Machine vision for wood species classification

Xyl Tron

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Forest Products Laboratory

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Xyl?Tron

Xylo – from Greek, prefix meaning wood
Tron – from Greek, suffix indicating instrument
XyloTron – A wood identification instrument

Problem:

- Global exports of timber products in 2016 worth US $227 billion (FAO)

- The illegal harvesting of trees ranks third in international crimes[1]

- Constitutes about 25% to 70% of the deforestation certain economies[1]

- US $10 billion annually in lost revenue[1]

- Combined with unsustainable agricultural practices, deforestation contributes to nearly 25% of CO_2 emissions (Smith et al., 2015)

[1] Interpol/World Bank (2009)
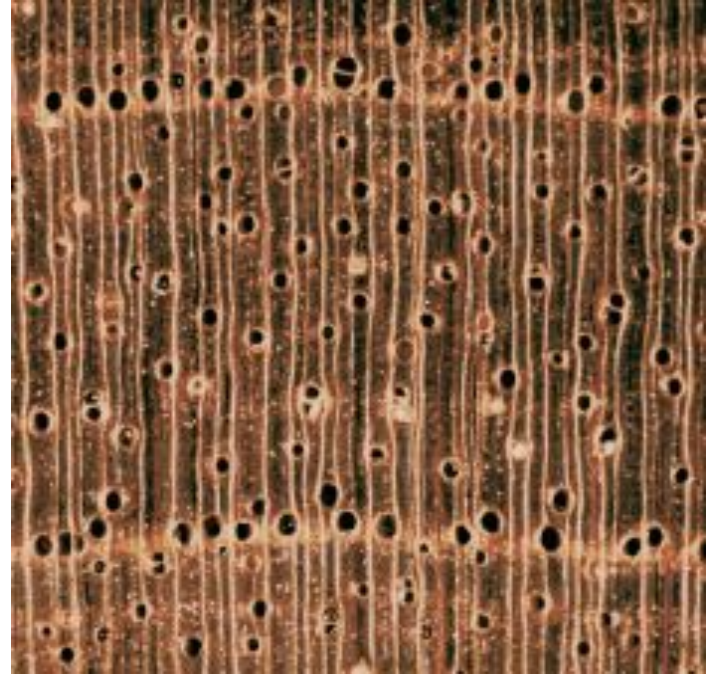
Cedrela odorata

Solution:

- UNEP & INTERPOL: "Environmental crime and the illegal grabbing of natural resources is becoming an ever more sophisticated activity requiring national authorities and law enforcement agencies to **develop responses commensurate with the scale and the complexity of the challenge** to keep one step ahead"
- Domain experts agree that wood identification seen as the primary need to mitigate illegal harvesting
- UNEP & INTERPOL: **Build a machine vision system that can be used as a field deployable tool to identify woody taxa**

Wood anatomy

Trained wood anatomists can identify woods to botanical:

- Family level
- Genus level
- Subgenus level
- Species level

Kingdom

Division

Class

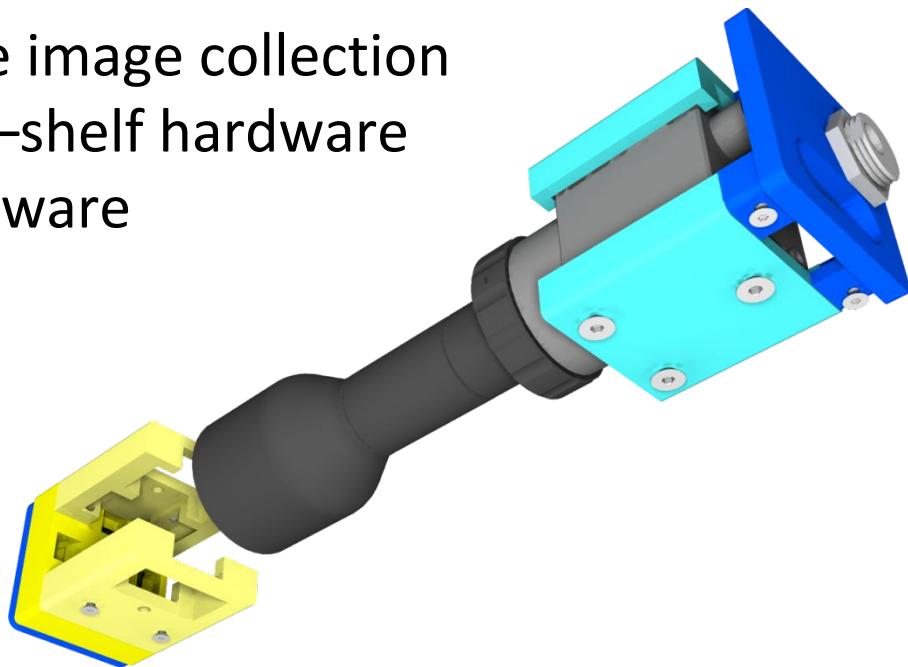Order

Family

Genus

Species

XyloTron: Philosophy

- Have an open reference image collection
- Utilize low cost off–the–shelf hardware
- Utilize open source software
- Economical < 2000 USD
- High–throughput
- Easy–to–use
- Repeatable
- Portable

XyloTron: Uses

- Designed to be field portable
  - Ports of loading
  - Ports of entry
  - Checkpoints
  - Logging sites
  - Sawmills
  - Lumber yards
- Law enforcement
- Private sector supply chains
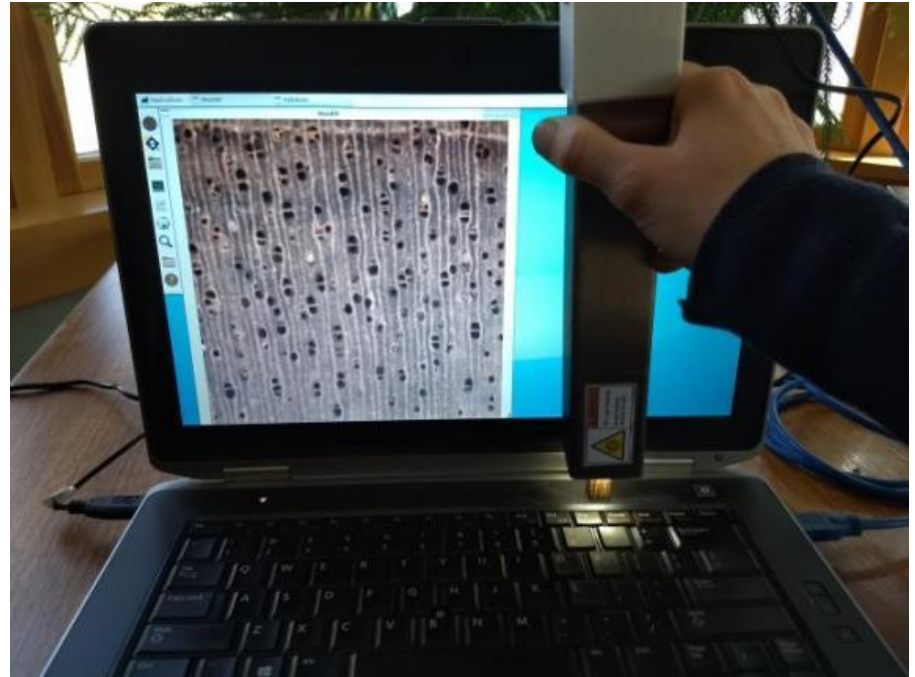
XyloTron: Development History

- Research began - 2011
- Proof of concept - 2012
- XyloTron version 1 - 2014
- 2014 to present - adding species to the digital image reference library, improving algorithms and hardware
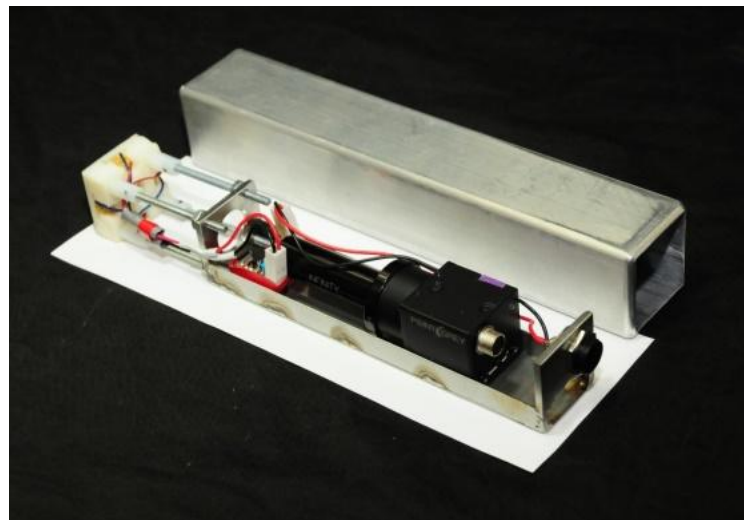
XyloTron: Status

- Classification is robust for 39 species in current database
- Image capture system is robust and can be used as a stand-alone tool
- Images can be uploaded to a wood anatomist for identification
- XyloTron links to Arbor Harbor providing taxonomy, conservation, geography, and trade regulations
  http://woodid.info

XyloTron: Challenges/Limitations:

- Reference image library lacks the depth and breadth to be used broadly
  - Need high quality reference material (true for all methods)
  - Wood specimens with vouchers (30 samples from different trees seems to be sufficient)
  - Need international collaboration to get depth and breadth
- Image classification dependent on specimen preparation
  - Sanding (most consistent quality but most time intensive)
  - Microtome (specimen size is limited)
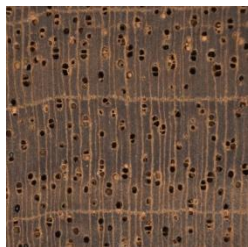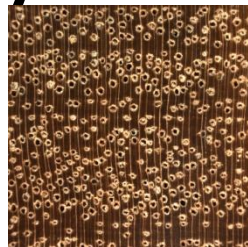 - Knife cut (most expedient but surface quality can be very low quality)

Vouchered samples from xylaria

- Not all wood **blocks** are equal!
- Vouchered samples are more reliable
- Of 16 *D. nigra* at FPL, 3 were misidentified, all unvouchered*
- Accuracy of XyloTron went from 70% using all samples to 98% when using vouchered samples

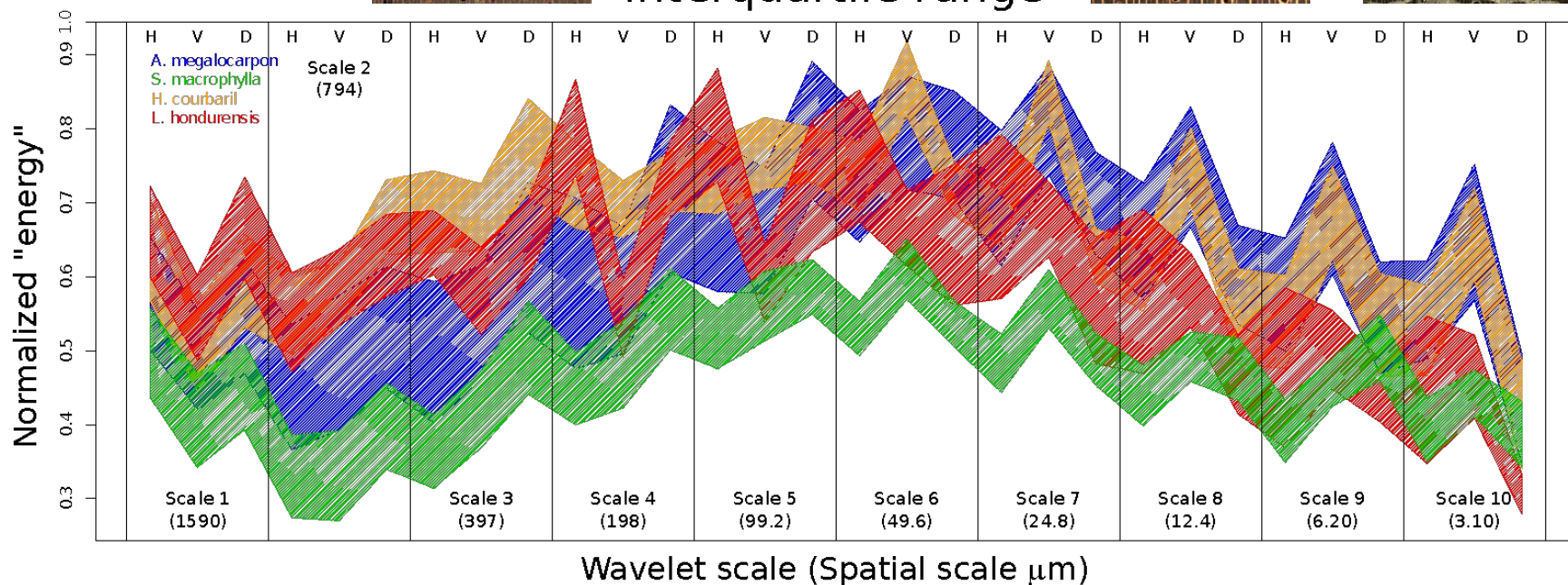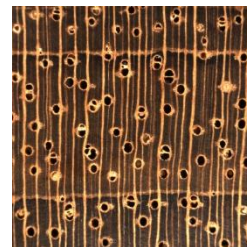*Wiemann & Espinoza (2017)

XyloTron: Theory

Interquartile range

XyloTron: Results

Predicted species

Confusion Matrix
- 39 species
- 3606 images tested
- 3560 correct (green)
- 46 incorrect (red)
- 98.7% accuracy

Actual species

XyloTron: Results

- Distinguishing Eucalyptus globulus, E. nitens, and E. nitens-globulus hybrid
- Overall accuracy rate is 93.5% (the hybrid is confusing factor)
- Accuracy rate between nitens and globulus is 98.7%

Actual species

	Predicted species		
	E. globulus	**E. hybrid**	**E. nitens**
E. globulus	1123	35	12
E. hybrid	19	889	55
E. nitens	17	67	1104

XyloTron: Results

- Comparing *Dalbergia nigra, Dalbergia spruceana,* and all other Dalbergias in MADw and SJRw

	Predicted species		
Actual species	*D. nigra*	*D. spruceana*	*D. spp.*
D. nigra	84	0	0
D. spruceana	2	44	0
D. spp.	0	0	91
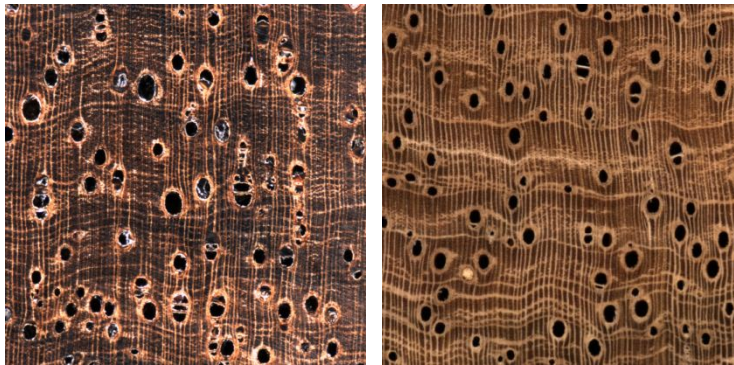
XyloTron: Scaling up

- The XyloTron is operational and has been used in pilot studies at the Port of Seattle, Port of New Orleans, and Port of Houston

- Currently the XyloTron is best suited for small timber exporting economies that the image library covers (Central America)

- Build the digital image reference library

XyloTron: Scaling up

Building the digital image reference library

- Working with international partners to add species:

• Belize	• Canada	• Chile*	• France*
• Guatemala	• Honduras	• Madagascar	• Peru

XyloTron: Acknowledgements

Our sincere appreciation to:

- US Department of State
- US Forest Service International Programs
- US Forest Service Forest Products Laboratory

Questions

And thank you for your time

Nothing in Nature is random. ... A thing appears random only through the incompleteness of our knowledge.

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Baruch Spinoza

Machine vision: XyloTron

Anacardiaceae	Anacardium	excelsum
	Astronium	graveolens
	Tapirira	guianensis
Apocynaceae	Alstonia	scholaris
	Aspidosperma	megalocarpon
Bignoniaceae	Jacaranda	copaia
	Tabebuia	rosea
Burseraceae	Bursera	simaruba
Calophyllaceae	Calophyllum	brasiliense
Caryocaraceae	Caryocar	glabrum
Chrysobalanaceae	Licania	heteromorpha
	Licania	octandra

Machine vision: XyloTron

Clusiaceae	Symphonia	globulifera
Combretaceae	Terminalia	amazonia
Ehretiaceae	Cordia	alliodora
Euphorbiaceae	Hura	crepitans
Fabaceae	Albizia	saman
	Dialium	guianense
	Dicorynia	guianensis
	Enterolobium	cyclocarpum
	Enterolobium	schomburgkii
	Hymenaea	courbaril
Goupiaceae	Goupia	glabra
Malvaceae	Ceiba	pentandra

Machine vision: XyloTron

Meliaceae	Carapa	guianensis
	Cedrela	fissilis
	Cedrela	odorata
	Khaya	ivorensis
	Swietenia	macrophylla
Moraceae	Brosimum	alicastrum
	Brosimum	utile
Sapotaceae	Franchetella	anibifolia
	Manilkara	bidentata
	Manilkara	zapotilla

Machine vision: XyloTron

Simaroubaceae	Simarouba	amara
Vochysiaceae	Vochysia	ferruginea
Zygophyllaceae	Guaiacum	sanctum
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Fabaceae	Dalbergia	calycina
	Dalbergia	glomerata
	Dalbergia	retusa
	Dalbergia	stevensonii
	Dalbergia	tucurensis
Meliaceae	Swietenia	humilis