Test of the Center for Automated Processing of Hardwoods' Auto-Image Detection and Computer-Based Grading and Cutup System

by

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Tests of the *Center for Automated Processing of Hardwoods'* Auto-Image Detection (Color Camera) and Computer-Based Grading and Cutup System

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Abstract

Automated lumber grading and yield optimization using computer controlled saws will be plausible for hardwoods if and when lumber scanning systems can reliably identify all defects by type. Eisting computer programs could then be used to grade the lumber, identify the best cut-up solution, and control the sawing machines. The potential value of a scanning grading system depends on the accuracy and reliability of the computer-assigned grades compared to the performance of human graders. The potential worth of any scanning cut-up system is largely dependent on the parts recovered compared to today's standard rough mill processing systems.

The *Center for Automated Processing of Hardwoods'* (CAPH) scanning system tested is a color line-scan camera-based image processing system. We compared the system's scanning-grader performance with the NHLA (National Hardwood Lumber Association) grades assigned by company graders. The scanning-grader results indicated that 20 of 50 company graded boards were graded too high and 5 too low. In total , 50 percent of the boards were manually misgraded. Initial results indicate that the CAPH color camera system missed small sections of some defects and misclassifyed some clear wood as defective.

We also compared the CAPH system's color camera scanning-optimization system to a fixed-width rip-first rough mill processing system. The scanning-optimization results indicated a potential increase in rough part yield of 4 percent might be realized with a moderately sophisticated CAPH color camera optimization system.

Introduction

Over the past several years, we have been developing an automatic image detection system (2,6) at the *Center for Automated Processing of Hardwoods* (CAPH) at Virginia Tech. The CAPH Center is an activity of the USDA Forest Service Southern Research Station in cooperation with the Northeastern Forest Experiment Station, and the Bradley Department of Electrical Engineering and the Department of Wood Science and Forest Products at Virginia Tech.

Our goals are to develop image detection systems and link them to applications software developed within CAPH and with cooperators at West Virginia University to provide automated processing systems for the wood products industry. We are developing software to locate and label surface and internal defects and wood characteristics with three different scanning devises (color line-scan camera system, laser scan-based imaging system, and x-ray system). Some applications will require more than one type of scanning devise. We are also developing software to automatically grade the scanned material and to process the scanned material into products.

We present the results of some preliminary testing of our color line-scan camera in this paper. Scanning accuracy will be explored. We will also compare the relative yield performance of the *Center for Automated Processing of Hardwoods'* scanning-optimization system (color line-scan camera only) to rip-first rough mill processing. Results are also given on the performance of the scanning-grading system to that of company graded lumber. In both situations, NHLA grading rules (7) were used.

The Sample Boards

Sample boards to test scan were taken from two large samples of 4/4 red oak boards collected from two secondary manufacturers. We selected 50 boards (21 - 2A Common, 22 - 1 Common, 2 - 1 Face, and 5 - FAS) for this test. The boards were abrasive or knife planed and clean. We made an effort to select boards with knots that differed in color to the clear wood. This was a best case scenario for test scanning mixed red oak lumber in the CAPH system.

Scanning Accuracy

The CAPH color line-scan camera and software were able to recognize and label defects and reconstruct the boards with good accuracy. The system labeled most defects correctly (knots, holes, splits, bark pockets, wane and checks) and properly sized the defects. The system did miss parts of some splits and small checks (Figure 1). Some parts of wane, knots, and holes were also missed. We are trying to correct these deficiencies and tighten our defect recognition software. It also recognized some stains that we did not declare as grading defects or defects in cuttings. This information is being used to calibrate the scanning software so that this type of board discoloration will be overlooked in cases where it is not objectionable.

Processing Results

Table 1 shows of the CAPH system-based lumber grade and cut-up optimization results and the results from manual grading and cut-up operations.

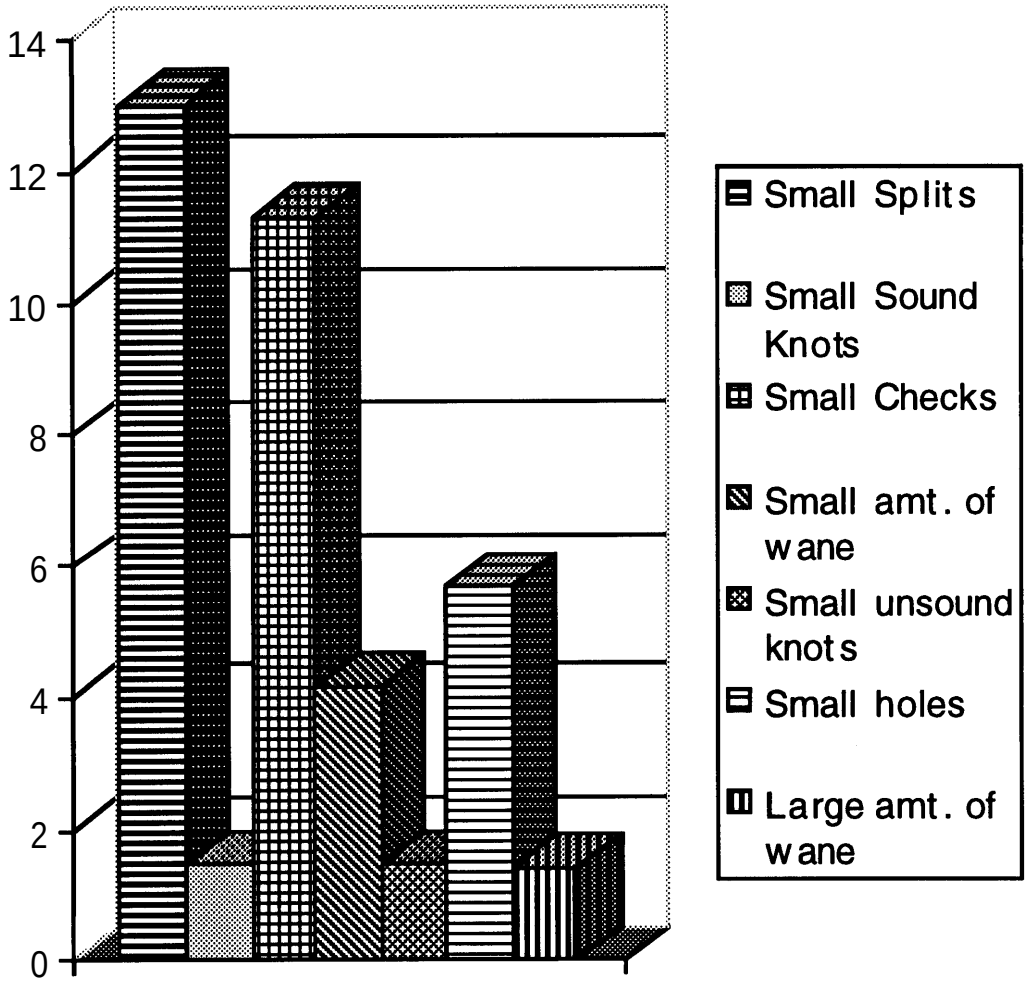


Figure 1. Percent of board surfaces where certain defects were not totally found by the CAPH scanner.

Table 1. Results of no-scan manual and CAPH scanning-system-based processing for grading lumber (NHLA rules) and processing lumber to cuttings with a fixed- arbor gangrip-first rough mill.

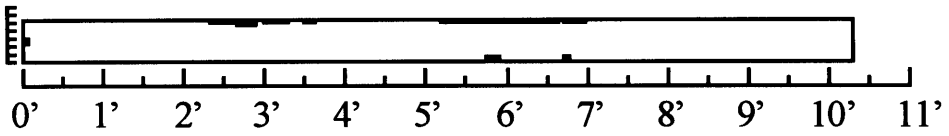
Board Number	Supplier's Grade	**Scan-computer** Grade	Fixed Gang-Rip Yield (%)	**Scan-Optimal** Fixed Gang-Rip Yield (%)
1	1 Common	1 Common	61.41	61.41
5	2A Common	2A Common	65.13	68.20
7	1 Common	2A Common	47.02	47.02
8	2A Common	3A Common	40.08	54.11
9	2A Common	2A Common	63.43	64.61
12	FAS	1 Common (Selects)	68.33	70.09
13	1 Common	1 Common (Selects)	72.71	72.71
14	1 Common	1 Common (Selects)	38.46	40.49
15	1 Common	2A Common	57.48	60.41
18	2A Common	1 Common	54.25	54.25
19	1 Common	2A Common	51.89	60.44
20	FAS	1 Common (Selects)	70.20	70.79
21	1 Common	1 Common	64.99	65.33
22	1 Common	1 Common	64.35	65.43
23	1 FACE	1 Common	63.79	63.79
26	1 Common	2A Common	44.63	54.80
27	1 Common	1 Common	68.62	68.62
28	2A Common	3A Common	39.55	41.83
30	2A Common	2A Common	65.94	65.94
31	2A Common	2A Common	36.14	54.36
32	FAS	1 Common	75.90	75.90
34	1 Common	1 Common	51.35	64.55
35	2A Common	1 Common	62.46	62.46
36	2A Common	3A Common	34.96	42.28
42	1 Common	1 Common	59.53	69.21
45	2A Common	1 Common	75.19	75.19
46	1 Common	1 Common	56.56	56.56
47	1 Common	FAS	52.03	61.60
48	2A Common	2A Common	46.95	52.07
53	2A Common	3A Common	34.97	40.26
56	2A Common	1 Common	52.36	52.36
57	FAS	1 Common (Selects)	68.30	68.30
59	2A Common	2A Common	19.29	38.57
75	1 Common	1 Common	58.18	64.71
80	2A Common	2A Common	67.72	67.72
106	1 Common	1 Common (Selects)	84.74	84.74
107	1 Common	1 Common (Selects)	59.84	66.99
112	2A Common	3A Common	22.48	39.63
113	1 Common	2A Common	31.50	39.85
114	FAS	1 Common	62.72	68.31
117	1 Common	1 Common	57.03	57.03
118	2A Common	3A Common	50.90	56.03
119	1 Common	1 Common	82.42	82.42
120	1 FACE	1 Common	74.13	74.13
121	1 Common	2A Common	52.56	57.62
233	2A Common	3A Common	43.97	52.82
238	1 Common	1 Common (Selects)	55.23	55.23
240	2A Common	2A Common	66.42	69.98
241	2A Common	2A Common	53.75	60.16
242	2A Common	2A Common	50.59	58.38
Average			56.75	60.97

When comparing the supplier's grades to the computer determined NHLA lumber grades (3,4,5), we found large discrepancies. Fifty percent of the boards were assigned different grades. The scanning-grader found 20 of 50 boards graded to high by the company graders. Only 5 of 50 boards were graded to low by the company graders. We also found six 1 Common boards that could have been upgraded to Selects.

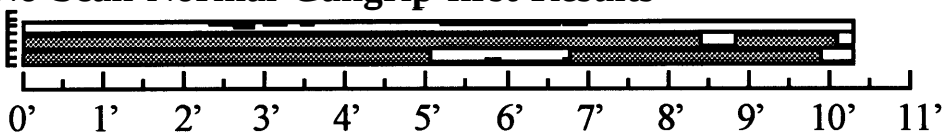
The scan-optimizer automated gangrip-first system produced a 4 percent increase in yield over the no-scan manual gangrip system. To determine the yields, we fed the board data into AGARIS (8). AGARIS is a gangrip-first cut-up simulator. We estimated the potential yield impact of the CAPH scanner-optimizer by comparing AGARIS fixed-arbor gang-rip yields (simulating a no-scan manual cut-up system) and AGARIS optimizing fixed-arbor yields (simulating a scanning-optimizer-based automated system). For both simulation runs we produced 2" wide parts in standard lengths developed by Araman, Reynolds and Gatchell (15, 18, 21, 25, 29, 33, 38, 45, 50, 60, 75, and 100"). By knowing the defect locations on the boards, we were able to utilize the optimizing-fixed-width version of AGARIS. The simulation results showed that 31 of 50 boards had higher yields with the scanning-optimizer-based optimizing fixed-arbor AGARIS processing option. Without the scan information, this is not possible.

Figures 2-4 show examples of yield improvements from AGARIS, made possible with accurate scanning. Normal gang-rip processing of the board in Figure 2 shows a 62.7 percent yield in cuttings. The scanning-optimizer-based gang-rip solution improved the yield to 68.3 percent. Figures 3 and 4 show other examples of potential yield improvements. Given a ruler, a calculator and enough time, a person may or may not find the optimal solutions. Furthermore, most plants could not let workers take the required time to find the optimal solution. Most decisions are based on minimizing edging losses from the gang-rip process and not in optimizing cuttings from the boards.

The Board With Defects

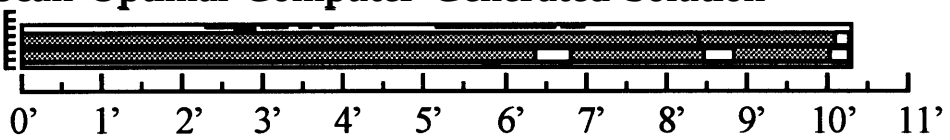


No Scan Normal Gangrip-first Results



Cutting #l -- 2.0” x 60.0”
Cutting #2 -- 2.0” x 38.0”
Cutting #3 -- 2.0” x 100.0” **Yield = 62.7%**
Cutting #4 -- 2.0” x 15.0”

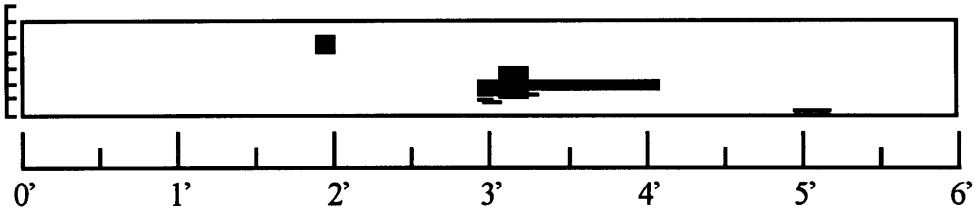
Scan Optimal Computer Generated Solution



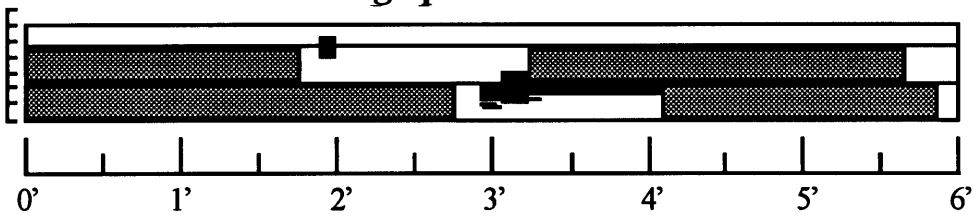
Cutting #l -- 2.0” x 75.0”
Cutting #2 -- 2.0” x 21.0”
Cutting #3 -- 2.0” x 15.0” **Yield = 68.3%**
Cutting #4 -- 2.0” x 100.0”
Cutting #5 -- 2.0” x 21.0”

Figure 2. Results from no-scan and scan processing of a 1 Common red oak board to cuttings.

The Board With Defects



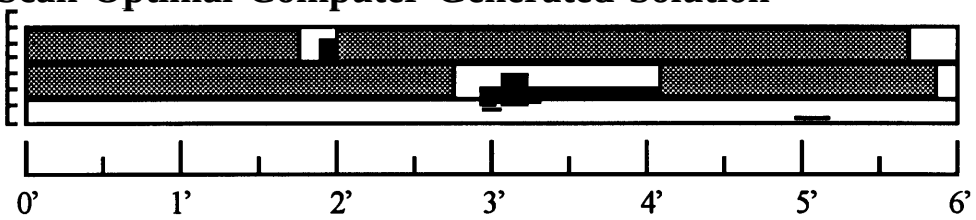
No Scan Normal Gangrip-first Results



Cutting #l -- 2.0" x 33.0"
Cutting #2 -- 2.0" x 21.0"
Cutting #3 -- 2.0" x 21.0"
Cutting #4 -- 2.0" x 29.0"

Yield = 50.6%

Scan Optimal Computer Generated Solution

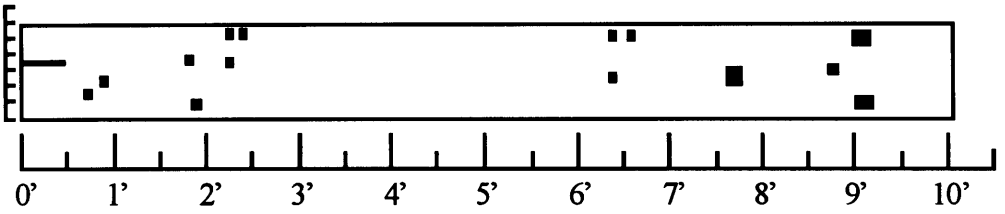


Cutting #l -- 2.0" x 33.0"
Cutting #2 -- 2.0" x 21.0"
Cutting #3 -- 2.0" x 21.0"
Cutting #4 -- 2.0" x 45.0"

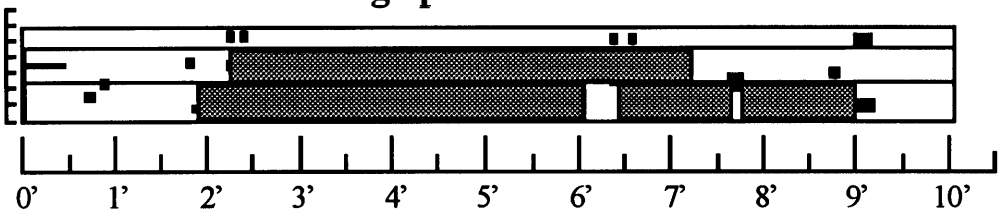
Yield = 58.4%

Figure 3. Results from no-scan and scan processing of a 2A Common red oak board to cuttings.

The Board With Defects



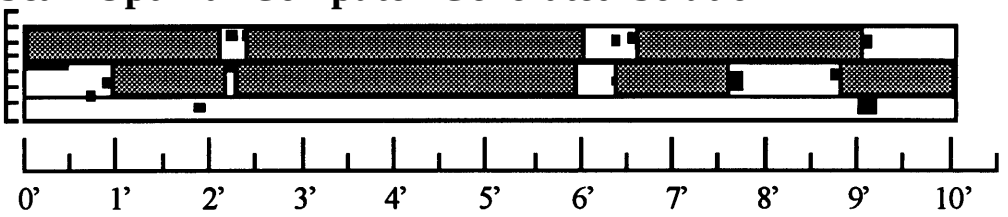
No Scan Normal Gangrip-first Results



Cutting #l -- 2.0" x 50.0"
Cutting #2 -- 2.0" x 15.0"
Cutting #3 -- 2.0" x 15.0"
Cutting #4 -- 2.0" x 60.0"

Yield = 40.1%

Scan Optimal Computer Generated Solution



Cutting #l -- 2.0" x 15.0"
Cutting #2 -- 2.0" x 45.0"
Cutting #3 -- 2.0" x 15.0"
Cutting #4 -- 2.0" x 15.0"
Cutting #5 -- 2.0" x 25.0"
Cutting #6 -- 2.0" x 45.0"
Cutting #7 -- 2.0" x 29.0"

Yield = 54.1%

Figure 4. Results from no-scan and scan processing of a 3A Common red oak board to cuttings.

Summary

The CAPH color line scan camera system for clean, planed, good contrast red oak lumber is very effective in finding and properly labeling defects. It is actually too good at times; we need to filter some of the characteristics that it is finding. This test on a sample of 50 boards indicated the CAPH scanning system can generate significant yield improvements and more accurate lumber grading. We will be performing larger scale and more rigorous tests on the color-line-scan camera imaging system with improved recognition software and the other scanning devices over the next 6 months.

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