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June/July 2022
Issue 111

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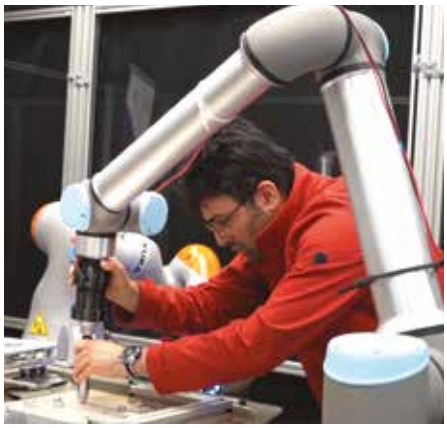

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Greg Blackman

The semicon thorn

The semiconductor shortage has been a thorn in the machine vision sector's side for more than a year, but we're now starting to see the results of that shortage – namely, camera makers are having to redesign cameras with what components are available. Matrix Vision has released a revised version of its GigE camera series MvBlueCougar-X, with alternative hardware for its MvBlueFox3 series to follow. And Matrix Vision is not alone in firms having to do this. It's a significant investment, but a necessary one that many companies are having to make because – and here's the positive side of all this – demand is there, and there's plenty of it. Cognex, Stemmer Imaging, Basler and others have all posted strong growth in 2021 and the early part of this year, although Robert Willett, Cognex's CEO, has said its growth might be slowing as projects are delayed. Lockdowns in China are also causing disruption, the VDMA's Anne Wendel writes in her column on page 8.

This summer sees the welcome return of trade fairs in Europe. Embedded World and Automatica will both take place at the end of June, and this issue has articles on building embedded vision devices (page 18), along with a robotic project investigating ways to automate the process of recycling electric vehicle batteries (page 10). It's difficult to predict how this year will pan out for the machine vision sector, but the mood is positive and firms are as industrious as ever to meet the demand for automation.

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EUROPA SCIENCE

News

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Cognex Q1 sales up 18%, but signs of growth slowing

Robert Willett, Cognex's CEO, has said the firm's growth might be slowing, as Cognex reported first-quarter revenue of $282m, up 18 per cent from Q1-21.

Willett said: 'We are currently hearing from customers that automation projects are taking longer to deploy, and some are being delayed, because of supply chain challenges and staffing shortages.'

It's a familiar story for the machine vision sector, as order books fill up but component shortages and supply chain difficulties delay delivery. In its end-of-year report, Basler said challenges in procuring semiconductor components are expected to remain the limiting factor for growth in 2022.

Some firms have taken to redesigning products to overcome component shortages. Matrix Vision recently released a statement announcing a revised version of its GigE camera series, MvBlueCougar-X, with alternative hardware for its MvBlueFox3 series to follow.

'Our development department is working at full speed to finalise them [MvBlueCougar-X revisions],' the statement read. 'In parallel, the firmware will be adapted to the new components, so the first cameras can be expected to be delivered as early as June 2022. Our procurement and production are already geared with additional capacities to restore the usual delivery capability shortly thereafter.'

Embedded computing and vision provider, Phytec, has said the shortage of components is affecting future product planning. 'Many components are being withdrawn from the market as a result of the [chip] crisis, or long-term availability is deteriorating because only a few fabs now offer the necessary manufacturing process,' a Phytec blog post interviewing the firm's head of development, Marcus Lickes, stated.

Lickes explained that 'many fabs are being converted to modern processes earlier than planned. And the new fabs no longer offer the old processes. So these components are discontinued or poor availability has to be expected. That's why we [Phytec] are concentrating more consistently than before on using the latest generations of components.'

For now, revenues remain strong. Basler's sales for 2021 were €214.7m, while Stemmer Imaging's 2021 revenue was €130.1m, both up by 26 per cent compared to 2020.

Cognex said its growth in the first quarter of this year included 'a notable contribution by customers in logistics'. This follows on from its 2021 financial report, where, not only did the firm surpass $1bn in annual revenue for the first time, but logistics became the company's largest end market.

Cognex's revenue from the logistics sector grew by 65 per cent year-on-year in 2021.

Cognex expects revenue in Q2-22 to be between $265m and $285m. On a sequential basis, the company believes higher revenue from the consumer electronics industry will be offset by the timing of large projects in logistics and slower spending trends in the broader factory automation market.

For all of 2022, Cognex expects annual revenue from both consumer electronics and logistics will grow over 2021.

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LONG DISTANCE CONNECTION

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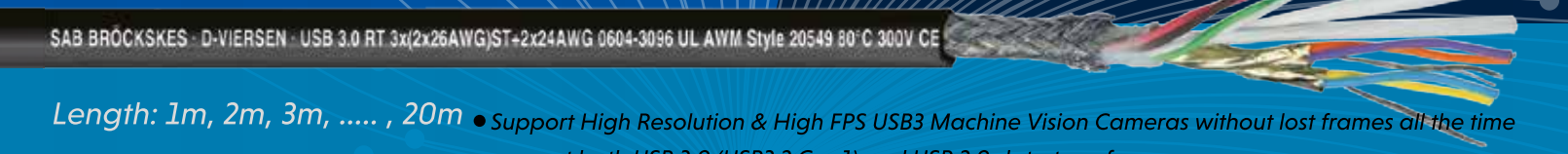

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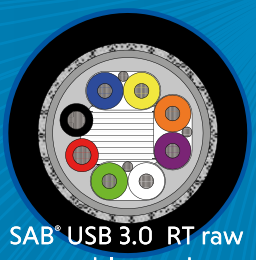

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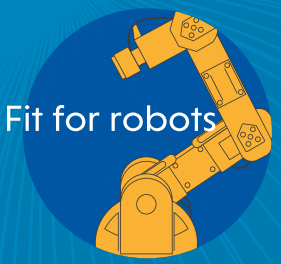

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Up & Down
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USB3.2 GEN1 Micro-B CABLES

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Angle Micro-B

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New modulator adds time-of-flight to any sensor

Researchers at Stanford University have developed a light modulator that can turn any image sensor into a time-of-flight imager.

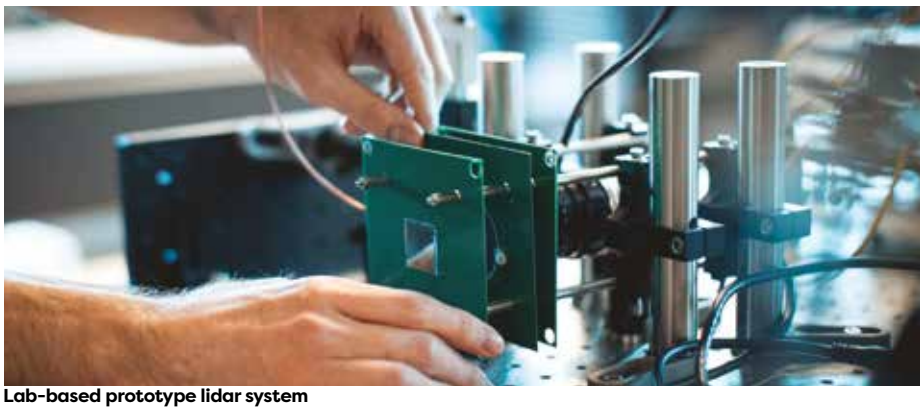
Authors of the paper, published in *Nature Communications*, say the modulator could enable megapixel-resolution lidar at a low cost.

The device can modulate light from visible to near-infrared wavelengths at megahertz frequencies extremely efficiently. Existing modulators can operate at megahertz frequencies, but they require relatively large amounts of power to do so.

The Stanford team's solution relies on a phenomenon known as acoustic resonance. The acoustic modulator uses a thin wafer of lithium niobate coated with two transparent electrodes.

Lithium niobate is piezoelectric, so when electricity is introduced through the electrodes its crystal lattice vibrates. The piezoelectric effect creates an acoustic wave through the crystal that rotates the polarisation of light in such a tuneable manner.

The rotation is converted into intensity modulation by placing a polarising filter after the modulator – it makes the light brighter and darker, effectively turning the light on and off millions of times a second.



Andrew Brodhead

Lab-based prototype lidar system

Okan Atalar, a doctoral candidate in electrical engineering at Stanford and the first author on the paper, explained: 'While there are other ways to turn the light on and off, this acoustic approach is preferable because it is extremely energy efficient.'

The modulator's design is simple and integrates into a system that uses off-the-shelf cameras. Atalar and adviser Amin Arbabian, associate professor of electrical engineering and the project's senior author, think it could become the basis for a new type of compact, low-cost, energy-efficient lidar.

The team built a prototype lidar system on a lab bench that used a commercial digital camera as a receptor. The authors report their prototype captured megapixel-resolution depth maps, while requiring small amounts of power to operate the optical modulator.

With additional refinements, Atalar said the team has since further reduced the energy consumption by at least 10 times that reported in the paper, and they believe further energy reductions are within reach.

UKIVA turns 30

UKIVA
UK Industrial Vision Association

By Neil Sandhu, UKIVA chairman

This year is the 30th anniversary of the formation of the UK Industrial Vision Association. This is a period that has seen enormous growth in, and maturation of, the worldwide vision industry.

There are some interesting parallels between the current economic environment and the backdrop to the association's formation. In 1992, the UK was a member of the European Exchange Rate Mechanism (ERM), which essentially required the government to ensure exchange rate variations between the pound and the other member currencies did not exceed 6 per cent. However, the day before UKIVA's first committee meeting, the UK withdrew from the ERM on the now infamous Black Wednesday. While the direct costs of this action had a significant impact on the UK economy, there is a view that the subsequent changes in economic policy set the foundation for a strong economic recovery during the following years.

Fast-forward to 2022 and the UK is in its first full year of post-Brexit trading. Of course, it is still far too early to assess whether Brexit will have a positive or negative overall impact on the UK economy in general and the UK vision industry in particular. Indeed, it may prove to be difficult to get the full picture as the effects of the pandemic are also inextricably woven into the economic scene and additional pressures on inflation resulting from the conflict in Ukraine have yet to be fully realised. While businesses continue to adapt to the post-Brexit paperwork changes and complications in import and export processes, worldwide supply chain issues, even before the crisis in Ukraine, were having a major impact on the availability of critical components for vision systems, creating long lead times for installations.

In spite of these day-to-day challenges faced by the UK vision industry, the general outlook is very encouraging. The need for automation, of which vision is a key component, has never been more apparent in many industries. For example, the food processing and agriculture sectors have traditionally been labour intensive, but continued developments in areas such as 3D, hyperspectral and NIR imaging, and embedded vision are allowing more and more applications to be addressed.

It is always difficult to predict what developments will come next in machine vision technology, but a lot of interest is expected in the research being done into quantum dot SWIR sensors. UKIVA will continue its efforts to promote the use of machine vision and as part of its mid-term strategy will explore ways to enhance pathways into working within the vision industry, as well as other training initiatives that could benefit the industry as a whole.

Robots get to grips with laundry automation

IDS and sewts

German start-up Sewts has built a robot cell to automate the process of loading industrial laundry folding machines.

The Velum robot system is able to pick individual laundry items – towels and similar linen made of terrycloth – and feed the folding machine, thanks to 3D and 2D imaging.

According to Sewts, 90 per cent of the process steps in industrial washing are already automated. However, people have to feed the folding machines by spreading out laundry items without any wrinkles. This accounts for 30 per cent of labour costs; it is also a monotonous and strenuous task.

Clean laundry arrives at the folding machine either in containers or on a conveyor. A combination of 2D and 3D images are used to locate the hems on a towel and, from that, where the corners are.

Tim Doerks, co-founder and CTO at Sewts, explained: 'We match the images from the 2D and 3D cameras to have a higher 2D resolution together with the 3D data. So we use the respective advantages of the 2D camera, in this case the higher resolution, and the 3D camera – that is, the precise depth data.'

Depending on customer requirements or configuration, two to three uEye 2D or Ensenso 3D cameras, both from IDS Imaging Development Systems, are used.

The Ensenso S10 uses a 3D process based on structured light: a narrow-band infrared laser projector produces a dot pattern that is captured by a 1.6-megapixel Sony sensor to give a point cloud with up to 85,000 depth points. Velum extracts the coordinates for the gripping points from the point cloud.

Doerks added: 'We are experts in preparing the generated data, which is especially important when working with 3D point clouds. This pre-processing is an important component of our systems to generate suitable input for our artificial intelligence.'

The data supplied by the uEye CP (5MP) or Ensenso S cameras is processed via convolutional neural networks and classical image processing. The software analyses the topology of the textiles using features such as the course of the seam, local elevations or the relative position of seams, classifies them according to textile type and class using various textures and embroidery patterns, and translates these findings into robot commands.

'By closing this significant automation gap, we can almost double the productivity of a textile washing line,' noted Sewts CEO Alexander Bley.

Sewts is also working on systems to handle clothing such as shirts and trousers. 'It is important to understand the properties of these materials to implement robust processes. We achieve this through sophisticated material simulations,' added Bley.

Datalogic buys AI firm Pekat Vision

Fibre laser provider nLight has bought Plasmo Industrietechnik to add Plasmo's machine vision and analysis products to nLight's manufacturing solutions. Plasmo is an Austrian-based provider of automated quality assurance and diagnostic solutions, primarily for the welding and additive manufacturing markets. The solutions will complement nLight's industrial laser portfolio.

Jake Bell, general manager for industrial lasers at nLight, commented: 'Combining lasers with Plasmo's real-time process monitoring solutions provides customers with a significant advantage as they develop, qualify and produce increasingly complex laser-printed or welded parts, particularly for high volume electric vehicle production.'

Laser welding is expected to play a role in battery production, as well as other manufacturing steps in electric vehicle production plants. Plasmo includes in-line triangulation cameras for inspecting weld seams at a processing speed of 30kHz, as well as sensors incorporated directly into welding optics for seam inspection. nLight will expand its European footprint with the addition of Plasmo's Germany and Austrian sites.

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In brief

Basler is to buy a 25.1 per cent stake in its French distribution partner, i2S. The joint venture would operate under the name Basler France. Basler intends to acquire the remaining 74.9 per cent stake on 1 July 2024.

Daniel Seiler, the former managing director of IDS, has taken over from Michael Wandelt as CEO of Automation Technology. Wandelt, who co-founded the firm, steps down after 24 years. Wandelt will remain at the company in charge of infrared product management.

Pedro Durán Martín has been appointed CEO of Barcelona-based Infaimon, part of the Stemmer Imaging group.

Uncertain year for mechanical engineering

VDMA Machine Vision

By Anne Wendel, VDMA Machine Vision

Looking at preliminary production data for the mechanical engineering sector in the USA, China and Europe, 2022 has started quite well. In China, the machinery sector made a dynamic start to the year. However, production in the general engineering sector contracted in March. The Chinese government's zero-Covid policy is leaving deep scars in the manufacturing sector, where production and new orders were noticeably weaker in April than in previous months.

According to VDMA colleagues in Beijing and Shanghai, only a minority of companies in China anticipate an improvement in the business situation in the coming six months. The resumption of production, especially in the Shanghai area, is very slow. The costs of 'closed loop' operation for factories – a bubble-like arrangement, where employees work and live on factory premises – are high, the approval process is tough, and additional costs are to be expected for employee supplements, for beds, for disinfection and other things.

The US mechanical engineering sector grew by six per cent in the first quarter of the year, as did production in the 27 countries of the European Community in the first two months of 2022, according to preliminary calendar-adjusted data from Eurostat. However, according to economic surveys, sentiment in the manufacturing industry continued to deteriorate in many countries in April. Many uncertainties, bottlenecks and price increases are burdening business activity. The International Monetary Fund revised its macroeconomic forecasts in April downward for both 2022 and 2023. In March, the VDMA lowered its 2022 production forecast for the German mechanical engineering sector, from seven per cent to four per cent growth in real terms in view of the Ukraine war, ongoing material shortages and disruption in supply chains.

Looking at the last VDMA survey, there's still an acute shortage of electronic components in the robotics and automation industry leading to extended lead times, higher costs and to a backlog in orders. In general, the situation in supply chains remains tense; VDMA expects an aggravation in the next three months.

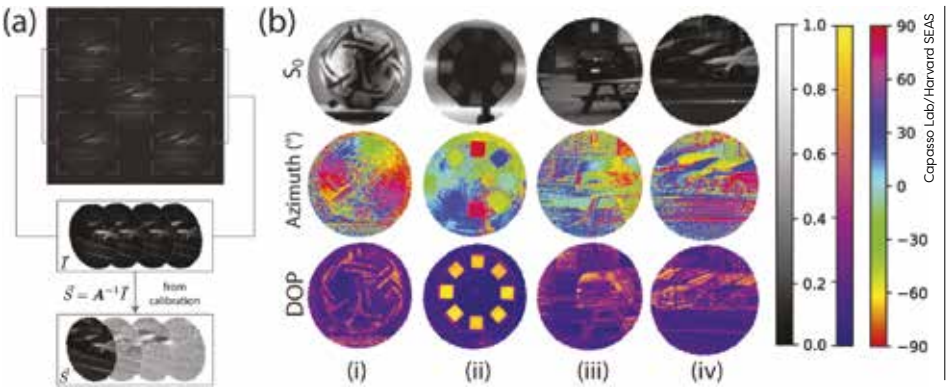
Looking at the monthly VDMA Machine Vision Index (incoming orders and turnover), the European machine vision industry finished 2021 above expectations and started quite well in the first three months of 2022. But this does not reflect the struggles and uncertainty the European machine vision industry is currently facing. There seem to be no direct effects from the war in Ukraine, since Russia and Ukraine are not really important markets for the European machine vision industry. But indirect effects might also affect the sector and, of course, there's the shortage of semiconductor components.

Trade fairs resume

The summer and autumn months are going to be a busy time for the European machine vision industry. The VDMA has restarted its physical meetings; VDMA meeting rooms are filled with around 100 guests a day. VDMA Machine Vision will be organising events at Automatica and Embedded World, both of which take place in June: the Vision Expert Huddles presentation forum at Automatica in the vision pavilion in hall B5, and a panel discussion on embedded vision at Embedded World. The panel discussion – Integration of embedded vision: towards plug-and-play – will be on 22 June from 11:30 to 12:30 in hall 2, with representatives from Allied Vision, Framos, MVTec Software, Vision Components and Edge Impulse.

Needless to say, VDMA Machine Vision's focus is on preparing for Vision in Stuttgart from 4 to 6 October. Together with Messe Stuttgart, VDMA will organise the Industrial Vision Days, a three-day presentation forum with around 60 lectures – the call for presentations has just been published. In addition, many exciting new companies will be at the start-up area and will give start-up pitches during the Industrial Vision Days. Don't miss Vision; schedule a visit!

Metasurface turns any camera into polarisation imager



A raw exposure by selecting four sub-images (a), and four imaging examples (b).

Harvard researchers have made a metasurface attachment that adds polarisation capabilities to imaging systems.

The attachment is a metasurface grating containing subwavelength nanopillars that direct light based on its polarisation. The camera with the attachment compiles an image that captures polarisation at every pixel.

The research from the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) is published in *Optics Express*.

As a demonstrator, the scientists attached the polarisation metasurface to an off-the-shelf machine vision camera, simply screwing it on in front of the objective lens, in a small tube that also housed a colour filter and field stop. From there, all they needed to do was point and click to get polarisation information.

Metasurfaces are optical components containing an array of structures smaller than the wavelength of light. These pillar elements are designed in such a way as to shape how light interacts with the surface.

The nanopillars on this particular metasurface grating direct light based on polarisation, which forms four images, each showing a different aspect of the polarisation. The images are then put together, giving a full snapshot of polarisation at every pixel.

'The addition of polarisation sensitivity to practically any camera will reveal details and features that ordinary cameras can't see, benefiting a wide range of applications, from face recognition and self-driving cars to remote sensing and machine vision,' said Federico Capasso, the Robert L. Wallace Professor of Applied Physics and Vinton Hayes Senior Research Fellow in Electrical Engineering at SEAS, and senior author of the study.

In 2019, Capasso and his team developed a compact, portable camera that used a metasurface to image polarisation in a single shot. In this research, the team explored how to generalise the concept of a polarisation camera.

'After building the specialised polarisation camera, we wanted to go more in depth and investigate the design rules and trade-offs that govern pairing a special polarisation component with a conventional camera system,' said Noah Rubin, a graduate student at SEAS and co-first author of the study.

'This metasurface attachment is incredibly versatile,' added Paul Chevalier, a postdoctoral research fellow at SEAS and co-first author of the study. 'It is a component that could live in a variety of optical systems, from room-size telescopes to tiny spy cameras, expanding the application space for polarisation cameras.'

Recycling EV batteries: a pressing automation problem

Greg Blackman speaks to the Faraday Institution's **Dr Alireza Rastegarpanah** about work to automate disassembly of lithium-ion batteries

Dr Alireza Rastegarpanah working with a cobot on the task of unbolting a lithium-ion battery.

By 2030, no new petrol or diesel vehicles will be sold in the UK, with sales of hybrid vehicles stopping in 2035. The RAC in the UK estimates there are almost 400,000 battery electric vehicles on the UK's roads at the moment, and a little over 300,000 plug-in hybrid electric vehicles.

The switch to electric vehicles is happening all over the world as countries put in place measures to curb their greenhouse gas emissions. Around 2.5 megatonnes of new batteries are expected to be produced in the EU by 2030, according to the Fraunhofer Institute for Systems and Innovation Research (ISI), which conducted a study into the opportunities and challenges for mechanical engineering in recycling lithium-ion batteries. The study was commissioned by the Impuls Foundation of the VDMA.

In Europe, the volume of end-of-life lithium-ion batteries and battery components to be recycled could amount to around 230 kilotons per year from 2030, and around 1,500 kilotons per year from 2040, the report found.

In a statement, Dr Christoph Neef, who coordinated the study, said: 'To be able to handle such recycling volumes, recycling capacities, which are currently still in the low double-digit kiloton range per year in Europe, must be significantly expanded. This will require plant technology in Europe that, depending on the speed of market growth and the global share of European recycling capacities, will require investments of around €6.6bn by 2040.' For the year 2040, this corresponds to a European market size of about €810m for new system technology, according to Fraunhofer ISI.

In the UK, the Faraday Institution has funded the Relib project – one of the first it funded in 2018 – investigating reuse and recycling of lithium-ion batteries. One of the work packages, specifically looking at automating the process of testing, disassembly and sorting, uses advanced robotics, machine vision and AI techniques. Dr Alireza Rastegarpanah, a Faraday Institution Research Fellow and a researcher at the University of Birmingham's Extreme Robotics Lab, told *Imaging and Machine Vision Europe*: 'There are some technical challenges related to robotic battery disassembly that could be solved using machine vision techniques.'

As part of Relib, a team of roboticists led by Dr Rastegarpanah is using machine vision and machine learning techniques to compile a dataset of the components that make up the batteries used by different car manufacturers. The challenge for building an automated system for taking batteries apart, according to Rastegarpanah, is that there's no standard in battery design, and also there's a lack of information about battery design from the manufacturers.

Rastegarpanah explained that, in battery disassembly, detecting and localising battery components for vision-guided manipulation tasks could be challenging if CAD models of the objects are not available, or if the battery is damaged and doesn't match with the original CAD files.

One of the batteries the Relib team is focusing on is that used in the Nissan Leaf. The battery pack for the 2012 model has 48 modules connected in three stacks, with the stacks covered in metal casings, which in turn are covered in plastic. For Jaguar Land Rover, the type of battery and its makeup is completely different, explained Rastegarpanah – the way the modules are stacked is different; JLR puts modules in boxes and then welds around that. 'From an assembly point of view, this might be easy, and it's safe and is a nice design,' he said. 'But from a disassembly point of view, if you are going to use welding… are we still able to extract the modules safely and do the testing? These are all the questions that have to be answered, and it comes back to the manufacturer – they have to standardise these processes.'

The Relib team is using high-resolution 3D scanners, including Artec Eva and Spider scanners, to create a 3D model of a battery as it is taken apart manually, layer by layer, to understand how it was assembled. The resulting CAD model will be used as a baseline, to compare a damaged battery with the CAD model, for instance.

The main reason for disassembly is to reuse healthy modules, or to recover critical materials. Rastegarpanah explained that most salvage centres will send faulty batteries – from a car accident, for instance – straight to the shredder and then separate the material, rather than testing the battery pack and removing the faulty modules.

'Sometimes, in traffic accidents, only one of the modules is damaged and the rest is fine,' he said. 'So it can be repurposed for its second life as a car battery, or it can be used for other applications, like solar panels or energy storage systems.'

Batteries usually reach end-of-life at 70 to 80 per cent state-of-charge. 'At the moment, end-of-life batteries are not recertified and an appropriate testing framework is needed to test end-of-life batteries,' Rastegarpanah said.

The robotics team at the Relib project is developing vision-guided manipulation techniques as part of the disassembly process, and for this they are using RGB-D cameras like the Ensenso camera from IDS. The RGB-D images are used for robot path planning, object detection, object tracking and localising the object in a scene. Rastegarpanah said that detecting and localising partially viewed shiny industrial objects in a cluttered environment is sometimes challenging. 'These issues can lead to some degrees of error for the vision system,' he said.

'We will be faced with lots of waste material from EV batteries very soon'

One of the disassembly tasks is to use a robot to make cuts in the module casing. 'We've developed a method to find the area of interest based on the depth image,' explained Rastegarpanah. 'Then, based on that, we make a tangential on the surface and then angle the cutter perpendicular to the surface to make the cuts.'

'Disassembly is a very complex, challenging task,' he continued. 'It requires a consortium of different universities, experts and manufacturers sitting together and looking at the problem from different angles – looking at how we should standardise disassembly, for example, how we should use vision, how we should use robot manipulation.'

He added that, currently, there's not a general method of disassembly because of the variety in battery designs, but that Relib researchers are working to automate some standard, fundamental tasks, such as unbolting. Bolts and screws used in electric vehicle batteries come in different sizes and shapes, and Rastegarpanah has developed a vision-tactile-based method to generalise the process of unbolting.

The initial Relib project began in 2018 and was funded for three years; now the project has received a two-year extension. What was developed at the University of Birmingham's Extreme Robotics Lab in the first phase of Relib will now be moved to an industrial environment to operate at scale at Tyseley Energy Park. Here, the engineers will use industrial Kuka robots to work with battery backs.

The lifespan of an electric vehicle battery is around eight years; Tesla's battery warranty lasts for eight years and varies in mileage between models. Some of the electric vehicle batteries in circulation today in the UK and elsewhere are reaching the end of their life already. 'We will be faced with lots of waste material from EV batteries very soon,' Rastegarpanah warned. 'There should be infrastructure; there should be some way to handle these waste materials. It would be very useful if we could find a way to reuse it for energy storage, for instance.'

'There's also a lack of regulation in the UK,' he continued. 'We are working with policymakers and we are proposing what could be done to simplify that process.'

Stereo scan and AI returns car parts into service

A project to scan used car parts to identify those that can be reused is underway as part of work funded by the German Federal Ministry of Education and Research's 'Resource Efficient Circular Economy – Innovative Product Cycles' (ReziProK) measure.

The aim of the EIBA project is to build a system that scans automotive used parts in 3D to assess their condition and whether they can be reused.

Circular Economy Solutions has collected images of approximately 1,400 different used parts. A neural network is then trained to identify the parts automatically, achieving a recognition rate of 98.9 per cent in one study.

The part is weighed and scanned with three 3D stereo cameras. The data is combined with any part-specific commercial data, such as the origin and location, to identify the part. The information is processed by two AI systems simultaneously, one trained for image processing and the other for commercial data.

The Fraunhofer Institute for Production Systems and Design Technology (IPK), and Technische Universität Berlin are project partners. Marian Schlüter, a scientist at Fraunhofer IPK, explained: 'In the automotive industry, once the used part has been removed, it is assessed at the sorting centre [Circular Economy Solutions in this case] to determine whether it can be reused. This is far from trivial, however. Part numbers, which are the only visually reliable feature, are no longer legible, are scratched, painted over, or the type plates may have fallen off. This means the worker [will] discard it by mistake and it is recycled purely as a material.

'This is precisely where AI comes into play,' he continued. 'It identifies the used parts based on their appearance, and sends them off for a new lease of life.'

Identification features such as weight, volume, shape, size and colour are used, but customer and delivery data are also included in the evaluation.

Circular Economy Solutions employees still examine the part to look for any loose components or burnt parts.

Every year, about 5-7 per cent of one million used parts processed by Circular Economy Solutions – that is, up to 70,000 – are discarded because they cannot be identified. Based on a recognition accuracy of 98.9 per cent, it is expected that AI will allow 67,200 more used parts to be fed back into the

Fraunhofer IPK/Larissa Klassen

The system assesses different parts, like these two generators.

Lights-out logistics

Could computer vision be the key to fully autonomous warehouses? **Benjamin Skuse** investigates

Though the pandemic undoubtedly accelerated warehouse automation – with challenges in terms of staff absences, and huge demand forcing companies to explore more efficient and less labour-intensive ways of working – automation solution providers were making good business long before the term Covid-19 had crossed anyone's lips.

The first automated storage and retrieval systems – computer-controlled systems akin to huge vending machines that store and retrieve items in warehouses and distribution centres – were introduced as early as the 1960s. And as the world embraced consumerism, automation steadily seeped deeper into warehouse operation in the following decades to help in as many steps in the order and fulfilment process as possible.

But it wasn't until the 2000s that investment in automation exploded: e-commerce had arrived. This disruption to shopping patterns, customer expectations and the industry's competitive landscape became known as 'the Amazon effect,' so named after the company whose success pushed established retail giants to transform their business models and invest heavily in their own e-commerce operations and warehouse networks.

The result has been an automation revolution. Wherever there is a dull, dirty or dangerous (or possibly dear) task for a human in the warehouse, there is now a robot for that. Yet you will still see humans milling about. Why? 'Humans are extremely good at adapting,' explained Cognex's Ben Carey, senior manager for logistics vision products. 'For example, if they go to pick something up and they drop it, they know how they're going to pick it up a second time. That innate intelligence is extremely difficult to build into machinery.'

Robots equipped with vision systems still struggle with various basic warehouse tasks that their human counterparts find a breeze. A large part of why is the sheer inconsistency of the work and environment. A warehouse or distribution centre is a fast-paced, variably lit workplace, handling thousands of items every day, packaged in thousands of different ways and going to countless different destinations.

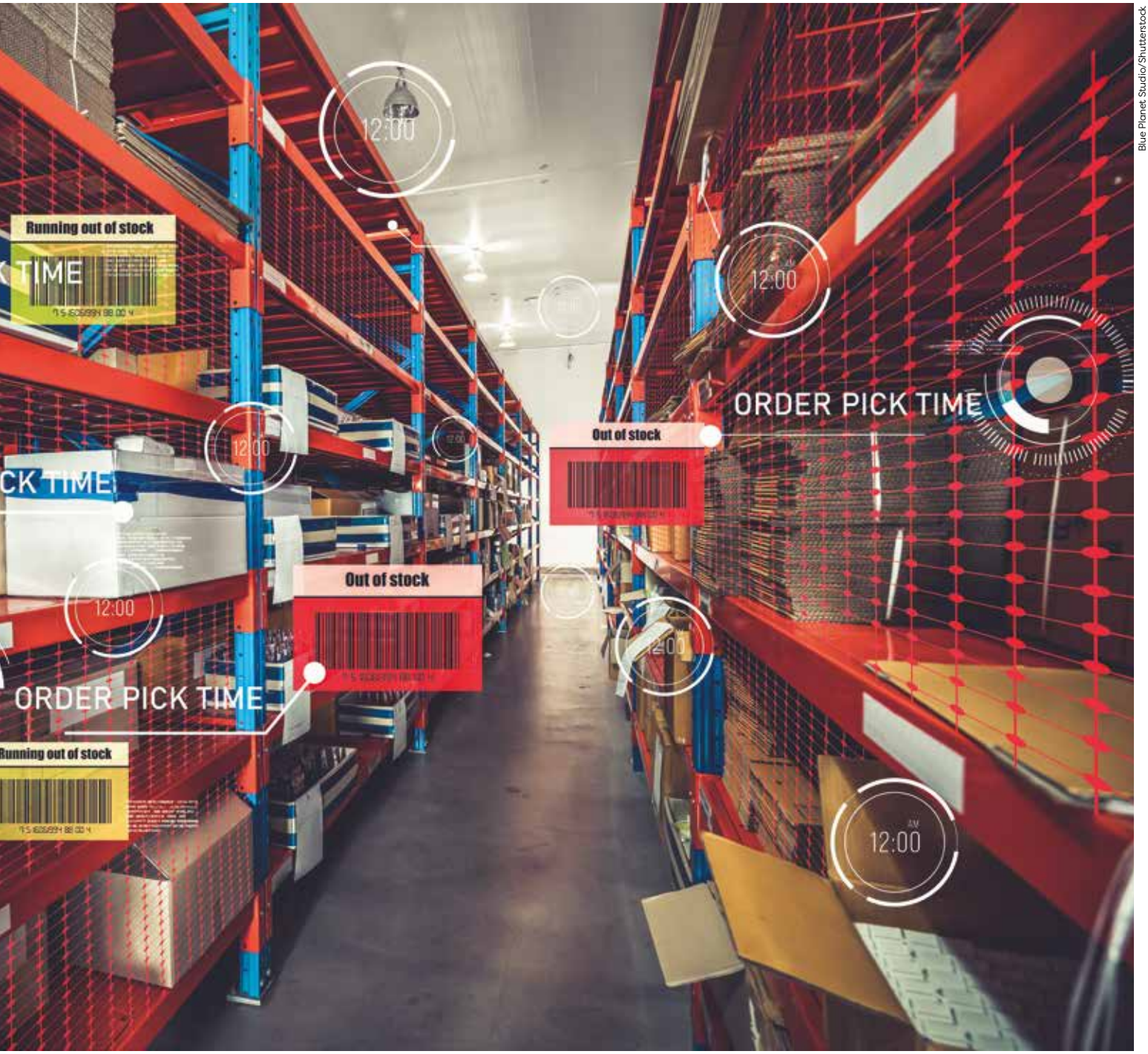
Given most machine vision systems have traditionally been developed for factories, where they repeatedly identify and process the same objects in the same conditions indefinitely, it is little surprise that when faced with the messy, dynamic world of logistics they get confused. But, more recently, advances in camera technology, machine vision and deep learning have come together to make inroads into many higher-level, traditionally human duties.

Smarter sorters

Cognex, based in Natick, Massachusetts, USA, manufactures a raft of machine vision systems, software and sensors for automated gauging, inspection, guidance and identification in factories and warehouses.

One example is it's 3D-A1000 compact snapshot smart camera, combining both 2D and 3D vision and requiring no difficult integration. 'This is running rules-based software today, using both 3D and 2D data and locking them together with a lot of logic in between,' Carey said. It can be used for identifying the presence or absence of objects on sorters, while collecting additional useful information at the same time. For example, deciphering the 3D properties of the object – size, shape, volume and so on – improves 2D inspections, such as figuring out where a package's label is.

Sick, based near Freiburg, Germany, is a close competitor of Cognex, with a similarly broad product range to cater for



Blue Planet Studio/Shutterstock

‘I don’t think there’s any limiting technology [for a lights-out warehouse]... it’s now more about willpower and integration’

innumerable different warehouse tasks. For example, it’s TriSpector 1000 is a 3D triangulation camera projecting and recording a laser line on objects passing by on a conveyor, broadly comparable to Cognex’s In-Sight 3D-L4000. Ryan Morris, Sick market product manager for machine vision, explained some of the benefits of the TriSpector 1000 and 3D sensing more generally. ‘In the 2D world, a stuck label on a conveyor looks like an item, but with 3D, we get height information, so we can basically ignore that stuck label,’ he said. ‘Moreover, 3D sensing doesn’t care about low contrast between different objects or challenging lighting scenarios.’

Cognex and Sick also offer a raft of sensor solutions for a growing trend in logistics: mobile robots. Automated guided vehicles, automated guided carts and, increasingly, autonomous mobile robots (AMRs) are often seen trundling along the warehouse floor. They might be moving through the aisles to pinpoint an item or detect →

Fizyr

Difficult segmentation of parcels by Fizyr software.

→ hazardous spills, or doing any other task that involves loading, sorting, delivering or fetching.

Autonomous mobile robots first came to prominence in 2012 when Amazon acquired Kiva Systems' pod-transporting robots. Since then, the sector has been flooded with both established and new companies offering a host of different AMR solutions, from AutoGuide Robots' driverless forklifts to Boston Dynamics' dog-like, four-legged Spot product. Visual information is crucial to any AMR's navigation and function, which is why many developers have turned to Cognex and Sick. For instance, Morris said that Sick's time-of-flight and stereoscopic 3D cameras, Visionary-T and Visionary-S, respectively, are increasingly being used for mobile robot vision in warehouse applications to offer more flexibility and information than traditional automated systems.

A more recent trend in warehouse vision systems is the launch of products with more sophisticated onboard processing. With similar capabilities to Sick's InspectorP611 2D sensor that can conduct inline machine vision inspections, the new In-Sight 2800 from Cognex is a prime example. 'For logistics, it's a deep-learning-lite technology for complex classification,' explained Carey. 'Unlike traditional rules-based tools, it's able to cope with large amounts of variation.' So, for example, from seeing five to 10 images with its 2D camera, the In-Sight 2800 can classify mixed, skewed objects, and provide outputs to sort them appropriately.

One of Cognex's most advanced products for logistics is the In-Sight D900. 'This is one of the world's first smart cameras that can run full neural network deep learning algorithms,' Carey said. With the deep learning software deployed on the smart camera itself and accessible to non-programmers, in logistics the In-Sight D900 is particularly well-suited to optical character recognition for label identification. Given packages are coming from multiple countries and vendors, and made using multiple printing processes, labels can be badly deformed, skewed or poorly etched, making identification challenging. 'You can just imagine, there's a lot of variance,' he said. 'This is where deep learning really comes into its own in logistics.'

'There's a lot of variance. This is where deep learning really comes into its own in logistics'

Tricky tasks

Other companies are expanding the reach of computer vision in the warehouse too, both in terms of capabilities and scope. Fizyr, based in Delft, The Netherlands, focuses exclusively on developing advanced computer vision software for pick-and-place tasks traditionally performed by humans. The company began as TU Delft spin-off Delft Robotics in 2014. Soon after, the team won the 2016 Amazon Picking Challenge – where the aim is to build an autonomous robot to pick items from a warehouse shelf as well as, or better, than a human. 'But then we realised how unique our deep learning capabilities were, so we decided to pivot to a software-only company,' said Shubham Singh, Fizyr technical sales consultant.

Fizyr's deep learning algorithms enable automated handling of unknown objects being picked from bulk. 'If you look at parcels or groceries, they always vary in shape, size, colour, how they're stacked, and robots are not good in these situations where they need to understand what items to →

Sick

Scanning parcels in 3D.

Rabot

Rabot CEO, Channa Ranatunga, watching Rabot Pack in action.

→ detect, segment, pick and place,' explained Singh. 'That's where Fizyr comes in.'

A key advantage of Fizyr's technology over competitor offerings, said Singh, is its high accuracy even in situations where other algorithms – and even humans – struggle, such as picking an item from a bin of overlapping and similarly coloured items. 'Our software is trained using supervised deep learning, with hundreds of thousands of images from real-life logistics environments, collected in collaboration with our industry partners,' he explained. 'Unlike other approaches, where the robot learns on the go, we ensure the end user is in control and that the robot learns all the things we want it to learn.'

Fizyr's software is used in production worldwide by more than 20 leading system integrators. Singh said the technology is hardware-agnostic, though it requires an industrial-grade 2D and 3D stereo camera for triangulation. As a result, robots equipped with Fizyr software can handle extreme object variation in e-commerce, parcel services and logistics in general. They perform a range of traditionally human tasks, not only picking diverse SKUs in warehouses, but also parcel handling, depalletising, truck unloading, mixed placement and even baggage handling at airports.

Rabot, located in San Francisco, California, USA, is another company carving out a niche in the warehouse vision space, focusing on improving worker efficiency. 'Our sole goal is really to augment existing warehouse operations today, rather than implement a solution that could be disruptive,' explained Sandeep Suresh, Rabot co-founder and chief product officer. Rabot Pack uses off-the-shelf, industrial-grade cameras set up over packing stations, and then performs machine learning to identify errors and inefficiencies, and verify orders have been packed correctly. 'It really serves as a virtual assistant to the packer,' he continued. 'It visually verifies all the different objects in the packing station, performing simple checks to ensure any labels, packing material or bubble wrap that need to be applied, have been applied, and checking if there is any damage.'

Results from installing Rabot Pack have been impressive, with customers reporting 25 to 50 per cent productivity increases within months, faster training of new employees and significant reductions in troubleshooting or resolution time for customer complaints.

Like Rabot, Vimaan – a computer vision company based in Santa Clara, California, USA – is also looking at the big picture in terms of improving warehouse efficiency. The company has a suite of inventory tracking and verification technologies

'A more recent trend in warehouse vision systems is the launch of products with more sophisticated onboard processing'

that permit wall-to-wall and door-to-door visibility from when items arrive to when they leave the warehouse. These products scan and image goods and packages on pallets and conveyors, on forklift trucks and even from the air, with autonomous drones performing flybys of warehouse racks. Vimaan's solutions completely remove human error in inventory management, and can save a single warehouse millions of dollars in write-offs.

With these and many more vision technologies reducing costs and errors, and improving efficiency throughout the warehouse, it begs the question: are we near the point where humans no longer need to step foot in the warehouse?

'I think we're getting there,' said Morris. 'I don't think there's any limiting technology out there right now that we're waiting on to be able to do that – it's now more about willpower and integration to make it all come to reality.'

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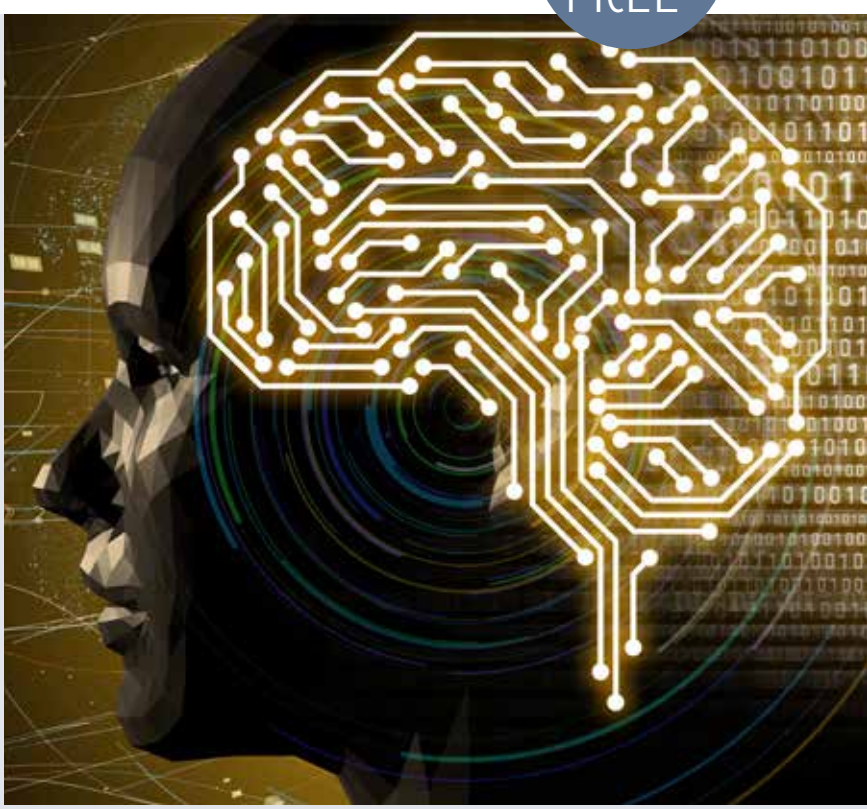
Join us as we discuss how deep learning is best applied to industrial inspection, including how to make the best use of image data, as well as combining different techniques to get good results.



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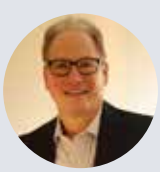
Speakers



David Dechow

David Dechow, vice president of outreach and vision technology at LandingAI, will speak about ways to work with data to get the best out of deep learning in industrial inspection.

Daniel Soukup

Daniel Soukup, a deep learning specialist at the Austrian Institute of Technology's high-performance vision systems group, will give his take on how to get good results using deep learning. AIT's approach is to use a combination of more traditional image processing techniques together with deep learning.

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Spoilt for embedded choice

Tim Reynolds asks what developers must consider when building an embedded vision system

Advantech

ICam-500 series is an industrial AI camera with variable focus lenses, LED illumination, Sony image sensor, multiple core Arm processors and Nvidia AI SoM.

Embedded computing power is increasing and more devices are appearing on the market. In recent years, machine vision camera makers have been getting involved by their own embedded camera or sensor modules that fit a particular board, or by working with computer hardware providers.

Jan-Erik Schmitt, vice president of sales at Vision Components, believes it has never been as easy to integrate embedded vision into any device as it is currently. 'Developers just need to choose the perfect level of integration for their projects,' he said.

Hardware is one consideration. Typically, selecting hardware components depends on: required performance (CPU, GPU or NPU); choice of operating system; real-time or latency requirements; power consumption; resolution and image capture rate; interfaces necessary; availability of hardware and vendor support; ease of use and ease of development – especially when deciding between an FPGA- or CPU-based approach; and how much the developer knows about their choice of hardware.

Nathan Dinning, director of product management at Framos, sees the core technology – the processor – as the starting point, with a good understanding of the required vision capabilities in terms of 2D, 3D, whether megapixel resolution is needed, what the field of view requirement is, or how high the dynamic range must be. Finally, the specific nature of the application must be considered – for example, will industrial components for a specific temperature range or environment be needed?

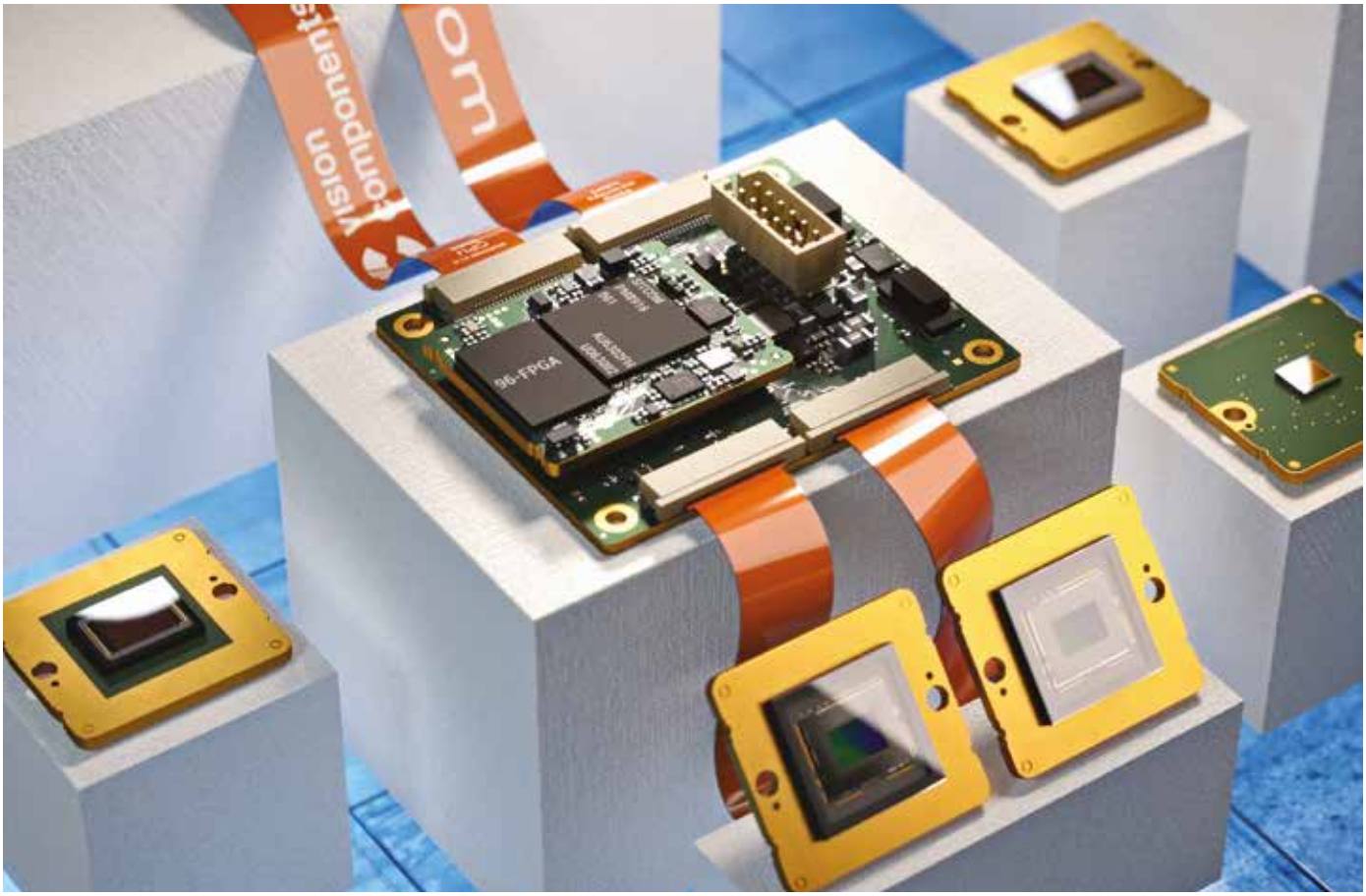
However, from the perspective of Neil Chen, senior manager, video solution master division within the Cloud-IoT group of Advantech, the software definition is always the primary priority. 'The service and data flow between edge and cloud will drive different hardware architectures,' he said. Chen then noted performance, price-per-watt and optics integration, including sensor, illumination and lens as key factors.

In the past he said that embedded systems were mainly seen as applicable to stand-alone systems. But with the wider application of AI within embedded vision, broader deployment opportunities beyond stand-alone systems are available.

This requires different software architecture that will change the core idea of embedded vision. Typically, the user or programmer would think only about the run time of the embedded vision system, but now they must think about both programming and also the development and deployment of embedded vision.

Design criteria

'Traditionally, vision sensor firms have developed their cameras for specific applications from scratch,' said Schmitt. 'This is very time- and cost-intensive, with



Vision components

Vision Components' Power SoM is an FPGA-based hardware accelerator.

'Our strategy for embedded vision systems is to link up with AI'

high design risks.' Companies now need to decide if this is worth the effort, or if they can benefit from shorter development cycles and spending less on time and costs if they use ready-to-deploy solutions, such as the VC PicoSmart. From the point of view of Vision Components, the benefits from proven hardware and perfect integration of image acquisition and processing are undeniable.

Vision Components has also recently released an FPGA-based hardware accelerator, VC Power system on module (SoM). This 28 x 24mm SoM can be deployed between Mipi camera sensors and the embedded processor of the final application. The FPGA module can tackle pre-processing or analysis of the image data, leaving the higher-level CPU free to focus on the application.

For Florian Schmelzer, product marketing manager for embedded vision solutions at Basler, it is all about the use case. 'When designing embedded vision systems for our customers it is absolutely mandatory to understand the use-case of the application. What problem is the customer trying to solve?' he said. 'As there are always many different ways to realise a system – such as the type of camera sensor, interface, processor unit, software and so on – we need to be clear what the goal of the system is. Only then is it possible to develop the leanest solution with the best price-to-performance ratio.'

Chen has software support – including the operating systems, third party software package and programming language – at the top of his list, followed by the data interface between camera and processor, power consumption and the application-driven image signal processor (ISP).

'Our strategy for embedded vision systems is to link up with the AI opportunity,' he concluded. Taking advantage of AI means creating more partnerships with ISP providers and adapting software design and features.

A changing market

But how are these choices and changing criteria impacting the market? Chen finds standardisation and modularisation as the most significant migrations in machine vision currently. 'In the past, it took multiple different engineering resources to design and build the embedded vision system, and this resulted in a high entry barrier both for customers and makers,' he said.

With more advanced computer vision technology and embedded vision and AI alliances, more camera vendors are releasing standard embedded vision cameras. The AI system on chip (SoC) or system on module (SoM) companies offer not only scalable AI engine SoMs in the same form factor, but also the software development kit and board support package, so that learning curves are reduced and the time-to-market is accelerated.

Chen believes this has led to a more user-friendly market. 'In the past, embedded meant difficult, more proprietary technology. It took a lot of resources and time to get to market, but the products enjoyed a long lifecycle. Now with standardised, modular systems, time-to-market is better and lifecycles are shorter,' stated he. This reduces prices, making the market more accessible – both for the programmer and user. →

In terms of vision sensor design, Schmitt said that the new technologies and components being developed enable faster time-to-market at lower costs for individually designed sensors. He cited the VC PicoSmart as one of the smallest complete embedded vision systems on a single board. It integrates image sensor, CPU and memory; developers just need to add optics, lighting, interface board and the human-machine interface to build a vision sensor for their application.

'More generic PC-based approaches are being replaced by a more specialised embedded approach, which can drive down system costs significantly,' said Schmelzer. He said embedded vision offers both cheaper solutions for existing applications and new vision solutions, such as those in medical diagnostics, robotics and logistics, traffic management systems, and products for smart home applications.

Supply chain issues

Of course, one issue that is making an impact is the global shortage of semiconductors, something that is not expected to resolve itself in the near-term. Schmitt said that Vision Components has largely been able to absorb the effects of the supply shortage for customers, thanks to long-term purchasing and forward planning. But the firm sees increasing requests for specific sensors, especially in combination with Mipi CSI-2 interface capability. 'In particular, with the special design of our VC Mipi camera modules and an integrated adapter we can supply Mipi modules with almost any sensor, even if they do not natively support this interface,' he said.

A key aspect is designing products that take into account component supply chains, said Dinning. Companies are getting involved in long-term supply contracts; some are taking on more risk or holding more inventory.

'The global shortage and Covid lockdowns impacted the whole supply chain,' said Chen. 'We spent lots of time, resources and expense to sustain our existing models, but meanwhile, we needed to strengthen our design and production capability to be more agile.'

One of the results of this agile approach is the industrial AI camera, ICam-500. 'This model, which goes into mass production in May, follows the standard video interface, certifies multiple chip vendors, and creates and offers more features on software,' Chen said. The redesign approach means that Advantech could push more technology from hardware back to middleware, giving more value, multiple vendor choice and more features.

'The service and data flow between edge and cloud will drive different hardware architectures'

Chen sees software design as a key feature for increasing integration. 'The software stack is increasingly important,' he said. The need for software to be able to connect with different operating systems is a major change from most existing systems, and concepts such as embedded systems as a microservice are important.

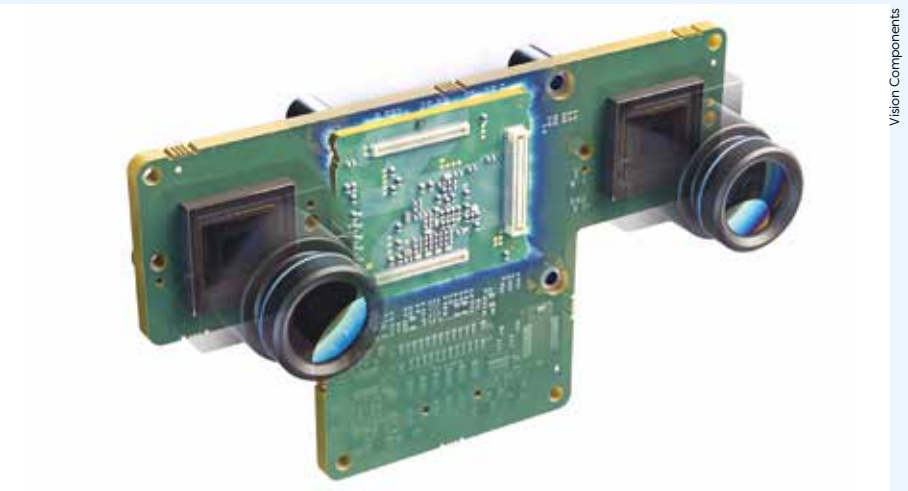
Embedded World

Basler, Framos and Vision Components will be exhibiting at the Embedded World trade fair, taking place from 21 to 23 June in Nuremberg, Germany.

Basler (2-550) will demonstrate an edge AI vision solution for automated optical inspection; it will also show an approach for anomaly detection that finds defective areas using cloud services. In a classification task, AI and imaging are used to classify bacterial samples. A case study in 3D imaging for circuit board inspection rounds up the trade show presentation: using fringe light projection and a self-developed algorithm, a 3D height image is created that is suitable, among other things, for those applications that require hardware-accelerated image preprocessing.

Basler's product highlight is its embedded vision processing board. It includes various interfaces and is based on a system on module and carrier board approach, using the i.MX 8M Plus system on chip from NXP. It can be used not only for prototyping, but also in volume production, thanks to its industrial grade design.

Framos (2-555) will demonstrate its ability to integrate Sony's sensor technology across a multi-platform ecosystem, including Nvidia Jetson, Xilinx Kria, Renesas RZ/v2m and Texas Instruments Jacinto. In addition, there will be an Nvidia Jetson zone, highlighting time-of-flight 3D depth maps, a development kit for event-based vision sensors, as well as the GMSL3 interface, all running on Nvidia's Jetson platform.



Vision Components

VC Stereo Cam

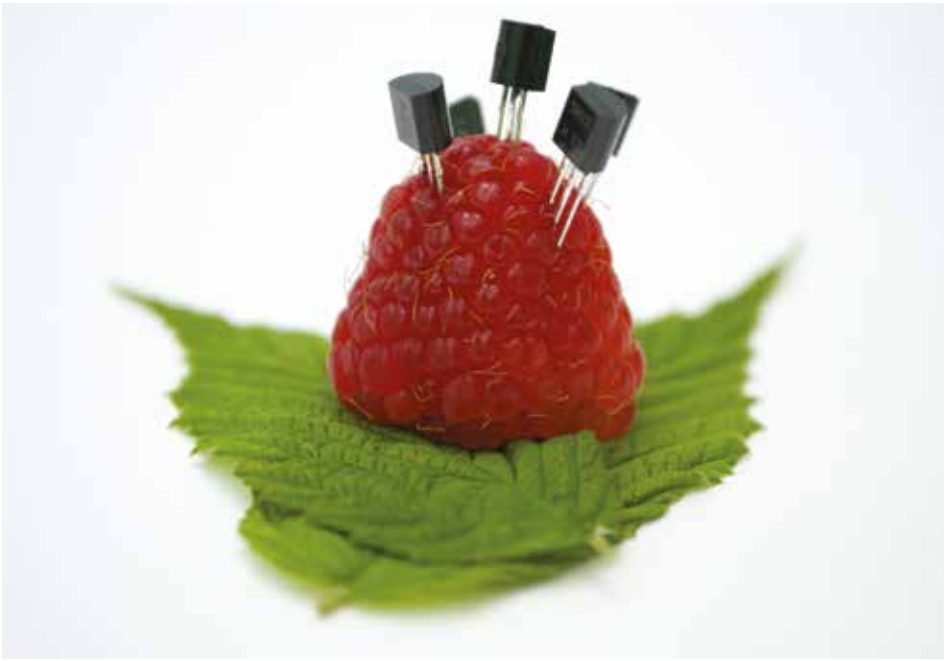
Visitors can see imaging components from Sony, including the latest sensors with SLVS-EC solutions, Spresense microcontroller boards with LTE support, and MOLED image display products. Framos will also show its embedded vision standard kits, which include EMVA1288-certified sensor modules, lenses, drivers and adapters. In addition, Framos will highlight its camera system production capabilities.

Vision Components (2-450) will present Mipi modules and OEM components. The firm will launch the VC Stereo Cam for 3D and two-camera applications. This stereo camera is based on the FPGA hardware accelerator, VC Power SoM, which can process large data volumes in real time. It captures images via two Mipi camera modules and executes image pre-processing routines including, for example, 3D point cloud generation.

New Mipi camera modules will also premiere at the trade fair, integrating various global shutter sensors from the Sony Pregius S series with minimal noise and high light sensitivity: IMX565, IMX566, IMX567 and IMX568. The modules with a Mipi interface, trigger input and flash trigger output are designed for easy connection to common, single-board computers.

Vision gets piece of the Pi

Scorpion Vision's **Paul Wilson** spoke at the UKIVA conference in April about how Raspberry Pi cameras are now more than just a device for hobbyists. **Greg Blackman** reports



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The Raspberry Pi is 10 years old this year. What started out as a piece of kit for teaching basic computer science in schools has morphed into a computing ecosystem for performing a whole host of functions, including industrial machine vision. Sony's factory in Pencoed, Wales, is now able to make one Pi every 3.1 seconds, and has produced around 37 million boards since it began manufacturing them in 2012.

Paul Wilson, managing director of Scorpion Vision, speaking at the UKIVA machine vision conference at the end of April, said that Sony is now building 15,000 Raspberry Pi units a day.

Scorpion Vision sells many Raspberry Pi imaging boards to customers in medical imaging, vertical farming and other sectors. Scorpion Vision provides industrial imaging equipment primarily, working with optical engineers and automation engineers, but Wilson recognises the power the inexpensive Raspberry Pi camera module holds for many applications. A Pi camera module can cost as little as £20. Add a USB shield to convert the Mipi interface to USB, customise it with other modules that are all plug-and-play, and you've got a camera set-up.

'There's been an awful lot of development outside the Raspberry Pi bubble,' Wilson said. It means Raspberry Pi now supports an impressive list of attributes, including: up to 64-megapixel sensors; 16-megapixel near-infrared sensors; synced quad-camera set-up; ISP tuning; multiple lens mount options; optical filters from the UV to the NIR; motorised infrared cut options; a broad selection of sensors, including global shutter versions; stereo vision versions; multiple focal length options; up to 180fps frame rate; and an HDR option to 140dB.

There are limitations, of course, as Raspberry Pi is designed mainly for hobbyists; Wilson pointed to the lack of industrial camera features, such as strobing. In addition, there's no autofocus option in the official Raspberry Pi offerings, although Scorpion Vision sells 8MP, 12MP, 16MP and 21MP Arducam autofocus camera modules.

Arducam initially released the 16-megapixel autofocus version late last year as part of a Kickstarter campaign, which has since raised more than £112,000. The camera is based on a Sony IMX519 sensor and is capable of 60fps at full resolution; Scorpion Vision quotes its list price as £25, or £27 with housing.

The Arducam 21-megapixel version has hardware ISP functionality offering auto exposure, programmable focus control, auto white balance, auto gain control and lens shading correction. The latest version from Arducam is a 64-megapixel autofocus camera, and Wilson said a 128-megapixel version is coming, 'which blows my mind,' he said.

Multi-camera devices can be built with Pi. Wilson noted that a high-end stereo camera system, of the kind that Scorpion Vision and its sister company, Tordivel, make can cost as much as £15,000. Whereas, a user could combine two Pi camera modules, write some code for depth sensing, and the result is a stereo camera. 'It really does work,' Wilson said, adding that Scorpion Vision has customers using it.

> 'A 128-megapixel version is coming, which blows my mind'

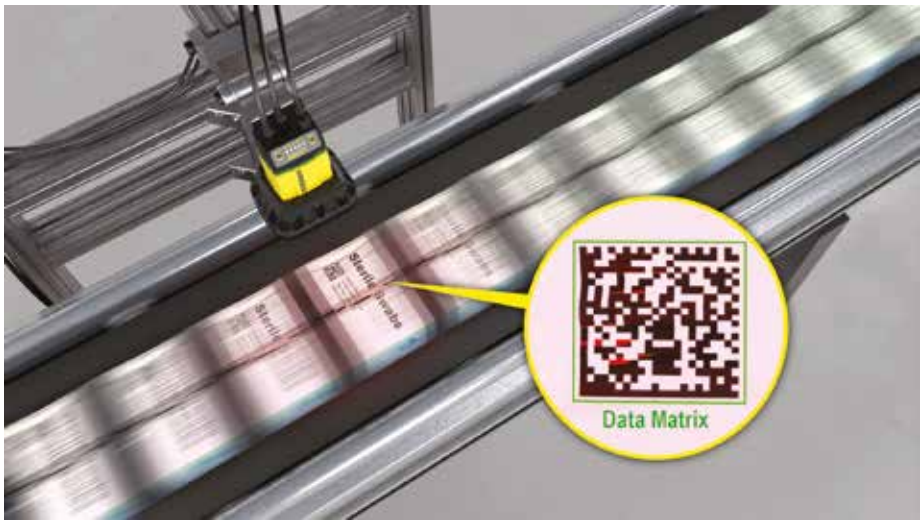
At the other end of the spectrum, Thor Vollset, CEO of Tordivel, presented a stereo vision camera running a neural network at the UKIVA conference. This high-end system is designed for robot guidance tasks – such as a robot system placing automotive parts on a moving hanging conveyor.

Vollset explained that deep learning object location is fast, so the system can work with motion in real time. It doesn't require a point cloud – Vollset said it is higher precision than a point cloud, but does need high-resolution cameras, 29 megapixel or more. The neural network is able to extract precise 3D information from 2D images using true subpixel resolution 2D processing.

Tordivel's neural stereo vision camera is a world apart from a Raspberry Pi stereo vision set-up in just about every conceivable way. But both have their place. Wilson said that the Pi stereo vision products offer a broad choice, and that growth in the ecosystem around Pi has been pushed by interest from industry, not just home hobbyists. Scorpion Vision is selling industrial versions with a covering and a USB interface. The humble Raspberry Pi is now a force to be reckoned with.

Code reading made easy

Abigail Williams finds that traceability systems used in pharma packaging are now becoming more common for consumer goods



Cognex

Pharmaceutical packaging lines require a very thorough traceability solution.

In the ongoing quest to keep pace with regulatory change and operational complexity, machine vision-based track-and-trace systems are a key tool in pharmaceutical manufacturing.

One example is a traceability solution installed at German firm, A. Nattermann and Cie, a subsidiary of Sanofi Aventis Group, by Cognex integrator K+P Qualitäts-Kontrollsysteme. Joshua Deats, global account manager, pharmaceuticals at Cognex, said the system effectively put a stop to drug counterfeiting. The solution is based on a Cognex In-Sight camera used alongside a DataMan fixed-mount barcode reader to read and inspect data matrix codes and printed text labels using optical character recognition (OCR).

Another example is at Bosch Packaging Technology, which manufactures packaging lines and uses CPS packaging machines specifically adapted for pharmaceutical track-and-trace applications. Here, a randomised serial number is allocated, and the serialisation process managed through software.

Cognex cameras are used on these lines as well, to verify the data printed during the packaging process in real time. Cognex's In-Sight smart camera is capable of reading all common code types and fonts, such as 1D codes, 2D data matrix codes and plain text. It can also be configured to read codes on folding cartons with a high-gloss finish.

In many countries, the requirement to keep track of raw materials and products is a mandatory obligation for pharmaceutical companies. In the US, for instance, the regulation is 21 CFR part 11, which deals with electronic documentation, overseen by the US Food and Drug Administration. Such track-and-trace processes generally apply to every stage of the drug production supply chain – from suppliers to manufacturing lines and warehouses, and from warehouses to pharmacies and end users.

As Samar Hamdy, chief business officer at Cairo-based AI vision solution company, DevisionX, explained, systems used to underpin track-and-trace processes at the manufacturing phase are generally based on machine vision technology.

'Throughout the wider supply chain, track-and-trace processes involve the management of data between facilities, warehouses and other suppliers, with full management and control across every drug lifecycle by pharma companies under supervision from regulators,' said Hamdy.

One of the steps where vision is used is to verify unique device identification (UDI) codes are printed correctly and are legible. Codes can be applied using a variety of methods, commonly with thermal transfer labels or direct part marking (DPM).

Deats at Cognex commented: 'Using a robust OCR library and toolset, our vision systems detect the presence or absence of codes and verify that its chain of numbers and letters is correct.' He said that now deep learning OCR algorithms can decipher even deformed, skewed and poorly etched characters.

According to Deats, Cognex inline and handheld barcode verifiers can also grade the quality of label and DPM codes to ensure they meet quality thresholds. 'By monitoring verification results, code issues can be identified when quality starts to decline, so corrective action can be taken right away,' said Deats.

Tracking consumer goods

Deats pointed out that many regulations related to consumer goods also require specific information on labels and packaging, and often involve marking labels or packaging with unique alphanumeric codes or barcodes. This is to authenticate the product, deter counterfeiting, and to make it easier to collect taxes and customs duties.

'Codes also are used to alert consumers, poison centres and medical professionals about hazardous ingredients in products, such as laundry detergent. For food products, labels or packaging must also carry alerts about the presence of allergens,' he said.

In addition, Deats observed that compliance with regulations also involves a

substantial investment in terms of planning and implementation time, as well as in hardware, software, systems integration and training. One of the first steps here is to redesign packaging and labels to include codes and product-identifying icons.

He said: 'Icons are often pre-printed, but codes, especially unique item-level codes, are typically inkjet-printed, thermal-printed, or laser-marked on the packaging line. This makes it necessary to equip the packaging line with code-printing systems, the connectivity to transmit code data to and from the line, and vision sensors or systems to perform verification, inspection and data collection.'

In cases like these, Deats said that vision sensors or systems are capable of carrying out a wide range of tasks, from confirming each code is readable and correct, to collecting data and identifying inadequate print quality, trends and errors. Other key functions include: automation of the aggregation process that links unit-level codes to carton-level codes to case-level codes and, ultimately, to pallet-level codes; the validation of tax stamps; the provision of alerts whenever coding equipment needs maintenance, thereby helping to prevent waste and need for rework; and checking for the presence and readability of date, lot code and allergen information.

'For full end-to-end traceability, vision systems or sensors must also be installed at each point in the supply chain to collect the data needed to authenticate the product and track it from manufacturer to consumer,' said Deats.

'These coding and machine vision systems are also needed on packaging lines to meet existing and future coding requirements for many products, including pharmaceuticals, foods and beverages, medical devices and tobacco,' he added.

Hamdy agrees that the types of track-and-trace system used in pharmaceuticals could absolutely apply to other industrial sectors – particularly consumer goods. 'Track-and-trace systems help organisations to trace their products, shipments and assets with full management and control – and also record data that can be analysed and turned into helpful insights that support business goals and reflect increased ROI. On the other side, it is also under the supervision of governments,' she said.

Machine learning

Code reading is one area where image processing based on deep learning algorithms is likely to outperform more traditional algorithms. Although AI-enabled systems might initially only push read rates up by a few percentage points, this is still likely to be highly significant for manufacturers checking large volumes of product.

'Deep learning OCR algorithms can decipher even deformed, skewed and poorly etched characters'

According to Hamdy, the adoption of AI technologies alongside machine vision systems also has the potential to open up a wide range of additional applications and capabilities.

'DevisionX's experience is mainly in vision and AI technologies that can be applied in many areas of manufacturing processes, to solve challenges such as quality inspection,' she said.

'In the pharmaceutical sector, in addition to track-and-trace functions such as counting, sorting and gauging, integrated machine vision and AI systems could also be used for monitoring packaging safety and integrity and printing inspection,' she added.

Looking ahead, Hamdy predicts that adding AI capabilities to machine vision technologies will give systems the flexibility to manage more complex cases and enable users to learn from data instead of explicitly programming it.

'If you have a quality inspection system based on AI and vision and want to detect a new defect in your product, you can easily bring images for the new defect, retrain the machine learning model and integrate it in your existing solution,' she said.

'In the case of track-and-trace, using machine learning for analysing data will help companies to predict future changes and plan and adapt to them,' she added.

Making the unpredictable predictable

According to Hamdy, the current generation of AutoML and no-code platforms are an important step that will shape the future of AI, machine learning and vision systems not only in manufacturing, but also in all industries. In her view, systems like AutoML, which automate tasks relating to the application of machine learning and enable its use alongside no-code tools, also place the power of AI in the hands of each industry's experts to build AI-based solutions to their daily challenges.

'AutoML no-code tools like our Tuba platform make the process of building machine learning models easy, like using apps in smartphones,' she said.

'AI and smart hardware systems are also available – including deep learning cameras from different producers such as Teledyne Flir, Basler and IDS – which are ready to be deployed with integrated machine learning models. The future of AI-vision systems will be plug-and-play,' she added.

Meanwhile, Deats observed that deep learning-based machine vision systems or software already plays a key role to confirm the presence, print quality and correctness of alphanumeric codes and provides human-like code readability beyond the capability of standard vision algorithms.

He said: 'This improves read rates and reduces scrap that must be checked or reworked by a human operator. Deep learning can also solve previously intractable inspection and identification problems that involve visual distortions, reflections, ambiguity and defect unpredictability.'

Cognex

Vision solution developed for Bosch Packaging Technology.

Glorious technicolour

A look at colour imaging and some of the products available

Oleksiy Mark/Shutterstock.com

Colour images can provide much more data than greyscale images. However, historically, the use of colour has been perceived as a more expensive or difficult technique for machine vision systems.

More recently, with advances in camera technology and the algorithms to support colour vision, colour image processing has become more widely accessible. As such, its use has increased significantly over the last decade, with more applications opening up that require or benefit from colour imaging.

When it comes to inspection, colour imaging is widely used in electronics, pharmaceutical, and food and beverage markets. Colour can be used to sort objects, while in the automotive sector, colour is used to inspect body panels. In automotive manufacturing glues are differentiated by colour, so colour vision can help to make sure the right type and amount of glue has been applied.

The type of camera will largely depend on the type of application. Area scan colour cameras, for example, are suited to inspecting items with definite shapes, whereas line scan cameras are more commonly used for inspecting objects that have different lengths or sizes. Within area scanning, there are two additional options: Bayer mosaic or prism-based technology. Bayer filters work by processing RGB pixels with an arrangement of two green for every one red or blue, known as a mosaic colour filter array. As one might expect, prism-based technology uses a prism within the camera, which separates the light into red, green and blue wavelengths.

Commercial products

Vendors that offer colour imaging products include **Advanced Illumination**, which provides lighting solutions for colour inspection. Its RL4260 medium aimed, bright field ring light has precisely aimed LEDs to bring a higher level of lighting control. It is available in a wide range of

wavelengths, from UV to IR, including a three-channel RGB version. The large inner diameter of the ring light can accommodate lenses up to 55mm in diameter.

On the camera side, **Chromasens** provides a range of line scan cameras. Its most recent launch is the Pixa Evo 8K DXGE Color X camera that supports challenging colour line-scan vision tasks, such as food, PCB and electric vehicle battery inspection. It is effective in high-speed web and print verification where it reduces waste, improves quality and ensures colour precision. The camera has a 16-line, 8k pixel CMOS sensor, featuring time delay and integration options for increased responsivity. It has a maximum line rate of 3 x 90kHz in 12-bit RGB mode. NIR pass filters enable the sensor to recognise object features in the visible and NIR spectrum at line rates of 4 x 68kHz when set in RGB+NIR mode.

JAI offers a selection of area scan and line scan cameras for colour imaging applications among its Go-X, Go, Spark, Fusion, Sweep and Sweep+, Apex and Apex Medical series. The most recent launch in the Apex series is a 3.2-megapixel, three-CMOS prism colour camera that runs at nearly double the fastest frame rate of its previous 3 x 3.2-megapixel models. The AP-3200T-10GE features a 10Gbase-T (10 GigE Vision) interface that delivers full resolution, 24-bit RGB output at 106fps. Three 10-bit and three 12-bit outputs are also supported.

It is built around three Sony Pregius IMX252 1/1.8-inch CMOS sensors with 3.45µm² pixels. The gain – both analogue and digital – and the exposure time can be set independently for the red, green and blue sensor channels, allowing for better signal-to-noise management. This maximises the dynamic range for each colour channel, resulting in improved image quality.

The AP-3200T-10GE also features a colour enhancer tool to strengthen certain colours in the image for additive (red, green and blue) and subtractive hues (cyan, magenta and yellow). This is particularly useful in applications such as microscopy and medical imaging.

Fujifilm's most recent launch is the Fujinon TF-MA lens series, which provides three machine vision lenses for high-resolution, three-chip colour cameras. The series is optimised for precise measurement and inspection tasks, and the lens design is optimised to deliver high image quality with consistent sharpness from the centre to the corners, as well as a low level of distortion. The working distances of the lenses are 100mm for the 6mm and 14mm lenses, and 200mm for the 25mm lens. The 6mm lens measures 48 x 62mm, while the 14mm and 25mm lenses measure 34 x 63mm.

Midwest Optical Systems supplies a range of optical filters across multiple industries, including those for accurate colour rendition. As an example, when using a colour camera and imaging with white light, the near-infrared portion of the spectrum must be blocked to achieve natural, realistic colour images because, unlike the human eye, colour cameras are sensitive to near-infrared light.

MidOpt supplies a range of short pass and near-infrared cut filters to achieve this. Its Vis Pass SP series is designed to separate colours in monochrome or colour applications and improve contrast and resolution. Its Near-IR Block SP series is commonly placed over a camera's image sensor to block NIR light and achieve natural colour rendition.

JAI

JAI AP-3200T-10GE prism camera.

Chromasens Featured product

ChromaPIXA

To evaluate colour differences similar to a human observer, it is necessary to perform the calculation of colour values in a standard colour space. For this, the Chromasens ChromaPIXA colour line scan camera offers colour output directly in standard colour spaces, such as sRGB or CIELAB. The colour values are calculated in the camera in real time using an algorithm that achieves a significantly lower deltaE deviation than standard approaches with a 3x3 matrix.

An important prerequisite for conversion of RGB in standard colour spaces is the colour calibration of the camera and lighting. ChromaPIXA includes the user-friendly calibration software, ChromaCalc, for colour calibration. Common standard colour charts and also self-defined charts are supported. For output, the standard colour spaces sRGB, CIELAB, Adobe RGB, eciRGB are available.

ChromaCalc generates a data set that is loaded into ChromaPIXA for reliable inline colour measurement. Typical applications include printing and package printing, wood and laminate inspection, and sorting applications.

www.chromasens.de/en/product/chromapixa-4k

Products

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Infrared imaging

Toshiba Teli and TriEye launch SWIR CMOS camera

Toshiba Teli is releasing an industrial HD shortwave infrared camera integrating TriEye's CMOS-based SWIR sensor. A prototype was shown at the Industrial Camera Expo in Japan in April.

TriEye's Raven SWIR sensor provides 1,284 x 960-pixel resolution with a 7µm pitch, and is sensitive over a wavelength range of 0.4µm to 1.6µm.

New CMOS-based SWIR sensors promise to lower the cost of SWIR imaging from the more traditional InGaAs sensors – TriEye states on its website a 1,000-times price reduction compared to InGaAs technology.

Shinichi Itokawa, CTO of Toshiba Teli, commented: 'TriEye is providing markets with SWIR imaging capabilities needed for reliable automation in industrial processes at an unprecedented cost. This joint effort will accelerate the development of next-generation superior imaging tech capabilities for industrial cameras that will translate into every aspect of our lives. Toshiba Teli is thrilled to be at the [fore]front of this technological revolution.'

At the beginning of the year, it was announced that Tier 1 automotive supplier, Hitachi Astemo, is to evaluate TriEye's sensing technology for an advanced driver assistance system. TriEye has also recently announced funding to support product commercialisation and expansion.

www.toshiba-teli.co.jp/en
https://trieye.tech

SWIR Vision announces long-range 3D depth sensing

SWIR Vision Systems has demonstrated sub-five nanosecond sensor response times in its colloidal quantum dot (CQD) infrared sensors.

The company reported the advance, along with other developments, in a paper presented at the SPIE Defense and Commercial Sensing conference in Orlando, Florida in April.

With the new capability, SWIR Vision Systems is targeting shortwave infrared lidar systems and direct time-of-flight 3D sensors for AR and VR headsets, according to Dr Ethan Klem, the firm's chief technology officer.

The company is engaging consumer electronics OEMs, sensor OEMs, CMOS sensor foundry partners and automotive lidar companies to commercialise the technology.

SWIR Vision Systems was the first company to commercialise quantum dot-based image sensor technology. The company introduced 2.1-megapixel SWIR cameras, which have been in production since 2018.

'The company's CQD quantum dot sensor technology has already enabled the commercialisation of high-resolution 2D SWIR cameras, and now it promises to provide a solution to the challenge of ToF depth sensing in bright sunlight conditions and over longer ranges,' commented George Wildeman, CEO of SWIR Vision Systems. 'Our customers and partners are guiding us to apply our CQD sensor technology to solve their next-generation gesture recognition, under-display SWIR imagers and lidar system challenges.'

www.swirvisionsystems.com

Ceres LWIR cameras

Ceres V 640 and Ceres V 1280 are new long-wave infrared cameras from Xenics. The cameras are designed for industrial vision applications, process monitoring, medical applications and scientific uses.

Ceres V is a LWIR camera family with very high stability performance. It is based on 12µm-pitch uncooled microbolometer sensors, and provides SXGA resolution (1,280 x 1,024 pixels) and interchangeable optics with five horizontal field-of-view options: 12°, 16°, 25°, 48° or 71°. The cameras have a Camera Link or GigE interface, and are GenICam-compliant, which makes them easy to use in industrial environments. Xenics' Xeneth GUI and its GenICam SDK complete the offer.

www.xenics.com

Lighting

CSBack collimated backlight

TPL Vision's new collimated backlight brings high intensity illumination in a small package for projects requiring precise silhouetting. CSBack has a profile of 21mm thickness with 5mm borders, making it ideal for working in confined spaces or with small objects that are difficult to inspect.

The backlight was designed to facilitate machine vision projects with a focus on the pharmaceutical, food and beverage, automotive and manufacturing sectors.

Key application areas include the imaging of clear parts and objects with rounded edges, which are notoriously hard to inspect with improper lighting because of the lack of contrast. This is a common concern, especially for pharmaceutical and food and beverage applications, where traditional backlights can wash out the edges and features of parts being inspected. Using the collimation effect solves this issue by preventing the diffuse light from spreading around the edges of parts, thereby increasing contrast and measurement accuracy.

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 are all suitable tasks for the backlight.

CSBack can be used with C-mount lenses, as well as telecentric lenses, providing uniform illumination at various sizes, from 50 x 50mm to 200 x 200mm.

www.tpl-vision.com

Lenses

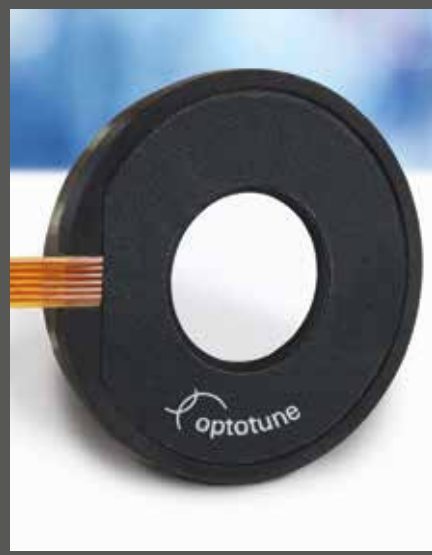
Liquid lens and lens controller

Optotune has released the EL-12-30-TC liquid lens and ICC-4C lens controller. The EL-12-30-TC tunable lens can be shaped from a flat zero-state into a plano-concave or plano-convex lens, resulting in a focal power range of -6 to +10 diopters (at -250 to +250mA).

The lens design has been optimised for fast response times and low thermal sensitivity. The lens housing is 6mm, it has rise and settling times of 3ms and 10ms, a power consumption of 55mW, and temperature sensitivity of 0.01dpt/°C. Cover glasses are AR-coated for 420 to 950nm.

The ICC-4C controls up to four Optotune lenses simultaneously with ±500mA per channel. Numerous interfaces are provided, including USB, Ethernet (PoE+), I2C, UART and 0-10V analogue. It has a robust industrial design, and thermal compensation and step signal conditioning.

www.optotune.com



F-mount lenses

Basler is expanding its CXP portfolio to include F-mount lenses, offering customers an all-in-one hardware solution for applications requiring high resolutions. Basler's F-mount lenses are perfectly matched to the firm's Boost cameras, with large-format sensors from Onsemi's XGS series, although the lenses can also be used with other cameras. The combination is ideal for applications requiring high resolution and a large field of view, such as in factory automation or electronics inspection. The lenses feature a blue dot for aperture adjustment to ease the set-up.

www.baslerweb.com

Event-based vision

Evaluation kit for event-based Sony sensor

Prophesee has made available an HD evaluation kit (EVK4) for computer vision developers wanting to work with the new Sony IMX636ES HD stacked, event-based vision sensor. The sensor, a collaboration between Sony and Prophesee, has a 4.86µm pixel pitch and 1,280 x 720 pixel resolution.

The EVK comes with Prophesee's Metavision Intelligence Suite, a set of software tools that facilitate application development. It features 95 algorithms, 67 code samples and 11 ready-to-use applications, and is augmented by an open-source community of developers. Developers can perform a variety of design exploration steps and incorporate customised software applications to meet specific market requirements.

The EVK is built with efficient heat dissipation, electrical isolation and overall casing shielding. It measures 30 x 30 x 36mm, weighs 40g and has been tested in a wide range of challenging industrial conditions, including changes in temperature, moisture, rough handling and shocks, and it can manage electrostatic discharge.

The kit is designed so that there's optical alignment between the sensor, optical barrel and camera body. Developers can switch between C- or CS-mount compatible lenses, from an 8mm objective lens to microscope or telescope imaging ports. The kits are supplied with a C-mount 1/2.5-inch lens, a C-CS lens mount adapter, tripod and USB-C to USB-A cable.

www.prophesee.ai

Cameras

Zenith 100GigE camera

New from Emergent Vision Technologies is the 10-megapixel HZ-10000-G camera, the latest in the firm's line of Zenith 100GigE cameras. Through the 100GigE QSFP28 interface, the camera can reach 1,000 fps.

Available in both monochrome and colour versions, the camera is based on Gpixel's GSprint4510 CMOS image sensor – a 10-megapixel, 22.9mm CMOS image sensor with 4.5 x 4.5µm pixel size. Both GigE Vision and GenICam compliant, the camera reaches 1,000 fps in 8-bit mode and 810fps in 10-bit mode.

In addition to the HZ-10000-G, the Zenith 100GigE series comprises the 21-megapixel HZ-21000-G, the 65.4-megapixel HZ-65000-G, and the 103.7-megapixel HZ-100-G. Later this year, the company will introduce the HZ-150-G Zenith camera, which is based on a 152-megapixel CMOS image sensor.

All Emergent Vision Technologies cameras have low CPU utilisation, low latency, low jitter, and high frame and data rates, with standard accessories and cabling options to cover most lengths. The GigE Vision cameras can be synchronised with IEEE 1588 PTP.
www.emergentvisiontec.com

Intel RealSense D405 depth camera

Framos now supplies the new Intel RealSense D405 depth camera. The D405 camera operates over a range of 7cm to 50cm and achieves minimum object detection of up to 0.1mm at 7cm. At a distance of 25cm, depth accuracy is better than 0.7 per cent.

A USB 3.1 interface and multiple mounting threads allow for easy integration. Its power consumption in streaming mode is 1.55W and 35mW in standby mode.

The camera weighs 60g and measures 42 x 42 x 23mm; it is ideally suited for robotics applications. Primary applications include industrial manufacturing, automated inspection on assembly lines, and high-precision placement of small objects at close range. The D405 depth camera is also helpful in smart farming: it provides accurate measurement and positioning data so that robotic arms can grip fragile fruits and vegetables without damaging them.

The camera's global shutter sensors have a field of view of 87 x 58° with a depth resolution of up to 1,280 x 800 pixels. It can operate between 0°C and 55°C, while the camera's image signal processor optimises the depth sensor's 1,920 x 1080 RGB pixel data (up to 90fps).
www.framos.com

FXO series

SVS-Vistek now offers 24 versions of its FXO series machine vision cameras featuring Sony Pregius S image sensors. Available in resolutions from 5 megapixels (2,448 x 2,048 pixels) to 24.4 megapixels (5,312 x 4,600 pixels), the FXO series cameras can be specified with either 10GigE or Coaxpress-12 interfaces.

FXO cameras are suitable for a wide range of applications, from inspection of semiconductors, food, and electronics, to scientific research and medical imaging. Along with standard functions such as ROI, LUT and binning, there are PTP or Colour Transformation Control, which go beyond standard white balance. A GenICam four-channel LED strobe controller saves implementation costs by driving LED lighting directly or in connection with an integrated sequencer via the camera's power outputs.

Designed for use with C-mount lenses, FXO cameras come in a rugged, CNC-milled aluminium housing with thermal management to achieve stable image homogeneity in environments up to 60°C. The cameras measure 50 x 50mm.

The 10GigE cameras' large frame buffer and packet resend helps optimise frame rates to 124fps, and supports maximum cable lengths of 100 metres with the added benefit of PoE. The CXP-12 version is suitable for cable distances up to 25 metres with PoCXP.
www.svs-vistek.com

Linea ML 8k multispectral camera

Teledyne Dalsa has introduced a multispectral Camera Link HS (CLHS) line scan camera in its Linea product line. The camera has spectrally independent RGB and NIR outputs with independent exposure control for each channel for better white balancing. The camera is ideal for handling challenging inspection applications such as banknote, passport and print inspection, and for looking for defects in semiconductor wafers and printed circuit boards.

The Linea ML 8k multispectral camera uses Teledyne Dalsa's CMOS 8k quad linear sensor with a 5 x 5µm pixel size. It delivers a maximum line rate of 70kHz x 4 using a CLHS fibre optic interface. The camera also has built-in SFP+ transceivers that convert electrical signals to optical signals, and connects directly to fibre optic cables using LC connectors.
www.teledynedalsa.com

Software

Halcon 22.05

MVTec Software has released Halcon 22.05, which includes new deep learning technology for anomaly detection. The Global Context Anomaly Detection feature requires only good images for training, without the need for labelling. The tool can detect completely new anomaly variants, such as missing, deformed, or incorrectly arranged assembly components, for example. This function is suitable for inspecting printed circuit boards in semiconductor manufacturing or print verification.

The new release also includes improvements to Halcon's core technologies. With version 22.05, users can train the Deep OCR tool with their own dataset. This makes it possible to read text with poor contrast, on tyres, for example. It also makes it possible to train Deep OCR to recognise special characters and print styles that are rarely used.

Halcon supports various standards for evaluating the print quality of 1D and 2D codes. Version 22.05 makes the determination of the module grid for print quality inspection of ECC200 codes more robust. Moreover, print quality inspection of 2D data codes is now up to 150 per cent faster.
www.mvtec.com

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Pixelink
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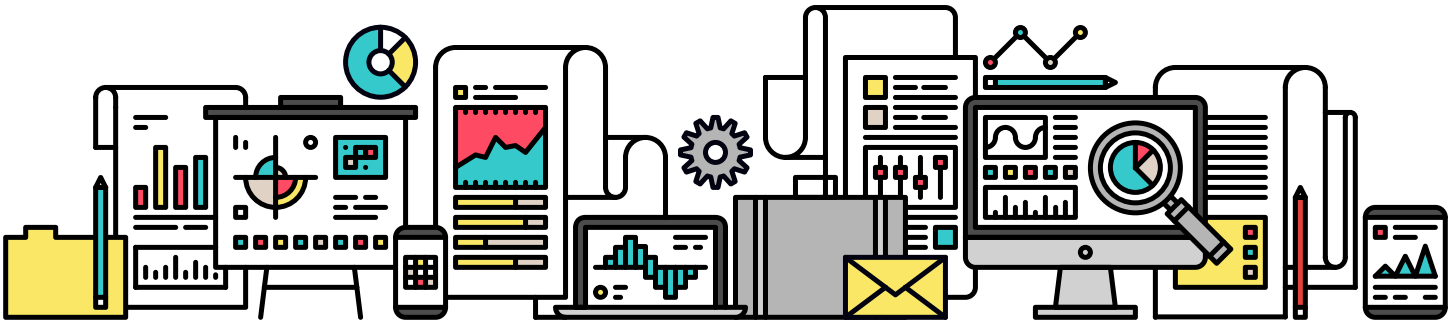

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