AUTOMATED LUMBER PROCESSING SYSTEM: GRADING THE HARDWOOD LUMBER?

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ABSTRACT

For the past few decades, researchers have devoted time and effort to apply automation and modern computer technologies towards improving the productivity of traditional industries. To be competitive, one must streamline operations and minimize production costs, while maintaining an acceptable margin of profit. This paper describes the effort of one such endeavor directed towards improving the hardwood lumber industry in the U.S.A.—specifically to automatically grade and analyze hardwood lumber.

Automated lumber grading will be plausible for hardwoods when lumber scanning systems can reliably identify all defects by type. The potential worth of a scanning grading system depends on the accuracy and reliability of the computer-assigned grades compared to the performance of human graders. This paper presents the preliminary results of the scanning-grading system compared to manual lumber grading using NHLA rules. The system uses a nondestructive vision system to scan a hardwood lumber board for its dimension and the location and type of surface defects. This information is then used to determine a lumber grade. The scanning-grader results indicated that seven out of fifteen manually graded boards were graded too high. Initial results also showed that the scanner is missing parts of defects and also misclassifying some clear wood as defective.

INTRODUCTION

It is not uncommon for the same lumber to be graded several times. Part of this re-grading effort arises because buyers need to check their purchased lumber. Further grading occurs when there are disputes between the buyer and seller in interpreting the NHLA grading rules (1). Computer grading of hardwood lumber thus becomes an attractive proposition. Computers are consistent and fast, and computer- based grading is more feasible than ever due to the ever decreasing cost and increasing power of successive generations of computers.

Computer grading of hardwood lumber has been accomplished by Hallock and Galiger (2). However, deficiencies with this program impedes widespread commercial applications. These deficiencies include the inability to adapt the program code into a working environment with other programs to evaluate and control lumber processing, and the inability to extend the grading to specialized species. Probably its greatest limitation lies in the consideration of only one face in the grading process. These deficiencies have been addressed by Klinkhachorn et al. (3-7). These efforts consider both faces in the grading process and can be extended to incorporate species-dependent rules.

APPLYING AUTOMATION TO THE HARDWOOD LUMBER INDUSTRY

For the past few decades, researchers have devoted time and effort to applying automation and modem computer technologies towards improving the productivity of traditional industries. One such system, acronymed ALPS (Automated Lumber Processing System) was proposed by McMillin et al. (8). The proposed ALPS system, shown in Figure 1, consists of six subsystems:

1) A material handling system (9,10).
2) A computer vision system to determine defects on boards using nondestructive scanning methods (11-15).
3) A computer program to assign NHLA grades to lumber.
4) A yield optimization program to compute an efficient cutting placement strategy based on a manufacturer's cutting bill (16- 19).
5) A path optimization program to compute an efficient path for the laser to follow in its attempt to effectively punch out the cuttings placed by the yield optimization program (16).
6) A high powered laser cutting system to cut the parts placed on the board (20-21).

The ALPS prototype has been successfully integrated and built (22). There are two primary advantages of ALPS in secondary manufacturing. First, the use of lasers allows any shaped cutting to be effectively punched out. Second, the use of computers ensures a consistently high yield. Secondary benefits, like reduced kerf loss (the laser requires a kerf of less than 1/16"), further add to the attractiveness of the ALPS package. Feasibility studies on ALPS have shown it to be economically attractive (23-26).

The ALPS grading system, however, is the last piece of the puzzle yet to be accomplished. The system must accurately assign one of the following grades: FAS, 1-Face, Selects, #1 Common, #2A Common, or #3A Common and Below. A computer program which assigns NHLA grades to lumber and uses both faces in the grading process was developed and has been tested extensively. However, the data obtained from the vision system describing the boards and the classification of the defects are not quite as accurate as required by NHLA rules. The vision systems must classify defects into one of the seven categories commonly found on lumber: wane, knot, hole, check, split, bark, and bark pocket. These categories are only a subset of the defect types being used by NHLA rules. To determine if the current vision system is adequate to be used in automated lumber grading, we tested the VA Tech/Forest Service color camera scanning prototype (Figure 2). The vision system forms the front end of the ALPS-grading system. It needs to obtain the dimension of a board and the location and expanse of the defects on it. This information is required by the computer grading subsystem.

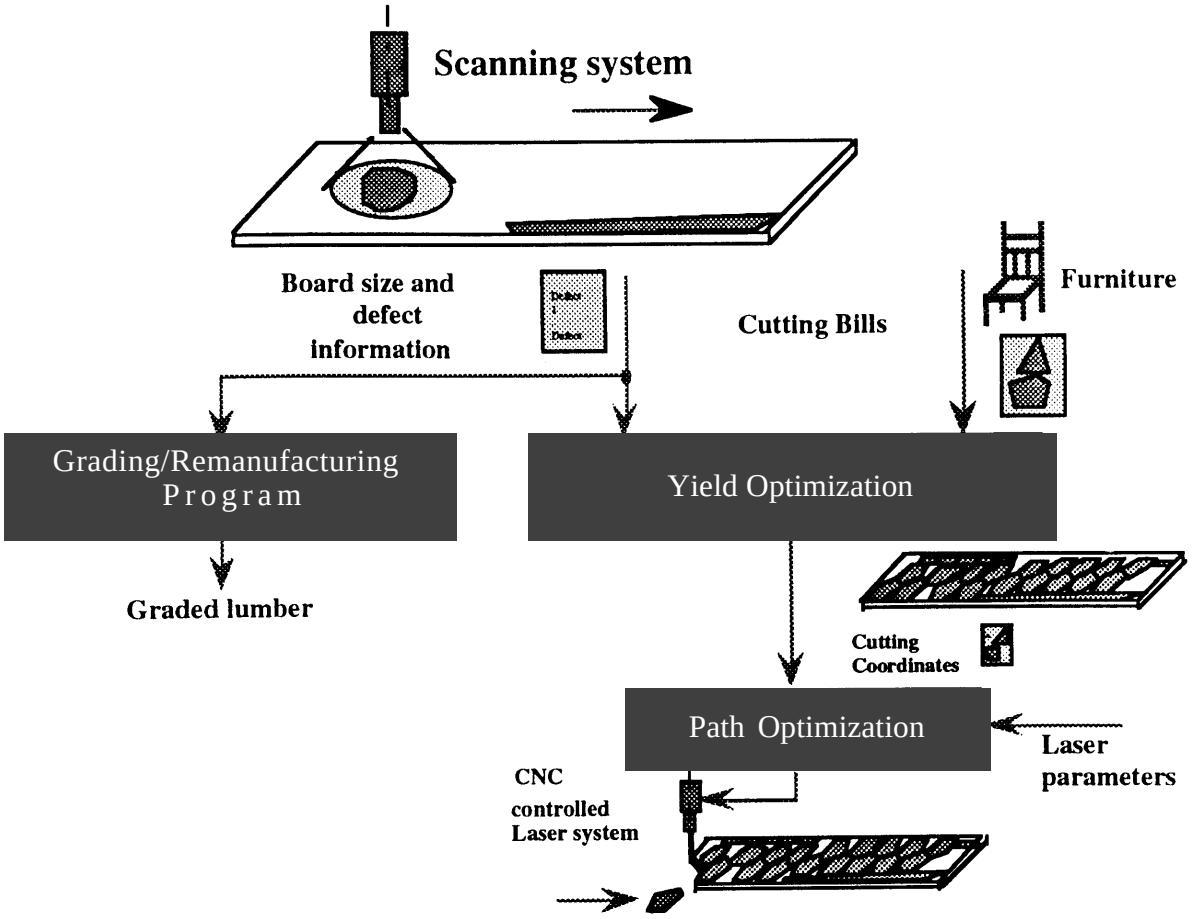

Figure 1. Automated Lumber Processing System (ALPS).

PRELIMINARY TESTING AND RESULTS

The sample boards were taken from two large samples of 4/4 red oak boards collected from two secondary manufacturers. We selected 15 boards (six #2A Common, seven #1 Common, one 1-Face, and one FAS) for this test. The boards were abrasively planed and clean. We made an effort for this test to use boards with knots that were different in color than the clearwood. This was a best case scenario for testing the scanning system.

Test runs have confirmed that the vision system and its software to reconstruct, recognize and label defects are quite accurate. It labeled most defects correctly (knots, holes, splits, bark pockets, wane and checks) and properly sized the defects. The system did miss parts of some of the splits and small checks. It also recognized some stains that we did not declare as grading defects or defects in cuttings. We need to correct the system so that these characteristics will be removed from the image when not needed.

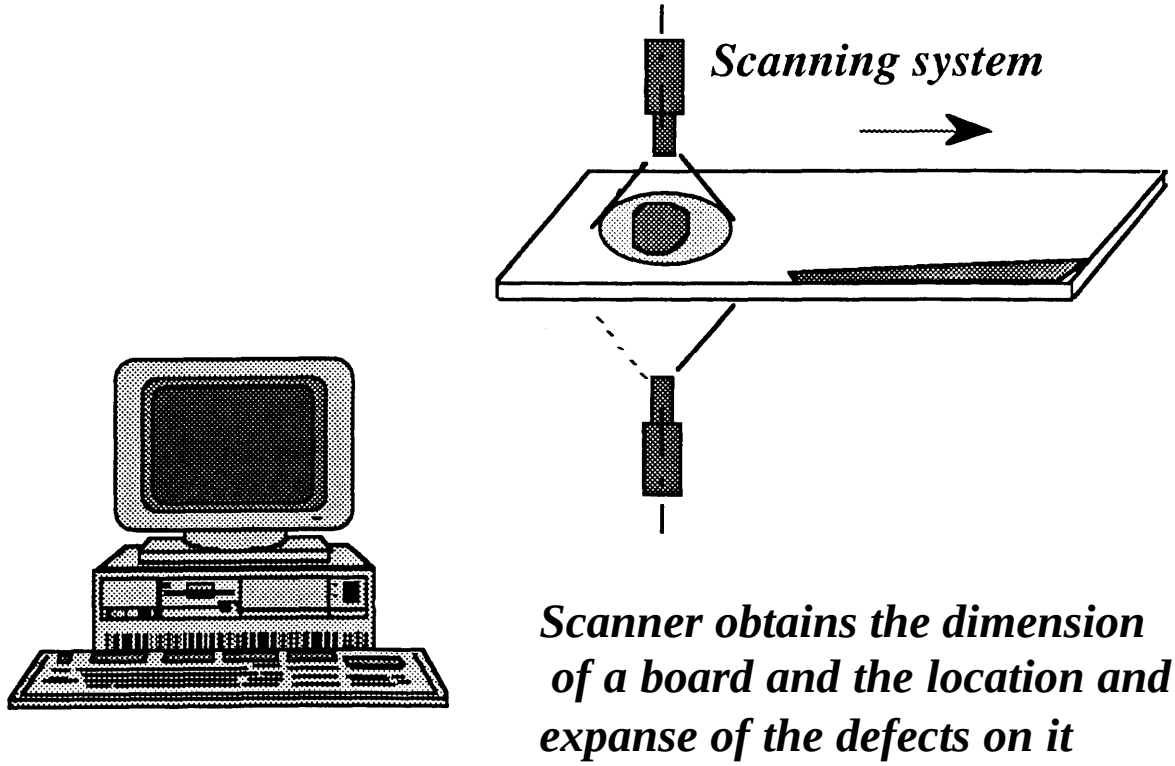

Figure 2. Automated Lumber Grader.

Table 1 shows the results of head-to-head comparisons of scan-based, computer-grading versus manual grading of fifteen hardwood boards scan results. When comparing the manual grades to the computer-

Table 1. Comparison of manually assigned lumber grades to computer scanned and assigned grades.

Board Number	Manual Grade	Computer Scan Grade	Upgrade Potential
1	1 Common	1 Common	Selects
2	1 Common	1 Common	Selects
3	2A Common	3A Common	
4	1 Common	2A Common	
5	FAS	1 Common	
6	1 Common	1 Common	
7	2A Common	3A Common	
8	1 Common	1 Common	
9	1 Face	1 Common	
10	1 Common	2A Common	
11	2A Common	3A Common	
12	1 Common	1 Common	Selects
13	2A Common	2A Common	
14	2A Common	2A Common	
15	2A Common	2A Common	

determined NHLA lumber grades, we found large discrepancies. Forty-seven percent of the boards did not have the same grades. The scanner-grader found 7 of 15 boards graded too high by company graders. We also found three #1 Common boards that could have been upgraded to Selects.

CONCLUSION AND FUTURE WORK

This paper presented preliminary results based on efforts directed towards realizing a prototype of an automated grading system as part of the Automated Lumber Processing System. The testing of the system is in its preliminary stage. Though there are large variations observed between the computer grader and the company graders, the preliminary test showed that grading improvements are possible. It is noted that when using the camera scanning system on clean, planed, good-contrast red oak lumber, the system effectively finds and properly labels defects. It is actually too good at times; we need to filter some of the characteristics that it is finding. The successful implementation of an automated grading system is heavily dependent on the accuracy and reliability of the scanner to correctly label defects according to the NHLA rules. Continued vision research is directed towards detecting additional types of defects and improving our ability to scan lumber in different conditions. More intensive testing on additional red oak lumber will be conducted in the near future.

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