When the AI model detects anomalies that could represent manure spreading, it labels them and assigns a confidence score. Any detection above a chosen confidence threshold gets flagged for human review.

Satellites And AI Zoom In On Farming Practices

Every day, satellites scan the Earth's surface and collect aerial imagery, which many companies and research organizations use for real-time monitoring.

Stanford's Regulation, Evaluation and Governance Lab (RegLab) is one of those entities. RegLab partners with government agencies to design and evaluate programs, policies, and technologies that modernize government.

RegLab's Stanford home allows it to leverage state-of-the-art advances in machine learning, artificial intelligence and causal inference to build a bridge between government agencies and academic frontiers in data science, particularly in the area of environmental compliance. A portion of its work involves using machine learning and satellite imagery to identify potential noncompliance with environmental regulations, which can then be prioritized for review by regulators.

An example is a recent project that attempted to identify manure spread on frozen or snow-covered ground in Wisconsin. By state law, Concentrated Animal Feeding Operations (CAFOs) aren't allowed to spread manure during winter months due to the large scale at which they operate and the high risk of runoff polluting water sources.

RegLab completed the project using imagery from Planet Labs, a private satellite company that provides access to images through paid subscriptions. Its images have a resolution of about 3 meters per pixel, meaning broad patterns can be seen, but not finer details.

The AI model scanned daily satellite images of CAFOs during the winter and learned to recognize manure spreading patterns by analyzing 1,813 manually labeled examples from winters between 2018 and 2020. When it detects anomalies that could represent manure spreading, it labels them and assigns a confidence score. Any detection above a chosen confidence threshold gets flagged for human review.

"The model cannot always distinguish manure from other dark features in the snow, such as tree lines, hedges or solar panels," says Data Scientist Mihir Bhaskar. "This is why we emphasize human verification as a key step. The model provides a useful first alert, but it isn't perfect."

To determine the amount of manure, it estimates the identified area by drawing a box around it.

"To clarify, our model by itself cannot assess the legality of the spread. It only attempts to detect whether manure has been spread," Bhaskar says. "It's up to state regulators to determine legality, relative to what has been reported and/or approved."

Bhaskar hopes tools like these will support regulators and environmental groups working together for more consistent monitoring and compliance activities.

"The next steps depend on how these groups choose to use the information," he says.

"We make all our tools, code and research papers publicly available to support broader learning and adoption. We partner with public agencies, nonprofits and other organizations to test these tools in real-world settings."

RegLab has also worked on several satellite imagery projects to detect other environmentally impactful activities, including industrial runoff, factory farms, aquaculture and accessory dwelling units.

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Research team has developed the test to detect multiple pathogens, including those that cause blight in tomatoes and potatoes, as well as diseases affecting forestry.

Quick Test For Plant Disease

Plant disease tests that currently take days or even weeks can be completed in 20 to 30 min. with technology developed at North Carolina State University (NCSU). The rapid test uses chemical reagents that change color when they come into contact with diseased tissue. The research behind it was funded by grants from the USDA's Animal and Plant Health Inspection Service.

"We're using molecular detectors," explains Jean Ristaino, NCSU plant pathology professor. "They allow us to do in-field diagnostics and confirm a disease."

Ristaino was the founding director of the Emerging Plant Disease and Global Food Security cluster of researchers who have developed the technology. It measures volatile organic compounds (VOCs) that plants release through their leaves. When a plant is diseased or attacked by insects or even damaged mechanically, the type and concentration of the VOCs change.

Each disease or plant impact has its own unique VOC profile. For example, tomatoes release hexenal when attacked by late blight. Traditional methods of measuring VOCs often involve expensive equipment, such as gas chromatography, and require time-consuming sample preparation. These factors lead to high costs and preclude portability. Until now, real-time tests have not existed.

Over the past several years, the research team has developed several variations of real-time VOC testing devices. One that's still being developed is an electronic wearable patch. It can be attached to the underside of a plant leaf to continuously monitor for different pathogens. It incorporates other sensors that monitor for temperature, humidity, salinity and more.

"Right now, the wearable sensors are too large," says Ristaino. "We're working on making them smaller. We'll be testing them in greenhouses. You can't put them on a plant in an open field, as there are too many things happening there."

A second device uses reagents embedded in strips of paper that indicate the presence of a disease when exposed to the VOCs. The device plugs into a smartphone to display results.

Ristaino and the team are working on a third device that uses reagents in a tube. The solution also contains a fluorescent dye that can be visualized with a smartphone.

"We add a tissue sample to the tube and the colors in the tube change from purple to blue," she says. "We can use a smartphone or a commercial device to interpret the change."

The test is so effective that, in some cases, it can detect the disease before symptoms appear. The research team has developed the test to detect multiple pathogens, including those that cause blight in tomatoes and potatoes, as well as diseases affecting forestry. NCSU is working to patent the device. Ristaino hopes to license it for commercial production.

Verdia Diagnostics is an NCSU spinout startup that's building on the research to develop real-time tools. Co-founder Qingshan Wei, Ph.D., is a member of the NCSU research team. The company's goal is to build sensor technology that helps farmers protect yields and reduce input costs.

"I expect that diagnostic labs will be the first to adopt the tests," says Ristaino. "I don't see growers using the technology unless we get the wearable version fully developed."

This past year, Ristaino took the test tube device to Ireland during a sabbatical.

"I demonstrated it in tree plantations and ran the test tube assays in 20 min.," she says. "The test tube version has potential for crop consultants."

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Farmers Share Ideas In Online Meetings

Troubleshoot soil and water stewardship-related challenges with other farmers through Good Idea Shop Talks. Conducted online via Zoom, the call connects 15 to 30 farmers at a time. Each session consists of three weekly meetups. Extension specialists and educators at Midwest and Mid-South land grant universities coordinate the calls.

"Shop Talks was an offshoot of One Good Idea podcasts that featured farmers sharing their experiences," says Jenny Seifert, Watershed Outreach Specialist, University of Wisconsin, Madison. "The goal is to provide more two-way communication. This provides a way for farmers to reach out to other farmers on issues of mutual interest. Farmer-to-farmer learning is really powerful."

Shop Talks began in 2024 and have been conducted seasonally in off-months for crop farming. Moving forward, the extension group plans to offer the Zoom calls three times a year.

Each call focuses on an issue or problem suggested by a participating farmer. Other farmers in the call group share what they've done related to the problem.

"We're trying to reach farmers on the threshold of trying a new conservation practice, such as getting started with cover crops," says Seifert. "Our call this past March focused on cover crop termination, including roller crimping and timing. It drew a lot of interest."

The extension group is evaluating the impact of the initial calls. Seifert emphasizes the importance of providing value to the farmers on the call.

"The participating farmers are finding a lot of value in this type of community building," she says. "A lot of them are in areas where a particular conservation practice isn't being used. Shop Talks lets them learn from what other farmers have done."

Although the number of participants hasn't been a problem yet, consideration is being given to breakout rooms. They would accommodate larger groups.

"We would never limit how many want to join, just modify the way we facilitate the conversation," says Seifert.

"Shop Talks lets them learn from what other farmers have done," says Seifert.

A big question moving forward is funding. Seifert notes that the effort relies on grants to keep it going. She encourages interested farmers to visit the website and register to be notified about future calls. The website also features podcasts of farmers discussing a wide range of crop and livestock-related topics.

"We won't turn farmers away, but the upper Midwest and the Mid-South are the regions we're focusing on," says Seifert.

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