United States Department of Agriculture

Machine Vision

How Machine Vision Works

The Forest Products Laboratory, a part of Forest Service Research and Development, and Forest Service International Programs have produced a prototype machine vision-based automated wood identification system that permits non-specialists to identify unknown woods. This document summarizes how machine vision works.

About Machine Vision

There is an urgent need for a technology that can identify wood in the field in real-time. Anti-illegal logging legislation in the U.S., European Union, and other countries have increased the demand for field-based wood identification as a first step in inspections of wood products. Despite the urgent need for such field expertise, training and deploying humans to identify wood in the field (i.e. at ports, border crossings, weigh-stations, airports, and other points of entry for commerce) is prohibitively expensive and difficult logistically. The machine vision wood identification project (MV) has developed a prototype machine vision system for wood identification.

About the Machine Vision System

This machine vision system is a custom, open source computing platform running on off-the-shelf hardware. The system uses wavelets to analyze the image signal and partial least squares (PLS) methods to classify the resulting power spectra in order to find a closest match in a reference database.

Hardware and Software

- Xyloscope (custom machine housing and 3D-printed light holder that sets the position of the LEDs, lens, and digital camera)
- Cables to connect the xyloscope to (USB 3 for the digital camera, USB 2 to power the 5V LED assembly)
- Netbook-type CPU with integrated battery to power system and process images
- Linux operation system, camera API, C++, Python, OpenCV, and R for image capture, imaging processing, and statistical analysis (all open-source or included with requisite hardware)

Components of the machine vision system.
Credit: USDA Forest Service.

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Operating the System

- Preparing the substrate: The user must prepare, either by sanding or cutting, the transverse surface (end grain) of the wood to ensure that anatomical features are visible to the device and artifacts of preparation are minimized.
- Imaging the substrate: The user must ensure that the rays in the wood are oriented vertically in the real-time view on the screen. The system is capable of digitally rotating the image automatically, by the process is prohibitively intensive computationally for the low-cost CPU platform currently used in the system.
- Decision to accept/reject the output: The system presents a ranked list of matching woods to inform the user's decision regarding the unknown specimen.

The Future

Significant additional research, development, and field-testing are necessary to finalize a design suitable for scale-up and deployment. An international collaboration involving major xylaria in several countries around the world is helping to increase the breadth and depth of the reference database by leveraging in-kind contributions to the program, but direct support is also needed.

Future Research

- Improve the hardware design with ever evolving components
- Train the system to identify commercial Brazilian woods
- Improve, test, and refine feature detection algorithms
- Add explicit quantitation of anatomical characters to the system
- Data-mine existing and incoming images for new "characters"
- Automate specimen preparation and imaging
- Collect data from tangential and radial surfaces of wood
- Establish a list of critical species and confusable taxa and creating methods to separate these woods with the system
- Explore 3D imaging of wood surfaces for enhanced character acquisition

Field Deployment

- Identify rigorous, committed partners for testing
- Develop interactive/interrogative/iterative graphical user interface for field users
- Transfer the manufacturing of the systems from the laboratory to the commercial sector
- Develop regionally-targeted reference datasets to facilitate more efficient identification
- Test global database in parallel with regional datasets
- Process incoming data centrally and communicate with international partners in law enforcement and forensic science to prevent illegal logging in real time.

For more info, contact: **Shelley Gardner**
Illegal Logging Program Coordinator
shelleygardner@fs.fed.us