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

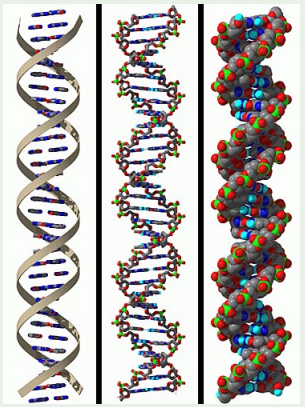
Chemical methods

- 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

Context	Wood/Product	Anatomy	DNA	Chemo-metrics
Reference database	Heartwood	No*	Maybe	Yes
	Sapwood	No*	Yes	No
	Non-wood	No*	Yes	No
Field application	Heartwood	No*	Maybe	Yes
	Sapwood	No*	Yes	No*
	Plywood	No*	Probably	Yes*
	OSB/Flakeboard	No*	Possibly	Yes*
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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

Build a machine vision system that can be used as a field-deployable tool to identify woody taxa.[1]

[1] **The Fine Print:** with an accuracy equal to or better than average field personnel with one week of training

The Approach

Pros and cons of a machine vision system for wood ID

Pros

- Digital imaging can be more sensitive than the human eye
- Machine vision systems collect copious amounts of data
- The collected data can be "mined" to enhance the knowledge of wood anatomical structure

Pros continued

- Machines do not forget, get bored, promoted, fired, etc

Cons

- Machines are dumb
  - Garbage in garbage out
  - Requires robust programing
  - Needs 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

Details

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

Cooperators

- Dr. Yafang Yin, Chinese Academy of Forestry, Beijing, China
- Dr. Flavio Ruffinatto, Turin, Italy
- Dr. Gerald Koch, Thunen 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, Sao Paulo, Brazil
- Dr. Hisashi Abe, Forestry and Forest Products Research Institute, Tsukuba, Japan

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LaTeX with the BEAMER class

Questions

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

Baruch Spinoza