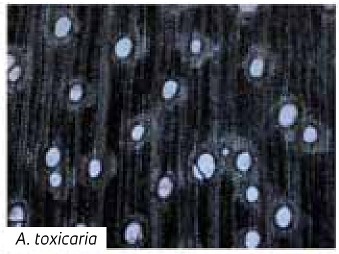
Wood identification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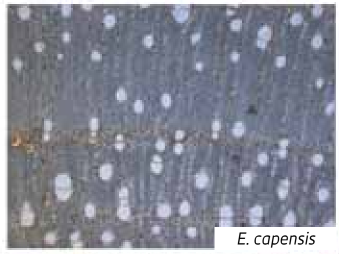
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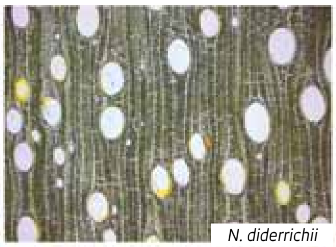
L. alata


M. excelsa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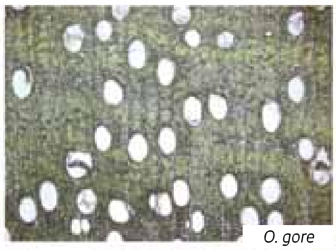
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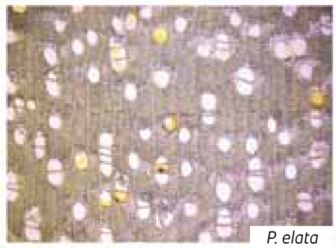
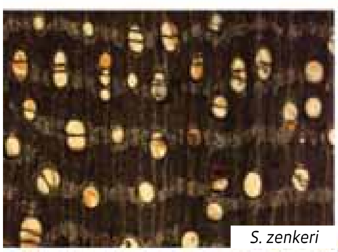

P. elata


P. aningeri

Computer vision systems identify the quality of wood boards and their tree species

PUBLISHED IN JULY 2017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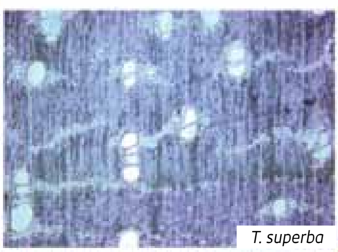
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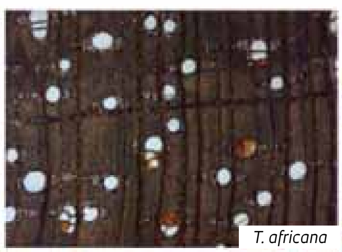
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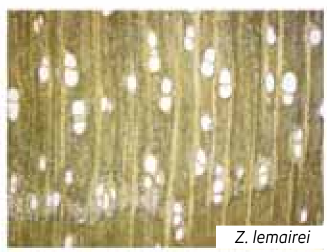
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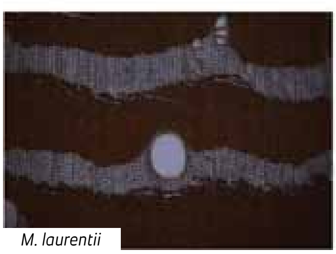
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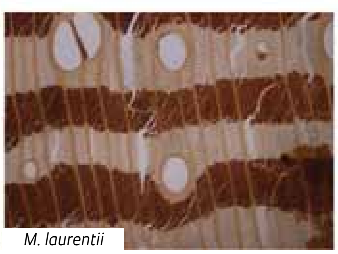
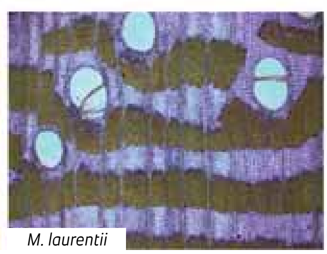

M. laurentii


M. laurentii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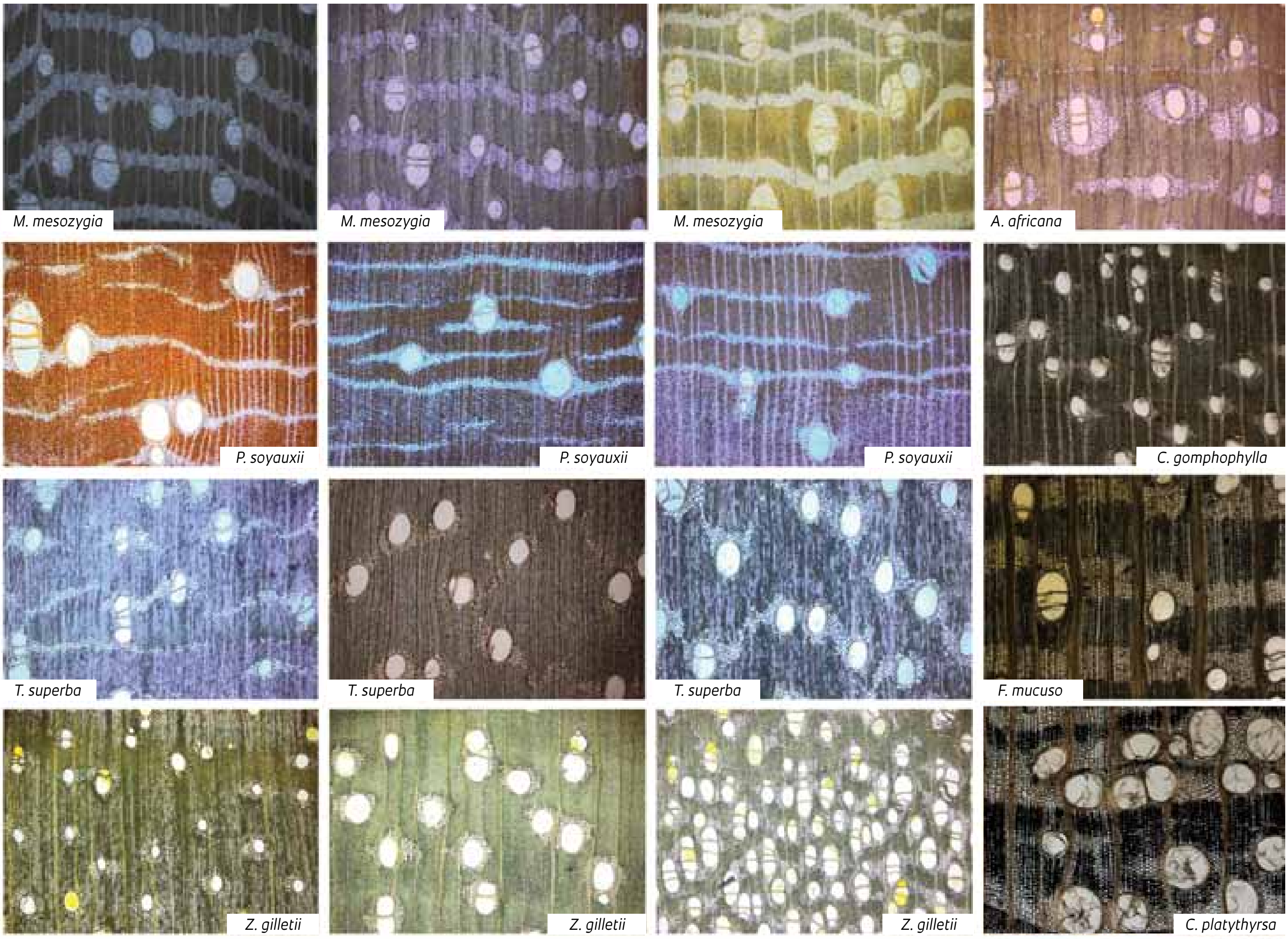
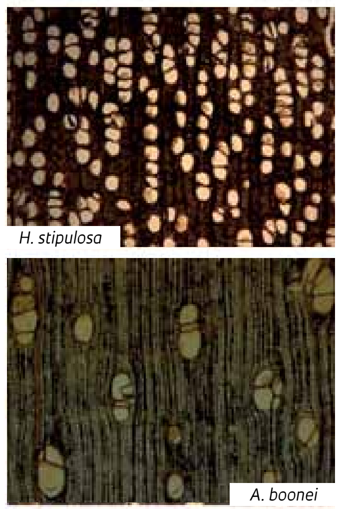


Two artificial vision systems that use images to identify and classify woods have recently been developed in São Paulo. One such system, called NeuroWood, was designed by researchers from São Paulo State University's (UNESP) Itapeva campus, and the Institute of Mathematical Sciences and Computation at the University of São Paulo (ICMC-USP) in São Carlos. It consists of a set of webcams, a computer and a software program that differentiates the wood into three categories: A (Excellent), B (Good) and C (Rejected). The other system, created at the USP Physics Institute in São Carlos (IFSC-USP), is a mathematical method that led to software that can determine the species of tree that the board came from. The two technologies are intended primarily for the wood and furniture industries.

The wood industry usually uses technicians who classify board quality by visual inspection. It is a subjective process that relies on the quality of their training, and the percentage of correctly identified wood is therefore not very high. Studies show that the level of accuracy hovers at approximately 65%.

In light of this scenario, mechanical engineer Carlos de Oliveira Affonso, a professor in the wood industry engineering program at UNESP/Itapeva; computer scientist André Luís Debiaso Rossi, a professor in the production engineering program at UNESP/Itapeva; and civil engineer Fábio Henrique Antunes Vieira, a professor at the Capão Bonito School of Technology in São Paolo State designed an instrument to perform wood classification automatically. The NeuroWood project is receiving support from the Center for Mathematical Sciences Applied to Industry (CeMEAI), one of the Research, Innovation and Dissemination Centers (RIDCs) funded by FAPESP, headquartered at the ICMC. The system consists of a webcam, a monitor and a programmable logic controller (PLC)—a microprocessor that handles the interface between the computer and the actuators (electric motors or conveyor belts).

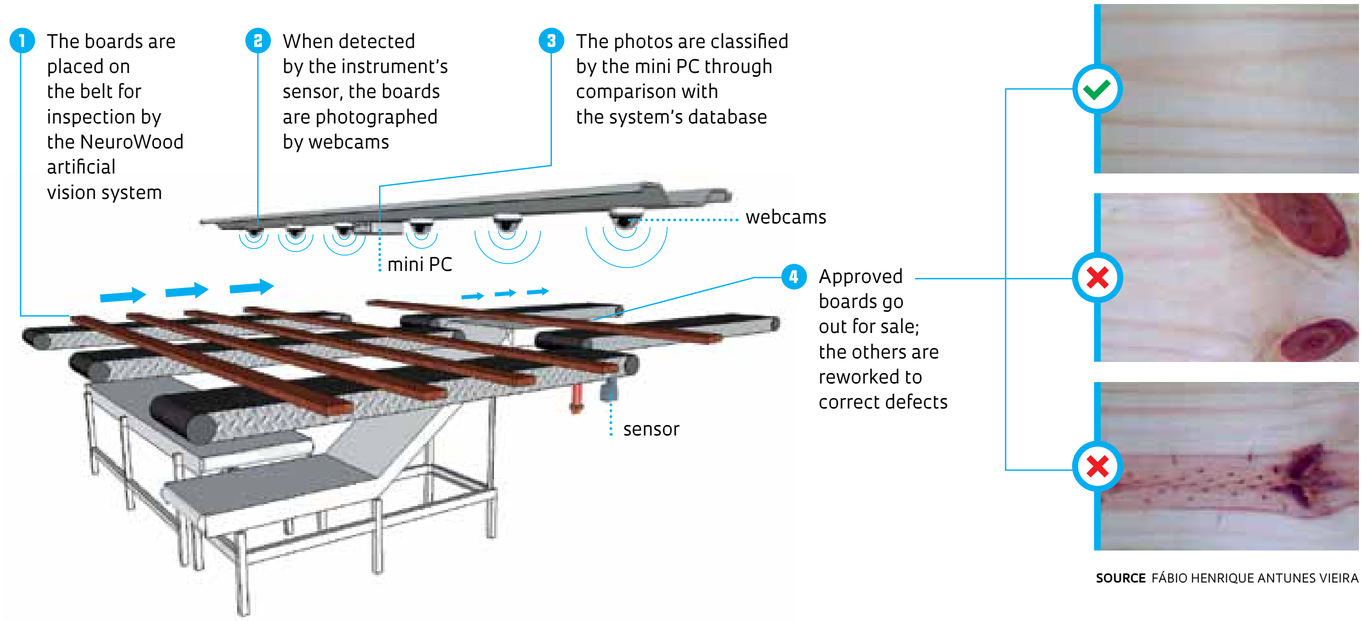


Microscopic images show structural details of woods from different types of African trees

ANNALS OF FOREST SCIENCE

Eyes on wood

Learn how the instrument analyzes and classifies wood boards according to quality



SOURCE FÁBIO HENRIQUE ANTUNES VIEIRA

INFOGRAPHIC ANA PAULA CAMPOS ILLUSTRATION ANDRÉ LUIS DEBIASO ROSSI PHOTOS FÁBIO HENRIQUE ANTUNES VIEIRA

The computer program that they developed uses machine learning techniques. "They are similar to the ones used by facial recognition systems, but simpler," Affonso says. They are built using artificial neural networks, computer techniques that mimic the functioning of the human brain to learn from experience. "To do this, the computer is given a numerical pattern corresponding to a given class of objects," he explains. "After a certain number of repetitions, these programs are able to identify which class the object belongs to, even if it was never presented as an example."

In the case of NeuroWood, the system was "taught" to classify the wood boards according to their quality (A, B or C). The software was provided with data on levels of quality and board defects, such as knots and cracks. A database was then created from more than 600 photos of samples of all three qualities. The photos were processed to improve contrast and brightness and to highlight details, taking into account features such as texture and color.

The system was tested under actual production conditions at Sguario Indústria de Madeira, a company in Itapeva that is a partner on the project. There, it was subjected to the same levels of pollutant dispersion, vibration and variations in light levels as in a normal environment at a furniture or wood manufacturer. The cameras were installed along and above the sawmill's classification conveyor belt. "The captured images are sent to the computer for processing and comparison with the ones in the database. Using this procedure, the software determines board quality as A, B or C," Affonso explains.

One of the programs was tested in a sawmill under actual conditions and yielded a high level of accuracy

According to Affonso, the results were satisfactory. "The system's wood classification performance was similar to what we observed in the lab," he noted. "It is now analyzing 45 boards per minute—a task that would require six workers. The level of accuracy, 85%, was also higher than that of the specialized technicians."

SPECIES IDENTIFICATION

The software developed at the Physics Institute in São Carlos also yielded good results, but that case involved the identification of tree species by their wood. Pieces from the Royal Museum for Central Africa in Tervuren, Belgium, were analyzed. They represented 77 different species of lumber trees that are typically sold in African countries. The work was carried out in partnership with Belgium's Ghent University. "The success rate was 88% at the botanical species level, 89% at the genus level and 90% at the family level," says computer scientist Odemir Martinez Bruno, a professor at IFSC-USP in São Carlos, who coordinated the project.

To perform the identification, the program is fed microimages of wood pieces. "Each species has a distinct composition of cellular structures that differentiates it from the others," Bruno says. "The software analyzes the microscopic patterns formed by the wood's cellular arrangements."

Artificial vision systems could help with the inspection process in Brazil's wood industry

ALAN MARQUES / FOLHAPRESS

Bruno explains that this project is an offshoot of another project being conducted by his team, an ongoing, long-term study of plant biodiversity and identification and plant physiology using computers. In the case of the microimage identification software, he says that for now, the work is purely academic. "The article was published in a scientific journal in that field, and it could attract attention from companies that are interested in turning it into a product," he conjectures.

According to Bruno, to date, there is no quality control or inspection system that can verify commercial wood species. "Our software can be used for quality control, product certification and inspection. It could be used by inspectors to ensure that a given shipment of wood was not sourced from a forest reserve, or from a species protected by law because it is native or in danger of extinction."

INDUSTRIAL USE

NeuroWood, which was founded by UNESP's Affonso, was the subject of a patent filing at the Brazilian National Institute of Industrial Property (INPI) and is ready for use. The company that offered its production line for system testing could be one of the first to adopt it. Today, Sguario produces between 15,000 and 20,000 wood boards per day and does not routinely classify boards according to quality. The pieces are evaluated only by their size. "It would be practically impossible to do a board-by-board visual inspection," says Luiz José Sguario Neto, a partner in the sawmill. "With the UNESP system, it's possible to separate boards by quality and use differentiated pricing."

That system is not entirely novel. There are other, similar systems on the global market that also use computer vision to classify wood. The problem is that they are costly, which hinders acquisition by small and medium-sized companies. "The cost of installing the equipment runs around R$65,000, and imported systems are about R$1.8 million," Affonso says. "The difference is due to the fact that we are developing our own software." To enable the system to be freely used with no need to purchase commercial packages, all the routines were written in open-access computer language. The use of cryptography makes it difficult to pirate the software.

Although the system is ready for use, Affonso has no plans to establish a company to make the software. "Our group's focus is to operate academically," he says. System improvements, however, will now continue, in partnership with com the University of Oulu in Finland. To that end, a contract has been signed between UNESP and that institution's Center for Machine Vision and Signal Analysis (CMVS) to promote student-faculty exchanges. "Like us, the Finnish group noticed that the main difficulty in building an automated image classification system lies in the computer learning phase. It requires a great deal of manual labor to build the database needed for the program to learn from the samples," Affonso comments.

He has been doing postdoctoral research in Finland since February 2017 and will remain there until the end of 2018 to study ways to speed up the online learning process. "The idea is to look at the sample images, identify which ones add more information, and prioritize them during the learning process."

Carlos Alberto Oliveira de Matos, who heads the wood industry engineering program at UNESP/Itapeva, believes Affonso's project is important because it involves undergraduate students and because it partners with lumber companies. "It has shown a high-level capacity on the part of the university's applied research for solving production-related problems," he explains. "Brazil's lumber potential is unmatched around the world; it calls for specialized personnel and high-level research," he points out. "These factors contribute urgently necessary added value to wood-based products." ■

Projects

1. Artificial vision and pattern recognition applied to vegetal plasticity (No. 14/08026-1); **Grant Mechanism** Regular Research Grant; **Principal Investigator** Odemir Martinez Bruno (USP); **Investment** R$174,860.82.

2. CeMEAI – Center for Mathematical Sciences Applied to Industry (No. 13/07375-0); **Grant Mechanism** Research, Innovation and Dissemination Centers (RIDC); **Principal Investigator** José Alberto Cuminato (ICMC-USP); **Investment** R$27,982,568.59 (for all projects during a five-year period).

3. Adaptive visual inspection methodologies for low cost high performance systems (No. 16/23410-8); **Grant Mechanism** Scholarships Abroad; **Principal Investigator** Carlos de Oliveira Affonso (Unesp); **Investment** R$129,810.62.

Scientific articles

AFFONSO, C. *et al.* Deep learning for biological image classification. **Expert Systems with Applications**. May 17, 2017.

SILVA, N. R. *et al.* Automated classification of wood transverse cross-section micro-imagery from 77 commercial Central-African timber species. **Annals of Forest Science**. June 2017.