Hardwood Log Scanning & Optimization

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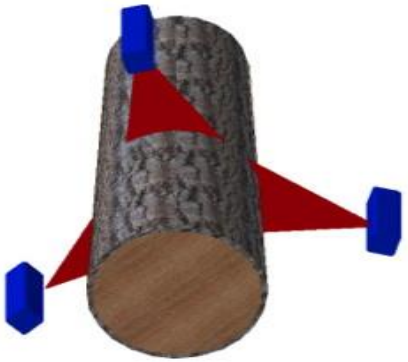
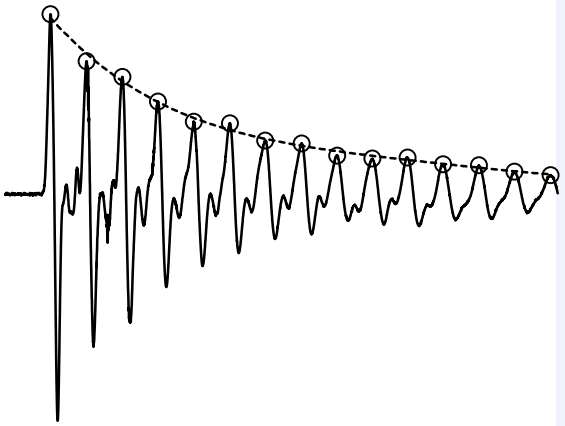
Introduction

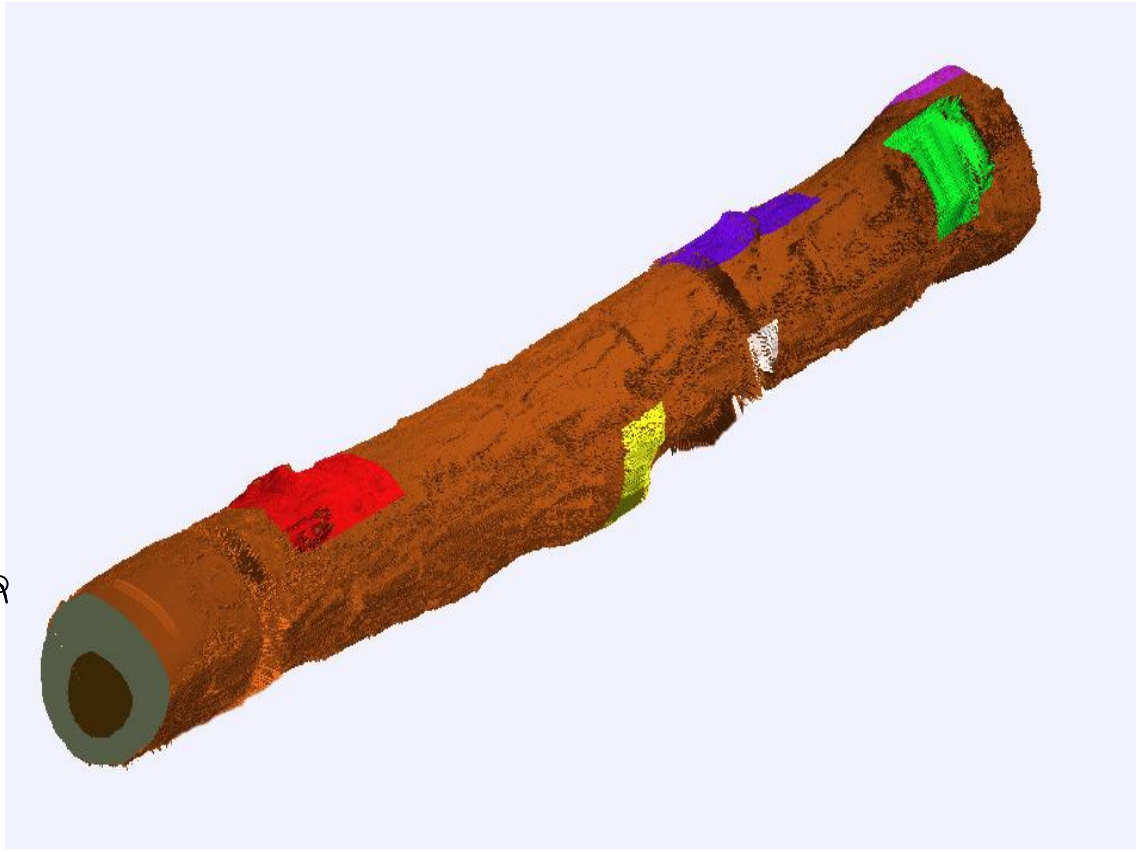
- There are several non-destructive methods that can be used for assessing hardwood log quality.
  - X-Ray/CT Scanning
  - MRI
  - Microwave
  - Ultrasound/Acoustic
  - Laser Scanning

Introduction

- Collaboration: WVU & Forest Products Laboratory
  - ✓3D laser scanning
  - ✓Acoustic wave impact testing & waveform analysis

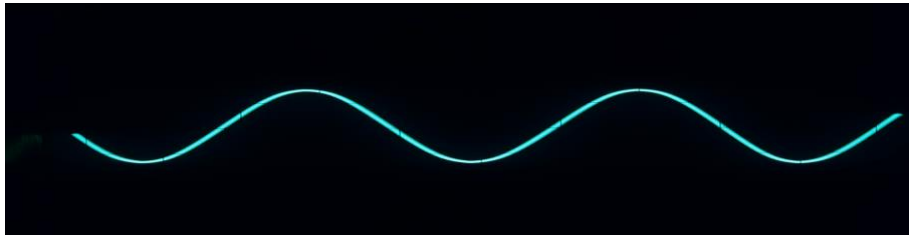


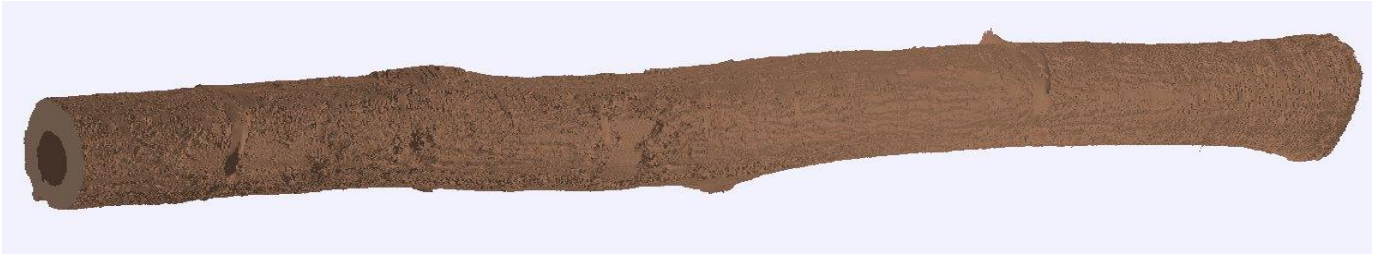




Introduction

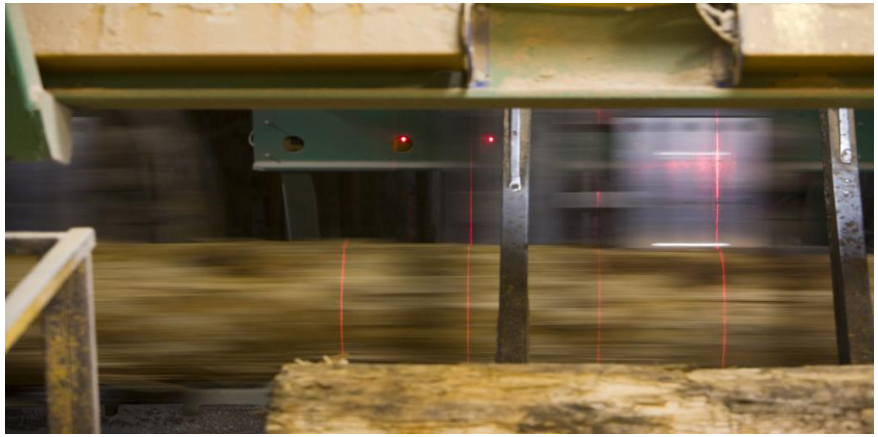
- We are exploring a new approach that combines two, inexpensive methods.
  - Laser Scanning
  - Acoustic





Introduction

- A combined scanning approach has several advantages.
  - Low cost
  - Easy data acquisition and processing
  - History of use in the field and in mills
  - No shielding issues

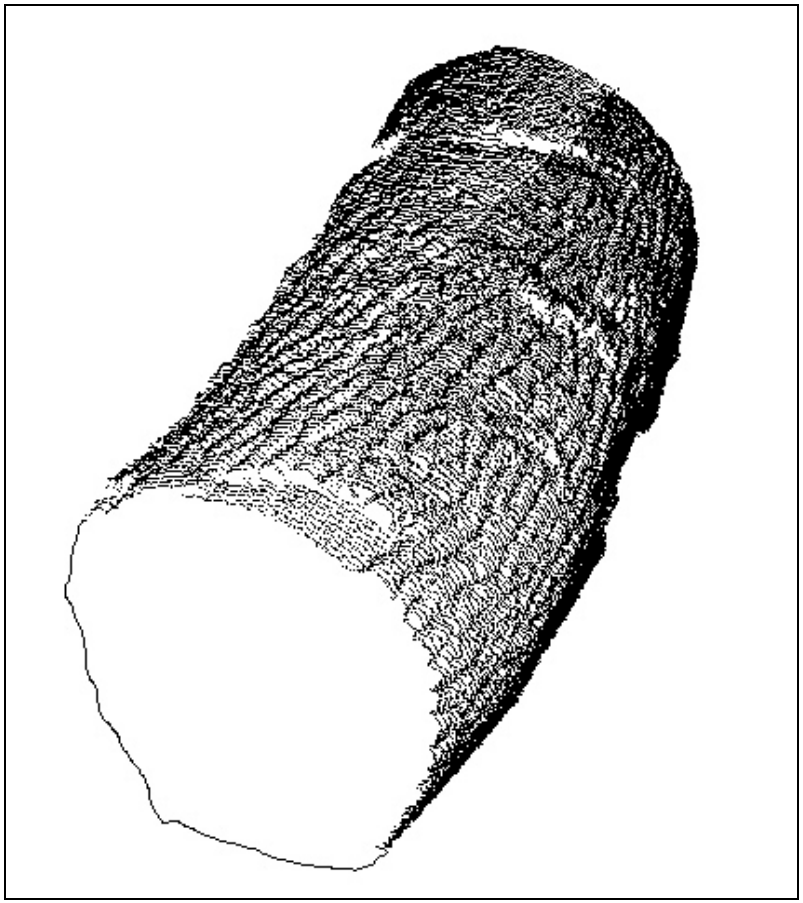


High-Resolution Laser Log Scanning

- Research with a laser scanner began in 2001.
- Scanner had moderately high resolution around the log circumference (~40 points per 25mm)
- Low resolution along log length (1 point per 20mm).

High-Resolution Laser Log Scanning

- Typical scans from the Perceptron scanner consisted of 150,000 to 300,000 data points.
- We quickly discovered that the resolution was too low to detect defects accurately!

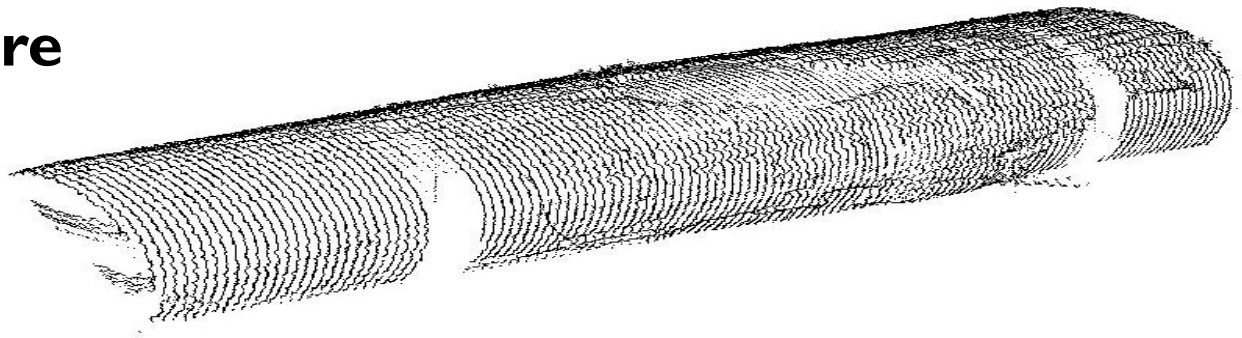


HighER-Resolution Laser Log Scanning

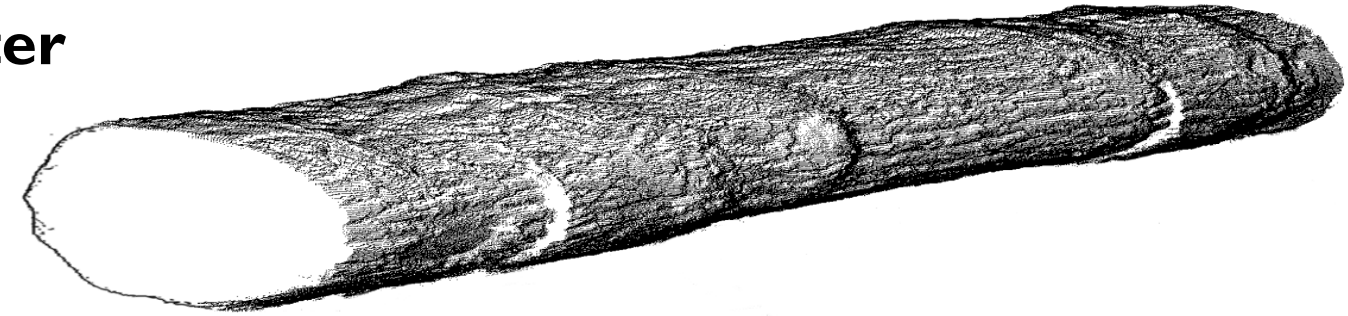
- In 2007 we finished building a custom scanner using off-the-shelf components from JoeScan.
- Much higher resolution. Approximately 1 data point for every 2mm^2 on the log surface.
- Typical log scan now has 1,000,000+ data points.

HighER-Resolution Laser Log Scanning

Before

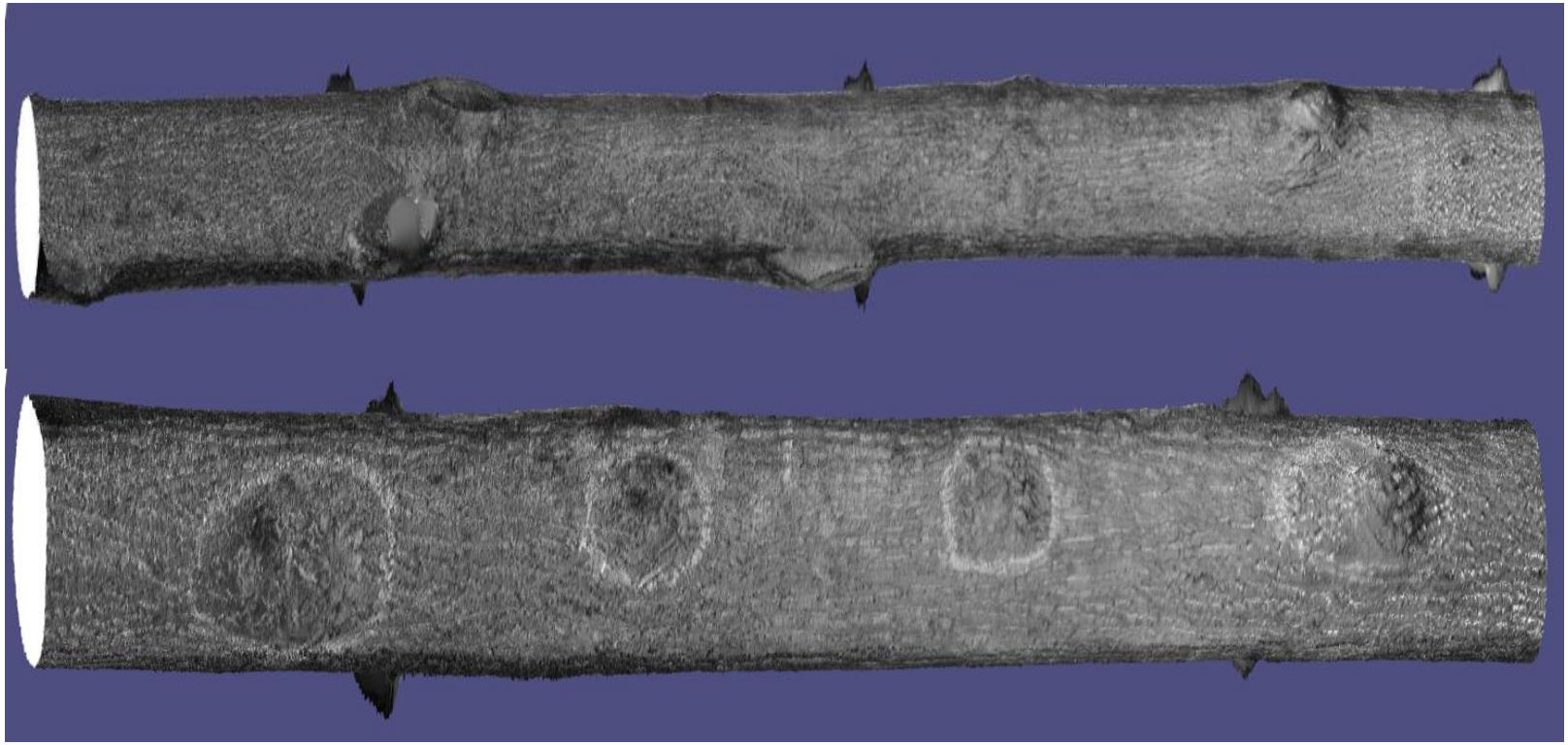


After



HighER-Resolution Laser Log Scanning

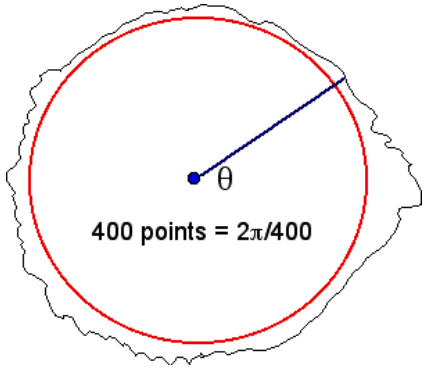
- More recently, in 2013, we started exploring the full capabilities of the scan heads.
- The JoeScan heads also record energy/color for every datapoint.

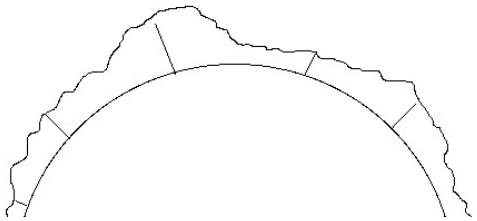


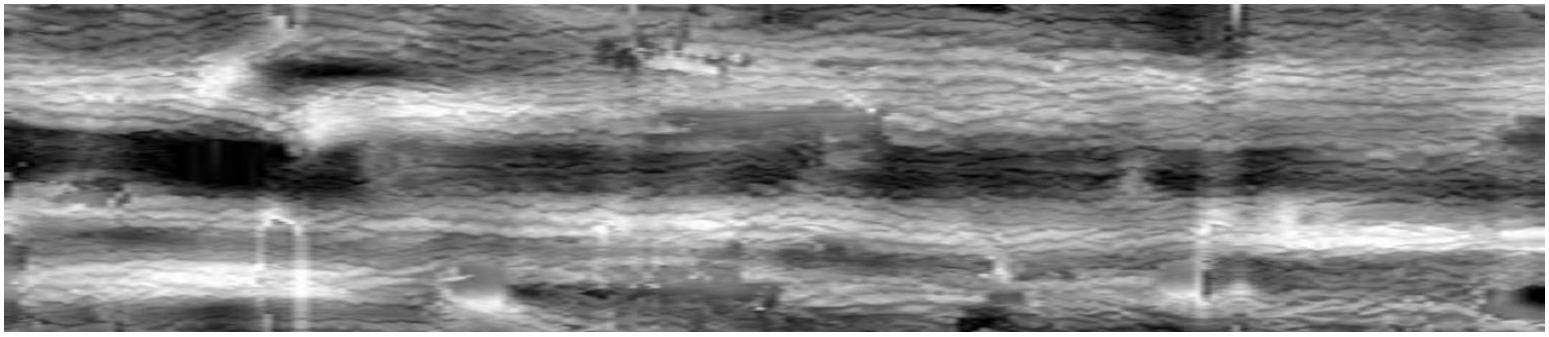
High-Resolution Laser Log Scanning

To find the surface defects, translate the 3D image data to a 2D surface.

- Using fitted ellipses or circles as a reference line is established for each scan line.

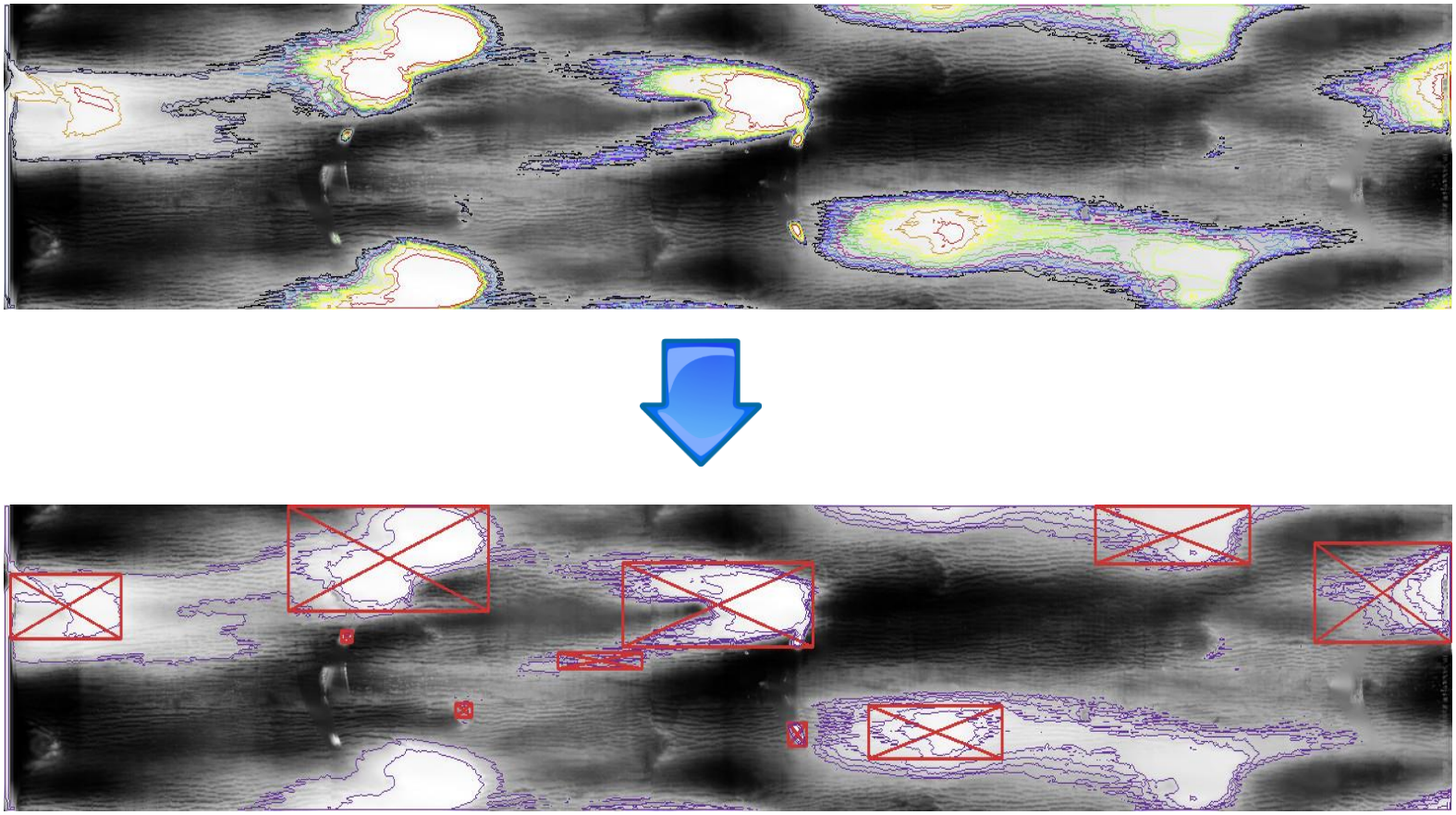






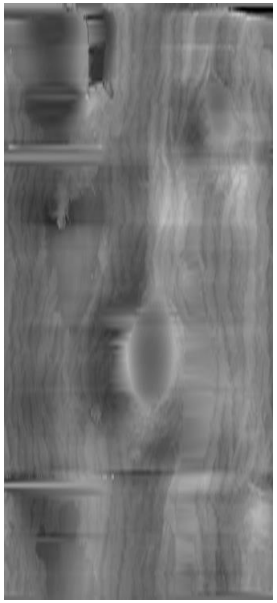
High-Resolution Laser Log Scanning

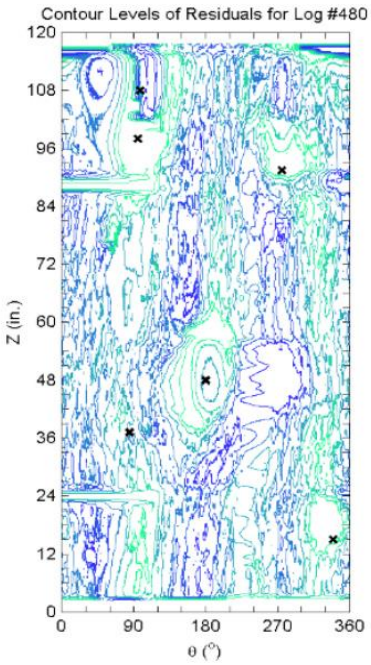
- Surface defects are located in the residual image using contour-analysis within an expert system.

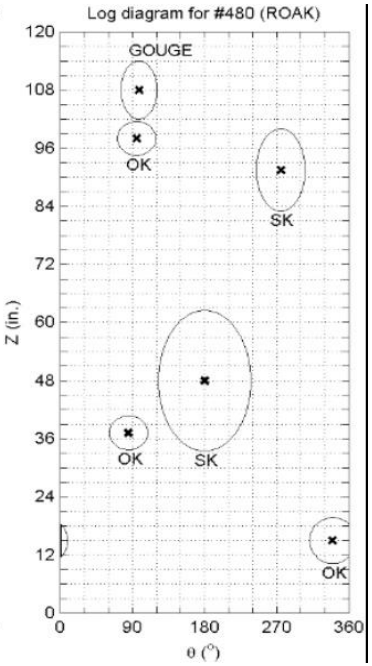


High-Resolution Laser Log Scanning

- Average processing time on an laptop computer is about 1 second.
- This methodology finds approximately 62% of all grade defects on hardwood logs.
- Currently the system detects on average three false-positive defects per log.

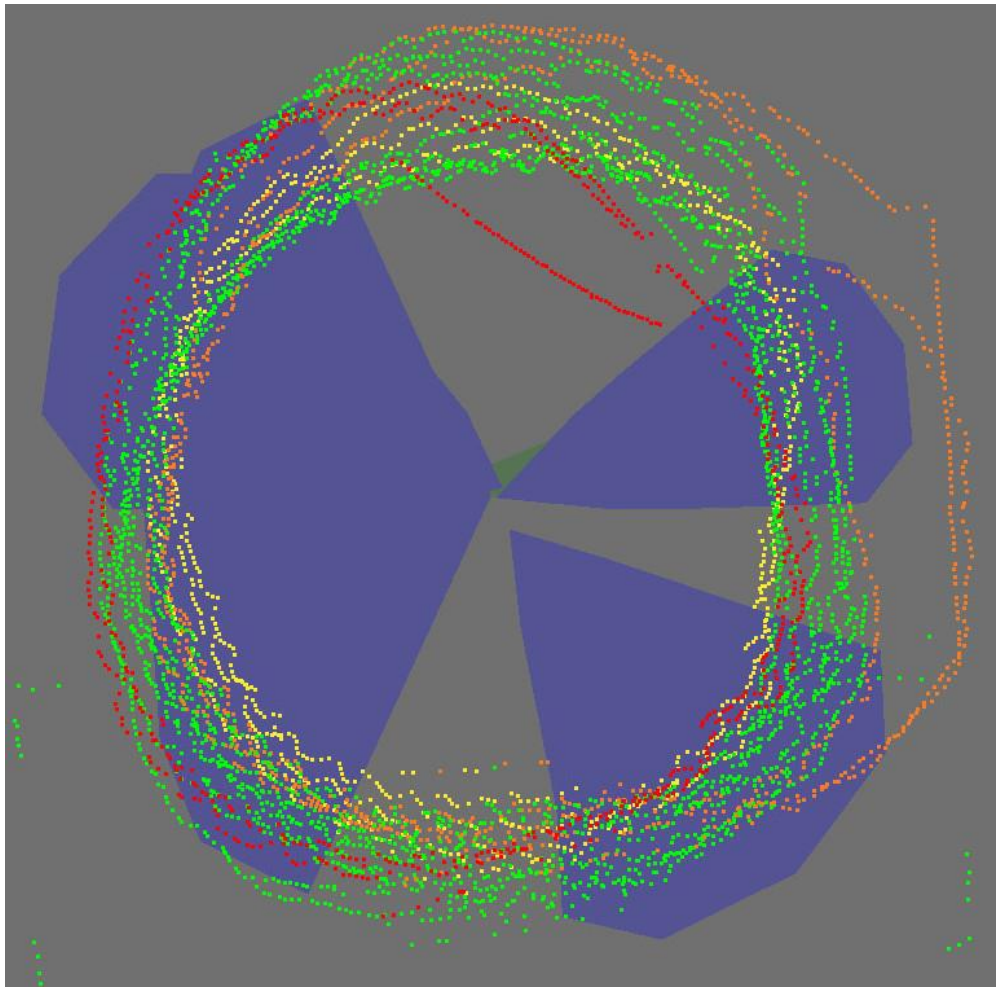




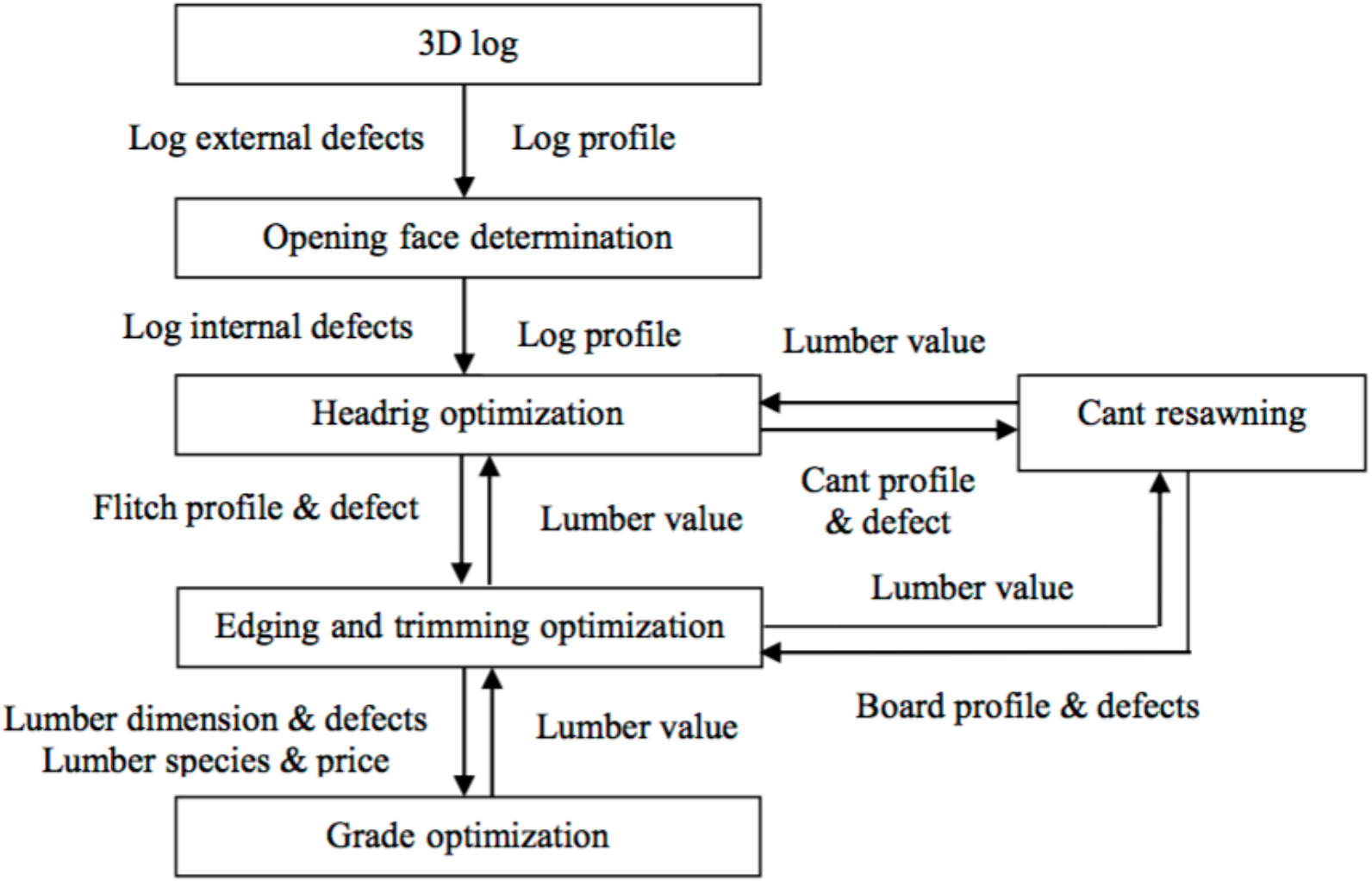


Internal Defects

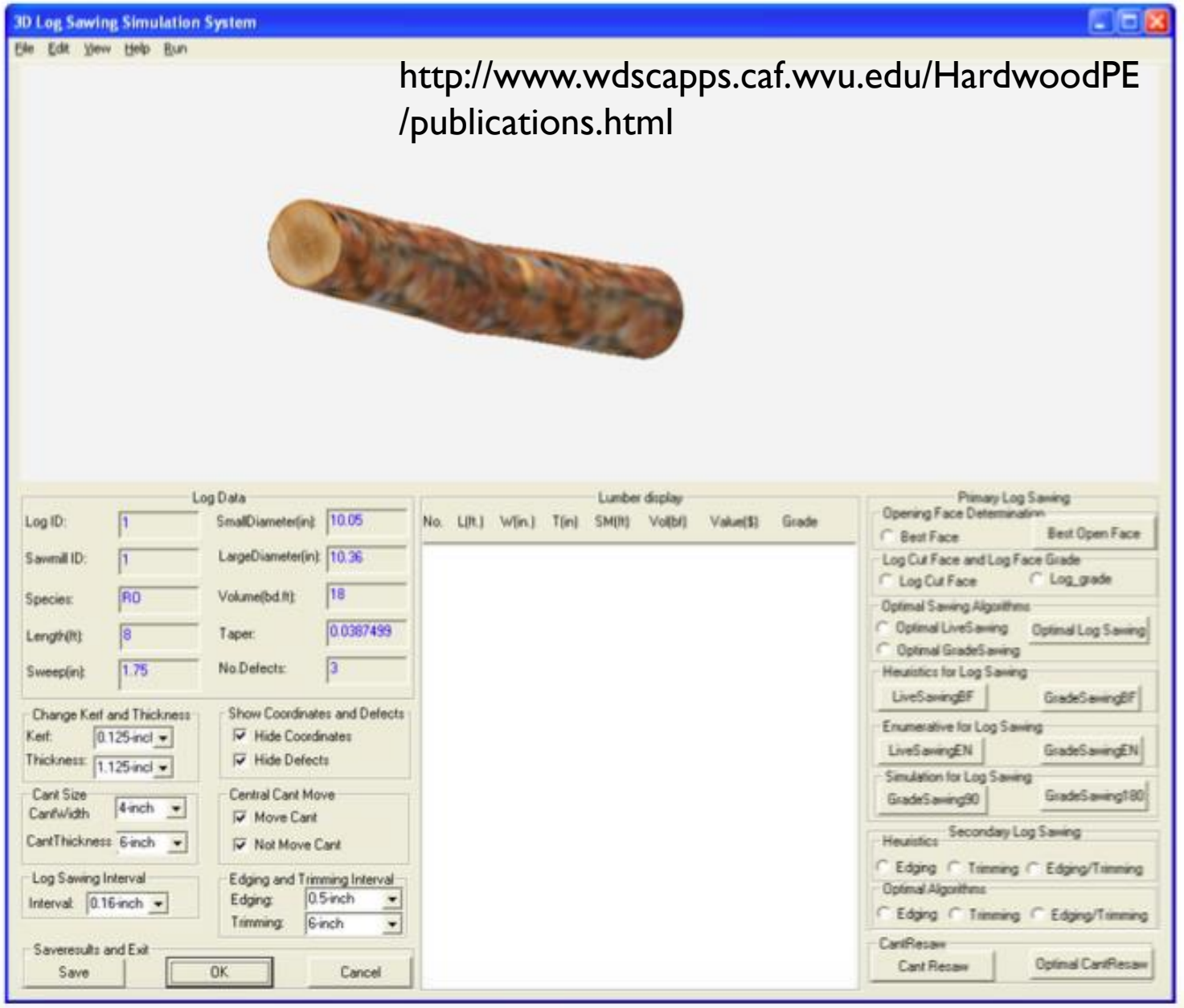
- The size and severity of internal defects are modeled based on external defect features.



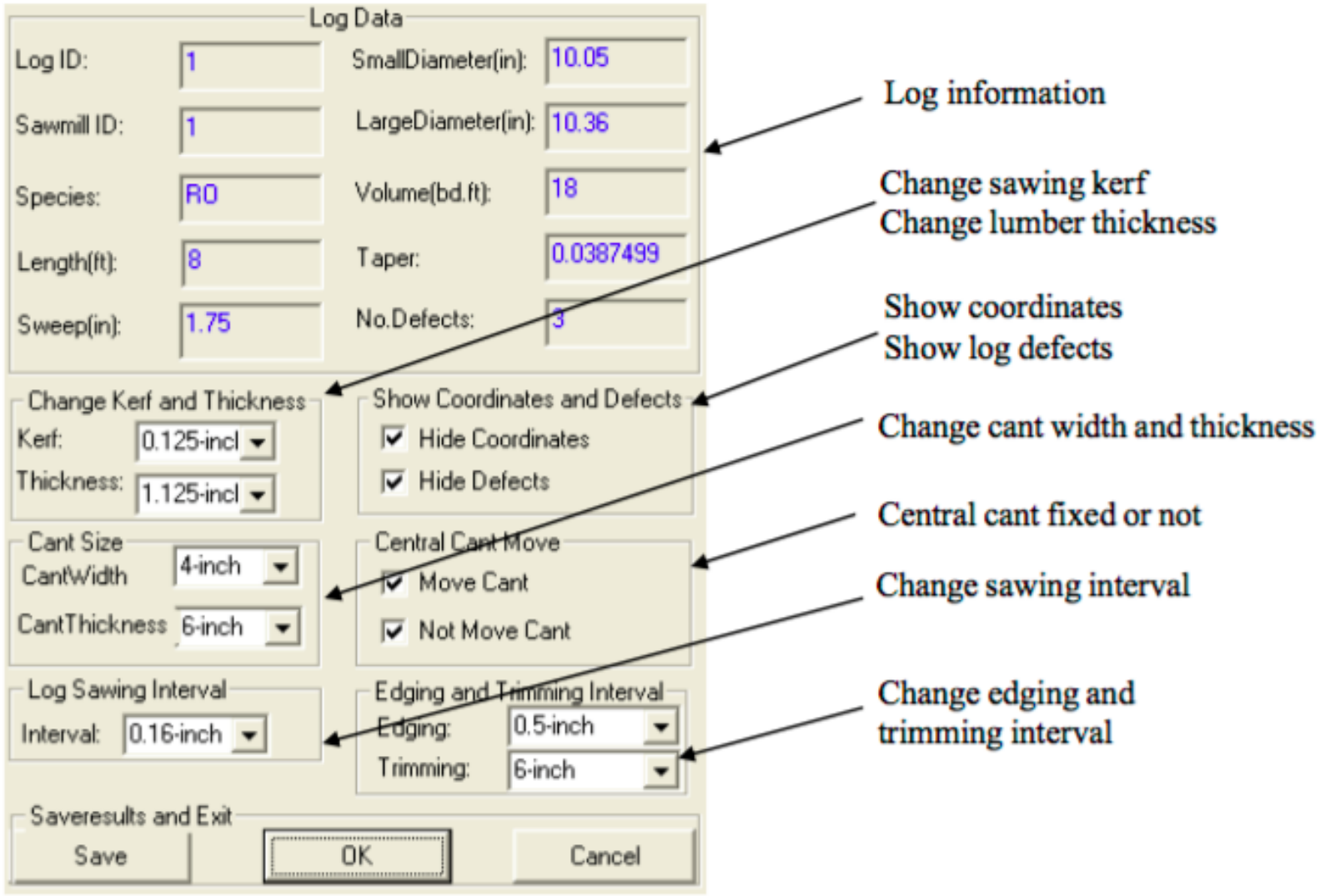
3D Log Sawing System (Wang and Lin, 2016)



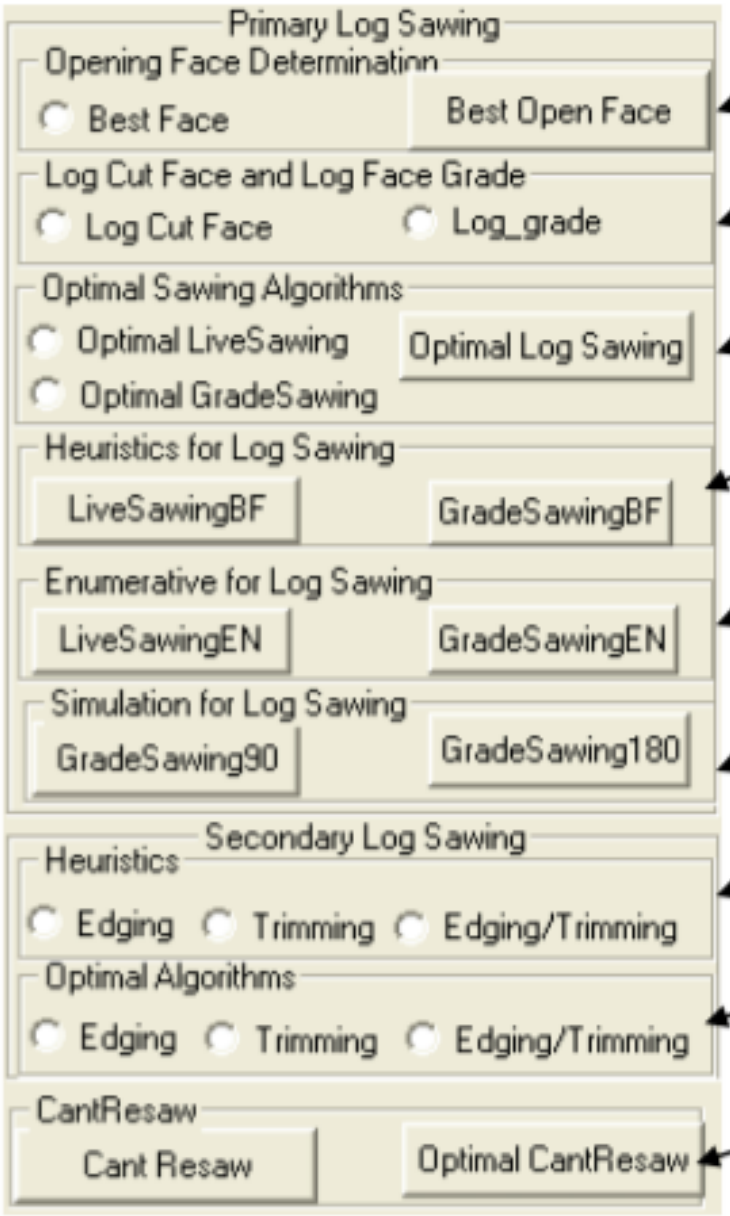
3D Log Sawing System



3D Log Sawing System



3D Log Sawing System



Determine the opening face

Divide sawing face
Determine log grade

Log sawing by dynamic programming algorithm

Log sawing by heuristic

Enumerative for log sawing (log rotation by 5 degrees)

Simulation for log sawing (without algorithms)

Flitch edging and trimming by heuristic

Flitch edging and trimming by Dynamic programming

Central cant sawing

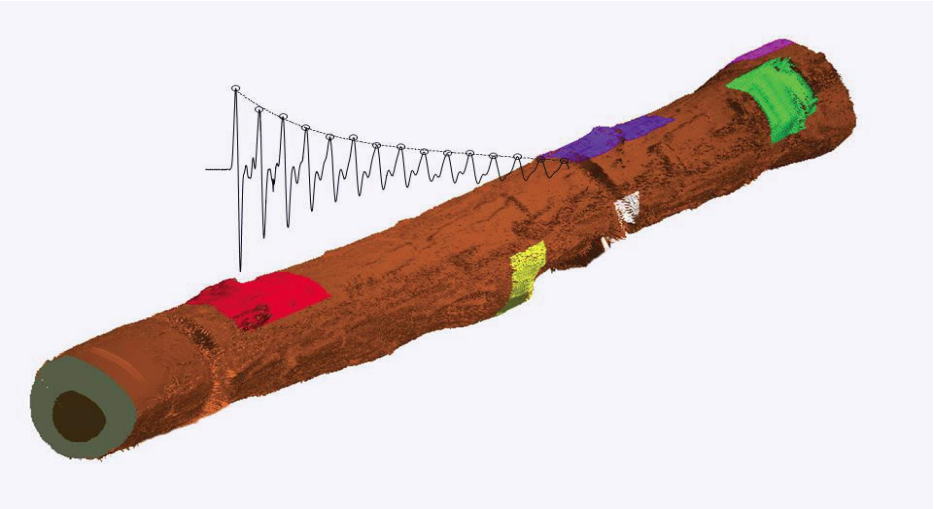
3D Log Sawing System

	Actual			Heuristic			Dynamic		
Log No	Volume (bf)	Value ($)	$/bf	Volume (bf)	Value ($)	$/bf	Volume (bf)	Value ($)	$/bf
1	43.77	17.06	0.39	45.27	20.12	0.44	38.04	20.26	0.53
2	35.56	14.27	0.4	40.08	19.42	0.48	37.65	19.53	0.52
3	36.34	21.67	0.6	38.54	28.66	0.74	38.84	29.26	0.75
4	45.22	26.44	0.58	46.54	32.35	0.7	43.65	32.93	0.75
5	35.69	10.4	0.29	42.69	14.73	0.35	39.94	14.89	0.37
6	37.07	11.29	0.3	41.75	16.08	0.39	39.08	16.53	0.42
7	40.71	20.97	0.52	40.08	27.36	0.68	40.05	28.57	0.71
8	36.92	21.44	0.58	38.75	25.45	0.66	34.06	25.58	0.75
9	56.74	18.9	0.33	57.16	23.8	0.42	53.06	23.8	0.45
10	52.23	18.38	0.35	53.32	22.18	0.42	48.56	22.67	0.47
11	51.91	30.46	0.59	50.01	35.3	0.71	46.53	35.88	0.77
12	52.23	27.68	0.53	52.89	35.06	0.66	48.51	35.79	0.74
Mean	43.67	19.91	0.46	45.59	25.04	0.55	42.33	25.47	0.61

- Lumber value can increase 2.9 percent when opening face cutting is used
- 3D Sawing System is still very time consuming, so we started investigating alternative approaches using scanning systems

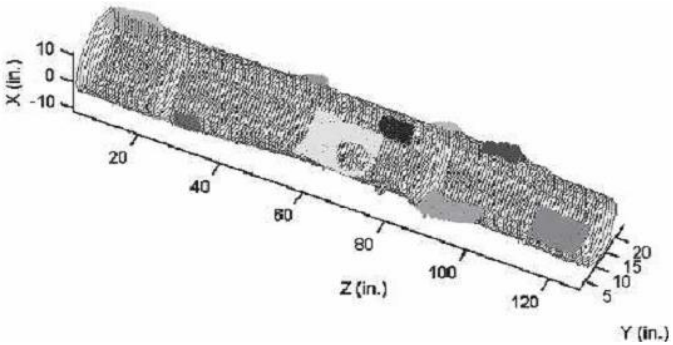
A Combined Approach

- However, laser surface scanning cannot determine the soundness of the log, or "see" degrade due to
  - Splits
  - Shake
  - Rot
- An approach combining the advantages of laser scanning and acoustic methods, overcomes these limitations.



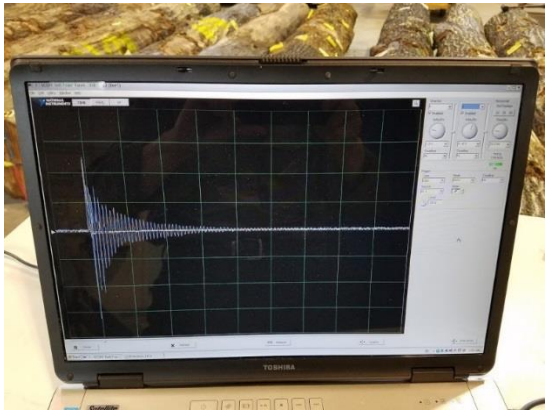
3D Laser Scanning

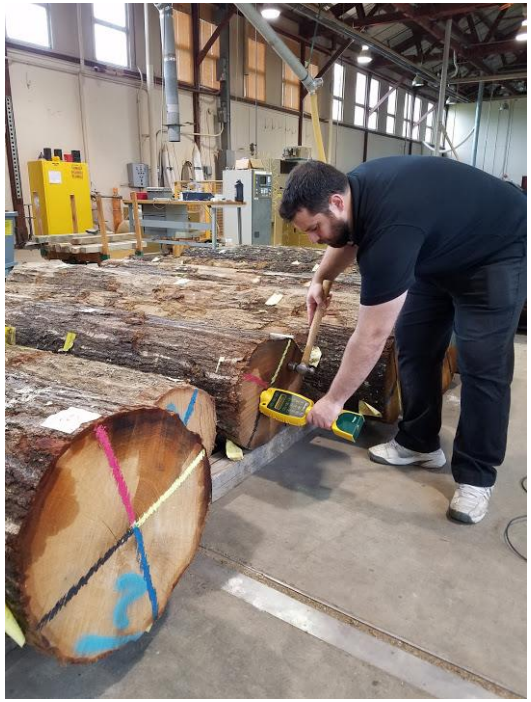
- 17 fresh cut red oak logs
- 17 fresh cut yellow poplar logs
- 10 old yellow poplar logs

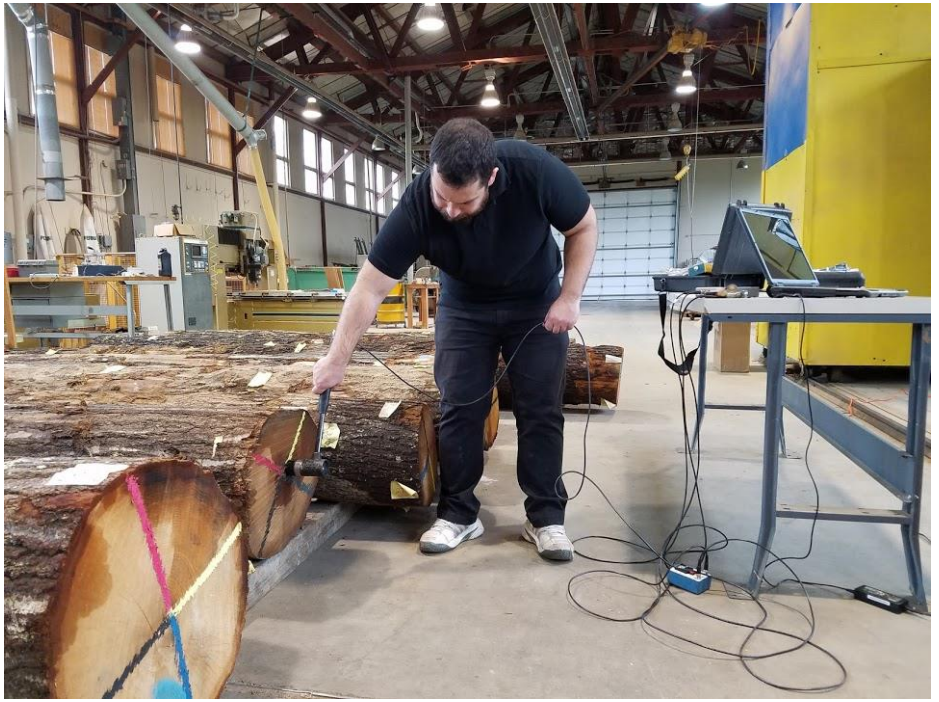


Acoustic impact testing

- Resonance testing (Hitman HM200)
- Impact testing with instrumented hammer
  - ✓Impact signal
  - ✓Response signal

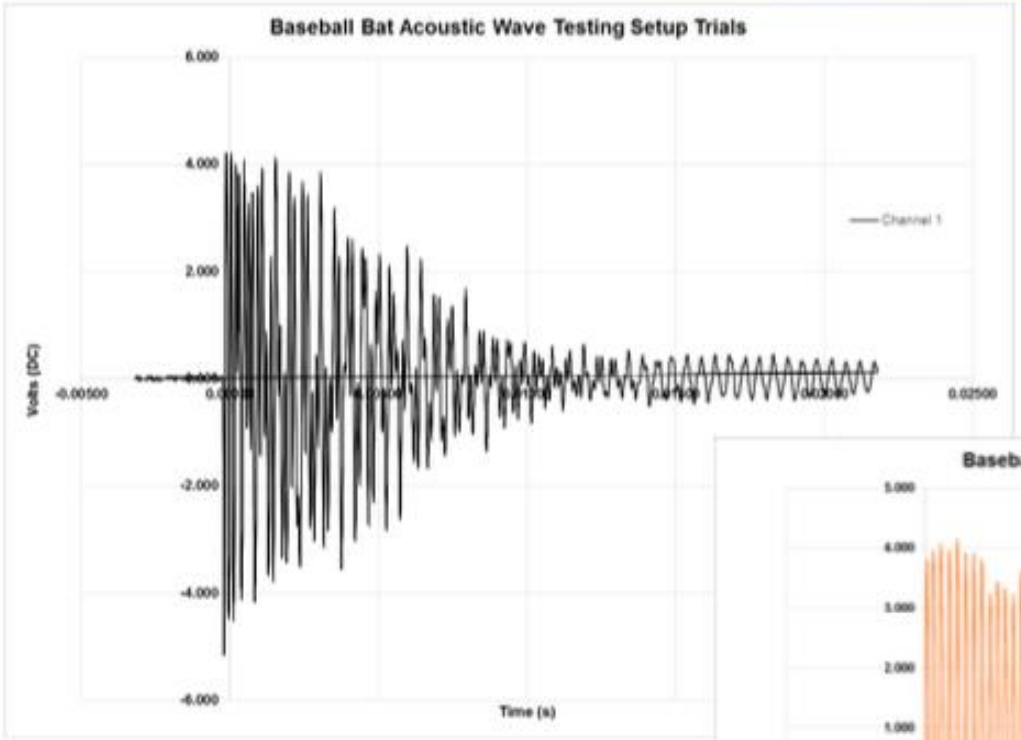


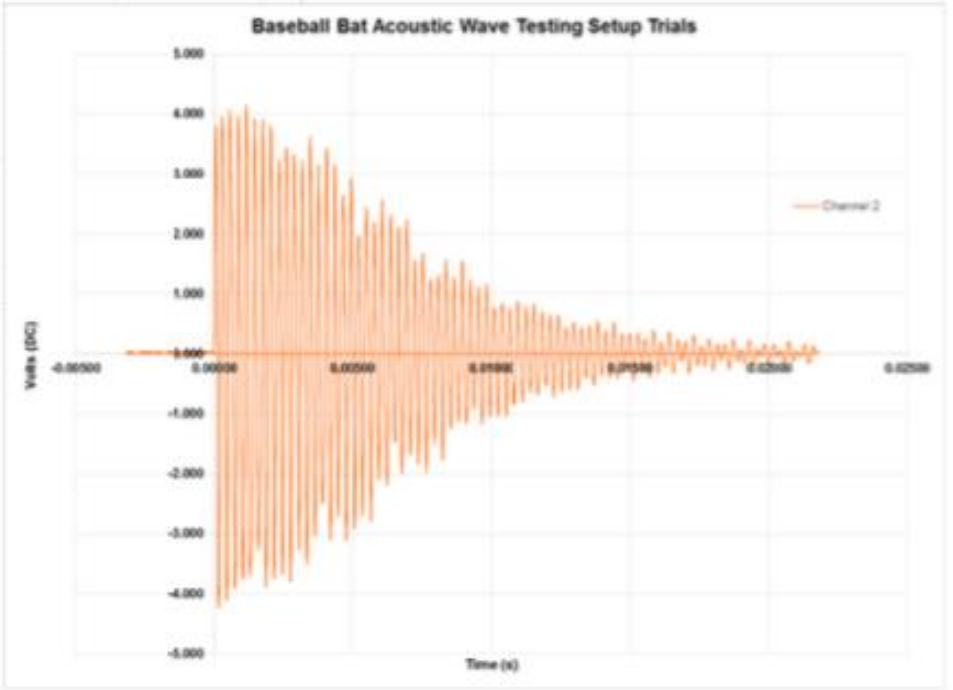


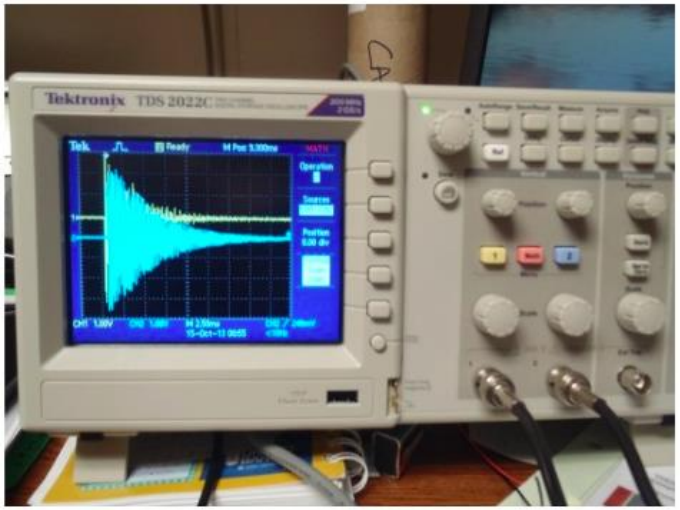


Similar to our work on baseball bats

Billet/bat Acoustics







Future Work

- Continue testing and analysis of combined detection approach.
- Continue development and refinement of contour analysis and detection expert system.
- Evaluate lumber value recovery
- Develop updated visual grading techniques for improved lumber value recovery
- Develop low-cost optical lumber scanning system for hardwoods

Questions?

On-going work is supported by the WVU hardwood Research Trust and U.S. Forest Service

This resource toolkit site is supported by Wood Education and Resource Center

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Appalachian Hardwood Center

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