

RESEARCHERS DEVELOP NEW METHOD TO AMPLIFY BIOELECTRONIC SENSING

In a breakthrough that could transform bioelectronic sensing, an interdisciplinary team of researchers at Rice University (Houston, TX) has developed a new method to dramatically enhance the sensitivity of enzymatic and microbial fuel cells using organic electrochemical transistors (OECTs). The research was recently published in the journal *Device*.

The innovative approach amplifies electrical signals by three orders of magnitude and improves signal-to-noise ratios, potentially enabling the next generation of highly sensitive, low-power biosensors for health and environmental monitoring.

"We have demonstrated a simple yet powerful technique to amplify weak bioelectronic signals using OECTs, overcoming previous challenges in integrating fuel cells with electrochemical sensors," said corresponding author Rafael Verduzco, professor of chemical and biomolecular engineering and materials science and nanoengineering. "This method opens the door to more versatile and efficient biosensors that could be applied in medicine, environmental monitoring, and even wearable technology."

A lithographically patterned organic electrochemical transistor (OECT) device, used for measurement with enzymatic and microbial fuel cells. Researchers at Rice University are using OECTs to amplify weak bioelectronic signals.

Traditional biosensors rely on direct interactions between target biomolecules and the sensor device, which can pose limitations when the electrolyte environment is incompatible. This research circumvents that challenge by electronically coupling fuel cells with OECTs instead of introducing biomolecules directly into the sensor.

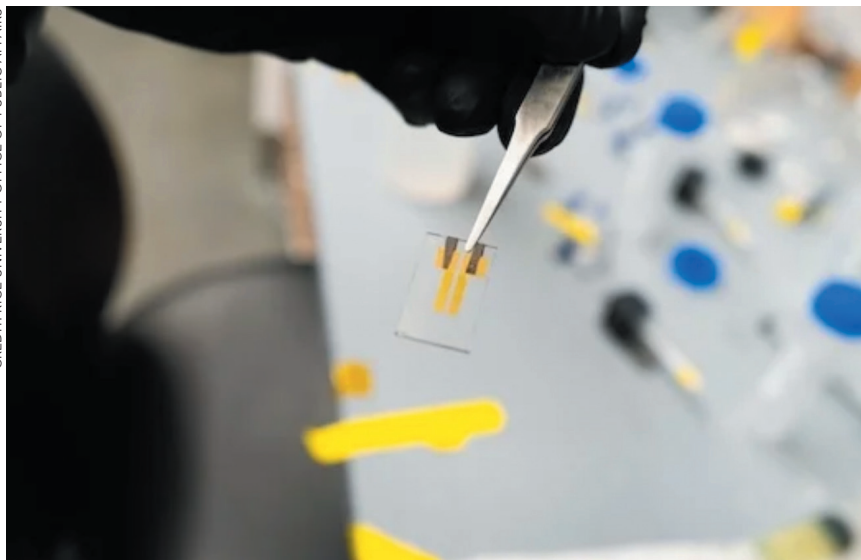
"One of the biggest hurdles in bioelectronic sensing has been designing systems that work in different chemical environments without compromising performance," said corresponding author Caroline Ajo-Franklin, professor of biosciences, director of the Rice Synthetic Biology Institute, and Cancer Prevention and Research Institute of Texas (CPRIT) Scholar. "By keeping the OECT and fuel cell separate, we ensured optimal conditions for both components while still achieving powerful signal amplification."

OECTs are thin-film transistors that operate in aqueous environments and have gained attention for their high sensitivity and low-voltage operation. For the study, the team integrated OECTs with two types of biofuel cells to enhance their performance. The first type, enzymatic fuel cells, utilize glucose dehydrogenase to catalyze glucose oxidation, generating electricity in the process. The second type, microbial fuel cells, rely on electroactive bacteria to metabolize organic substrates and produce current. The OECTs were coupled with the fuel cells in two different configurations: a cathode-gate configuration and an anode-gate configuration.

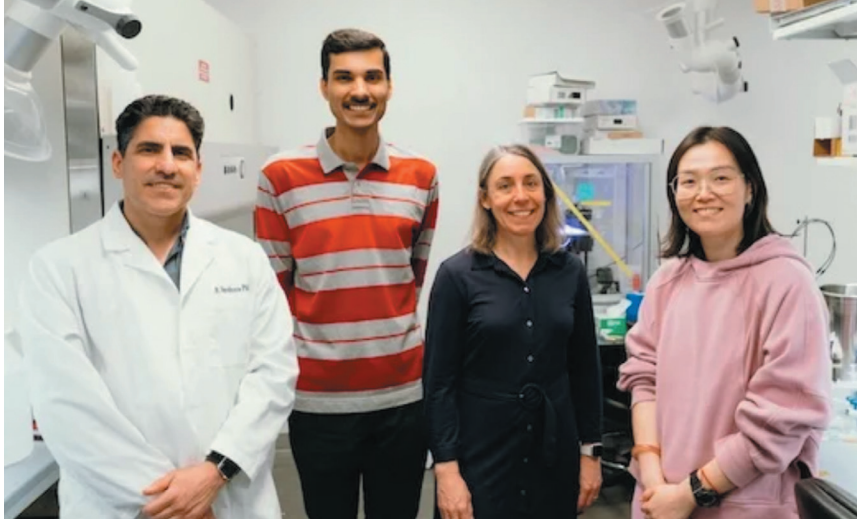
The researchers found that OECTs can amplify signals from enzymatic and microbial fuel cells by factors ranging from 1000 to 7000, depending on the configuration and fuel cell type. This amplification is significantly higher than traditional electrochemical amplification techniques, which typically achieve signal enhancements in the range of 10 to 100 stronger.

The team discovered that the cathode-gate configuration provided the best amplification, especially when using a specific polymer as the channel material. The anode-gate configuration also showed strong amplification but posed potential challenges at higher fuel cell currents, leading to irreversible degradation in some cases.

Along with boosting signal strength, the researchers found that OECTs reduced background noise, making measurements more precise. Traditional sensors can struggle with interference and weak signals, but the OECTs produced clearer, more reliable data.



CREDIT: RICE UNIVERSITY OFFICE OF PUBLIC AFFAIRS



The Rice University research team that developed a new method to dramatically enhance the sensitivity of enzymatic and microbial fuel cells using OECTs (from left to right): Rafael Verduzco, Ravindra Saxena, Caroline Ajo-Franklin, and Xu Zhang.

"We observed that even tiny electrochemical changes in the fuel cell were translated into large, easily detectable electrical signals through the OECT," said Ravindra Saxena, co-first author of the study and graduate student in the applied physics program at Rice's Smalley-Curl Institute. "This means that we can detect biomolecules and contaminants with much greater sensitivity than before."

The real-world applications for this technology are vast, and the research team successfully demonstrated a miniaturized version of the system on a single glass slide, proving that the technique is scalable and can be used in portable biosensors.

One of the most promising applications is arsenite detection—a critical need in water safety. The team engineered *E. coli* bacteria with an arsenite-responsive extracellular electron transfer pathway, enabling them to detect the presence of arsenite at concentrations as low as 0.1 micromoles per liter with a clear, measurable response from the OECT-amplified signal.

Beyond environmental applications, the system could revolutionize wearable health monitoring, where power-efficient

and highly sensitive biosensors are in high demand. For example, lactate sensing in sweat, which is an indicator of muscle fatigue, was successfully demonstrated using microbial fuel cells.

"Athletes, medical patients, and even soldiers could benefit from real-time metabolic monitoring without the need for complex, high-power electronics," said co-first author Xu Zhang, a post-doctoral fellow in the Department of Biosciences.

The researchers emphasized that understanding the power dynamics between OECTs and fuel cells is key to optimizing sensor performance, identifying two distinct operational modes. In the power-mismatched mode, the fuel cell generates less power than the OECT requires, leading to higher sensitivity but operating closer to short-circuit conditions. In contrast, the power-matched mode occurs when the fuel cell produces sufficient power to drive the OECT, resulting in more stable and accurate readings.

"By fine-tuning these interactions, we can design sensors tailored for different applications, from highly sensitive medical diagnostics to robust environmental monitors," Verduzco said. "We

SOCIETYNOTES

ASNT AND AWS FORMALIZE COLLABORATION TO EXPAND IN INDIA

In March, the American Society for Nondestructive Testing (ASNT) and the American Welding Society (AWS) announced the signing of a program agreement formalizing their collaboration to expand, develop, and implement training and certification activities for welding and nondestructive testing (NDT) professionals in India and the Middle East region. This agreement solidifies both organizations' commitment to address the growing demand for skilled professionals in these critical industries.

This partnership will leverage the strengths of both organizations to provide world-class training and certification opportunities. A key element of the agreement is reciprocal access to each other's authorized training and certification facilities. This will enable ASNT and AWS to conduct qualification and certification training and examination services at each other's approved locations, significantly increasing accessibility for professionals seeking to advance their careers.

ASNT, through its subsidiary ASNT India, operates a facility in Chennai, India, providing NDT education and certification. This existing presence, combined with AWS's expertise in welding education and certification, creates a powerful synergy for expanding, developing, and implementing a wide range of training and certification activities for welding and NDT professionals in India and the Middle East.

ASNT and AWS will also establish a new training and certification center in Gujarat, India. This strategically located facility will serve as a hub for program activities, providing state-of-the-art training and examination resources to individuals and organizations in the region.

believe this approach will change how we think about bioelectronic sensing. It's a simple, effective, and scalable solution."

This research was sponsored by the Army Research Office, CPRIT, and the National Science Foundation.

SQUID-INSPIRED FLEXIBLE SCREEN STORES AND DISPLAYS ENCRYPTED IMAGES WITHOUT ELECTRONICS

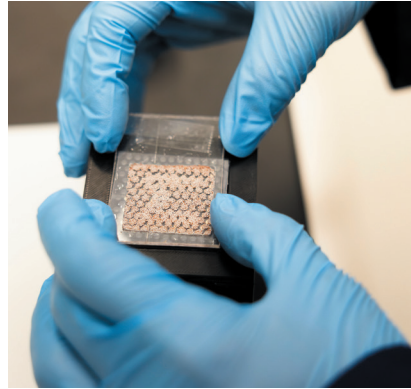
A flexible screen, inspired in part by squid, can store and display encrypted images like a computer—using magnetic fields instead of electronics. Researchers from the University of Michigan (UM) recently reported the innovation in *Advanced Materials*.

"It's one of the first times where mechanical materials use magnetic fields for system-level encryption, information processing, and computing. And unlike some earlier mechanical computers, this device can wrap around your wrist," said Joerg Lahann, the Wolfgang Pauli Collegiate Professor of Chemical Engineering and co-corresponding author of the study.

The innovative screen could be applied in scenarios where light or power sources are impractical, including with clothing, stickers, ID badges, barcodes, and ebook readers. It displays a public image when near a regular magnet and a private, encrypted one when placed over a complex array of magnets that functions as an encryption key.

"This device can be programmed to show specific information only when the right keys are provided. And there is no code or electronics to be hacked," said Abdon Pena-Francesch, UM assistant professor of materials science and engineering and co-corresponding author. "This could also be used for color-changing surfaces—for example, on camouflaged robots."

Shaking the screen erases its display, similar to an Etch-A-Sketch, but the image is encoded in the magnetic properties of beads inside the screen. It reappears when exposed to the magnetic field again.



The palm-sized, transparent square screen contains orange and white beads, roughly the size of sand grains, arranged in a smaller square inside. By holding the screen near magnets of varying strengths, the magnetic properties of specific pixels can be altered, allowing different magnet arrays to program different images. When held over a magnet, the magnetic pixels in the screen flip to display the University of Michigan block M.

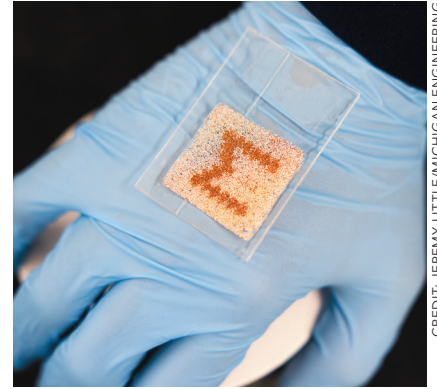
The beads function like pixels, switching between orange and white hemispheres. Magnetic particles within the beads enable them to rotate, providing color contrast. A weak magnetic field can reprogram pixels made with iron oxide particles, while those with neodymium require a stronger magnetic pulse.

By holding the screen over a grid of magnets with varying strengths and orientations, the pixels' polarization can be selectively changed, encoding an image. Private images can be displayed by using a second magnetic grid that reprograms certain pixels, while the public image remains accessible under a standard magnet.

Multiple private images can be generated from a single public image, each requiring a unique key. The decoding keys can also be programmed to only work with specific encoding keys, for extra security.

The researchers designed the screen's resolution by studying squids and octopuses, which change color by expanding and contracting pigment sacs in their skin.

"If you make the beads too small, the changes in color become too small to see," said Zane Zhang, a UM doctoral student and the study's first author. "The squid's pigment sacs have optimized size and distribution to give high contrast, so we adapted our device's pixels to match their size."



CREDIT: JEREMY LITTLE/MICHIGAN ENGINEERING

The research was funded by the American Chemical Society Petroleum Research Fund and the National Science Foundation. An invention disclosure has been filed with the assistance of UM Innovation Partnerships. Jeffery Raymond is a co-author of the study, along with Zhang, Lahann, and Pena-Francesch. The paper can be accessed at <https://doi.org/10.1002/adma.202406149>.

TRIGO ACQUIRES CONTROREUPE TO BOLSTER AEROSPACE AND DEFENSE QUALITY CONTROL CAPABILITIES

TRIGO announced the acquisition of Controreupe, a specialized nondestructive testing (NDT) company based in Saint-Geneviève-des-Bois, France, on 16 January 2025. This acquisition strengthens TRIGO's position in the industrial quality control market and expands its service portfolio in the aerospace and defense sectors. Controreupe specializes in penetrant testing and 3D measurement of complex parts.

With 30 years of expertise, Controreupe generates annual revenues of €3 million (US\$3.12 million) from NDT. The acquisition is a key step in TRIGO's strategic plan to expand its component inspection, control, and testing solutions. This initiative follows the recent achievement of TRIGO's Aerospace, Defense,

and Rail (ADR) division surpassing €100 million (US\$104 million) in annual revenue, with growth exceeding 20%.

"By integrating Controreupe into TRIGO's global network, we are transforming how specialized control services are delivered in the aerospace and defense sectors," said Emmanuel Marquis, Managing Director of TRIGO's ADR division. "This acquisition perfectly aligns with our mission to provide comprehensive quality solutions to our international clients."

TRIGO aims to triple Controreupe's revenue by 2030. The company plans to create over 30 new positions, primarily for metrologists and NDT technicians. This acquisition is part of TRIGO's strategy to grow its 3D testing and measurement services business, with a goal of reaching €100 million (US\$1.04 million) in revenue by 2030 through a combination of organic growth and acquisitions of specialized players.

Lucile Crayssac, who joined TRIGO in 2015, has been appointed Managing Director of Controreupe. Crayssac previously served as International Business Manager in TRIGO's Aerospace and Defense division and has over 20 years of experience in the aerospace industry.

TRIGO is a global leader in quality management services for the automotive, aerospace, rail, and heavy transportation industries. With 10 000 employees in 28 countries, TRIGO provides a full range of services across the supply chain, including inspection, auditing, consulting, engineering, and training. The company also develops advanced technological solutions using AI, virtual reality, battery management, and data analysis.

PIPELOGIX PARTNERS WITH PIPEALD TO AUTOMATE SEWER DEFECT RECOGNITION AND CODING

PipeLogix, a leading developer of pipe-line inspection software, announced in December a strategic, long-term partnership with PipeAld, a provider of AI-powered solutions designed to automate and improve condition

assessments. This integration will allow users of PipeLogix Phoenix software to automate the recognition and coding of sewer and stormwater system defects and features within their existing workflow, resulting in greater data accuracy and operational efficiency.

"The quality and completeness of PipeAld's analysis and coding, and the

simple workflow we created through a seamless integration with our Phoenix software, will greatly enhance the value of customers' investment in PipeLogix," said Jeremy Wagner, CEO of PipeLogix.

PipeAld was developed by Burgess & Niple, an engineering firm with over a century of experience in infrastructure design and maintenance. With



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MT L I /II (SNT-TC) – April 7-9, May 5-7, June 9-11, July 7-9, Aug 4-6, Sept 8-10, Oct 13-15

PT L I/II (SNT-TC) - April 10-11, May 8-9, June 12-13, July 10-11, Aug 7-8, Sept 11-12, Oct 16-17

UT L I – April 11-15, May 12-16, June 16-20, July 14-18, Aug 11-15, Sept 15-19, Oct 20-24

UT L II – April 14-18, May 19-23, June 23-27, July 21-25, Aug 18-22, Sept 22-26, Oct 27-31

Radiation Safety (IRRSP Prep)– April 7-11, May 5-9, June 9-13, July 7-11, Aug 4-8

RT L I – April 11-15, May 12-16, June 16-20, July 14-18, Aug 11-15, Sept 15-19, Oct 20-24

RT L II – April 14-18, May 19-23, June 23-27, July 21-25, Aug 18-22, Sept 22-26, Oct 27-31

Film Interpretation – Jan 27-31, July 28-August 1

ET L I – August 25-29

ET L II – Sept 2-5

VT L II – May 27-29, Nov 24-26

NDT Level III Refresher Courses

Basic Level III – April 28-May 2, Oct 6-10

VT L III – Dec 22-23

UT L III – Sept 29-Oct 1

ET L III, MT L III, PT L III, RTL III – Please call for dates

NDT Additional Training Courses

NAS410 MT/PT- Call for Dates

UT Thickness – June 30-July 2

Computed Radiography – TBA

Digital RT- TBA

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over 20 years and thousands of miles of sewer inspection video data, PipeAld has built and trained advanced computer vision algorithms to identify and code sewer defects and features according to NASSCO standards. Every defect is geospatially mapped through a digital twin of the collection system, providing a highly accurate, consistent, and detailed representation of system conditions. This empowers utilities to make data-driven decisions, effectively manage assets, and optimize maintenance and repair budgets.

"This partnership is a testament to our focus on data quality and commitment to unlocking the power of data through an integration-first approach," said Andrew Stauffer, CEO at PipeAld.

PipeAld's AI-powered capabilities are now available to over 500 municipalities, utilities, and inspection contractors using PipeLogix. Once customers purchase the PipeAld integration, it is activated without the need for new software training. PipeAld pricing follows a pay-as-you-go model based on linear feet and includes comprehensive quality assurance.

EXTENDE RENEWS QUALIOPi CERTIFICATION

EXTENDE has successfully renewed its Qualiopi certification, which is now valid until November 2027.

Qualiopi is a French quality standard for training centers. In addition to the company's ISO 9001 certification, the Qualiopi certification underscores the high level of EXTENDE's "CIVA" and "Reliability in NDE" training programs.

For EXTENDE's French customers, this certification means that the company's training programs can now be included in any OPCO's reference catalog, potentially enabling funding support for course registration.

ADVANCED LEGGED ROBOT CREATED FOR SAFER, FASTER PIPELINE INSPECTION AND REPAIR

Tmsuk Corporation (Kyoto, Japan) unveiled the SPD-X, a legged robot

designed for pipeline inspection, in January. Capable of fitting through pipes with diameters larger than 7.87 in. (20 cm), the SPD-X can travel at speeds of up to 0.19 mph (0.3 kph) using its 16 legs.

Developed specifically for pipeline inspection and repair, the SPD-X is a significant upgrade from Tmsuk's earlier SPD1 model, offering improved stability and functionality. Compared to the SPD1, the SPD-X is smaller, longer, and roughly 3x heavier. Despite its increased weight, it maintains the same top speed and is now fully waterproof. The SPD-X also features an enhanced camera, offering 360° vision at 12.3 degrees, a significant improvement over the SPD1's 62.2 degrees. This advanced camera allows the robot to navigate more challenging conditions, such as pipe joint misalignment or sediment buildup.

Like its predecessor, the SPD-X is controlled remotely via a gaming pad-inspired controller. However, its additional advanced legs allow it to tackle obstacles more efficiently. The robot is also designed to access narrow spaces that are otherwise hazardous or impossible for humans to enter.

The SPD-X is part of a growing global network of "pipebots"—robots designed to maintain pipeline integrity. In the US alone, a water main ruptures approximately every two minutes, resulting in a daily loss of six billion gallons of treated

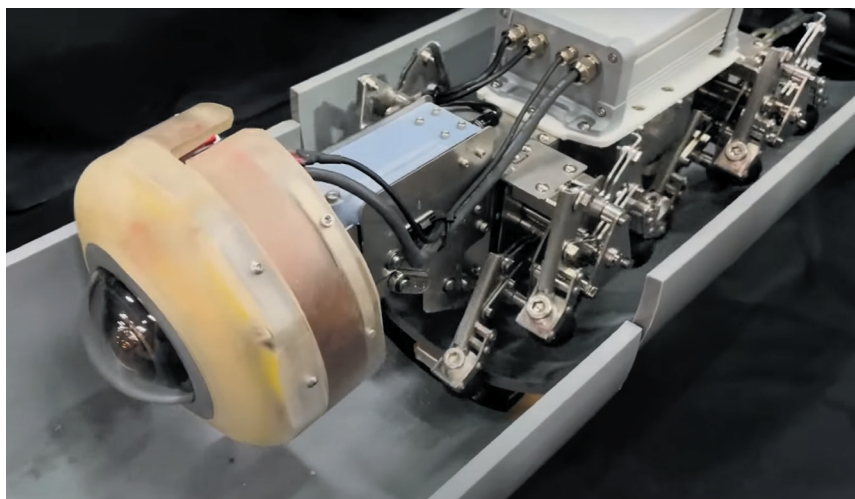
water. Traditional inspection and repair methods are time-consuming and labor-intensive, but robots like the SPD-X could significantly reduce both the time and cost of such operations.

Tmsuk's development of the SPD-X included extensive 3D simulations to predict its performance in various environments, including its ability to handle sediment buildup in pipes. Real-world testing followed, with improvements based on feedback from SPD1 users in 2022. These updates addressed challenges like accommodating both larger and smaller pipe diameters, handling pipe blockages, and improving water flow.

Tmsuk plans to continue developing robots that can operate in areas humans cannot reach, perform dangerous tasks, and function in environments where traditional machinery would struggle. The company is also focused on refining the SPD-X to perform more advanced tasks, helping to address labor shortages and improve safety in hazardous work conditions.

NEW BIOMIMETIC PANORAMIC CAMERA MIMICS INSECT EYES FOR REAL-TIME IMAGING AND MOTION DETECTION

Natural compound eyes (NCEs) were first studied by Robert Hooke in 1664 after

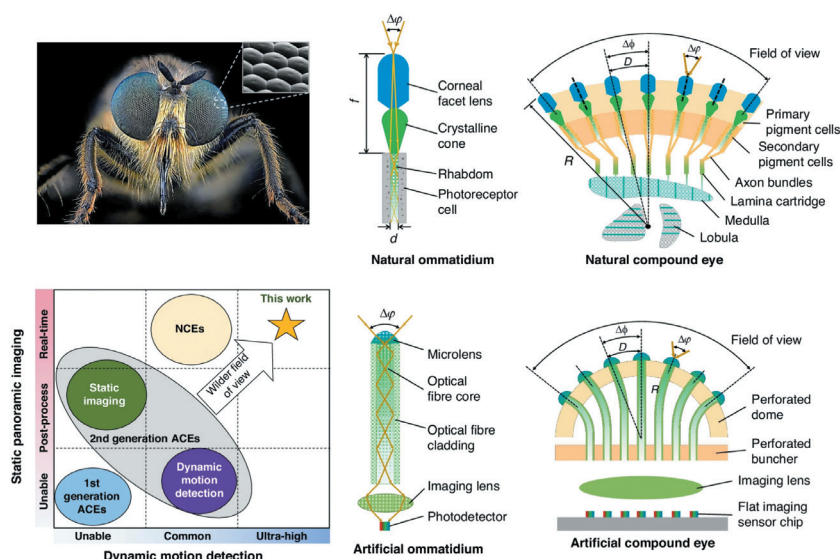


Tmsuk's SPD-X pipebot, an upgrade from its predecessor SPD1 model, has an enhanced camera and additional legs that allow it to maneuver better through challenging areas.

CREDIT: TMSUK CORPORATION

he observed orderly arranged pearls in the cornea of a grey drone fly. These NCEs inspired the development of artificial compound eyes (ACEs) based on planar microlens arrays, curved microlens arrays, and metasurfaces. However, none of these ACEs could match the NCEs in achieving both real-time panoramic direct imaging and dynamic motion detection simultaneously. The main challenge with curved microlens array-based ACEs is how to transmit light rays collected by many microlenses on a curved surface to a flat imaging sensor (e.g., a CMOS chip) while preserving their spatial relationships.

In a paper recently published in *Light: Science & Applications*, a team of scientists led by Professor Xuming Zhang from the Department of Applied Physics at the Photonics Research Institute (PRI), and the Research Institute for Advanced Manufacturing (RIAM), both at The Hong Kong Polytechnic University in China, have developed a biomimetic ACE as a panoramic camera, called ACEcam. This ACEcam offers a 180° field of view (FOV), compared to the 150° – 180° FOV typical of most arthropods, making it particularly well-suited for applications in surveillance. Its real-time, distortion-free panoramic imaging eliminates the need for redundant post-processing, making ACEcam suitable for imaging and distance measurement among moving objects in real-world scenarios. The nearly infinite depth of field enhances realism in augmented reality experiences. Additionally, its translational and rotational motion perception, coupled with ultrafast angular motion detection (up to 5.6×10^6 degrees per second), positions ACEcam for use in kinestate tracking and motion control for machines ranging from cars to high-speed airplanes and even spacecraft. The combination of these features also positions ACEcam for niche applications, such as the integration into obstacle avoidance systems for high-speed unmanned aerial vehicles. This reduces the need for multiple lenses, eliminating excess weight and size, and the compact design makes ACEcam suitable for endoscopy.



Concept and principle of the artificial compound eye for a panoramic camera (ACEcam) that uses conical-microlens optical fibers to mimic natural ommatidia.

In the proposed ACEcam, lensed plastic optical fibers serve as artificial ommatidia. By adding a conical microlens to the distal end of the fiber, the optical fiber mimics an ommatidium, collecting and transmitting light to the sensing unit. A bundle of lensed plastic optical fibers evenly distributed on a hemispherical surface replicates NCEs, and the ACEcam demonstrates exceptional static imaging and dynamic motion detection capabilities.

The team designed a conical microlens onto the distal end of the plastic optical fiber to reduce the light acceptance and increase the angular resolution. Their simulations showed that a half-apex angle of 35° is optimal, reducing the fiber's acceptance angle from 60° to 45° . The rounded tip of the conical microlens ensures light information in the central angular range isn't lost.

The conical-microlens optical fibers were fabricated in batches through 3D printing, electroplating, and molding. Each batch produced approximately 200 optical fibers, each with a smooth surface and rounded tip.

Then the team arranged 271 lensed optical fibers on a 3D-printed perforated dome, with the bare ends placed into a perforated planar buncher. Light from the bare ends was projected onto a flat imaging sensor via an imaging lens. The dome, buncher, imaging lens, and

flat imaging sensor chip were housed in a hollow tube, with the dome's black color absorbing stray light, much like the pigment cells in NCEs to prevent crosstalk. The fiber bundle ensures that light is confined, preventing ghost images. This setup transmits light from the curved surface to a flat image sensor, replicating the ommatidia in an NCE. The final images are processed digitally after projection onto the sensor.

"ACEcam holds the promise of becoming the cornerstone for future ACEs, owing to its synergy with diverse disciplines," the scientists concluded. "For instance, the imaging optical fiber bundles can emulate natural ommatidia to replicate optical and neural superposition observed in NCEs, potentially enhancing ACEcam's imaging resolution and dynamic perception speed." They suggested that the integration of optofluidic lenses with ACEcam presents an opportunity to harness the advantages of both arthropods' compound eyes and vertebrate monocular eyes.

The paper was coauthored by Heng Jiang, Chi Chung Tsoi, Weixing Yu, Mengchao Ma, Mingjie Li, and Zuankai Wang along with Zhang, and can be accessed at <https://doi.org/10.1038/s41377-024-01580-5>. **ME**

EDGE COMPUTING MAKES NDE SMARTER

Traditional nondestructive evaluation (NDE) has no use for edge computing, but that is about to change.

The use of artificial intelligence (AI) and machine learning (ML) requires significant computational power. As AI/ML adoption grows, the computational demands on inspection equipment increase rapidly. This is especially true for ultrasonics, but the same trend is seen in other NDE methods as well.

While cloud computing offers power, it's cumbersome for handling large, sensitive datasets. Standard laptops and off-the-shelf NDE equipment lack the necessary computational resources. The emerging solution is to add a separate computing unit to the system: an edge computer. This has surprising implications.

Background

Traditional inspections are done by keying in the settings on the screen of the NDT machine. The equipment may employ sophisticated electronics (like field-programmable gated arrays, FPGAs), but they must remain versatile—configurable and adjustable for any potential task the inspectors might face. As inspections grow more complex, it's becoming increasingly problematic to configure or program these machines. This leads to overly complex procedures,

where human inspectors need to manage the minute details of the inspection settings and oversee the process.

Then there are highly automated inspection cells, which complete predefined inspection routines with the help of complicated mechanics or robotics, acquiring data in a fully automated way. However, even in these cases, the underlying NDE electronics are often built on a general-purpose NDE device, with the smart features focused more on the mechanics than the NDE itself.

Inspections are getting more complex, with more channels, more elements, and more data. While more data improves inspections, it also places a significant burden on the evaluation process. Increasingly, advanced signal processing techniques like total focusing method (TFM) beamforming are used, further raising computational requirements.

All of this leads to overcomplicated inspection software and procedures for inspectors. The complexity then translates to reduced focus on inspection targets and increased risk of human error.

Progress Up Until Now

The way to deploy AI locally and easily on top of existing inspections turns out to be edge computing. These small

boxes contain impressive computational power and can be connected to the inspector's PC or local network, processing the huge data files produced by modern techniques in seconds. Additionally, software installations, updates, and version control can be handled directly on the box, avoiding the typical hassle of installing additional software on corporate computers. (This was the immediate issue that brought edge computers to the industry.) But there's more.

As soon as the computational power is available, it can also be used to improve signal processing. This enables the use of many techniques that have been known for a long time but were too complex to be used in practice, such as the synthetic aperture focusing technique (SAFT) in ultrasonic testing. Sophisticated signal processing can be provided in software tailored to the needs of the procedure.

Edge computers can also be directly connected to traditional NDE equipment, such as ultrasonic or eddy current machines, or cameras for visual inspection. This allows the edge computer to take over tasks traditionally assigned to the machine's electronics, enabling the freedom to use even the most sophisticated signal processing, filtering, and reconstruction algorithms.

Taken together, this enables us to build systems that process and automatically evaluate data as it's acquired and generate reports on findings as soon as the acquisition is complete. It allows us to upgrade traditional rule-based automated inspection systems used in manufacturing to more robust smart systems that reduce false calls, improve sensitivity, and, most importantly, enable better discrimination between benign indications and unacceptable defects.



CREDIT: TRUEFLAW LTD.

Edge computing devices are commonly used to implement local AI/ML evaluation on top of existing inspections.