IMAGING & MACHINE VISION EUROPE

For suppliers, integrators and OEMs using machine vision

August/September 2022
Issue 112

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Leader
Greg Blackman

Show time!

The Vision show in Stuttgart is fast approaching, and in this issue we're looking forward to some of the technology that will be on display when the trade fair opens its doors. There's a preview of product presentations on page 28, while on page 24 we run through the technical details of the five innovations shortlisted for the Vision Award. *Imaging and Machine Vision Europe* is proud to sponsor the award, and our managing director, Warren Clark, will present the winner with the prize live at the show on 5 October.

The award is a good indicator of how the machine vision sector is changing. This year, the shortlist contains two instances of ways of using machine learning; software to automate path planning for robot inspection; 3D vision technology; and a shortwave infrared camera. Innovations in 3D imaging have been present throughout the award's history, stretching back to 1996, which in itself says something about 3D vision, how varied the area is and how much room there is for new developments. What's also recognised in the shortlist are the rapid advances being made in machine learning and AI, which are now coming to the fore in the industrial vision sector, as well as the potential for new ways of designing vision systems *in silico*, and the promise quantum dot sensors bring for making SWIR imaging more accessible.

It's exciting times for the vision industry, and there's a great deal of anticipation surrounding the show in Stuttgart. The team at *Imaging and Machine Vision Europe* will be there, reporting from the event, so please do drop by our booth, 10A90. We look forward to seeing you!

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Business News

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Cognex loses $44.9m of stock in fire at Indonesia plant

Cognex posted 10 per cent growth year-on-year for the first half of 2022, but has had to write off $44.9 million of inventory stock from a fire at its manufacturing plant in Indonesia in June.

No injuries were reported from the fire, and there was no significant damage to the production floor and equipment used to assemble Cognex products. However, a large portion of the company's component inventory was destroyed.

Cognex will recover $27.5m of the losses from insurance, but recorded a non-cash net charge of $17.4m in Q2-22.

The firm's CEO, Robert Willett, said the lost stock 'was particularly disappointing given all our hard work to put us in a strong supply position prior to the fire'.

The company is working to replenish its inventory.

The fire, which happened on 7 June, did not have a material impact on Cognex revenue in Q2-22, given the timing of the incident.

However, Cognex expects revenue for Q3-22 to be between $160m and $180m, which is around $100m down on its Q2 revenue, largely because of the impact of the supply disruption caused by the fire, as well as lower expected revenue from e-commerce logistics.

Revenue for Q2-22 was $274.6m, an increase of 2 per cent from Q2-21 and a decrease of 3 per cent from Q1-22 (in constant currency, revenue increased by 6 per cent year-on-year and declined by 1 per cent sequentially).

Revenue from customers in the consumer electronics industry grew significantly over both Q2-21 and Q1-22, Cognex reported, thanks to the timing of large deployments and higher expected revenue for the year overall.

In contrast, revenue from the logistics industry declined substantially both year-on-year and sequentially because of lower spending on automation projects for new fulfilment centres. Customers are scaling back spending on new e-commerce centres after two years of heavy investment that benefitted Cognex, according to Willett.

Cognex also experienced slower spending trends in the broader factory automation market relative to Q2-21 and Q1-22.

Covision and Newsight join Nvidia programmes

Covision Quality, a provider of visual inspection software based on unsupervised machine learning, and Newsight Imaging, which develops 3D machine vision sensors and spectral vision chips, have both joined Nvidia development programmes.

Covision Quality has joined the Nvidia Metropolis partner programme, which offers an application framework and a set of developer tools to help bring to market a new generation of vision AI applications.

Franz Tschimben, CEO of Covision Quality, commented: 'We expect that Nvidia Metropolis, which sits at the heart of many developments happening in the industry today, will give us a boost in our go-to-market efforts and support us in connecting to customers and system integrators.'

Covision Quality is a spin off of Covision Lab, a European computer vision and machine learning application centre. Covision Quality licenses its visual inspection software product to manufacturing companies in several industries, ranging from metal manufacturing to packaging.

Newsight has joined the Nvidia Inception programme, which is designed to nurture start-ups. The programme will enable Newsight to expand its approach to the automotive depth-vision ecosystem, which includes makers of lidars, advanced driver-assistance systems, autonomous vehicle-safety technology and to support customers wishing to build products based on Newsight's sensors and the Nvidia AI platform.

Eli Assoolin, Newsight Imaging's CEO, said the collaboration with Nvidia will provide Newsight with additional resources to scale faster, and advance its sensors and solutions for 3D machine vision and spectral analysis.

Jochem Herrmann retires on Adimec's anniversary

Jochem Herrmann, Adimec's chief scientist, has retired 30 years after co-founding the company.

Herrmann, and his co-founders, Just Smit and Bas Heijn, began the company in 1992. He also served on the board of the European Machine Vision Association from 2012, and was president from 2015 to 2019.

Herrmann was instrumental in the development and success of the Coaxpress standard, which won the Vision Award at the Vision show in Stuttgart in 2009. During the company's 30th anniversary celebrations in July, Just Smit said: 'Without Jochem's contribution, this interface would not have been where it is now, in this structured way with all the competitive advantages for Adimec.'

The director Of R&D at Grass Valley Cameras, Klaas Jan Damstra, added his praise: 'Jochem is interested in a broad range of technologies, always looking for customer and market solutions, never just trying to find a customer-specific solution, but always with a broader view for a better applicability, preferably working towards market standards.'

Speaking to *Imaging and Machine Vision Europe* in 2015, after being voted in as president of the EMVA, Herrmann pointed to embedded systems playing a more important role in the vision industry in the future, something that has certainly been proven true.

He also said that the EMVA wanted 'to sharpen its profile as an interface between academia and industry'. The EMVA launched its European Machine Vision Forum in 2016, with an aim to bring together machine vision and academic research – the 2022 version will take place in Cork, Ireland, at the end of October.

Based in Eindhoven, The Netherlands, Adimec has grown from 15 initial employees to almost 200 today. The company can trace its roots back to Eindhoven's dominant employer in the 1980s, Philips.

Adimec now has offices in Boston, Seoul, Shanghai, Shenzhen, Singapore, and Tokyo.

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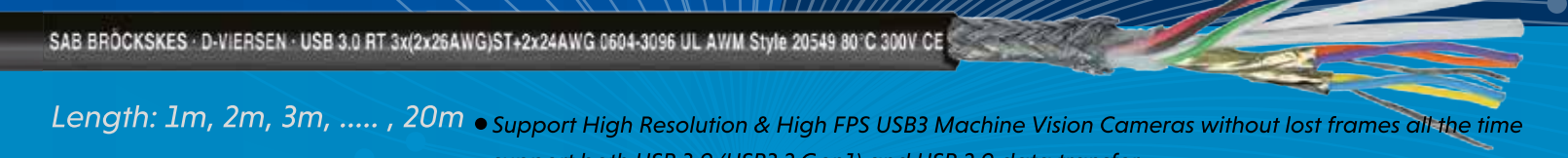

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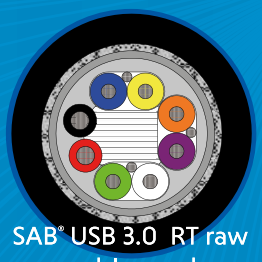

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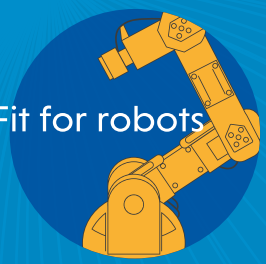

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News from EMVA

By Thomas Lübkemeier

Vision 2022 is approaching and hopes are high to see the show again in full format without any travel restrictions. As is usual at Vision, EMVA is organising the International Vision Standards Booth and we invite all visitors to stop by at hall 8E24.

Furthermore, EMVA is organising the popular International Vision Night event on 3 October, the evening before the trade show opens. This will be the 13th Vision Night, where the machine vision community will meet for a pleasant evening in a casual setting, enjoying dinner and networking opportunities. This is the place to meet CEOs, managing directors, corporate strategists, marketing and technical managers, and media representatives to exchange market intelligence before the trade show begins. Limited tickets for the networking event can be booked via **www.vision-night-emva.org**.

European Machine Vision Forum

'Academic research meets machine vision industry' – this statement is at the core of the EMVA's annual two-day vision forum, taking place from 27-28 October in Cork, Ireland. Here, both academia and industry will find a platform to learn from each other, get an understanding of the newest research results, discuss open problems from applications, learn about new and emerging application fields, and exchange new research cooperation between industry and academics. The event will include invited plenary talks, poster presentations and software demonstrations. This year's motto, 'Accuracy, reliability and limits of machine vision', is supported by local partner, Tyndall National Institute, which is hosting the event. More information and registration is available at **www.european-forum-emva.org**.

New members

Three more companies have recently joined the EMVA. Photonis, a high-tech organisation experienced in innovating, developing, manufacturing and selling photo sensor technologies. Headquartered in France, Photonis manufactures electro-optic components used in the detection and amplification of ions, electrons and photons. EMVA also welcomes Tower Semiconductor, a stock-listed leader in analogue semiconductor foundry solutions providing technology and manufacturing platforms for integrated circuits in markets such as consumer, industrial, automotive, mobile, infrastructure, medical and aerospace and defence.

Last but not least, Heliotis from Switzerland has joined. Heliotis develops, manufactures and distributes optical 3D measurement technology for industrial quality control. Its core competence is in the development of CMOS image sensors, FPGA-based cameras and optical measurement technology. Welcome all!

Headwall buys software and optics firms

Headwall Photonics has acquired Netherlands-based spectral software provider, PerClass, along with US optics company Holographix.

PerClass's Mira spectral analysis software package is designed for spectral image analysis for machine vision applications in research, industrial and various commercial deployments.

Headwall's Hyperspec MV.X already uses the software to create spectral classification models and deploy them in applications such as the detection of food contamination and material sorting in recycling.

Meanwhile, Holographix will enhance Headwall's manufacturing processes, and ultimately its hyperspectral imaging business.

Holographix designs and manufactures diffraction gratings, microlens arrays, diffusers, diffractive waveguides and other custom optics. It has replication technology able to reproduce any kind of surface relief structure on an optical element, from macro-surfaces such as mirrors or lenses, to nanostructures with feature sizes less than 10nm.

This shortens the time to prepare optical masters, such as the master holographic gratings that Headwall manufactures. Holographix says its UV replication process takes a matter of minutes to reproduce the optic.

Don Battistoni, president of Headwall, said: 'Adding Holographix's replication technology opens channels to new customers and markets.'

Both firms have manufacturing facilities in Massachusetts.

TKH gains stereo vision with Nerian acquisition

The TKH Group, which owns Allied Vision, Chromasens, LMI, Mikrotron, Net, SVS-Vistek and Tattile, has acquired Nerian Vision to add stereo vision to its portfolio.

Based in Stuttgart, Germany, Nerian's sensors incorporate an FPGA to capture and process stereo vision images into 3D data at more than 70 million 3D points per second and frame rates of up to 125Hz. This allows for real-time capture of high-resolution 3D data at both near and far range.

Nerian will join TKH Vision, while continuing to sell its products under the Nerian brand and maintaining its existing partnerships.

Nerian cameras are available with IP67 protection ratings for use in harsh environments and with synchronised inertial measurement units embedded in the sensors. Nerian 3D cameras are fully compatible with active pattern projectors for increasing accuracy on difficult-to-measure objects.

In brief

SVS-Vistek and **Mikrotron**, both owned by TKH Vision, have merged to bring together their competencies in high-end camera technology. The partnership is intended to open up new market segments and create the conditions for further growth.

Basler's sales have increased by 14 per cent year-on-year to €130.8m in the first half of 2022. The company also reached the milestone of 1,000 employees this year.

Edmund Optics has appointed Samuel Sadoulet as its CEO and Marisa Edmund as chair of the board of directors, as Robert Edmund retires. Sadoulet has 25 years of management and engineering experience at Edmund Optics.

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Stemmer building on solution expertise as it turns 35

Stemmer Imaging celebrated its 35th anniversary this year. We spoke to Stemmer's **Mark Williamson** about adapting to a maturing vision sector

Stemmer Imaging is celebrating three anniversaries this year: it turned 35 in the summer; the origins of its UK branch is 25 years old; and its software suite, Common Vision Blox, has also reached the 25-year milestone.

All three have changed substantially since their inception, largely because they are now operating in a very different world to the one 25 or 35 years ago. Mark Williamson, managing director of Stemmer Imaging UK, said there are now two strands to Stemmer's business: the solutions side, working with volume customers to devise a subsystem solution to a specific problem; and selling components to customers who are familiar with vision technology and know what they're looking for.

The solutions side is thanks in part to growth in markets outside of factory automation, which are becoming aware of the power of vision technology. Williamson said factory automation is still growing, but the faster growth from Stemmer's perspective is in other areas, such as entertainment – companies, for example, setting up social gaming venues, an extension to bars and nightlife venues, are using computer vision to track objects to create a fun, real-time interactive experience. It's these types of customer, whose core business has nothing to do with engineering, that value the services Stemmer can offer, Williamson said, such as consulting during the system design phase and manufacturing the vision subsystem for deployment. Building the subsystem can include component assembly, lens and camera set-up, along with calibration to make deployment in the venue easier.

Stemmer Imaging

Common Vision Concept, the precursor to Common Vision Blox, being shown at the Hannover Messe in 1999

'Selling components is very different to partnering together to create a bespoke solution to solve a specific imaging problem,' Williamson explained. 'That [creating a bespoke solution] is an engineering sale.'

Stemmer Imaging is still selling vision components into machine vision and factory automation, but here, the system integrators generally have the skills to build and configure their machines and also know the specifications of what they need in their systems. 'These integrators want us to have stock that's on the shelf and easy to deliver, and that was the original concept of Stemmer Imaging's European strategy in 2004,' explained Williamson.

The year 2004 was when Stemmer Imaging bought Firstsight Vision, the company Mark Williamson and David Hearn founded. Prior to this, Stemmer Imaging was only present in Germany, but the founder Willi Stemmer had ideas to have a central warehouse of stock – the machine vision market was still relatively small at this time, but there were thousands of potential →

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Stemmer Imaging

The Stemmer Imaging UK team celebrating the 35th anniversary

products, too many for small regional companies to stock. The 'Stemmer Goes European' concept relied on this central warehouse and having regional offices in different European countries that could then offer next-day shipping on the widest number of products. Stemmer Imaging UK was established in 2004 as the first outside Germany, and by 2014 Stemmer Imaging had subsidiaries in 11 European countries. Expansion has continued, with more than 20 countries in Europe and Latin America covered by Stemmer's subsidiaries at the end of 2021.

The UK branch has its roots in the two companies Mark Williamson and David Hearn set-up in 1997, Pinnacle Vision and Vortex Vision respectively. Willi Stemmer had a stake in Vortex Vision, and when Vortex Vision and Pinnacle Vision merged in 2001 to form Firstsight Vision, creating the largest distributor in the UK, his financial interest carried over to the new firm.

Stemmer Imaging was founded in 1987 from Stemmer Electronics, which originally provided data acquisition technology involving imaging and networking. Willi Stemmer eventually sold the acquisition and networking part of his business to focus on Stemmer Imaging. 'At that time, the networking industry was probably like the vision industry is now,' Williamson said. 'Now, networking is mainstream with different commercial drivers and a different business model.

'Networking has migrated to commodity component sales,' Williamson added, with few value-based solution providers that can create complex architectures. 'Vision isn't at that stage, as you do need technical know-how to get the basic components to work together and hence require support,' he continued. 'Our market isn't a commodity market yet but is trending in that direction.'

Today, Stemmer Imaging employs around 330 people, with revenue in 2021 of €130.1m. It's differentiating itself in terms of the solution side of its business by adding value for customers, with consultation, modification and component assembly, writing software modules or manufacturing subsystems. Stemmer has always done customisations, but there is a subtle shift to focusing on projects where the vision expertise of its staff really pays dividends.

Meanwhile, the company still holds around 20,000 components in its central warehouse for shipping all over Europe. The component side of its business will continue to grow, and Williamson said Stemmer Imaging is working on a new website with a lot of functionality to help customers find the right components for their systems, and automate the transactional business to some extent.

> 'Where the [advantage of] expertise will come in is talking to new markets that are not factory automation'

'We're recruiting more people that have worked in more mature industries who understand the challenges, and restructuring how we do things to be more efficient, enabling us to scale while delivering improved services,' Williamson said.

He added that one of the challenges facing machine vision companies is how to scale quickly. Williamson said: 'The best people are the people that have been in the industry for a while. To get good you need many years' experience in the industry. This is a problem for all vision firms, as the modern trend is for young people to move jobs much more readily than they used to.'

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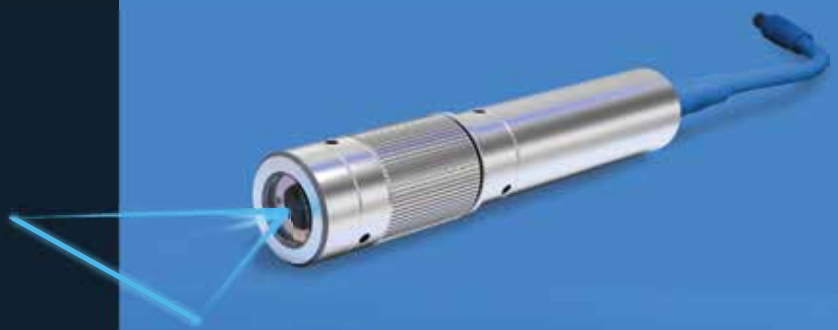

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→ Software building blox

Stemmer Imaging's Common Vision Blox (CVB) software suite dates from the same year Williamson started Pinnacle Vision, in 1997. At that time, building a vision system required a custom cable, and each hardware manufacturer provided different APIs for different software packages. 'Vision software companies had to support lots of different hardware, and hardware companies were struggling to get their boards supported by software,' recalled Williamson. The Common Vision Concept, the precursor to CVB, was originally a layer that allowed different software tools to be run with different camera and frame grabber hardware. CVB's image manager tool is still going, and is now included with every GigE Vision or USB3 Vision camera Stemmer Imaging sells.

When the first machine vision camera interface standard, Camera Link, was launched, the cabling problem was simplified, but not from a software standpoint. CVB really made a difference, which led to Stemmer's CVB developers being instrumental in establishing the GenICam standard – the generic programming interface for machine vision cameras – which is now adopted in all machine vision camera interface standards.

'We're tending to focus Common Vision Blox more on making [image] acquisition as easy as possible, while developing processing tools for specific unique use cases,' Williamson explained. As a distributor, Stemmer Imaging also sells other software, such as Sherlock from Teledyne Dalsa and Halcon from MVTec in some regions – Halcon also celebrated its 25th anniversary this year. 'We recognise the need to recommend the right product for the right job to give the customer the best outcome,' Williamson said.

Stemmer Imaging

Stemmer Imaging UK after Vortex Vision and Pinnacle Vision merged in 2001. Four of the nine original employees are at Stemmer UK today

A bright future

Looking to the future, Williamson said machine vision cameras will continue to get faster and produce more data, requiring higher bandwidth interface standards. There's also a lot of processing inside of cameras now, thanks to FPGAs and ASICS. Features such as JAI's Xscale allow the user to define virtual pixels, making migration between sensors a lot easier. Meanwhile, Allied Vision's Alvium ASIC delivers features such as 5 x 5 advanced image processing, and Dalsa's Turbo-drive allows camera data rates to exceed that of the camera interface.

'Where the [advantage of] expertise will come in is talking to new markets that are not factory automation, because they [factory automation customers] already know their technology,' he added. 'It's these new markets, where there is a steep learning curve to understand vision, where they need a consultant to say: "These are the components you need, this is the right algorithm to solve the problem", with the ability to write demonstrator software to accelerate the time to market.'

Williamson has a poster from Stemmer Imaging's 25th anniversary, 10 years ago, showing everyone working for the company at the time. While a significant number of staff remain, there have been lots of changes in the last 10 years: David Hearn sadly passed away in March 2020; Willi Stemmer sold his shares in the company to Munich-based AL-KO, now Primepulse, in 2017; and Stemmer Imaging is now listed on the Frankfurt Stock Exchange. Arne Dehn took over as CEO from Christof Zollitsch in 2019 – Stemmer's executive board is now made up of Dehn and Uwe Kemm (CEO), with a strong senior leadership team being a mix of old and new faces.

> 'One of the challenges facing machine vision companies is how to scale quickly'

'I'm sure there will be further expansion for Stemmer Imaging at some point,' Williamson said. 'Stemmer Imaging, after 35 years, remains successful with its original business concept. However, it is building new initiatives, evolving its culture and adopting modern working practices.'

In 2017, *Imaging and Machine Vision Europe* asked Willi Stemmer, who had recently retired, what advice he would give young vision engineers. He said: 'Come and stay in the industrial imaging business. A career in this sector is guaranteed for life. Industrial imaging has so many opportunities, because this market will find new applications. Whether you are employed, or if you have the confidence to build your own business, [this] industry is a good one to choose.'

Stemmer Imaging

Celebration in 2004 for 'Stemmer Goes European', with (from left) Christof Zollitsch, David Hearn and Willi Stemmer.

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Hyperspectral remote sensing to be added to ISS lab

Computer vision firm Metaspectral, along with remote sensing data analysis firm, HySpeed, are designing a hyperspectral imaging Earth observation payload for the International Space Station.

The system, known as 'Onboard Programmable Technology for Image Classification and Analysis' (OPTICA), will enable real-time compression, streaming and analysis of hyperspectral data from low Earth orbit.

OPTICA is scheduled for launch in early 2023 on the SpaceX CRS-27 mission, with a six-month deployment on the ISS following soon after. The mission is sponsored by the ISS National Laboratory, which works in collaboration with NASA to use the orbiting laboratory on the ISS to its fullest research and technology development potential.

Metaspectral is supplying the hardware and software for the payload, with HySpeed Computing responsible for creating the necessary data processing pipeline and analysis tools.

The system will use data compression and machine learning to overcome some of the bandwidth constraints when downlinking hyperspectral image data to Earth for analysis.

Multi-view 3D light-field research sees hidden objects

Researchers at UCLA have demonstrated a 3D imaging method able to provide excellent depth range, while also imaging around scene occlusions.

The technique is called compact light-field photography (CLIP). Study leader, Liang Gao, an associate professor of bioengineering at the UCLA Samueli School of Engineering, said the novel computational imaging framework 'for the first time enables the acquisition of a wide and deep panoramic view with simple optics and a small array of sensors'. The work was published in *Nature Communications*.

The researchers combined CLIP with lidar sensors. Conventional lidar, without CLIP, would take a high-resolution snapshot of the scene but miss hidden objects.

Using seven lidar cameras with CLIP, the array takes a lower-resolution image of the scene, processes the output from the individual cameras, and then reconstructs the combined scene in high-resolution 3D imaging.

Researchers demonstrated the camera system could image a complex 3D scene with several objects, all set at different distances.

The work is a new class of bionic 3D camera system that can mimic a fly's multi-view vision combined with depth sensing, resulting in multi-dimensional imaging.

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The technique mimics an insect's multi-view vision

'If you're covering one eye and looking at your laptop computer, and there's a coffee mug just slightly hidden behind it, you might not see it, because the laptop blocks the view,' explained Gao, who is also a member of the California NanoSystems Institute and runs the Intelligent Optics Laboratory. 'But if you use both eyes, you'll notice you get a better view of the object. That's sort of what's happening here, but now imagine seeing the mug with an insect's compound eye. Now multiple views of it are possible.' According to Gao, CLIP helps the camera array make sense of what's hidden in a similar manner.

The researchers state in the paper that 'compact light-field photography will broadly benefit high-speed 3D imaging and open up new avenues in various disciplines'.

Multimodal sensors promise better vision for machines

Scientists investigating multimodal imaging have highlighted how nanostructured components can be fabricated on image sensors to gather more information about incoming light.

In a paper published in *Applied Physics Letters*, researchers at the University of Wisconsin-Madison, Washington University in St. Louis, and OmniVision Technologies detail how two such components – a spectrometer and silicon nanowires that can detect the angle of light – can be integrated on image sensor chips.

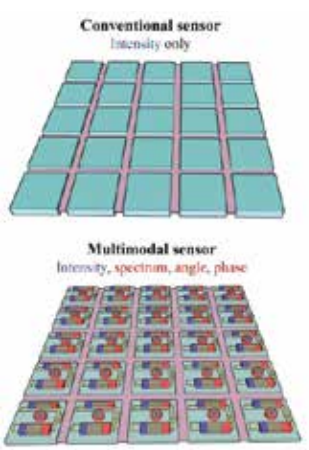
The developments could enable autonomous vehicles to see around corners, biomedical imaging to detect abnormalities at different tissue depths, and telescopes to see through interstellar dust.

'Image sensors will gradually undergo a transition to become the ideal artificial eyes of machines,' said co-author Yurui Qu, from the University of Wisconsin-Madison. 'An evolution leveraging the achievement of existing imaging sensors is likely to generate more immediate impacts.'

One promising approach to detect multiple-band spectra is fabricating an on-chip spectrometer. Researchers deposited photonic crystal filters made up of silicon directly on top of the pixels to create complex interactions between incident light and the sensor.

The pixels beneath the films record the distribution of light energy, from which light spectral information can be inferred. The device – less than a hundredth of a square inch in size – is programmable to meet various dynamic ranges, resolution levels and almost any spectral regime from visible to infrared.

The researchers also built a component that detects angular information to measure depth and construct 3D shapes at subcellular scales. Pairs of silicon nanowires, used as resonators, support optical resonance. Millions of these nanowires can fit on a 1mm² chip. The work could support advances in augmented reality and robotic vision.



Yurui Qu and Soongyu Yi

Schematics of a conventional sensor that can detect only light intensity, and a nanostructured multimodal sensor that can detect various qualities of light through light-matter interactions at subwavelength scale

Quantum computer vision tested for defect detection

Can a quantum computer improve defect detection? **Victor Onofre** at Multiverse Computing finds it can

Scientists have demonstrated what they believe is the first implementation of quantum computer vision for a quality inspection problem on a manufacturing production line.

Researchers at Multiverse Computing, which delivers quantum computing solutions, and Ikerlan, a technology transfer centre in Spain, have developed a quantum-enhanced kernel method for classification on universal gate-based quantum computers, as well as a quantum classification algorithm on a quantum annealer.

The team found that both algorithms – described in a paper published in arXiv: Quantum Physics – outperformed convolutional neural network approaches (CNN) for classifying manufacturing defects.

Victor Onofre, quantum software developer for Multiverse Computing and one of the authors of the research paper, told *Imaging and Machine Vision Europe* that the team's approach offers a training time of only six minutes, with inference times of two seconds on average. The CNN comparison approach, on the other hand, has training times of hours with many parameters involved.

Onofre noted the quantum algorithms the team developed need less parameter tuning, are more accessible for modification and improvement, and are more interpretable when compared to a CNN.

'We have demonstrated a significant improvement in the capacity of detecting defects, both in precision and number of detected defects, using two quantum machine learning models compared to the classical counterparts,' Onofre said. 'These findings show the potential of quantum algorithms for taking computer vision performances to the next level.'

Bartlomiej K. Wroblewski/shutterstock.com

The quantum vision system was benchmarked against classical counterparts for an unbalanced dataset of images from the GDXray+ public dataset. This dataset consists of X-ray images of fractures in manufactured car parts.

Onofre said the pipeline for quantum machine learning algorithms is designed very similarly to the ones used in classical machine learning: there are data preprocessing, training, fitting and inference stages.

'Once the mathematical model amenable to be trained on quantum hardware has been developed, the integration is done like industry standard ML pipelines, with the quantum parts of the code securely sent to be run on the quantum hardware of choice, instead of to standard CPUs or GPUs,' he said. 'Most importantly, the end user will have a product that can be used the same way as the current ML models, with the quantum parts working behind the scenes.'

He added that the key difference in algorithm development is it requires a combination of various frameworks, from quantum physics to computer science and mathematical modelling. 'It is essential to build a collaborative and interdisciplinary workforce, where people with different backgrounds combine their skills to create new solutions to real industry problems, manufacturing being one of them,' Onofre advised. 'This is the type of talented and diverse workforce that Multiverse Computing is building.'

Onofre said quantum annealers are the most advanced type of hardware for difficult optimisation problems, and gave the best results in the study.

'We are at a critical moment for quantum technologies,' Onofre observed. 'Multiple companies realise the potential of quantum algorithms and are building their quantum journeys through real use-case projects and roadmaps for implementation into their pipelines.'

Quantum hardware is expected to advance rapidly over the next few years, and Onofre said the availability of quantum models depends on the improvement of quantum hardware. However, Multiverse is also working with quantum-inspired algorithms, like Tensor Networks, which use a mathematical framework from quantum physics and so are particularly suited to handling large and complex amounts of data, but are able to run on CPUs or GPUs.

Onofre said these techniques can add business value to real use cases right now, in manufacturing, finance and general machine learning applications, as they are independent of the development of quantum hardware. 'These algorithms are being intensively researched and developed

'We are at a critical moment for quantum technologies'

by Multiverse, showing a clear advantage over state-of-the-art classical methods, for example, in reducing dramatically the number of parameters and massively improving the training speed of industry deep learning models,' Onofre said.

The co-authored paper, titled 'Quantum artificial vision for defect detection in manufacturing,' shows examples of the images analysed by the quantum algorithms and further details the context, metrics and methods used by the researchers.

Ion Etxeberria, CEO of Ikerlan, stated: 'This collaborative study confirmed the benefits of applying quantum methods to real-world industrial challenges. We strongly believe quantum computing will play a key role in providing AI-based solutions to particularly complex scenarios.'

Industry 4.0: powered by machine vision, smart factories are coming

In a post-pandemic world where staff shortages are the new norm, the need for efficient, optimised factories has never been greater, finds **Andrei Mihai**

The idea of a Fourth Industrial Revolution – or Industry 4.0 – has been floating around for a while now. At its crux is interconnectedness – from the IoT platforms and the sensors picking up the data, to the cloud where everything is brought together; Industry 4.0 factories will no longer be a set of different machines working on individual – and independent – tasks, but a coordinated mechanism fed by data and smart algorithms.

Some companies are already experiencing that future today. From Siemens calling Industry 4.0 'the future of industry' to Ericsson hailing it as 'a new era in manufacturing,' there's no shortage of momentum around this transformation, but exactly what kind of role can machine vision play?

The edge of a new revolution

Humans are fundamentally visual creatures. All of us rely heavily on visual cues to assess situations and make decisions. Even for machines, which can use all sorts of sensors and aren't faced with any inherent biological limitations, vision is likely to be one of the key sources of information.

'Vision is one of the most important senses for humans, but also for machines,' agrees Sören Böge, head of product management 2D image acquisition at Basler, a manufacturer of imaging components for computer vision applications. 'You have several sensors in a factory – for example, photoelectric sensors or proximity sensors – but comprehensive tasks, such as sorting, quality analysis or orienting an AGV [Automatic Guided Vehicle] requires vision to deliver the significant data you need to make a factory smart enough to make its own decisions.'

For factories looking to incorporate machine vision, the challenge lies not so much with the sensors themselves, but rather how these sensors communicate with each other. A factory's ability to make its own decisions based on this dialogue is what truly differentiates a smart factory.

The first prerequisite for this (and Industry 4.0 in general) is true interconnectedness. You can't have islands or isolated components in a factory. Everything needs to be connected. This is not a new idea, but what is new is how they connect. Increasingly, emerging communication technologies and protocols are enabling the processes required for smart factories to happen.

'You still have bus system-based factories but, if you look in the future, 5G, wi-fi 6 and other standards of wireless connection will play a significant role, which will allow you to interconnect broader spaces, broader areas and even multiple factories in the future,' Böge adds. Basler's prioritising of communication standards is also clear from the fact it is the first machine vision company to join the 5G Alliance for Connected Industries and Automation.

> 'Vision is one of the most important senses for humans, but also for machines'

Even with the new standards of wireless connection, however, the industry still faces sizeable limitations. Machine vision implies a lot of information; even standard-speed cameras can stream at 120 MB per second and, if you have dozens – or hundreds – of cameras and machines and other utilities, even wi-fi 6 likely won't be sufficient to support all this data transfer. So Böge expects we're not quite done with wires yet, and there's still a way to go before streaming becomes truly wireless.

But there are alternatives. An important accelerator of machine vision in smart factories is a combination of edge computing, →

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→ where smaller computers are embedded into systems with sufficient calculation power to do some of the pre-analysis work on the edge. Edge systems exist, but there are important cost and security challenges. When edge systems become cost-competitive with PCs, then you can set up a truly smart and independent factory.

Despite these shortcomings, however, Industry 4.0 isn't something on the near-horizon – it's happening already. 'If we look at the factory, the game changer for me in Industry 4.0 is not hard cut,' says Böge. 'I don't think it's something that's starting now, but is an evolution that began quite some time ago.'

As more large companies share their success stories, we can expect confidence to increase and the new industrial revolution to truly take shape, with machine vision as its core accelerator. When that happens, how could we expect a smart factory to work? 'Almost like a home automation system,' suggests Böge. The idea would be to have an automated supply store, where the operative supply management could be initialised automatically for tasks such as reordering and stock management. Then the parts would be transported to the assembly machines, where robots would load and unload them. Everything would be quality inspected and the final product put on the storage shelf, where there would be a connection to shipping and so on. 'So, working back from the customer order, you could more or less complete production planning and, in nearly every step of this, vision systems would be a central success factor,' adds Böge.

Artificial intelligence, real images

Industry 4.0 – and digitisation in general – have become relatively 'fuzzy' terms and terminology also has a geographical component. In the USA, for instance, IIoT (Industrial Internet of Things) is the buzzword that organisations respond to; it's not Industry 4.0. Although, no matter what you call it, it is all based on AI, and deep learning specifically.

It is widely recognised that deep learning is now the state-of-the-art in machine learning for machine vision and it is being increasingly widely deployed across industrial applications. As well as studies showing this, Nvidia, one of the key players in the vision game, also clearly states it. AI, and deep learning specifically, enable computer vision models to learn, adapt and perform comparably to a human expert in a factory, while requiring significantly less input (and lower costs in the long run). In the food industry, for instance, AI systems have already become proficient at detecting and grading various food products – in some cases with an accuracy of more than 95 per cent, or even 99 per cent, according to research by Lili Zhu and Petros Spachos et al in their recent study, *Deep learning and machine vision for food processing: A survey*.

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'Machine vision systems are widely used in food safety inspection, food processing monitoring, foreign object detection and other domains,' write the authors. 'It provides researchers and the industry with faster and more efficient working methods and makes it possible for consumers to obtain safer food. The systems' processing capacity can be boosted to a large extent, especially when using machine learning methods.'

'There remains a significant gap between something being possible and something that supports a good business case'

Methods such as those common in food detecting, grading and processing can also be used in factories to deal with components or products, but there remain significant obstacles. Among these is visual data availability. To train your deep-learning algorithm for tasks such as sorting, picking and quality inspection, you need a lot of visual data, and obtaining good quality data is rarely easy. But solutions are emerging on this front, too. Siemens' SynthAI generates thousands of randomised annotated synthetic images just from 3D CAD data. This data can then be used for training, enabling organisations to handle the training of their systems with fully annotated datasets. This not only shortens data collection and training time, but also eliminates tedious manual images and labelling, and produces a model that can also be used offline.

Developing easily accessible and high-quality data is important for developing efficient algorithms that, in turn, not only speeds up the machine vision-based process, but also makes the entire system consume less power, which is important as it makes it easier to run on edge machines and pass-through wireless connectivity.

Other companies, including Basler, have demonstrators for automating various aspects of factories and are working at automating robots, often remarkably quickly. Within hours, an example demonstrator can be set up to separate various products placed randomly below the robot, even for people without any machine vision or programming experience – something that would have taken thousands of lines of code and thrown up many complications just a decade ago.

So, what's the delay?

Given all this, why aren't we seeing smart factories pop up everywhere? Based on signals from both industry and academia, the technology required for Industry 4.0 is already here, but there remains a significant gap between something being possible and something that supports a good business case. We know that, in general, industry is slower than research to adapt.

Perhaps the biggest current deterrent for smart factories is that, despite tangible progress being made, there are few large-scale success stories. Setting up a factory is complicated in the first place: it's a big investment and you need everything to work smoothly. Investors are often understandably hesitant to implement the latest technology because that technology doesn't have a track record.

There's also a knowledge gap to bridge. Even a smart factory needs ongoing monitoring, so you need engineers who are well-versed in new wi-fi standards, machine learning algorithms and edge computing. You can't just expect your existing engineers, who usually work with legacy systems, to be automatically confident or capable in every new technology.

It's going to take time, but the signs are already out there. It's perhaps just a matter of confidence and cash – and this isn't an era when either are in plentiful supply.

AI Vision is more than a trend topic

It is clear that intelligent image processing opens up many new possibilities, but what does this actually mean for small and medium-sized enterprises? Find out how user-friendly systems will pave the way for the new technology, true to the claim: 'Deep learning: a game changer in automation'

Artificial intelligence (AI) plays a key role in the digital age. Self-learning algorithms have the potential to improve processes and products in the field of machine vision and to secure competitive advantages. They are equally suited to automation and logistics as they are to monitoring products and processing goods. This is also due to the fact that classical image processing solutions work with a fixed set of rules, making organic or fast-changing objects a major challenge. AI, on the other hand, can handle such cases effortlessly. So, where are the challenges to technology? And what needs to be done to make it widely accepted?

The hurdle for the application of AI-based image processing solutions is still quite high. They usually require expertise, programming efforts and investment in computer and storage hardware. Not only training a neural network, but also using it and evaluating the results require knowledge of hardware, software and interfaces. This poses challenges for many companies. IDS shows it can be done differently: the IDS NXT AI vision system comes with all the necessary tools and workflows, allowing users to easily build intelligent vision solutions.

Using the IDS NXT lighthouse Cloud software, even users with no prior knowledge of AI or camera programming can train a neural network. Since it is a web application, all functions and the necessary infrastructure are immediately available. The engineer or programmer does not need to set up his own development environment, but can immediately start training his own neural network. Three basic steps are required for this: uploading sample images, labelling the images and starting the automatic training. The generated network can be run directly on the IDS NXT industrial cameras, which are capable of delivering the desired information or passing commands to machines via REST or OPC UA.

The IDS NXT AI vision system allows users to easily build intelligent vision solutions

Object detection using the IDS NXT industrial camera

Deep learning – a game changer in automation

One thing is certain: artificial intelligence is a game changer. The technology is penetrating new areas with incredible speed and enabling applications where classic image processing is too expensive, inflexible and also too complex. Dr Alexander Windberger, AI specialist at IDS Imaging Development, explains: 'Not only has the game changed, but also the players. AI-based image processing works differently from classic rule-based image processing, because the quality of the results is no longer just the product of manually developed program code, but is primarily determined by the quality of the datasets used.'

Thus, users need different core competences to work with AI vision. The approach and processing of vision tasks is therefore changing. Domain experts are coming into the picture, as they can use their knowledge to keep the creation of data value going and react flexibly to shifts in data and concepts during operations.

> 'Ultimately, AI is a tool for humans and so it must be intuitive and efficient to use'

However, many companies still have reservations about the new technology. There is a lack of expertise and time to familiarise themselves with the subject in detail. At the same time, the Vision community is growing from the IoT sector and the start-up scene. With the new application areas and user groups, there are inevitably other use cases and requirements. The classic programming SDK is no longer sufficient to provide the best possible support for the entire workflow, from the creation of datasets and training to the implementation of a neural network.

Looking to the future, Dr Windberger states: 'We realise that entirely new tools are emerging today for working with AI vision, which are used by very heterogeneous user groups without AI and programming knowledge. This improves the usability of the tools and lowers the barrier to entry, which is currently significantly accelerating the spread of AI-based image processing. Ultimately, AI is a tool for humans and so it must be intuitive and efficient to use.'

Driving force behind current developments

No other component collects and interprets as much data as image processing. It enables what is seen, such as product characteristics (for example, length, distance, number), states (presence/absence) or quality, to be monitored in the production process, processed and the results passed on to the value-added systems in the network. This not only determines whether the inspected part meets the desired characteristics or is good or bad, but also triggers an intelligent action, such as automated sorting, depending on the result. Especially small and medium-sized enterprises, for which the automation of their production could not be realised competitively due to a lower number of pieces in production, benefit from this plus in flexibility.

Factory automation with smart cameras therefore also offers the possibility of reacting more flexibly to difficult market conditions while guaranteeing consistently high production quality and efficiency. Companies for whom the leap to end-to-end digitisation and automation is too great can make significant progress thanks to AI-based image processing. Holistic, user-friendly systems such as IDS NXT pave the way for this.

More information
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The business case for warehouse automation

Warehouses operate on dollars per square foot, with very different drivers for vision tech than a factory, writes **Tom Brennan**, president of Artemis Vision

Market forces and disruptions are driving profound changes in the warehousing industry. A summary of the forces involved could fill an entire edition of this magazine but, suffice to say, companies are turning to technology for a solution and, typically, this means automation.

We generally think of automation as something that replaces a person doing the mechanical aspect of a task, such as putting a pallet on a truck or packing an item in a box. However, we must consider that the person doing these tasks is performing a lot of visual checks along the way, which we may not immediately think of. For example, they check that: the pallet has no damage; the slats hold as the pallet is lifted; the truck is pulled up to the dock; there is space to load the pallet; the pallet belongs on the appropriate truck; and the pallets are stacked in tightly and strapped as needed. This illustrates that the mechanical automation needed to replace human tasks inevitably involves lots of vision, and a device that drives pallets onto trucks is a lot more than wheels and a battery pack for power.

While the technologies are the same, designing vision for a distribution centre or warehouse is significantly different than for the factory floor. The end goal for the warehouse is the speed at which a product reaches the customer at the lowest cost. Quality in a warehouse environment is not about improving the inherent quality of the product, it is avoiding damage and getting the right thing to the right destination.

There is also usually less on-site engineering in a warehouse, if any at all. Machine vision technology can be 'right,' but the economics are often made on dollars per square foot, dollars per minute and inventory turns – by this logic, a more automated warehouse that costs more can lose its competitive edge to a more local, less automated option. In factories, the more automated, advanced factory has generally won out against its less automated, local rival – but in warehousing and logistics, this isn't necessarily the case.

One other aspect of the distribution market is that no one party controls the entire network. There are inevitably many more points of interconnectivity to other parties that have other needs, and you have to cooperate to get things done. Pre-sorting packages, for instance, is much more efficient for the downstream carrier, but requires fairly intense cooperation for the distribution centre, which is configuring sorters based on a downstream shipper's route

'The two biggest forces requiring vision investment in a [logistics] environment are navigation and quality'

network. There are a lot of things outside the control of a distribution centre worker: they are loading orders that arrive that day, or from the truck on the dock, while dealing with the reality that customers may have ordered specific items, some of which are on the truck that showed up and some of which are on one that did not. They simply have to adapt and get the job done – but no manufacturer runs that way.

In warehousing, we end up with a complex marketplace where vision can be a difficult sell. In our experience, the money is more often spent in tracking the products and, sometimes, preventing damage than in anything else. And warehouses are routinely operating at huge scales and with high-value items. Even a cheap product, such as a can of beans, will end up on a pallet with 6,000 to 8,000 others, which quickly equates to a €10,000 pallet. There are, of course, also many foods more expensive than beans and, beyond food, there are medicines, consumer goods and automotive parts. It all adds up. There are a lot of €100,000 pallets that need to be moved quickly, accurately and without damage being caused.

Suddenly, an AGV solution that tips over a pallet a month because the wooden slats are broken doesn't save as much money as you thought. Yes, you save €20 an hour paying the forklift driver but, because you can't unilaterally control the quality of the pallets you're receiving, the solution becomes no longer viable.

The two biggest forces requiring vision investment in this environment are navigation/guidance and quality. We all need vision to navigate our world and a quality-control mechanism is needed in this context to assess whether to proceed with the task, or to take action to correct an issue, such as a broken pallet. These two issues are not as easy to resolve as they seem and are often intertwined.

However, technology is filling this gap. 3D time-of-flight has made enormous improvements, and reliable centimetre accuracy in motion is enabling accurate navigation of warehouses and finding problematic pallets, so people can correct the problem. Larger, higher resolution global shutter cameras continue to enter the market, allowing imaging of larger fields of view – entire pallets – to accuracies of 1mm per pixel, and this is enabling cameras to track freight by barcode, with the added benefit of photographic documentation, and find problems in pallets or individual boxes or bags.

We'll see how the market continues to evolve, but vision is going to play a central role.

Artemis Vision, with headquarters in Denver, Colorado, builds machine vision systems for automated quality inspection and optimisation for manufacturing and logistics.

Embedded vision: plug-and-smile!

Anne Wendel, VDMA Machine Vision, reports on what was said during a vision panel discussion at Embedded World earlier in the year

Embedded vision is not only a hot topic in the machine vision industry, but computer vision is also one of the most promising technologies in the embedded community. Visiting the Embedded World trade fair in Nuremberg in June 2022, it was clear embedded vision has become an indispensable part of numerous applications and a future part of the embedded community.

Gion-Pitchen Gross from Allied Vision, Jan Jongboom from Edge Impulse, Olaf Munkelt from MVTec Software, Jan-Erik Schmitt from Vision Components and Frederik Schönebeck from Framos discussed the topic of embedded vision integration and 'towards plug-and-play' as part of a VDMA-organised panel discussion at the event.

Embedded vision generally has the reputation of being relatively complicated technology; plug-and-play seemed unachievable in this field for a long time, and in fact the technology was often only suitable for experts due to a lack of tools.

The technical developments have meanwhile simplified and accelerated its use considerably. Jan-Erik Schmitt sees a similar development here as with deep learning: 'A lot has changed in the past few years. There are tools that are now much easier to understand. The tools for realising embedded vision systems are also developing further because hardware and software are constantly becoming more powerful. This generates new ideas about where the technology can be used. Also, with the many embedded vision applications that have emerged over the past 20 years, there are more and more people who are interested in this topic and want to dive further into the technology.'

In addition, until a few years ago, mathematicians, physicists or engineers were required to create vision applications, and it was only through hands-on experience with technology that they could gain the necessary experience. 'Today, young people leave universities and are already vision experts because they have already dealt with this topic during their studies,' Schmitt said. 'Therefore, there are many more machine vision experts today than in the past.' Schmitt therefore described the current state of the technology more as 'plug-and-smile'.

Embedded World

According to Gion-Pitchen Gross, another factor that simplifies embedded vision is the use of open-source software: 'Much of it is very easily available today and can be adapted to the specific application with little effort. This trend is still relatively young, but manufacturers such as Allied Vision now make their drivers available as open source, so that users can adapt them to their use case and use prepared samples. This also makes it easier for users to realise their applications.'

Boost from AI

Artificial intelligence (AI) methods are currently being used in almost all technical fields. This is also a clear trend in the field of embedded vision, as Jan Jongboom explained: 'From the user's point of view, AI makes it easier to develop systems that do generalisation well. The use of transfer learning, in which a large number of pre-taught images from other applications serve as the basis for training, with only a relatively small number of new images of a specific use case added, minimises the effort for users enormously.

'This revolutionises the way machine vision systems are programmed and dramatically lowers the hurdle for developing practical models,' he added. 'Just a few years ago, it was necessary to collect and train an extremely large number of images.'

However, there is also a negative aspect to AI methods, Dr Olaf Munkelt pointed out, which is one of trust. 'AI systems are very powerful, but they are not very good at explaining why they made a decision,' he said. 'We spend quite a lot of time building trust among customers in these kinds of algorithms, because people won't use them if they don't have that trust.' This is especially true for applications that require very precise results, Munkelt said.

Nevertheless, the positives outweigh the drawbacks, Munkelt felt, as AI accelerators, among other things, help to simplify the use of embedded vision. MVTec has provided an abstraction layer in its software for this purpose, which makes it easier for developers to work with AI accelerators such as TensorFlow, OpenVino or other products. 'Users really appreciate this because it means they no longer have to worry about coding all the bits and bytes,' Munkelt said.

Supply chain problems

Like all other areas of the electronics industry, the embedded vision scene is also affected by delivery shortages and supply chain problems. Delivery times for many hardware components have increased significantly and, depending on the component, can be half a year or even longer. In addition, there is a huge order backlog that many companies have to work off first. Munkelt is convinced the current supply problem will not be resolved within a year, but will burden the entire industry for a longer period.

> 'Young people leave universities and are already vision experts because they have dealt with this topic during their studies'

Despite these current limitations, the experts agree the use of embedded vision in industry will benefit greatly, with a certain time lag, from technological developments in the consumer sector and the increasing computing power of embedded systems. For these reasons, devices equipped with embedded vision, such as mobile barcode or data code scanners, drones, self-driving vehicles, delivery robots, autonomous transportation systems and many other applications, continue to face a very positive outlook.

Expanded shortlist for prestigious Vision Award

Brighter AI, Edge Impulse, Kitov.ai, Saccade Vision and SWIR Vision Systems have all been nominated

Judges were so impressed by the range of this year's entrants, they expanded the shortlist for 2022's Vision Award to five.

Submissions from Brighter AI Technologies, Edge Impulse, Kitov.ai, Saccade Vision and SWIR Vision Systems were selected by the judges from 61 entries. The winner of the award, sponsored by *Imaging & Machine Vision Europe*, will be announced at Vision, held in Stuttgart, Germany, at the beginning of October.

The entries include: two instances of clever uses of machine learning; software that automates inspection planning using CAD models; a novel 3D camera containing a MEMS scanner and disruptive shortwave infrared camera technology.

The Vision Award recognises innovation in the field of machine vision and has been awarded at each Vision show since 1996.

Prophesee won last year's award for its neuromorphic approach to imaging, which Martin Wäny of the judging panel called a 'new paradigm' in imaging technology.

Along with Wäny, of TechnologiesMW, the judges that selected this year's shortlist are Jens Michael Carstensen, Videometer; Michael Engel, Vision Components; Gabriele Jansen, Vision Ventures; Dr-Ing Ronald Mueller, Vision Markets; and Christian Ripperda, Interroll Innovation.

The five shortlisted award entries are as follows.

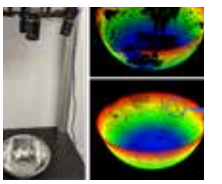
Join us online at imveurope.com for exclusive show reports at Vision and details of the winner of the Vision Award, due to be revealed on 5 October.

Deep Natural Anonymisation

Entry led by Patrick Kern, Brighter AI Technologies

Brighter AI Technologies' Deep Natural Anonymisation Technology (DNAT) is a solution that protects personally identifiable information (PII) in image and video data. This technology automatically detects and anonymises personal information, such as faces and vehicle number plates, and generates a synthetic replacement that reflects the original attributes. The solution therefore protects identities while keeping necessary information for analytics or machine learning.

General video redaction techniques include blurring PIIs, but this leads to loss of information and context of the image. DNAT, on the other hand, replaces the original PII with an artificial one that has a natural appearance and preserves the content information of the image.



Patrick Kern, co-founder and CTO

Each generated replacement is constrained to match the attributes of the source object as precisely as possible. Nevertheless, this constraint is selectively applied, so the user can control which attributes to maintain and which to obscure. For faces, for example, it could be important to keep attributes like gender and age intact for further analytics. DNAT effectively breaks the trade-off between removing and anonymising data.

What the judges say:

'This is a topic [keeping personal information anonymous] that is very relevant within society. Anonymisation with a synthetic replacement is a potential enabler for future applications where personal information is present.'

DNAT anonymises personal information while also generating synthetic data

Extended SWIR cameras with colloidal quantum dot sensors

SWIR Vision Systems

SWIR Vision Systems' camera are sensitive from 400 to 2,000nm

SWIR Vision Systems has developed the Acuros CQD eSWIR family of cameras. These cameras with their colloidal quantum dot (CQD) sensors provide sensitivity from 400 to 2,000nm wavelength and are offered in three resolutions.

The firm's current 2.1-megapixel camera offers the lowest cost per megapixel on the market, SWIR Vision Systems says, with interfaces designed around international standards. The company has now extended these high-density, full HD focal plane arrays with responsivity out to 2,000nm.

The CQD eSWIR camera sensors are fabricated with low-cost materials and CMOS-compatible fabrication techniques representing an advance towards broadly accessible, high-definition shortwave infrared imaging. It is expected that the camera's lower cost point and its non-ITAR, EAR99 export classification will drive higher adoption rates globally, broadening the market for SWIR camera technology.

Ethan Klem, CTO

SWIR Vision Systems synthesises lead sulphide-based quantum dot nanoparticles and processes these into thin-layered photodiodes. The QD particles are typically designed to provide a spectral response tuned for the 400 to 1,700nm visible-SWIR wavelength band.

The company made use of a property of its CQD sensor technology, whereby larger diameter quantum dot semiconductor particles are designed to broaden the sensor's optical response to longer wavelengths. Broader bandwidth sensors can address a wider range of SWIR imaging applications.

Shortwave infrared cameras are already deployed to inspect silicon wafers and semiconductor die for void and edge defects. The technology is also used to detect moisture levels in packaged products; thickness and void detection on clear coat films; glass bottle imaging; bruise detection in fruits and vegetables; inspection of lumber products; detection of water or oil on metal parts; imaging through smoke and mist environments; surveillance and security monitoring; crop monitoring; glucose monitoring and many more applications.

What the judges say

'SWIR Vision Systems has created a novel camera line – Acuros – within the much needed UVA-Vis-SWIR range. In addition to a wide spectral range, the cameras offer significantly higher resolution than comparable InGaAs-based cameras.

'The camera line has the potential to be a game changer in many important fields, including spectral imaging, scattering reduction imaging, recycling, food and agricultural quality assessment, semiconductor inspection and medical imaging.'

Ground-breaking algorithm that brings real-time object detection, tracking and counting to microcontrollers

Mihajlo Raljic, Edge Impulse

This new machine learning technique has been designed to run real-time object detection on devices with very small computation and memory capacity. Edge Impulse provides a platform for creating machine learning models for edge computing.

Called Faster Objects, More Objects (FOMO), the deep learning architecture can unlock new computer vision applications. Most object-detection deep learning models have memory and computation requirements beyond the capacity of small processors. FOMO, on the other hand, only requires several hundred kilobytes of memory, which makes it a great technique for TinyML, a subfield of machine learning focused on running machine learning models on microcontrollers and other memory-constrained devices that have limited or no internet connectivity.

The idea behind FOMO is that not all object-detection applications require the high-precision output afforded by state-of-the-art deep learning models. By finding the right trade-off between accuracy, speed and memory, the user can shrink deep learning models to small sizes while keeping them useful.

Instead of detecting bounding boxes, FOMO predicts the object's centre. This is because many object detection applications are just interested in the location of objects in the frame and not their sizes. Detecting centroids is much more 'compute-efficient' than bounding box prediction and requires less data.

FOMO can be applied to MobileNetV2, a popular deep learning model for image classification on edge devices. According to Edge Impulse, FOMO is 30 times faster than MobileNet SSD and it can run on devices that have less than 200 kilobytes of RAM. On a Raspberry Pi 4, FOMO can detect objects at 60fps, as opposed to the 2fps performance of MobileNet SSD.

Edge Impulse says that, where an application might have needed an Nvidia Jetson Nano, now it can run on an MPU at significant cost savings. In addition, since the algorithm runs on C++, it is hardware-agnostic and a natural hedge against hardware volatility.

What the judges say

'The jury sees ground-breaking work between the algorithm and the [computer] architecture, with the potential to enable more embedded vision on devices with very small computation and memory capacity. Up to 95 per cent of cost savings shows the potential [for the innovation].'

MEMS-based 3D camera for industrial inspection and robotic guidance

Alex Shulman, Saccade Vision

Saccade-MD is a feature-based static laser line scanner based on a MEMS scanner for absolute scanning flexibility. The technology is similar to that used in solid-state lidar modules for autonomous vehicles, except that the MEMS mirror is in full control on both axes.

Employing patent-pending technology, Saccade imitates the saccadic movements of the human eye, whereby the brain captures an image using low-resolution receptors first, identifies objects of interest and then captures interesting parts with high-resolution receptors.

Not only can the direction of the Saccade-MD scan be optimised so that the part doesn't have to be rotated to get a different viewing angle, but the system can vary the resolution, scanning the entire part at low resolution and then honing in on certain areas at very high resolution. This scanning flexibility means images can be acquired separately for different elements inside the field of view and selective sub-pixel resolution can be achieved in 3D.

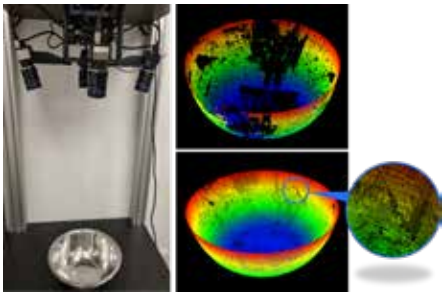
The three founders (from left) Alex Shulman, Evgeni Levin and Ran Sagi

The data acquisition can be locally optimised based on a CAD model analysis of the scanned sample.

Saccade Vision is currently focusing on critical dimension measurements and 3D inspection in a few segments of precise manufacturing. The first is integrated inspection and metrology for metal working machines for tasks such as initial alignment or precise positioning of the piece inside the manufacturing tool; post-manufacturing off-line inspection and metrology to provide predictive process and machine analytics.

Saccade Vision has partnered with Euclid Labs, a provider of off-line robot programming, to deliver an inspection system integrated with a robotic material handling system and installed on metal working machines.

The second area Saccade is concentrating on is 3D inspection in automated assembly lines. Recently, an electronics manufacturer installed a Saccade-MD system for 3D quality inspection on its fully automated assembly line. The Saccade-MD system has been running non-stop for the past six months. The camera system has already inspected more than one million units, where each assembly arrives for inspection on the line every 10 seconds.



Generating a point cloud of a reflective aluminium bowl

What the judges say

'Saccade Vision has developed a product for 3D measurement and inspection that addresses some major challenges for line scan-based 3D technology today. Its MEMS scanner... enables orientation and density of projected lines to be individually adapted to the part and surface properties, as well as to the measurement or inspection task.

'Only areas of interest are targeted, and the data resolution is adapted to each area based on digital CAD model analysis of the sample.

'The Saccade approach avoids the requirement for relative movement between part and sensor, leads to very time-efficient data acquisition and increases the 3D data quality, through the avoidance of glare or occlusions, for instance.'

CAD2Scan: Automating visual inspection planning

Dr Yossi Rubner, Kitov.ai

Dr Yossi Rubner

Kitov.ai's CAD2Scan software automatically takes all available information from a CAD model, including geometric and component specifications and specific inspection requirements, and uses it to plan a robot inspection task. This might include the best 3D camera and illumination directions for each inspection and the optimal robot path.

An engineer can set inspection requirements directly in CAD software using CAD2Scan. Once all requirements are marked, CAD2Scan automatically extracts the specific geometric and semantic information for each inspection requirement. This is passed to the semantic detectors performing the inspection tasks.

Kitov's semantic detectors include a surface detector, label detector, screw detector and an existence detector. In addition, Kitov's open software platform allows easy integration of third-party detectors.

Each inspection requirement is processed by the appropriate semantic detector, which generates the imaging parameters and the requested 3D poses for the camera and light. The inspection plan is then optimised to give full coverage, reduce the number of images needed, minimise the total inspection time and calculate the best camera positions and illumination angles for each feature of interest.

In addition, the planner can capture multiple inspection points in a single image, reducing the overall inspection cycle time.

Automatic CAD-based inspection planning is ideal for industries that manufacture complex parts and products. For example, CAD2Scan technology improves the inspection of single-material parts with complex 3D geometric shapes, such as turbine engines, blades, wheels and metal moulding; CNC parts, where it is difficult and time-consuming to carry out full inspection manually; and custom-made or other low-volume parts, such as medical implants or 3D-printed parts.

CAD2Scan is implemented as a plug in to common CAD software and is available for SolidWorks and Creo. It also supports the evolving quality information framework ISO standard and can parse visual inspection requirements embedded into it.

Kitov.ai believes CAD2Scan is the only technology that can automate general-purpose visual inspection test requirements directly from a CAD model.

What the judges say

'Kitov.ai has developed a product highly relevant to manufacturing markets, specifically in light of the market shift towards local manufacturing and mass customisation.

'The main USP of the company's offering is a software platform for automating inspection planning... taking the input from a CAD drawing of the part. There's a separate module for actual quality inspection of a part.

'Both modules make use of rule-based and deep learning-based vision tools. With its software, Kitov is helping solve a major obstacle for the wider proliferation of vision tech in manufacturing: the need for experts to set-up and fine-tune a vision system for complex inspection and measurement tasks.'

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Vision Stuttgart gathers best of industrial imaging

We round up some of what will be on display when the Vision show opens its doors

Expectations are high for the Vision show, which will take place from 4-6 October in Stuttgart.

In July, more than 300 companies had signed up to exhibit, with Florian Niethammer, head of trade fairs and events at Messe Stuttgart, commenting that the show organiser expects the number of exhibitors to grow by around 25 per cent on last year.

In 2021, the trade fair hosted 296 exhibitors, at a time when the pandemic was much more disruptive than it is now in Europe.

Among some of the hottest technology on display will be that shortlisted for the Vision Award, which recognises innovation in the field of machine vision.

Brighter AI Technologies, Edge Impulse, Kitov.ai, Saccade Vision and SWIR Vision Systems are the five candidates selected by the judges this year, with the winner to be announced at the show on 5 October (more on this on page 24).

There will be a strong presence of start-ups at the trade fair, with 18 young companies part of the Start-up World section, and four start-ups per day pitching their technology as part of the Industrial Vision Days forum.

Around 17 per cent of the companies exhibiting will be attending Vision for the first time this year, companies such as Beckhoff Automation. In addition, 56 per cent of exhibitors will be from outside Germany, as of July, with exhibitors from the US especially heavily represented, followed by Japan, China, the Netherlands and Switzerland.

Niethammer pointed to advances in hyperspectral imaging, AI and deep learning, and new developments in embedded vision and 3D, as being key technology trends that will stand out at the trade fair.

Vision Stuttgart will showcase the entire range of machine vision technology from across the supply chain, from component providers and those building systems to vision integrators. Here's a snapshot of some of what visitors can expect when the trade fair opens its doors.

'Vision Stuttgart will showcase the entire range of machine vision technology from across the supply chain'

Camera providers

JAI (10F57) will present an extended range of compact, lightweight and affordable area scan cameras from its Go-X series. There are 24 new cameras (colour and monochrome) equipped with Sony Pregius S fourth-generation CMOS sensors, with the series reaching a total of 48 models tailored to different vision needs.

Camera resolution now reaches up to 24.5MP, and all new Go-X models are compatible with C-mount lenses and available with 5GigE and Coaxpress, as well as the standard GigE interface.

In addition, JAI has introduced Xscale and Xpress on new models. Xscale is an in-camera feature for rescaling pixel sizes, while Xpress is a lossless image compression function that enables the 1GigE models to achieve higher frame rates.

Also new from JAI is an 8.1MP ultraviolet camera in the Go series, along with a prism-based, four-channel line scan camera that combines visible and shortwave infrared imaging. The four-sensor line scan camera in the Sweep+ series features an integrated prism that splits the incoming light onto four separate CMOS sensors, making it possible to simultaneously image red, green and blue visible wavebands, as well as SWIR light in a single camera.

The three visible sensors provide a resolution of 4,096 pixels in a line, while the SWIR channel provides 1,024 pixels in a line. To compensate for variation in pixel size between the RGB sensors and the SWIR sensor, the new Sweep+ model is available with an ROI-scaling function. Other features include colour temperature presets, shading correction and chromatic aberration correction.

Japanese firm **CMICRO** (10H50) will show its line-up of line scan cameras with 1k to 16k resolution. The cameras use either single sensors or are prism-based multi-sensor cameras using visible light and SWIR sensors.

IO Industries (8A34) will be displaying its new Redwood camera series with 12MP, 45MP and 65MP sensors, as well as its Victorem and Flare camera series. Along with a Coaxpress interface, Redwood models are available with the new Coaxpress-over-fibre output interface, enabling very long connections while retaining the reliable point-to-point connectivity of Coaxpress.

Also on display will be the Rodeo DVR, IO Industries' latest RAW video recorder for

Coaxpress cameras of any type. More than 2GB/s of video data can be recorded to an internal high-capacity SSD.

Emergent Vision Technologies (8D60) will showcase its latest 10, 25 and 100GigE cameras, volumetric capture software and high-speed imaging accessories.

There will be a live demonstration of the new eCapture Pro software, designed for those looking to build metaverse and volumetric capture stages, motion capture systems, or other immersive 3D content applications. The software delivers turnkey integration, camera setting flexibility, advanced preview and recording capabilities, synchronised capture to microsecond accuracy, and calibration, background and production management capabilities. →

Processing power

Aetina (10A21) will be showing its AI platforms and carrier boards for edge computing. Among the display will be the MegaEdge AI inference platforms, able to run AI inference tasks via rich I/O interfaces that support various types of peripherals, including sensors, cameras, monitors and robotic arms. To satisfy different deployment needs, Aetina rolled out MXM series and PCIe series of MegaEdge platforms. The PCIe series supports GPUs powered by the Nvidia Ampere architecture.

The Swiss industrial research centre and developer of ultra low power ASICs and embedded software, **CSEM** (10G2.3), will be showing a range of edge-computing applications, including solar-power face recognition, quality control in a grain mill, and pilot safety in aircraft.

EFCO Electronics (8C11) will present its U3-D80 industrial PC family, a hardware platform optimised for Win11 IoT. On board are digital IOs, which facilitate integration into existing machine concepts and, thanks to its modern hardware architecture, the industrial PC can also increase the IT protection level of existing control systems.

Hailo-8 AI processors from **Hailo** (10H38) enable smart devices to perform advanced deep learning tasks, such as object real-time detection with minimal power consumption. Hailo-8 is optimised for high performance and high accuracy vision analytics in applications such as security, intelligent transportation, access control, and robotics. The AI accelerator is scalable – up to 156 TOPS – and is in production and available.

The **Hema** (10B71) embedded vision platform is available with system-on-modules from Xilinx, including the new Xilinx Kria K26 SoM, and Enclustra. At the booth, Hema partners will demonstrate how customers can benefit from the Kria environment with developer tools, software and AI solutions.

SXIVE is a platform developed by **Solectrix** (10C16) for rapid prototyping imaging systems. The solution for real-time video processing offers a Halide-based video engine with the SXIVE Soft image signal pipeline. It supports various image sources, graphics acceleration and a flexible selection of algorithms.

→ The software will be highlighted in a volumetric capture set-up featuring 36 x 10GigE HR-12000-S cameras (12MP Sony Pregius IMX253), along with a line scan imaging demonstration using the 10GigE Pace LR-8KG camera (8K Gpixel GL0816).

Additional demonstrations include: the new 100GigE Zenith HZ-10000-G camera (10MP Gpixel GSprint4510), with the new Zeus PZ-100 network interface card; the 25GigE Bolt HB-12000-SB camera (12.4MP Sony Pregius S IMX535), with an Nvidia Jetson AGX Orion edge AI platform; and the 25GigE Bolt HB-25000-SB camera (24.47MP Sony Pregius S IMX530), working with a Nvidia RTX A6000 GPU in GPUDirect implementation.

Also on display will be the new 25GigE Bolt HB-127 camera (127.7MP Sony IMX661) and the new 100GigE Pinnacle LZ-16KG5 camera (16K Gpixel GL5016).

Zebra Technologies (8B30) will be exhibiting the firm's suite of machine vision cameras and Zebra Aurora software. With Zebra Aurora, users can perform machine vision inspection and fixed industrial scanning on a single device, for tasks from track-and-trace to complex quality inspection checks. The combination of

Zebra's machine vision cameras and Zebra Aurora makes it easy for all users – not just machine vision experts – to set-up, deploy and run these solutions.

Zebra's acquisition of Matrox Imaging – which will exhibit on its own booth 8C45 – expands Zebra's machine vision portfolio to include design assistant software, software development kits, smart cameras, 3D sensors, vision controllers, input/output cards and frame grabbers.

Matrox Imaging (8C45) will show: a 3D machine vision demo using two 3D profile sensors and software tools for 3D location, measurement and inspection; a deep learning and machine vision inspection demo, pairing a smart camera with flowchart-based vision software to inspect bottles for defects; and a distributed computing and FPGA offload demo, exploring how freeing up the host CPU yields more effective image analysis for demanding tasks, using Coaxpress frame grabbers inside a vision controller.

Matrox will also have a live inspection demo showcasing the complementary capabilities of Zebra's fixed industrial scanner and machine vision smart camera portfolio, and an interactive station where visitors can explore the latest Matrox Imaging Library (MIL) X and Matrox Design Assistant X software.

Opto Engineering (8D48) will show its Itala cameras. The Itala G is a series of GigE Vision industrial PoE cameras with resolutions ranging from 3.2MP to 31MP. The cameras feature robust and reliable industrial cameras with excellent quality-to-price ratio. The Itala G.EL is a series of GigE Vision PoE industrial cameras, with integrated liquid lens control. With resolutions ranging from 3.2MP to 12MP, the cameras simplify the integration of Optotune liquid lenses, thanks to a built-in driver to avoid external hardware.

On **Active Silicon**'s booth this year (10F59), visitors will be able to see the firm's Harrier block cameras with multiple output options, high-speed FireBird frame grabbers, and custom-built embedded systems.

One demo will highlight image acquisition and simultaneous display from four cameras using Active Silicon's fastest Coaxpress frame grabber, taking advantage of its four-link CXP-12 capability and eight lane Gen3 PCI Express interface.

Another demo will show the company's Harrier 10x AF-zoom USB/HDMI camera streaming video while mounted on an RC helicopter. Interface boards supporting

3G-SDI, HDMI, USB3, HD-VLC and Ethernet IP will also be on show, along with camera modules with global shutters and up to 40x zoom.

Highlights from **Basler**'s booth (8D50) are new Ace 2 models with a 5GigE interface, providing an excellent price/performance ratio and easy integration; new SWIR and thermal cameras; 3D time-of-flight and stereo vision cameras; and roughly 200 new lighting components, all designed and tested for industrial use.

In terms of software, Basler will focus on image processing modules within its Pylon vTools package, which give users the flexibility to design, test and integrate functions like intelligent structure recognition, precise object positioning, or robust code recognition. This can be accomplished alongside camera control and image acquisition.

Basler will illustrate product performance in several live demonstrations at its booth, including a demo on vision-guided robotics showing pick-and-place, measurement and barcode reading. The company will also present a wafer inspection system developed in collaboration with NXP. Here, visitors can simulate defects on a wafer, which are detected by a vision system using AI and deep learning.

Teledyne Vision Solutions Group (8B10) will be showcasing live product demos from Dalsa, e2v, Flir and Lumenera. These product demos include: a new high-speed and high-resolution fully integrated line scan contact image sensor; a 2M Mipi optical module, for integration into embedded vision systems; and a 5 GigE camera platform, the first area scan camera to harness the combined customer knowledge and technical expertise from Teledyne Flir, Dalsa and Lumenera.

Also on display will be new Falcon4-CLHS M6200 and M8200 models based on Teledyne e2v's Emerald 37M and 67M sensors. The new models are easy to use and engineered for applications requiring high-speed data transfer.

In addition, the Z-Trak2 high-performance 3D profiler sensor for in-line measurement and inspection applications will be shown, as will the Hydra3D, a high-resolution, multi-tap time-of-flight image sensor.

Matrix Vision (8C30) will demonstrate how to distribute the network data stream to multiple CPU cores using its Multicore Acquisition Optimiser (MAO) and the MvBlueCougar-XT 10GigE camera. In this way, data loss in high-end applications can be avoided. In addition to the MvBlueNAOS4, which is specifically designed for the fast sensors of the Sony Pregius S series, the company will expand its embedded vision portfolio with another camera family.

Matrix Vision will also show its GigE Vision camera, MvBlueCougar-X, with a UV sensor, as well as present a new 3D camera. Finally, the company will show its MvImpactT Acquire SDK, a software development kit for all interfaces and platforms.

Automation Technology (10F54) will present its two recent flagship products: the new 3D sensor C6, as well as the smart infrared camera IRSX.

With its new C6 sensor, AT offers a 3D laser triangulation sensor that combines speed and resolution. The sensor chip incorporates the company's Widely Advance Rapid Profiling (WARP) technology, allowing the camera to reach a profile speed of up to 38kHz at an image size of 3,072 x 201 pixels, and with a resolution of 3,072 points per profile.

The IRSX smart infrared camera is developed as an all-in-one stand-alone solution for thermal machine vision. The camera combines a calibrated thermal →

→ imaging sensor with a powerful data processing unit in a rugged IP67 housing, and communicates directly with the clients' process control. A number of product-specific measurement plans can be stored on the camera through the multiple job feature. In addition, the camera has numerous integrated interfaces, including Modbus, LUA scripting or REST-API/OpenAPI.

Infrared imaging

Xenics (10E55) will present its two latest SWIR industrial cameras: Wildcat+ 640 and Wildcat 1280. The Wildcat+ 640 camera's VGA sensor offers high dynamic range and can run at up to 300Hz, while Wildcat 1280 is the higher resolution SXGA format. Both are targeted at industrial inspection, with Wildcat 1280 suitable for demanding tasks, such as semiconductor inspection.

Xenics will also show thermographic cameras, such as Ceres T 1280, which combine high temperature accuracy and high resolution.

At Vision 2022 **Emberion** (10B10) will release a variant of its VS20 camera, which has a wide spectral range from the visible into the shortwave infrared (400-2,000nm). The camera has a GigE interface and high dynamic range.

These cameras are based on nanostructured quantum dot sensors. Machine vision is a key focus area for the GigE camera, which can support up to 400fps, targeting optical sorting applications. Moreover, it can be used in surveillance, waste recycling and moisture detection at around 1,920nm, providing benefits in food sorting, for instance. Pharmaceutical packaging inspection, semiconductor imaging and laser beam profiling are also key applications for the camera.

First Light Imaging (10F76) will highlight two cameras. C-Red 3 is a SWIR InGaAs 640 x 512-pixel compact camera running at 600fps with a readout noise of less than 40 electrons. The camera offers adaptive bias and high dynamic range options, and is particularly suited for applications requiring short exposure times.

The second camera is C-Red 2 Lite, a high-performance SWIR InGaAs 640 x 512-pixel robust and compact camera with TEC stabilisation, designed for high flux SWIR applications. The camera is able to acquire 600 images per second with a readout noise of 30 electrons. It offers many features such as high dynamic range and anti-blooming.

Raptor Photonics (10H34) will show a range of camera solutions, from high-energy x-ray detectors to SWIR cameras. On display will be the Owl 320 InGaAs camera, covering visible to SWIR wavelengths from 600nm to 1,700nm. It has 320 x 256 pixels with 30µm pixel pitch, and runs at 349Hz speed at full resolution. It is the ideal camera for hyperspectral imaging applications, offering low read noise for best sensitivity.

Artificial intelligence

Conundrum's (10D90) Euler system is designed to monitor product quality in real time and identify defects, such as colour deviations, differences in texture and geometry deformation. It uses a neural network trained on synthetic data, which means the model can be trained quickly without needing to collect and annotate component photos with defects. The input data is a 3D model of the component, images of ideal components and a high-level defect description.

DenkWeit (8E60.3), a Fraunhofer spin-off, will be demonstrating its Vision AI Hub, where users can create AI image analysis solutions with just a few clicks and no know-how.

Deutschdata's (10E70.4) 36Zero Vision product is an AI-powered vision solution developed for quality control in manufacturing. The deep learning technology automatically tracks parts, detects surface defects and verifies norm-conformity. 36Zero Vision is an end-to-end software solution that can run on the cloud and on edge devices.

Pleora (8C23) will show its AI solutions to help manufacturers reduce errors and risks, lower costs and automate manual tasks for end-to-end quality inspection in automated and manual applications.

The company's AI Gateway edge processor lets manufacturers cost-effectively add AI capabilities to existing machine vision inspection applications. With an integrated no-code development platform, manufacturers can design and deploy AI skills without changing existing machine vision infrastructure and end-user processes.

Pleora's Visual Inspection System ensures human decisions are subjective, consistent and traceable for manual processes. Integrated inspection apps are transparently trained based on operator actions to highlight potential product deviations and suggest a decision. Standard and customisable tracking and reporting apps gather data from manual processes for traceability, inventory and shipment management, and batch tracking.

Irida Labs (8C21) will display PerCV.ai (called Perceive AI), an AI software and services platform that empowers the development of scalable vision-based solutions. Using USPTO patented CV and ML cores running at the edge, PerCV.ai brings together all the necessary building blocks for building and using Vision AI products – from vision system design and data management all the way to ready-to-use deployment and orchestration tools.

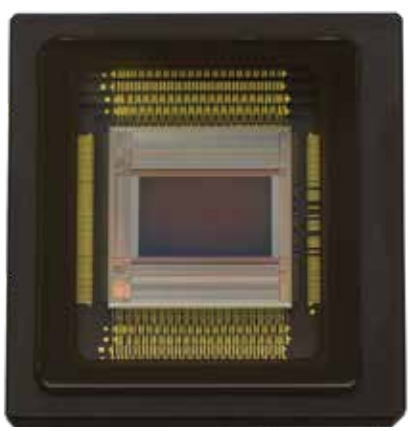
The higher resolution Owl 1280 offers 1,280 x 1,024 pixels with 10µm pixel pitch. It is flight proven, with cameras on Leo cubesat missions. Also on display will be the Hawk 800 visible camera, which offers low readout noise, low dark current and high sensitivity, even in low light levels.

Headwall Photonics (10G38) will show its MV.C NIR hyperspectral NIR camera systems, which features fast data acquisition and both high spatial- and spectral-resolution over a range of 900 to 1,700nm. Headwall's PerClass Mira software can be used to capture data and build spectral classification models that can run in real time on a production line.

Sensors

Gpixel (8B40) will be showing its GSprint4502, a 2MP 2/3-inch image sensor designed with the latest 4.5µm global shutter pixel. The sensor delivers 3,300fps in 8-bit mode and 3,800fps with an ROI of 1,024 rows in a dedicated 3D laser profiling mode. With on-chip 2x2 charge binning, full well capacity is increased and frame rate is almost quadrupled.

Also on display will be the GL7008, a global shutter line scan image sensor with 7µm square pixels, 8,192 horizontal resolution, and a line rate up to 200 kHz. The colour sensor supports three-line true colour and four-line RGBW multispectral output. The exposure time of each line can be individually adjusted by an external trigger. The line spacing of the sensor is equivalent to the pixel size to satisfy the requirements of line frequency matching.



Finally, Gpixel will show GMax32152, a 152MP global shutter image sensor with 3.2µm pixels. GMax32152 delivers 16fps with 38 pairs of sub-LVDS channels running at 960Mb/s. It provides high throughput and high-quality images for demanding colour imaging applications, such as aerial imaging.

Photolitics (10H54) will show its LS2G line scan sensor family, including the new LS2G-6k model. The pixel pitch of the sensors can be changed via SPI configuration, allowing them to cover scanning applications with a 5µm pixel pitch, as well as with a 7µm pixel pitch. These configuration features allow the sensor to cover many different scanning applications, be it monochrome high-speed scanning, RGB colour scanning, or multispectral applications. All members of the LS2G family offer up to 300 kHz scan rate and provide low-noise, high-sensitivity pixels.

The new LS2G-6k sensor can cover scanning resolutions of 4k pixels with 7µm pitch, or 6k pixels with 5µm pitch by changing the SPI register configuration of the sensor.

Frame grabbers

BitFlow (10H46) will be showing the Claxon Fiber, a frame grabber capable of CXP12 over fibre. It offers four links, each carrying 12.Gb/s of data, supporting one to four cameras. It's CXP 2.0 compliant and uses standard QSFP+ ports.

BitFlow's grabber interfaces are Camera Link, Coaxpress and Differential, with the firm offering several options with each interface.

Euresys (10D70) will demonstrate its latest Coaxpress-over-fibre Coaxlink QSFP+ frame grabber, compliant with 40Gb/s optical modules and cameras from various makers, along with the eGrabber image acquisition and recording software, including Gigelink for GigE Vision cameras. →

→ The company will also show its new Open eVision libraries for embedded applications, including EasyOCR2 for reading date codes on Raspberry Pi with an entry-level camera, and inspection using deep learning on an Nvidia Arm system with a GPU. 3D libraries to automatically extract, align and measure 3D objects from point clouds or ZMaps will also be highlighted.

Finally, Euresys's sister company, Sensor to Image, will show its latest GigE Vision IP core, featuring support for 25 GigE Vision, along with USB3 Vision and Coaxpress and Coaxpress-over-fibre bridge IP cores.

Lighting

TPL Vision (10C84) will be exhibiting its multi-UV dome light. The fluorescence illumination solution can enhance fluorescence inspection on a variety of surfaces, from traceability to UV glue and tax stamp inspection applications.

In addition, TPL Vision will demonstrate the benefits of collimation on rounded and transparent parts with the introduction of the firm's CSBack collimated backlight. The CSBack is designed for applications where high contrast or high-edge definition is required. It's ideal for detecting subtle scratches or dents in transparent parts, and precision measurements of small or rounded components in the pharmaceutical, electronics and automotive markets.

The company will also present the latest additions to its bar light range, including modular bars with angle changers ideal for robotics and automation applications, and IP69k illumination dedicated to washdown food and beverage applications.

Leistungselektronik Jena (10C16) will show the Luxyr LED One Flex light engine. The optical output can be connected to a 3mm or 5mm light guide, as well as used via free beam. Furthermore, collimation optics can be connected to a microscope adapter.

The light source has three different operating modes and has a light output that reaches up to 21W optical. The LED light has a lifetime of more than 10,000 hours, as well as a configurable timer.

The light engine was designed for machine vision and for UV applications, and is particularly suitable for image processing, automatic optical inspection, semiconductor manufacturing, UV curing and material testing.

DCM Sistemes (10D80) will show its AMS family, a low-angle diffuse series of ring lights, which allows uniform illumination of highlights and defects without glare from the LEDs. The AMS2520A is available in a multi-wavelength version (with four sectors) or a monochrome version with a four-sector option. The multispectral ring has four independent sectors and the possibility of combining up to eight colours. The wavelengths included in the standard version are: 400nm, 470nm, 525nm, 630nm, 730nm, 850nm, 940nm and white, but other colours and combinations are possible.

Lumimax (10D51) will show its LQHP area floodlights, which have a brightness of up to 5,000,000 lux. The floodlights are ideal for code reading tasks, as well as presence and position checks, for example in the logistics, food or automotive industries.

The Flexpoint Radial laser module will be shown on **Laser Components**' stand, (10C20). The module can be used to measure the inside of a pipe, detecting irregularities as small as 50µm. The beam has a homogeneity of 80 per cent, with an output power of 50mW at a wavelength of 660nm. Laser light is directed onto a cone-

shaped mirror and reflected uniformly at an angle of 360°, without rotating elements that would make it prone to failure. The focus is adjusted in production to the requirements of the customer's application.

Flexpoint Radial was developed in cooperation with MSG Maschinenbau to facilitate the inspection of high-pressure pipelines. To withstand the immense stresses of daily operation, the tubes must have a perfectly round cross-section. In the past, this could only be determined via inaccurate measurements on the outside. With the ring laser module, surveying equipment can create a detailed 3D model of the inside of a pipe.

Frankfurt Laser Company (10E90) will show the HSML-E, a series of laser diode line modules delivering very fine lines. The laser head and driver are separated, with the laser head measuring just 12.6 x 44mm. The beam line can be focused to a thickness of 10µm at 40mm distance. Standard fan angles are 10° to 90°. The wavelength range is from 405-1,060nm with output powers

up to 50mW. The power stability is typically ±5 per cent over eight hours at an operating temperature range from 10-50°C.

As an option these modules are offered with potentiometer for power adjustment, external TTL modulation up to 1MHz, and analogue modulation up to 100kHz. The housing is electrically isolated and satisfies the protection class IP67, which makes these modules ideal for use in industrial applications with harsh environmental conditions. The major applications are machine vision, scanning, profiling and laser triangulation.

Software

MVTec Software (8C56) will present the latest versions of its machine vision software products, Halcon and Merlic. Both will be released this autumn.

The deep learning-based bin-picking application, AnyPicker, will be demonstrated, whereby a robot arm picks up arbitrary objects with unknown shapes with the help of MVTec Halcon. The application combines 3D vision and deep learning for the first time, with the aim of robustly detecting gripping surfaces.

In another live demonstration, MVTec shows how Merlic software can be set-up to inspect electronic components on printed circuit boards using the new Global Context Anomaly Detection technology. In this process, both local, minor defects such as scratches, as well as large-scale logical errors, such as misplaced labels, are detected. The technology introduced in the new Merlic 5.2 release can be used for completeness checks and defect detection as part of quality control.

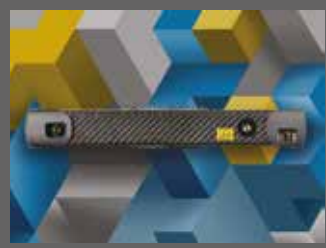
As part of the Industrial Vision Days, Christian Eckstein will speak on the topic →

3D vision

3D Global Solutions (10H58) will be showing Scalereo, an eyepiece-free digital 3D working and inspection microscope. The microscope incorporates a stereo camera system, in combination with modular adjustable illumination, with the depth of the object seen on a 3D screen. It is designed for precision work, such as assembly and gluing, deburring and soldering, and testing and checking.

Nerian's (10G58) new Ruby 3D depth camera works as a hybrid solution of active illumination and passive stereo vision, by using an infrared laser dot projector. Ruby integrates three image sensors: two monochrome sensors for depth perception, and one additional colour sensor. With this set-up, Ruby is able to perform precise measurements even on difficult surfaces, while maintaining the capabilities of a stereo vision camera, like functioning outdoors and sensing colour. The camera can run at 40 fps or 1.6MP without consuming processing resources on the host PC.

Photoneo (10C40) will showcase its new colour 3D camera MotionCam-3D Color. The camera fuses three key properties: 3D data, motion and colour, which, according to Photoneo, makes it the only device on the market



that enables real-time colour 3D point cloud creation of moving scenes in high resolution and accuracy.

The secret behind MotionCam-3D Color's power is Photoneo's parallel structured light technology, similar to its black and white sister camera.

MotionCam-3D opens up a range of possibilities for AI-based decision-making and visualisation applications, including object recognition, inspection and quality control, VR and AR, 3D model creation for the metaverse and digital twins, or data streaming for distant teleoperation of industrial applications.

Phil-Vision (8A01) will be showing its PvRecord modular multi-camera system as an example of its high-speed video recording and 3D-reconstruction capabilities.

PvRecord offers real-time reconstruction of an arbitrary number of scenes in 3D using four high-speed cameras calibrated to each other. The system offers the possibility of replaying the captures as a video stream and an option to freely select the perspective.

For the localisation of objects, Halcon-based 3D matching (surface-based matching) is performed on the point cloud. In addition, the scene can be further analysed with various Halcon algorithms.

The 3D scenes are played back in a specially developed player. The solution is widely used in research, but also in high-speed material analysis, where there is a need to analyse processes quickly in 3D that are happening at high speeds.

The firm will also be showing its LED light panels in the PvLight series. The panels impress with extremely homogeneous light, diffuse highly intensive light distribution, a long service life, as well as their excellent price/performance ratio. Thanks to special temperature management, the LEDs have low power consumption and generate little heat, resulting in a service life of more than 100,000 hours.

Vision Components (8C31) will premier its miniature VC PicoSmart 3D laser profile sensor. This OEM component has been developed for fast-track design of economic, tailored 3D systems. It combines two modules: the image processing system VC PicoSmart, which is fully integrated on a 22 x 23.5mm board; and a line laser module.

Additional trade fair highlights include the compact FPGA-based image processing booster VC Power system-on-module (SoM), with a board footprint of 28 x 24mm and, based on it, the VC Stereo Cam. The hardware accelerator executes complex image pre-processing operations in real time, for instance, for colour space conversion, barcode identification or data fusion from stereo vision or multi-camera applications. It allows vision OEMs a flexible choice of processor board and is easy to integrate in different embedded vision electronics designs.

For series development,

the VC Power SoM can be integrated into mainboard designs as a module, or combined with an I/O board with multiple Mipi ports. Vision OEMs can therefore achieve series maturity in less time and more efficiently.

Finally, Vision Components will also present its growing portfolio of Mipi camera modules, including modules for SWIR and time-of-flight applications.

→ of 'Deep learning and AI combined with traditional methods to facilitate automation,' while Ricardo Juarez Acuna will be part of a presentation on 'Building machine vision with standardised behaviour and interfaces,' as part of the VDMA OPC Machine Vision initiative.

Robot guidance

The new Robot Image Capture Tool from **Evotron** (10E70.6) turns industrial robots into a universal inspection machine. The tool is attached to standardised robot connection plates. It combines all the necessary components for robot-supported image acquisition: CMOS camera, high-resolution lens, high-intensity LED ring light and digital illumination controller.

The tool is electrically connected to the robot's path control (trigger, status, power supply) without additional wiring. The digital illumination controller synchronises the flash lighting and the image acquisition. Repeatable short flash pulses of up to 1µs duration are possible. These ensure blur-free images even with fast movements. Flash time and camera trigger are freely programmable with 20ns resolution. This simplifies the time-consuming synchronisation of flash lighting. The tool is configured via industrial WLAN.

The four sectors of the LED ring light can be controlled with the capture tool in any order and combination, which means that even difficult lighting scenes or 3D lighting scenarios can be achieved.

Liebherr (10D16) has been active as a robot integrator in the field of bin picking for 10 years and has now bundled this experience in a technology package. It consists of a vision system for image data acquisition and software for object identification and selection, collision-free part removal and robot path planning up to the deposit point. Liebherr uses colour cameras from Zivid.

Lenses

Kowa will present its range of vibration-proof and waterproof lenses on booth 10B40. Besides the rugged 1-inch and 2/3-inch series, a vibration-proof and IP67 version of the 1.1-inch 24MP FC24M series is new in the portfolio.

Kowa will also show lenses optimised for the SWIR and vis-SWIR range. New in the portfolio are lenses for the UV wavelength range adapted to the new Sony sensor IMX487. The focal lengths 75mm and 100mm complete the 1.1-inch 24MP FC24M series. Kowa lens experts can also advise visitors on custom lens projects.

Corning Varioptic (10B48) will display its C-T-39N0-A1-XXX electronically focused, controllable telecentric lens modules based on the A-39N0-A1 variable focus lens. The C-T-Series incorporates all the necessary electronic components to drive the lenses, and only requires a DC power supply; focus can be controlled through either an RS232 or I²C input. The lens series is compatible with C-mount cameras featuring sensor sizes up to 1-inch, and has been specifically designed for machine vision applications. They are available in 0.5X and 1X magnification.

Edmund Optics (10D50) will be showing rugged imaging lenses designed to maintain performance and accuracy in a wide range of environments where imaging is challenging.

The company's Techspec athermal imaging lenses provide optothermal stability in a rugged lens housing, making them ideal for harsh environments. These lenses use passive athermalisation to mitigate the effects of thermal defocus in applications that are prone to temperature fluctuations. These lenses are also stability ruggedised to minimise pixel shift after shock and vibration.

Edmund Optics' waterproof Techspec Cw series of fixed focal length lenses are designed to meet IEC ingress protection codes IPX7 and IPX9K. These lenses withstand exposure to water up to one metre depth for 30 minutes and operate in close-range high pressure, high temperature water spray downs. They include a hydrophobic coated window to prevent water droplets from settling on the lens surface.

Fujifilm Electronic Imaging (10F50) will show the Fujinon HF-1F series, which has five fixed focal lengths, from 8mm to 35mm, and is designed for a sensor size of 2/3-inch to 1/1.2-inch. It delivers a resolving power of 3.45µm (5MP). The lenses are optically based on the existing HF-XA-5M series. However, they have been mechanically improved and are now equipped with Fujifilm's anti-shock and vibration technology. The housing of the new lenses is slightly larger, with a diameter of 34mm.

In addition, the new HF-1F series offers a fixed iris (with three interchangeable iris rings). The focusing is done via the depth of screw-in and is fixed with a lock nut. The lenses do not incorporate any moving parts inside the housing and are therefore very robust and ideally suited for use with 3D cameras and robot applications.

The Phenix FF lens series for machine vision is an ultra-high resolution, ultra-low distortion lens developed by **Phenix Optics** (10C16). The lenses are equipped with F2.8 aperture; the focal length covers 50-80mm, and the resolution is up to 100MP. The FF series is suitable for all types of high resolution cameras and 5µm 8K line scan cameras. There is a choice between V-mount and F-mount.

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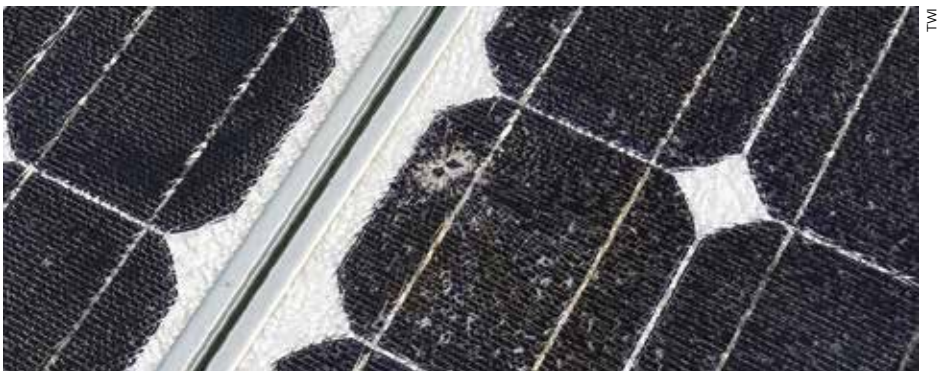
A bright future for the next generation of solar-powered technologies

How companies are unravelling the conflicting demands of increasing inspection speeds while increasing efficiencies, by **Holly Cave**



TWI

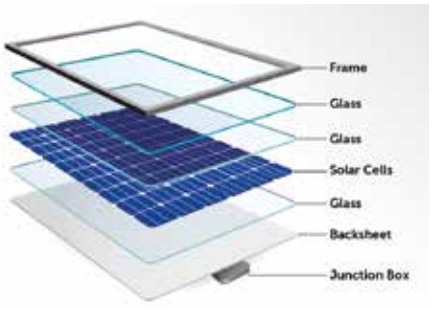
Microcracks can eventually cause an entire panel to shatter

Globally, the solar industry continues to be in dynamic growth, especially in China and Southeast Asia, with India rapidly becoming the main driver of the market. In the past few years, Isra Vision alone has installed, on average, a couple of hundred systems per year, 90 per cent of which were in Asia.

But the industry is also seeing 'the signs of a renaissance of the solar industry in Europe,' according to Christian Probst, managing director Isra Vision – GP Inspect. 'The war in Ukraine and the resulting political developments will accelerate growth,' he says.

But even in the face of huge growth, the solar industry is not an area in which quality can be compromised. During production, inspection systems examine the surface conditions and geometry of the wafer, checking for distortion, cracks, chips and contamination. Microcracks can eventually cause an entire panel to shatter, causing possible knock-on damage to equipment and other panels in the array and requiring an expensive shutdown of the line for clean up and repairs.

It is therefore no surprise to hear from Xing-Fei He, senior product manager at Teledyne Dalsa, that 'solar cell manufacturers are moving to 100 per cent inspection of each panel after every major processing step. They are under pressure to increase the quality of their products and reduce costs. Yield is critical, and optical inspection is a vital tool.'



TWI

Solar panel diagram: the different layers of a solar panel

Compare and contrast

'The inspection of solar cells can take place at various stages of the production process,' says Probst. 'However, this also depends on the producer. Does it want to detect defective cells already within the process and reject them as quickly as possible? Or is a final inspection at the end of the production line sufficient?

The Isra Vision – GP Inspect portfolio starts with the incoming inspection for raw wafers, where they are checked for surface defects, microcracks or chippings. This is usually followed by texture monitoring, where the quality of the surface is reviewed after the chemical bath. Next comes coating inspection, followed by print and structure inspection on the front and rear sides, and the final cell classification and sorting.

Dr Jonas Haunschild, head of the inline wafer, process analytics and production control group at the Fraunhofer Institute for Solar Energy Systems ISE, says that one of the greatest challenges lies in characterising the many interacting thin layers that make up modern solar cells. Each of these layers must be controlled, preferably not only at one point but over the entire surface.

Probst agrees the fineness of the layers and the weak contrast between them makes inspection very challenging: 'Different structures within the cell must precisely align with each other to achieve the highest possible efficiency. Meanwhile, these structures are so fine that the regions responsible for charge separation are only a few hundred micrometres apart. The patterns are only faintly visible and often have shallow contrast.

'Depending on the layer, this is already very demanding, but we want to go one step

further,' explains Haunschild. 'The processes to be developed should be so fast and so cheap they can be used in the production environment of solar cell manufacturers.'

Inspecting flexible photovoltaics

Back in 2018, 16 partners joined forces as part of the EU-funded OledSolar project to accelerate the widespread commercialisation of organic light-emitting diodes (OLEDs) with thin-film solar cells. Focused on developing innovative manufacturing, monitoring and inspection processes, the technologies developed during the project, which closed earlier this year, may help deliver new types of solar-powered devices, such as energy-efficient lighting, flexible display screens and solar panels that could be smoothly integrated into the structure of buildings.

TWI, based in Cambridge, UK, was one of the project partners. Working closely with the project co-ordinators, VTT Technical Research Centre of Finland, TWI has been developing inline quality-control techniques for photovoltaic module production, with the aim of automating a defect detection method for roll-to-roll printed flexible solar cells, ultimately improving quality, yield, processing efficiency and sustainability.

'We developed our thermography system here at TWI and that was then taken to VTT to be integrated with its production system,' explains Martin Bourton, principal project leader. It made sense for the TWI team to go for an approach making use of dark lock-in thermography (DLIT). Inspected parts are usually in thermal equilibrium. When it comes to photovoltaic materials, the main options for creating a thermal contrast between defects and the background material are either applying a current light source or introducing a new one. Both approaches can spread heat through the sample and muddy spatial resolution, but it was reasoned that voltage could be more easily regulated. This also worked well for VTT's testing line.'

TWI

TWI's custom-designed relay circuit switches the power supply on and off according to the square wave generated

TWI's DLIT system has proved a success in the lab and in field trials, where it has been validated on VTT's roll-to-roll pilot line. The new approach identified sub-millimetre defects (appearing as hot spots) far more clearly than standard inspection methods. 'The system looked at hundreds of pieces and successfully identified all the defects that had been artificially introduced onto the sample to replicate defective printing,' confirms TWI's senior project leader, Haitao Zheng.

When the electrical characterisation of the printed film begins, it triggers the synchronised thermography inspection by an infrared thermal camera located below the test area. TWI's DLIT system applies a square wave current to heat the test film and a thermal image is produced, ready for post-processing.

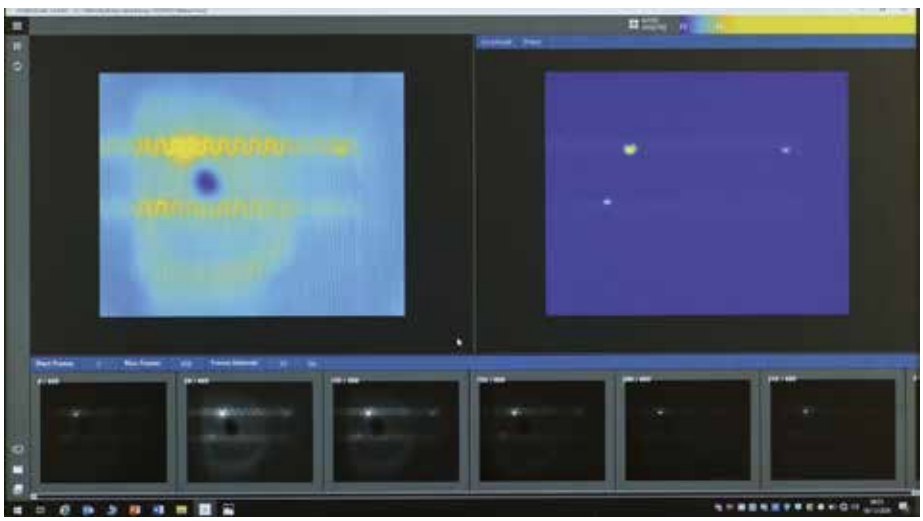
'Microcracks can eventually cause an entire panel to shatter'

TWI's custom-designed relay circuit switches the power supply on and off according to the square wave generated. This enables high voltages to be applied using a low-voltage signal. As well as capturing thermal images, the camera also records the synchronised square wave reference signal created by a signal generator.

'We also developed a graphical user interface software in-house, which provides thermography data acquisition, data visualisation, lock-in post-processing and data analysis capabilities,' says Zheng. 'When we compare our DLIT system to the standard approach, you can see there is far less background noise and our processed image shows defects very clearly.'

And the biggest challenge? 'That has been the inline implementation,' says Zheng. 'DLIT is not as fast as standard inspection methods. It's a stop-and-go inspection approach, requiring about 20 to 30 seconds between the input signal and post-processing.'

TWI is now looking to optimise the system to develop it into a commercial product, Zheng explains. 'We're looking to improve the speed, by developing a shorter input signal and programming the post-processing software in the C programming language, rather than using Matlab and Python, for example.'



TWI

As well as capturing thermal images, the camera also records the synchronised square wave reference signal created by a signal generator

How to inspect 45,000 tortillas an hour

Packaging lines are becoming more automated thanks to vision, especially lines processing food and fresh produce, as **Abigail Williams** finds out

Packaging inspection is machine vision's bread and butter, so to some extent the advances happening in the vision sector – the introduction of AI, for instance, as well as shortwave infrared imaging becoming more accessible – are now finding their way onto packaging lines.

Machine vision technologies are widely used for a range of purposes in packaging inspection – with key applications including presence verification, alignment, label inspection and print inspection, as well as product handling, pick-and-place and packaging logistics. As Simon Hickman, managing director at Multipix Imaging, explained, many of these tasks are relatively simple and lend themselves to what he described as smart sensor or smart camera technology, where the image processing is performed by a processor inside the camera.

'These [smart] cameras are becoming more capable and user friendly, which makes them a good choice for many packaging inspection tasks,' he said.

Smart cameras are, however, less suitable for multi-view or high-speed applications, and they generally do not have the processing power for complex tasks. For example, Multipix developed and set-up an automated quality control system to inspect disposable plastic mouldings at rates of up to 1,200 parts per minute. This system required a PC for processing.

Hickman explained the system was designed to detect and expel defect parts and reduce damage waste to zero. 'It was necessary to inspect parts from multiple angles to ensure all sides were free from damage,' he said, 'and to perform optical character recognition of the cavity number at the bottom of the part.'

A second camera measured the diameter and a third camera measured the height and profile to complete the full inspection. 'Handling data from three cameras at these speeds required a PC-based system with the power of Halcon software processing,' Hickman said.

Scorpion Vision

Inspecting tortillas on a high-speed packaging line

Well baked

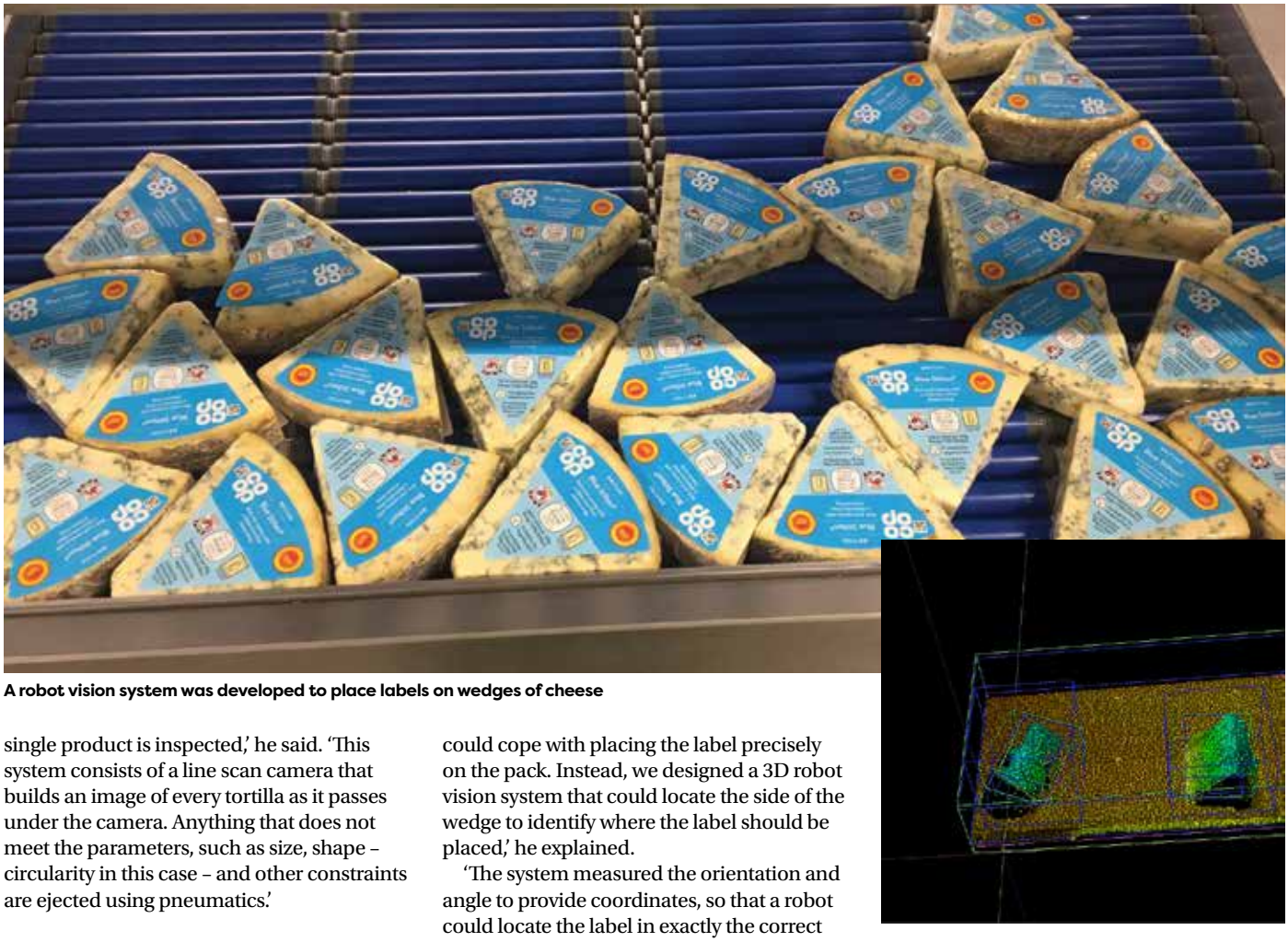
One task where a vision system can be employed is to inspect how the product is presented to the packaging machine. In the case of food, it also needs to be inspected for damage or poor quality that wouldn't be accepted by a supermarket.

'The product has to conform to maximum dimensions and shape,' explained Paul Wilson, managing director of Scorpion Vision, who gave the example of packaging bakery items. 'If they [baked goods] are too big, they may not fit into the packaging and can cause a blockage at the wrapper, causing the line to stop,' he said.

'So, inspections might include colour and size and perhaps orientation, but each product type comes with a specific challenge that can cause blockages, so there are often additional inspections required for those scenarios,' he added.

According to Wilson, some quality checks before packaging might simply result in the product being rejected from the line. One example is a system Scorpion has developed for flatbread tortilla inspection, which inspects an impressive 45,000 tortillas per hour.

'Such a fast production line cannot rely on human inspection, and it is critical every



Scorpion Vision

A robot vision system was developed to place labels on wedges of cheese

single product is inspected,' he said. 'This system consists of a line scan camera that builds an image of every tortilla as it passes under the camera. Anything that does not meet the parameters, such as size, shape – circularity in this case – and other constraints are ejected using pneumatics.'

Mature cheese

Wilson also cited another solution devised by Scorpion for a challenging problem experienced by a cheese producer. As he explained, the producer cuts cheese wedges from a large drum of cheese and sends them through a wrapper, after which the cheese is weighed and then labelled. However, the labeller experienced what Wilson described as 'a real headache', because the process was based on a mechanical system that placed the label on the cheese in an approximate location and often not very straight – forcing the producer to manually re-label as much as 60 per cent of the cheese.

'The source of the problem was the inconsistent shape and size of each cheese wedge, whereby no mechanical system could cope with placing the label precisely on the pack. Instead, we designed a 3D robot vision system that could locate the side of the wedge to identify where the label should be placed,' he explained.

'The system measured the orientation and angle to provide coordinates, so that a robot could locate the label in exactly the correct position, ensuring it was central and straight,' he added.

Sustainable materials

Another company active in this area is the electronics multinational, Omron, which has developed vision technology used at many of the main stages of the packaging process. As Jamie Steed, EMEA product marketing manager for vision and traceability at Omron, explained, the primary and secondary packaging process can often have similar types of inspection requests – depending on the product type being inspected, this can also be the consumer-facing packaging.

'Manufacturers are looking to protect their brand integrity and use more sustainable materials in the packaging process, as the appearance of the product is a key feature. One way to ensure brand integrity is the use of a machine vision inspection system in the packaging process. These are often added to prevent faulty products entering the supply chain,' he said.

One common application of vision technology in the primary and secondary packaging segments is label inspection – an area where Omron has introduced a new fine-matching AI algorithm to check label artwork for defects.

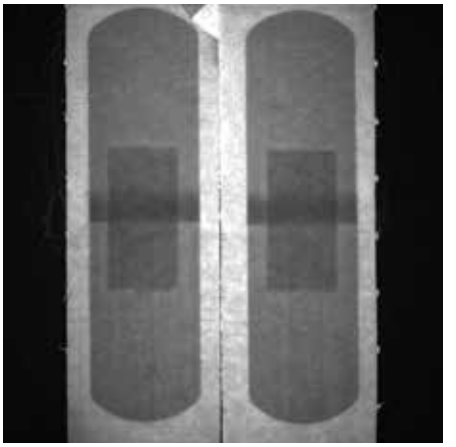
Another common application is checking the position of the label to make sure it is placed accurately. 'This is often solved by detecting a feature on the label artwork and referencing this point to the edge of the packaging. The vision system can then calculate the offset and reject the product if it is out of tolerance,' said Steed.

Correct lighting and illumination

As with all vision applications, Steed stressed working with a good image is essential and selecting the right illumination is a critical part of the process. In an effort to ensure these critical criteria are met, he also noted that Omron's latest smart camera, the FHV7, comes with multi-colour LED lighting, allowing users to select the best light for the application.

'Another key application area we have looked at is cap colour and cap placement – and the placement of key drivers behind caps to prevent leakages. The camera is placed after the capper to investigate if the cap has been applied squarely and fitted to the correct level. This is often done by →

'Manufacturers are looking to protect their brand integrity and use more sustainable materials in packaging'



Omron

Shortwave infrared imaging can be used to image products through plastic packaging, as well as check for fill levels in bottles

→ placing an LED light behind the bottle and cap to create a silhouette image,' he said.

After the camera has acquired the image series of edge tool algorithms, Steed said it can check to see if the cap is within tolerance and, if not, a signal will be given to a reject mechanism.

'Lines can run at very high speed and a second output can be used to stop the line if there are too many consecutive failures,' he said.

The third stage is tertiary packaging, which protects the product when in transit. Typical vision applications can be used to check if the contents of the packaging are complete, as the tertiary packaging normally contains multiple items of the primary or secondary packaging.

Future innovations

This autumn, Steed revealed that Omron is set to launch a range of shortwave infrared cameras manufactured by Omron Sentech – initially with a GigE interface in 0.3MP and 1.3MP resolutions.

'SWIR imaging allows users to solve applications that are invisible to the human eye,' Steed explained. With a SWIR camera, lens and LED light, operating from 900nm to 1,650nm, the user can detect clear liquid droplets that could indicate a leaking product, for instance, or check the fill level in an opaque plastic bottle, as SWIR can image through plastic.

'Additionally, it is possible to penetrate thin films and printing on packaging with SWIR technology, meaning in certain applications the camera can see inside the package – allowing machine vision tools to inspect the actual packaged item,' Steed added.

Vision can be used to guide a machine to trim leeks

'It's the availability of 3D vision and AI that can now supplement or replace the human trimmers'

Looking ahead, as human labour becomes more expensive, Wilson predicted there will be even greater pressure to increase automation. Scorpion Vision has designed vision systems to automate some very complex tasks for trimming and processing fresh vegetables, tasks that would otherwise require a human operator.

'It's the availability of 3D vision and AI that can now supplement or replace the human trimmers, as a 3D vision system can look at a vegetable and decide where it needs to be cut,' Wilson explained. 'AI is used to great effect here, as it can make the final decision – this is the key to high-yield, low-waste automated produce processing and packaging. We have delivered systems using this technology for growers of leek, turnip and swede, for example, and the demand for more developments in this area is significant.'

Meanwhile, Hickman observed that, moving forward, there is no doubt AI will play a major role in future development, but cautions it is not the answer to everything. 'We must all remember the core of any camera inspection system is the quality of the images, and this requires vision knowledge – selecting the most appropriate camera, lighting, lens and analysis technique will always separate properly engineered solutions that are truly robust and reliable,' Hickman concluded.

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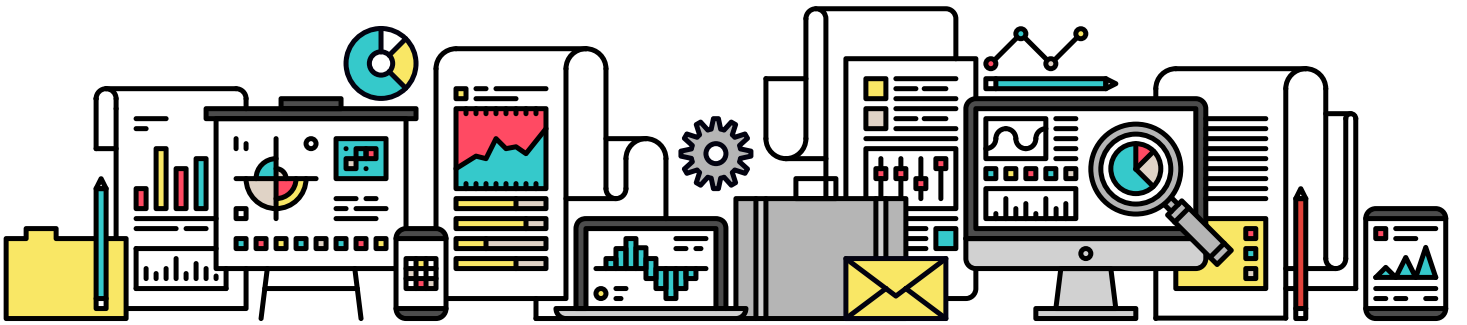

C6 Series: The next generation of 3D sensors

AUTOMATION TECHNOLOGY

The new C6 series of 3D sensors from AT - Automation Technology is based on a new sensor platform that supports the latest technology trends such as GenICam 3D.

Industrial camera interface guide

TELEDYNE DALSA

There are many types of cables and connectors used with today's industrial cameras. This white paper explores and provides an understanding of the available interfaces within the industrial and scientific area scan camera market.

Triton Edge: The promise of industrial embedded vision systems

LUCID VISION LABS

This white paper will discuss in detail how Lucid's Triton Edge camera helps vision application designers reduce their time-to-market while integrating their own IP into a compact vision system.

The importance of data quality when training AI

TELEDYNE DALSA

In its latest whitepaper, Teledyne Dalsa explains why data quality is a key consideration to deploy an accurate AI-based system.

Improving visual inspection quality with AI

PLEORA TECHNOLOGIES

This white paper from Pleora Technologies discusses how AI can provide decision-support for visual and manual tasks throughout incoming, in-process, and outgoing (final) inspection steps of manufacturing.

Multi-Core Acquisition Optimizer for fast GigE Vision cameras

MATRIX VISION

The Multi-Core Acquisition Optimizer is a software-based innovation for using 10GigE cameras at maximum frame rate without any concerns and running time-consuming algorithms for processing the images at the same time.

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IMAGING & MACHINE VISION EUROPE

At full speed

From cakes to cars, **Keely Portway** looks at how the latest developments in 3D sensing are opening up a world of application possibilities where speed is of the essence

AT

aku.automation used the C6 sensor to devise an application to reliably check the coplanarity of connector pins in the automotive industry

3D profiling is the accurate three-dimensional topography of a given surface. It is widely used for height and shape measurement in applications, including metrology and surface inspection. As the technology behind it has become more advanced, more opportunities have opened up, for example, in the food production and automotive industries.

One company to benefit is US-based start-up Beehex Automation, which was founded in 2016 as a spin out from NASA, where the company's founders had worked on a project to develop a 3D food printer system that could personalise food for astronauts during long-term space missions. The team used the expertise they had built up to devise an application for the bakery industry, where, in the US, brightly coloured frosting, decorations and food colouring are incredibly popular. It is also common in the US to buy cakes in a supermarket, rather than a traditional bakery.

Baking up a storm

Managing director Benjamin Feltner and his team, therefore, had the idea to develop a system for the automatic labelling of cakes that can be used in any supermarket. They knew it needed to be an uncomplicated application that could respond quickly and flexibly to the size, texture and background, whilst also maintaining reliability. Feltner explains: 'Cakes have been popular in this country for decades and always will be. People will still be interested in great cakes for the next hundred years. That's why this is a particularly exciting market for us to work in, where there are always challenging things to discover.'

The company made contact with AT – Automation Technology (AT) through the imaging sensor specialist's American sales partner, moviTHERM, with whom AT has already been working for more than 15 years, and made the decision to incorporate the company's 3D sensors into its design.

The C6 sensor technology from AT currently offers the world's fastest 3D laser line profiling, with a profile speed of 38kHz or more achievable, depending on the height range of the application. It includes a sensor chip with a widely advanced rapid profiling (WARP) feature. The imager offers a resolution of 3072 pixels per row and enables the C6 profiler to generate high-resolution 3D scans. It supports the latest technology trends, such as GenICam 3D and includes new features such as MultiPart, which enables the parallel output of up to 10 different characteristics (for example, range, reflectance, scatter) at maximum profile speed; while MultiPeak allows the output of up to four different peaks for more greatly robust 3D data and for scanning transparent objects without disturbing reflections.

André Kasper, founder and CTO of AT, comments: 'The 3D sensors are unique in their combination of resolution and speed, so with their features we are opening up completely new horizons in 3D image processing. There is no other sensor chip in the world with which high-resolution profile data can be recorded so galactically fast. With our chip design and the on-sensor processing we have developed, we can achieve an unprecedented 3D data rate of 128 million 3D points per second.'

Feltner continues: 'We decided to work with AT because we have enormously demanding requirements due to the different nature of the cakes to be labelled, which not every component manufacturer can fulfil. With its C6 sensor, AT has a 3D solution in its portfolio that is, on the one hand, compatible with our software for evaluating the data and, on the other, can be used flexibly.'

Beehex now has a comprehensive range of products that not only allows for an enormously wide spectrum of colours when it comes to design, but also allows for any form of design the customer would like their cake to be decorated in. Feltner says: 'In the food industry, there are hardly any limits when it comes to designing cakes,

AT

Cake Applikation Mixbild: Beehex Automation used AT's C6 3D sensors to develop a system for the automatic labelling of cakes that can be used in any supermarket

and we had to come up with something that would make us better and faster than the competition in this industry. However, thanks to the long development time and the many optimisations, we are now the only ones in the USA to offer such a flexible, fast and individual design service.'

Making a connection

Moving from the US to Germany, and from cakes to connectors for the automotive industry, Baden-Württemberg-based aku.automation has also benefited from the new sensor technology of AT. The company is internationally renowned as a system integrator for high-quality image processing solutions. Its challenge was to develop an application to quality check the some 5,000 connectors in a vehicle. This can be particularly tricky because these different connectors also have numerous pins that control the vehicle's electronics – on average, around 100,000 pins are used per vehicle. The malfunction of a single pin could lead to the complete failure of the entire car electronics.

The system integrator developed an application to reliably check the coplanarity of these pins – in 24/7 operation in up to 40 machines at the same time, resulting in a check of approximately 1.7 million pins per day. The additional challenge here was to

AT

The C6 sensor technology can achieve a profile speed of 38kHz or more

check the condition of the pins, because after assembly they must not be permanently and flawlessly restricted in their function, even by external influences such as movement and moisture.

An experienced team of developers wanted to find the optimal design of the application. This initially involved putting together all the components for a reliable system, programming customer-friendly software, implementing the output of the quality data and coordinating the signal control for the machine. Having worked with AT for a number of years, aku.automation approached the company to help with a solution. That solution was a control using high-resolution 3D dual-head sensors from AT's C6 series.

The sensors scan the pins of the electronic connectors directly from two sides at the same time to avoid occlusion on the one hand, and to provide more detailed data for the 3D point cloud on the other. Again, the WARP feature, combined with the profile speed of up to 38kHz and resolution of 3,072 points-per-profile allowed a new dimension for electronic connector testing.

Martin Stengel, head of sales at aku.automation, explains: 'We have been working with AT for many years and benefit time and again from the extensive expertise of this component manufacturer. AT was also able to respond most effectively to the high demands in this application, thanks to its modular and flexible solutions in its 3D portfolio, so that we actually met all requirements 100 per cent. For us, two factors were decisive in the development. On the one hand, a reliable quality procedure was a priority, but on the other hand, we also wanted to make it as easy as possible for the customer to use the solution. Therefore, we designed the application in such a way it can be used for checking an infinite number of types of electronic connectors and thus has a high multiplier effect.'

Aku.automation performs connector testing for numerous well-known automotive manufacturers. The company's reject rate of defective pins is always less than one per cent.

Zoomik/Shutterstock.com

The cornerstones of vision illumination

Daryl Martin at Advanced Illumination says preparation on lighting set-up will pay dividends when building a vision inspection system

It is well-understood that the quality and appropriateness of machine vision lighting are critical aspects of creating robust and timely vision inspection. Sorting through the numerous light types and illumination techniques, geometries, filters, sensor characteristics and wavelengths is both challenging and time-consuming.

However, it is critical to spend that valuable time up front preparing the initial analysis of the inspection environment, including part presentation and object-light interactions, which will provide a foundation upon which to design an effective vision lighting solution.

There are several relevant aspects you will need to consider, and for our abbreviated framework we will refer to these as the four cornerstones of vision illumination:

- **Geometry** – the spatial relationship among the object, light and camera;
- **Pattern, or structure** – the shape of the light that is being projected onto the object;
- **Wavelength, or colour** – the characteristics of the lighting wavelength, how it is differentially reflected or absorbed by the object, and its immediate background; and
- **Filters** – act to block or pass wavelengths and/or light directions.

A common question will eventually come up: should you prioritise these four considerations within the overall investigation? As a general rule of thumb, no, lighting geometry and pattern become more important when working with specular objects, whereas wavelength and filtering are often used when working with coloured objects and transparent applications. The critical takeaway may be that some or all of the

Sponsored by

four cornerstones presented here must be evaluated and considered together, because they each have considerable overlap.

1. Geometry
This technique involves moving the relative positioning among objects, lighting equipment, and/or the camera until a suitable configuration is found. The combination of positions is best achieved under partial brightfield, directional lighting geometries where the light orientation is greater than 45 degrees.

This type of lighting is a desirable choice for enhancing topographical detail on flat to mixed surfaces that have a matte surface reflectivity profile. Conversely, imaging the surface of a specular object requires dark-field techniques, although the issue is frequently generating brightfield effects that exhibit saturation on a small defect, such as a scratch on a phone screen, with the remaining dark-field areas low in intensity.

2. Pattern (structure)
This refers to the pattern or shape of the light projected onto the object. Contrast changes through changes in pattern are generally accomplished by aiming or arranging the LED light heads, or through the use of various lighting techniques.

3. Wavelength
Materials reflect and/or absorb various wavelengths of light differently. This is true for both black and white and for colour imaging applications. Like colours reflect, which brightens the surfaces; conversely, opposing colours absorb, which darkens those surfaces. Opposite colours on the colour wheel generate the greatest distinct difference in contrast.

4. Filters
There are several types of filter, which will require more research outside of this summary. Filtering provides a straightforward method of enhancing the contrast of the image while blocking out unwanted illumination. There are many specific ways filters enhance contrast, and each filter exists to solve a unique problem. Some common filter types used for machine vision applications are coloured glass, interference, neutral density and polarisation.

Summary
These cornerstones were developed as a teaching tool for demonstration purposes, to enhance or even create feature-appropriate image contrast between the object of interest versus their background(s). This analysis can yield seemingly contradictory results, so compromise and patience are good virtues to lean on. Your efforts will be rewarded, with a stable and effective process that produces consistent and robust features, resulting in overall inspection stability.

No matter the level of analysis, or hard knocks experience, there is really no substitute for first-hand testing with two or three light types and techniques in a controlled environment prior to an actual floor implementation.

SMART VISION LIGHTS Featured product

Multiple inspections. Multiple spectrums. One light.

The patented DoAll is an all-in-one solution unprecedented in its flexibility for machine vision lighting applications and automatic inspection. The DoAll combines six products into a single multifunctional unit. The lights in the DoAll can be used individually to replace six products, but DoAll Imaging offers more: Use the lights in conjunction with each other to create a variety of multimodal illumination effects. For example, you can combine the dome light and a dark field light to increase contrast of surface features, or you can combine visible light with NIR for multispectral applications. The DoAll, with its RGBW and NIR ring lights, has native multispectral capabilities, but it can do even more with two expansion ports for connecting auxiliary lights. Add UV lighting, spots, linear, on-axis, or structured lighting, for almost limitless possibilities.

The DoAll Controller allows for easy set up through a user-friendly interface.

More information:
https://smartvisionlights.com

Commercial products

Among the vendors offering illumination products and solutions, **Basler**'s lighting portfolio for vision applications recently increased by a total of 200 new lighting products. This includes seven new lighting types – such as flat dome lights, back lights and spot lights – and 144 lights and additional matching accessories. The expanded portfolio is designed to offer a greater variety of components to individualise customers' vision solutions.

To help customers navigate this broad range of options, the company also unveiled a Lighting Advisor tool to help select the correct lighting set-up more quickly and efficiently.

The company's lights are tested for stability and usability, and complement its range of cameras and lenses, for the best possible application results. Industry-proven LED lights are used to provide the high uniformity required for repeatable image quality in machine vision systems. They also ensure low maintenance and a long operating lifetime, thanks to

Laser Components Featured product

Laser-pumped White Light Source

The LS-WL1 provides high luminance output that enables long throw distances, narrow beam angles and small optic sizes for speciality lighting applications. The white light laser module allows precise, high-contrast illumination in areas that are difficult to access. This opens new possibilities in endoscopy, surgical headlamps, and other biomedical applications. It can provide 100-times the intensity of a white light LED, with typical fibre output being >500mW (1mm fibre). Its luminance exceeds that provided by plasma light sources and other white broadband LED light sources.

The light is coupled into a multimode fibre with a core diameter between 50µm and 1mm. The LS-WL1 can be switched on and off quickly. In addition to this it has an inbuilt thermal management system with two miniature fans and a temperature sensor to provide overheating protection. The LS-WL1 can also be completely controlled using software such as LabVIEW via a Mini-USB port.

More information:
www.lasercomponents.com/uk/product/fiber-coupled-white-light-module

Zoomik/Shutterstock.com

efficient thermal management.

The latest light launches from **CCS** include the PFB3(A) Series, which was designed to provide light output exceeding that of a 100W halogen light source. It uses LEDs, which the company says offers a lower power consumption over halogen, which means a reduction in running costs. It also has a long lifetime of 25,000 hours and a compact design to save space.

The company also recently launched high-power HLDL3 Series bar lights and HLDR3 Series ring lights for long-distance and wide-area irradiation. The HLDL3 Series is available in two sizes, from 150 to 1,800mm (in 150mm increments). Three types of light directivity are also available, depending on the application conditions: narrow, medium and wide. Wavelengths offered are red, white, blue and infrared. The housing is also light and compact.

Newly available from **ProPhotonix** is a 375nm laser within its Photon laser modules range, designed to address the increasing interest in UV lasers, including applications such as UV curing and particle measurement. The UV Photon laser is available in power levels up to 70mW and is well suited to UV curing applications that require fast curing from a very focused UV light. 3D printing applications, many of which currently use 405nm lasers, could also benefit. The shorter wavelength allows the use of resins that are not as light sensitive, reducing waste and the need to shield the resin from environmental light to prevent accidental curing. It also has the potential to take particle analysis applications to another level with the shorter wavelength, allowing even smaller particles to be detected and measured. The laser modules are compact, reliable and configurable to address a wide range of applications.

The company has also extended its Cobra HyperSpec range with the introduction of the Cobra HyperSpec SWIR line light. This tunable SWIR (short wavelength infrared) line light allows for high-resolution, reliable imaging. It is fully customisable and can be configured to a range of applications, including textile recycling and quality control in the food industry. It allows users to optimise the spectrum to maximise contrast, compensate for camera sensitivity and deliver clearer, higher resolution images for increased accuracy and speed. Precise control of the light via its user-friendly GUI allows system designers to easily fine tune the performance of their system.

The MTD-LED HSL SWIR from **MTD Line Lights** is a high-power hyperspectral SWIR LED line light in the range of 1000-1,700nm. The illumination combines up to 12 different SWIR-wavelengths into a homogenous broadband spectrum. Each wavelength is separately programmable, so the spectra can be adapted to customer requirements. An integrated temperature control enables a stable spectral output. The SWIR-intensity at a working distance of 300mm is comparable to high-power halogen light without any significant heat radiation.

Metaphase Technologies recently launched a catalogue of configurable LED products. Built by CadenasPartsolutions, the tool makes it faster and easier for manufacturing

TPL Vision Featured product

Fluorescence Imaging Solution

TPL Vision's new Fluorescence Imaging Solution (FIS) is the first UV dome light that allows users to test and select multiple UV wavelengths (365, 395 and 405nm) along with white illumination for secondary inspection. The dome shape and integrated filter block all direct UV radiation, thereby maximising the safety of operators without the need for additional enclosures.

The dome's patented design provides outstanding homogeneity for the inspection area, which means the product is suitable for complex glass or metal surface inspection. It is easy to set up and compatible with any camera, from smart cameras to entry-level code readers. Application areas include the inspection of glue seals, bank notes, and fluorescent safety features typically found in pharmaceutical products, electronics and luxury goods.

The FIS greatly simplifies the process of identifying the optimum wavelength(s) that produce the perfect balance of bright fluorescence and high contrast for the best imaging results.

More information:
www.tpl-vision.fr/en/uv-range/fis

Chromasens Featured product

Complex inspection tasks with different types of defects often also require different lighting concepts. In most cases these are realised with several inspection stations. This leads to high costs for separate camera systems and for required handling stations. With line scan cameras, such inspection tasks can be realised by flashing different illuminations. However, due to the size of the individual types of illumination, collisions often occur in the installation space.

The new innovative combined illumination from Chromasens Corona II series solves this problem elegantly in one compact module: Tube light, bright field and dark field illumination can be combined accordingly within one housing. The performance of the individual components remains correspondingly high: for the tube light, up to 1.2 MLux is possible with white LEDs, and the dark field still achieves 800 kLux despite the compact design. The cooling options from the regular Corona range are still available.

More information:
https://chromasens.de/en/product/combined-light

engineers to source the correct lighting product for their application. The company designs and manufactures LED illuminators for machine vision, military and specialty lighting applications. Its products have a variety of features and options, which ensure accurate performance and fit for all applications.

Formerly, engineers would call or email the sales team to discuss the application requirements and work together to select the correct product. Now, these capabilities are available online for engineers on-demand.

The new tool also enables engineers to test the product in their design by downloading CAD models in more than 150 native and neutral formats. The online catalogue of LED illuminators will also deliver PDF datasheets, complete with configured product details and an interactive 3D preview.

TPL Vision's collimated backlight brings high-intensity illumination in a small package for projects requiring precise silhouetting. Due to its slim profile of 21mm thickness and narrow 5mm borders, the CSBACK makes it possible to achieve high-contrast images, even in challenging applications working with confined spaces or small objects that are difficult to inspect. Key application areas include the imaging of clear parts and objects with rounded edges, which are notoriously hard to inspect with improper lighting due to the lack of contrast.

Offering increased precision where high accuracy is a necessity, the CSBACK can help applications with measuring thread pitch, checking the placement of lids, analysing the profile of thick and round workpieces, checking the presence of needles and examining scratches or dents on transparent surfaces. It can be used with regular C-mount lenses, as well as telecentric lenses, providing uniform illumination at various sizes, from 50x50 to 200x200mm.

This is not an exhaustive list. If you provide illumination products and would like your company to be included, please email **editor.imaging@europascience.com**.

Walk the line

Keely Portway looks at some of the challenges for engineers, system integrators and anyone else selecting components for a line scan camera system, and finds out how the process can be simplified

Line scanning can produce two-dimensional images using a single sensor element. In its early iterations it was used for both visible light and infrared imagery from the 1960s through to the 1980s, particularly in aerial reconnaissance applications.

Today's line-scan cameras use a single line of pixels or, in the case of colour, multiple lines of pixels, that image across an object to build up a 2D image. It is mainly used in applications that require a continuous flow of objects on a conveyer belt, or where the object itself is 'endless,' such as foil inspection or roll-to-roll printing, thanks to their high-speed and high resolution compared to area scan systems. Other applications include printing machine manufacture, the production of wafer inspection systems and machines for PCB inspection and food sorting systems.

With such diverse applications, it can be a challenge for engineers to design and assemble the line-scan camera element of the system, depending on their level of vision experience. There are many components from which to select, and many require extensive knowledge about cameras, optics and lighting. For example, when choosing a camera and suitable lens, it needs to be considered whether it will be just one camera with a long sensor, or whether a solution with two cameras and shorter sensors would be more suitable.

Klaus Riemer, project manager at Chromasens, explains: 'If you design a normal matrix camera system, you can take a camera, light and lens and play around with it, and in maybe an hour, you could gain a good idea of what might work. With line scan, it is more difficult to play around with the system because an image is created only with the movement of the object or the camera. To optimally adjust light and sharpness, the object must often be captured several times. It's a good idea to first have the components that already fit what the application will require.'

Cost challenges

Another major challenge is in keeping the system costs low. The requirements may be fulfilled by, for example, simply choosing the perceived 'best' lens, but this is not always necessary and can make the system unnecessarily expensive. Riemer continues: 'Line scan lenses need to cover a large image diameter and are made in smaller quantities compared to C-Mount lenses. This makes them very expensive, up to €3,000. A higher-cost lens could match your requirements, but it is important to look at the whole system performance to avoid over engineering. You have to find the trade-offs and look at what's really necessary, because sometimes the specification or the requirements might be too sophisticated or over-specified. From this, a lens with less performance might work as well and save cost. Often, applications require high resolution and a large field of view. So, even with 15,000 or 16,000 pixels, you cannot cover the whole field of view. So, then you use multiple cameras in a row. Then, the trade-off may be a camera with a shorter pixel length, but a cheaper lens. Therefore using three cameras may be a better choice than, say, using two cameras with a higher-resolution and a more expensive lens.'

Another consideration is the light. What makes the defects or features to be detected visible? Should they use dark field, bright field, diffuse light or co-axial light? Or even a combination of light characteristics: for example, dark field and co-axial light may be required, depending on the defects and object surface. Light intensity is also important. 'It depends on the surface,' says Riemer. 'If you have a very shiny surface and you want to find dust particles, for example, dark field imaging works well because it's a black image on which only the dust particles appear bright. But, if you want to see structure on a shiny surface, you need more co-axial light. Sometimes the customer wants to see both the structure and the dust, and then they need both types of light.'

Component testing can also be challenging with line scan systems because it requires the object to be transported, and in doing so, the lens and light must be exactly aligned to each other. To save time, it

is important to have only a limited number of components for testing that are as close as possible to a suitable solution. 'Let's say, for example, in an application with a conveyor,' says Riemer. 'The object is placed on the conveyor, and it is switched on. Then the camera and the conveyor must be synchronised, because, if the camera runs much faster than the conveyor, you can get a condensed image whereas, the other way around, the image can be elongated.'

Last but not least is system integration, which needs to bring all components into a stable system: aligning camera, light and transport system. The object transport needs to be synchronised with the line rate of the camera using encoders. 'Sometimes the machine builder has to test in the machine and cannot use the lab because here the conditions of the machine cannot be exactly reproduced. On the other hand, it's more time consuming in the lab, so they just want to use the objects that are already running in the machinery and they need quite a realistic scenario,' explains Riemer.

A helping hand

To help address all of these challenges, Chromasens developed the Line Scan Vision Platform. It is designed to not only simplify the design of a complete line scan camera system, but also to offer the possibility to create an 'all-in-one' solution, using standard products and predefined elements from a modular framework. This approach can reduce the time for system design and provide an optimised, cost-efficient solution.

The platform is based on the requirements of the application, such as resolution, speed, scan width and so on, so the engineers and other system designers can determine the appropriate components with the help of a configuration tool. Numerous components are contained in the platform architecture, so the most suitable ones can be selected. This benefits customers as they can be assured of a system that is optimised exactly for their application requirements. Different line scan cameras from 4k to 15k are available, as is a large variety of lenses and lights to provide an optimal solution for a wide range of applications.

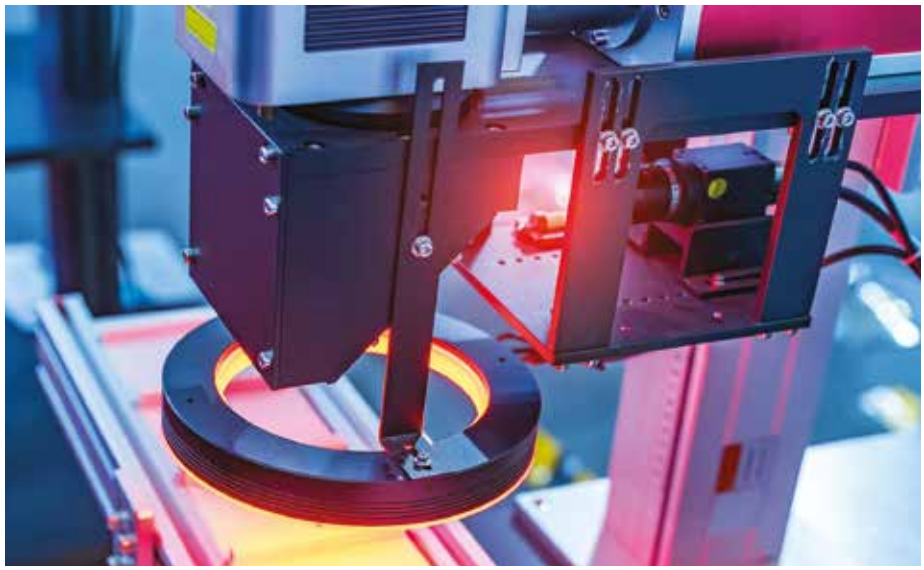
The lighting arrangement can be adjusted to the surface and the type of defects, and different light configurations – such as dark field, bright field, dome light and co-axial illuminations – can be achieved. The platform also contains alignment adapters that, together with easy-to-use software, can help to enable the fast yet accurate alignment of the components. The platform is scalable and can support several cameras in a row to cover large scan widths and high-resolution applications. With the predefined components from the modular platform, a complete system – including cameras, lenses and light – can be configured that makes design and installation a whole lot simpler.

'With such diverse applications, it can be a challenge for engineers to design and assemble the line-scan camera element'

Riemer explains: 'We have lots of different requests from different customers. Often, it's not only a line scan camera, but it can be a complete system that can incorporate multiple cameras. The platform is the gap between the customer obtaining a camera, light and lens and doing all the integration on their own or having a fully customised solution. Most different light set-ups can be achieved with the unit, and it can be placed inside of, for example, a printing machine or a machine that inspects semiconductors – there are many different applications where there is a fast-moving object, and the customer requires high-resolution with multiple light types.'

Chasing the interface race

Integrators are faced with a fast-moving picture when it comes to choosing the correct interface for their vision system, finds **Tim Gillett**



osharkyu/Shutterstock.com

The giant steps taken in Industry 4.0 have led to fast-growing opportunities in the industrial vision marketplace in recent years, with inspection and security products seeing wide commercialisation, particularly in the manufacturing sector.

Fast growth in smart manufacturing technologies worldwide have led to an increased demand for vision systems that can provide quality control automation and inspection. This trend has fired growth through the overall industrial vision sector; the global industrial camera market was valued at $12.9bn in 2021, but is predicted to grow at more than five per cent for the next decade, with an estimated worldwide value of $21.5bn by 2031.

According to a survey on the industrial vision market in June this year, by Transparency Market Research: 'A rise in need to monitor the harsh environmental conditions to prevent accidents in industries such as mining is augmenting the demand for industrial security cameras, industrial CCTV cameras, and industrial inspection cameras.

'Additionally, the advent of Industry 4.0 has resulted in rapid changes in the manufacturing sector, with the development of new and augmented networking systems across the world. This opens up lucrative opportunities for industrial camera manufacturers to introduce highly enhanced industrial camera systems for end-use applications.'

Drivers – more complex equipment, more varied markets

With the general growth of the vision industry, and its widespread use in ever-more diverse applications, comes an increased focus on the plethora of interfaces used to connect cameras and the wider systems in which they are used.

The last few decades have seen the development of various different interfaces, guided by scientists and industrial groups to define, maintain and standardise them. Users of vision systems have also been tasked with keeping on top of the relevant information regarding the capabilities of each interface to ensure they have made the correct decisions when procuring industrial vision equipment – no easy task given the rapid development in the marketplace and the constant rise in the number of new applications for vision systems.

While industrial and scientific cameras have moved on impressively in terms of speed, quality and improved sensor design, the use of the right connectors and cables into vision systems continues to augment and push the boundaries of imaging applications with higher bandwidths and more reliable data transfer.

Different requirements

According to Eric Bourbonnais, software designer at Teledyne Dalsa and chairman of the GigE Vision Committee at the Automated Imaging Association, for users – and, specifically, for buyers at industry integration companies – the key aspect to understand is there are a plethora of complex options when it comes to interfaces, and the choices made are very much dependent on the requirements of the job in hand.

He added: 'Of course, it needs to be considered that camera technology is moving fast – not just at the front end with sensor design, but within the camera interfaces themselves. Ethernet capabilities are growing fast too, and CPU advances mean there are new and faster ways of managing data and leveraging an internet that is improving constantly in terms of speed and reliability.

'We, and the wider industry, are bringing new connectors and cables into vision systems and this is helping to push the boundaries of imaging applications with higher bandwidths and more reliable data transfer. It is important for the industry to leverage and improve what has already been developed, by developing standard equipment and evolving systems that are already in place.'

Key interfaces

The simplest interface – largely due to its ubiquity and its long history – is the universal serial bus, commonly known as the USB. The interface has been in use for more than 25 years and, to this day, most personal computers come equipped with at least two USB3 ports as standard. Obtaining or replacing USB parts is easy and cheap, and the interface has very few compatibility issues, meaning a large number of USB

cameras can be added to a vision system without prohibitive costs.

Following in the footsteps of USB, and introduced around a decade later, came GigE Vision – aimed at high-performance industrial cameras, allowing the transmission of high-speed video and related data via Ethernet. The GigE standard was introduced by a group of 12 vision companies, and is administered by the Automated Imaging Association. A key benefit of GigE Vision is it allows multiple cameras to be controlled and synchronised on a 24-hour basis from a remote location. The most powerful GigE cameras, 5GigE, are capable of speeds up to 5 Gb/s, while a TurboDrive system from Teledyne Dalsa can potentially further double the standard data rate.

The CoaXPress (CXP) interface, as the name suggests, uses coax cables that require being attached to a frame grabber, or capture card. This system allows a higher performance and the capability to process larger amounts of data and increase a given system's overall bandwidth with maximum speeds of 25Gb/s, using cables of up to 35m in length.

CameraLink, developed around 20 years ago, is designed to be an easy and reliable way to connect cameras and frame grabbers. Using this system, cables of up to 10 metres can be used, though this needs to be reduced slightly when running at full capacity. Speeds of up to 850MB/s are achievable and multiple cameras can be controlled through one interface.

CameraLinkHS (CLHS), developed around 10 years ago, uses standard cables or fibre optics to maximise speed and range. CLHS can connect over distances as long as 5,000m when using fibre cabling, with speeds of more than 50Gb/s on a single cable.

Conclusion

The vision industry appears set to continue its fast growth in the coming years, with smart manufacturing technologies requiring the implementation of systems for quality control automation and inspection across a huge range of widely differing applications.

Clearly, there is a wide variety of camera interfaces available, and a decision as to which one best suits a particular imaging application can be a difficult one, given the multitude of variables in play. These include the distances involved and therefore the length of cable required, the speed of data transfer required and, of course, the cost implications for the buyer, both in terms of the original set-up and the ongoing need to maintain, improve and develop the system in question.

'It is important for the industry to leverage and improve what has already been developed, by developing standard equipment and evolving systems that are already in place'

Bourbonnais concluded: 'Buyers at integration companies need to understand the bandwidth, synchronisation, ease of deployment and cable length that each interface offers, then it becomes much easier to make a decision. By comparing the bandwidth of each interface, the difference in how much image data can be collected becomes clear.

'Using a CXP or CLHS camera will provide much higher bandwidth for a vision system, but in applications where a frame grabber is not necessary or not possible, options such as USB and GigE become a good choice. Deciding which interface best suits a particular system comes down to the needs of the application.'

Products

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Cameras

uEye Warp10 10GigE camera family

With uEye Warp10, IDS Imaging Development Systems has launched a camera family with a 10GigE interface. The first models with the IMX250 (5MP), IMX253 (12MP) and IMX255 (8.9MP) sensors from the Sony Pregius series are now available.

Applications such as inspection on a production line with high clock speeds, or image processing systems in sports analysis benefit from the fast data transfer.

The uEye Warp10 cameras are initially offered with C-mount lens holders. In the future, versions with TFL mount (M35 x 0.75) will also be available for use with particularly high-resolution sensors up to 45MP. The cameras are supported by IDS Peak software development kit.

www.en.ids-imaging.com/ueye-warp10.html

EoSens Creation 2.0CXP2

The Mikrotron EoSens Creation 2.0CXP2 camera allows engineers to embed custom image processing algorithms into its programmable Xilinx Kintex UltraScale FPGA. The Xilinx FPGA processes video streams at the edge at up to 5GB/s, therefore reducing network congestion, latencies and CPU workloads while improving response times.

The camera is GenICam compliant and can be tailored to a wide range of machine vision applications, including laser triangulation, inspection, sorting, additive manufacturing and metrology, among others.

Equipped with a LUX19HS 2MP CMOS sensor, the EoSens Creation 2.0CXP2 combines high resolution streaming with the speeds of the CXP-12 interface, switchable between 1, 2 or 4 links depending on requirements. Each link delivers 12.5Gb/s. The camera is capable of streaming video at 1,920 x 1,080-pixel resolution images at 2,240fps, or a maximum 170,575fps at lower resolutions, when using all four CXP lanes.

In low-light environments, the camera's 20V/Lux at 550nm sensitivity helps capture high-contrast, richly detailed images. It also has 60dB dynamic range.

www.mikrotron.de

Sick to bring Aeva 4D lidar to industrial sensing

Sick has partnered with lidar provider, Aeva, to bring frequency modulated continuous wave (FMCW) lidar to industrial sensing applications.

Aeva's Aeries II lidar module has a sensing range of up to 500 metres, and is able to measure velocity for each pixel. The FMCW lidar technology is fabricated on a silicon photonics platform and integrates all components on a single chip.

Dr Niels Syassen, member of the executive board responsible for technology and digitisation at Sick, said: 'We are convinced that [Aeva's] unique approach to FMCW technology... will provide new opportunities for us and our customers in a variety of industrial sensing applications, where traditional time-of-flight lidar technologies are challenged.'

Aeva's FMCW 4D lidar technology provides excellent dynamic range for operating outdoors. The device is also immune to blooming and ghosting from retroreflectors, such as safety vests, cones and tape.

www.sick.com

Cameras

Gocator 2600 series

LMI Technologies has released the Gocator 2600 series of 4K+ resolution smart 3D laser line profile sensors.

These factory pre-calibrated sensors come equipped with custom optics and a 9MP imager to deliver 4,200 data points per profile for high-resolution 3D scanning and inspection across wide fields of view (up to 2m at 0.55mm X-resolution). The profiler is ideal for applications such as battery inspection, food processing, building material inspection, automotive check, such as air spring and wheel inspection, rubber and tyre production, and general factory automation.

www.lmi3d.com

Fxo487 ultraviolet camera

SVS-Vistek introduces the Fxo487 ultraviolet camera, with a maximum frame rate of 194fps and 8.1MP resolution. This opens up new possibilities for industrial inspection tasks in the ultraviolet wavelength range.

SVS-Vistek's fastest UV model is the Fxo487MCX12-2C with two Coaxpress 12 connections, ensuring fast and loss-free transfer of data, as well as low trigger latency. Technical features of the Fxo487, such as the signal voltages, temperature resistance, input and output control, integrated strobe controller and numerous firmware features, are geared towards applications in demanding industrial automation.

The camera is ideal for tasks in battery, semiconductor, glass, recycling, gemstone and automotive industries. SVS-Vistek also offers matching lenses for its UV cameras.

www.svs-vistek.com

Image sensors

NIT and CNRS-Sorbonne develop quantum dot HgTe sensor

NIT has partnered with the French National Research Agency, The Institute of Nano Sciences from CNRS-Sorbonne University, to develop HgTe nanocrystal focal plane arrays.

The Institute of Nano Sciences is currently researching and producing quantum dot materials of HgTe, sensitive in the extended SWIR wavelength range.

Through a partnership with NIT, a first sensor-camera was produced showing impressive results.

QCD deposition has been demonstrated, with response up to 2µm on NIT ROICs. The technology is promising to design low-cost and small pixel pitch focal plane arrays, as well as to expand the spectral range of the SWIR camera up to 2.5µm.

www.new-imaging-technologies.com

Computing

Vision Box AI GPGPU system

Imago Technologies is expanding its deep learning product offering to include Vision Box AI, an ultra-high performance GPGPU vision system for AI and other applications requiring GPU computational power.

The fanless, compact vision computer is powered by the Nvidia AGX Orin GPGPU. It has up to 12 Arm CPU cores with access to up to 64GB of RAM for standard applications. Tasks can be distributed and there is enough memory available for image data, even when acquired by very high-resolution cameras. The computer achieves an AI-relevant computing power of 275 TOPS (tera operations per second, 8-bit integer) with excellent energy efficiency.

The GPU accelerator used in the Vision Box AI supports AI applications with high process cycles or complex networks. The Vision Box AI can execute both the learning program and the inference program of an AI solution. The GPGPU vision system also provides the necessary computing power for other applications that require a Cuda-based accelerator, such as hyperspectral imaging or light field cameras.

The system has standard I/O ports, such as real-time digital IO, an RS422 for connecting incremental encoders, Ethernet, USB and an optional monitor output. The first type of Vision Box AI offers up to four GigE interfaces for connecting standard GigE cameras.

www.imago-technologies.com

Ryzen Embedded R2000 series

AMD has announced the Ryzen Embedded R2000 series, second-generation mid-range system-on-chip processors optimised for a wide range of industrial and robotics systems, machine vision, IoT and thin-client equipment.

With support for up to 3200 MT/s DDR4 dual-channel memory and expanded I/O connectivity, the Ryzen Embedded R2000 Series processors deliver 50 per cent higher memory bandwidth and up to 2x greater I/O connectivity compared to R1000 series processors. A broad set of high-speed peripherals and interfaces are available, with up to 16 lanes of PCIe Gen3, 2x SATA 3.0 and 6 USB ports (USB 3.2 Gen2 and 2.0).

www.amd.com

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