



**Asia-Pacific
Economic Cooperation**

2025/SOM3/EGILAT/DIA/012

Agenda Item: 6

Development of Artificial Intelligence (AI)-Powered Automation of Microscopic Feature Detection in Wood Identification

Submitted by: Korea



**Dialogues and Mini-Exhibition on Enhancing
Enforcement and Legal Timber Trade through
Stakeholder Collaboration and Innovation
Incheon, Korea
28 July 2025**

Development of AI-Powered Automation of Microscopic Feature Detection in Wood Identification

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Traditional wood anatomy is **the gold standard**, but it's slow, requires rare expertise, and often fails to distinguish between closely related species—a critical flaw in regulatory enforcement.



Slow & Destructive

The manual process of preparing thin sections is a time-consuming craft, limiting throughput and requiring destruction of part of the sample.



Expert Dependent

Identification relies on a small and diminishing pool of highly trained anatomists, creating a significant bottleneck for large-scale analysis.



Genus-Level Barrier

Anatomical similarity between species within the same genus makes definitive species-level ID unreliable, hindering CITES enforcement.

The Search for a Better Way

Computer Vision (Classification)

Uses AI to recognize the overall pattern of a wood image. It's fast and accessible but suffers from the "black box" problem—its reasoning is opaque and not based on scientific anatomical features, making it hard to verify.

DART-TOFMS

Creates a unique chemical fingerprint of a wood sample. It's fast and powerful for certain applications but is lab-bound, expensive, and its accuracy depends heavily on the statistical models used.

NIR Spectrometry

A rapid, non-destructive method analyzing how wood interacts with near-infrared light. Its accuracy can be modest and is affected by factors like moisture content. Requires sophisticated statistical models to interpret results.

DNA Barcoding

Offers the highest potential for species-level accuracy by reading the genetic code. However, extracting usable DNA from processed wood is extremely difficult, costly, and often fails, making it impractical for large-scale use.

The Database Bottleneck

The Common Achilles' Heel

Every single modern method, regardless of its technology, is fundamentally dependent on a **large, comprehensive, and high-quality reference database**. Building these databases is **the true bottleneck** for the entire field.

DART-TOFMS

Chemical Fingerprinting



41% Complete

DNA Barcoding

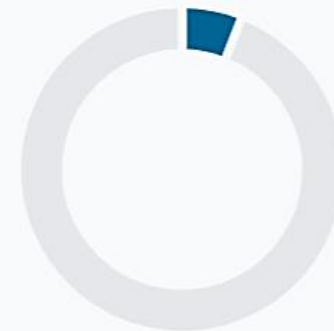
Genetic Identification



86% Complete

NIR Spectroscopy

Light-based Analysis



6% Complete

Overcome the Bottlenecks and Barrier



[1] Slow & Destructive

**Very difficult to overcome,
but not impossible**

Remove the necessity to make microscope slides by utilizing sanded wood blocks and surface observation microscopy



[2] Expert Dependent

**Automated investigation
system for microscopic
features of wood**

Use trained object detection models for investigation with an automated imaging system



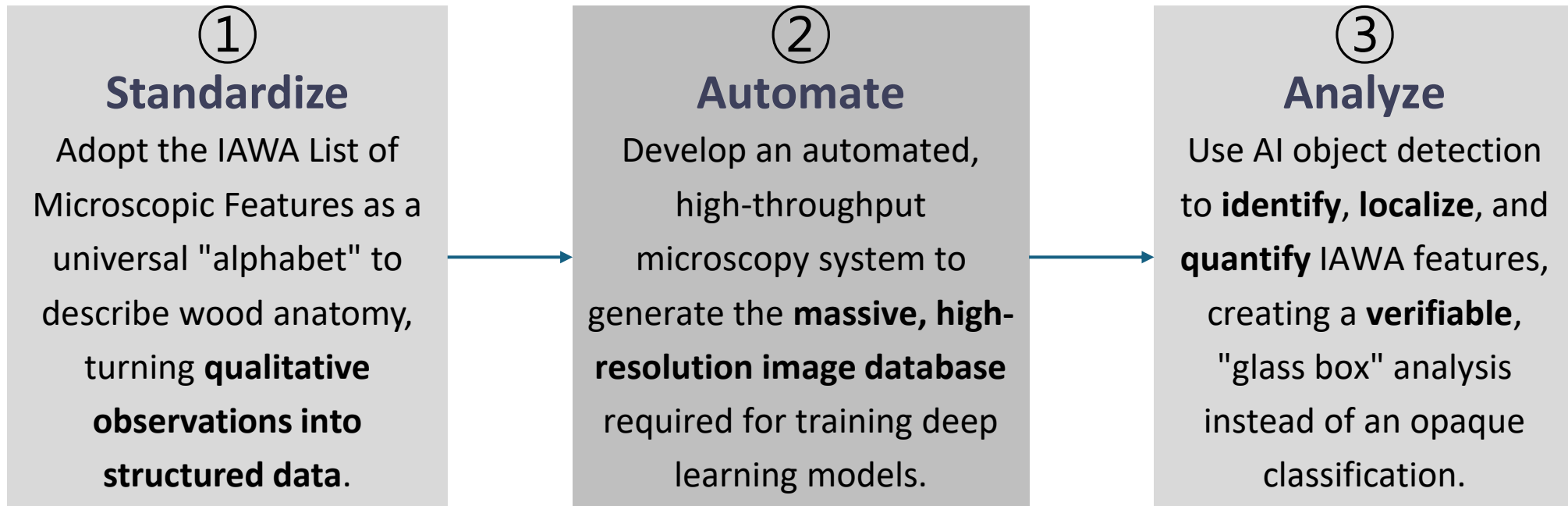
[3] Genus-Level Barrier

**Large-scale investigation for
anatomical features of
wood**

Construct large-scale microscopic image database and examination at various magnification and modality

Overcome the Bottlenecks and Barrier

We propose an automated system that uses AI to objectively quantify standardized anatomical features from microscopic images.



A New Approach: Object Detection AI on Microscopic Features of Wood

1. Automated Imaging

High-throughput scanner captures thousands of images.

2. Large-Scale Database

A massive, carefully annotated image library is built.

3. Object Detection AI

AI finds & measures IAWA features, not just guesses the species.

4. Verified ID

Feature list is matched to knowns for a verifiable result.

OLD WAY: The Black Box

Standard AI classifies images but can't explain its reasoning. It's a "trust me" system that lacks scientific verifiability.

Image → [???] → "Oak"

NEW WAY: The Glass Box

Our object detection AI shows its work. The output is a verifiable list of anatomical features, just like a human expert.

Image → [Feature List] → "Oak"

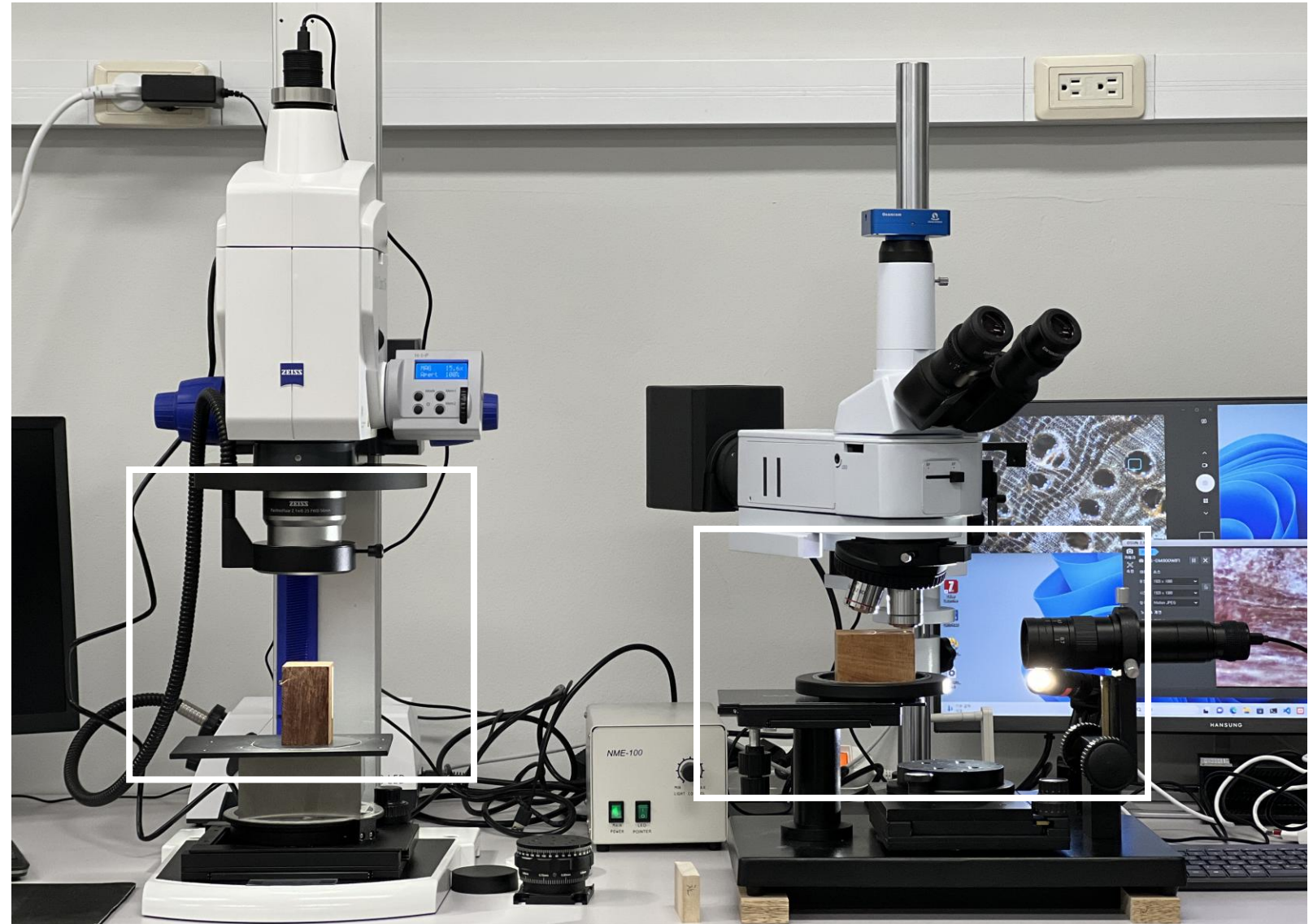
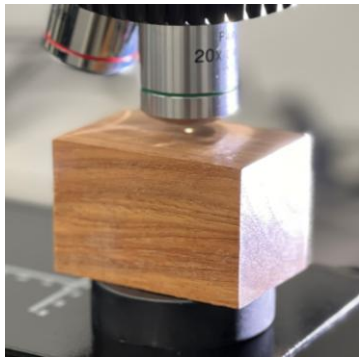
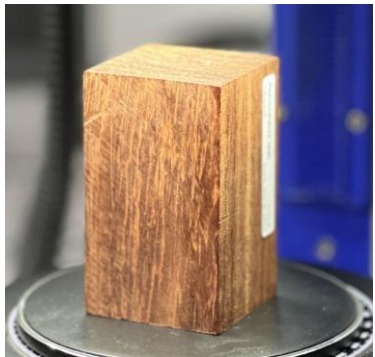
Overcome the Bottlenecks [1]: Wood Anatomy from Wood Surfaces

Epi-illumination Light Microscopy

Stereomicroscope

Reflected light microscopy

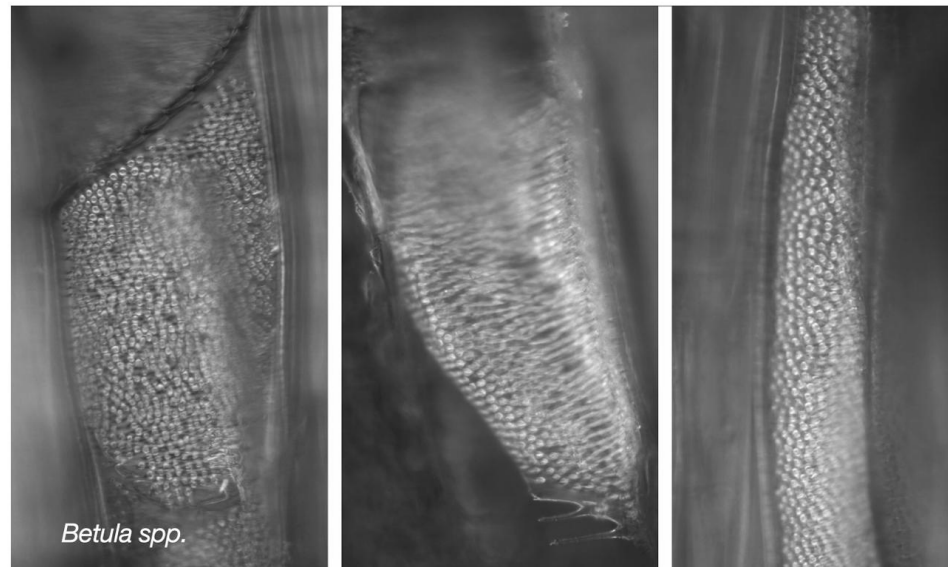
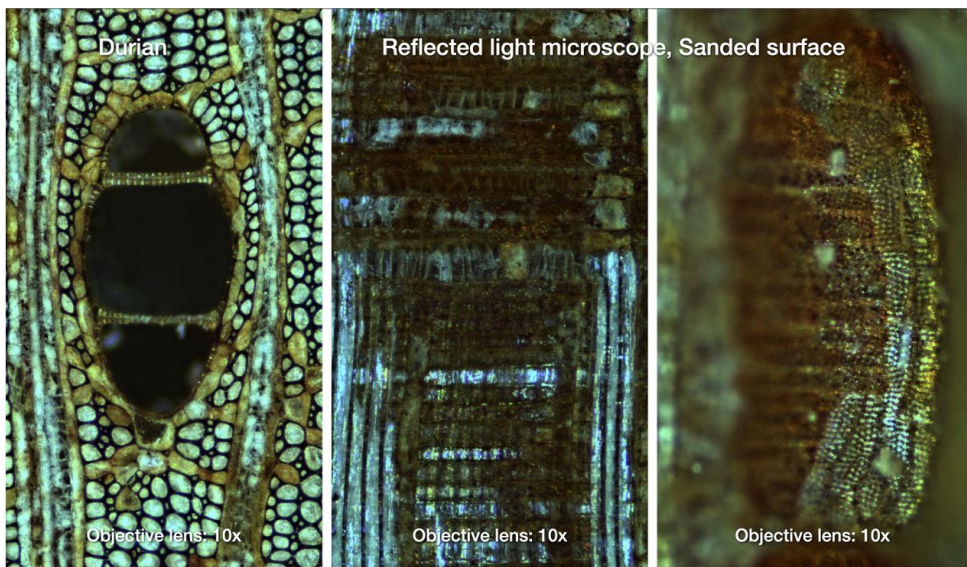
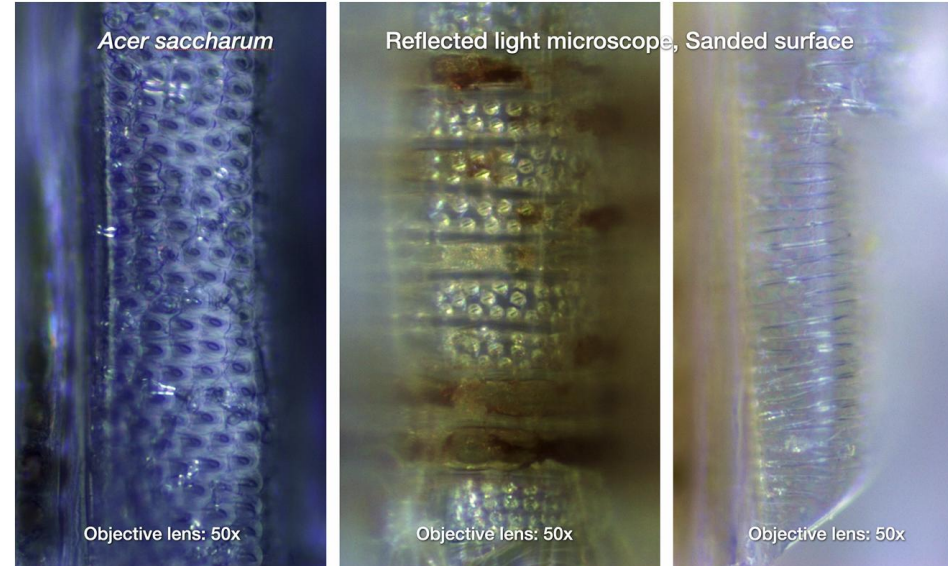
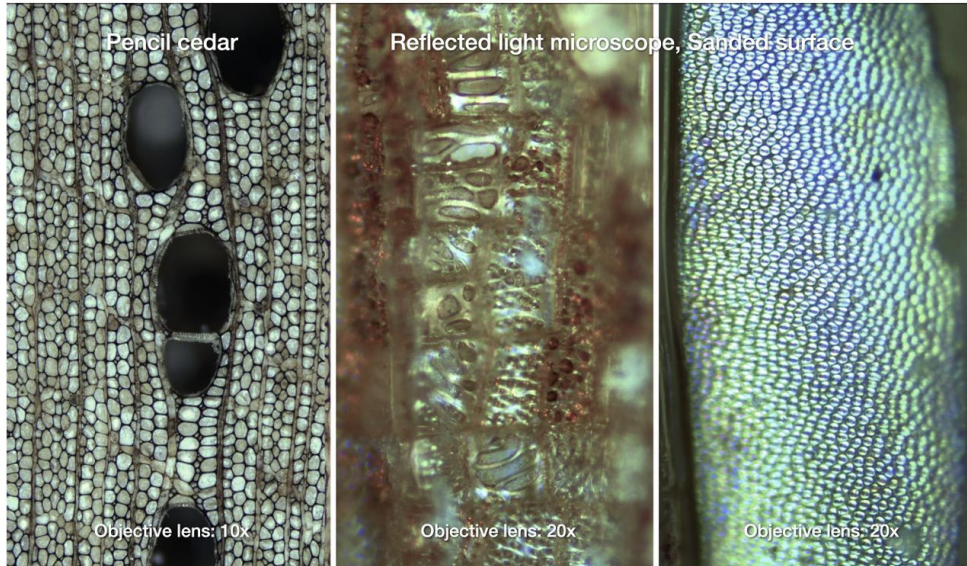
Fluorescence microscopy



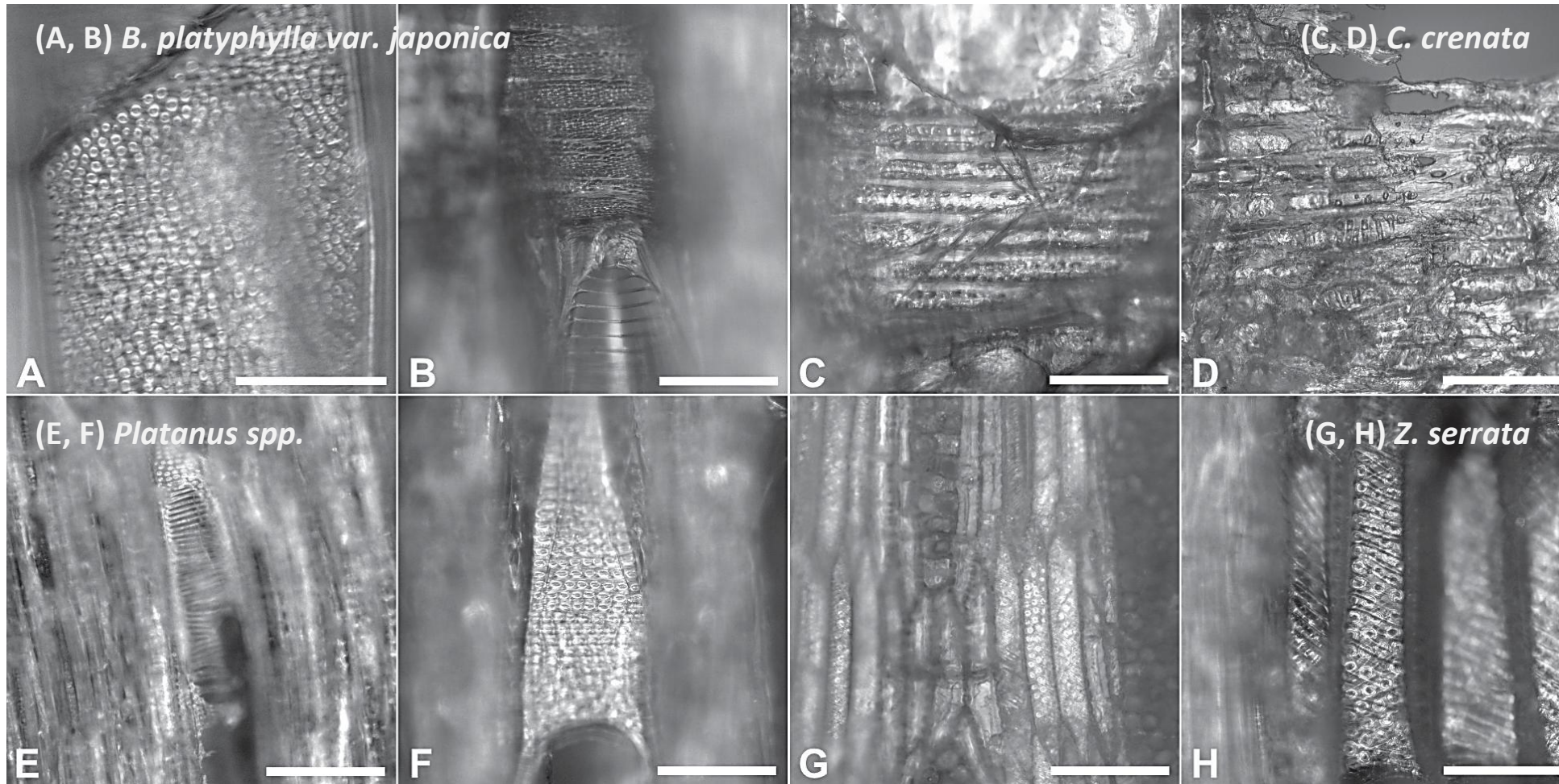
[1] Wood Anatomy from Wood Surfaces: Stereomicroscope



[1] Wood Anatomy from Wood Surfaces: Reflected Light Microscope



[1] Wood Anatomy from Wood Surfaces: Reflected Light Microscope



Scale bars:
(A) 50 μm
(B–H) 100 μm

(A) intervessel pits, (B) vessel-ray pits and scalariform perforation plates, (C, D) vessel-ray pits, (E) scalariform perforation plates, (F) intervessel pits, (G) ray and axial parenchyma cells, (H) intervessel pits and helical thickenings

Overcome the Bottleneck [2][3]: Automated Imaging for Large-Scale Image Collection

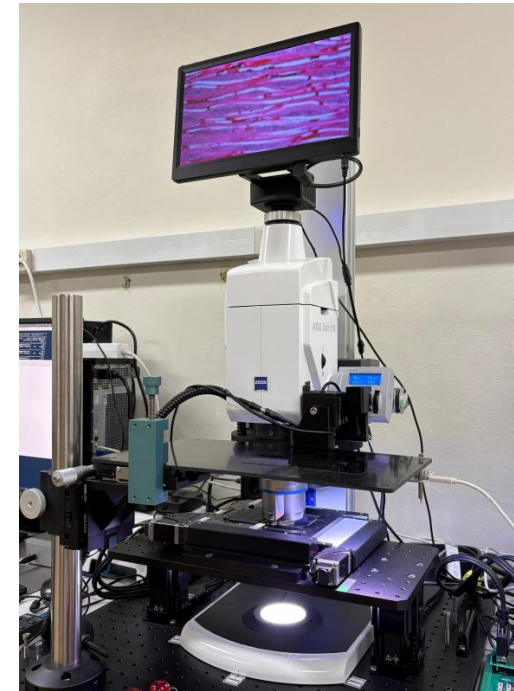
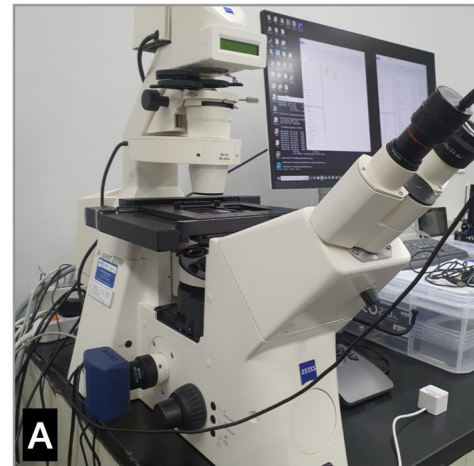
Commercial Products

Slide scanners
Motorized light microscopes
No customized focus control
Single plane image



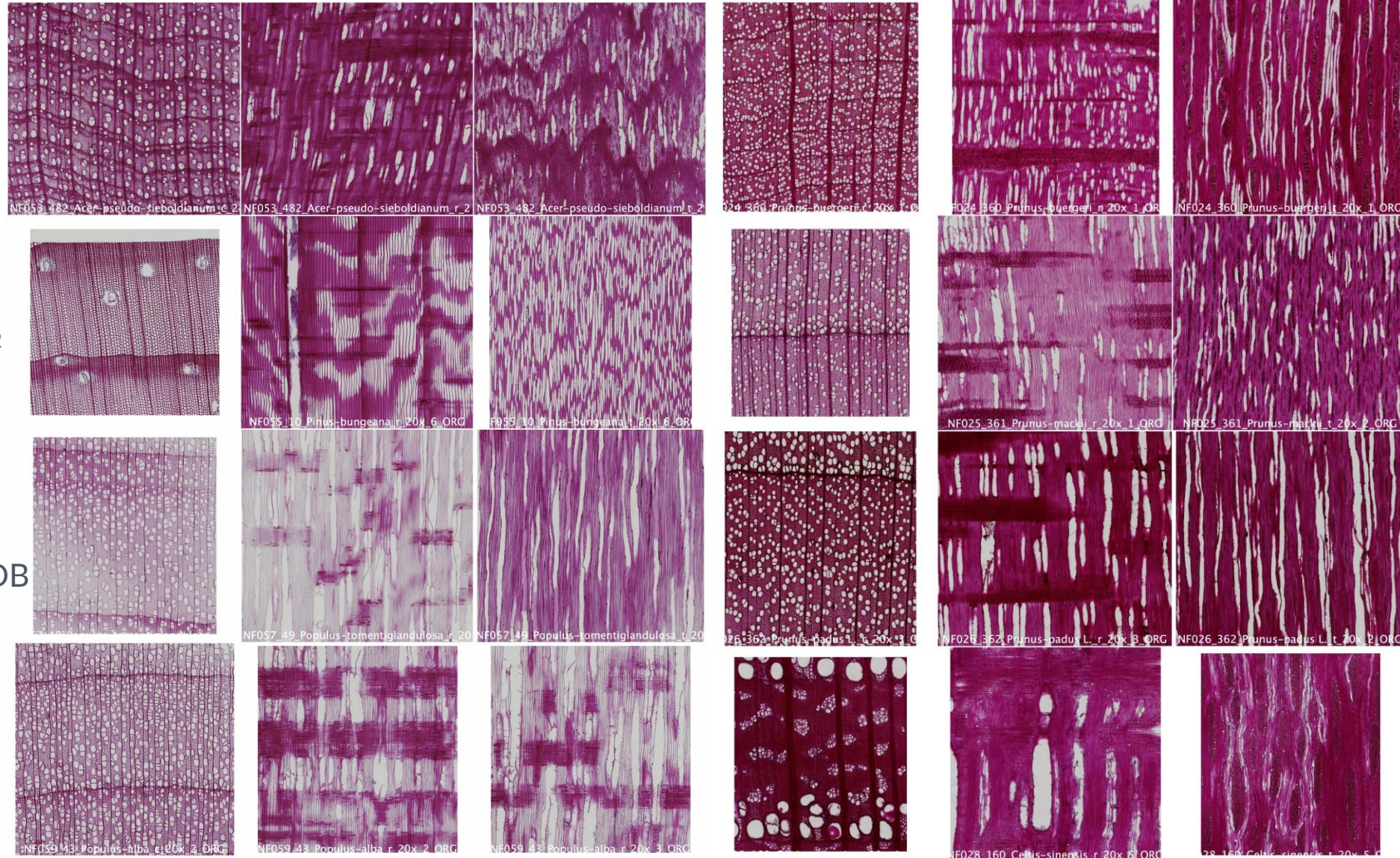
In-House Motorized Microscope

Smart focus control
Multi-slice images
Varying magnification for desired
anatomical features

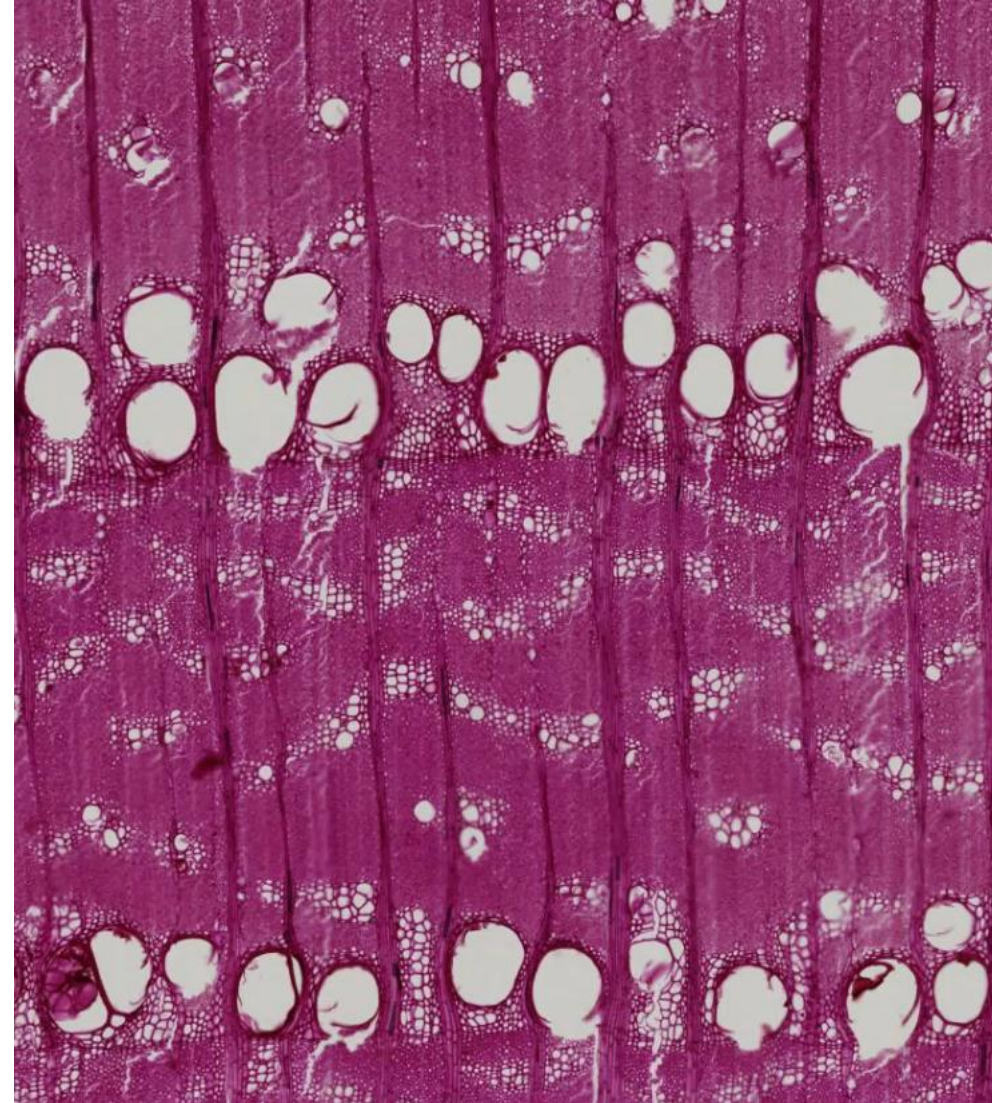
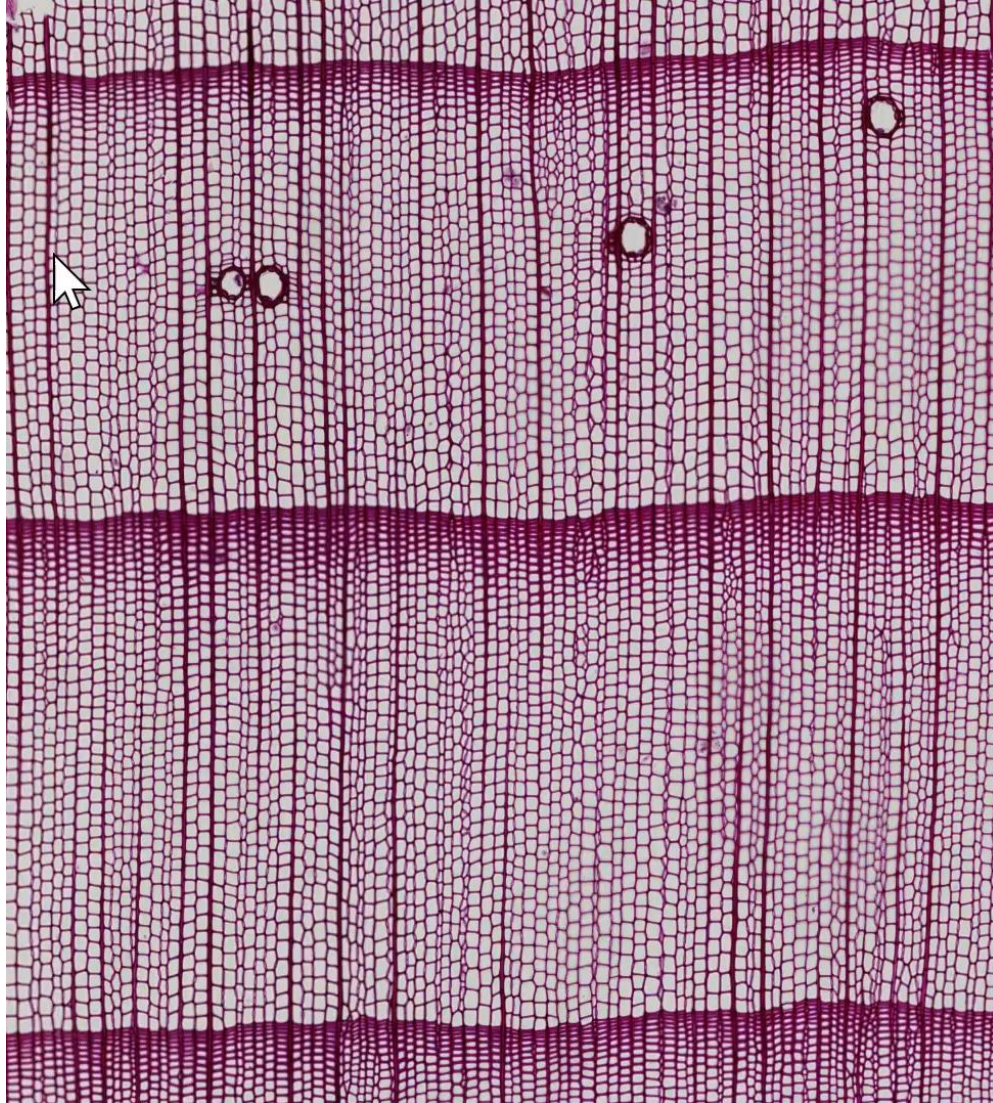


[2][3] Building Large-Scale Microscopic Image DB

1. Objective lens: 20x/0.8
2. Imaging area: < ~15 x 15 mm²
3. Stitched image dimension:
> 20,000 x 20,000 pixels
4. > 3,000 microscope slides
5. > 9,000 images in the image DB

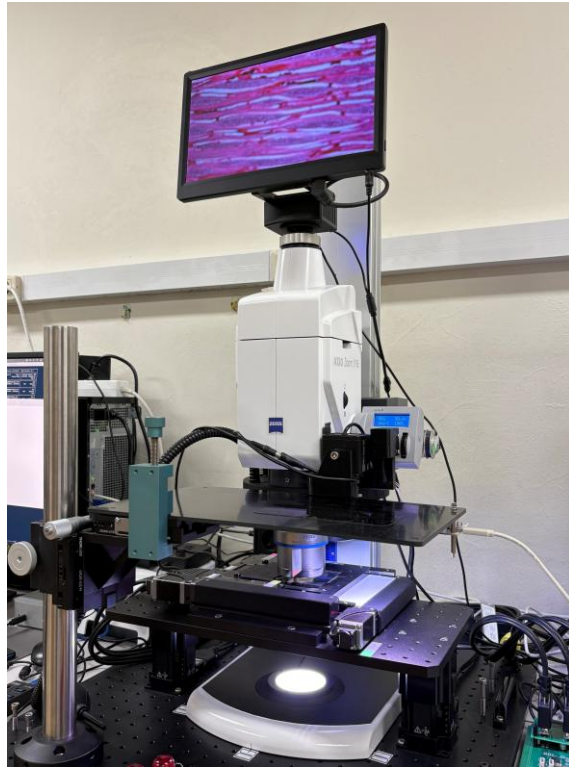
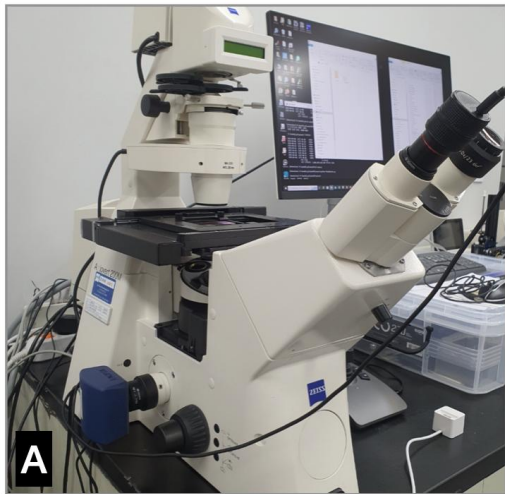


Exploring the Anatomical Features of Wood, Virtually!



Automated Imaging

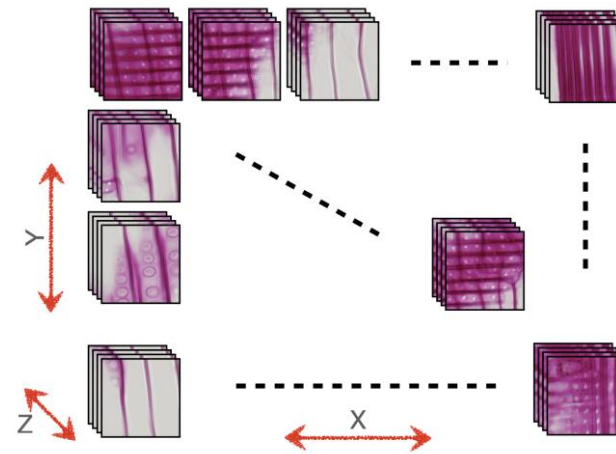
A robotic microscope captures thousands of high-resolution, standardized images of wood anatomy.



In-House Motorized Microscope

Smart focus control and multi-slice images
Varying magnification for desired anatomical features

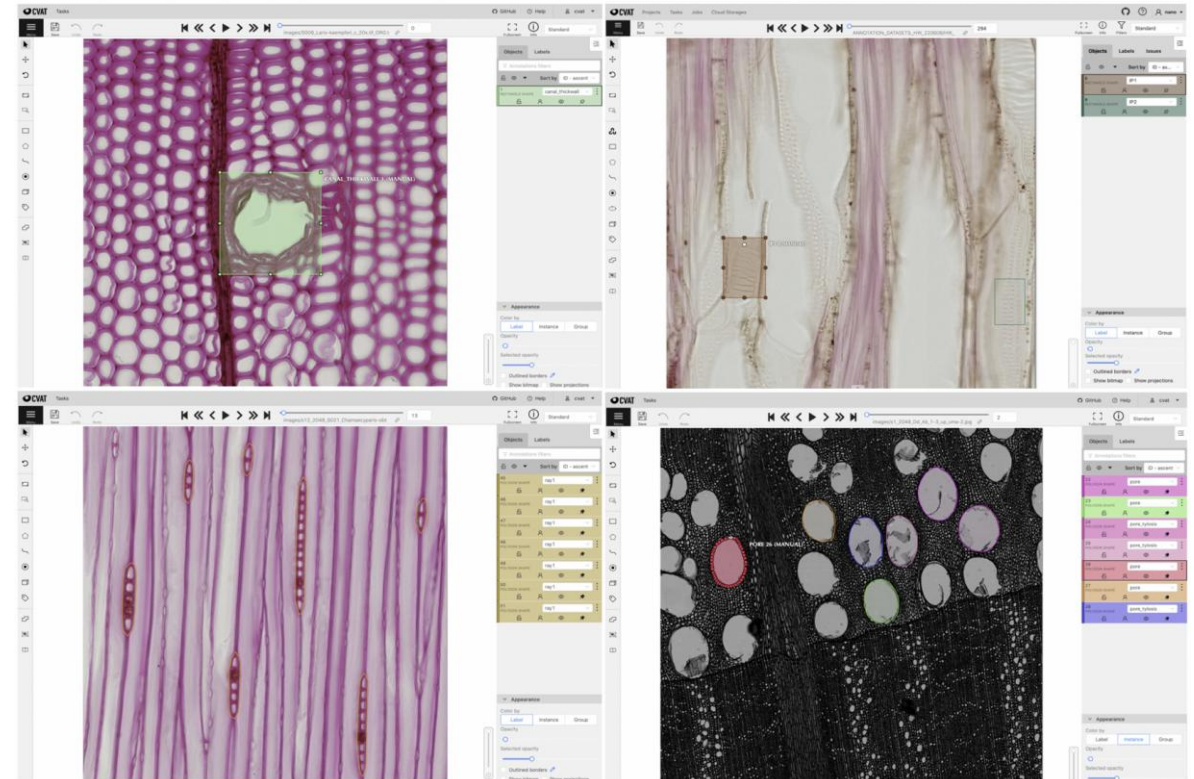
1. ~2 sec/image → ~1 hour/slide, 3 section/slide
2. Imaging at various focus positions
3. Feature-optimal magnification (in progress)
4. Feature-optimal focus control (in progress)
5. Stitched images can be generated from the tile images.



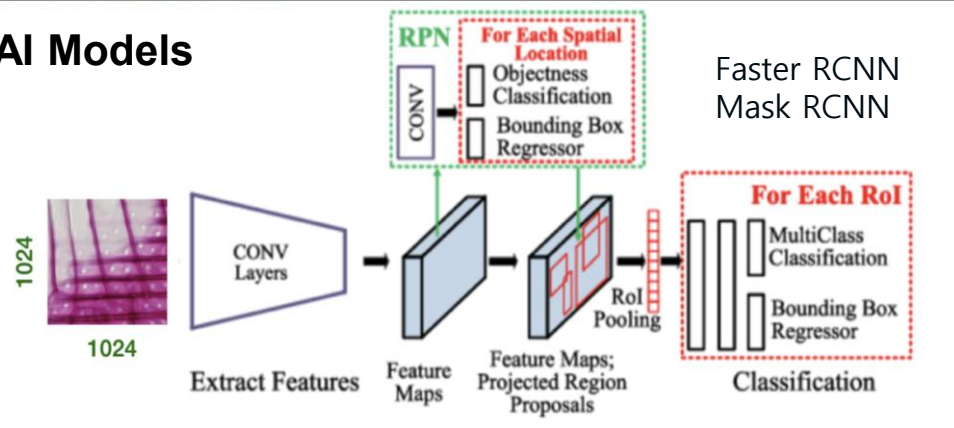
[2] Object Detection Model Training for Microscopic Features of Wood

Preparation of train datasets from the microscopic image database

Annotation for anatomical features of wood according to IAWA codes



AI Models



[2] Object Detection Model Training for Microscopic Features of Wood

Dataset Details

3968 Total Images [View All Images →](#)

Dataset Split

TRAIN SET 99%
VALID SET 1%
TEST SET 0%

3580 Images
256 Images
132 Images

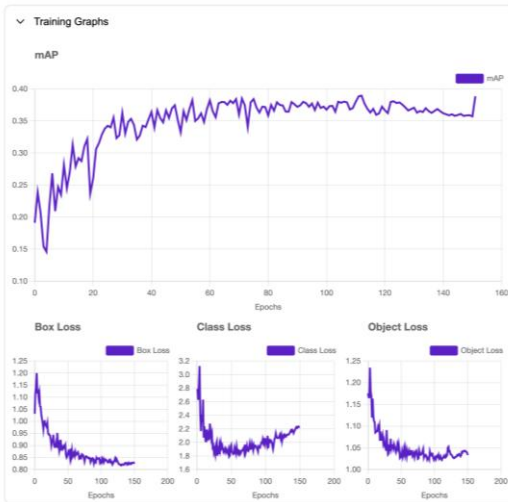
Preprocessing

No preprocessing steps were applied.

Augmentations

Outputs per training example: 4

- Bounding Box: Flip: Horizontal
- Bounding Box: Crop: 0% Minimum Zoom, 20% Maximum Zoom
- Bounding Box: Rotation: Between -15° and +15°
- Bounding Box: Shear: ±9° Horizontal, ±6° Vertical
- Bounding Box: Blur: Up to 2.5px



HW_MICRO_C_2.5x Dataset Health Check

Generated on November 27, 2023 at 5:04 pm. [Regenerate](#)

Images: 1,289 (1 missing annotations, 10 null examples)
 Annotations: 5,462 (4.2 per image (average), 9 across 9 classes)
 Average Image Size: 1.05 mp (0, from 1.09 mp, 0, to 1.05 mp)
 Median Image Ratio: 1024x1024 (1 square)

Class Balance

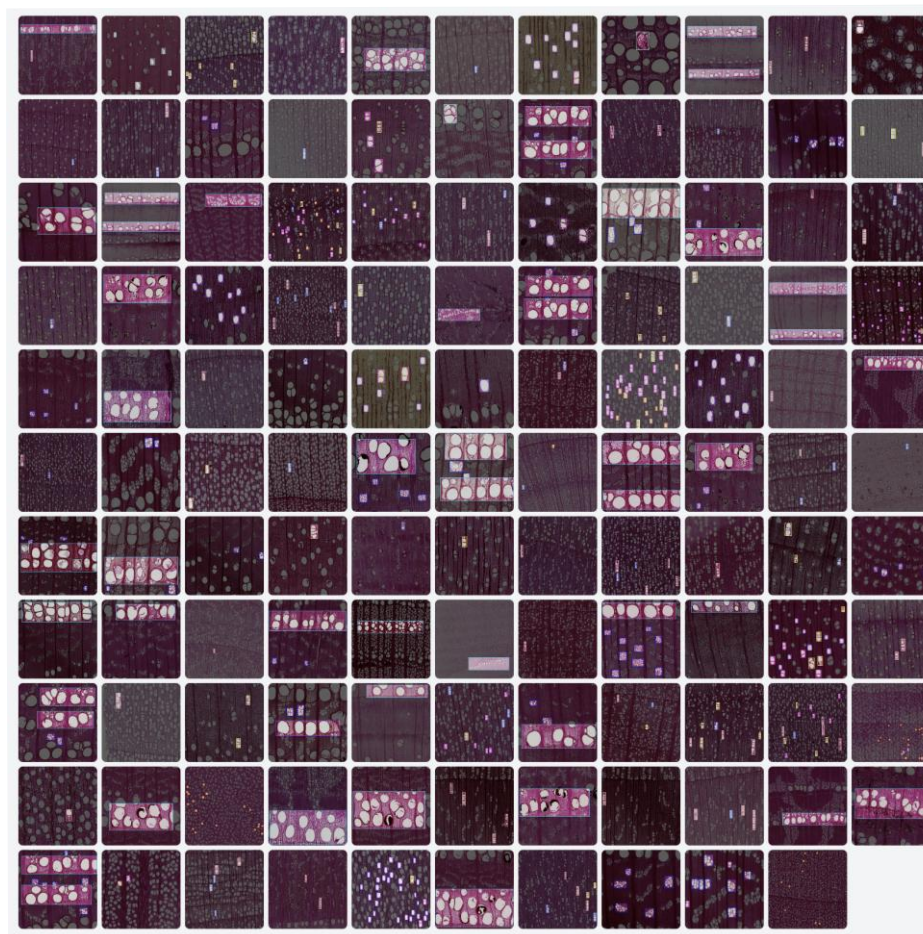
Class	Count
pore_solitary	970
pore_cluster	870
pore_solitary_angular	712
pore_multi_2	631
vessel_band	564
pore_multi_4	555
pore_multi_3	487
pore_multi_4	420
pore_lyosis	395

under represented / under represented

Confusion Matrix

Confidence Threshold: 0.2% | Precision: 30.0% | Recall: 49.0%

Ground Truth \ Prediction	pore_cluster	pore_multi_2	pore_multi_3	pore_multi_4	pore_multi_4	pore_solitary	solitary_angular	pore_lyosis	vessel_band	False Positive
pore_cluster	191	0	0	1	0	0	0	0	1	67
pore_multi_2	0	32	2	0	1	1	0	0	0	192
pore_multi_3	0	1	62	0	0	0	0	1	0	86
pore_multi_4	0	0	5	73	18	0	0	3	0	36
pore_multi_4	0	0	1	7	98	0	0	0	0	61
pore_solitary	0	0	0	0	0	87	0	0	0	114
solitary_angular	0	0	0	0	0	1	11	0	0	207
pore_lyosis	0	0	0	0	0	0	0	77	5	38
vessel_band	0	0	1	1	0	0	0	1	152	16
False Positive	383	156	209	110	138	387	193	117	93	0



Model Performance Dashboard

HW_MICRO_C_2.5x

Trained On: HW_MICRO_C_2.5x 3968 Images | View Images +

Model Type: Roboflow 3.0 Object Detection (Fast) | mAP: 38.9% | Precision: 33.0% | Recall: 45.2%

Checkpoint: COCO

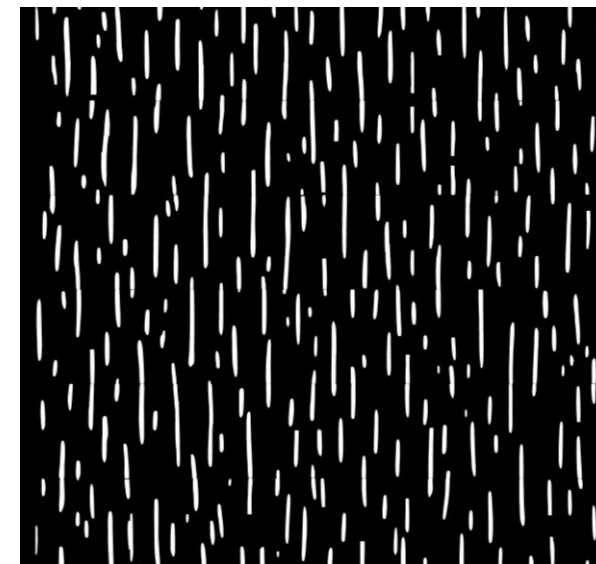
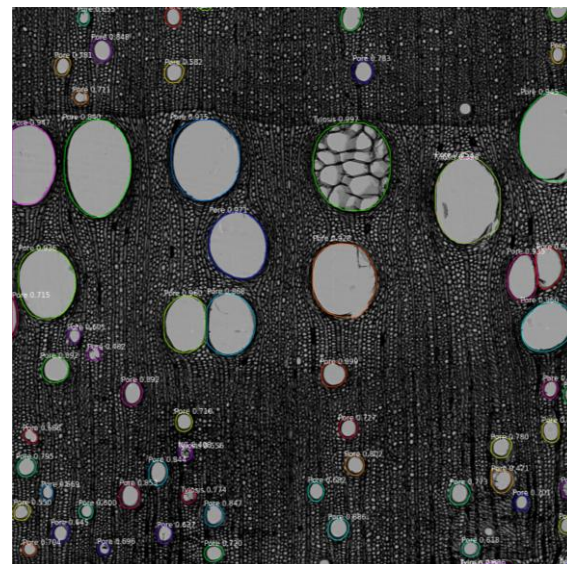
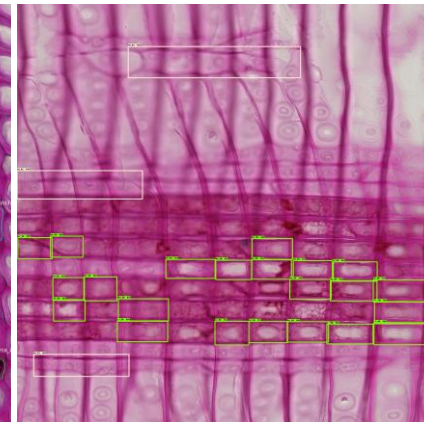
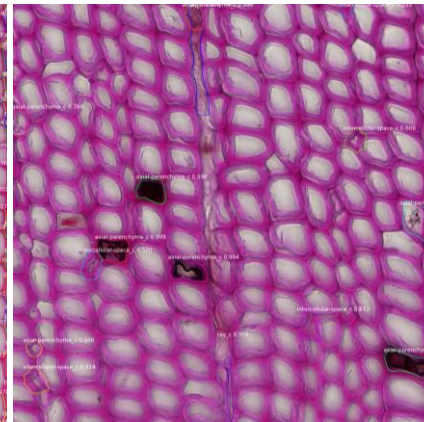
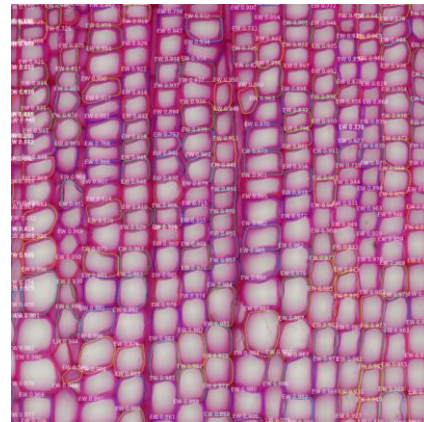
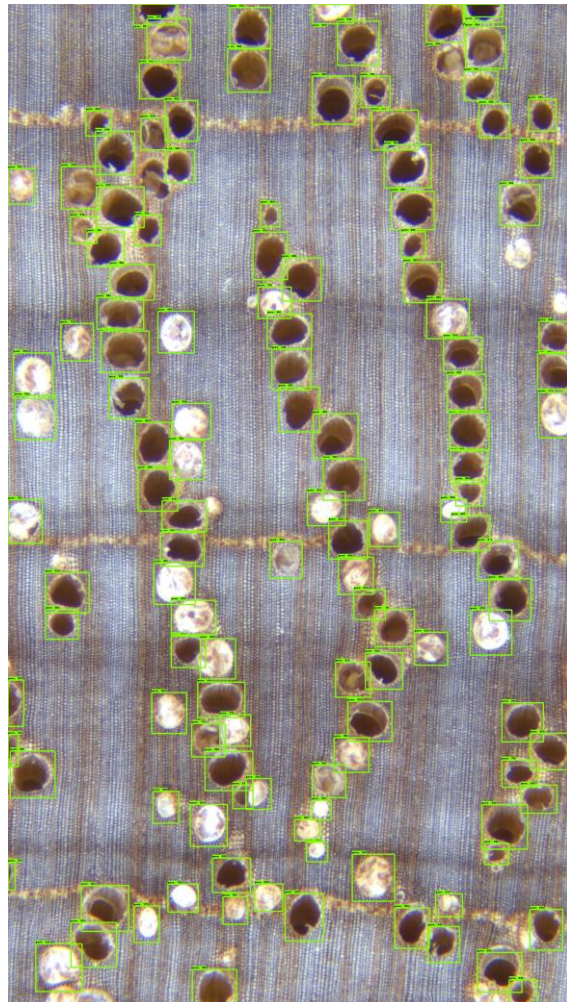
Model Configuration

Confidence Threshold: 50%
 Class Threshold: 50%
 mIoU: 50%
 Label Display Mode: Show Confidence

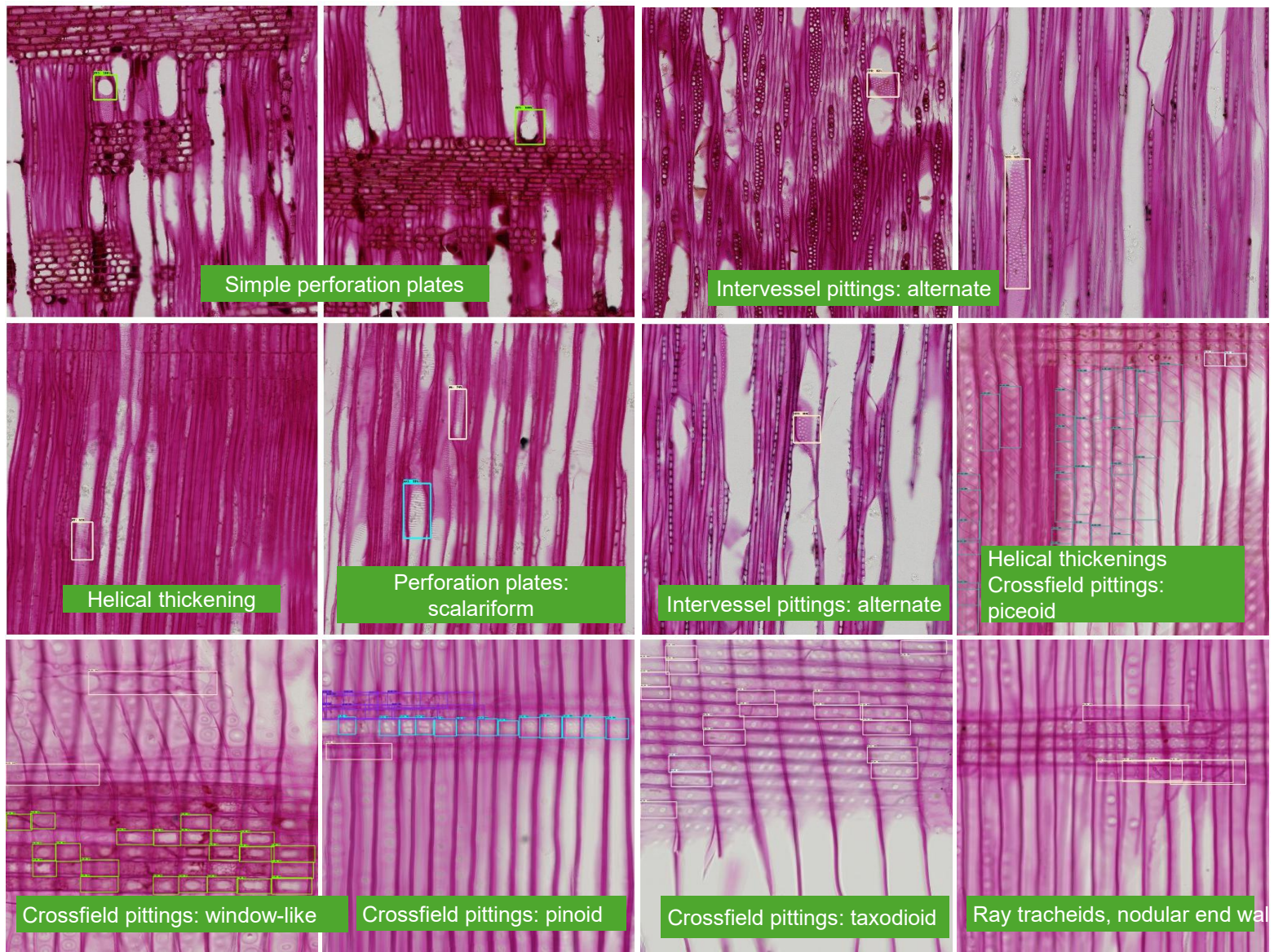
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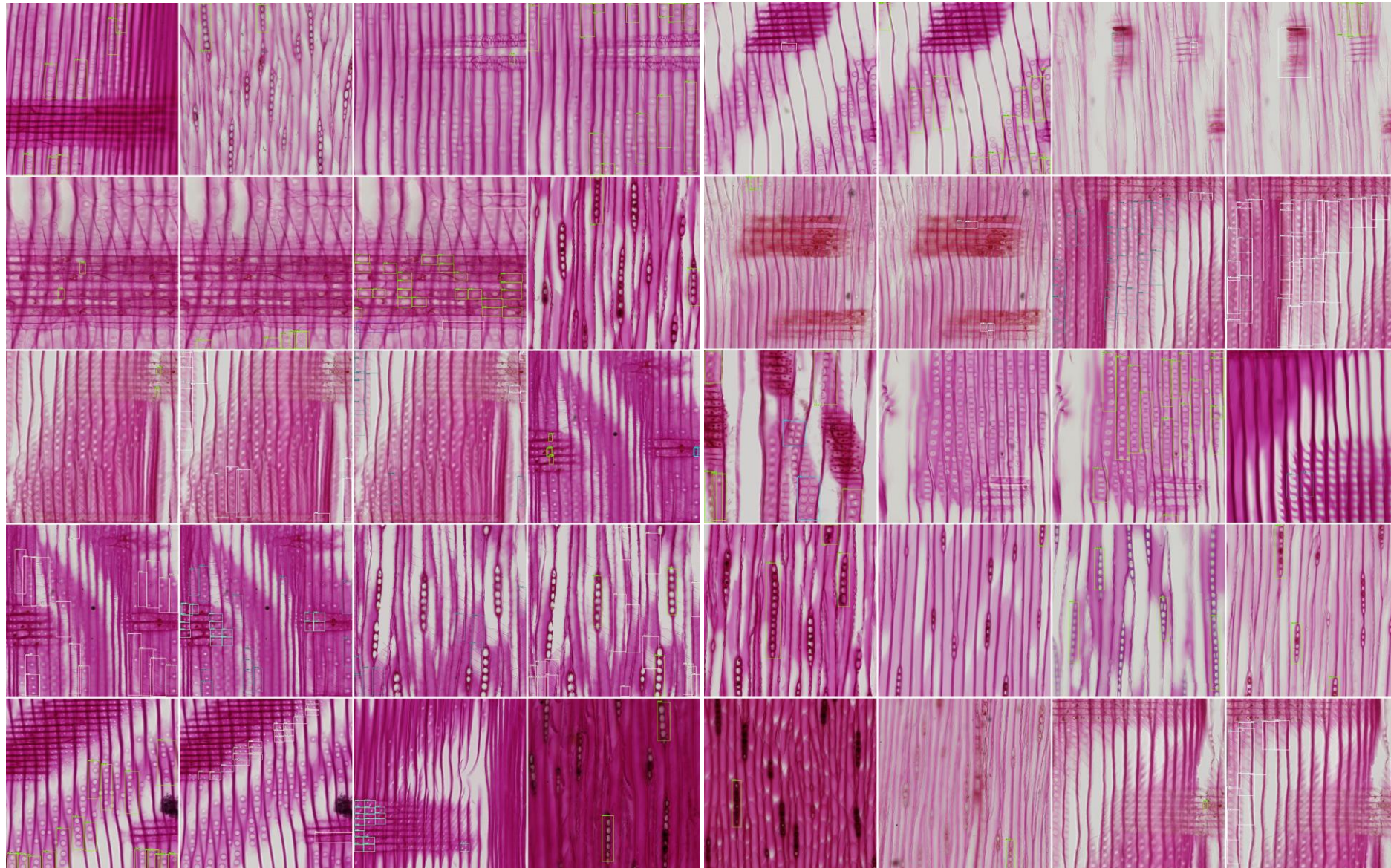
[2][3] Automatic Detection and Segmentation of Microscopic Features of Wood



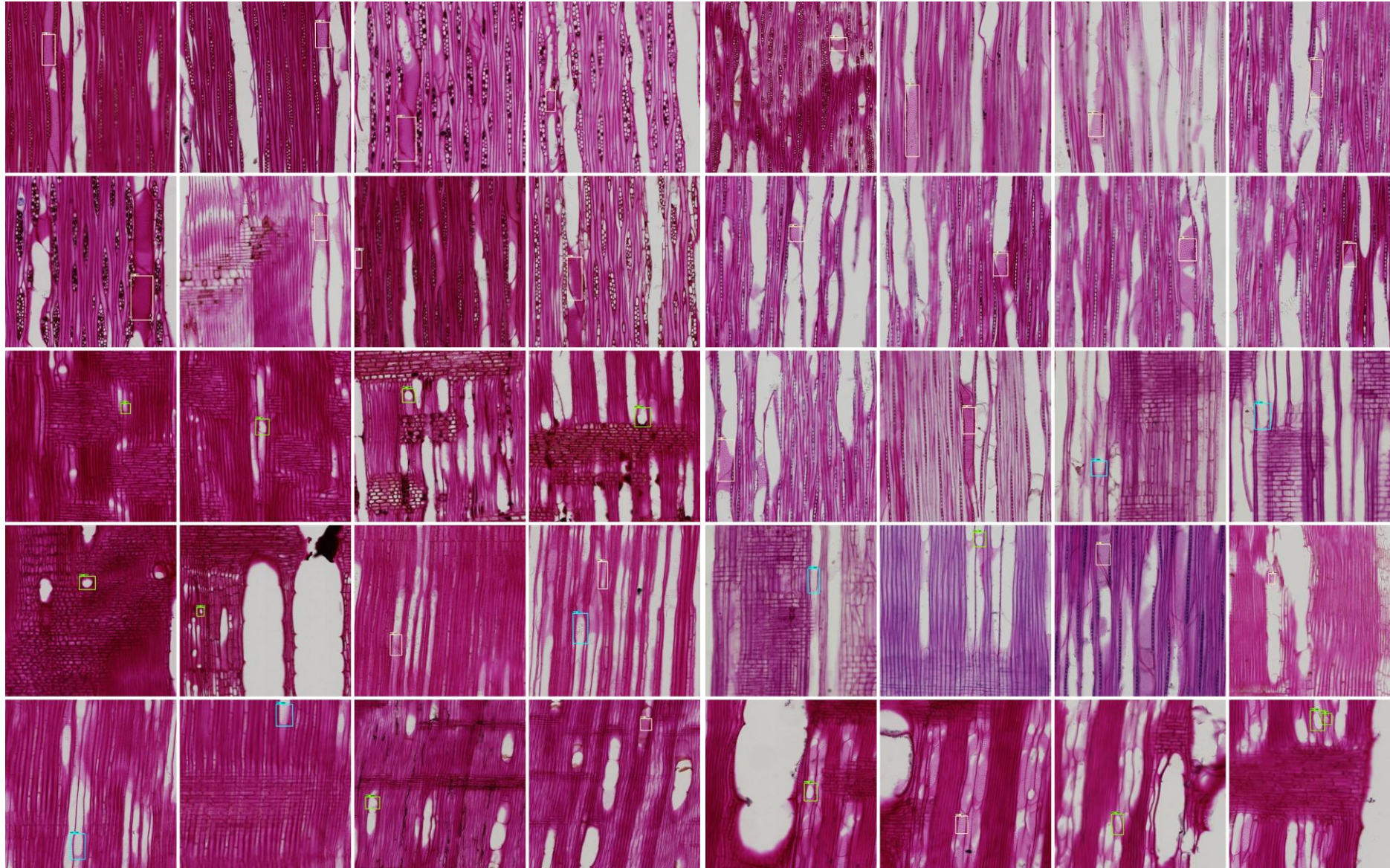
[2] Automatic Detection of Microscopic Features of Wood



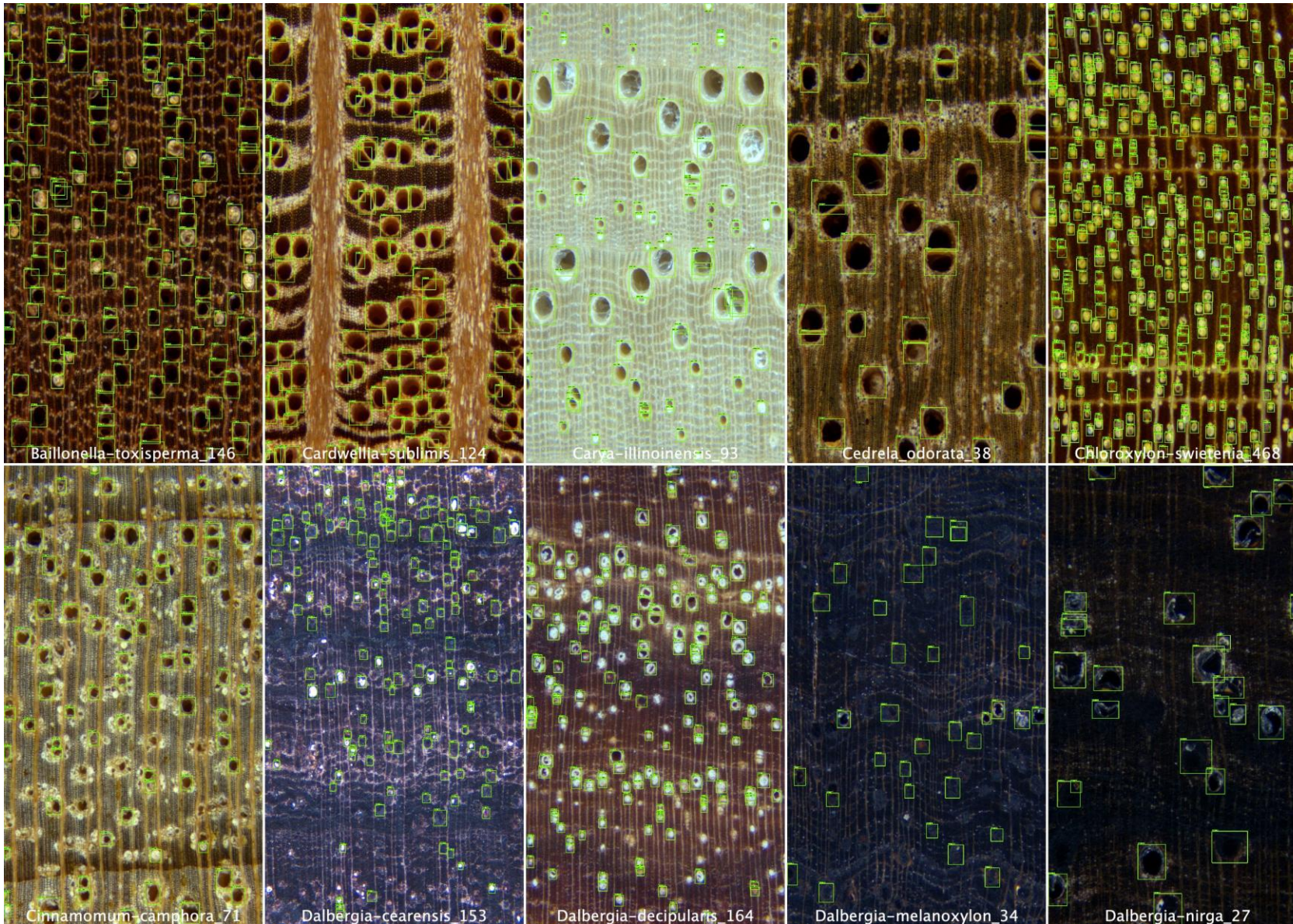
[2] Automatic Detection of Microscopic Features of Softwood



[2] Automatic Detection of Microscopic Features of Hardwood



[2] Automatic Detection of Pores on Hardwood Surface

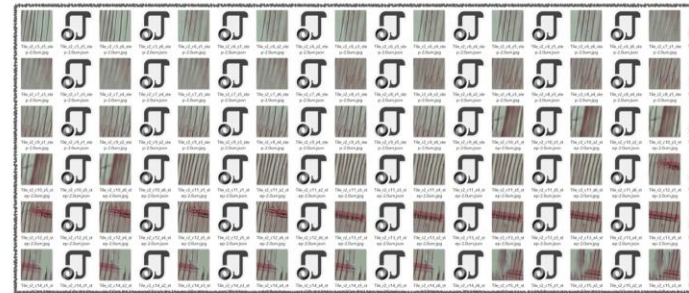


[2] Automated Microscopic Imaging, Extracting IAWA Codes, and Wood Identification

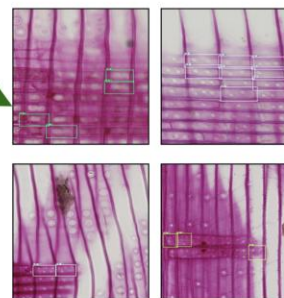
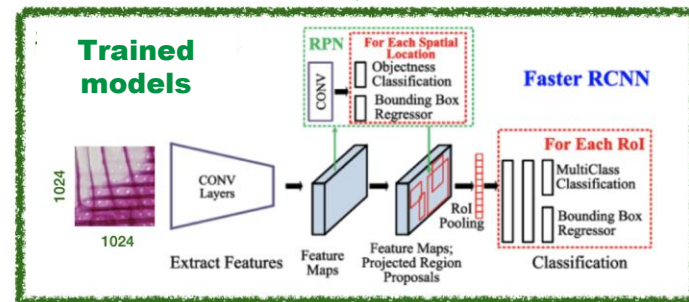
Motorized microscope: automatically collecting large number of microscopic images of wood

Detection model: automatic detection of anatomical features of wood

Automatic selection of candidate species



Collected images



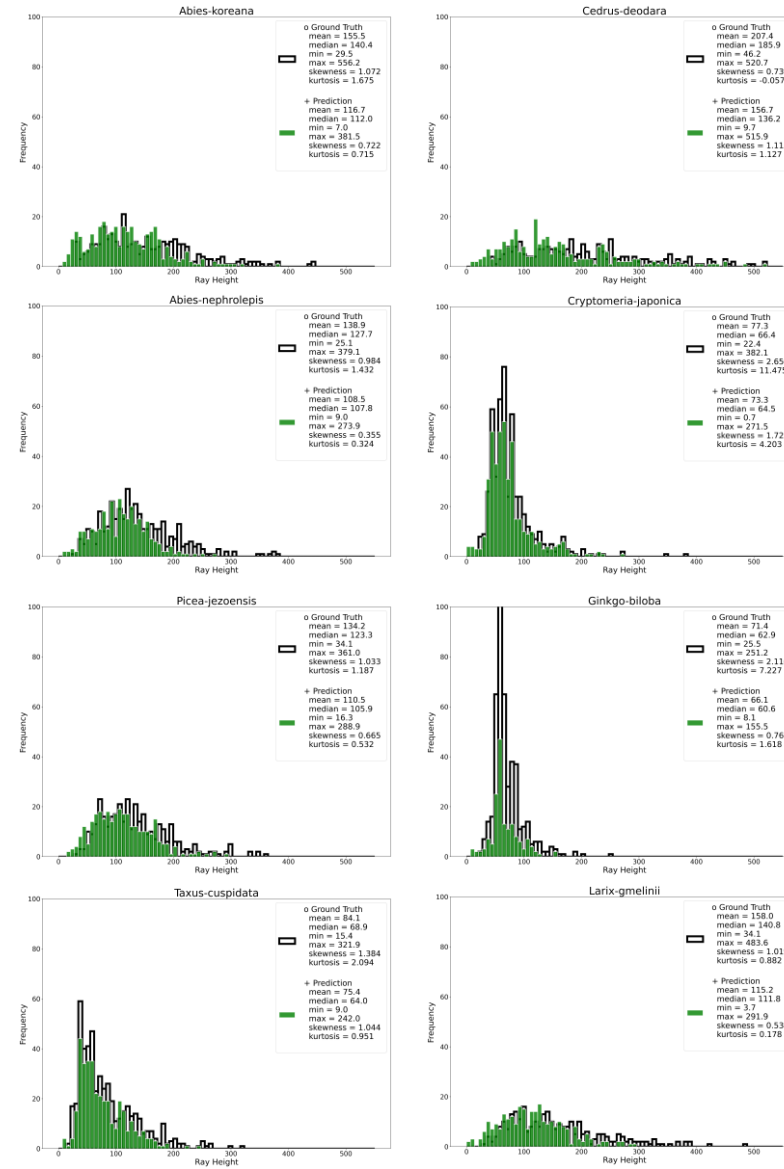
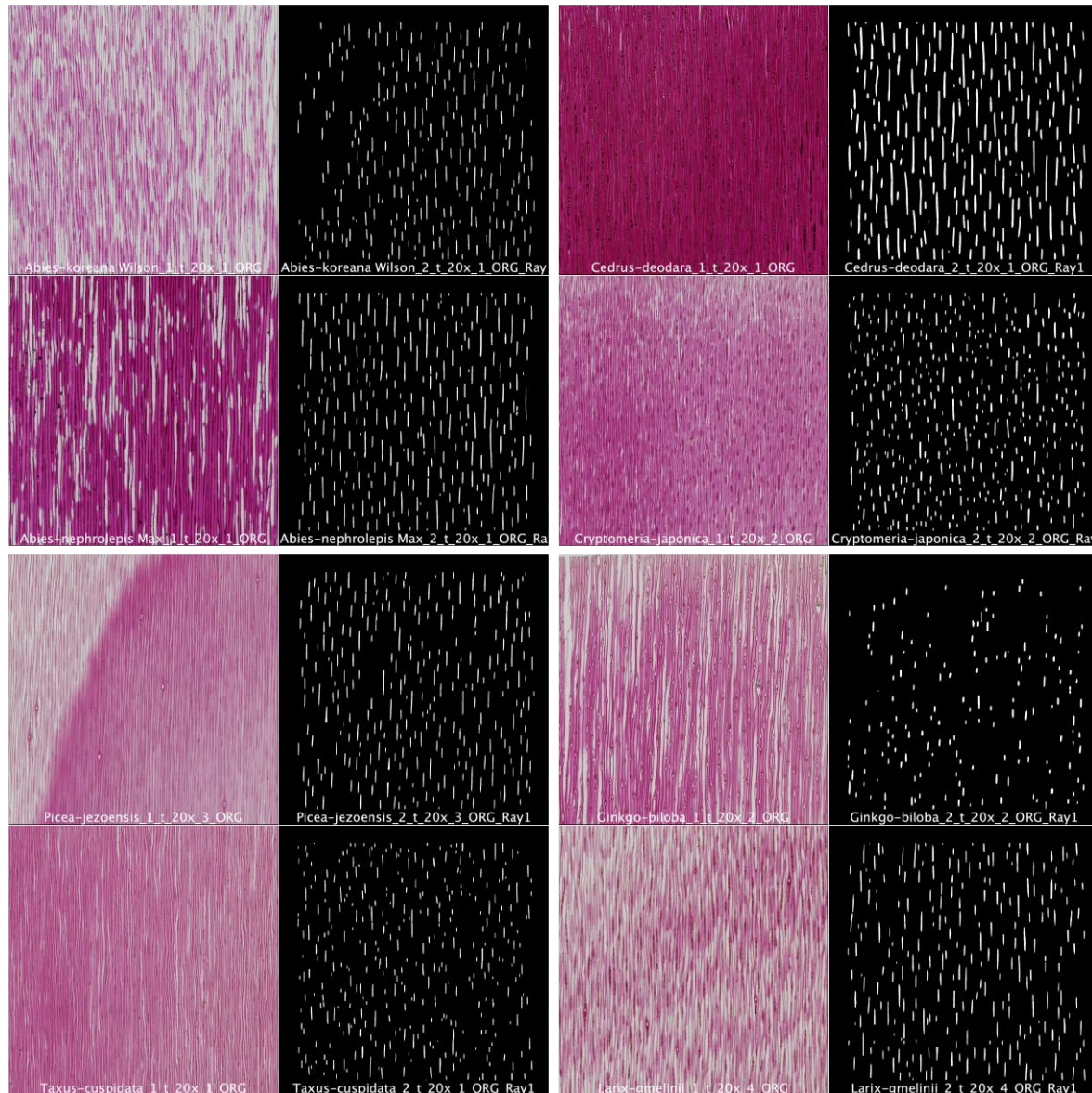
Detecting anatomical features

List of feature codes

	species	matching codes
0	Pinus albicaulis	[90, 0, 117]
1	Pinus armandi	[90, 91, 117]
2	Pinus brutia	[0, 91, 117]
3	Pinus bungeana	[0, 91, 117]
4	Pinus canariensis	[0, 91, 117]
5	Pinus caribaea	[0, 91, 117]
6	Pinus cembra	[90, 0, 117]
7	Pinus densata	[90, 0, 117]
8	Pinus densiflora	[90, 0, 117]
9	Pinus echinata	[0, 91, 117]
10	Pinus fenzeliana	[90, 0, 117]
11	Pinus halepensis	[0, 91, 117]
12	Pinus heldreichii	[0, 91, 117]
13	Pinus jeffreyi	[0, 91, 117]
14	Pinus kesiya	[90, 91, 117]
15	Pinus koraiensis	[90, 91, 117]
16	Pinus krempfii	[0, 91, 117]
17	Pinus lambertiana	[90, 0, 117]
18	Pinus latteri	[0, 91, 117]
19	Pinus luchuensis	[90, 0, 117]
20	Pinus massoniana	[90, 0, 117]
21	Pinus monticola	[90, 0, 117]
22	Pinus morrisonicola	[0, 91, 117]
23	Pinus mugo	[90, 0, 117]
24	Pinus nigra	[90, 0, 117]
25	Pinus palustris	[0, 91, 117]
26	Pinus parviflora	[90, 0, 117]
27	Pinus patula	[0, 91, 117]
28	Pinus peuce	[90, 0, 117]
29	Pinus pinaster	[0, 91, 117]
30	Pinus pinea	[0, 91, 117]
31	Pinus ponderosa	[0, 91, 117]
32	Pinus pumila	[90, 0, 117]
33	Pinus pungens	[0, 91, 117]
34	Pinus taeda	[0, 91, 117]



[3] Quantitative Analysis for Microscopic Features of Wood: Ray Height Distribution of Softwoods



A Necessary Revolution in Wood Identification

Automated Wood ID that utilizes the microscopic features of wood is **NECESSARY**.

1. **The "Glass Box" AI:** By shifting from simple classification to **object detection**, our AI identifies the specific, verifiable IAWA anatomical features that form the basis of wood science. This provides transparent, trustworthy, and legally defensible results.
2. **The Engine of Progress:** This AI is powered by a **large-scale microscopic image database**. The creation of this database, which has been the primary obstacle for all other methods, is now possible.

A Collaborative, Data-Driven Future

- **Automated microscopic image collection is required** to overcome the bottlenecks of the traditional wood anatomy.
- **International collaboration is required.** Our automated system makes this collaboration **more feasible than ever before**, allowing partners worldwide to contribute to a single, unified, open-access resource.
- The ultimate vision is to transition wood identification from **a specialized, manual art** into **a scalable, objective, and globally accessible data-driven science**.