

A machine vision system for automated field-level wood identification

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Background

What is forensic wood science, and how does it work?

- Scientific basis for determining
 - Species identification
 - Provenance
- Scientific techniques vary in strength, cost, and timeliness
 - Morphological methods
 - Traditional anatomical identification
 - **Machine-vision**
 - Molecular methods
 - Analytical chemistry
 - DNA identification

Background

Traditional anatomical identification

- Field deployable
- Not species-specific – usually only the genus
- Not always genus-specific – sometimes only a group
- Rarely provides provenance



Background

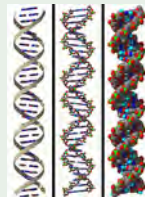
Chemical methods

- Chemical fingerprinting
 - Identify species-specific chemicals in wood
 - Laboratory analysis
- NIR spectroscopy
 - Identifies chemical patterns. Ongoing research to establish robustness
 - Field-deployable
- Isotopes
 - Identifies provenance based on chemical differences between locations
 - Laboratory analysis

Background

DNA methods

- 'Fingerprinting' – Individual specificity
- 'Barcoding' – Species identification
- Phylogeography – Provenance
- Not (yet) field-deployable



Overview

Taxonomic identification table

Context	Wood/Product	Anatomy	DNA	Chemo-metrics
Reference-database	Heartwood	Yes	Maybe	Yes
	Sapwood	Yes	Yes	No
	Non-wood	No	Yes	No
Field-application	Heartwood	Yes	Maybe	Yes
	Sapwood	Yes	Yes	No*
	Plywood	Yes	Probably	Yes*
	OSB/Flakeboard	Yes	Possibly	Yes*
	Particleboard	Yes	Probably not	Yes*
	Fiberboards	Yes*	No*	Maybe
	Paper	Yes*	No*	Maybe
	Pulp	Yes*	No*	Maybe
Wood-Plastic Composites	Yes*	No*	Maybe	

Overview

Provenance identification table

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The Problem

Botanical identification of wood and wood products is a limiting factor for enforcing laws that combat illegal logging

- Traditional anatomical identification is limited
 - Time to train
 - Cost of training
 - Mobility of individuals
 - Lacks species and provenance
- Need a technological rather than a human solution
 - Chemical and DNA are not ready for widespread field deployment

The Project

Solution

Build a machine vision system that can be used as a field-deployable tool to identify woody taxa.

The Approach

Pros and cons of a machine vision system for wood ID test

Pros

- Digital imaging can be more sensitive than the human eye
- Machine vision systems collect copious amounts of data
- Machines do not forget, get bored, promoted, fired, etc

Cons

- Machines are dumb
 - Garbage in garbage out
 - Requires robust programming
 - Requires Big Data

The Operational Philosophy

Develop an open system

- Utilize low cost off-the-shelf hardware
- Utilize open source software
- Have a central database
- Create an open platform for others to further development
- High-throughput
- Repeatable
- Easy-to-use
- Economical

We use this system to capture digital images of unknown wood specimens

Demonstration

Take-home message

This is a field-deployable machine vision system that, as of right now, is as accurate as a person with one week of wood identification training and exceeds traditional human anatomists in identifying species

Details: 8000+ images, 55 genera, 160 species

Classification	First	Second	Third	Sum
Genus and species	42%	18%	9%	69%
Genus	60%	21%	8%	89%

Global Cooperators

- Dr. YIN Yafang, Chinese Academy of Forestry, Beijing, China
- Dr. Flavio Ruffinatto, Turin, Italy
- Dr. Gerald Koch, Thünen Institute Centre of Competence on the Origin of Timber, Hamburg, Germany
- Dr. Peter Gasson, Royal Botanic Gardens Kew, London, England
- Dr. Sandra Florsheim, Secao de Anatomia de Madeira, Instituto Florestal, São Paulo, Brazil
- Dr. Hisashi Abe, Forestry and Forest Products Research Institute, Tsukuba, Japan

Acknowledgements

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

L^AT_EX with the BEAMER class

Conclusion

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

I want to hear from you on what features you think are important

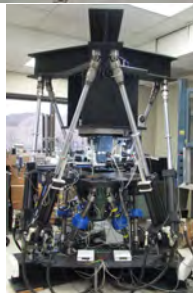
谢谢

спасибо

Background

Do not ask me to identify wood without the “xyloscope”

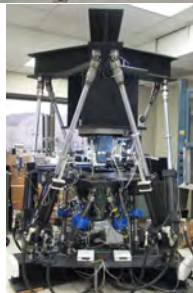
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- Interested in Physical System Identification (curious)
- Love gadgets (nerd)
- My “microscopes” that I built \implies
 - Latin pronunciation challenged
 - Thus I am a wood aNERDomist



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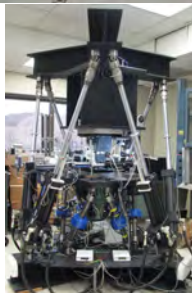
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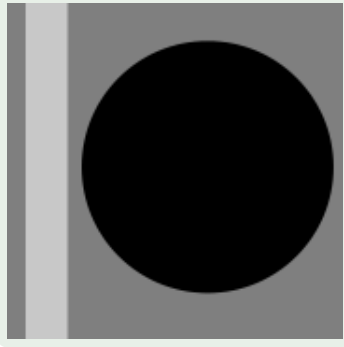
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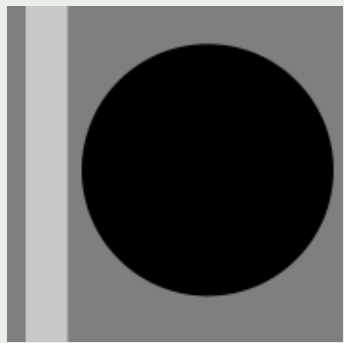
Anatomy of a Digital Image

A simple image

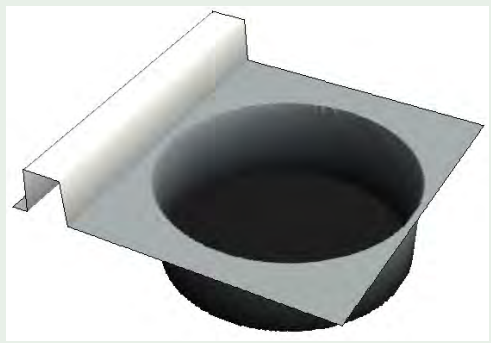


Anatomy of a Digital Image

A simple image

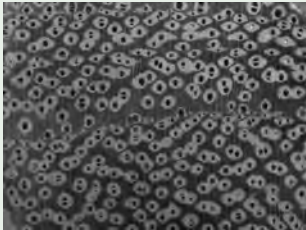


A 3D representation



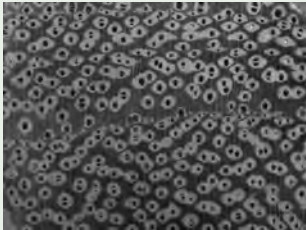
Anatomy of a Digital Image

A less simple image

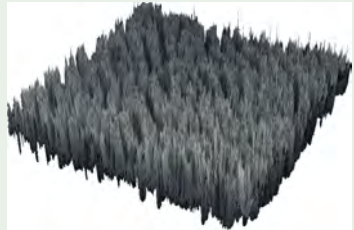


Anatomy of a Digital Image

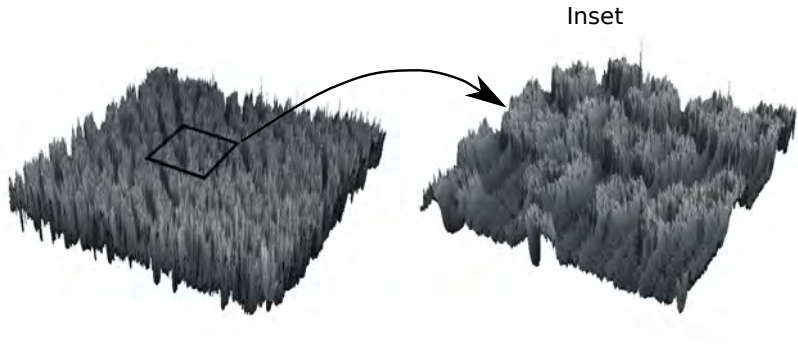
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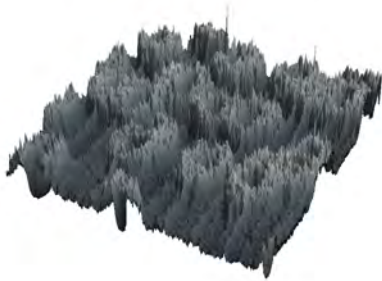
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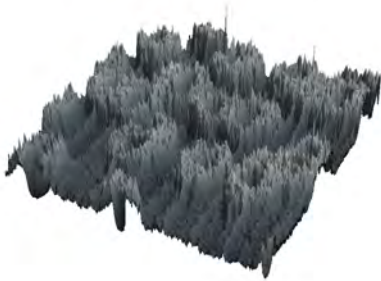
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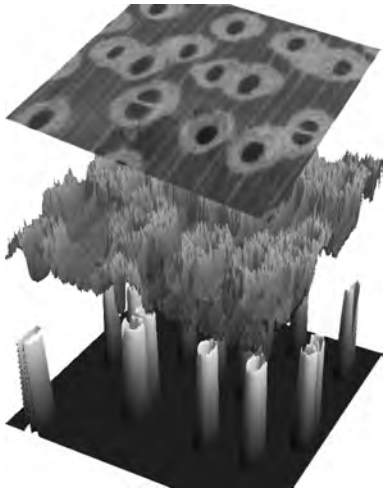
Anatomy of a Digital Image



Anatomy of a Digital Image



Anatomy of a Digital Image



The computational demands of feature detection exceed the capacity of affordable, portable devices, so we need an alternate method to analyze the digital images

Analysis of a digital image

Signal processing methods

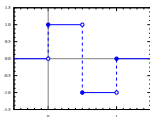
- Commonly used in digital image processing
 - Optical Character Recognition
 - Fingerprint recognition
- Computationally, they are fast and efficient
- Their output cannot be readily mapped back to specific wood anatomical features

**The signal processing technique
we have chosen is wavelets**

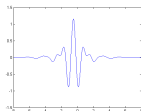
Analysis of a digital image

Wavelets

- Characterizes the topology of the image using a function
 - Extracts signal horizontally and vertically from the image
 - Extracts signal at iterative reductions in scale, capturing variability across scales
- We calculate the energy in the image at 10 scales
- This gives us a 33-dimensional space for analysis and identification



Haar Wavelet



Meyer Wavelet

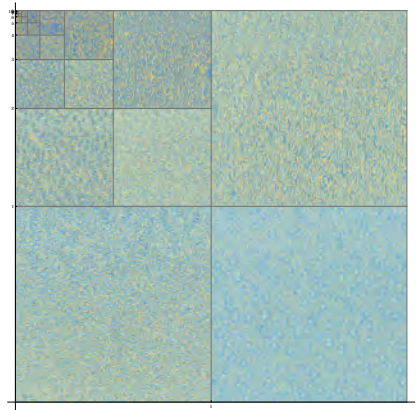


Signal

Analysis of a digital image



Analysis of a digital image



Analysis of a digital image

