Advancements in Hardwood Processing Technology
23rd March 2017
Federico Giudiceandrea

2017 HMA National Conference and Expo
Charleston, SC
Ash
Vision and Cognition

LGN circuit

- **g**: retinal ganglion cells
- **r**: LGN relay cells
- **c**: cortical cells
- **i**: LGN interneurons
- **t**: thal. retic.(TRN) cells
- **BRF**: brain stem input

**Connections**:
- Excitatory conn.
- Inhibitory conn.
- Modulatory conn.
Image recognition fails
100 Billion Neurons
Intel claims that by 2026 processors will have as many transistors as there are neurons in a brain
Human eye
Multi-sensor approach to artificial vision
UPON DARTING INTO THE HOSPITAL...

MY PATIENT HAS A GLASS
FRAGMENT IN HIS BRAIN SOME-
WHERE, BUT BECAUSE ORDINARY
X-RAYS CAN'T REVEAL THE
LOCATION OF THE SLIVER,
I CAN'T OPERATE...

HMM! MY OWN
X-RAY VISION
HAS A GREATER
RANGE THAN ANY
HOSPITAL X-RAY
MACHINE, SO DON'T
WORRY!

I SEE THE SLIVER!
ALL RIGHT, DOCTOR,
GET READY TO
OPERATE!
Goldeneye the Multisensory Scanner
Multisensory-Scanning

- Color
- X-ray
- 3D laser triangulation
- Laser scattering
- Grain deviation
Color Scanning

Color scanning with LED Illumination
Color Scanning

Color images through RGB analysis (red, green, blue):

Original board
Maple
X-ray Scanning

- Determination of a density map on the whole length and width of the board.
- Accurate measuring of the wood density in kg/m3.
- Radiography applied to wood permits detection of knots and density.
X-ray Scanning

Excluding false knot detection on dirty and rough areas

Original board - Oak

Scanning result without X-ray

Scanning result with X-ray avoiding over-detection caused by dirt and under-detection of knots covered by roughness
X-ray Scanning

Excluding false knot detection on dirty and rough areas

Scanning result without X-ray

Scanning result with X-ray avoiding over-detection caused by dirt and under-detection of knots covered by roughness
X-ray Scanning

Improving knot detection especially of sound knots with similar color to the clear wood – example on Oak
X-ray Scanning
3D Laser Triangulation

Laser
Image Sensor

3D Imaging:
Every image point represents the distance from a reference plane
Laser Scattering

Laser scattering image: every pixel represents the amount of scattered light
Grain deviation
<table>
<thead>
<tr>
<th>Method</th>
<th>Wood Defects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser</td>
<td>Dimension, warping, wane, cracks, lack of material</td>
</tr>
<tr>
<td>Color</td>
<td>Heartwood, sapwood, knots, coloration, stain</td>
</tr>
<tr>
<td>X-ray</td>
<td>Knots, density, internal defects, metal inclusions</td>
</tr>
</tbody>
</table>
Multi-Sensor Scanning
The purposes of this Hardwood Sales Code are as follows:

1. To establish uniform practices in the conduct of transactions, involving the sale and purchase of hardwood lumber, by defining in plain unequivocal terms, the approved customs and usages of the trade under which such transactions are conducted.

2. To supply reasonable regulations governing elements of transactions that are not already covered by established customs.

3. To provide practical and responsive means for the settlement of disputes arising between sellers and buyers of hardwood lumber, without recourse to litigation.
ARTICLE X – Inspection

Section 6. If the result of the dispute inspection reveals that less than 80% of the total footage in the shipment is in accordance with the specifications of the order, the seller shall reimburse the buyer for any freight paid by the buyer on the shipment, and the shipment shall be held for the disposition of the shipper, who is to pay all expenses of the inspection and labor charges at actual cost or at the rate of $15.00 per M feet, whichever is less.

Section 7. If the result of the dispute inspection reveals that at least 80% of the total footage in the shipment is in accordance with the specifications of the order, then the total value of all lumber of the species ordered, as revealed by this dispute inspection, is to be calculated, using prices shown on the order and recognized price differentials for other items of the species ordered.
ARTICLE X – Inspection

Section 8. Should this dispute inspection result in not more than 4% deductible difference in money value from the gross amount of the invoice, the buyer is to pay all expenses of the inspection, accept all lumber and honor the seller’s invoice in full. If the deductible difference be more than 4% money value the seller is to pay all expenses of the NHLA inspection and labor charges at actual cost or at the rate of $15.00 per M feet, whichever is less. The seller shall invoice for and the buyer shall retain and pay for all items reported on the dispute inspection certificate of the species and thickness ordered. All other items shall be held for the disposition of the shipper.
Minimum Performance

x 96% on Value (within 4% of invoice)

x 80% on Grade
Hardwood Lumber Grading System

- MiCROTEC Goldeneye™ Scanner
- Purdue University HardwoodGrader™ Software
Hardwood Lumber Grading System

- 9 hardwood species:
  Ash, Basswood, Cherry, Hickory, Poplar, Soft Maple, Hard Maple, Red Oak, White Oak
- 1,000 boards/species
- About 36,000 board feet total
## Completed to Date

<table>
<thead>
<tr>
<th>Species</th>
<th>All Grades</th>
<th># of Boards by Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BF boards</td>
<td>S&amp;B</td>
</tr>
<tr>
<td>Ash</td>
<td>2,814</td>
<td>701</td>
</tr>
<tr>
<td>Basswood</td>
<td>4,037</td>
<td>1,023</td>
</tr>
<tr>
<td>Cherry</td>
<td>4,130</td>
<td>1,095</td>
</tr>
<tr>
<td>Hard Maple</td>
<td>1,445</td>
<td>305</td>
</tr>
<tr>
<td>Hickory</td>
<td>3,964</td>
<td>1,021</td>
</tr>
<tr>
<td>Poplar</td>
<td>4,289</td>
<td>1,024</td>
</tr>
<tr>
<td>Red Oak</td>
<td>1,567</td>
<td>444</td>
</tr>
<tr>
<td>Soft Maple</td>
<td>1,908</td>
<td>428</td>
</tr>
<tr>
<td>White Oak</td>
<td>464</td>
<td>118</td>
</tr>
<tr>
<td>Overall</td>
<td>24,618</td>
<td>6,159</td>
</tr>
</tbody>
</table>
Hardwood Lumber Grading System

Performance

99.98% on Value (0.02% off invoice)

93% on Grade
<table>
<thead>
<tr>
<th>Species</th>
<th>Off Value</th>
<th>On Grade</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash</td>
<td>-0.32%</td>
<td>90%</td>
<td></td>
</tr>
<tr>
<td>Basswood</td>
<td>1.23%</td>
<td>94%</td>
<td>*completed</td>
</tr>
<tr>
<td>Cherry</td>
<td>-0.03%</td>
<td>93%</td>
<td>*completed</td>
</tr>
<tr>
<td>Hard Maple</td>
<td>-0.44%</td>
<td>97%</td>
<td></td>
</tr>
<tr>
<td>Hickory</td>
<td>-0.83%</td>
<td>92%</td>
<td>*completed</td>
</tr>
<tr>
<td>Poplar</td>
<td>-0.32%</td>
<td>94%</td>
<td>*completed</td>
</tr>
<tr>
<td>Red Oak</td>
<td>0.30%</td>
<td>91%</td>
<td></td>
</tr>
<tr>
<td>Soft Maple</td>
<td>0.34%</td>
<td>92%</td>
<td></td>
</tr>
<tr>
<td>White Oak</td>
<td>1.27%</td>
<td>92%</td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>-0.02%</td>
<td>93%</td>
<td></td>
</tr>
</tbody>
</table>
## Value by Grade

<table>
<thead>
<tr>
<th>Species</th>
<th>Off Value</th>
<th>by Grade</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>S&amp;B</td>
<td>1C</td>
<td>2C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>-0.32%</td>
<td>-1.23%</td>
<td>0.00%</td>
<td>1.79%</td>
</tr>
<tr>
<td>Basswood</td>
<td>1.23%</td>
<td>-2.46%</td>
<td>0.25%</td>
<td>11.90%*completed</td>
</tr>
<tr>
<td>Cherry</td>
<td>-0.03%</td>
<td>-1.67%</td>
<td>-0.24%</td>
<td>7.84%*completed</td>
</tr>
<tr>
<td>Hard Maple</td>
<td>-0.44%</td>
<td>-2.95%</td>
<td>2.56%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Hickory</td>
<td>-0.83%</td>
<td>-3.43%</td>
<td>-0.62%</td>
<td>2.41%*completed</td>
</tr>
<tr>
<td>Poplar</td>
<td>-0.32%</td>
<td>-1.92%</td>
<td>-0.01%</td>
<td>4.16%*completed</td>
</tr>
<tr>
<td>Red Oak</td>
<td>0.30%</td>
<td>0.00%</td>
<td>-1.90%</td>
<td>3.78%</td>
</tr>
<tr>
<td>Soft Maple</td>
<td>0.34%</td>
<td>-1.01%</td>
<td>1.62%</td>
<td>0.00%</td>
</tr>
<tr>
<td>White Oak</td>
<td>1.27%</td>
<td>0.00%</td>
<td>1.27%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Overall</td>
<td>-0.02%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Public Demonstration
March 29, 2017
or by appointment
Akron, Indiana

Contact
Dr. Rado Gazo
765-494-3634
gazo@purdue.edu

Automated Hardwood Lumber Grading Demonstration
March 28, 2017
at Pike Lumber Company
Akron, Indiana

Purpose: For over a century, hardwood lumber has been inspected and graded by human inspectors with appropriate training and experience. National Hardwood Lumber Association is the "keeper" of the rules for the inspection of hardwood lumber and provider of the training of lumber inspectors. In the age when computers, sensors and scanners are ever more present in our lives, this event will demonstrate a working, industrial-grade system of software and hardware that can be used to assist human graders to become more efficient in inspecting lumber, or to grade lumber automatically. Demonstration will include hardwood species of white oak, red oak, hard maple, soft maple, ash, poplar, hickory, basswood and cherry.

Audience: Hardwood sawmills, distribution and concentration yards, lumber sales, furniture factories

Instructors: Dr. Rado Gazo, Logan Wells and Vojtech Krs, Purdue University

Registration: The registration fee is $90. Lunch will be provided. Space is limited. If there is a sufficient interest, program will be repeated on March 29, 2017.

Lodging: Nearest motels are in Rochester, IN.

Safety: Each attendee assumes responsibility for his/her own safety. Please bring earplugs, safety glasses and steel-toed shoes.

Location: Pike Lumber Company, 719, Front Street, Akron, IN 46910

PROGRAM
9:30 a.m. Registration. Meet at front office.

10:00 a.m. Examination of Sample Lumber. Approximately 15 pieces of rough lumber of each of the nine above-mentioned species in variety of NHLA grades will be laid out for inspection. Lumber will exhibit common defects, features and characteristics relevant in determining grades.

11:00 a.m. Automated lumber grading (part 1). The sample lumber will be scanned by Micotec Goldeneye™ lumber scanner and graded by a program HardwoodGrade™ developed at Purdue University. Step-by-step automated grading process will be displayed and explained. Each board will be made available for manual inspection and comparison.

12:00 p.m. Lunch will be provided

12:30 p.m. Automated lumber grading (part 2). Continuation of part 1 above. Additionally, if there is sufficient interest, a larger board sample can be run through the scanner.

2:30 p.m. Summary. Approximately 1,000 boards of each of the nine species in grades Selects & Better, 1 Common and 2 Common have been scanned, software-graded and verified by a NHLA trained inspector. The results of this 3-month long, automated lumber grading study will be presented.
<table>
<thead>
<tr>
<th></th>
<th>Lumber</th>
<th>Log</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser</td>
<td><img src="image1.png" alt="Laser Image" /></td>
<td><img src="image2.png" alt="Log Laser Image" /></td>
</tr>
<tr>
<td>Color</td>
<td><img src="image3.png" alt="Color Image" /></td>
<td><img src="image4.png" alt="Log Color Image" /></td>
</tr>
<tr>
<td>X-ray</td>
<td><img src="image5.png" alt="X-ray Image" /></td>
<td><img src="image6.png" alt="Log X-ray Image" /></td>
</tr>
</tbody>
</table>
CT Log Scanning
It has always been the dream of sawmillers...
Thank You.
Hardwood Scanning Technology
for
Automated Lumber Grading according NHLA Rules