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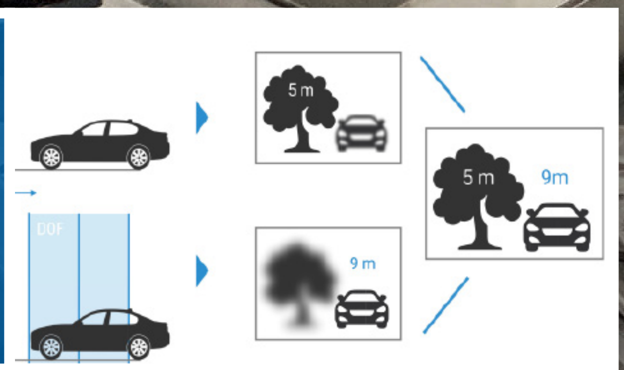
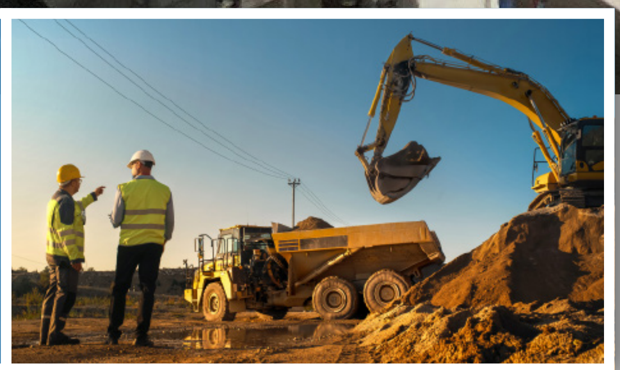
Bin Picking: Deep Learning enables Robust Detection Rates even with 2D Images

Vision Systems at Automate 2025: Trends, Products, and Market Insights

Expert Knowledge: Focus-Variation and its Advanced Extensions



AI-Driven 2D/3D Collision Warning System for Mobile Machinery



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Automate 2025: a Review

What a show that was! Three and a half days packed with conversations with exhibitors and gathering information about new products and applications. With over 900 exhibitors, it was a mammoth task. I didn't even count the steps I took. But much more important than anything else for me was making new contacts and strengthening existing ones. In other words, meeting the people behind the brands and products. And in that respect, this year's Automate in Detroit was a complete success.

When asked – and as a journalist, you get asked this regularly – what I liked best at the trade fair, i.e., which product was the most exciting, I have to pass. There was simply too much. And whatever I mention, in the end I won't have brought up most of the things that are worth bringing up. But so that these lines don't come across as an excuse, here are a few examples – and apologies to everyone I don't highlight: I thought the demo by Excelitas was great, where they use a lens and beam splitter to extract color images from a monochrome camera. Theia presented an exciting improvement: its motorized lenses are now available in 4K resolution and multispectral. There was also a lot to see in the field of robot vision and 3D vision, whether at Universal Robots, Epson, Cambrian Robotics, Cognex (3D smart camera), or Wenglor (ToF camera).

All in all, it was a thoroughly successful trade fair, which was also reflected in the mood among the exhibitors. I am already looking forward to Automate 2026, which will be held in Chicago again.

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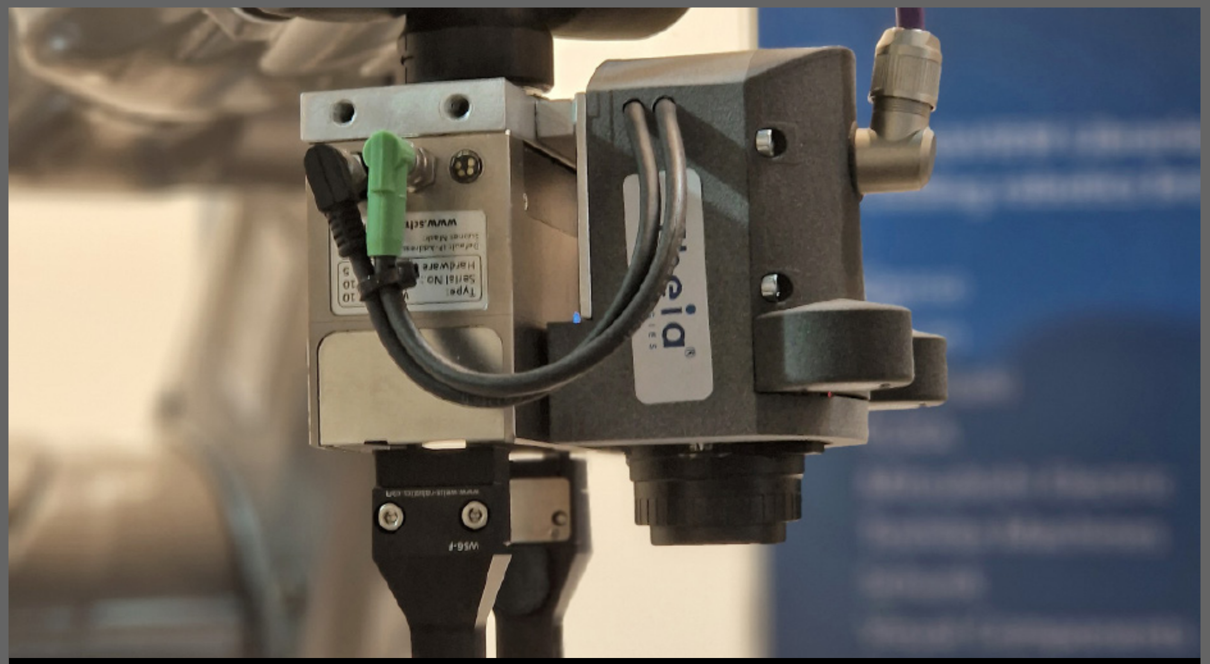


NEWS

Hexagon acquires software solution

Hexagon acquires the rights to Conet Communications' UCRS software to enhance its offerings for law enforcement agencies. UCRS combines various communication methods such as digital, analog, and mobile communications with emergency call systems and video surveillance. This technology will be integrated into Hexagon's existing platform to provide authorities with a comprehensive solution for emergencies. Norbert Hanke from Hexagon explains that the acquisition will improve communication in emergencies and promote future innovation.

The acquisition includes UCRS's software rights and customer base, as well as approximately 50 employees. UCRS will become part of Hexagon's Safety division. The expected revenue for 2025 is approximately EUR 10 million. The acquisition is expected to be completed in the second quarter of 2025, after all approvals have been obtained.

3D hand modeling wins award

(From left to right): EMVA Board Member Petra Thanner; EMVA Young Professional Award 2025 winner Dr. Rolandos Alexandros Potamias; EMVA President Dr. Chris Yates.

Dr. Rolandos Alexandros Potamias received the EMVA Young Professional Award 2025 for his work on high-precision 3D hand modeling, recognition, and reconstruction in world coordinates.

Potamias, a postdoctoral researcher at Imperial College London, focuses his research on human perception and modeling. His award-winning research addresses the challenges of hand modeling, which is crucial for human interaction and behavior, especially for the deaf and hard-of-hearing community.

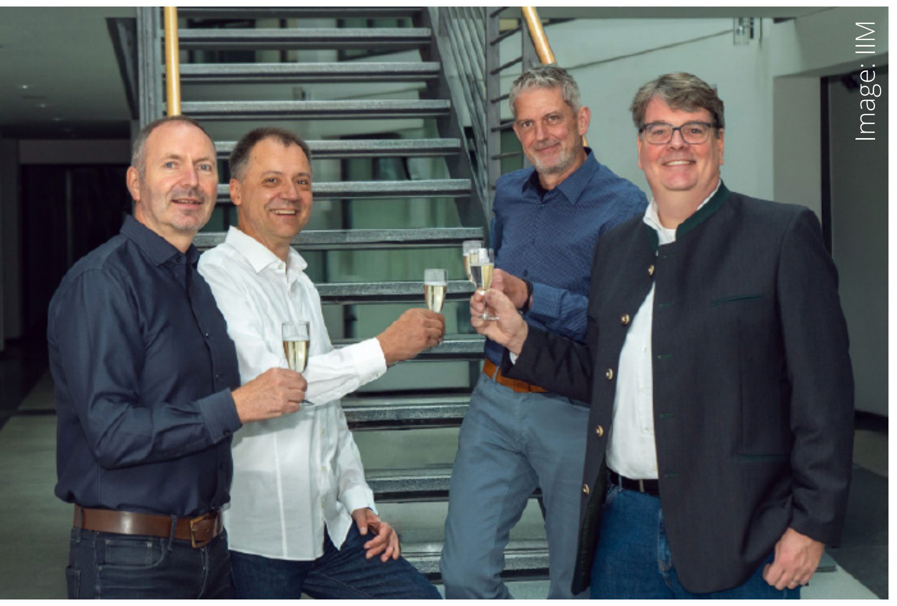
He developed the "Handy" model with over 1,200 participants, which captures both the shape and appearance of hands. He also introduced WiLoR, a pipeline for real-time recognition and reconstruction of multiple hands, and HaWoR, a model for hand motion reconstruction in world coordinates. These technologies could drive industrial applications in AR/VR, virtual fitting, and embodied AI.

MVTec and Siemens intensify their cooperation

The focus is particularly on Siemens industrial PCs, which support demanding image processing applications with MVTec Halcon. Roman Moie from MVTec and Peter Berger from Siemens emphasize the importance of the partnership for the expanded product portfolio.

Industrial PCs are essential for complex machine vision applications. With the Simatic IPC BX-35A and BX-39A, Siemens offers powerful devices for tasks such as anomaly detection, shape-based matching, object recognition, quality control, and optical character recognition (OCR). A highlight is the Nvidia Jetson Orin NX module in the Simatic IPC BX-35A, which serves as an AI accelerator and significantly speeds up deep learning inferences. MVTec Halcon offers a wide range of deep learning methods that can now be used more easily and with fewer resources. This enables the automation of demanding and new machine vision applications that were previously not feasible.

Reorganization of the management team



From left to right: Heiko Freund, Peter Anacker, Axel Müller und Thomas Buschmann

Due to the integration of IIM into Exaktera, the company is adjusting its strategy and restructuring its management. Axel Müller is stepping down from the management board to focus on customer support for the Lumimax brand as Key Account Relationship Manager. Peter Anacker is also leaving his management position to focus on software development for Visio Cable Pro.

Heiko Freund will remain in a leading position as site manager and managing director and will be responsible for site strategy. Thomas Buschmann has been appointed as the new managing director and will support IIM in addition to his existing responsibilities at Z-Laser and Exaktera. This restructuring strengthens the strategic and operational alignment of IIM within the Exaktera Group and promotes technological development and closer customer relationships.

Vision Systems at Automate 2025: Trends, Products, and Market Insights

Review of the Automation Trade Fair in Detroit

The Automate Show 2025 in Detroit confirmed its status as North America's leading trade fair for robotics and automation. With over 900 exhibitors and more than 45,000 registered attendees, the event highlighted the growing importance of machine vision technologies across industries. A wide range of 2D, 3D, and embedded vision systems were presented, reflecting the sector's technological diversity and application breadth.

all images: David Löh/Wiley

With over 900 exhibitors and more than 45,000 registered attendees, Automate Show highlighted the growing importance of machine vision technologies across industries.

Teledyne Dalsa showcased its Genie Nano-10GigE camera series, designed for high-speed data transfer in demanding inspection environments. Vision Components introduced the VC Stereo Cam, a compact embedded stereo vision system for real-time 3D applications. Basler presented its boost series with CoaXPress 2.0 interface, targeting high-resolution, high-speed inspection tasks. IDS highlighted the Ueye XCP camera family, offering compact housing and USB3 connectivity for space-constrained installations. Allied Vision demonstrated the Alvium 1800 U-501c, a USB3 camera optimized for embedded vision platforms.

Lenses, Software, Metrology

Opto Engineering focused on telecentric lenses, essential for precise dimensional measurements in quality control. Zebra Technologies introduced the Aurora Design Assistant, a graphical development environment for vision applications. Cognex presented the In-Sight 3800 vision system, combining fast image acquisition with integrated processing for inline inspection. Creaform exhibited the Metrascan Black Elite 3D scanner, designed for high-precision metrology in manufacturing environments.

A wide range of 2D, 3D, and embedded vision systems were presented, reflecting the sector's technological diversity and application breadth.

Successful Conference

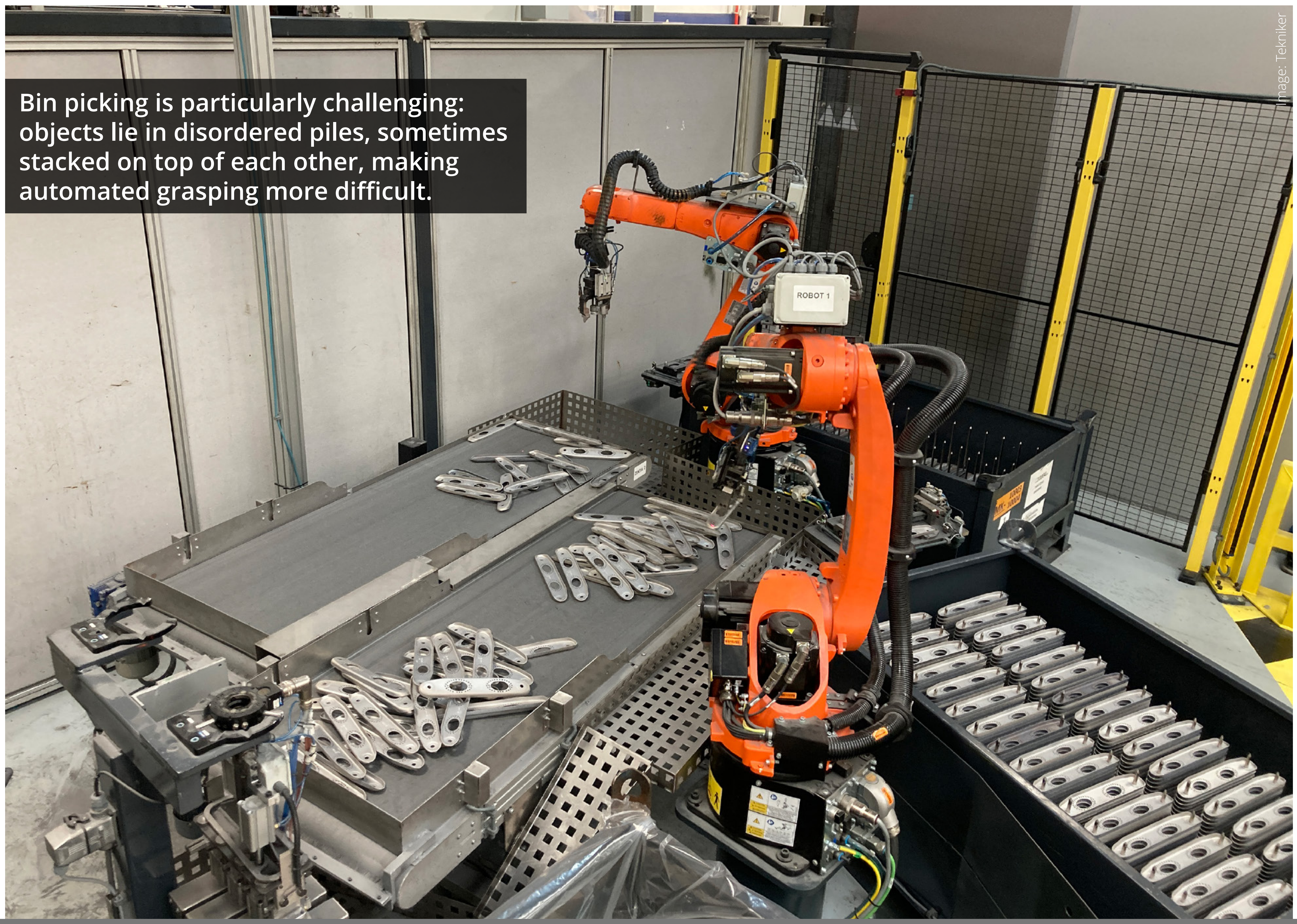
The accompanying conference program addressed topics such as Edge AI, secure vision systems, and automated quality assurance. Start-ups and established companies used the Innovation Stage to present new developments, including modular vision systems and AI-based inspection tools.

Overall, Automate 2025 demonstrated that machine vision is not only a key enabler for industrial automation but also increasingly relevant in sectors such as logistics, medical technology, and agriculture. The diversity of solutions and the strong international presence underscore the strength and market potential of the vision industry in North America. ■

Targeted Grasping of the Right Object

2D Images Combined with Deep Learning Enable Robust Detection Rates

3D-based machine vision methods provide support in identifying and inspecting objects in three-dimensional space. A new bin picking software goes one step further by leveraging advanced deep learning algorithms. The result: exceptionally robust detection rates, easy training, and the ability for robots to reliably, quickly, and efficiently grasp various objects—even under challenging conditions.



Bin picking is particularly challenging: objects lie in disordered piles, sometimes stacked on top of each other, making automated grasping more difficult.

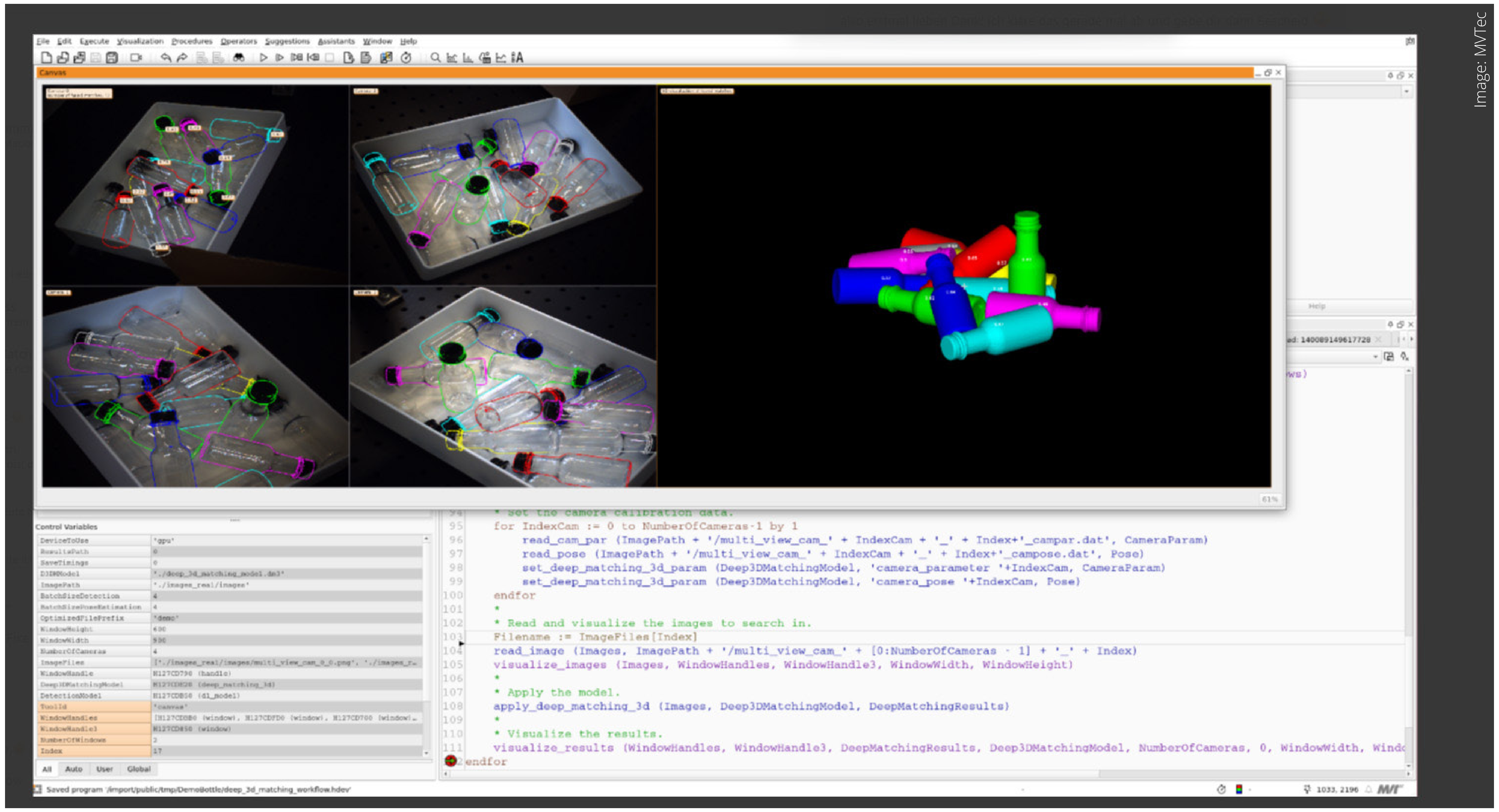
Image: Tekniker

3D vision technologies are used for machine vision to capture, evaluate, and process 3D data for controlling mechanical systems or processes. These capabilities enable applications that cannot be realized with 2D approaches at the same level of robustness. For instance, 3D vision can detect defects, dents, or deformations on surfaces with precision, perform high-accuracy measurements of components at the micrometer level, or reliably inspect weld seams.

MVTec's machine vision software products, Halcon and Merlic, offer a broad range of tools and operators to successfully implement 3D applications. These include 3D matching techniques and various methods for 3D object localization to determine precise positions. MVTec's products stand out due to several key advantages: in addition to advanced technologies, the software is hardware-independent, allowing integration with a wide variety of hardware components. This ensures a high flexibility for users.

Bin Picking: A Challenge for Robotics

A common application involves accurately determining the position and orientation of objects in 3D space. This is critical for automated handling processes where robots interact with complex and variable parts, such as bin picking or standard pick-and-place tasks. Bin picking is particularly challenging: objects lie in disordered piles, sometimes stacked on top of each other, making automated grasping more difficult.



Deep 3D Matching only requires synthetic image data for training. These data sets can be generated fully automatically using CAD models of the target objects.

Three main products of MVTec's portfolio: standard software Halcon, easy-to-use software Merlic and AI-training software "DL Tool".

Image: MVTec

To address such complex scenarios, MVTec developed the Deep 3D Matching technology, which is included in the current version 25.05 of the Halcon software. What makes this technology unique is its combination of deep learning algorithms with rule-based methods, one of the first solutions of its kind. This hybrid approach enables robust detection rates that conventional matching technologies cannot achieve. Deep 3D Matching determines object positions using only 2D images.

Synthetic Training Data and Low Labeling Effort

Another key benefit: Deep 3D Matching only requires synthetic image data for training. These data sets can be generated fully automatically using CAD models of the target objects. This eliminates the need for manual image labeling, saving significant time and costs. Additionally, it requires only minimal parameter configuration while still achieving robust results. This makes it ideal for implementing industrial bin picking and pick-and-place applications in a simple, efficient, and cost-effective manner.

Affordable 2D Cameras Reduce Costs

The required images are captured using simple 2D cameras positioned at various angles. Due to their low cost, these cameras offer a significant economic advantage and can be used flexibly thanks to MVTec's hardware-independent software. Moreover, the system architecture allows additional cameras to be integrated easily, without major setup changes. This flexible camera configuration helps minimize ambiguities and false positives in detection results.

Machine Vision Software as Easy to Implement as Possible

Interview with John Campbell, Key Account Manager at MVTec

The new 3D Deep Matching function from MVTec's Halcon shows that bin picking also works with 2D images. This proves the essential role that software plays in machine vision. But what if the user is not a software expert? And how complex is it to learn how to use new image processing software? These and other questions are answered by John Campbell, Key Account Manager.

inspect: What role does software play in modern machine vision systems?
John Campbell: Simply put, software is the intelligence of a vision system. It is responsible for using the available compute power of the system to acquire, process, and analyze data from the imaging hardware to produce outputs that can, for example, control a manufacturing process. In today's increasingly automated world, modern vision systems are being used in more and more demanding ways. As a result, greater intelligence is required from the vision systems. They must be flexible enough to acquire data from a variety of sources, equipped to solve a wide range of complex tasks, and easily adaptable to efficiently run on a variety of compute platforms and under a variety of challenging conditions.

inspect: What is the most important aspect of machine vision systems for your customers?

Campbell: As a pure software manufacturer for machine vision, we have a wide range of customers, each with different priorities for using machine vision. However, I think it's fair to say that value is the most important aspect of a machine vision system. Customers expect their investment to produce an attractive return, be it with improved quality, reduced costs, increased efficiency, etc. MVTec's hardware-agnostic software provides value by offering high performance for even the most challenging applications, being easily scalable, extendable, future-proof, and easy to support.

John Campbell, Key Account Manager at MVTec

Image: MVTec

inspect: Why are easy implementation and accessibility so important?
Campbell: It is important because it means implementing and supporting a vision system doesn't require highly skilled or trained resources. Experts are often difficult to find and typically come at a much higher cost. So having software that can be used without extensive training leads to savings in terms of the human capital needed.

inspect: What are the disadvantages of a system that is easy to install and operate?
Campbell: Ease-of-use and accessibility often come with frustrating limitations and costly tradeoffs in performance, capability, and flexibility. That's why it's important to consider how critical machine vision is to your long-term automation strategy. I work with companies that are constantly challenging the limitations of machine vision technology. For them, easy, off-the-shelf vision systems are too performance-limited and too expensive to scale. To keep up with their innovation requirements, they need highly optimizable vision software that supports the entire vision hardware market. They need to easily adapt their existing software applications to add new inspection tasks or leverage newly available acceleration hardware.

inspect: How does MVTec resolve this contradiction?
Campbell: At MVTec we are extremely focused on finding the balance between ease-of-use and the probability of success in solving all types of highly challenging applications. For example, in our latest Halcon release, we have introduced support for large language models to simplify the development of applications with our software. Additionally, our rapid prototyping is being modernized to improve the user experience and further shorten development times.

inspect: How do users benefit from the hardware independence of Halcon and Merlic?
Campbell: I'll use a real-life example to illustrate why hardware independence can drastically reduce capital expenditures: A customer I work with was using an off-the-shelf 3D laser profilometer system to inspect and measure the height of a dispensed material across a large surface. Due to hardware limitations of the system, they were unable to achieve the throughput needed with a single station. So, the customer ended up doubling the number of inspection stations on each line. Eventually they decided to try a profilometer from another vendor. The new sensor had a larger field of view and higher scan rate than the previous system. They used MVTec's software to interface with this sensor and process the data. With this configuration, they got more accurate inspection results at the required throughput with a single system. At scale they saved hundreds of thousands of dollars by using the best hardware for their application with a powerful standard software that could support it.

inspect: What can users do if their use case, and therefore their system changes?
Campbell: One of the benefits of having hardware-agnostic standard vision software as the foundation of a machine vision strategy is the flexibility to make adjustments as requirements change. Instead of installing additional hardware into a machine to add new inspection capabilities, you can often use the existing hardware and simply program the new inspection functions into the existing software. Similarly, upgrading performance doesn't always mean upgrading the whole system. A faster computer or new AI accelerator hardware or even a software upgrade can be a lower-cost way to unlock next-generation performance improvements.

inspect: What is required on the part of the user to implement a suitable machine vision system with Halcon?
Campbell: Experience is a good place to start. Having a clear, measurable objective and performance requirement, and the budget, timeline, resources, and technology available to achieve the desired outcome will make design and implementation much more efficient. Understanding the limitations of technology is also important. These days we hear so much about the ability of deep learning models to solve tasks once thought impossible. While deep learning is a very powerful tool in image processing and analysis, it comes with its own set of trade-offs, prerequisites, and performance limitations. Understanding the implications of those and any other technology for that matter is critical to developing a successful system or strategy.

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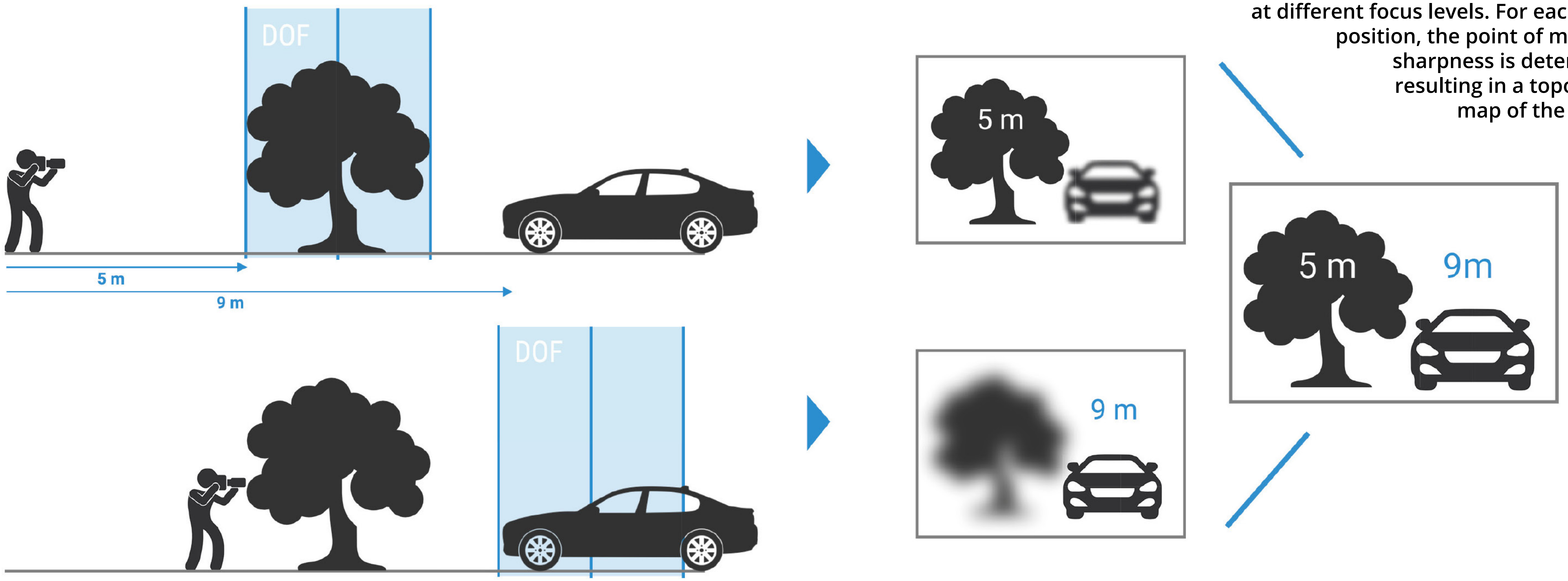
Optical Metrology Technology: Focus-Variation and its Advanced Extensions

Basics of Measurement Technology

Optical technologies have become indispensable in non-contact surface measurement, particularly for complex micro-geometries and high-resolution surface characterization. Among these, Focus-Variation has established itself as a robust and versatile method. But as production requirements evolve, so must the technologies behind quality assurance. This article explores how Focus-Variation has been extended to meet new challenges—through Advanced Focus-Variation, Verti-cal Focus Probing, and Focus Probing.



Focus-Variation combines the limited depth of field of an optical system with vertical scanning to generate high-resolution 3D surface data. As the system scans vertically, it captures a stack of im-ages at different focus levels. For each lateral position, the point of maximum sharpness is deter-mined, resulting in a topographic map of the surface.

All images: Bruker Alicona

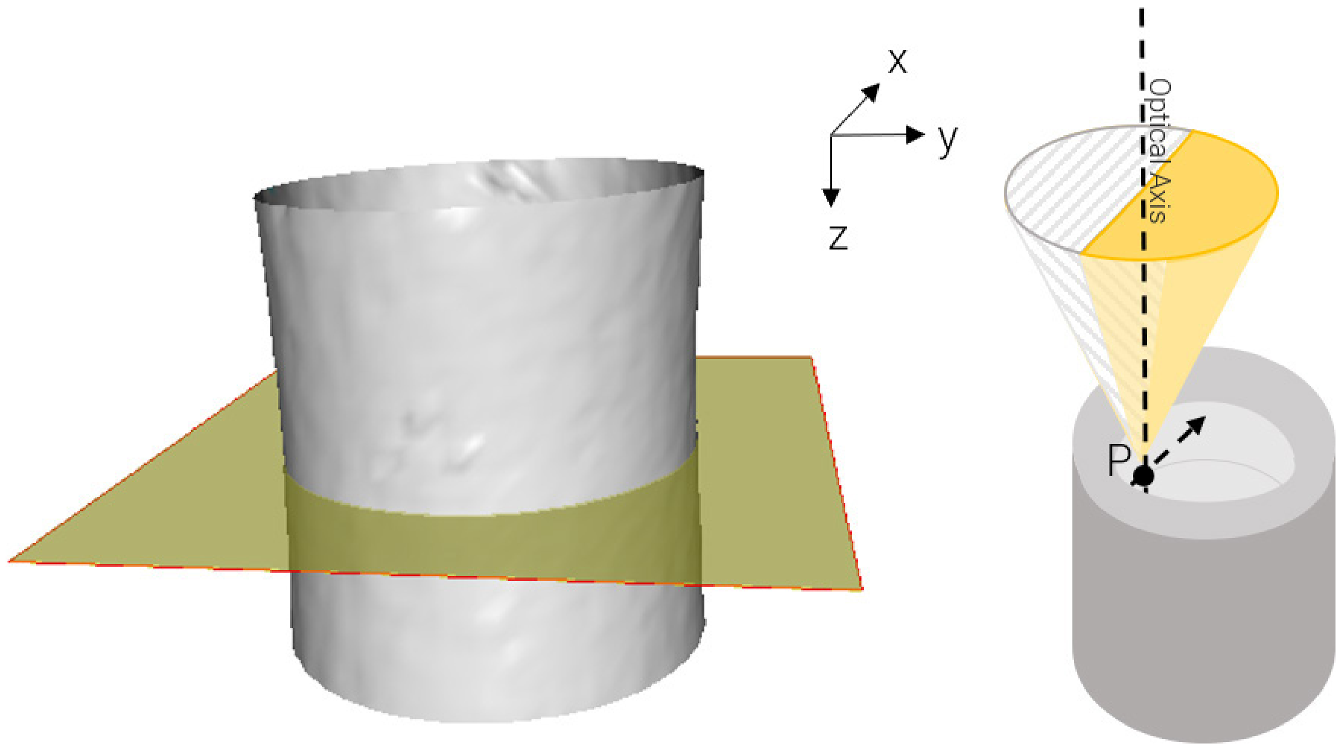
Focus-Variation combines the limited depth of field of an optical system with vertical scanning to generate high-resolution 3D surface data. As the system scans vertically, it captures a stack of im-ages at different focus levels. For each lateral position, the point of maximum sharpness is deter-mined, resulting in a topographic map of the surface. This method is particularly effective for measuring steep flanks (up to 87°), varying surface reflectivities, and microstructures, while also providing true-color information.

Its flexibility in illumination—ranging from coaxial to ring light and polarized light—makes FV suita-ble for a wide range of materials and surface conditions. However, traditional FV has limitations when it comes to extremely smooth or highly reflective surfaces, as well as vertical geometries.

Advanced Focus-Variation: Pushing the Boundaries

Advanced Focus-Variation (AdvFV) is a significant enhancement of the original FV principle. It was developed to address the limitations of standard FV when measuring surfaces that are smooth, specular, or polished to a mirror finish. These surfaces typically lack the micro-texture needed for conventional focus-based depth detection. AdvFV overcomes this by using optimized illumination strategies and advanced signal processing to extract reliable topographic data even from low-contrast regions.

The technology features an improvement in both lateral and vertical resolution while significantly reducing measurement noise. The result is a system capable of delivering nanometer-level preci-sion across a wide range of surface types.



One of the most significant breakthroughs enabled by AdvFV is Vertical Focus Probing (VFP). This technique allows for the optical measurement of vertical walls and deep micro-holes—features that were previously only accessible through tactile or computed tomography methods.

AdvFV also ensures consistent performance across different magnifications and objectives, making it suitable for both roughness and form measurements. It is robust against environmental influ-ences such as vibration and temperature fluctuations, which makes it ideal for use in production environments.

Vertical Focus Probing: Measuring the Unmeasurable

One of the most significant breakthroughs ena-bled by AdvFV is Vertical Focus Probing (VFP). This technique allows for the optical measurement of vertical walls and deep micro-holes—features that were previously only accessible through tactile or computed tomography methods.

VFP works by leveraging partial illumination and detection cones. Even when the surface is ori-ent-ed parallel to the optical axis, a portion of the reflected light can still be captured, enabling the sys-tem to reconstruct vertical geometries. Unlike standard FV, which assigns one height value per lateral position, VFP can assign multiple height values, effectively capturing undercuts and steep internal features.

This capability is particularly valuable in dimensional metrology, where lateral probing—common in tactile systems—is now possible optically. Applications include the measurement of injection noz-zles, boreholes, and vertical flanks in precision components. VFP has demonstrated sub-micron accuracy in measuring features with diameter-to-depth ratios up to 1:10.

Focus Probing: Optical Tactility in Action

Focus Probing builds on the capabilities of FV and VFP by enabling fast, contact-free probing of contours and geometries. Unlike traditional scanning, which requires vertical movement and image stacking, Focus Probing determines the 3D coordinates of each measurement point directly from a single image, eliminating the need for multiple focus layers. This drastically reduces measurement time, especially for small features.

The method mimics the user experience of tactile coordinate measuring machines (CMMs), but with the added benefits of speed, automation, and non-contact operation. It is particularly effec-tive for quickly measuring small geometric features without the need for axis movement, making it ideal for inline inspection and automated quality control.

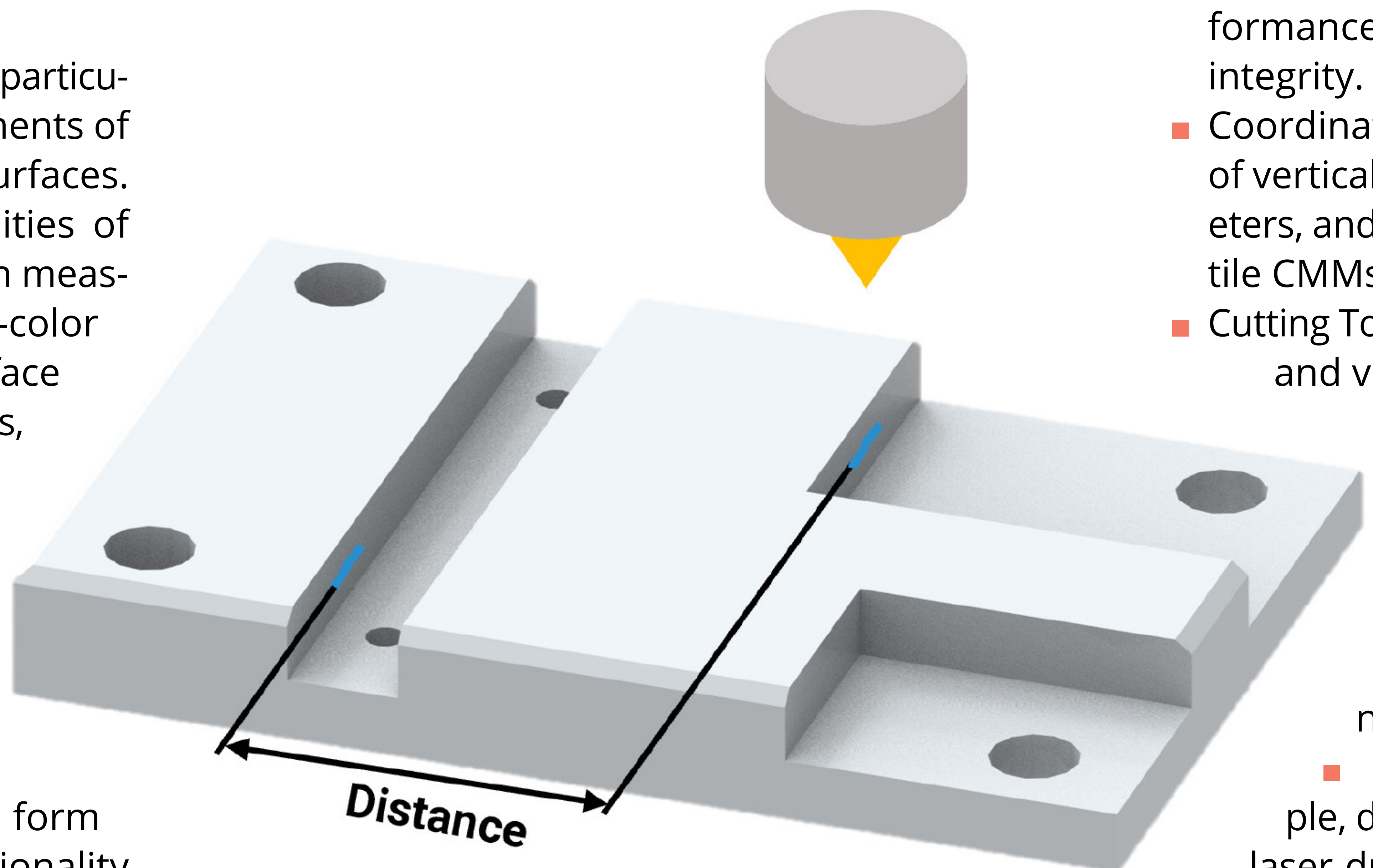
Real-World Application Examples

Advanced Focus-Variation (AdvFV): This is particularly suited for high-resolution measurements of smooth, reflective, and highly polished surfaces. Importantly, it includes the full capabilities of standard Focus-Variation—meaning it can measure steep flanks up to 87°, capture true-color 3D data, and handle a wide range of surface reflectivities and geometries. In other words, everything that could be measured with Focus-Variation can also be measured with Advanced Focus-Variation—plus much more.

It is used in:

- Medical Technology: Measurement of orthopedic and dental implants with mirror-like sur-faces, where both form and surface finish are critical for functionality and regulatory com-pliance.
- Precision Manufacturing: Inspection of high-precision machined components with tight tolerances, steep flanks, and varying surface finishes.
- Tool and Mold Making: Quality control of high-gloss injection molds to detect micro-defects that could compromise the surface quality of molded plastic parts.
- Aerospace and Automotive: Measurement of sealing surfaces, valve seats, turbine blades, and other safety-critical components where both dimensional accuracy and surface integ-ri-ty are essential.

Vertical Focus Probing (VFP): VFP enables optical measurement of vertical surfaces and deep holes—without the need for rotation axes or tactile probes. Typical applications include:



Focus Probing builds on the capabilities of FV and VFP by enabling fast, contact-free probing of contours and geometries. Unlike traditional scanning, which requires vertical movement and image sta-cking, Focus Probing determines the 3D coordinates of each measurement point directly from a single image, eliminating the need for multiple focus layers. This drastically reduces measurement time, especially for small features.

- Deep Bore Inspection in Automotive and Aerospace: VFP allows the precise measurement of deep, narrow holes such as injection nozzles in combustion engines and cooling holes in turbine blades. These features often have extreme diameter-to-depth ratios (up to 1:10) and require accurate capture of both inlet and outlet geometries to ensure functional performance, thermal efficiency, and structural integrity.
- Coordinate Metrology: Optical lateral probing of vertical walls to determine distances, di-ameters, and form tolerances—comparable to tactile CMMs.
- Cutting Tools: Measurement of clearance angles and vertical flanks on drills, end mills, and thread cutters, supporting full 3D form analysis.

Focus Probing: This is suitable for fast, contact-free measurement of 3D contours—without vertical scanning. It is used for:

- Fast Hole Measurement: For example, determining the distance between two laser-drilled holes from a single field of view.
- Inline Metrology: In automated production lines, Focus Probing enables rapid inspection of features such as edges, radii, or small geometries with minimal cycle time.
- CAD Alignment: Captured contours can be directly compared with CAD data for part posi-tioning or dimensional verification.
- Contour Scanning: The latest enhancement of Focus Probing allows for intuitive scanning of complex contours across larger areas. Using waypoints and automatic illumination, users can define scan paths and capture high-precision contour profiles in seconds—ideal for evaluating angles, radii, and form deviations in quality assurance workflows. ■

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Measurement uncertainty in manufacturing: Understanding the basics

Why precise measurement results alone are not enough

Measurements are indispensable for quality assurance in manufacturing. However, every measurement result is subject to uncertainty. The following article explains key terms in measurement technology and uses an example to show how measurement uncertainties can be systematically determined and evaluated.

Although measuring instruments can provide accurate results, a measurement result is always subject to a certain degree of uncertainty. The question is how to deal with this correctly.

Image: smuay - stock.adobe.com

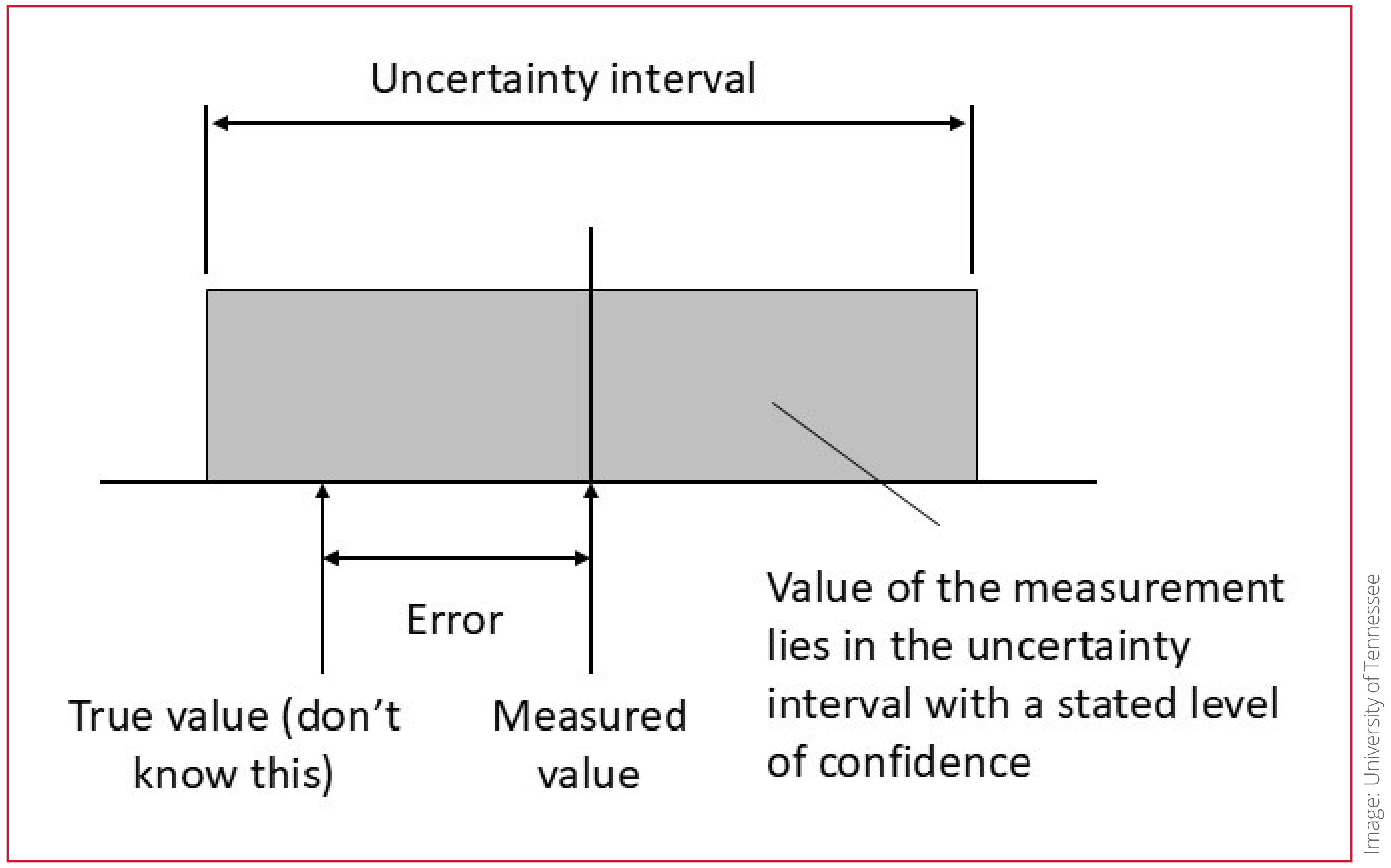

Figure 1: The relationships between the measured value, the true value, the error, and the uncertainty: The value of the measurement with a specified confidence level lies within the uncertainty interval.

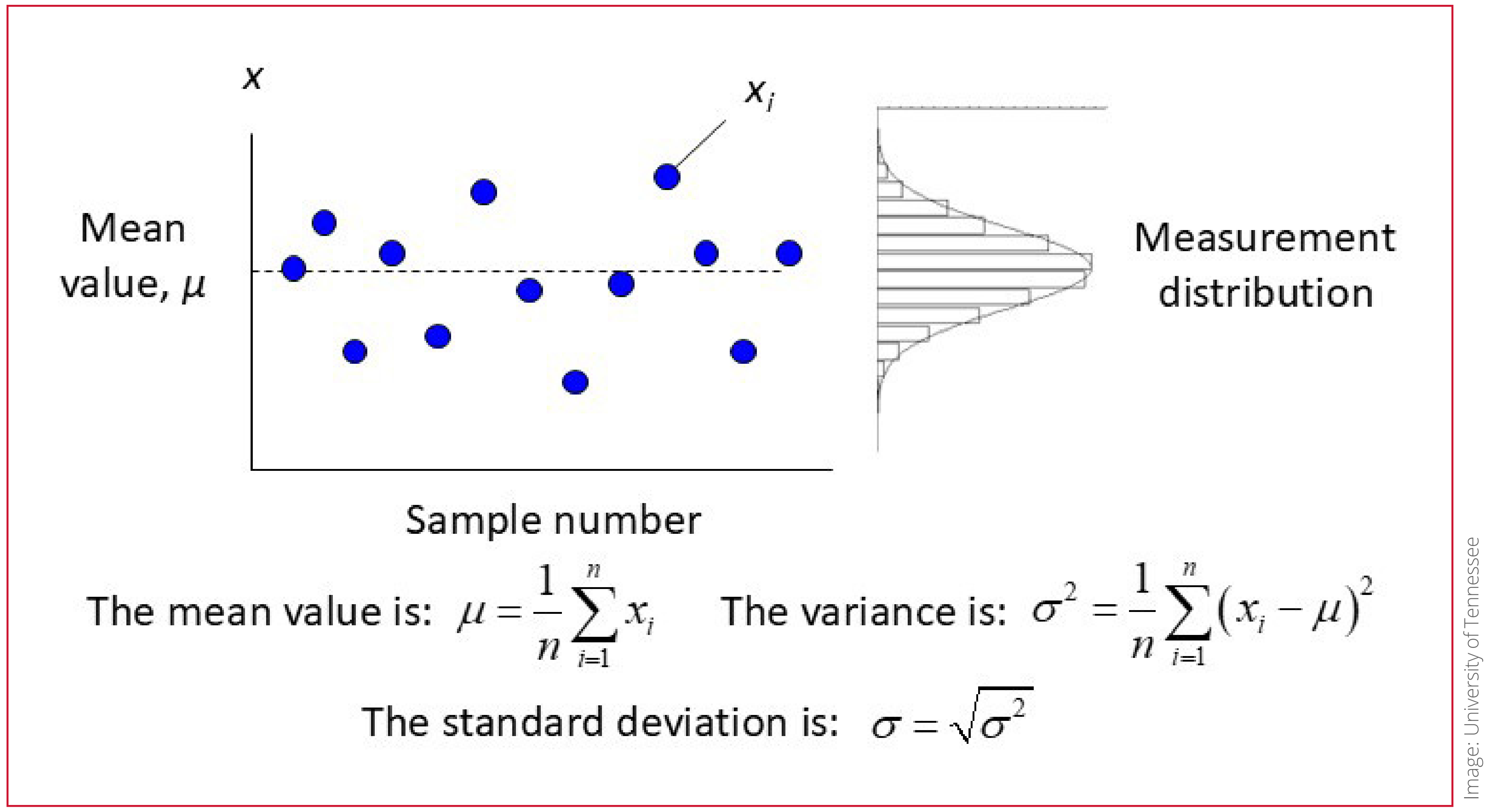

Figure 2: The graph shows the relationships between the samples x_i, the mean μ, and the distribution in the samples. A normal distribution is evident. The equations for the mean, variance, and standard deviation are shown below.

Metrology, or the science and application of measurement, is a value-added process in manufacturing environments. Using geometric measurement systems, such as coordinate measuring machines and structured light scanners, for example, we determine if component dimensions meet design tolerances. Similarly, we use optical and stylus surface measurement systems to confirm that the surface roughness meets design requirements for assembly and function. While these instruments can provide accurate results, there is always uncertainty associated with a measurement result. As stated in the ISO Guide to the Expression of Uncertainty in Measurement, it is our responsibility to report not only the measurement result, but also a "quantitative indication of the quality of the result", or uncertainty [1].

A good starting point for implementing this guidance is a review of common metrology terms and definitions [2].

- The accuracy (of a measurement) is the closeness of agreement between the result of a measurement and the (true) value. It's important to note that accuracy is a qualitative concept. In other words, numbers should not be associated with it. Numbers should be associated with measures of uncertainty instead.
- The error (of measurement) is the result of a measurement minus the (true) value. Because the true value cannot be determined, in practice a "conventional true value" is sometimes used.
- The uncertainty (of a measurement) is a parameter that characterizes the dispersion of the values that could reasonably be attributed to the measurement result. Uncertainty can be quantified using statistical methods or from assumed probability distributions based on experience or other information.
- Resolution is the minimum detectable quantity.
- Repeatability (of results of a measurement) is the closeness of agreement between the results of successive measurements of the same parameter carried out under the same conditions of measurement (i.e., the same procedure, opera-

tor, instrument, and location over a short time). Precision has the same meaning as repeatability; it should not be used interchangeably with accuracy.
- Reproducibility (of results of a measurement) is the closeness of agreement between the results of measurements of the same parameter carried out under changed conditions of measurement, such as a new operator.

The relationships between the measured value, true value, error, and uncertainty are shown graphically. It is seen that the value of the measurement lies in the uncertainty interval with a stated level of confidence. When we describe the measurement uncertainty, we are estimating the standard deviation that we'd expect from that measurement carried out using the selected measurement device under the specified conditions.

Statistics can be used to characterize the expected scatter for n measurements of a quantity x. The relationships between the samples, x_i, mean value, μ, and the distribution in the samples are again depicted graphically. A normal distribution is shown. The equations for the mean value, variance, and standard deviation are also provided.

Measurements with Multiple Variables: Density of an Aluminum Block

Some measurements are based on multiple inputs. In this case, we want to determine the combined effects of the individual inputs on the uncertainty in the measurement result. For example, consider that we wanted to determine the density, μ, of an aluminum block. We would need both the mass, m, and volume, V, of the block. If we calculate the volume from measurements of the three side lengths, L_1, L_2, and L_3, this gives four inputs to the density calculation.

The combined standard uncertainty in the density, uc(μ), depends on the uncertainty in the mass measurement and the three length measurements. It is determined using a first-order Taylor series expansion of the density equation.

The combined standard uncertainty

The combined standard uncertainty equation is composed of four separate terms, where each one is the product of the square of the partial derivative (sensitivity) and the square of the measurement uncertainty (or variance) for each input. The partial derivatives are calculated from the mean values of the inputs. The measurement uncertainties for the inputs can be determined from the standard deviation of repeated measurements (Type A evaluation) or can be based on other information, such as a value provided by the manufacturer (Type B evaluation).

The four separate terms can be compared to determine which input has the largest effect on the combined standard uncertainty. If the combined standard uncertainty is larger than desired, the largest term can be used to determine where to invest in improved measurement devices. For the density example, if the first term in the combined standard uncertainty equation is the largest, then it would make sense to purchase a scale with reduced measurement uncertainty.

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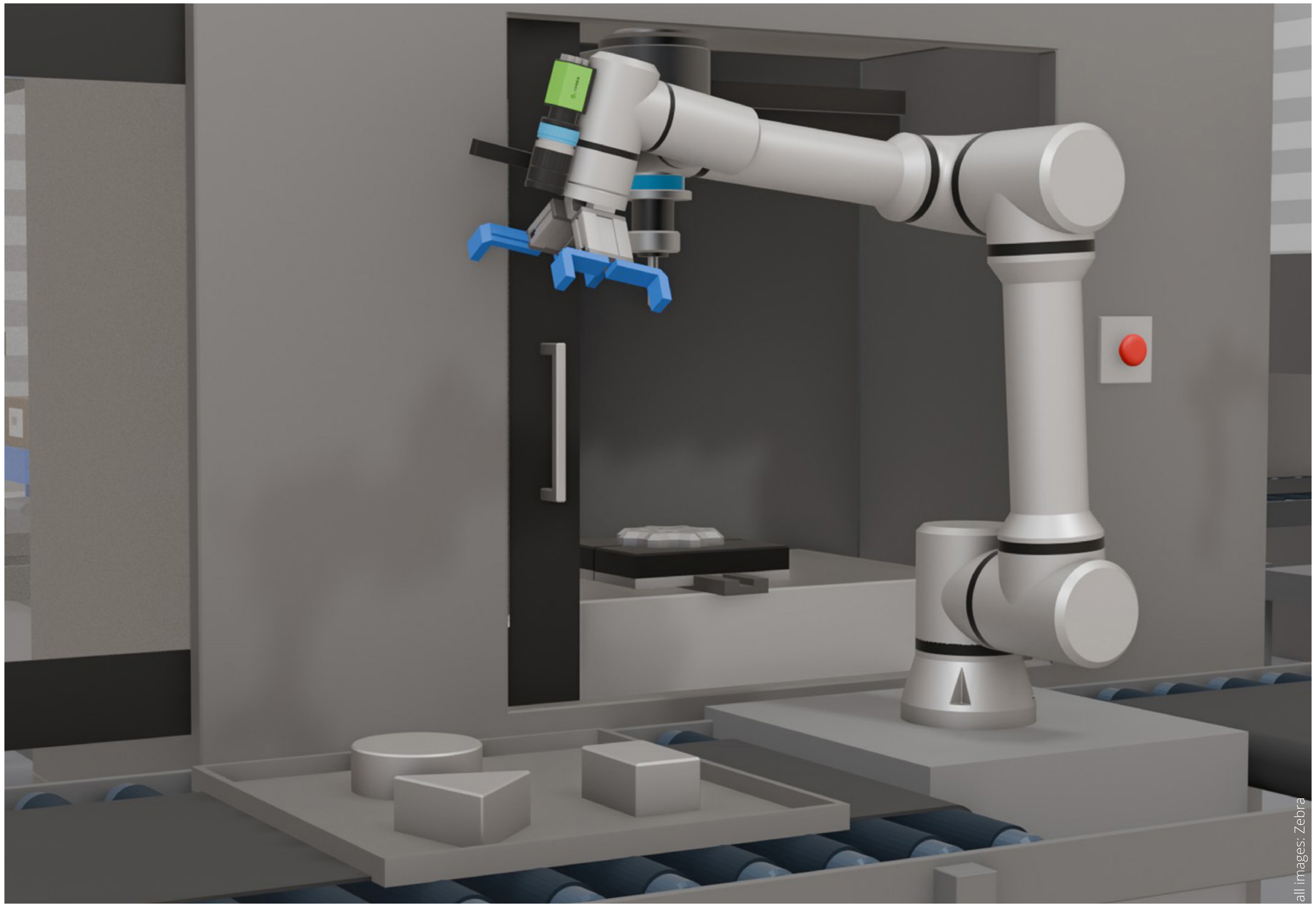
Productivity Boost for the Frontline

Machine Vision and AMRs as Part of AI-Driven Strategies in Manufacturing and Warehouse Operations

Many manufacturers prioritize digital transformation. Therefore, an automation company offers a range of AI-driven strategies to streamline workflows, reduce costs, and enhance quality. The portfolio includes software for vision-guided robotics, AMR-assisted-picking solutions, as well as 3D profile sensors.



The Zebra 2024 Manufacturing Vision Study revealed 92 % of manufacturers have prioritized digital transformation. The study also showed that 61 % of manufacturers expect AI to drive growth by 2029, up from 41 % in 2024. Plus, according to its Warehouse Vision Study, seven in 10 leaders plan on accelerating timelines of modernization project and automating workflows. The adoption of AI-driven strategies and solutions such as machine vision, RFID and AMRs to automate essential business-critical workflows will lead to significant improvements in visibility and data integration across applications, optimizing quality and enhancing frontline performance.

"The adoption of AI and intelligent automation enables manufacturers and warehouse leaders to leverage data more effectively to identify, react, and prioritize problems and projects, delivering new efficiencies for maximum impact," says Andy Zosel, Senior Vice President and General Manager, Intelligent Automation, Zebra Technologies.

Zebra´s Aurora VGR Assistant is an add-on software tool for Aurora Design Assistant designed to simplify the configuration and deployment of 2D vision guided robotics tasks with collaborative robot (cobot) models.

The CV60 area scan camera is used for machine vision inspection applications.

Simplifying Vision-Guided Robotics Integration

One of these solution is the Aurora VGR Assistant, a software add-on tool for Zebra´s Aurora Design Assistant software. It simplifies the configuration and deployment of vision-guided robotics (VGR) tasks. This software targets common VGR applications such as machine tending, packaging, and guiding assembly tools. It leverages machine vision software to simplify the integration of 2D robot guidance and machine vision inspection tasks in a single software platform.

Zebra Symmetry Fulfillment is the latest AMR-assisted-picking solution utilizing Zebra Connect Fulfillment AMRs, wearable technologies, software, and analytics designed to increase productivity and reduce costs in warehouse operations. This AI-powered solution combines the functions of a warehouse execution system (WES) with robot fleet management and analytics. It enables workers to load and unload orders to and from carts without requiring the AMR to remain permanently attached to each cart, increasing utilization and reducing by up to 30 % the number of AMRs needed versus legacy systems.

Zebra also offers the Altiz 4200 3D profilers which are built to deliver tight fields of view in a compact form factor along with high resolution. It features more data points per profile and faster capture speeds to address challenging inspection tasks in electronics and automotive manufacturing applications.

In addition, Photoneo, now part of Zebra Technologies, features the Motioncam-3D (Blue). The 3D VGR solution delivers improvements in key 3D sensing capabilities, leveraging Photoneo's bin picking software for robot guidance to enable precise picking of metal parts at various depths in a more efficient and accurate way. Mounted on a robotic arm in hand-eye position, the Motioncam-3D provides high scanning performance through multi-angle scans. As the arm moves, the sensor captures a continuous 3D data stream to build complete scene models in real time.

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Perfect Baked Goods in Record Time

3D Laser Scanner Checks 100,000 Rolls Per Hour

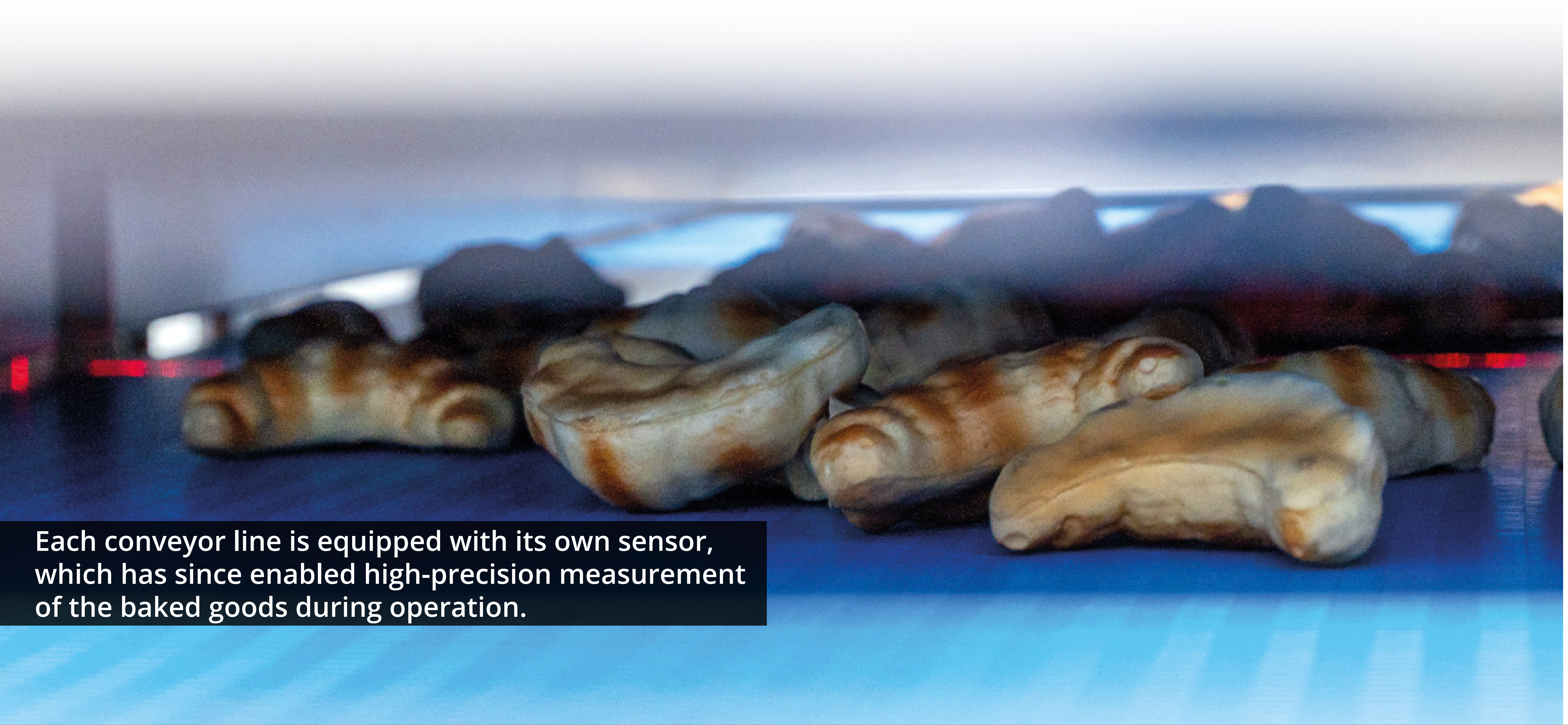
3D sensor technology together with intelligent software at ultra-modern baking lines manage to inspect 100,000 baked goods like croissants or rolls per hour. Because in industrial bakery production there's no room for error.

In the federal state of Schleswig-Holstein, Germany, a normal sliced bread roll currently costs between 0.40 and 0.60 Euros on average. The prices for special rolls such as grain rolls or pretzel sticks are sometimes significantly higher. This price trend has led to a massive increase in expectations of the quality of industrially produced baked goods. Both producers and consumers demand consistent results in terms of appearance and taste. While supermarket chains want to retain their customers through consistent product quality, consumers are increasingly paying attention to every detail as prices rise. Today, a bread roll should not only be fresh and crispy, but should also always look and taste the same.

With this in mind, system integrator ISW and technology company AT Sensors joined forces to develop a high-performance application for the automated quality control of baked goods. The aim was to create a solution that can simultaneously detect and evaluate a wide range of quality characteristics at high throughput and without a clocked process. The initial impetus for the project came from Ilapak, an internationally active machine manufacturer headquartered in Europe that develops and produces packaging lines and baking lines for large industrial customers. These are used by retail giants such as supermarket chains.

As a long-standing manufacturer of baking lines, Ilapak is a key partner for many large bakeries worldwide. The company's systems are characterized by their high robustness, scalability and speed. Ilapak was founded in Switzerland in 1970 and has since developed into a global supplier of packaging machines. Its specialization in flexible packaging solutions has made Ilapak a partner to many food manufacturers who value not only productivity but also quality. In order to set new standards in quality assurance, Ilapak wanted to upgrade its systems with modern 3D machine vision.

Previously, only line scan cameras with 2D technology were used there. These only provided simple shadow images of the baked goods and could not provide any information on the exact geometry, surface structure or distribution of details. However, this is precisely what end customers are increasingly demanding: Detailed information about shape, structure, elevations, volume distribution or topping placement. A requirement that could only be met with 3D sensor technology.



Each conveyor line is equipped with its own sensor, which has since enabled high-precision measurement of the baked goods during operation.

The captured 3D data is processed using the software developed by ISW, which is based on the Halcon image processing library. The processed information is forwarded directly to the programmable logic controller (PLC), where it controls the sorting mechanisms of the packaging system.

The Challenge

The baked goods are inspected directly on the conveyor belts of the Ilapak systems – without a timed process sequence. Several quality parameters have to be checked at the same time: These include dimensions such as height and size, cutting characteristics and specific surface properties such as the distribution of cheese on lye pastries. Such complex inspection tasks exceed the capabilities of conventional 2D machine vision systems and therefore require the use of advanced 3D sensor technology.

„The production lines pass up to 100,000 bread rolls per hour, which are neither organized nor all next to each other, but rather partly on top of each other. The conveyor belts are also wider than one meter, so the sensor we were looking for had to have a wide field of view and a high resolution," reports ISW Managing Director Tobias Wichmann. He also explains that the inertia of the conveyor belts was a difficult factor during application development. „The industrial baking lines operate 24/7 and must not be interrupted. The large baking lines are programmed in such a way that they sometimes have an hour's lead time if changes need to be made," mentions Wichmann.

An industrial baking line is a finely tuned interplay of several process stages that interlock seamlessly. From the raw dough to the packaged product, the entire production process is automated and continuous. As soon as a dough piece enters the line, it moves through proofing chambers, oven modules, cooling units, inspection systems and packaging lines. This continuous movement ensures a constant throughput. If the line is stopped, the entire material flow jams. The oven can overheat, dough pieces overcook or cool down, packaging units get out of sync. To prevent all of this, a line stop must be initiated with great care and a precisely calculated lead time of at least one hour. This is the only way to avoid losses and system damage. The following therefore applies to every system used, especially for quality control: it must function with absolute reliability.

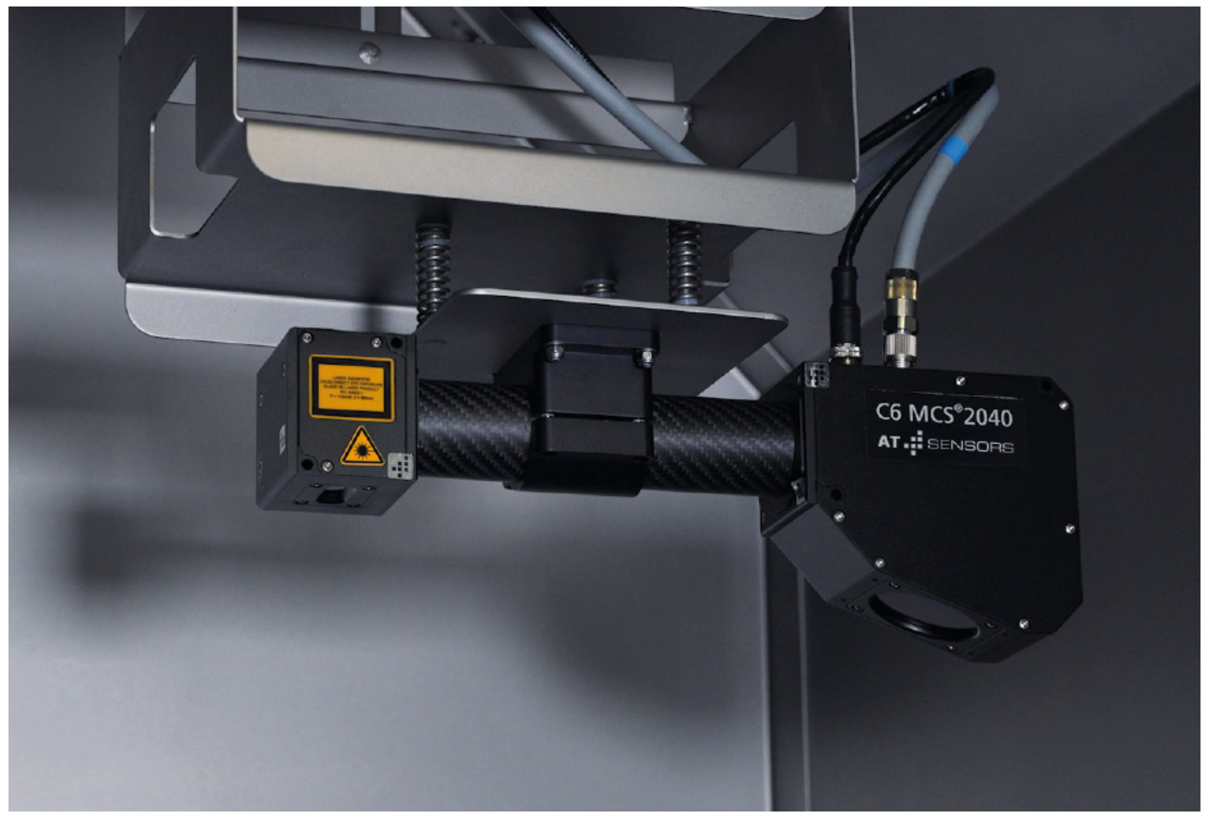
The Solution

The requirements of Ilapak and ISW were therefore correspondingly high: to find a sensor manufacturer that not only met the technical requirements, but could also be used reliably in industry. And this is where AT Sensors came into play, offering the solution with its modular MCS 2040 3D sensor.

A key feature of the MCS series is its modular design, which makes the sensors a solution for a wide range of applications. „The MCS stands for high flexibility: thanks to many configuration options, we build sensors that are precisely tailored to the respective application – whether cost-optimized or high-performance. Our aim is not to supply just any sensor, but exactly the right one. Because once you've worked with AT, you stay with AT," reports AT Sensors Head of Sales Dr. Athinodoros Klipfel.

In fact, with the MCS series, each sensor can be individually adapted to the specific requirements of the application – without additional costs, without minimum purchase quantities and without long delivery times. At the same time, the sensors have standardized interfaces such as GigE Vision, which considerably simplifies integration into existing systems.

Each conveyor line was therefore equipped with its own sensor, which has since enabled high-precision measurement of the baked goods during operation. The MCS 2040 records 2048 measuring points per profile and achieves a resolution of 0.5 millimeters in the X-axis and an impressive 0.03 millimeters in the Z-axis. A field of view of 1 meter and a profile speed of up to 25 kilohertz ensure fast and continuous data acquisition even at very high throughput rates.



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A red laser with a wavelength of 660 nanometers is used, which delivers a particularly high intensity to the detector and therefore enables extremely sensitive and precise measurement. In addition, the Multipeak and Multipart functions developed by AT Sensors enable the simultaneous detection and evaluation of several quality features, allowing a comprehensive geometric and structural analysis of the products in real time.

The captured 3D data is then processed using the software developed by ISW, which is based on the Halcon image processing library. The processed information is forwarded directly to the programmable logic controller (PLC), where it controls the sorting mechanisms of the packaging system. This allows the baked goods to be packaged specifically according to defined quality and quantity specifications for the retail trade.

The baked goods are inspected directly on the conveyor belts of the Ilapak systems – without a timed process sequence.

Why Supermarket Chains Rely on Quality Control

The stakes are high for large supermarket chains. Their brand image is closely linked to the quality of the products they sell. Especially when it comes to fresh foods such as baked goods, customers expect a uniform appearance, fresh taste and consistent texture. Deviations are quickly noticed and can lead to shopper churn. Supermarkets also have clear specifications for product quantities per pack. If a pack is delivered with too many or too few rolls, there is a risk of complaints or even contractual penalties. This makes it all the more important that quality control not only detects errors, but also controls processes intelligently.

Long-Term Partnership Through Reliability

This quality control of baked goods has now been implemented successfully and reliably for several years and is used by numerous end customers in Europe. ISW recently placed another order with AT Sensors for a large number of sensors to equip further baking lines. AT Head of Sales Klipfel comments: „As the company used to be an integrator itself before it shifted its core business to the manufacturing of sensor technology, AT understands exactly what its customers are looking for. We know what is important in practice and I think that gives us a huge advantage in the development of our products.“

ISW has also been working with Ilapak for many years, which quickly resulted in a suitable cooperation with which the partners were able to make a name for themselves internationally.

Conclusion

Because of AT Sensors‘ 3D sensor technology, ISW's software and Ilapak's packaging lines, it has been possible to establish efficient and reliable quality control for baked goods. This ensures that large supermarkets, for example, receive consistently high-quality products while minimizing economic losses due to production downtime. ■

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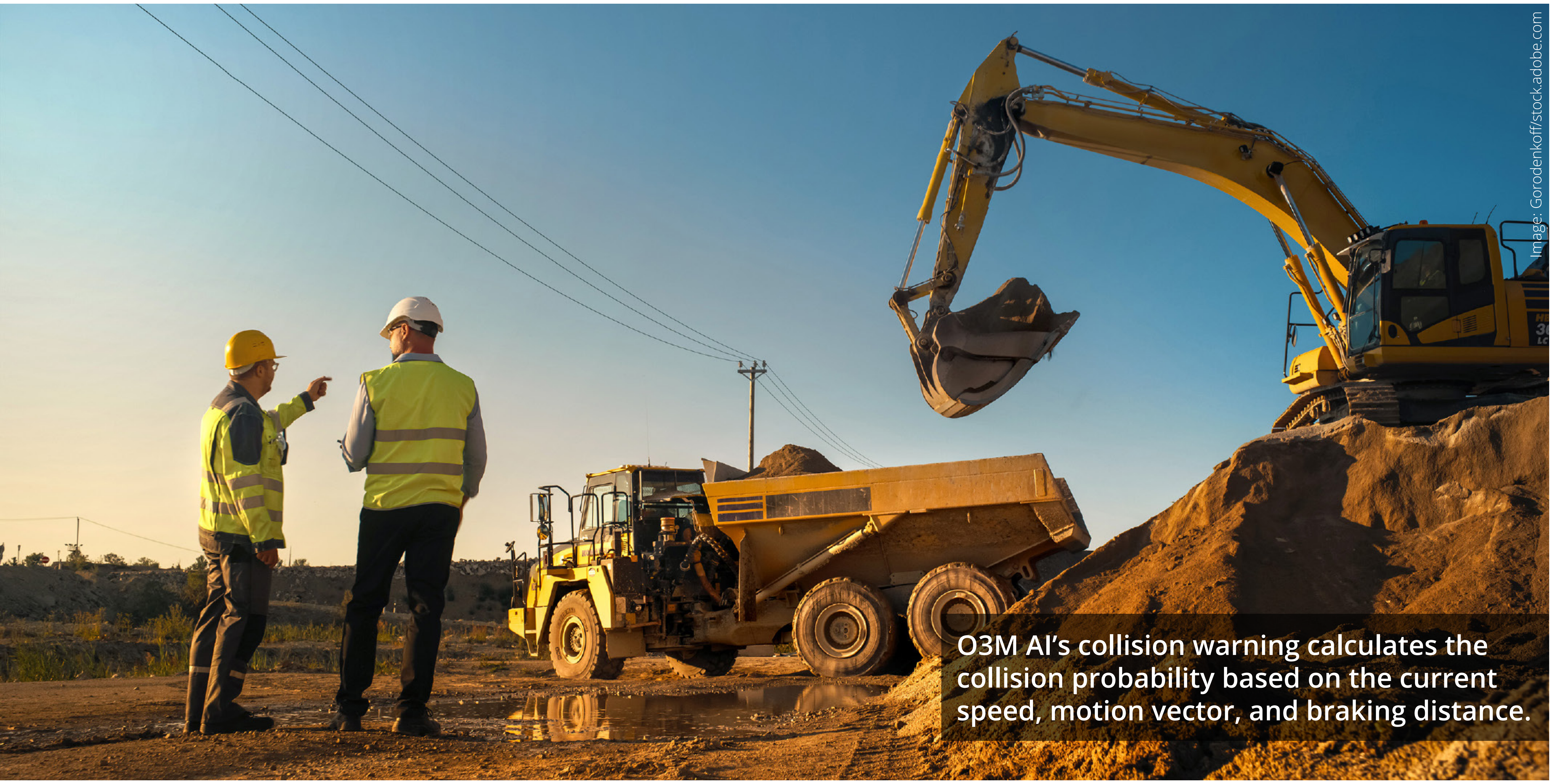
Sensor Fusion in Outdoor Applications

AI-Driven Collision Warning System for Mobile Machinery

Mobile machines operate in complex, unstructured, and cluttered environments. Thanks to the fusion of two measurement principles and AI specifically trained for working environments, a new assistance system analyses the environment with great precision and delivers reliable hazard warnings.

IFM is expanding into the assistance systems segment with a new solution: O3M AI. It consists of a PMD camera system that combines two technologies–time-of-flight and 2D vision. Thanks to this fusion, the collision warning system can more accurately determine obstacle types and distances. Much like adjusting the contrast and brightness on a TV sharpens the image, fusing two data sources enhances a mobile machine's perception of its surroundings, allowing it to recognise people and objects with greater accuracy.



O3M AI's collision warning calculates the collision probability based on the current speed, motion vector, and braking distance.

Image: Gorodenkoff/stock.adobe.com

3D and 2D Video in One System

The 3D PMD sensor for distance measurement and the 2D ethernet camera for person detection are both integrated into a single embedded system. A high-performance processor manages both signals and intelligently correlates them. Simultaneously, a neural network analyses the live image from the high-resolution 2D ethernet camera. To accomplish this, the camera is equipped with its own powerful processor and an AI accelerator (NPU). This enables fast processing of the AI algorithms for person detection directly within the system, enhancing both person and object recognition. Depending on the application, depth mapping from the 3D PMD sensor and the video from the Ethernet camera can be used either separately or in combination. The system also features extraneous light suppression, withstands extreme temperatures, and is protected against water and dust.

IFM's 3D PMD sensor uses the Time-of-Flight (ToF) method. An infrared light source installed on the vehicle emits modulated, invisible IR light. The sensor detects the reflected light, and measures the distance to the object for each pixel based on the phase shift between the transmitted and received signals.

Distinguishing People from Objects

In order to ensure the efficient operation of mobile machinery in complex environments, however, assistance systems must reliably distinguish between people and objects–and be capable of drawing smarter conclusions than conventional technologies currently allow. This capability is crucial for tasks such as dynamically adjusting speed while reversing or maintaining uninterrupted 360° situational awareness in cluttered environments with blind spots. Ultimately, the goal is to reliably prevent accidents involving personal injury. Yet many systems available today still deliver unsatisfactory results: false alerts and emergency braking are triggered too frequently–a consequence of safety first logic. This reduces productivity and impairs efficiency. For drivers, false alerts mean lost time and added stress. After all, not every bump or dirt pile should trigger an emergency stop.

To enable smarter and more situation-aware driving, IFM leverages the high-precision distance data provided by the 3D sensor. By analysing over 1,000 distance values, the system can calculate braking distances and collision probabilities with high accuracy. Smart features, such as the ability to deactivate 3D object checking, offer additional flexibility: for example, when a vehicle is reversing over a long distance in clear, open surroundings, speed can be increased accordingly. In confined spaces, such as when forklift trucks or municipal vehicles are manoeuvring, O3M AI ensures reliable stopping–but only when it is truly necessary and the detected obstacle is indeed a person and not just a pile of dirt. Depending on the situation, O3M AI can determine whether emergency braking, a controlled stop, or deceleration is the appropriate response.

Trained on Reality

In addition, IFM has developed its own AI-supported person detection system. Instead of relying on off-the-shelf AI, IFM has trained its neural network using proprietary data collected from real-world working environments, significantly improving algorithm accuracy. Conventional AI solutions often depend on sample images that bear little relevance to local work settings. By contrast, O3M AI, powered by proprietary image data, can reliably detect people and objects as they appear in typical working environments–whether it is a person lying on the ground, wearing dark clothing, partially obscured by large tools, or adopting an unusual posture. The system operates effectively in both bright sunlight and twilight, and has a range of up to 25 metres and an accuracy of 10 centimetres. It can assess up to 20 object types simultaneously.

Image: IFM

IFM's all-in-one solution combines several measurement principles into one robust system–for greater precision and safety in harsh environments.

The results of the data analysis are transmitted to the machine control system via CAN bus or ethernet and signalled to the driver. Information and warning messages are displayed on a screen inside the vehicle. The sensor system overlays warning symbols, icons, line objects, and text onto the video image, seamlessly integrating them with the video signal. The digital video output supports the most common codecs, including H.264, H.265 and MJPEG via fast ethernet. Two independent video streams can be configured and used simultaneously.

The system is configured using the IFM Vision Assistant software. Even complex setups involving multiple 3D sensor systems can be configured easily, without requiring specialised expertise. The 2D/3D smart camera system simplifies work in off-road environments and enhances safety. ■

CONTACTS

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MWIR system camera for continuous industrial operation

Entry into infrared imaging

This infrared camera with cooled photon detectors provides users with performance advantages at a good price/performance ratio. Due to the latest detector technology and a robust, compact construction, the camera is useful for demanding OEM and continuous operation applications.

MADE IN GERMANY

Image: Infratec

The radiometrically calibrated system camera Image IR 6300 from Infratec is equipped with a cooled focal plane array photon detector. By combining the detector format of 640 × 512 IR pixels with a pixel pitch of 10 µm, the camera delivers sharp images. Due to its snapshot mode, at which all pixels are exposed at the same time, moving objects can also be displayed without distortion.

The XBN detector technology enable the detector to operate at a higher working temperature than the usual approximately 80 K. This allows lowering size, weight and power (SWaP) of the integrated detector/cooler unit. Thus, the MTTF of the camera can be increased to about 30,000 hours for a basic load profile.

Its pixel pitch of 10 µm gives the system camera a comparatively small detector size. This allows for a compact optical design while maintaining high image quality.

The infrared camera comes with a range of different interchangeable camera lenses.

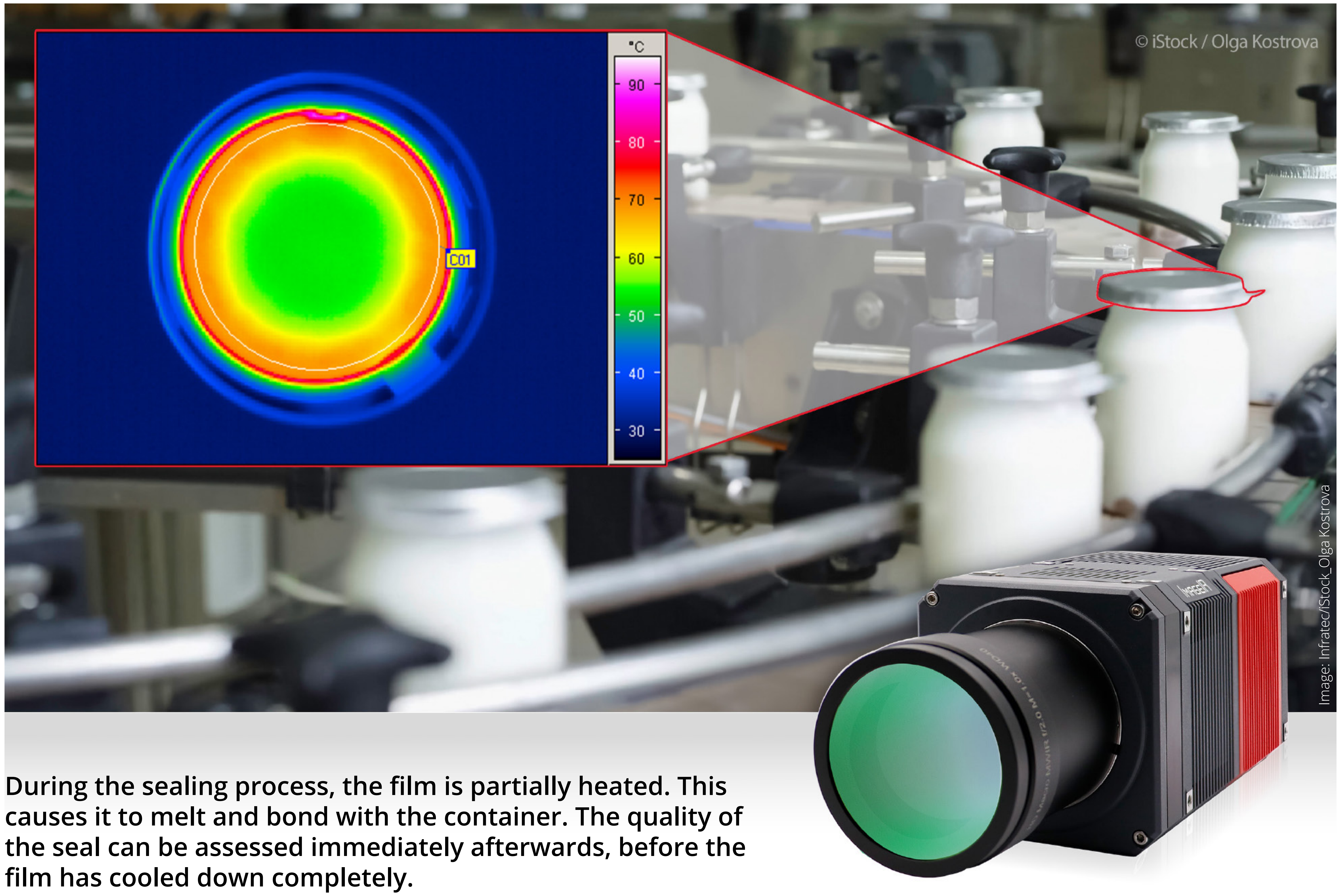
The small size and the higher MTTF are key features that qualify the camera for use in OEM and continuous operation applications. With a range of different interchangeable camera lenses available between 12 and 50 mm (with an optional 300 mm close-up), and 1x microscope, the Image IR 6300 can be configured for a wide variety of applications, from inline inspection to laboratory test stations.

Quality control of sealing process with MWIR

The camera can be used for many industrial processes. The Peel-Scan automation solution, for instance, has been created by Infratec for the inline quality control of foil sealings of plastic containers, that are often used in the pharmaceutical and food industries.

For a long time, uncooled infrared cameras were applied for checking seals and similar tasks. However, due to their low frame rates, longer integration times and a line-by-line readout processes (rolling shutter), leading to distortions in the imaging and measurement of moving objects, these systems quickly reach their limits. Peel-Scan solution with Image IR 6300 detects even small defects that cause temperature differences of 20 mK and visualizes them by using Infratec's control and analyzing software Irbis.

During the sealing process, the film is partially heated. This causes it to melt and bond with the container. The quality of the seal can be assessed immediately afterwards, before the film has cooled down completely. The software compares the image captured with that of a flawless seal and uses temperature differences to detect defects in the sealing seams and films.



During the sealing process, the film is partially heated. This causes it to melt and bond with the container. The quality of the seal can be assessed immediately afterwards, before the film has cooled down completely.

A particular requirement of the application is the short integration time. Within the production process plastic containers are fully automatically sealed with foil at high cycle frequencies, leaving very little time for quality control. Thermal imaging triggered by a visual signal offers the possibility to evaluate the quality of the seal non-destructively in fractions of a second, and continuously for each individual container.

The colors in the thermal image represent different calibrated temperature values. Deviations can be identified quickly and reliably, using analysis algorithms integrated into the thermography software. Containers with seals that are recognized as faulty will be removed from further processing.

Advantages in industrial processes

The infrared camera Image IR 6300 can be easily integrated into the production line via plug & play and precisely controlled using fast triggers. The data obtained is stored directly on the infrared camera or transmitted uncompressed via Gigabit Ethernet to professional control units.

The MWIR System Camera from Infratec is suitable for monitoring fast processes, even in 24/7 operation. Due to an optimized cooler concept, the cost-effective infrared camera is permanently maintenance-free, even in difficult environments.

The Image IR 6300 is the first model in the ImageIR® series to feature a new integrated operating system of Infratec. This opens a wide range of new functions, such as fully autonomous camera operation without the need for an additional control PC. The camera can also be controlled via a web interface using a smartphone or tablet. In addition, users can run their own software directly on the camera and access the data stream directly via the integrated SDK.

Frame rates up to 620 Hz

Measurements with the camera can be carried out at two speeds. In normal mode, the device achieves full frame rates of up to 180 Hz. With the binning function, the frame rate can be increased by more than three times up to 620 Hz. This is made possible by combining four detector pixels into one. Thereby the sensitive pixel area is increased to compensate for the shorter integration times, and the readout of the pixel data is accelerated. At the same time, the thermal resolution improves by a factor of two in high-speed mode. Even higher frame rates can be achieved by reducing the field of view to freely definable subframe modes.

Wide measurement ranges

The MIT (Multi Integration Times) function increases the dynamic range up to 16 bit and significantly extends the temperature measurement ranges. Objects with large temperature gradients can be recorded with one measurement range while maintaining the maximum image refresh rate and temperature resolution.

With constant aperture/filter setting, different integration times can be selected for up to four calibration ranges and combined with these to form a total range. The system calibration can remain unchanged. Manual switching of the measurement range becomes dispensable as well, but MIT is limited to a temperature range defined by the calibrations with the same filter settings.

One calibration fits all

Different measurement scenarios often require temperature measurement ranges or integration times that vary from the initial factory calibration and are individually adjusted. Thanks to the High Sense function the measurement accuracy of the cameras is also preserved when integration times or the measurement ranges are changed. With maximum flexibility users also save costs, for example, by avoiding additional application-specific special calibrations.

High Sense enables the possibility of setting up individual customized temperature measurement ranges in two different ways. The first one allows for the selection of a desired integration time. The resulting temperature measurement range is calculated automatically and can be used for accurate measurements. The second way is defining an upper and lower limit temperature measurement range. Afterwards, the appropriate integration time is calculated to achieve the optimum signal-to-noise ratio and stored as setting parameter for the planned measurement task.

In addition, the calibration of individual subframes is no longer necessary. The adjustment of the calibration data, which applies to these frames, takes place automatically as well. On this basis, accurate temperature measurement values are also provided for the corresponding window modes. ■

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Simplified Integration

Intelligent Lens Systems for Remote and Mobile Applications

A new lens system offers a compact solution that simplifies the integration of intelligent optics into machine vision systems. Designed for remote and mobile applications such as AMRs and UAVs, it enables precise control over zoom, focus, iris, and filter functions. With built-in calibration, the system delivers high image quality, and ease of use for advanced imaging applications.

Theia Technologies' IQ Lens System integrates a motorized lens, motor control board, calibration data, and software with a graphical user interface (GUI) into a modular, and configurable package. Previously, users developed their own control software. Now, Theia's system streamlines integration, reducing development time and cost. Its built-in calibration data enables optimal image quality and simplifies system setup. Compact and lightweight, the varifocal lens and control board are ideal for remote or mobile applications, enabling convenient integration into machine vision systems.

Remote Access and Control

Theia's motorized lenses and motor control board integrate into machine vision systems using stepper motors to control zoom, focus, iris, and filter functions. Designed for difficult-to-access environments, such as autonomous mobile robots (AMRs) and uncrewed aerial vehicles (UAVs), these lenses simplify setup and operation.

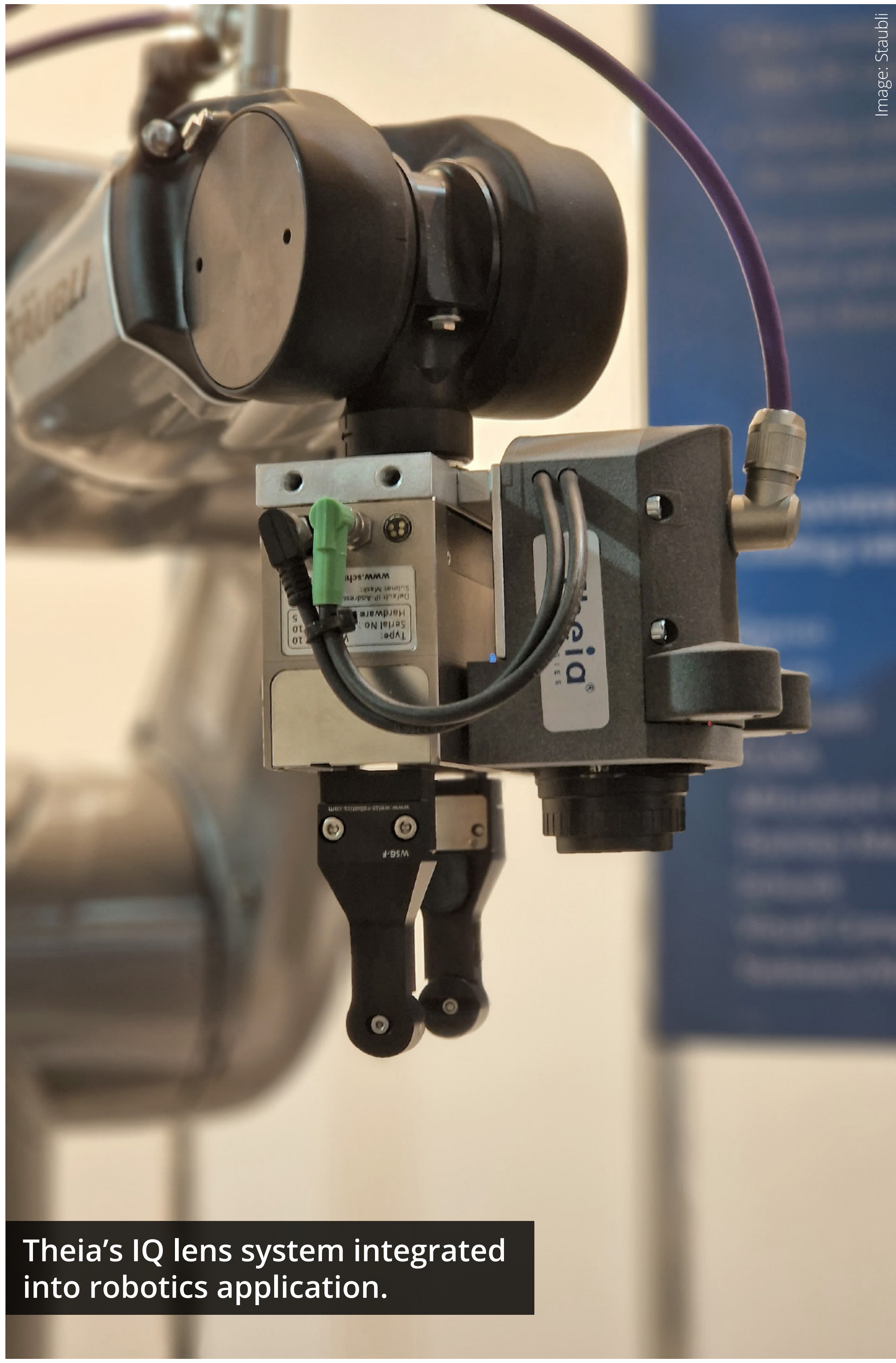
They enable remote zoom and focus, offering flexibility for variable camera placements and changing object distances. This is especially useful in Cobots, robotic-assisted medical applications, and automated lab testing environments.

The lenses also switch between visible and Near IR (NIR) light, enabling detailed multi-spectral imaging. Applications include tissue hydration monitoring, crop health analysis, and license plate recognition—balancing accurate color rendition and enhanced NIR sensitivity.

Plug and Play Integration

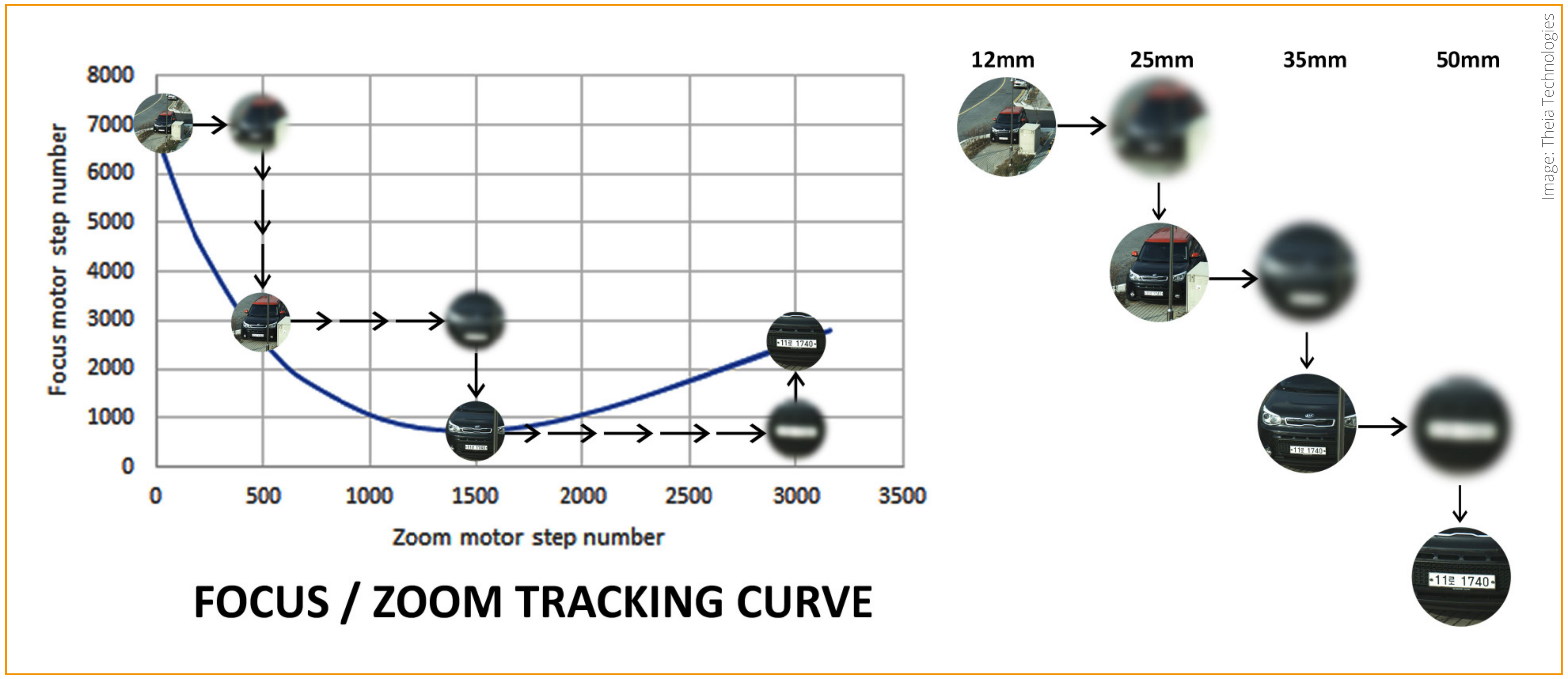
Until recently, using Theia's lens and control board required users to manually convert parameters into motor steps. The IQ Lens System now includes an SDK and GUI that translate engineering values into motor commands using Theia's control library.

Users can input field of view, aperture setting, or object distance, and the software handles the conversion to motor steps—no need for manual calculations or look-up tables. The system includes the MCR IQ Motor Control Board, which translates these steps into precise motor actions via USB, UART, or I2C communication.



Theia's IQ lens system integrated into robotics application.

Image: Staubli



Focus / zoom tracking curve of a 12-50 mm focal length lens, showing different focal length's focus/zoom motor positions

The SDK includes Python modules and a GUI application for convenient access and development. A royalty-free license is included with purchase, saving users time, resources, and reducing time to market.

Lens Intelligence

The IQ Lens features computer-readable calibration data to enhance imaging and processing. Varifocal lenses typically require refocusing when the focal length changes. The IQ Lens includes an average zoom/focus tracking curve, helping maintain focus during zoom or allowing preset focus for a known zoom level. This functionality improves image optimization for mobile or remote devices like AMRs and UAVs. Knowing the zoom motor step-to-focal length relationship allows precise field of view setup for dynamic applications, such as mobile enforcement cameras or robotic pick-and-place systems.

The lens includes key design data:

- Aperture size: Allows fine lighting control, improving depth of field in outdoor conditions. Useful in ANPR, crop inspection, and infrastructure monitoring.
- Geometric distortion: Enables spatial correction across focal lengths without requiring distortion grid jigs. Ideal for mapping, navigation, stitching, and de-warping applications.
- Relative illumination: Facilitates corner brightness uniformity across focal lengths and F/# settings—important for inspection tasks.

The IQ Lens System's modularity supports flexible configuration within tight mechanical constraints. The varifocal lens is under 52 mm long, and the motor control board measures 25 x 60 mm—ideal for integration in compact systems. ■

Motorized iris control allows users precise control over aperture size, useful in mobile applications including ANPR.

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Time of Flight Method Ensures Depth Perception

Shape Recognition, Object Positioning, and Distance Measurements in Logistics

Time-of-Flight (ToF) is much more than a sensor technology–it functions like an additional, precise pair of eyes in industrial manufacturing. But what exactly is behind it, what advantages does ToF offer, and how is the technology evolving?

Who doesn't know this situation? After a big shopping trip or a vacation, you stand in front of the car and wonder: How do I get all this into the trunk? Suitcases, shopping bags, maybe even a stroller–it seems impossible to fit everything in. But with a bit of spatial thinking and clever stacking, everything suddenly fits.

This ability to optimally arrange objects in a limited space is crucial not only in everyday life but also in industry. In factory halls, machines must precisely recognize, grasp, and place materials–and do so as error-free as possible. While we can improve our spatial thinking through practice, machines are helped by Time-of-Flight (ToF) technology. It gives them exact depth perception, allowing them to capture their surroundings in three dimensions and make optimized decisions–a key factor for the automation of the future.

Spatial Thinking and the Time of Flight Method

The goal is clear: fully automated robots that quickly detect objects and work efficiently. With the ToF method, this is possible: it measures the distance between the sensor and the object, providing precise 3D images. Three components make this possible: a light source emits modulated infrared light pulses, an image sensor captures the reflected light, and a computing unit calculates the time difference between the emitted and returning light. The principle is similar to a bat's sonar – only with light instead of sound. The camera emits a laser beam, which is reflected by an object.

The sensor measures the time it takes for the light to travel to and from the object, determining the exact distance to the object. A depth value is calculated for each pixel, creating a detailed depth map or point cloud.

Especially in logistics, the combination of ToF and 3D cameras offers decisive advantages. Unlike conventional 2D cameras, they capture not only the structure of an object but also its volume, shape, distance, and position in space. A vivid example of this is pallet picking: ToF cameras recognize not only the number of packages but also their dimensions and volume, allowing the available space to be optimally utilized. They work reliably regardless of contrasts or specific markings and function even in difficult lighting conditions, such as poorly lit rooms. Even moving objects are captured without problems. Compared to other 3D cameras, ToF systems are more compact, cost-effective, and less complex, making installation and integration significantly easier.

For an Improved Warehouse Automation

Among the pioneering models are the ToF cameras from Delta Electronics: The latest generation includes the ToF smart camera DMV-T and the RGB-D ToF camera DMV-TM, which are particularly well-suited for various applications and enable precise positioning, identification, and measurement for improved warehouse automation.

The ToF smart camera of the DMV-T series uses depth recognition technology to enable three-dimensional coordination in a space. The camera performs distance measurements, shape recognition, and object positioning even in complex environments such as poor lighting or cluttered spaces. With a range of up to 6 meters, a field of view of 67 degrees by 51 degrees, and 60 frames per second, the DMV-T camera is the standard model from Delta Electronics. With an integrated dual-core CPU, the camera is ideal for time-critical tasks such as pallet recognition on automated forklifts and positioning of objects in AS/RS systems. It features high accuracy (less than 1 % error probability), a detection time of under 80 ms, and robust protection class IP67. Seamless integration into existing systems is ensured by the Ethernet interface.

Hardware meets intelligent software: Thanks to the ARM Dual Cortex-A53 CPU and FPGA technology, Delta's ToF cameras DMV-T can process complete 3D image data without the need for external industrial PCs.

Small Dimensions in Automated Guided Vehicles

The DMV-TM camera is specifically designed for an integration into AGVs (Automated Guided Vehicles) and stacker cranes. Its lightweight and adaptable design, combined with precise navigation functions, enables collision avoidance and optimized performance in dynamic warehouse environments. It is 10 centimeters long, 3.5 centimeters high, and has a significantly wider field of view (FOV) of 105 degrees by 78 degrees compared to the standard model. This feature is crucial–after all, AGVs should primarily recognize the path ahead but also need a broad view of their surroundings for efficient use. For a 360-degree view, multiple mini-cameras would need to be installed on the AGV. For comparison, the human field of view is around 180 degrees–depending on age and person. The DMV-MT camera has a frame rate of 30 frames per second and a range of up to 4 meters. A key difference from the standard model is that the DMV-MT camera does not have an integrated processor. The image processing and corresponding computing power are therefore installed in the AGV or at the respective location–a reason for the smaller dimensions.

Automotive Industry, Logistics, and Hospitals

Warehouse optimization, reduction of pick and place tasks, fewer downtimes, increased flexibility and efficiency: ToF cameras have their core application area in the logistics industry. The automated takeover of pallet picking, container filling, or other logistics tasks relieves specialists and provides room for more demanding work. This is possible because cobots or AMRs can work fully automatically with the use of ToF cameras and can also be programmed to meet safety standards. Both the DMV-T and the DMV-TM are suitable for a wide range of applications in the areas of food and beverage packaging, electronics, automated production, and robot vision, demonstrating their versatility in various industries. ■

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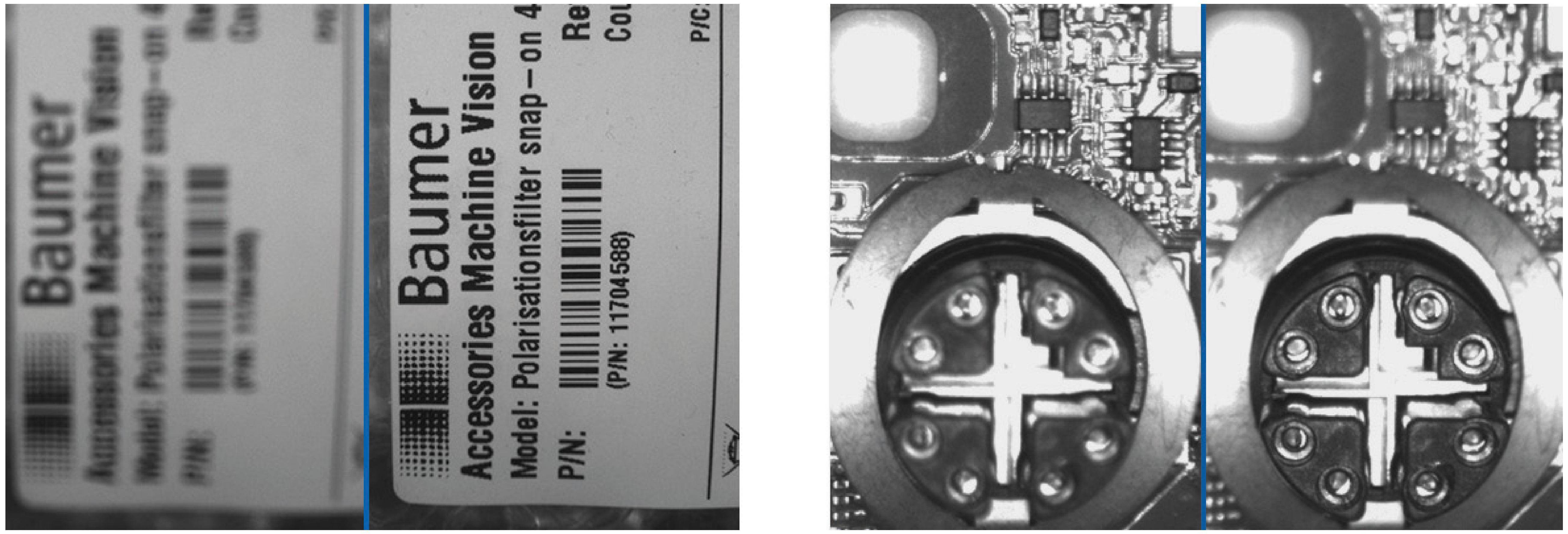
Making Machine Vision both Easy and Flexible

Compact camera system bridges gap to smart cameras

Industrial cameras are just one component on the way to a machine vision solution. There is a wide range of components and suppliers on the market that have to be tested, procured, integrated, wired, serviced and replaced in the event of discontinuation. With a new camera concept a manufacturer is taking the opposite approach: one component instead of many – optimally matching each other, highly integrated and with IP 67. The goal: making machine vision much easier.

The IXG cameras bridge the gap between high-performance PC systems and smart vision cameras. With this approach the camera series won the inspect award 2024.

all images: Baumer



Lens access for authorized persons only: The integrated autofocus with long-term stability can be adjusted by commands only to support process safety.

The realization of image acquisition is not only complex in terms of technology. There are further challenges in procurement, integration, installation, system costs and long-term availability. Consequently, a tempting idea are smart solutions in image acquisition with just a single hardware similar to smart vision. Image processing takes runs on a conventional high-performance PC providing all degrees of freedom – including optimum selection or use of even company-specific software.

Smart vision applications show that all-in-one is most often an appropriate compromise. Baumer is now taking this approach for PC systems in order to combine the advantages of both worlds: Simplicity, performance and flexibility. The main advantage of the concept is that mounting and image acquisition are reminiscent of the simplicity of vision sensors, while the powerful evaluation is handled by PC systems.

New product class enables easy installation without expert know-how

The Baumer IXG is an all-in-one camera integrating further to the image sensor also lens (6, 8 or 16 mm), autofocus and white LED lighting in a compact IP67 housing of 5 cm edge length. Display and LEDs provide user-friendly setup and operation. The IP 67 design is compatible with common photoelectric sensors without the need for complex enclosures.

The major benefit of a closed system is the simple installation less prone to errors of a single, tested component – even without expert know-how. Entire parameterization by GigE Vision commands would protect against unauthorized lens access, enables protected installation and provides the basis for tracking any change made, which means high-level process safety.

The GigE Vision interface opens the door to the world of camera systems, image processing PCs and software. This does enable using performant PCs for image processing with high flexibility. Multi-camera systems or additional cameras as retrofit are quickly and easily implemented.

Compact integration of lighting and electromechanical autofocus

Segementable lighting for optimum illumination supports applications up to 1.000 mm operating distance. Control of external specialized lighting for better flexibility in the application is another benefit. The electromechanical autofocus is designed to be thermally insensitive for long-term stable focusing.

It simplifies initial set-up and supports changing distance in different production batches. It is not intended for applications with short-term focus on individual objects – these are reserved to liquid lenses.

The optional polarization filter would suppress reflections from shiny objects made of metal or foil for improved evaluation reliability. The IXG is suitable for most varied applications across all industries, such as quality inspection, presence and completeness checks or identification. The all-electrical configuration used with appropriate software allows for parameter logging, as required for example in the pharmaceutical industry.

The compact, space-saving design ensures a small system footprint – important for machines in clean rooms. Besides OEM the camera is ideal for system upgrades like track & trace retrofit in positioning tasks in the pharmaceutical and food industries.

PC performance and smart vision simplicity combined

Image processing requires a PC with third-party PC-based software. This enables broad scalability in terms of flexibility and evaluation speed, including AI processing power. The free choice of software opens up many possibilities, application-specific user interfaces, backup solutions, access rights, logging and, last but not least, deep integration into own commands. This is supported by the IXG hardware since every change in configuration is made in the form of commands.

This concept becomes even more interesting when an existing application has already been implemented using a PC and now needs to be expanded. A typical use case: additional Track & Trace task in the form of object detection at a specific position with Datamatrix code. In this application, IXG adds like a satellite and becomes an integer part of the application via GigE Vision. The existing Vision PC is used. Identification utilizes the existing user interface or software. It may be possible to use existing software licenses. This is economical under several aspects.

The All-In-One GigE Vision cameras of IXG series are integrating lighting and autofocus in a compact housing.

Limiting factors

Of course, the compact design and selected components have their pros and cons. Thanks to the compact dimensions, IXG fits into installation space that previously was too tight for GigE Vision cameras and lighting. Lighting is limited by the front surface. A limiting factor is using polarizing filters absorbing 75 percent of light and shortest exposure time. Here, workarounds such as tilting the camera without filter or additional lighting should be considered. The technology, which differs from other Baumer cameras, cannot quite keep up with their values in terms of trigger delay and jitter, which is not critical for a large number of applications, but should nevertheless be taken into consideration.

Overall, the IXG cameras add a mainstream solution to the Baumer portfolio – where appropriate, users are provided with the mentioned benefits. Where not appropriate, the Baumer portfolio provides alternative solutions.

Conclusion

The cameras of the Baumer IX series are capable of many mainstream applications. They bridge the gap between high-performance PC systems and smart vision cameras. Users benefit from a compact plug & play product easy to integrate without expert know-how. A single component replacing several ones simplifies procurement while reducing space requirements and cost in parallel. Ultimately, a shorter time-to-market is achieved and in-house development resources are freed up for core tasks. Besides high performance, the PC allows a certain degree of freedom in the choice of software, application-specific modifications and logging. Of course, the pros and cons need to be weighed against each other. Where the camera having won the inspect award 2024, can be deployed, it will significantly reduce the image acquisition effort. ■

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Small and lightweight lidar sensor for robotics and drone applications

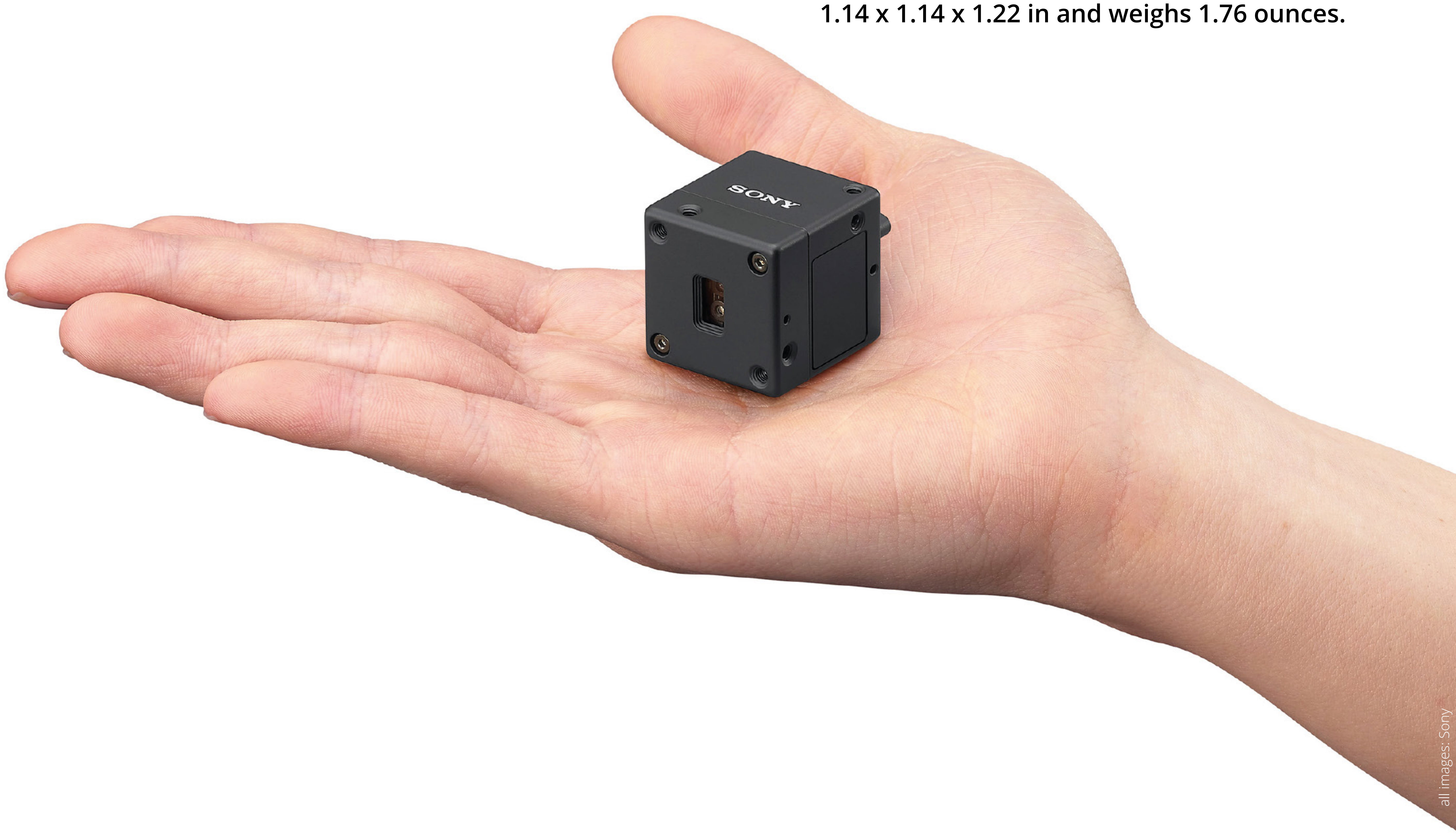
Lidar Depth Sensor Provides Precision Measurement Accuracy, Distance Resolution and Measuring Range

A compact Lidar depth sensor uses dToF technology to deliver accurate 3D measurements, even in challenging environments both indoors and outdoors. Its lightweight, robust design makes it ideal for drones, autonomous robots, and other space- or weight-constrained applications. Availability is planned for spring 2026.

Sony Image sensing Solutions is announcing commercialization of the AS-DT1 LiDAR depth sensor. This Lidar Depth Sensor structure measures 29 x 29 x 31 mm (approximately 1.14 inch width x 1.14 inch height x 1.22 inch depth), excluding protrusions, and weighing 50 g (approximately 1.76 ounces). The AS-DT1 leverages miniaturization and optical lens technologies from Sony's machine vision industrial cameras making it suitable for applications where space, and weight constraints are paramount including, drones, robotics, and more.

The sensor utilizes ‚Direct Time of Flight (dToF)' Lidar technology, which delivers fast and accurate measurement, distance resolution, and measuring range. The proprietary dToF ranging module equipped with a Single Photon Avalanche Diode (SPAD) sensor, utilizes multiple ranging points for distance measurement, and can accurately measure distances in three dimensions: length, width, and depth.

The AS-DT1 LiDAR depth sensor measures 1.14 x 1.14 x 1.22 in and weighs 1.76 ounces.



all images: Sony

The sensor's compact, lightweight design and rigid aluminum housing allow for integration for example into drones used for inspections and surveys.

The compact housing makes it easy to integrate into various devices, such as food service robots in restaurants, autonomous mobile robots in warehouses.

The AS-DT1 can even measure distances to low-contrast subjects and objects with low reflectivity, which are more difficult to detect with other ranging methods. This enables accurate measurement of distances even in environments such as retail stores, where various objects, including people and fixtures, are expected. In addition to its ability to accurately measure distances both indoors and outdoors, the sensor's compact, lightweight design and rigid aluminum housing allow for integration into a wide range of devices, such as food service robots in restaurants, autonomous mobile robots in warehouses, and drones used for inspections and surveys.

High Measurement Accuracy and Distance Resolution

Sony's proprietary dToF ranging module, equipped with a SPAD sensor, achieves accurate measurements and distance resolution. It can measure at various distances, for example at 10 meters (approximately 32.8 feet) with a margin of ±5 cm (nearly 2 inches) both indoors and outdoors. Additionally, it is capable of measuring distances to various objects that are difficult to detect with other ranging methods. This includes low-contrast subjects, objects with low reflectivity, and floating objects, making it suitable for integration into robots used in environments such as stores and warehouses.

Measurement Range

The AS-DT1 is accurate also at distances of 40 meters (approximately 131.23 feet) indoors and 20 meters (approximately 65.6 feet) outdoors under bright summer conditions (assuming 100,000 lux), which can be challenging when inspecting infrastructure such as bridges, highways, and dams.

Compact, Lightweight, and Robust Housing

By utilizing an aluminum alloy for the structure, it balances lightweight design and robustness. The compact housing makes it easy to integrate into various devices, such as autonomous mobile robots with limited space for depth sensors and drones where weight can impact flight time and distance.

The AS-DT1 is expected to be available in Spring 2026. ■

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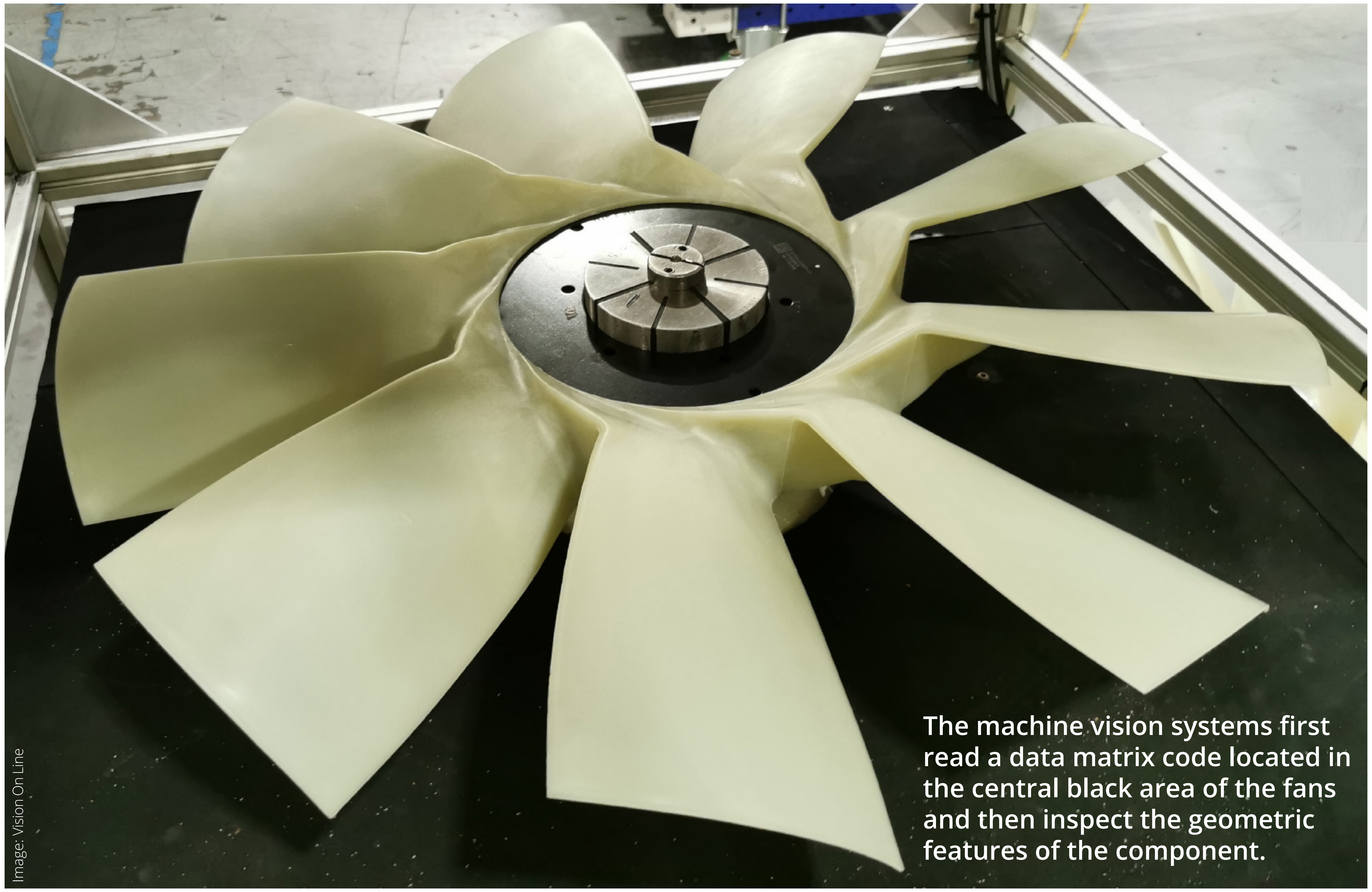
A New Approach to Fan Inspection

Reliable Quality Control during the Production of Fans for Diesel Engines

If engine's cooling fans fail, it can lead to the overheating of the power unit–and, in the worst case, to engine damage. That´s why an automotive components manufacturer inspects the quality of its fans. Since early 2024, machine vision systems have been ensuring reliable and cost-effective quality control at four testing stations in the company.



The machine vision systems first read a data matrix code located in the central black area of the fans and then inspect the geometric features of the component.

An automotive components manufacturer supplies many carmakers with its technologies. In the area of thermal management, this U.S.-based group also includes fans for large engines, such as those used in trucks, construction machinery, and other commercial vehicles.

"The company aimed to increase the level of automation in its production process and ensure that only flawless fans would be delivered to customers for later installation in engines to avoid consequential costs in the event of a defect," recalls Andreas Schaarschmidt, Managing Director of Vision On Line. "To implement the required vision systems, they were looking for an experienced partner. We had already successfully supported the company in previous projects, so we were very familiar with their processes."

High precision required

The machine vision systems from Vision On Line have been integrated into the production process of the fans, in four stations where the components are balanced. After placing a test specimen, the integrated vision system first detects a metallic, black-painted metal part that contains a data matrix code with information about the specific fan model. Once the vision system has read this information from the centrally located metal part, it is communicated to the manufacturer's internal PC-based control system to retrieve the target values for the fan under inspection.

Image: Büchner Lichtsysteme

A customized brightfield illumination from the TLS series by Büchner Lichtsysteme with an illuminated area of approximately 600 x 600 mm, fitted with a total of 3,500 blue LEDs ensures good lighting conditions when inspecting the fans.

Image: SVS-Vistek

SVS-Vistek´s Exo183MGE GigE Vision camera forms the perfect foundation of the deployed vision system, thanks in particular to its high resolution of 20 megapixels and a data rate of up to 120 MB/s.

In the next step, the vision system checks a number of characteristics of the components for compliance with the specifications. Among other things, it examines the correct number and geometric dimensions of the individual fan blades. For optimal performance of the finished fans, it is crucial that any overmolding or missing material be reliably detected with an accuracy of +/- 1 mm.

The measured data is then compared with the target values from the central control system, and if all specified parameters are met, the inspected fan can be statically balanced in the next steps and delivered to customers for later installation in engines. Faulty components are removed from the process and, depending on the type of defect, are either reworked or discarded.

A selected vision system

The task assigned to Vision On Line was extensive: on the one hand, the fan manufacturer had previously not used any system capable of automatically inspecting such fans. On the other hand, the components to be tested required a precisely tailored vision system configuration, as the fans demanded a relatively large field of view due to their diameters of up to 800 millimeters.

"The required precision could only be achieved by selecting a large brightfield illumination from Büchner and a high-resolution 20 MP camera from SVS-Vistek, combined with matching optics from OPT," explains Schaarschmidt. According to him, image evaluation is performed using the Halcon software library from MVTec.

A key factor in the final vision system for this application was the illumination, for which Vision On Line selected a customized model from the TLS series by Büchner Lichtsysteme. These brightfield area lights operate with either direct or diffuse light, are available in blue, green, red, white, and infrared, and can accommodate multiple camera openings as needed. For this specific application, it was important that the dimensions of the illuminated area could be configured up to 2 x 3 meters in 20 mm increments. For the fan inspection, Büchner produced a TLS variant with an illuminated area of approximately 600 x 600 mm, fitted with a total of 3,500 blue LEDs and an electrical power output of 177 W.

Based on his many years of experience with SVS-Vistek, Schaarschmidt trusted their cameras when making his selection: "We've integrated industrial cameras from this partner into our systems many times in the past. Since SVS-Vistek manufactures its cameras in-house at their facility in Gilching, Germany, we can also rely on timely delivery of the ordered units." For the inspection of the American manufacturer's fans, the Exo183MGE model is used. This camera is particularly well-suited to the application thanks to its high resolution of 20 megapixels and data transfer rate of up to 120 MB/s via the integrated GigE Vision interface. Another key advantage is the camera's integrated 4-channel power strobe controller, which enables precise timing of the LED lighting. This eliminates the need for a separate external controller, helping to reduce the overall cost of the vision system.

Defect Detection

A challenge for Vision On Line was to integrate the vision system into the manufacturer's internal PC-based control system, enabling seamless use and documentation of inspection results within the production environment. ■

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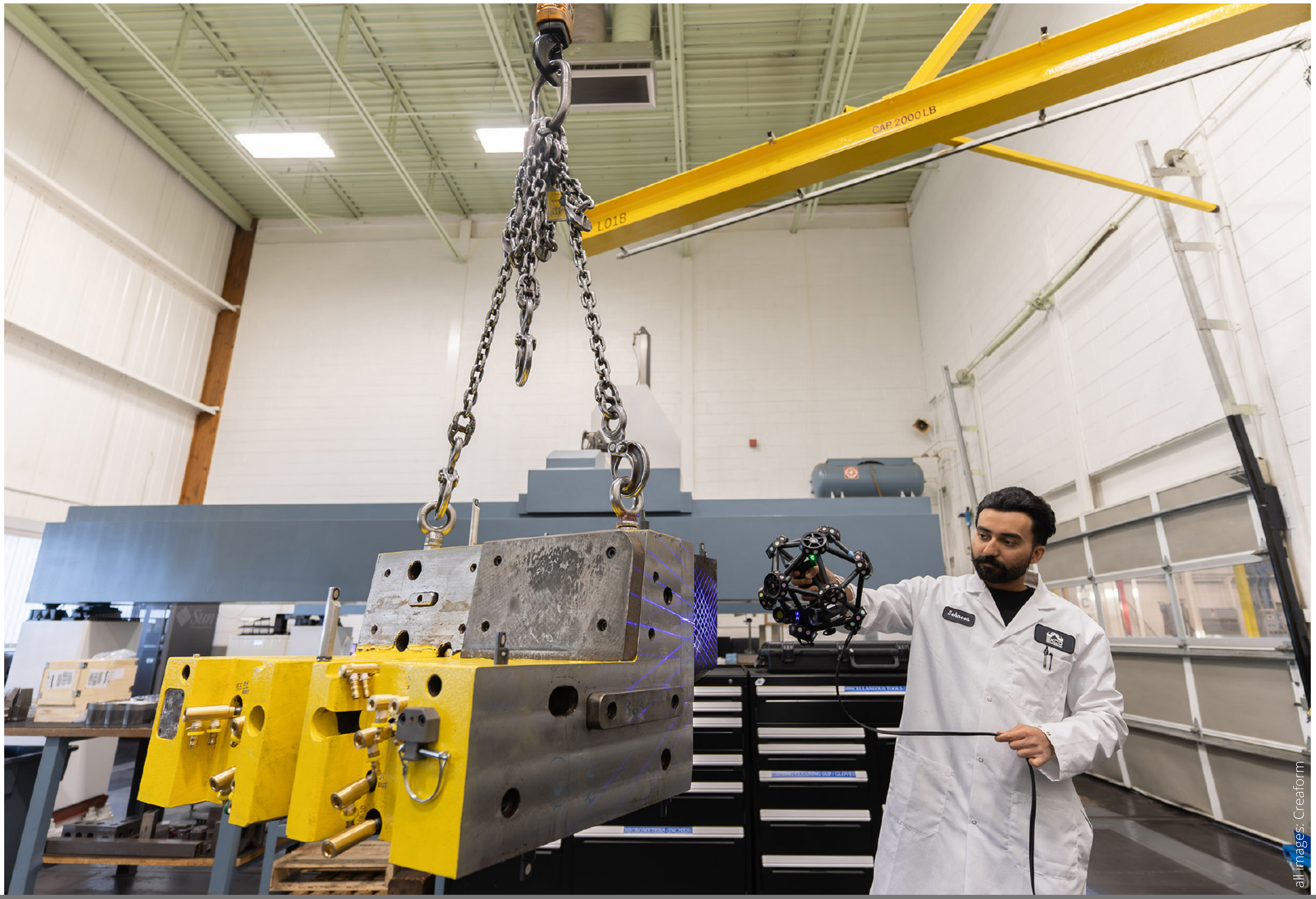
Part Inspection on the Shop Floor

3D Scanning Technology for High-Pressure Die-Casting Tooling

Quality control of high-pressure die-casting tools is challenging. For complex, large-format parts, CMMs quickly reach their limits. That's why a manufacturer now relies on a 3D scanner with inspection software. This allows components to be measured directly on the production floor—even inside CNC machines or while suspended from cranes. Unlike traditional methods, 3D scanning captures complete surface profiles and generates visual reports within minutes.



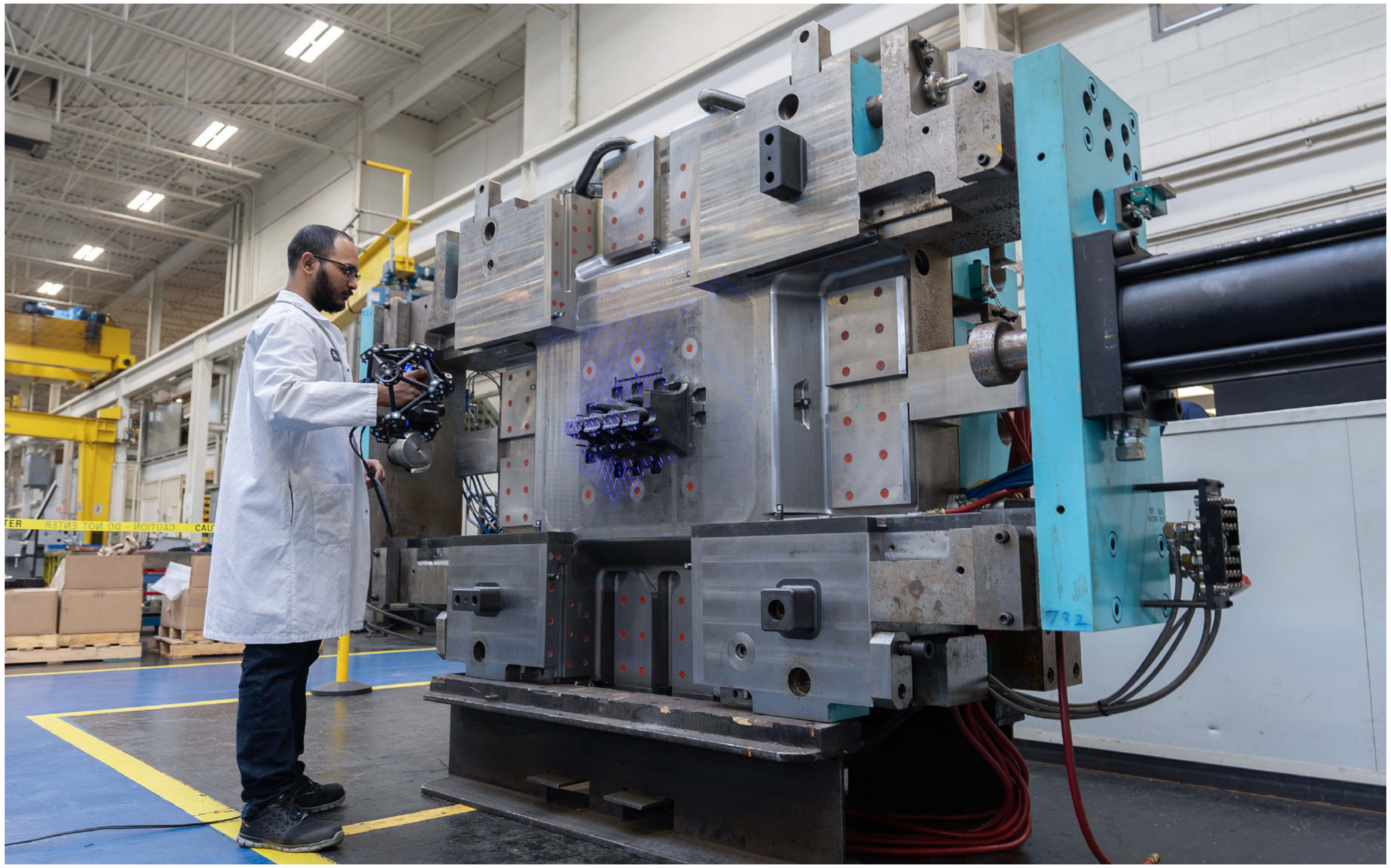
all images: Creaform

Exco Engineering supplies precision-engineered solutions to powertrain, body, and structural component manufacturers. From its advanced facility near Toronto, Exco delivers high-pressure die-casting tooling for automotive components—from engine blocks and transmission cases to body panels and structural parts. The company has made quality control a strategic priority. Traditional coordinate measuring machines (CMMs) and manual inspection tools once limited their ability to verify complex cavity features, especially in large die shoes. These limitations posed a risk of undetected machining errors, potentially leading to costly die crashes at customer sites.

Why 3D Scanning Became Essential

Exco's quality team recognized that probing systems could only capture isolated points, leaving gaps in inspection coverage. Deep ribs, long core pins, and intricate cavity geometries were often inaccessible. Even with one of North America's largest CMMs, full inspection of their largest tooling remained out of reach.

The Metrascan 3D scanner provides a high level of flexibility. This solution is capable of handling the intricate shapes and varying sizes of the components.



The inspection team quickly learned how to operate the Metrascan, improving their efficiency and accuracy.

To close this gap, Exco adopted Creaform's Metrascan 3D scanner and the Inspection software module. The transition wasn't immediate, as operators were initially skeptical. But as the team established standardized workflows and consistently achieved accurate results, confidence in 3D scanning grew rapidly.

Precision on the Shop Floor

Today, Exco's quality specialists use the Creaform Metrology Suite to inspect parts directly on the shop floor, even inside CNC machines or while suspended on cranes. The portability and speed of the Metrascan 3D system allow for real-time inspection of large, complex parts that were previously unmeasurable.

Unlike traditional methods, 3D scanning captures full surface profiles, enabling detailed colormaps that highlight deformations and deviations. These visual reports are generated in minutes, streamlining communication and accelerating decision-making.

"With the CMM, it seemed like we were looking at a molding area with one of the first black & white TVs. Now, after we implemented Creaform's scanning software using the MetraSCAN 3D in our daily activities, it seems like we are seeing the results in 4K as we can clearly see what's going on.", explains Jonathan Koot, Quality Systems Manager at Exco Engineering.

Improvement Through Digital Inspection

Exco now detects issues that traditional methods missed, refining machining, polishing, and programming processes with data-driven insights. 3D scanning has evolved from a measurement tool into a cornerstone of their continuous improvement strategy.

With Creaform 3D scanners and Inspection module, Exco Engineering not only prevented costly die crashes and the shipment of incorrectly shaped parts but also saved valuable operational time by cutting inspection time in half for certain parts.

Whether through rapid troubleshooting or on-site training, Creaform's team has been instrumental in helping Exco maximize the value of its investment. Commenting on Creaform's evolutive solutions, Jonathan concludes that "Creaform leads the way in portable 3D scanning. Whether it's speed, accuracy, or software, they're always improving." ■

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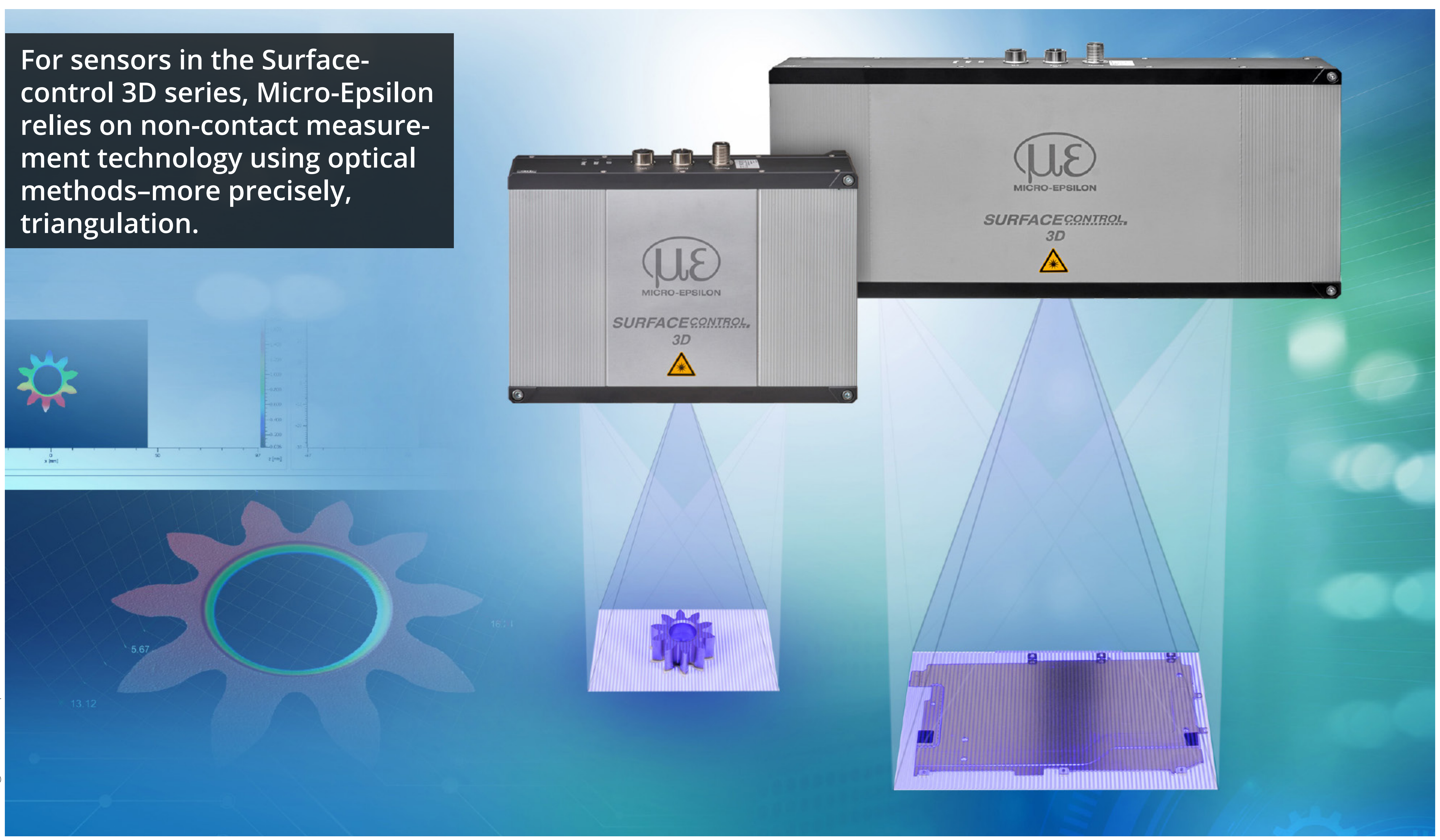
Precise Component Measurements

3D Sensors for Inline Inspection

Components with free-form surfaces, undercuts or fine structures are difficult to inspect which requires great effort. In order to fulfill these measurement tasks reliably, a sensor technology expert offers advanced 3D sensors with high measurement accuracies in the micrometer range for detecting small defects. The use of a 3D matrix technology eliminates the need for time-consuming sequential scanning of the surface, which enables a faster process. The 3D sensors are ideal for a wide range of industries–from metal processing and battery production to industrial automation.

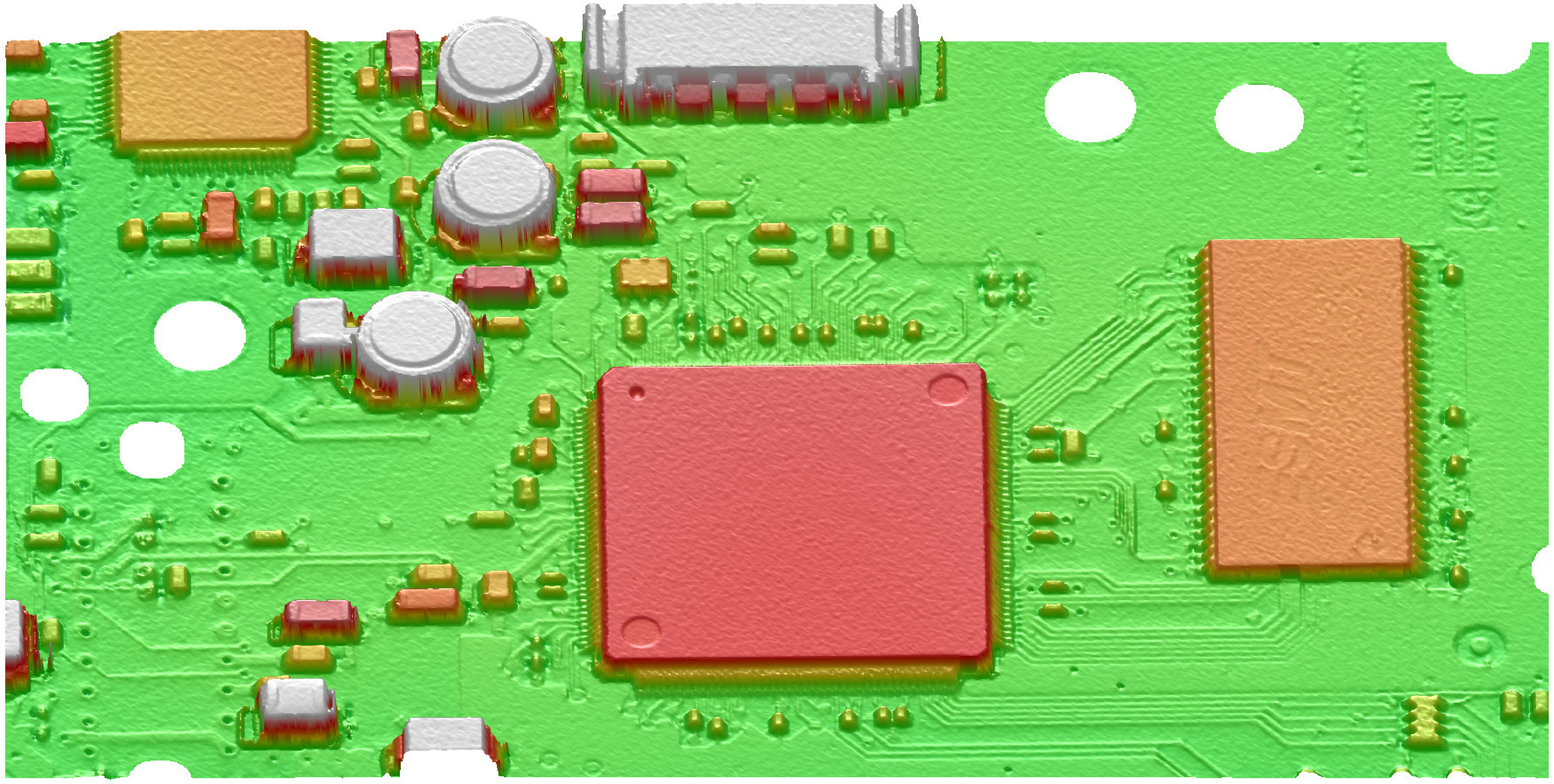


For sensors in the Surfacecontrol 3D series, Micro-Epsilon relies on non-contact measurement technology using optical methods–more precisely, triangulation.

all i Images: Micro-Epsilon Messtechnik

For sensors in the Surfacecontrol 3D series, Micro-Epsilon relies on non-contact measurement technology using optical methods - triangulation to be precise. The distance between the sensor and all points on a surface is measured using a triangular geometry: a so-called matrix projector in the sensor projects a striped pattern onto the surface of the measuring object with its LED light, the reflected light is recorded by two cameras in the sensor and evaluated using integrated signal processing based on trigonometric calculations. In this way, the sensor calculates the distance to each point on the surface of the measured object. The measuring method is suitable for a wide variety of surfaces, making it ideal for use in a wide range of applications and industries.

The sensors achieve recording speeds of up to 2.2 million 3D points per second, with each point having an x, y and z coordinate. Together, the measuring points result in a so-called 3D point cloud, which is generated in the sensor itself and output for further processing via standardized interfaces. It is used to generate and visualize measurement data for subsequent analysis and evaluation by software. The point clouds contain texture information of the measured object and can therefore reproduce a realistic image of the recorded object. To ensure the high quality of the products, all Micro-Epsilon sensors are calibrated and tested in the company's own factories and delivered ready for use with a test report.



With the small measuring range of the Surfacecontrol 3D 3500-30 sensors, a high-resolution 3D map of a BGA or the contact points can be created–allowing users to immediately detect and rectify defects or cold solder joints.

Measuring the Smallest Components

The current generation of 3D snapshot sensors Surfacecontrol 3D are available with different measuring ranges, starting at 30 mm up to 575 mm - depending on the variant and area of application. The latest addition to the model series is the Surfacecontrol 3D 3500-30 sensor with a measuring range of 30 mm and an x/y resolution of just 8 µm. It is suitable for the inspection of measuring surfaces with 31 mm x 19.5 mm. For measurements in harsh production environments or for use on robots, the sensor is installed in a robust aluminum housing and certified to protection class IP67. With a z-axis repeatability precision of 0.25 µm, the Surfacecontrol detects even small flatness deviations and height differences. As there are no moving parts in the sensor, it is low maintenance and cannot wear out.

The precise sensors are used in electronics production, for example: here, coplanarity describes whether all contact points or soldering points of ball grid array (BGA) components lie in one plane. Deviations lead to poor electrical connections or cold solder joints. With the small measuring range of Micro-Epsilon's surfaceCONTROL sensors, a high-resolution 3D map of the BGA or contact points can be created - allowing users to immediately detect and rectify defects or cold solder joints. Due to the high precision, height differences, parallelism and coplanarity can be reliably detected. The decisive factors here are the extremely low measurement noise, the fast measurement time of the sensors and the high insensitivity to ambient light, which ensure the high quality of the measurement data of the finished components.

Fast Commissioning and Calibration

To provide users with the best possible support in detecting defects, the manufacturer offers 3D Inspect software, a tool for quick commissioning and setup of the sensors. The software receives the measurement data from the sensor via Ethernet and displays it in three dimensions. Users can then process, evaluate and assess the 3D data on the PC in 3D Inspect with numerous integrated measuring programs and, if required, transmit it to a control unit via Ethernet. The 3D data can also be saved on a data carrier using the software. The sensor can also be easily configured and parameterized using the software. Alternatively, customers can use an easy-to-integrate software development kit (SDK) based on the GigE Vision and Genicam industry standards. ■

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Hyperspectral Imaging for Surface and Layer Analysis

Optical Wafer Inspection

By combining spectral analysis with high-resolution imaging, hyperspectral imaging enables full-surface, 100 percent inspection of wafers. This comprehensive approach detects layer thickness variations, contamination, and defects with exceptional accuracy. Hyperspectral imaging brings advanced, non-invasive inspection capabilities to the semiconductor industry and beyond. Direct inspection of production wafers leads to fewer defects, greater resource efficiency, and significantly faster inspection times.

Image: Dive Imaging Systems

Specim FX hyperspectral camera in wafer inspection

In semiconductor manufacturing, hyperspectral imaging evaluates the spatial distribution of thin film thickness of oxides, resists, or surface parameters before or after every processing step in lithography or CVD/PVD/ALD processes. Combining detailed spectral data with high-resolution imaging enables a thorough analysis of wafer properties, ensuring quality and consistency.

Dive Imaging Systems is a German-based manufacturer of tools for surface and layer inspection in semiconductor production. It builds Hyperspectral Vision systems – integrating hardware, software, and comprehensive solutions for industrial inspection tasks. With a primary focus on performance surfaces and thin film applications, the company addresses the need for meticulous inspection and quality control in thin-layer application processes.

Any deviation from specifications can lead to malfunctions, making accurate assessment crucial. Dive's technology offers a comprehensive evaluation of surface characteristics, particularly beneficial in semiconductor manufacturing. Beyond semiconductors, Dive's technology caters to a wide range of industries, including electronics production, glass or foil coating for optics, encapsulation, and cleanliness of bonding surfaces.

Dive's Vepioneer Hyperspectral Vision System for non-destructive wafer inspection

Specim FX10 and FX17 Hyperspectral Cameras

Dr. Philipp Wollmann, CEO of Dive Imaging Systems, states, "Our goal is to offer a fully integrated hyperspectral imaging solution for industrial inspection, providing comprehensive insights on surface characteristics and layer parameters like thickness, with the aid of artificial intelligence and machine learning."

With Dive's solutions, the success of processing steps in semiconductor manufacturing can be tested directly on production wafers, significantly reducing the need for standard test wafers. Hyperspectral cameras are crucial in this integration.

Improved Quality, and Faster Inspection with Hyperspectral Imaging

Hyperspectral imaging had a profound impact on Dive's system. By integrating Specim's FX10 VNIR and FX17 NIR hyperspectral cameras, Dive has achieved high accuracy and speed in their wafer inspection processes. According to Wollmann, hyperspectral imaging provides several advantages in wafer inspection over traditional imaging methods: "Hyperspectral imaging offers a significant leap forward in wafer inspection by enabling non-invasive, full-area analysis that improves reliability, supports the industry's zero-defect goal, and reduces both costs and waste. Notably, it reveals previously unknown quality-determining parameters and achieves high production efficiency with a scan time of 30 seconds for a 300 mm wafer."

"The integration of hyperspectral cameras has improved our imaging solution for industrial inspection regarding quality and efficiency. Looking ahead, we are excited to leverage this technology further to meet the evolving demands of the semiconductor industry", Wollmann states.

He believes that hyperspectral vision technology will revolutionize machine vision due to its ability to capture unique, detailed data from hundreds of images. This comprehensive data set is suitable for detecting nuances in industrial processes, surpassing the capabilities of traditional methods. Integrating machine learning and AI algorithms with chemical-analytical methods enables unprecedented combinations that offer innovative approaches to assessing product quality. ■

Technology in Detail

Hyperspectral Imaging

Hyperspectral imaging combines spectroscopy, which provides material and topology information, with imaging for shape and structure recognition, yielding a comprehensive data set. For instance, a layer stack data set can reveal layer thickness distribution, layer composition homogeneity, defect presence and classification, pore detection and quantification, quality classification, and downstream production step quality predictions.

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Products

S. 47

High-Speed Industrial Imaging
Lucid Vision Labs

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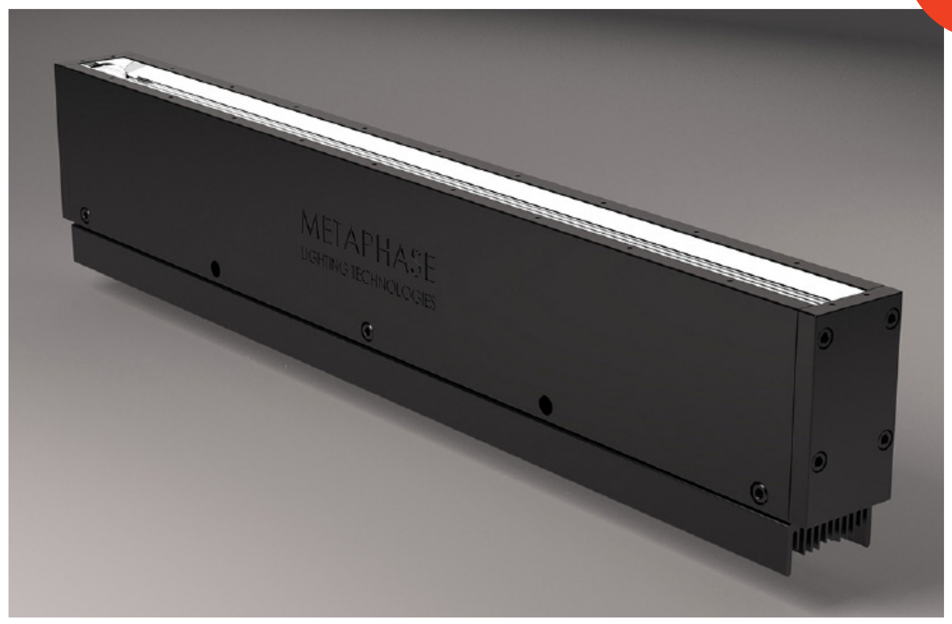
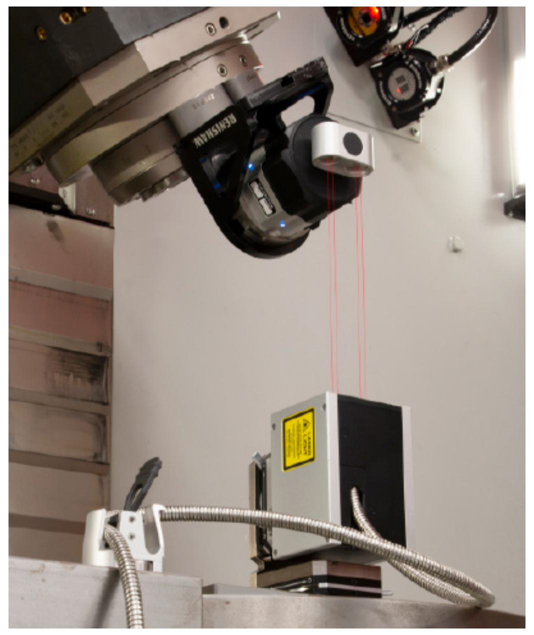


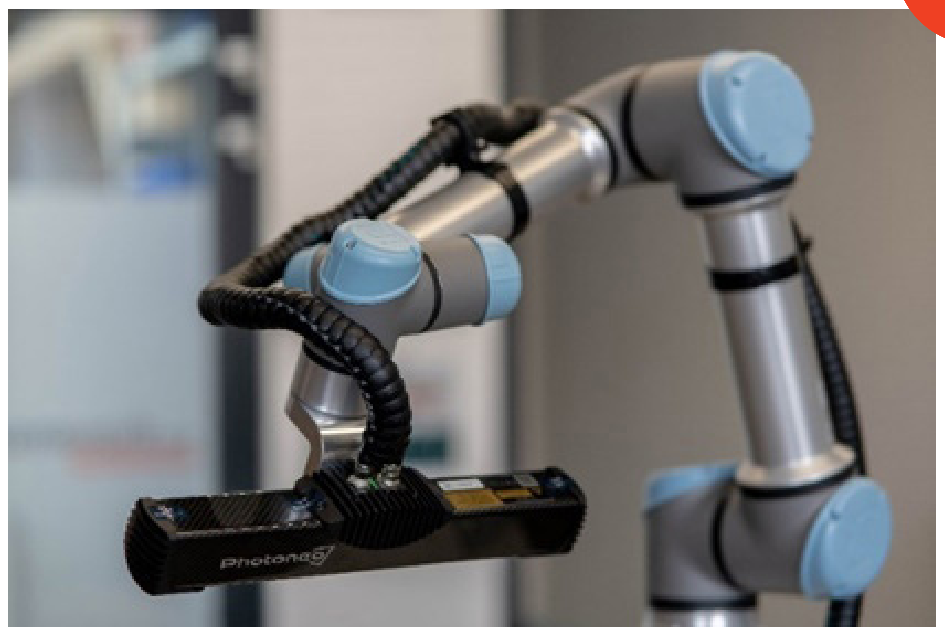
LED Line Light for Machine Vision
Metaphase Lighting Technologies

S. 47



Enhanced 5-Axis Measurement with New Calibration Tools
Renishaw

S. 48



Inline Quality Control with 3D Metrology
Senswork

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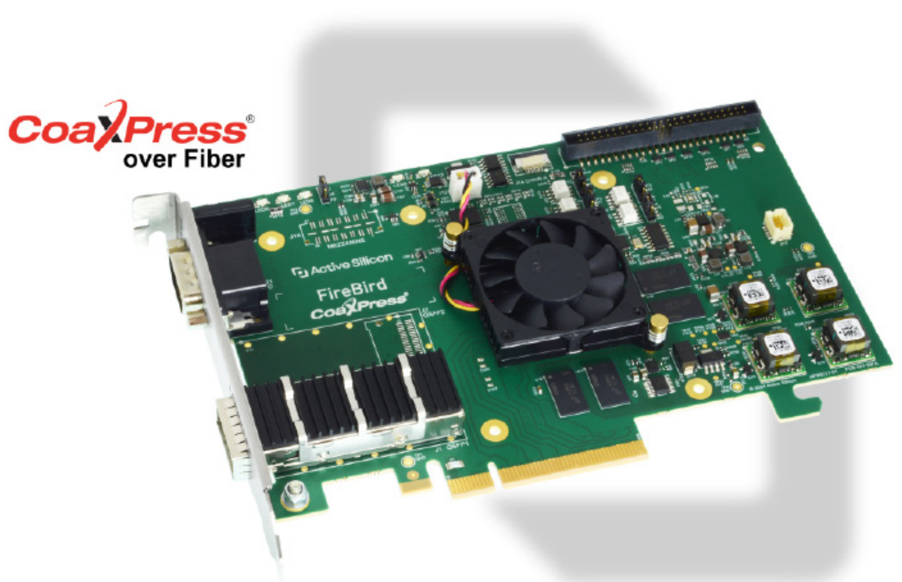

Frame Grapper with Fiber
Active Silicon

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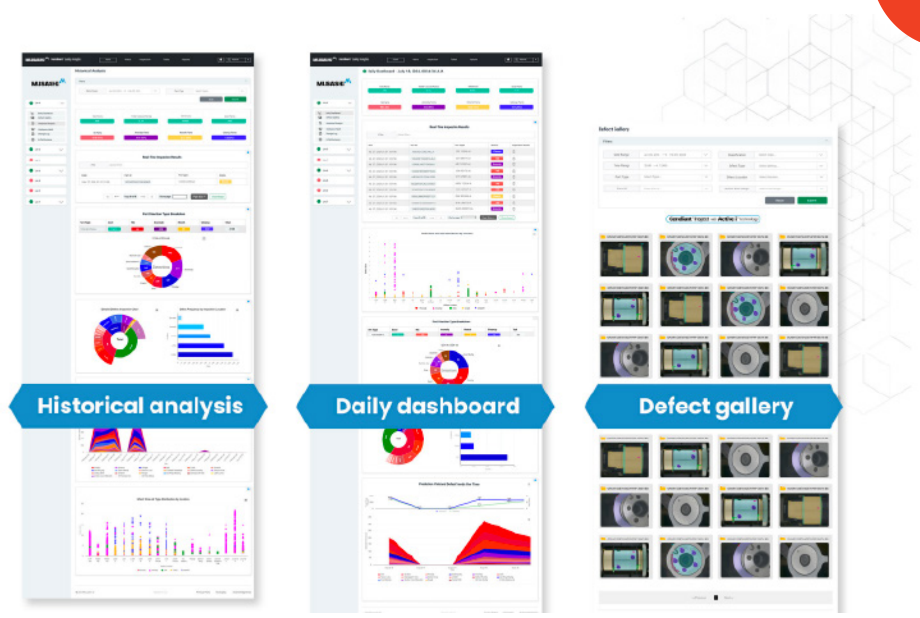


AI-Based Visual Inspection for Manufacturing
Musashi AI

Image: Lucid

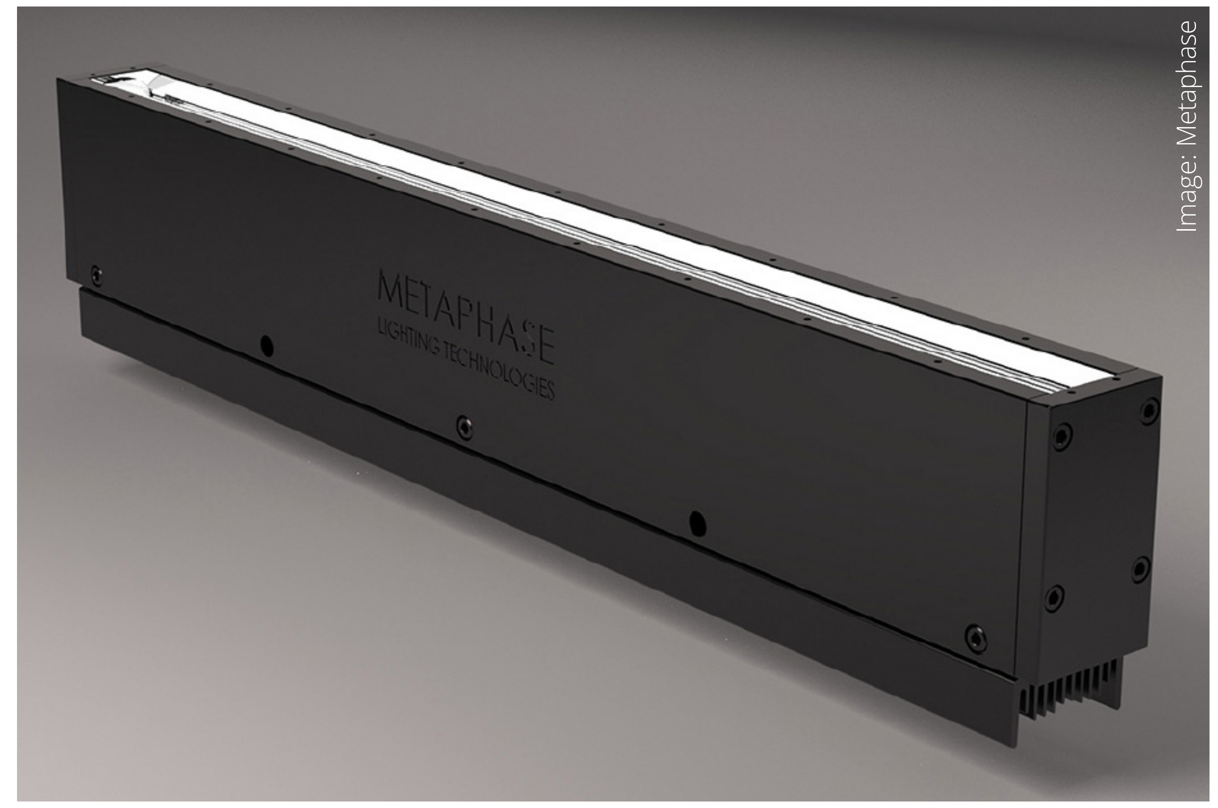


Image: Metaphase


Image: Renishaw

High-Speed Industrial Imaging

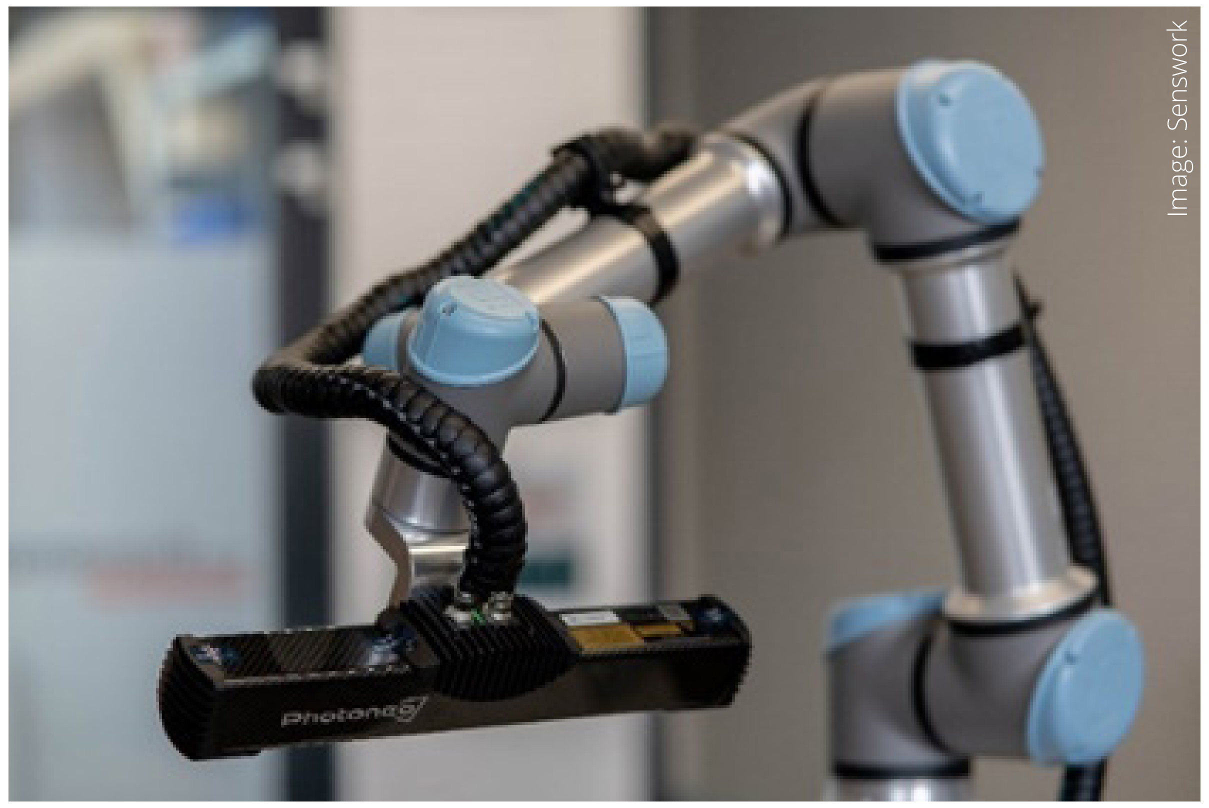
Lucid Vision Labs has launched the Triton10 camera family, featuring Sony's latest CMOS sensors from 5.0 MP to 24.5 MP. These cameras deliver high-speed imaging via a 10GigE interface with RDMA support, allowing zero-copy, high-throughput streaming up to 1.2 GB/s directly to main memory, reducing latency and CPU load. Built on Lucid's Factory Tough platform, the compact IP67-rated Triton10 is ideal for space-constrained environments, offering protection against dust and water. As a contributor to the GigE Vision standards committee, Lucid is integrating RDMA into the upcoming GigE Vision 3.0 standard, promoting broader adoption of high-speed Ethernet technologies. The Triton10 is designed for demanding applications like automated inspection and robotics, where performance and reliability are crucial. All Lucid cameras comply with GigE Vision 2.0 and GenICam³ standards and are supported by the Arena SDK, compatible with Windows, Linux 64-bit, and Linux ARM, and supports various programming languages.

LED Line Light for Machine Vision

Metaphase Lighting Technologies introduces the UB-LL, a passively cooled LED line light. Delivering up to 2.5 million lux, it offers uniform illumination for demanding machine vision applications. The UB-LL's design emphasizes high brightness and reliability without active cooling, enhancing energy efficiency and longevity. With a field-changeable beam configuration, it provides seamless lensing and customizable focal distances, optimizing high-contrast image capture for line scan cameras. The UB-LL is available in single or multicolor options, emitting UV, visible, or infrared wavelengths, with lengths from 5 inches to 10 feet. Its versatility addresses various machine vision challenges, from detailed inspections of printed circuit boards to highlighting defects on smooth surfaces. The UB-LL can be used as a front light for detailed inspections or as a backlight to reveal voids in high-speed web inspections, making it an adaptable solution for diverse industrial applications.

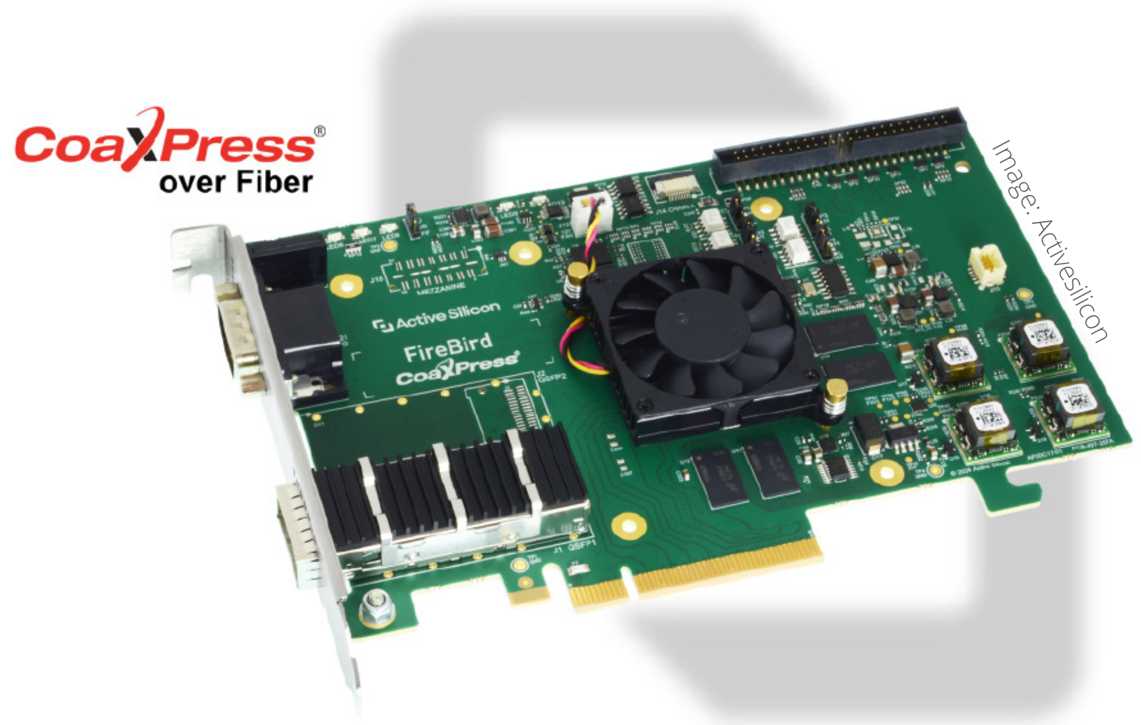
Enhanced 5-Axis Measurement with New Calibration Tools

Renishaw's latest Carto software suite version 4.8 introduces off-axis rotary measurement with the XM-60 multi-axis calibrator, streamlining the calibration of 5-axis machine tools. This new feature simplifies measuring all rotary axes using a single laser system, even when the Renishaw XR20 rotary axis calibrator cannot be mounted centrally. The XM-60 multi-axis calibrator enhances productivity by utilizing automatic sign detection and position-based triggers, reducing user errors. The XR20 remains a leading solution for direct rotary error measurement. The Carto suite, comprising Capture, Explore, and Compensate applications, enables users to collect, analyze, and correct errors efficiently. Renishaw will showcase this advanced digital ecosystem at the IMTS 2024 exhibition, highlighting its capabilities in laser calibration for various configurations. This development provides users with a comprehensive tool for quick, accurate data capture and analysis, improving overall calibration processes.



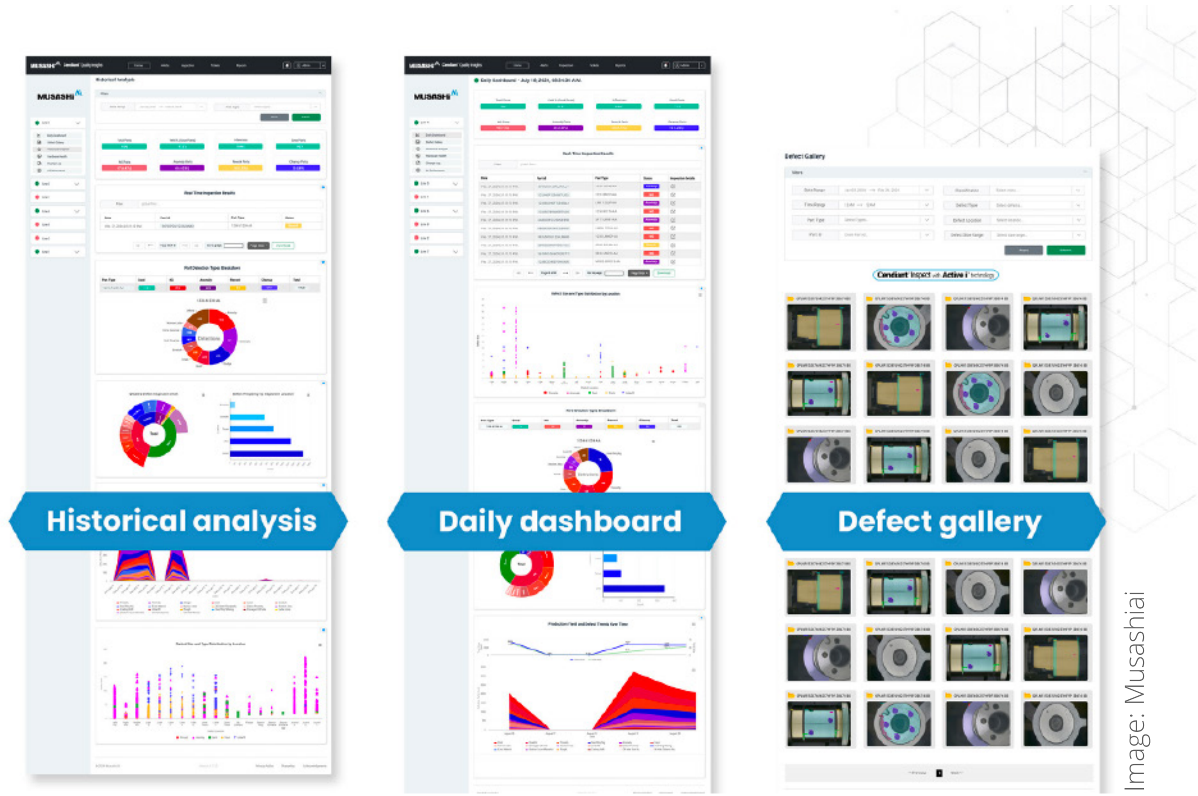
Inline Quality Control with 3D Metrology

Senswork, in collaboration with Photoneo, has developed an advanced robot-assisted 3D inspection and metrology system for real-time quality control in manufacturing. This innovative system utilizes collaborative robotics and cutting-edge 3D vision technology to enhance quality inspection processes. The system offers real-time defect detection, identifying imperfections with high precision, and GD&T-compliant 3D metrology for accurate inline measurements. It seamlessly integrates into production lines, supporting continuous automated quality control. Roman Rieger, CEO of senswork, highlights the potential of combining 3D machine vision with robotics for enhanced industrial inspection. František Takáč from Photoneo emphasizes the collaboration's success in achieving unparalleled accuracy and efficiency in quality control processes, providing a robust solution for detecting defects across various textures and materials directly on the production line.



Frame Grapper with Fiber

Active Silicon has introduced its latest Firebird capture card, the 4xCOF-12 frame grabber, which leverages the proven CoaXPress FireBird technology and is designed for use with fiber optic cables. Fiber optics offer significant advantages for high-speed image processing, especially over long distances or in electrically noisy environments. With the appropriate choice of cables and transceivers, cameras can be located kilometers away from the frame grabber and PC. The FireBird CoaXPress over Fiber 4xCOF-12 features a QSFP+ port that captures image data at speeds of up to 40 Gbps. It is fully GenICam-compliant and employs Active DMA technology for rapid data transfer without CPU intervention. Additionally, it provides data forwarding capabilities to distribute image processing across multiple PCs. Engineers can consider the robust Oncilla Machine Vision Computer with an integrated Firebird 4xCOF-12 frame grabber for a complete vision system.



AI-Based Visual Inspection for Manufacturing

Musashi AI has unveil updates to its Cendiant Inspect AI software and Automated Shaft Inspector. In automotive manufacturing, defects like chatter during grinding can affect part quality. The new surface inspection model in Cendiant Inspect effectively targets chatter, offering precision similar to optical shaft measurement machines, thus reducing waste and rework. Additionally, Musashi AI will introduce a chatter inspection module for its Automated Shaft Inspector. This demonstrates the flexibility of AI-enabled inspection software to handle complex applications across industries, from automotive to electronics and consumer goods. Enhancements to the Cendiant Quality Insights platform include a ticketing system for real-time feedback, improving inspection performance and integration speed. These innovations streamline processes for businesses, facilitating faster deployment and enhancing inspection accuracy across various sectors.

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