HIGH-SPEED COMPUTED TOMOGRAPHY

PASSION - INNOVATION - DEDICATION
RADIOGRAPHY VS. COMPUTED TOMOGRAPHY

RADIOGRAPHY RETURNS A TWO-DIMENSIONAL VIEW OF AN OBJECT

CT CAN “SEE” THE THIRD DIMENSION OF THE OBJECT
## Adding Value to the Timber-Log Processing Chain

<table>
<thead>
<tr>
<th><strong>LogEye</strong></th>
<th><strong>Multiple Log Radiography</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CT.Log</strong></td>
<td><strong>Computed Tomography for Logs</strong></td>
</tr>
</tbody>
</table>
LOGEYE

MULTI-VIEW APPROACH WITH MULTIPLE X-RAY LEVELS
X-RAY TECHNOLOGY
FOR OVER 33 YEARS, MICROTEC DEVELOPS SYSTEMS FOR THE RECOGNITION OF WOOD CHARACTERISTICS AND FOR INCREASING VALUE OF BOTH, MANUFACTURING PROCESS AND THE FINAL PRODUCTS. IN THE PAST 15 YEARS THE X-RAY TECHNOLOGY FOR TIMBER-LOGS AND SAWN-WOOD HAS BEEN A MILESTONE IN THE WOOD PROCESSING INDUSTRY.

1995: X-RAY SCANNER FOR SAWN-WOOD
(GOLDENEYE)

2000: X-RAY SCANNER FOR LOGS
(LOGEYE)
THE MULTI-VIEW APPROACH

BY USING MULTIPLE X-RAY SOURCES THE MULTI-VIEW SYSTEM IS ABLE TO DETECT INTERNAL STRUCTURES OF LOGS

THE DISCRETE TOMOGRAPHY ALGORITHM IS CAPABLE OF RECONSTRUCTING A SIMPLIFIED MODEL OF THE LOG FOR THE DETECTION OF GENERAL CHARACTERISTIC SUCH AS KNOTTINESS, INTERNODE DISTANCE, KNOTTY-CORE DIMENSIONS, DENSITY, ....
LOGEYE

ViSCAN

IDENTIKIT LOGEYE
Scales, and provides in-depth stem and log description
Determines volume under and over bark
Recognizes size and position of knots, shakes, cracks, ...
Sorts stems and logs according to stiffness and MOE
Enables optimum clearwood recovery
Increases throughput and products with higher value
Calculates cutting pattern with the highest yield, quality and value
**SCA Tunadal/Sweden**

**TOMOLOG**: X-ray scanning for determining internal wood characteristics

**SCREENLOG-PLUS**: Color scanning and laser triangulation for 3D reconstruction
COMPUTED TOMOGRAPHY

CT.LOG

INDUSTRIAL HIGH-SPEED CT-TECHNOLOGY FOR THE ULTIMATE ADDED VALUE OF LOGS
COMPUTED TOMOGRAPHY – THE TECHNOLOGY
COMPUTED TOMOGRAPHY

RECONSTRUCTION OF THE AXIAL IMAGE AFTER THE TOMOGRAPHIC INVERSION (RADON TRANSFORM) OF THE SINOGRAM
COMPUTED TOMOGRAPHY – FIRST TRIALS

FIRST LOG IN A CT SCANNER: IMATRON (CALIFORNIA) 1986

FIRST FULL LOG SCANNED: LOUISIANA STATE UNIVERSITY 1994
CONE BEAM CAT-scanner at the Wood Research Center of Freiburg Germany (FVA)

Operations were started October 2007.

The machine is used for developing and validating the algorithms for the LOGEYE by delivering the reference and simulating different projections for an optimal choice of number and angular distance of the multi-view projections.
CT.LOG

FIRST FULL SCAN
LARGE CONE BEAM COMPUTED TOMOGRAPHY
LARGE CONE BEAM COMPUTED TOMOGRAPHY
Wood property extraction with CT.LOG:

CT.LOG: one scanner for the internal inspection of multiple wood properties of each log during production.
Wood property extraction with CT.LOG:
Pith
Sound Knots

Wood property extraction with CT.LOG:
Pith
Sound Knots
Dead Knots

Wood property extraction with CT.LOG:
Wood property extraction with CT.LOG:

- Pith
- Sound Knots
- Dead Knots
- Splits
Wood property extraction with CT.LOG:

- Pith
- Sound Knots
- Dead Knots
- Splits
- Resin Pockets
Wood property extraction with CT.LOG:

- Pith
- Sound Knots
- Dead Knots
- Splits
- Resin Pockets
- Rotten parts
- Slope of grain
- Heartwood
- Metals
- Green density
- Annual ring spacing
- Compression wood
- Bark enclosures
- Specie recognition
- Under bark shape
CT data can be used to analyze and evaluate different production strategies for each log.
CT.LOG Virtual Sawing

All possible cutting pattern can be simulated
CT.LOG Virtual Sawing

Wood properties detected
CT.LOG Virtual Sawing

Virtual boards and wood properties intersected
CT.LOG Virtual Sawing

Each board analyzed
CT.LOG Virtual Sawing

Density image of a virtual board
CT.LOG Virtual Sawing

Intersection of wood properties with a virtual board

- shakes
- Sound knots
- Dead knots
- Pith
CT.LOG Virtual Sawing

Comparison with the real sawn board
CT.LOG

CUSTOMER INSTALLATIONS
CT.LOG INSTALLATION IN NORTH-AMERICA

INSTALLATION: JULY 2012
CONVEYING SPEED: 3 M/MIN
WOOD SPECIES: CHERRY, WALNUT, MAPLE, OAK
CT.LOG INSTALLATION IN NORTH-AMERICA

APPLICATION:

- Full digital log description including internal wood characteristics
- Automated quality and value determination with operator confirmation
- Manual grading and sorting based on quality, value and optimised cutting-pattern
- Manual cutting-pattern and break-down optimization based on internal quality
- Log-front marking for correct saw-infeed
CT.LOG INSTALLATION IN NORTH-AMERICA

RECOGNITION OF:

- Knots
- Insects holes
- Internal cracks
- Rot presence
- Bark inclusions
- Grain patterns
- Visual defects
- Pith identification
- Foreign body detection
CT.LOG INSTALLATION AT ARAUCO IN CHILE

INSTALLATION: SEPTEMBER 2012
CONVEYING SPEED: 60 M/MIN
WOOD SPECIES: RADIATA PINE
CT.LOG INSTALLATION AT ARAUCO IN CHILE

APPLICATION:
- **FULL DIGITAL LOG DESCRIPTION INCLUDING INTERNAL WOOD CHARACTERISTICS**
- **REAL-TIME GRADING AND SORTING BASED ON QUALITY, VALUE AND OPTIMISED CUTTING-PATTERN**
- **REAL-TIME CUTTING-PATTERN AND BREAK-DOWN OPTIMIZATION BASED ON INTERNAL QUALITY**
CT.LOG INSTALLATION AT ARAUCO IN CHILE

RECOGNITION OF:
- Knotty Whorls Position
- Pruned Length
- Knotty Core Diameter
- Knot Diameter Evaluation
- Bird-eye Presence
- Sapwood/Heartwood Density
- Internal Pith Position, Eccentricity
- Low Density Rot Identification
- External and Internal Cracks
- Foreign Body Detection
CT.LOG INSTALLATION AT ARAUCO IN CHILE
CT.LOG INSTALLATION AT SIAT-BRAUN IN FRANCE

Installation: December 2012
Conveying speed: 120 m/min
Wood species: Spruce, Fir, Pine
CT.LOG INSTALLATION AT SIAT-BRAUN IN FRANCE

APPLICATION:
- FULL DIGITAL STEM DESCRIPTION INCLUDING INTERNAL WOOD CHARACTERISTICS FOR STEMS UP TO 25 M
- REAL-TIME GRADING AND SORTING BASED ON QUALITY, VALUE AND CUTTING-PATTERN OF LOGS
- REAL-TIME BUCKING OPTIMIZATION FOR STEMS UP TO 25 M BASED ON INTERNAL QUALITY
CT.LOG INSTALLATION AT SIAT-BRAUN IN FRANCE

Recognition of:
- Species recognition
- Single knot identification and measure
- Whorls characterization
- Sapwood/Heartwood detection
- Internal pith position, eccentricity
- Density and weight measurement
- Ring width distribution
- Grain shape evaluation
- Resin pockets presence evaluation
- Rotten log identification
- External and internal cracks
- Spiral grain
- Foreign body detection
CT.LOG INSTALLATION AT SIAT-BRAUN IN FRANCE
EXTRACTION OF A FINGER PRINT PROFILE FOR EACH LOG USING CT DATA
EXTRACTION OF A FINGER PRINT PROFILE FOR EACH LOG COMBINING TOMOLOG AND DISHAPE INFORMATION
MATCHING OF THE FINGERPRINTS TO IDENTIFY THE CORRECT LOG

THE FINGERPRINT IS COMPARED WITH EACH COMPATIBLE LOG IN THE DATABASE
MATCHING OF THE FINGER PRINTS TO IDENTIFY THE CORRECT LOG

THE MINIMAL DIFFERENCE IDENTIFIES THE LOG IN THE DATABASE

Finger print DATABASE

DIFFERENCE WITH EACH FP IN THE DATABASE
MATCHING PROCESS

MATCHING OF 16,000 LOGS
ROTATION RECOVERY: SIMULATION OF *DiSHAPE* AND *TOMOLOG* AT DIFFERENT ANGLES USING *CT.LOG* DATA PROJECTION

**TOMOLOG** PROJECTION

Angle = 0°

SIMULATED **TOMOLOG** PROJECTION BASED ON CT AND ROTATION
MATCHING OF **Tomolog** Projection

**Tomolog** Projection

SIMULATED **Tomolog** Projection based on CT and Rotation

ANGLE = 5°
MATCHING OF **TOMOLOG** PROJECTION

**TOMOLOG** PROJECTION

ANGLE = 350°

**SIMULATED TOMOLOG** PROJECTION BASED ON CT AND ROTATION
BEST ANGLE MATCHED

\[ \text{ANGLE} = 123° \]

**TomoLog Projection**

**Simulated TomoLog Projection based on CT and Rotation**
EXAMPLES OF ANGULAR MATCHING OBTAINED FROM SOME LOGS. THE MINIMUM CORRESPONDS TO THE ANGLE IN THE ORIGINAL CT DATA.
CT.LOG

CLOSING THE LOOP
VIRTUAL SAWMILL
10A. INTEGRATION BETWEEN BREAKDOWN MACHINERY SOFTWARE AND CT.LOG

CT.LOG

MAXiCUT

Geometry
Cutting pattern

Virtual Boards

GOLDenEYE

Value
Cutting Pattern Evaluation

- Based on the diameter, the appropriate cutting pattern is selected
- Each cutting pattern is evaluated for each angle (step of 2°)
- The optimal rotation is selected in order to obtain the maximal price from boards
- Each board is classified and priced based on the defects on the 4 surfaces: sound knots, dead knots, wane, splits, resin pockets.
• Virtual sawmill approach: the cutting pattern is rotated and each single board is priced

- 0° Total price: 55€
- 45° Total price: 41€
- 120° Total price: 58€
- 160° Total price: 52€
- Rotation optimization based only on external shape
- Assuming board without knots or other internal defects
- Filtered to consider mechanical positioning errors
• Rotation optimization using internal knot evaluation (CT)
• Estimation of the real price of each board in the cutting pattern
• Filtered to consider mechanical positioning errors.
• Optimal angle based on external shape doesn’t coincide with the optimal angle for price.
• Using CT optimisation the price of the boards increases from 30,2€ to 43,8€
• Optimal angle based on shape: 84°. Price 148.8 €
• Optimal angle based on CT: 155°. Price 168.9 €
**CT.LOG**

**CLOSING THE LOOP**

**VIRTUAL PEELING**
VIRTUAL PEELING
TEST DESCRIPTION

Logs used: 50 pruned radiata pine from Arauco scanned with with the CT.LOG

Evaluation of the clear volume obtained with 2 different alignment methods:

1. Alignment based on the maximal cylinder contained in the log (using external shape)

2. Alignment based on the maximization of the clear volume in function of the effective knots position (using CT data)
CONVENTIONS FOR THE LONGITUDINAL VIEW IMAGES

- Scale in mm
- Log shape in the small end
- Log shape in the big end
- Knots longitudinal projection
- Peeling alignment in the center (0,0)
- Max cylinder entirely inside the log centered in (0,0)
- Knotty core cylinder centered in (0,0)
- Clear volume: region between green and purple circles
Peeling comparison on log 6

<table>
<thead>
<tr>
<th>N log</th>
<th>sed</th>
<th>led</th>
<th>length</th>
<th>DJAS</th>
<th>JAS</th>
<th>perfect diam</th>
<th>kcd</th>
<th>vol clean</th>
<th>Yield</th>
<th>increment with CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>396</td>
<td>450</td>
<td>2170</td>
<td>38</td>
<td>0.313</td>
<td>OPTIMIZED WITH SHAPE</td>
<td>378</td>
<td>0.126</td>
<td>40%</td>
<td>11.1%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>OPTIMIZED WITH CT</td>
<td>364</td>
<td>0.139</td>
<td>45%</td>
<td></td>
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</tbody>
</table>
Peeling comparison between optimization based on external shape and CT.LOG
Peeling comparison between optimization based on external shape and CT.LOG
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Peeling comparison between optimization based on external shape and CT.LOG
Peeling comparison between optimization based on external shape and CT.LOG
Peeling comparison on log 10

<table>
<thead>
<tr>
<th>N log</th>
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<th>length</th>
<th>DJAS</th>
<th>JAS</th>
<th>perfect diam</th>
<th>kcd</th>
<th>vol clean</th>
<th>Yield</th>
<th>increment with CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>440</td>
<td>516</td>
<td>2190</td>
<td>44</td>
<td>0.424</td>
<td>OPTIMIZED WITH SHAPE</td>
<td>418</td>
<td>0.171</td>
<td>40%</td>
<td>9.2%</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>OPTIMIZED WITH CT. LOG</td>
<td>405</td>
<td>0.187</td>
<td>44%</td>
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</tbody>
</table>
Peeling comparison between optimization based on external shape and CT.LOG
Peeling comparison between optimization based on external shape and CT.LOG
Peeling comparison between optimization based on external shape and CT.LOG
Log 10/ 4

Peeling comparison between optimization based on external shape and CT.LOG
Peeling comparison between optimization based on external shape and CT.LOG
Peeling comparison between optimization based on external shape and CT.LOG
Peeling comparison between optimization based on external shape and CT.LOG
Peeling comparison between optimization based on external shape and CT.LOG
Peeling comparison on log 21

<table>
<thead>
<tr>
<th>N log</th>
<th>sed</th>
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<th>length</th>
<th>DJAS</th>
<th>JAS</th>
<th>perfect diam</th>
<th>kcd</th>
<th>vol clean</th>
<th>Yield</th>
<th>increment with CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>307</td>
<td>353</td>
<td>2190</td>
<td>30</td>
<td>0.197</td>
<td>OPTIMIZED WITH SHAPE</td>
<td>298</td>
<td>227</td>
<td>0.064</td>
<td>33%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>OPTIMIZED WITH CT</td>
<td>288</td>
<td>191</td>
<td>0.080</td>
<td>41%</td>
</tr>
</tbody>
</table>
Peeling comparison between optimization based on external shape and CT.LOG
Peeling comparison between optimization based on external shape and CT.LOG
Peeling comparison between optimization based on external shape and CT.LOG

Optimized with external shape

Optimized with CT.Log
Peeling comparison between optimization based on external shape and CT.LOG
## Global Results on All Logs

<table>
<thead>
<tr>
<th>Alignment method</th>
<th>Total clear volume (m³)</th>
<th>Expected increment with CT.LOG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimization with shape</td>
<td>7.38</td>
<td>+7.1%</td>
</tr>
<tr>
<td>Optimization with CT.LOG</td>
<td>7.90</td>
<td></td>
</tr>
</tbody>
</table>
THANK YOU!

FEDERICO.GIUDICEANDREA@MICROTEC.EU