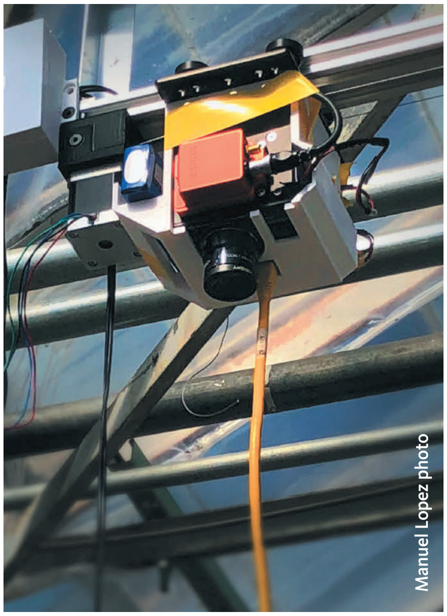
HYPERRAIL DETECTION

Unlocking the secrets of the invisible world to identify crop infections quickly

By Alan Dennis



Exotic new diseases have been traveling across the globe, infecting local crops and forests that lack strong immunities. Southwestern White Pines, for instance, are especially susceptible to a nonnative fungus that causes White Pine Blister Rust. What initially appears as yellow or red spots on a few needles can eventually spread throughout the branches, girdling and killing them.

OSU graduate student Marja Haagsma is working to address the threat by identifying natural resistances in native pine species. The study requires collecting precise data about the severity of infection in rows upon rows of pine seedlings. It's a tedious process, and the manual labor involved for technicians to hand-inspect each seedling's needles for spots can take as much as 70 hours per trial. But what if there were a faster way to see the symptoms?

Enter the electromagnetic spectrum.

Different molecules and biological processes absorb and reflect different wavelengths along the electromagnetic spectrum, including the vast ranges above and below the visible light spectrum. Each condition has its own signature pattern — a sort of disease fingerprint.

A hyperspectral imaging camera sensor can reveal these telltale signs. By gathering and correlating vast amounts of data, it can provide more complete fingerprints of various conditions as they emerge.

Haagsma wanted to validate this method and begin to identify the fungal fingerprints in a greenhouse on OSU's campus. However, she quickly ran into an issue — the camera, for all the spectral data it can collect, only outputs a slice of data 1-pixel-wide. In order to stitch the data slices together into a complete picture, the sensor would need to pan across the plants.

Manually moving the hyperspectral camera to gather usable data would be almost impossible, since a distortion-free image requires absolute consistency. Haagsma needed a way to precisely control the movement of the camera. Looking for help, she turned to the creative makers in OSU's Openly Published Environmental Sensing Lab — the OPEnS Lab, for short.

An Inventive Solution

Inside the machine shop at the OPEnS Lab, Manuel Lopez fits a milled aluminum carriage onto a supported rail that extends from one end of the shop to the other. He's a fourth-year student majoring in electrical engineering and the project lead on the aptly named HyperRail system.

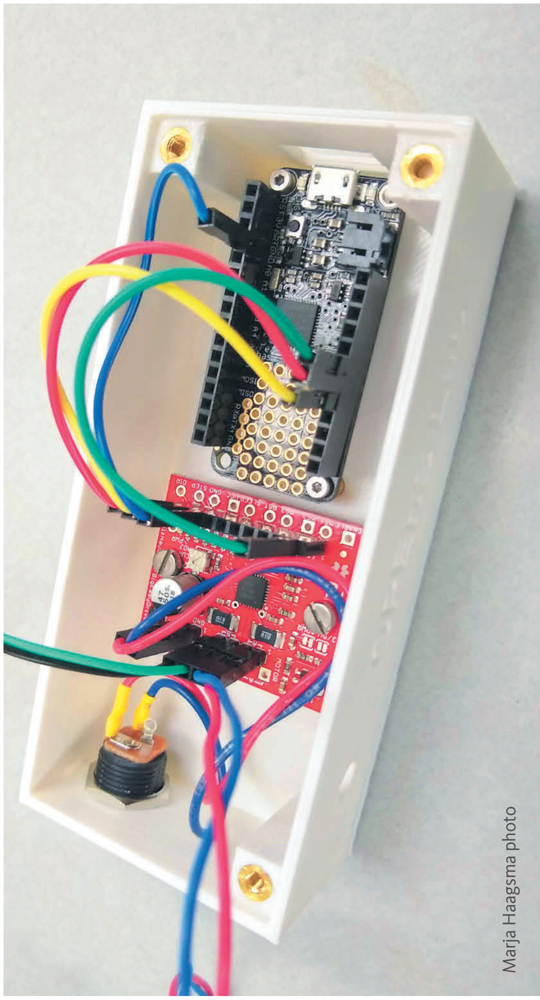
"We started with the hyperspectral imaging camera and put it on this linear motion system," Lopez explains as he glides the sensor carriage along an aluminum rail and points to the small electric motor at the far end. "We have a stepper motor that's driving all the fishing line," he says, referring to their low-cost solution to reliably pull the sensor carriage over long distances.

While the carriage with the hyperspectral camera moves along the rail storing multitudes of data slices, another OPEnS Lab sensor package called eGreenhouse

Opposite: The HyperRail's hyperspectral camera produces wildly colorful vegetation indices (or VIs) that reveal properties of plants invisible to the naked eye. These psychedelic strips show different readings of the same wheat taken by OSU graduate student Marja Haagsma.

Top left: Mounted on a motor-driven carriage, the hyperspectral camera sweeps along the HyperRail, capturing images of plants below with the 271 distinct wavelengths it can detect.

Top right: A box of pine seedlings ready for Blister Rust analysis at the Dorena Genetic Resource Center.



Above: Marja Haagsma operates a mobile, tripod-mounted HyperRail above a wheat field in Pendleton.

Above right: Inexpensive electronic parts in a simple 3D-printed container control the precise movement of the HyperRail's sensor carriage.

records data about temperature, humidity and CO_2 concentrations. That data, Lopez says, transmits wirelessly back to a hub where updates can be displayed in near real time.

After a pass is completed, software stitches the hyperspectral samples together seamlessly, creating a very long and distortion-free image that indicates the presence and severity of infection in the plants.

With one more modification needed to be made to the carriage, Lopez clamps it under the bit of an industrial drill press. Bradley Best, the OPEnS Lab's Director of Production, looks over his shoulder. "You want the collet to go all the way into the quill," he offers. He smiles as the motor hums to life. "Gotta love these old machines, huh? The Bridgeport is iconic."

In the nine months since Lopez has been leading the HyperRail project, he's been picking up machining experience to complement his electronics design and 3D-printing skills in a way that could be called an apprenticeship. "He's picking it up real quick," Best says. "In community college when they teach you this, they don't even let you fire up the machine until the third week."

With the final hole drilled, Lopez places the carriage aside, and we walk together to the nearby greenhouse that holds the HyperRail for Haagsma's research study.

Inside, a row of potted conifer trees grows under a 9-meter (29.5-foot) HyperRail. Lopez points upward. "We call this the SupraTerra version," he says, referring to this particular model that suspends from the ceiling of the greenhouse. There are two other versions. One, simply called the Terra version, can be elevated on tripods above lower-lying vegetation. The other is called the HyperPole and captures data while rotating like a lighthouse.

The disease-detection being done with these plants, Lopez explains, is accomplished without needing to do any kind of physical soil or foliage analysis, or any of the other methods usually required to diagnose infection.

The Maker Movement

Lopez's work is emblematic of a growing community of open source inventors that are a part of an emerging "maker movement." There are deep ties between the maker movement and open source technology often attributed to software development. Both are rooted in a sharing culture, with the belief that collaborating openly creates greater insights and opportunities for all.

According to the National Academy of Engineering, "free and open source hardware is changing the face of science, engineering, business, and law."

The maker movement is an extension of the DIY culture where science, art, and the curiosity inherent in tinkering collide. It's also a movement that very much aligns with the land grant mission of OSU as a leading public research university.

According to Lopez, "The open source part of this really connects everything. Each project that the OPEnS Lab collaborates on, including the HyperRail, are released under an open source license. This means that all of the design files, computer code, bills of materials and instructions are freely accessible to anyone who wants to download them from their website at **www.open-sensing.org**.

Some community members who download and use OPEnS projects modify the designs or code and even send their improvements back to the lab so that others can benefit from them. It's a collaborative, iterative process. "Many people tap into our projects at really high rates," Best says. "They work on it from there, and we work on our stuff from here."

Lopez is visibly proud as he says his role — and the role of the OPEnS Lab — is to "create tools that help researchers, and research in general, keep moving forward." | OAP

Alan Dennis photo

Manuel Lopez – Profile of a Maker

Manuel Lopez, an undergraduate majoring in electrical engineering at OSU, loves making things. During high school at Liberty High in Hillsboro, Lopez found support from the MESA program (Mathematics, Engineering and Science Achievement). There, he competed in robotics competitions and became interested in creating electronic devices. When making an enclosure for his capstone senior project required 3D printing, Lopez just taught himself how to use the technology.

Lopez continues to learn and teach himself new skills as a team member in OSU's Openly Published Environmental Sensing (OPEnS) Lab. He discovered the lab by luck, he says, job-hunting as a new undergraduate student. A student employment posting on the OSU Jobs website said they were looking for someone with makerspace interests like programming and 3D printing. "I've got a little bit of all of that," Lopez thought. He applied, got the job, and now gets to hone his making skills on a range of projects — including inventions like the HyperRail that support and enhance research at OSU.

In the future, Lopez aspires to a career in biotechnology or electrical engineering. He credits everyone he has met for steering his path in a good direction, and he's eager to give back. Describing the motivation behind his work, he says, "I'm here to serve a bigger purpose. I want to use what I know and learn to help other people."