# SCANNER

## MACHINE LEARNING APPROACH HELPS HIT 100% PREDICTION RATE

A research team led by Tao Sun, associate professor of materials science and engineering at the University of Virginia, has made new discoveries that can expand additive manufacturing in aerospace and other industries that rely on strong metal parts.

Their peer-reviewed paper, "Machine Learning Aided Real-Time Detection of Keyhole Pore Generation in Laser Powder Bed Fusion," was published 6 January 2023 in *Science Magazine* and addresses the issue of detecting the formation of keyhole pores, one of the major defects in a common additive manufacturing technique called laser powder bed fusion, or LPBF.

Introduced in the 1990s, LPBF uses metal powder and lasers to 3D print metal parts. But porosity defects remain a challenge for fatigue-sensitive applications like aircraft wings. Some porosity is associated with deep and narrow vapor depressions, called keyholes.

The formation and size of the keyhole is a function of laser power and scanning velocity, as well as the material's capacity to absorb laser energy. If the keyhole walls are stable, it enhances the surrounding material's laser absorption and improves laser manufacturing efficiency. If, however, the walls are wobbly or collapse, the material solidifies around the keyhole, trapping the air pocket inside the newly formed layer of material. This makes the material more brittle and more likely to crack under environmental stress.

Sun and his team, including materials science and engineering professor Anthony Rollett from Carnegie Mellon University and mechanical engineering professor Lianyi Chen from the University of Wisconsin-Madison, developed an approach to detect the exact moment when a keyhole pore forms during the printing process.

"By integrating operando synchrotron X-ray imaging, near-infrared imaging, and machine learning, our approach can capture the unique thermal signature associated with keyhole pore generation with sub-millisecond temporal resolution and 100% prediction rate," Sun said.

In developing their real-time keyhole detection method, the researchers also advanced the way a state-of-the-art tool—operando synchrotron X-ray imaging—can be used. Utilizing machine learning, they additionally discovered two modes of keyhole oscillation.

"Our findings not only advance additive manufacturing research, but they can also practically serve to expand the commercial use of LPBF for metal parts manufacturing," said Rollett, who is also the co-director of the Next Manufacturing Center at CMU.

"Porosity in metal parts remains a major hurdle for wider adoption of the LPBF technique in some industries. Keyhole porosity is the most challenging defect type when it comes to real-time detection using lab-scale sensors because it occurs stochastically beneath the surface," Sun said. "Our approach provides a viable solution for high-fidelity, high-resolution detection of keyhole pore generation that can be readily applied in many additive manufacturing scenarios."

The team's research is funded by the Department of Energy's Kansas City National Security Campus managed by Honeywell FM&T.

**Zhongshu Ren (left) and Tao Sun display the results of their research. Ren is the first author of the *Science* journal article.**
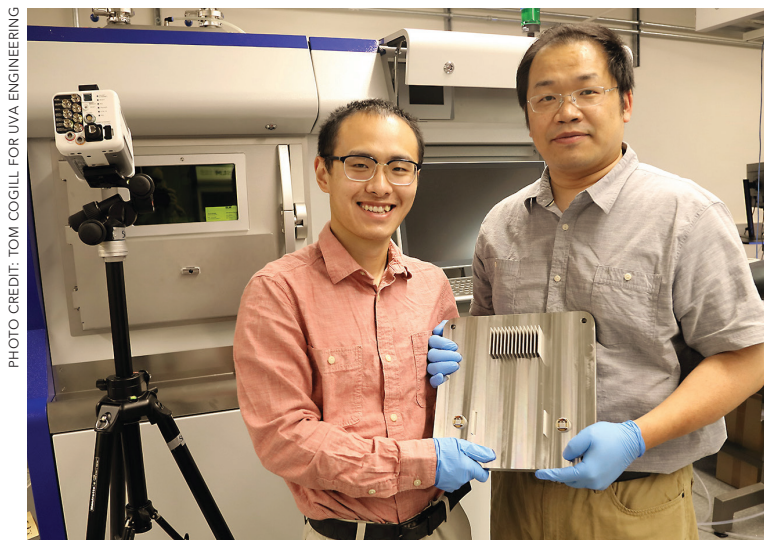


PHOTO CREDIT: TOM COGILL FOR UVA ENGINEERING

## NDT SOLUTIONS AND NDE LABS ANNOUNCE PARTNERSHIP

NDT Solutions (New Richmond, WI) and NDE Labs (Benbrook, TX) have announced a strategic partnership to deliver a single point of contact for all nondestructive engineering and testing services. With over 50 years of combined experience in nondestructive inspection, this alliance positions the two companies at the forefront of Industry 4.0.

Together, NDT Solutions and NDE Labs will provide a comprehensive range of nondestructive equipment, training, consulting, and testing services. Clients can now access solutions for their nondestructive inspection needs with just one phone call to either organization.

NDT Solutions is a provider of equipment and engineering services designed to meet exacting customer testing requirements for aerospace and defense applications. NDE Labs specializes in nondestructive product and materials testing services for diverse industries, ranging from deep-sea oil and gas exploration, aerospace, and space.

## TPI, WINDSTAR CREATE DIGITAL TWIN FOR WIND BLADE MANUFACTURING

TPI Composites Inc. (Scottsdale, AZ) collaborated with the Center for Wind Energy Science, Technology and Research (WindSTAR, Alexandria, VA), a National Science Foundation–funded Industry-University Cooperative Research Center (IUCRC), to design a composite manufacturing process based on a digital twin approach as released in the 2022 WindSTAR Annual Report. The project leveraged machine learning (ML), using big data to serve as the digital twin of the blade manufacturing process. This ML framework provides real-time feedback during fabrication, results in reduced defects, and enables more efficient production of wind blades versus the current high computational costs of the physics-based models.

Stephen Nolet, senior director of Innovation and Technology for TPI, worked alongside student researchers and faculty from the University of Texas at Dallas, as well as technical experts from Olin Epoxy (Midland, MI) and Westlake Epoxy (Stafford, TX), to develop a framework for the digital twin of the vacuum-assisted resin infusion molding process. By applying an ML approach,

the team achieved predictive accuracy of more than 95% with 100× faster computation than the physics-based simulations.

"The primary value of utilizing [an] ML framework is leveraging historical results and data to inform current manufacturing at a pace that significantly reduces defects from occurring in a real-time production environment," Nolet explains. "Additionally, this technology allows users to create alternative manufacturing scenarios to increase production velocity in manufacturing operations while simultaneously reducing infusion-related problems."

In the coming year, the WindSTAR research team plans to focus on scaling the technology to larger components



with greater manufacturing complexity. The work will apply tools taken from artificial intelligence to find patterns in historical data and predict outcomes on full-scale wind blade components including blade shells.

## DATA**FACTS**

### TRENDS IN MACHINE LEARNING FRAMEWORKS

At the heart of artificial intelligence/machine learning developments are machine learning frameworks, a platform that allows developers to build and deploy machine learning models. The most popular frameworks have been Tensorflow, PyTorch, and Keras, with PyTorch recently emerging as the most popular. One more recent development is Google JAX, which provides a more lightweight functional programming environment. All of these tools are freely available to use (companies make money by providing specialized cloud services and deep learning model training using these frameworks).
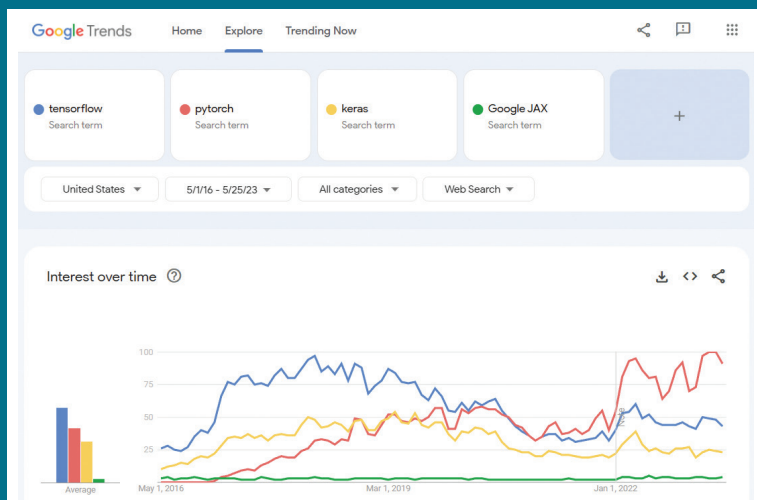


Source: Google Trends, 1 May 2016 to 25 May 2023.

TPI is an inaugural member of the WindSTAR IUCRC Industrial Advisory Board and is looking forward to contributing to more exciting projects as it enters its ninth year of partnership in 2023. The WindSTAR Center is operated jointly by the University of Massachusetts Lowell and the University of Texas Dallas and supported by 18 industry members, including TPI.

### NEW ASTM STANDARD PRACTICE FOR MATRIX ARRAY UT

In response to the growing demand for matrix array ultrasonic testing (MAUT) standards, ASTM International has recently published E3370-22: *Standard Practice for Matrix Array Ultrasonic Testing of Composites, Sandwich Core Constructions, and Metals used in Aerospace Applications*. The standard has its origins in ASTM E2580-17: *Standard Practice for Ultrasonic Testing of Flat Panel Composites and Sandwich Core Materials used in Aerospace Applications*, which is intended for use with single-element transducers. The new E3370-22 is designed specifically for use with non-phased, matrix array transducers. Such transducers operate with an isotropic matrix array of elements with a small pitch and high count (e.g., 128 × 128 elements at 0.25 mm pitch), operating in straight beam (i.e., 0°) mode. As such, they are unique in being capable of live C-scan generation.

As it sits between conventional straight beam ultrasonic testing and phased array, MAUT has previously been underrepresented by international standards. Dolphitech Defense CEO Jason Smith commented, "We are delighted by the publication of this standard by ASTM International. It provides our customers with a great starting point for building their own inspection procedures, through detailing all aspects that need to be considered. This document will also pave the way for further matrix array UT standards, with ASME and ISO standards already in the pipeline."

The standard itself covers two modes of operation, Test Procedure A: Pulse Echo, and Test Procedure B: Through Transmission. In addition, general considerations such as quality assurance provisions, test apparatus, physical reference standards, and reporting requirements are all discussed in detail. For more information, visit astm.org.

### AVONIX IMAGING EXPECTED TO BECOME SUBSIDIARY OF NIKON AMERICAS

Two companies in the industrial X-ray and computed tomography (CT) market have agreed to further their collaboration in providing innovative X-ray and CT systems and services.

Nikon Americas Inc. (NAI) (Melville, NY), a subsidiary of Nikon Corp., has executed an equity purchase agreement with Avonix Imaging LLC (Maple Grove, MN) that will make Avonix a subsidiary of NAI, subject to applicable regulatory clearances and other customary closing conditions.

The two organizations have worked together since 2015 to bring to market configurable X-ray and CT systems for companies needing nondestructive inspection of their products. The unique strengths of each company complement the other to deliver X-ray solutions tailored to customers' specific inspection needs.

"Nikon's proprietary rotating target X-ray sources and proven software combined with our expertise in the design of configurable systems, controls, and product handling create a customized experience for our clients, which can contribute to their efficiency and profitability," said Brian Ruether of Avonix.

Together, the companies will further advance the development of new products while enhancing their capabilities to support businesses in innovative industries, such as automotive, medical device, and aerospace.

### SIEMENS, DELOITTE DEMONSTRATE INDUSTRY 4.0 INNOVATION VIA SMART FACTORY

Siemens Digital Industries Software (Plano, TX) has announced the opening of eXplore Live at The Smart Factory @ Wichita, an experience center convened by Deloitte (New York, NY) that is said to marry an ecosystem of world-leading organizations with business strategy and cutting-edge technology to demonstrate Industry 4.0 innovation. Located on Wichita State University's Innovation Campus in Wichita, Kansas, The Smart Factory includes a fully operational production line and experiential labs for developing and exploring the innovative capabilities of smart manufacturing.

A founding member of The Smart Factory @ Wichita along with Deloitte and other ecosystem members, Siemens developed the eXplore Live space as a 3000 foot$^2$ area dedicated to hands-on learning opportunities for companies



**The Smart Factory @ Wichita, based at Wichita State University in Kansas.**

PHOTO CREDIT: SIEMENS DIGITAL INDUSTRIES SOFTWARE, DELOITTE

looking to modernize, reshore, localize, or regionalize operations in North America. The eXplore Live space will enable Siemens to expand customer engagements with a showcase focused on design and optimization using a closed-loop digital twin. It will also enable exploration of industry digital threads and provide space for innovation workshops and co-creation and help empower the next generation of engineers.

## WAYGATE TECHNOLOGIES AND PARTNERS AMONG WINNERS OF FARADAY BATTERY CHALLENGE

Waygate Technologies, a Baker Hughes business (Huerth, Germany), and its partners, the UK Battery Industrialisation Centre (UKBIC) and PXL-ICE, are among the winners of the most recent round of the Faraday Battery Challenge funding competition led by UK Research and Innovation (UKRI), a public body sponsored by the British Department for Business, Energy and Industrial Strategy.

The consortium funding is for a feasibility study to look at ways of potentially increasing the yield and productivity of UK gigafactories with data based on advanced industrial computed tomography systems. If successful, this could eventually lead to the development of a digital twin at UKBIC.

The Faraday Battery Challenge invests in research and facilities in the UK to drive the growth of a strong battery business in the UK. Established in 2017, the recently extended program aims to steer the development of battery technologies that are cost-effective, high performing, longer range, faster charging, long-lasting, safe, and sustainable. The total amount of this latest funding round is £27.6 million (US$34.7 million) allocated to 17 different projects.

One of the largest challenges for scaling up battery cell production is the pace to achieve high-quality battery cell throughput to meet the demand for electric vehicles, as well as other applications, such as marine, aerospace, off-highway vehicles, and static energy storage. The other is the ability to increase the yield while maintaining quality and limiting waste.

Last year, Waygate Technologies signed a Memorandum of Understanding with UKBIC, the national battery industrialization facility, to look at developing a solution that could significantly improve the yield and productivity of future battery gigafactories. Waygate Technologies and UKBIC have also partnered on the availability and use of an open access and industrial X-ray computed tomography digital solution, which should also contribute to significantly reducing battery waste in future battery gigafactories. According to UKRI, a 1% yield improvement in a 20 GWh battery gigafactory can save over £21 million (US$26 million) a year and reduce the waste of raw materials, including rare earth minerals.

The feasibility approach in the awarded project is intended to lead to the creation of a framework for a digital twin of UKBIC battery cell samples. It is also to explore and leverage the effectiveness of computed tomography scanning as an advanced analytical tool. Quality defects could—should the project get the go-ahead—be identified, analyzed, and resolved much faster and more accurately through digital twinning. This approach will enable a faster process development in the factory and ensure greater quality. Waygate Technologies' ambition is to leverage the data from the inspection processes across the life cycle of batteries, reduce waste, and ensure greater safety.

## NIST RISK MANAGEMENT FRAMEWORK AIMS TO IMPROVE TRUSTWORTHINESS OF AI

The US Department of Commerce's National Institute of Standards and Technology (NIST) has released its *Artificial Intelligence Risk Management Framework (AI RMF 1.0)*, a guidance document for voluntary use by organizations designing, developing, deploying, or using AI systems to help manage the many risks of AI technologies.

The AI RMF follows a direction from Congress for NIST to develop the framework and was produced in close collaboration with the private and public sectors. It is intended to adapt to the AI landscape as technologies continue to develop, and to be used by organizations in varying degrees and capacities so that society can benefit from AI technologies while also being protected from its potential harms.

"This voluntary framework will help develop and deploy AI technologies in ways that enable the United States and other nations and organizations to enhance AI trustworthiness while managing risks based on our democratic values," said Deputy Commerce Secretary Don Graves. "It should accelerate AI innovation and growth while advancing—rather than restricting or damaging—civil rights, civil liberties, and equity for all."



CREDIT: WAYGATE TECHNOLOGIES
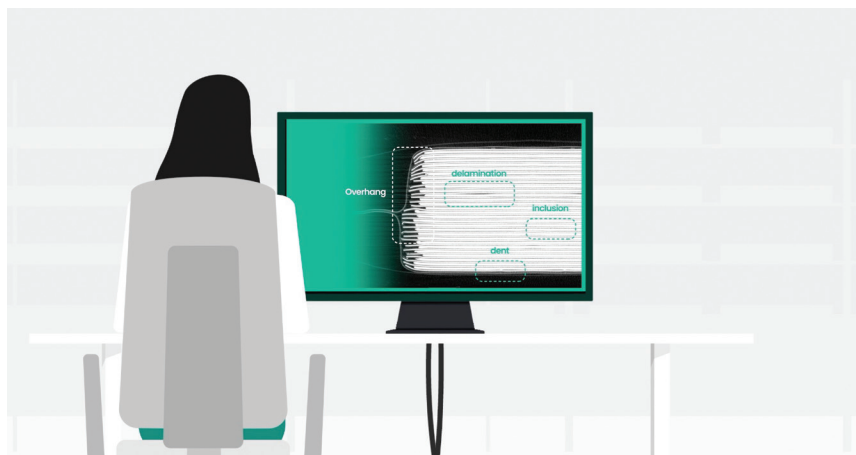
**By creating a framework for a digital twin, quality defects can be identified, analyzed, and resolved much faster and more accurately than with any traditional inspection method.**

Compared with traditional software, AI poses a number of different risks. AI systems are trained on data that can change over time, sometimes significantly and unexpectedly, affecting the systems in ways that can be difficult to understand. These systems are also "socio-technical" in nature, meaning they are influenced by societal dynamics and human behavior. AI risks can emerge from the complex interplay of these technical and societal factors, affecting people's lives in situations ranging from their experiences with online chatbots to the results of job and loan applications.

The framework equips organizations to think about AI and risk differently. It promotes a change in institutional culture, encouraging organizations to approach AI with a new perspective—including how to think about, communicate, measure, and monitor AI risks and its potential positive and negative impacts.

The AI RMF provides a flexible, structured, and measurable process that will enable organizations to address AI risks. Following this process for managing AI

risks can maximize the benefits of AI technologies while reducing the likelihood of negative impacts to individuals, groups, communities, organizations, and society.

The framework is part of NIST's larger effort to cultivate trust in AI technologies—necessary if the technology is to be accepted widely by society, according to Under Secretary for Standards and Technology and NIST Director Laurie E. Locascio.

"The AI Risk Management Framework can help companies and other organizations in any sector and any size to jump-start or enhance their AI risk management approaches," Locascio said. "It offers a new way to integrate responsible practices and actionable guidance to operationalize trustworthy and responsible AI. We expect the AI RMF to help drive development of best practices and standards."

The AI RMF is divided into two parts. The first part discusses how organizations can frame the risks related to AI and outlines the characteristics of trustworthy AI systems. The second part, the core of the framework, describes four specific



AI Risk Management Framework
Map · Measure · Govern · Manage

functions—govern, map, measure, and manage—to help organizations address the risks of AI systems in practice. These functions can be applied in context-specific use cases and at any stages of the AI life cycle.

Working closely with the private and public sectors, NIST has been developing the AI RMF for 18 months. The document reflects about 400 sets of formal comments NIST received from more than 240 different organizations on draft versions of the framework. NIST released statements from some of the organizations that have already committed to use or promote the framework.

The agency also released a companion voluntary AI RMF Playbook, which suggests ways to navigate and use the framework. NIST plans to work with the AI community to update the framework periodically and welcomes suggestions for additions and improvements to the playbook at any time. An updated version of the playbook was released in spring 2023.

In addition, NIST plans to launch a Trustworthy and Responsible AI Resource Center to help organizations put the AI RMF 1.0 into practice. The agency encourages organizations to develop and share profiles of how they would put it to use in their specific contexts. Submissions may be sent to AIFramework@nist.gov.

NIST is committed to continuing its work with companies, civil society, government agencies, universities, and others to develop additional guidance. The agency issued a roadmap for that work.

The framework is part of NIST's broad and growing portfolio of AI-related work that includes fundamental and applied research along with a focus on measurement and evaluation, technical standards, and contributions to AI policy. **ME**
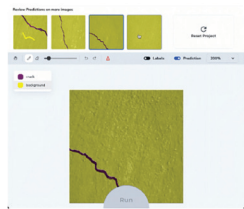
## AI DEPLOYMENT PLATFORM



Machine learning models can be a hassle to get into production. Trueflaw has developed the TrueflawBox edge computing platform to deploy its artificial intelligence (AI) models in a way that makes sense for nondestructive evaluation. The TrueflawBox is now open for everyone to deploy their own machine learning models.

This product is for those that have some in-house machine learning development for an NDE application or need a fast and secure way to run models in production, but don't want to start from scratch. The TrueflawBox includes powerful edge AI hardware fully configured to run your ML models and a tailored training workshop to get you started. Users can either write their own deployment code or let Trueflaw help.

**TRUEFLAW**
**TRUEFLAW.COM**

## DEEP LEARNING VISUAL INSPECTION



Landing AI announced the launch of LandingEdge, a new deployment application within the company's platform, LandingLens. With LandingEdge, manufacturers can more easily deploy deep learning visual inspection solutions to edge devices on the factory floor to better and more consistently detect product defects.

LandingEdge extends the capability of LandingLens into more manufacturing environments. LandingLens enables teams to build deep learning models. With the new edge capabilities, LandingLens customers will more easily integrate with factory infrastructure to communicate with cameras, apply models to images, and make predictions to inform real-time decision-making on the factory floor. If the factory is connected to the cloud, LandingEdge can update LandingLens with new data to continuously improve deep learning models.

LandingLens has also been enhanced to enable training a deep learning model up to 7× faster than before. By reducing the time it takes to train models, customers can achieve fast and iterative AI processes and optimize model accuracy.

**LANDING AI**
**LANDING.AI**

## HANDHELD ROTATING BOLT HOLE SCANNER



The new ECS-4 handheld rotating bolt hole scanner from UniWest is very lightweight (7 oz) and has an ergonomic form factor, with the probe exiting at a right angle from the scanner. In addition, the ECS-4 boasts variable speed (125–2250 RPM) and increased torque over UniWest's popular ECS-1 scanner. Three buttons are within easy reach of the user's thumb: null, erase, and on/off.

The ESC-4 scanner utilizes a rotary transformer to couple eddy current signals from the probe to the instrument. Compatible instruments include the UniWest EVi, EddyView® II, EddyView Pro, and EddyView Premium. In addition, the ECS-4 will operate on the NORTEC® 600 and NORTEC 2000. The ECS-4 probe connector is a 4-pin Fischer connector with O-rings. Compatible probes include the following UniWest probe styles: URB, URBA, US-5000, SSB probes; as well as some competitor's probes.

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## X-RAY LINE SCAN CAMERA



The X-ray line scan camera C14960-14C can take a high-sensitivity, high-resolution transparent X-ray image of an inspected object transported on a belt conveyor or similar apparatus. Since the content of an object, which is not visible with the naked eye, can be inspected without contact or destruction, this camera is suitable for broad interior X-ray observation, enabling the detection of a foreign body mixed in food, electronic components, and so forth. The C14960 series supports a wide usage, from thin to thick sample inspection.

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## WIRE ENCODER



The Phoenix ISL Wire Encoder is now available to order as a stand-alone product. The lightweight Wire Encoder is quick to set up and offers freehand scanning up to 3 m from a single position, without the constraints of a scanning frame. Available with magnetic, vacuum, or clamp mounts, the Wire Encoder is a versatile tool that can be mounted to any inspection surface and enables C-scan inspection in areas with limited access. The Wire Encoder is compatible with the Phoenix C-Clamp, which can hold any probe and wedge combination up to 55 mm wide.

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