demonstrate the operation of the program in the testing mode. The training mode operates similarly to the testing mode with a few exceptions. First, the **Next Board** menu item is disabled until after the lumber is processed and graded in the testing mode. In the training mode, **Next Board** can be selected at any time. Second, the **Optimum Cut** grading choice in the testing mode is disabled until after the processed lumber is graded. **Optimum Cut** can be chosen at any time in the training mode, even before any of the sawlines are moved. Finally, the procedure of moving sawlines and grading the resulting lumber can be repeated any number of times in the training mode whereas this procedure can be done only once in the testing mode. Therefore, the training mode is less restricted and allows the user to fully experiment on a given board to investigate how various edging and trimming solutions affect lumber value.

Conclusion

The computerized training system summarized in this paper was specifically designed for training hardwood lumber edger and trimmer operators to make better decisions. Recent studies have shown that hardwood lumber value recovery can be as low as 62 percent. A portion of such low lumber value recoveries can be attributed to problems associated with 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, and operator skill. The training system was developed to address these problems by allowing operators to experiment with various lumber edging and trimming decisions and their affect on lumber value. Inquiries related to the use of the hardwood lumber edger and trimmer training system may be directed to the senior author.

Literature cited

1. Bousquet, D.M. 1989. Saving volume and making money at the edger. Northern Logger and Timber Processor, June.
2. Flann, I.B. and F.M. Lamb. 1966. Effect of sawmill edging practice on the value of hard maple lumber. Forest Prod. J. 16(5):31-38.
3. Huang, S.S. and F.T. Sparrow. 1989. A computer-aided instruction tool for grading hardwood lumber. Forest Prod. J. 39(10):39-42.
4. Klinkhachorn, P., R.W. Conners, and H.A. Huber. 1988. Automated computer grading of hardwood lumber. Forest Prod. J. 38(3):67-69.
5. _____, C.J. Schwehm, C.W. McMillin, R.W. Conners, and H.A. Huber. 1989. HaLT: a computerized training program for hardwood lumber graders. Forest Prod. J. 39(2):38-40.
6. Microsoft Corporation. 1990. Microsoft Windows graphical environment, Version 3.0. Microsoft Corp., Redmond, Wash.
7. National Hardwood Lumber Association. 1986. Rules for the measurement and inspection of hardwood and cypress lumber. NHLA, Memphis, Term.
8. Regalado, C., D. E. Kline, and P. A. Araman. 1991. Optimum edging and trimming of hardwood lumber. Forest Prod. J. 42(l):