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December 2021/ January 2022
Issue 108

Spectral X-ray finds plastic in food

Lorne Trottier on Matrox at 45

Rise of the autonomous mobile robots

Life science labs get automated

Not scratching the reflective surface

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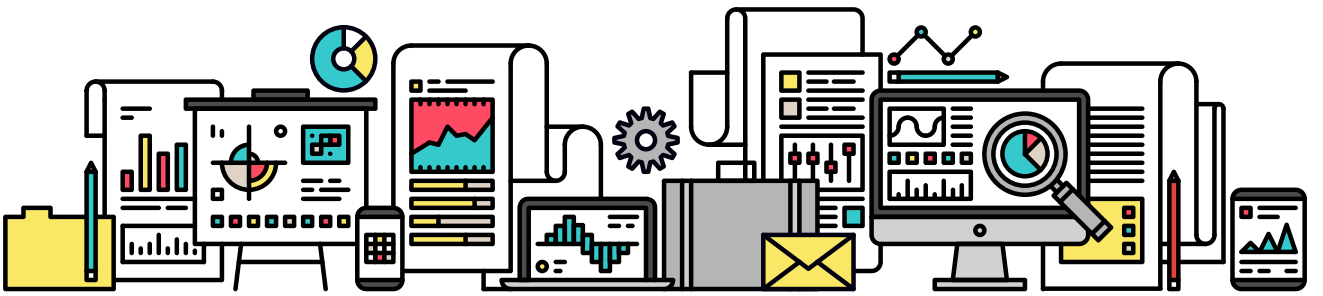

Event-based vision compared with machine vision

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From high-speed applications to tracking, vibration analysis and counting applications: event-based vision opens up new possibilities in numerous machine vision fields

Photometric stereo technique - 3D machine vision's next frontier

SMART VISION LIGHTS

Photometric stereo uses 3D surface orientation and its effect on reflected light to produce a contrast image accentuating local 3D surface variations, making complex inspections cheaper and more effective

High-speed imaging: The benefits of 10, 25, 50, and 100GigE Vision

EMERGENT VISION TECHNOLOGIES

The white paper presents a brief timeline of GigE Vision cameras; advantages of the interface; and information on using 10GigE up to 100GigE to stay on the leading edge of machine vision solutions in manufacturing and beyond

Deep learning: Its proper role and use in machine vision

MATROX IMAGING

Deep learning is a key enabler of Industry 4.0 in the manufacturing sector where machine vision is an important contributor. This white paper from Matrox Imaging details how and where machine vision benefits from deep learning technology, and how to get the best out of deep learning for machine vision.

Advantages of imaging lens ruggedisation

EDMUND OPTICS

Ruggedised lenses address some of the challenges faced in environments with high levels of vibration, shock, and moisture. Edmund Optics explores the features and advantages of different types of ruggedisation in imaging lenses.

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Leader
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A prosperous year

In many ways it's been an encouraging year: the order books are full following an enforced pause in automation projects during 2020, and, if anything, the momentum behind demand for machine vision has gathered pace as the year's progressed. What's put the brakes on growth is the shortage in semiconductor components that's affecting every industry from cars to consumer electronics, and it's unclear as yet when the supply chain issues will ease.

A number of firms celebrated significant milestones this year. Framos turned 40, as did Cognex. Robert Willett, Cognex's CEO, commemorated the occasion with a trip to the Nasdaq site in Times Square at the end of November to ring the opening bell. Matrox was formed 45 years ago in the early days of the microprocessor. In this issue, on page 10, we speak to Matrox co-founder Lorne Trottier about how image processing has changed since he developed his first product in 1976.

From the old to the new, this issue also features technology from two new ventures: Deep Detection (page 4), which has taken advances in particle physics to build an industrial spectral X-ray camera that can spot plastic contamination in food, something that other inspection methods are unable to do. And Isak du Preez's Axiscan (page 6), who has come up with a new twist on 3D deflectometry to measure reflective surfaces, which is getting interest from BMW and other car manufacturers.

Next year promises much for these early-stage companies, as it does for the more established players like Matrox. We wish all our readers in the vision industry a prosperous New Year.

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Spectral X-ray camera offers first for finding plastic in food

Deep Detection

Deep Detection's **Colin Burnham** says advances in X-ray detection promise much for industrial inspection. **Greg Blackman** reports

An industrial X-ray camera able to perform spectral imaging – which hasn't been possible before – is about to be launched into the marketplace.

Deep Detection was founded in July 2020 as a spin-out from the Institute de Fisica d'Altes Energie in Barcelona. It has recently secured €1 million in a funding round led by photonics investor Vigo Ventures for its X-ray camera called PhotonAI.

The company is currently involved in proof-of-concept trials with future clients and food production firms to address inspection challenges, the main one being detecting plastic contamination in food.

'There are no detection methods today that can pick up on plastics [in food production],' commented Colin Burnham, COO of Deep Detection and ex-senior director at PepsiCo.

Plastics are used across the entire supply chain for food manufacturing, whether that's plastic containers that move bulk material around from farms to factories, or the drives inside conveyor belts, the seals inside pipes and tube work, or from packaging and handheld tools.

Burnham said that there are around 130 product recalls every year in Europe because of a serious risk of foreign bodies in food, and around 30 per cent of those are plastics.

'Recalls in the food industry are highly disruptive,' Burnham added. There's a lot of cost associated with recalls, because it involves product storage, product disposal, liabilities, and not having a product in the market means lost sales.

Deep Detection's camera is able to detect plastic contamination in food where other inspection techniques cannot.

The science behind the technology comes from particle physics; it is based on photon counting using microelectronics with a very low noise base.

Traditional X-ray machines use a scintillator to detect X-rays and turn them into light, which is then picked up by photodiodes. The indirect detection method means information is lost. Deep Detection's sensor is able to detect X-rays directly using photon counting and then digitally bin the energy data. This means it can do spectral imaging, which is 'completely new in X-ray', Burnham said.

'You can use that spectral data to separate out images,' Burnham explained. Deep Detection will initially offer a camera with two levels of spectra, and is working to produce a multi-level spectral camera.

X-rays attenuate at a different rate according to their energy level, so the camera captures a spectral fingerprint in discrete energy bands.

A common application would be to measure the percentage of fat in meat products, for example, to grade meat and send it to different upstream clients. At the same time, the PhotonAI camera can inspect for foreign bodies.

The importance of spectral information when looking for lightweight materials like plastics is the ability to separate out images. The camera is able to read the energy signatures in X-ray at lower energy levels than conventional scintillators. Plastics absorb in a low-energy band, so being able to separate out images into different energy bands while having a low noise floor means the camera can differentiate and detect those materials.

The challenge with spectral imaging in X-ray is that the energy is so high – the wavelength so short – that it's difficult to separate out different X-ray wavelength bands, as happens for RGB in the visible spectrum, explained Burnham. To be able to do that involves measuring photon by photon and grouping that data into different bands.

> **'We're taking [photon counting] and building it into an industrial detector for line scanning'**

Medical equipment like CT scanners is adopting this photon counting technology, and achieving 'phenomenal gains,' said Burnham. The spectral data is used to separate out not just flesh from bone, but tissue down to the level of blood vessels.

'They're getting very precise results,' he said.

'We're taking that same science, building it into an industrial detector for line scanning, making it accessible at a price and performance level, while still getting the high-quality data,' Burnham said.

'We believe we can take those learnings [in medicine] and implement them for these industrial solutions,' he added.

Burnham said the camera is more expensive than a conventional camera, but the extra value brings a significant benefit. The camera is compatible with existing X-ray systems and machines, so integration is straightforward.

The camera uses a 330µm pixel, so achieves similar spatial resolution to a conventional detector, which has around a 400µm pixel. However, it's a precise pixel-by-pixel measurement, which allows multi-energy images to stay registered to each other.

Burnham said the camera is able to read enough data to produce a high enough contrast-to-noise ratio to detect foreign objects in food moving at 60m/min, which is what food production lines typically run at. In addition, because the data is grouped digitally, the detector can be configured for the energy band of most interest, or trade off spatial resolution with spectral resolution or speed – it can adapt to the needs of different inspection tasks.

Deep Detection plans to offer industrial prototypes for clients to test early next year. It will then launch the full series in the fourth quarter of 2022 or early in 2023.

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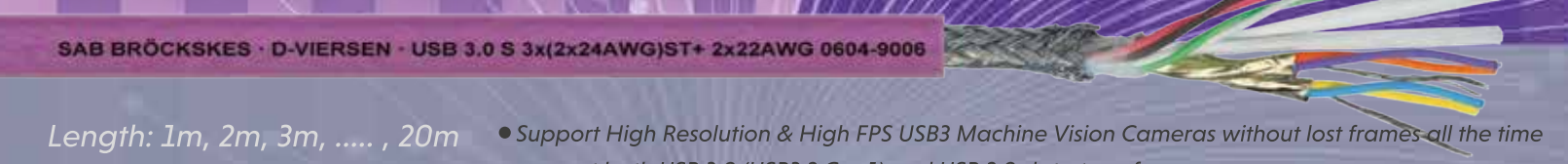

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Rethinking 3D scans of reflective surfaces

Greg Blackman talks to **Isak du Preez**, who's new approach to 3D deflectometry has attracted interest from BMW

Isak du Preez first had the idea for a 3D scanner for reflective surfaces in South Africa after talking to a friend who had spent the summer counting hail dents on cars. Insurance companies pay by the dent to repair hail damage; they want to know the number of dents, their size and their location. Du Preez thought it might be possible to scan a car's surface in 3D to find the dents.

In 2016 he built a miniature prototype of the scanner. A rudimentary draw machine moved a patterned light arch over a toy car. He used his cell phone camera to capture reflections from the shiny car body and developed software to calculate the surface profile in 3D.

Since then six large scanning machines have been built, mostly for scanning cars, and du Preez is working on a seventh for BMW. Counting hail dents is no longer the goal; now it's end-of-line inspection of cars, which is usually a manual task or uses a robot arm to scan the surface from different angles. Scanning car windscreens is another potential application, or large panes of curved architectural glass. Du Preez has also had interest from aerospace firms for inspecting some of their components. Any reflective surface – typically a large smooth surface – could benefit from this technology.

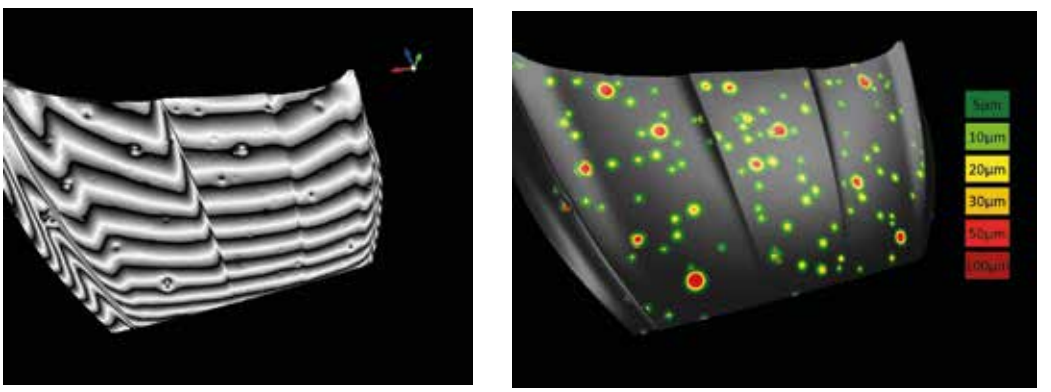
The technology is a type of deflectometry, although when du Preez started out he'd never heard of the term. The strength of du Preez's approach is to bring the precision of 3D deflectometry to large curved surfaces – previously not addressable by deflectometry – in a practical and economical way. Objects several metres wide can now be scanned with sufficient precision to detect micrometre-level local shape aberrations.

Isak du Preez/Axiscan

One of the early scanners using security cameras, and the 3D data generated by the software

Deflectometry works, traditionally, with a camera and a flat panel display, with each pixel of the camera mapped to a scene point on the display, normally the display pixels. When a reflective surface is introduced, what each pixel of the camera sees can be traced back, via specular reflection from the surface, to points in the surrounding scene. The mapping is based entirely on geometric information; it depends only on the surface shape and the positions of the camera and display.

The technique relies on specular reflection, so the surface does have to be shiny or at least glossy, but any reflection is extremely sensitive to shape – hence, hail dents only micrometres deep can be



Isak du Preez/Axiscan

A scanned hood of a car with dents mapped

detected using regular cameras. It is much more sensitive to depth than structured light scanning, which is based on triangulation between camera and projector, and disregards specular reflection as noise.

The disadvantage of deflectometry is that the reflection visible in an object – especially a convex object – is typically small. So, with standard methods, only a tiny patch of the surface can be mapped at one time, with the process repeated and all the patches stitched together to capture the entire 3D shape. A deflectometry sensor mounted on a robot would take hundreds of different images for each small neighbourhood when inspecting paintwork on a car body, for instance.

'[Standard deflectometry] is over-engineered; we don't need to display arbitrary images in order to encode the scene'

'The contribution of this technology is to reinvent the scene encoder,' he said. 'An electronic display is very convenient hardware for generating a flat scene, but far less practical if you need to comprehensively surround an object like a car. It is also over-engineered, as we don't need to display arbitrary images in order to encode the scene.'

Instead of a display, du Preez's method relies on a static pattern printed on the inside of an arch. Moving the arch over the car encodes a scene that is uniquely decodable. The pattern consists of a set of latitude codewords that when translated with longitudinal motion encode each scene point's latitude and longitude. To differentiate it from other varieties of deflectometry, du Preez calls this approach Latitude Code Scanning Deflectometry.

The pattern's design is optimised using a technique analogous to channel coding in telecommunications. The codewords are packed together inside a codespace as efficiently as possible. 'But where discrete communications codes are optimised by sphere packing, what we do could more accurately be described as spaghetti packing, since we are encoding a continuous variable,' du Preez explained.

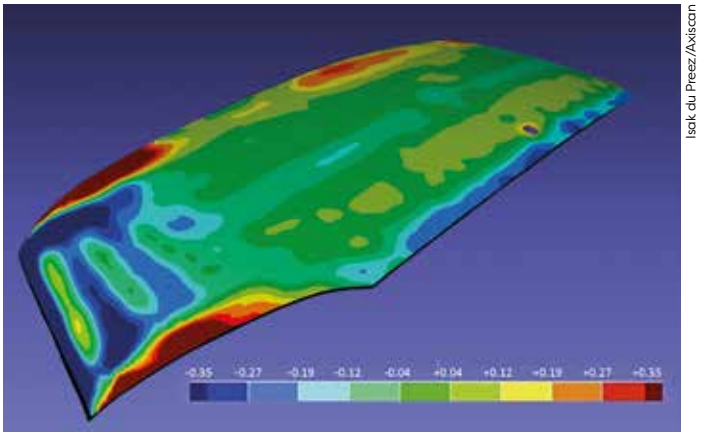
At one stage, du Preez said the easiest way to design the pattern was to work with a physical analogy. He fixed up a jig shaped like a pyramid to represent the codespace, and experimented with different ways of fitting a length of flexible pipe into the volume. 'An efficient encoding ultimately allows for shorter codewords, reducing the depth and mass of the required arch and the machine as a whole,' he explained.

Du Preez is a software →

Isak du Preez/Axiscan

Isak du Preez integrating Axiscan's software with the first full-scale machine

Isak du Preez/Axiscan



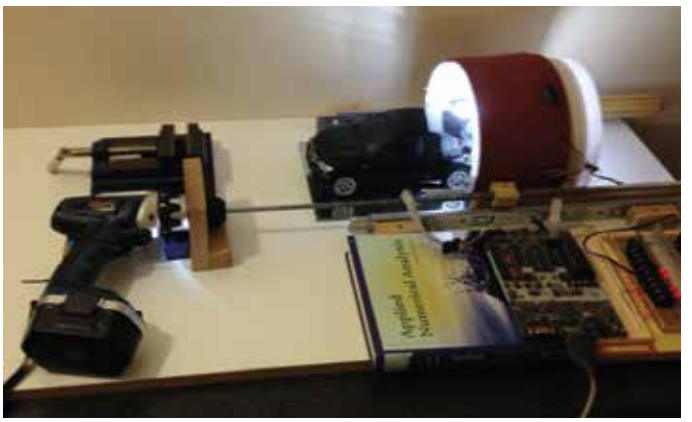
A 3D scan showing the curvature of a car windscreen

→ engineer and the software is where the complexity lies; the machines themselves are relatively simple. Through his company, Axiscan, du Preez provides the pattern and the software to decode it, while the large scanning machines are built or commissioned by his customers according to the requirements of the application. Ultimately, Axiscan's software accepts camera video as input and produces a 3D mesh of the surface as output.

The 3D mesh contains one vertex per camera pixel; its lateral density is limited only by the camera resolution. In addition, the system is self-calibrating, with the software automatically calculating each camera's position from its direct view of the encoded scene.

The early scanners built for assessing hail damage on cars used security cameras, which are less than ideal as they compress video. 'This is the last thing you want,' du Preez said. 'You want the pixels as independent as possible for this.

Isak du Preez



Isak du Preez

Isak du Preez's first prototype scanner, built in 2016 from hardware store materials

'But it still worked,' he added, saying dent reconstruction from different cameras was consistent with each other down to approximately 1µm. 'Considering the low camera specifications, the video compression, and the generally uncontrolled environmental conditions, this level of repeatability from the software is encouraging.'

He continued: 'The hardware specifications in this project are extremely relaxed. I don't think we're anywhere near the ceiling of attainable accuracy yet.'

Precision in the infrared

Most metal sheets that go into building a car scatter light a lot more than exhibiting specular reflection. It's normally only after the car has been painted that it becomes reflective. But rougher surface types can still resemble a mirror when imaged in the longwave infrared. If automakers could detect defects before the expensive step of painting the car it would add a lot of value.

Attempts at infrared deflectometry in the past have usually involved moving a pattern made up of heated elements in a complex motion with many degrees of freedom, and this still only encodes a planar scene. The technology has been difficult to engineer because of the lack of off-the-shelf infrared displays and because thermal elements only change temperature slowly.

Du Preez thinks Latitude Code Scanning Deflectometry might be ideal for working in the infrared because it already relies on a moving scene generator, and encodes large curved surfaces. The camera just needs to be changed to an infrared camera, and the pattern switched to a thermally emissive pattern painted on a heated arch. Testing this potential is one of the aims of a collaboration with a research lab at BMW.

'I don't think we're anywhere near the ceiling of attainable accuracy yet'

At the moment, du Preez's software takes about seven minutes to produce the 3D result, but that's running on a single threaded CPU. He expects with parallel processing to cut that down to 15 seconds or less, which would fit within the natural cycle time of the movement of the arch.

Du Preez hopes that Latitude Code Scanning Deflectometry will bring the precision of deflectometry to many new applications, and the interest from BMW and others will only help refine the technique. He said Latitude Code Scanning Deflectometry is not quite as accurate as interferometry, nor as versatile as structured light scanning, but that the combination of precision and versatility, while also being cost effective, suggests the approach has promise. 'There's a lot to explore,' he said.

Today, Matrox Imaging's portfolio includes frame grabbers, smart cameras, and software libraries

At the interface between microprocessors and video

This year saw Matrox celebrate its 45th anniversary. **Greg Blackman** speaks to co-founder **Lorne Trottier** about the imaging firm's history

In 1986, Matrox Imaging demonstrated a device able to run 3 x 3 convolutions on a 640 x 480-pixel image in real time using a graphics chip. This was the first PC-based image processing accelerator, and it was 'unheard of in our industry back then,' recalled Sam Lopez, senior vice president of sales and marketing at Matrox Imaging.

The device came about thanks to Matrox co-founder Lorne Trottier's experience with graphics cards. He came up with the idea of using a graphics engine in reverse to drive memory, and using the chip to run convolutions and histograms and implement image processing algorithms. CPUs in PCs were extremely slow in 1986, and here was a vision engine that didn't rely on the host CPU for processing.

'That's what I like doing, looking at technology and figuring out how to apply it,' Trottier told *Imaging and Machine Vision Europe*. 'We were already kind of into image processing, so we knew about needs for image processing. I knew about this particular graphics chip, so I figured out that I can use it for image processing.

'That's the kind of thing our creative people do at Matrox all the time,' he added. 'That's what's fun about this, there's always new technology coming out and more difficult problems to solve, and figuring out how to use that technology in clever ways to solve those problems is what we thrive at here at Matrox.'

The MVP-AT accelerator – which was used by Nasa in the early 1990s, for instance, in a satellite data analysis package called PC-Seapak – is just one example of the pioneering work done at Matrox.

Trottier and his co-founder started the company in 1976, in the early days of the microprocessor. The idea was to build an interface between microprocessors and video. 'The bidirectional in and out of the microprocessor was the core idea that started the company off, and has been a theme throughout its history,' Trottier said.

Matrox's first product was called Video RAM, a controller for a microprocessor to display computer-generated alphanumeric data. It was called Video RAM because the ACSII text, the binary code for characters, was mapped to memory.

'You didn't have to know anything about video,' Trottier explained. 'If you knew about RAM you could connect the RAM to your microprocessor, and as soon as you used ACSII text it was displayed automatically.'

Years later a different Video RAM technology was developed for graphics cards. At one point, Trottier got a call from the president of Micron asking about Matrox's Video RAM to see if Trottier could help out in a patent dispute Micron was having with Texas Instruments over VRAM. 'I told him that the only similarity between our VRAM and the one you're talking about is the name,' Trottier said.

Matrox began life very much as a personal project between the two founders. The company's first phone line was installed in the Trottier family home, with Lorne's mother acting as receptionist. Two months after Matrox's founding, Trottier visited a computer trade show in Atlantic City in July 1976, collecting data sheets from a number of small start-ups in the early personal computer space, among them a datasheet from the Apple I, which he still has in his archives.

Its pioneering spirit led Matrox to develop some of the earliest frame grabbers, a foundation that is in evidence today – Matrox still makes frame grabbers. 'Exactly when image processing started [for Matrox] is hard to say,' Trottier said. The first frame grabber

Matrox designed was in the late 1970s before the PC came out, for Intel's multi-bus board-level computer. 'Hardly anyone had done digitised video because it was high bandwidth back then,' he recalled. 'We used an A/D converter that cost $600 a chip – in the 1970s – to digitise video on our frame grabber.'

The price of those chips came down rapidly, and once the PC was introduced in the early 1980s, Matrox was the first to build a frame grabber for the PC. 'Exactly where along the road machine vision came in is a little fuzzy,' Trottier said. 'Those frame grabbers were used for all kinds of things back then; there were all kinds of research projects going on and machine vision and image processing was one of them.

'Back then image processing systems were mini computers and cost a fortune,' he continued. 'We were one of those pioneers that brought the prices down and made it much more accessible.'

In the early 1990s, the company split into three divisions: Matrox Graphics, delivering graphics solutions; Matrox Video, for the broadcast industry and digital video editing; and Matrox Imaging, focusing on component-level solutions for machine vision applications. The unified thread underpinning the Matrox model remained the original notion of interfacing between microprocessors and video.

In the early 1990s, Matrox Imaging decided to develop an imaging software library, releasing the Matrox Imaging Library (MIL) in 1993. By this time the company had a lot of different frame grabbers, and the software to support the MVP-AT accelerator was getting hectic, Trottier said, so MIL was created as a uniform library that worked on all Matrox products. 'That was a key thing, and was one of the reasons why we kept customers for such a long time,' Trottier added.

More recently, Matrox Imaging has released Matrox Design Assistant software, which takes away the need for programming by using flowcharts to create a vision application. Both MIL and Design Assistant now have deep learning functionality, which can solve problems that couldn't be solved with classic rule-based image processing tools.

One of the newest cameras from Matrox Imaging is the Matrox AltiZ 3D profile sensor,

'I'm a techno-geek myself; I started fooling around with electronics... as a kid. This is a continuation in a way'

Matrox's first product, Video RAM, in 1976

The Matrox Meteor-II PCI frame grabbers, launched in 1997

with a dual optical sensor design and data fusion capability. The camera's two sensors reduce occlusions found in more traditional laser profilers to give more complete 3D coverage of a scene.

'The combination of 2D and 3D, classic image processing, deep learning, with robotics, allows you to make some extremely powerful solutions,' Trottier said. 'When you integrate those pieces together you have something that's amazingly powerful.'

Trottier said that there are new areas that have a big demand for machine vision, highlighting the electrification of automobiles as one example. He said: 'Just the assembly of batteries and battery packs is a whole new sub-industry that's emerging,' and that Matrox Imaging is getting customers in that area.

Lopez noted that the reduction in cost plus the reduction in complexity for implementing machine vision systems has 'opened up a lot of new opportunities in industries where they couldn't afford to put vision in the past.' He said that standards, whether that's video standards, but also communication protocols to communicate with other devices like robots or PLCs, is lowering the complexity of vision systems. Matrox is active on a number of standardisation committees, including Coaxpress and GigE Vision, to help define and develop those standards.

Lopez added: 'There's going to be more competition going forward as the technology becomes more accessible and easier to use. There are a lot of good ideas out there that merit attention. We don't discount even the start-ups, which could come up with some interesting things moving forward.'

Trottier said that his advice for start-ups is to work with companies to get exposed to real imaging needs. 'That's the catalyst,' he said. 'If you become aware of needs and aware of new technology, you'll figure out new solutions.'

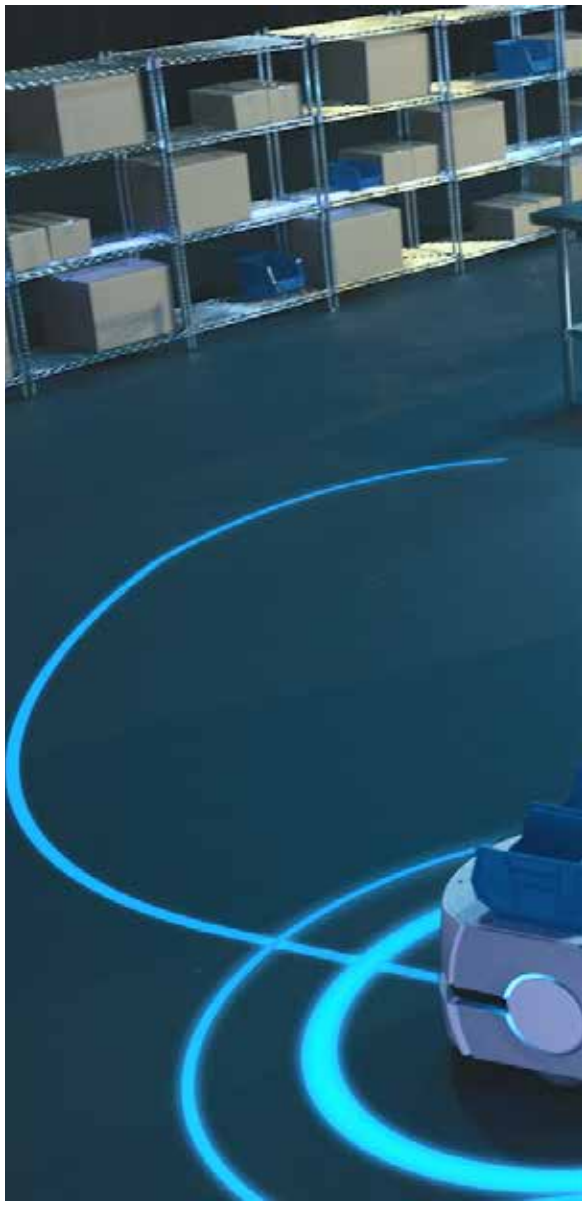
In 2019, Trottier acquired full ownership of Matrox, declaring renewed commitment to customers, suppliers, business partners, and employees.

'For 45 years to remain viable and profitable we've endlessly had to reinvent ourselves,' Trottier said. 'That's one of the things I love about this industry. I'm a techno-geek myself; I started fooling around with electronics, building crystal radios when I was a kid. This is a continuation in a way. Most of the engineers we have working for us have the same geeky love of technology, and we love staying on the leading edge, and figuring out what the newest technology is and how it can be applied to solve real-world problems.

'In the area of machine vision there has been no lack of innovation and new technology,' he continued, 'and we're right on the forefront of some of those things, including things like 3D... and deep learning – we have customers in many projects applying that [deep learning], all of which is very exciting.'

Sensor fusion gets robots roving around factories

Susan Curtis explores the burgeoning world of autonomous mobile robots



Automation is the key driving force that for many decades has delivered increased productivity across many different industrial sectors. In the most efficient assembly lines, such as those perfected by automotive manufacturers, robotic machinery plays a crucial role in boosting throughput, reducing operational costs, and optimising the quality of the end product.

These robotic systems excel at performing specific tasks in a reliable and repeatable way, while continuing innovation has allowed them to tackle ever more sophisticated and intricate production processes. But for the most part they remain dumb machines: they act only in a pre-defined way, and they must be controlled by complex computer code.

Meanwhile, industrial manufacturers are seeking to introduce greater flexibility into their production facilities, in many cases to offer their customers greater choice. Again, the automotive sector offers a good example. While the traditional assembly line produces the same product over and over again, buyers of new cars expect to be offered an array of different options – ranging from the interior and exterior finishes through to the addition of novel technologies that are designed to improve comfort or performance.

This requires a more flexible manufacturing environment, which in turn demands robots that can move and perform simple tasks without human intervention. 'Mobility and flexibility will be the next big step in manufacturing automation,' said Bruno Adam of Omron, a leading developer of robotic systems for industrial applications.

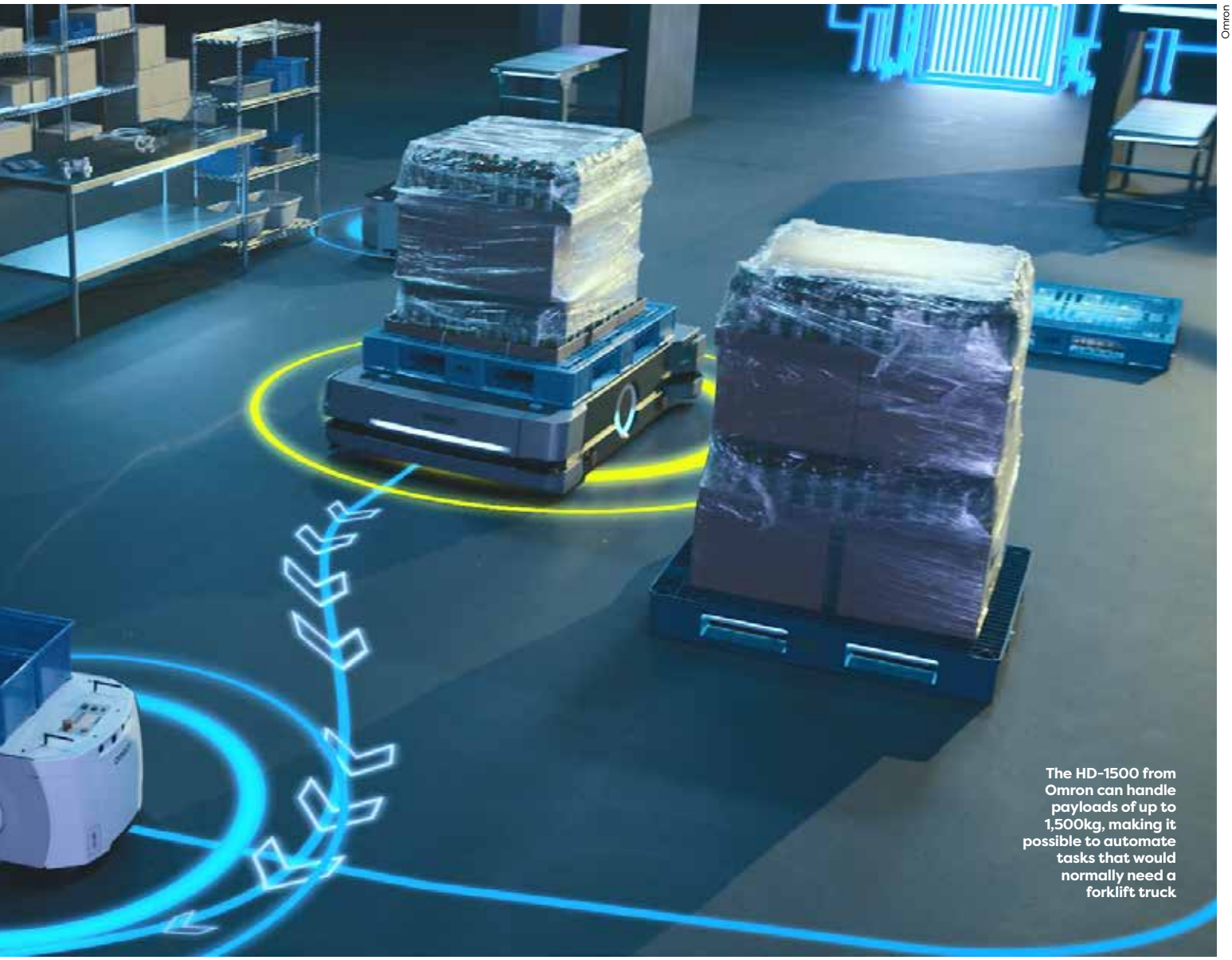
Adam explained that most manufacturing processes are organised around fixed conveyors and robotic systems. To vary the specifications of the end product, human operators are typically needed to move product pieces from one assembly process to another. 'Increasing flexibility requires more people to handle the work pieces and push them around, but this human intervention does not add much value,' he said.

For that reason large manufacturing companies are keen to deploy mobile robots to transport inventory and product pieces around the factory floor. These autonomous mobile robots (AMRs) are designed to move and operate by themselves, which means that they must be able to perceive their surroundings and react to them. Visual information is crucial to aid navigation and avoid collisions, as well as to enable the robot to perform simple functions such as selecting and picking up the objects that need to be moved.

Initial deployments of these autonomous robots have focused on safety, which is most reliably achieved by fitting them with a row of laser scanners around 20cm off the ground. Such 2D lidar systems can detect the presence of people and other obstacles at distances of up to 20m, although most systems can only sense objects at floor level. Omron, which has already deployed more than 2,000 AMRs with customers in Europe, has added a vertical scanner to detect hazards above the ground, such as a raised pallet on a forklift truck.

The problem with these lidar systems is that they don't know what the obstacle is, which means that they can't make decisions about what to do next. 'There will always be some configuration where we need more information than can be provided by a laser scanner,' Adam said. 'We are actively developing vision technology to collect more information about the environment and to improve navigation.'

Omron has the in-house expertise to develop its own vision systems, in part



Omron

The HD-1500 from Omron can handle payloads of up to 1,500kg, making it possible to automate tasks that would normally need a forklift truck

through the acquisition of Microscan – a company specialising in industrial barcode readers – in 2017. While safe and efficient navigation remains the primary motivation, Adam said that vision technology is also being developed to enable AMRs to perform simple operations, such as picking up and dropping off work pieces and inventory. This often requires more accurate positioning of the robot at the pick-up or drop-off point, particularly if items need to be taken to and from a moving conveyor. 'We need vision systems for that final accuracy, particularly for applications where a robot arm is installed on top of the mobile platform to perform a specific function,' commented Adam.

But it can be difficult for AMR developers to choose which vision technology to deploy. Conventional 2D cameras generally offer the cheapest solution, but 3D vision

'Optimal performance is achieved by combining 3D information with a lidar system'

provides the depth perception that's needed for the robot, for example, to work out whether to stop in front of an obstacle or to change its direction. '3D vision systems in particular is a very dynamic market in terms of the available technologies,' said Anatoly Sherman of sensor specialist Sick. 'Each one has pros and cons, so we always have to start by talking to our customers about their specific requirements.'

Key considerations include the field-of-view, which must be large enough for the robot to see enough of its surroundings in the desired direction, as well as sufficient small-scale information to enable accurate navigation and allow the robot to perform simple operations. Factors such as the reaction time, frame rate, and size of the robot are also important to consider, as well as whether the application requires an industrial design for 24/7 use.

Robots moving around a manufacturing facility also need to contend with challenging light conditions, including dark areas, highly reflective surfaces, and rapid changes in brightness levels. 'As an example, 3D time-of-flight systems are very good for resolving details up to five metres away, but any reflectors even 30m away can distort the data and they are not so good for imaging dark objects that are further away,' continued Sherman. 'Sometimes the customer would like to have everything in one package, but sometimes that just isn't possible.' →

→ Mark Davidson of DreamVu, an early-stage 3D vision company, agreed that no single technology can meet all the requirements for AMRs. 'There's no single sensor solution out there,' he said. 'The challenge is finding the perfect combination and making sure the different systems work together effectively.'

DreamVu's omnidirectional optical sensor looks like an upside-down coffee filter, with a series of curved surfaces that capture light for each point in the field of view at multiple vantage points. Powerful algorithms convert the raw data into two RGB panoramas that offer a 360° view over distances of up to five metres, and from these images traditional stereo depth techniques allow distances to be calculated with an accuracy of one per cent for objects that are one metre away.

'Our technology gives AMR robot designers the largest field of view as well as accurate depth information to create the most complete map of the robot's surroundings,' said Davidson. But he cautioned that the optimal performance is achieved by combining this 3D information with a lidar system that can reliably provide accurate distances over a longer range. 'That way we get the accuracy of lidar as well as the situational awareness of a camera,' he said.

Of course, the cameras and sensors are just the eyes of the AMR. Powerful data processing algorithms are needed for the robot to work out where it is, create a map of its surroundings, and follow a set navigational rules. The ability to make autonomous decisions also requires the addition of machine learning algorithms that enable the robot to evaluate the best course of action.

Here, again, there are compromises to be made. 'We need powerful computer processors to analyse the data and enable the robot to react quickly enough, but we also need to embed them on a mobile platform with limited access to electrical power,' said Adam. 'A bigger battery is needed to power a strong vision system with lots of onboard capabilities, but that places limitations on the size and agility of the robot.'

'For electric vehicles it's very important to be able to move the car body from one location to another'

For sensor manufacturers such as Sick and DreamVu, there is a clear preference among AMR developers for cameras with embedded processors. 'At the software level, customers are always keen to have a plug-and-play device,' said Sherman. 'They don't care about the technology, they just want to know that the robot can navigate in a reliable way. That means we need to provide on-board software to evaluate the visual information and decide which route to take.'

Davidson agreed. 'While the sensor itself becomes more expensive, customers want more of the workflow to be done within the camera,' he said. 'That reduces the workload for the host computer on the AMR, and requires less integration and less synchronisation between the different sensors that are deployed on the robot.'

But a central computing system is likely to be needed to support more advanced AI applications, particularly when fleets of AMRs are moving around a manufacturing facility at the same time. This will require significant computational resources to collect such large amounts of data, analyse them using sophisticated machine learning algorithms, and relay instructions to the robots quickly enough for it to react.

The PAL omnidirectional image sensor from DreamVu has a series of curved surfaces that capture light from all directions at multiple points on the sensor. This is converted into two RGB panoramic images from which distances can be calculated

As well as powerful processing capabilities, such deployments demand a high-bandwidth wireless communications channel for sending and receiving information. 'So far we have had to rely on WiFi, but that has limited bandwidth and supports only limited mobility,' said Adam. '5G technology will be a real game-changer, because it will make it possible to send an order and receive a response much more quickly.' As a result, Omron now has a partnership with Nokia to develop 5G technology specifically for mobile robots. 'We already have a few pilot plants testing this technology, and it looks really promising,' he added.

Omron currently sells around 70 per cent of its AMRs into the automotive sector, although during the pandemic interest has grown in applications such as food and commodities, as well as disinfection. But current deployments remain small in scale, with manufacturers still working out how they can derive most value from an emerging technology that remains relatively expensive.

'We are still in the innovation domain,' said Adam. 'Our customers know they need

Sick

AMR guided by a Sick 3D sensor

mobility in their factories, but they don't yet know how it will work in practice. They need to develop a reference application they can rely on and that will inform future deployments.'

One early implementation in the food industry has been for the production of coffee capsules. At the assembly level boxes are generally packed with the same flavour, but manufacturers can generate extra value by creating mixed collections of capsules. 'An AMR is an ideal solution for these so-called smart-kitting applications, since they can transport capsules from different product lines to the packaging station,' said Adam.

Another application within the automotive sector is the installation of the dashboard, which is an expensive part of inventory that also offers plenty of options for customisation. 'Manufacturers can't afford to have a huge inventory of dashboards, which means they must be produced on demand,' said Adam. 'Mobile robots are the right technology to facilitate that flexibility.'

But this is just the start. In the future AMRs could become just as ubiquitous in industrial environments as the fixed robotic machinery that has driven process innovation over the last 20 years. 'Our customers in the automotive sector are already thinking one step ahead,' noted Adam, who said that one key function for mobile robots will be transporting a car chassis to several different workstations where different options will be installed. 'For electric vehicles in particular it's very important to be able to move the car body from one location to another,' he said. 'They have different electrical connectors that in turn need different parts and pieces of equipment, and manufacturers want to use this extra mobility to install the connector, the engine and the battery, as well the optional extras.'

Once equipped with wheels and its own navigation system, Adam imagines that the cars of the future will be able to travel through the manufacturing facility by themselves – visiting different locations to collect the right finishing touches such as the windows, the dashboard, and the interior carpets and seats. 'The car itself will become part of the process,' he mused. 'It will become a kind of robot.'

Enabling a new wave of automation

Responding to a report on UK adoption of robots and automation, UKIVA's **Neil Sandhu** and **Allan Anderson** argue vision brings similar benefits for productivity

A report entitled *'Robotics and Automation: A New Perspective'* highlights how speeding up adoption of industrial automation and robotics can lead to dramatic improvements in productivity for the UK manufacturing sector.

Published recently by the Manufacturing Technology Centre, based in Coventry, UK, and the Industrial Policy Research Centre, Loughborough University, the report notes that the UK is 24th in the world for robot density in manufacturing businesses, and lags behind in productivity as a result.

As part of its wide-ranging suggestions for initiatives to address a variety of issues, it calls for a specific emphasis on SMEs to adopt automation and robotics technology. It could equally be argued that increasing the adoption of machine vision in the manufacturing sector would also bring significant benefits.

Machine vision faces many similar challenges to those highlighted for robotics in the report. Not only is it an enabling technology that has a clear role to play in complementing the use of robotics, it also has a much wider use in vision-driven automation of manufacturing processes and ultimately in the realisation of Industry 4.0 and the smart factories of the future. The scope of machine vision embraces a huge range of markets, from electronics to food and beverage, to transport, to sports and entertainment.

Guiding robots

The emergence of collaborative robots, or cobots, and rapid developments in 3D image processing in recent years have paved the way for greater use of vision and robotics, either using a robot to present a component for inspection, or using vision to guide the robot or locate an object for the robot to handle. Massive strides in vision-robot interfaces have made this process much easier.

Manufacturing Technology Centre

Robot solutions at the Manufacturing Technology Centre

With continued improvements in camera resolution and advanced image processing, vision-guided robot systems are becoming more sensitive and powerful, enabling robots to recognise shapes, textures and 3D objects faster and more accurately. They bring versatility for pick-and-place, machine tending, assembly, and complex bin-picking. The use of vision enables intelligent, real-time decisions to be made on behalf of an automation system. These advances mean fewer human overrides, vastly improved productivity and fewer product recalls.

While vision can enhance the role of robotics in automation it also has a significant role to play in its own right. This might be inspection for quality control in manufacturing, but also vision measurements can be directly linked into statistical process control methods. By analysing trends in measurements, interventions can be made to adjust the process before any out-of-tolerance product is produced.

In addition, a vision system can capture more information than any other aspect of the production line and generate much larger quantities of data than other sensors. For example, a line scan camera with a 16k sensor operating at 120kHz line rate produces data at 2GB/s. These sorts of data volumes can be processed using the big data analysis techniques that will be embodied in smart factories of the future under the umbrella of Industry 4.0.

Communication between all of the component parts and machines is a critical requirement for Industry 4.0 in order to allow data transfer and sharing. The continuing development of the machine vision companion specification for the platform-independent OPC UA open standard for machine-to-machine communications is providing a gateway for the inclusion of vision in the Industry 4.0 approach. There's also an OPC UA robotics companion specification.

Demystifying vision

Machine vision is established and versatile, with a multitude of building blocks. However, it is this very versatility that fuels the misconception that it is some sort of black art that can only be handled by vision specialists.

Rather like the world of robotics there is a need to develop skills and further educate the various markets to show what is possible using vision. A variety of initiatives are required in order to address this. One small step has been the emergence of out-of-the-box vision solutions designed to meet specific application requirements, such as for label inspection or PCB assembly inspection, or even out-of-the-box 3D vision-guided bin picking solutions.

While efforts to demystify vision technology are important, an additional approach would be to incorporate an understanding of vision capabilities and how to use them as a part of the engineering skill set so that engineers of the future are 'vision aware.'

UKIVA members frequently report that it is difficult to recruit new engineers into the industry with the right mix of vision knowledge and engineering skills despite the fact that there are many computer vision courses offered by UK universities. In an ideal world there would be a formal vision apprenticeship, run by an independent organisation that could provide an alternative route into the industry for those not pursuing a university education. These vision apprentices would emerge from their training equipped with the skills needed to progress into industry.

Finding a way to establish, administer and fund such a scheme dedicated to vision, however, continues to be a major challenge. Some help is available through PPMA Best, an independent charitable trust, funded by the Processing and Packaging Machinery Association.

'The objectives of improving education and widening vision skills require greater investment in basic infrastructure'

PPMA Best seeks to encourage young people to enter and develop a career in engineering in the processing, packaging, robotics, automation and industrial vision supply industries, through education, training and support. Some UKIVA members have used the resources offered by PPMA Best to introduce school students to vision technology as a potential career path, through Science, Technology, Engineering and Maths (STEM) one-day workshops. These STEM days have been held with groups of Year 10 students at a number of schools and have been very well received, with many students expressing an interest in attending follow-up work experience placements.

In addition, a prime objective of UKIVA is to promote the use of machine vision technology throughout industry and education.

Funding the dream

Faced with the realities of Brexit and the post pandemic labour and skills shortages throughout industry, machine vision and automation can offer real-world solutions, but that requires investment. Help from the government is available until 31 March 2023 through the super-deduction scheme (www.gov.uk/guidance/super-deduction), designed to encourage firms to invest in productivity-enhancing plant and machinery assets that will help them grow. This scheme allows companies to cut their tax bill by up to 25p for every £1 they invest. The wider objectives of improving education and widening vision skills require a much greater investment in basic infrastructure.

Neil Sandhu and **Allan Anderson** are the UK Industrial Vision Association's chair and vice chair respectively.

Report calls for support for automation adoption

Speeding up adoption of industrial automation and robotics can lead to dramatic improvements in productivity, according to a new report published by experts at the Coventry-based Manufacturing Technology Centre (MTC) and the Industrial Policy Research Centre, Loughborough University.

Robotics and Automation: A New Perspective says that the slow uptake of robotics among British manufacturers, and a reluctance to invest in automation, has contributed to the country's vanishingly small improvements in productivity in recent years.

The report, with experts from a wide range of fields contributing opinions and recommendations, calls for a renewed emphasis on the need to improve productivity through the use of automation, with manufacturers, research organisations, equipment suppliers and the UK government working together to help businesses improve their performance through the intelligent use of automation. The report also stresses the importance of independent advice to new users, particularly in the SME supply chain.

In the foreword to the report, Dr Clive Hickman, chief executive of the MTC, said: 'While the UK was traditionally a leader in world manufacturing, our productivity has been surpassed by other countries and, if ignored, this gap will continue to grow. It is necessary to address the opportunities available within manufacturing to get back on top form and make advances available for businesses across the UK.'

Mike Wilson, the MTC's chief automation officer, said that the pandemic had exposed weaknesses in the UK's extended supply chains leading to a recognition that there was a need to increase the resilience of UK manufacturing by increasing local content and reshoring production capacity.

He said: 'A significant expansion of manufacturing capability cannot be achieved using the current methodologies, which are largely based on manual labour and obsolete equipment. The Made Smarter Review identified that the application of automation and robotics in UK industry could contribute £183.6 billion over the next decade. The solutions are available and proven. The challenge in the UK is adoption, and also the education of the finance community so they understand and support investment.'

The report calls for more support for UK businesses to help them with adoption at every stage, from identifying opportunities, getting workforce buy-in, selecting suppliers, ensuring they have the right skills, and implementing solutions. It also calls for knowledge-sharing across industry and the automation supply chain in order to develop, demonstrate, test and de-risk affordable and deployable automation, targeting those UK manufacturers who have under-invested in the past.

Better training is also called for, particularly short courses which don't take key people out of the business for long periods of time.

The report also calls for a specific emphasis on SMEs to adopt automation and robotics technology, possibly through an extension to the Made Smarter programme. It also recommends stronger networks, specifically for robots and automation, to encourage more cooperation and communication, to share knowledge and expertise, and to represent the sector to other parties, including the UK government.

The Manufacturing Technology Centre aims to provide a competitive environment to bridge the gap between university-based research and the development of manufacturing solutions. The report can be downloaded here: **www.the-mtc.org/media/bdba0ls0/automation-and-robotics-research-paper-a4-pages.pdf**

Turbocharging cell imaging

From speeding up pathology scanning to event-based sensing, there's plenty of new technology finding its way into life science labs. **Rebecca Pool** reports

Earlier this year, Frost and Sullivan predicted the global digital pathology market will grow from $513 million in 2019 to $826 million by 2025. Largely fuelled by the drive to boost lab efficiencies and an increasing prevalence of cancer, this 8.2 per cent compound annual growth rate lies on the conservative side of other forecasts, which point to double-digit growth rates and market sizes that reach $1.3 billion by 2028.

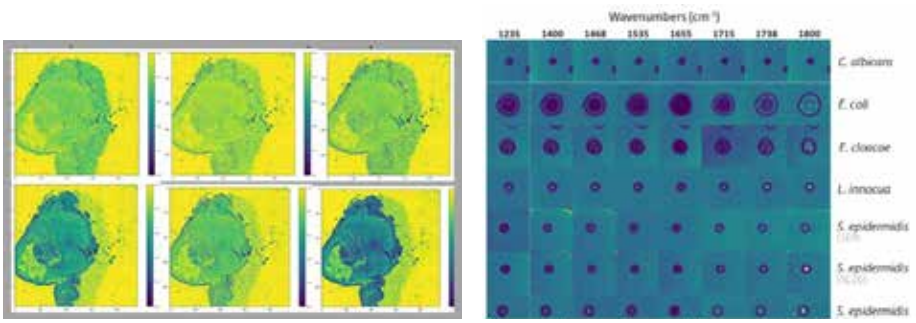
Double-digit growth or not, these figures spell good news for manufacturers of hardware, such as whole slide imagers, as well as associated software and storage systems. At the same time, the burgeoning market is also sparking the development of novel devices set to ease life in the lab. A quick look at recent products supports the rosy outlook.

In August 2020, Leica Biosystems launched its Aperio GT 450 DX digital pathology scanner, which aims to increase throughput, reduce turnaround times and generate high-quality images in primary diagnosis. Less than six months later, Roche delivered two artificial intelligence-based uPath image analysis algorithms that, combined with the company's Ventana DP 200 slide scanner and uPath enterprise software, are set to deliver precision patient diagnosis in breast cancer. Roche also introduced Digital Pathology Open Environment so software developers can integrate image analysis tools for tumour tissue with its enterprise software.

'We've been at the early stages of digital pathology for a while now,' said Mike Rivers, vice president and lifecycle leader, digital pathology, from Roche's Ventana Medical Systems. 'The market has been held back by factors such as IT infrastructure and storage costs, but these [issues] are resolving in the right direction, the technology is maturing and people are really seeing the opportunities.

'Ultimately we want to enable pathologists to take advantage of the digital environment and do things that they can't do manually... This could be synchronising multiple digital images together and allowing them to make annotations on multiple sequential sections of tissue with a single annotation,' he added.

CEA-Leti



Multispectral lensless imaging from CEA-Leti, used to differentiate tumour cells (left) and bacteria (right)

Leica Biosystems

Leica Biosystems' Aperio GT 450 DX is designed for high-volume clinical labs to scale up digital pathology operations

Ensuring that whole slide imaging and software can be integrated into a clinical setting's existing pathology workflow is critical, as is the move towards automated image analysis, to reduce turnaround times. And along the way, artificial intelligence will play a key role.

'Scanners have already improved dramatically in terms of speed and image quality so AI is going to be the next big thing that will push us past the tipping point – we have a good example of image analysis algorithms making a difference in breast pathology,' Rivers said.

Indeed, in October this year, Roche joined forces with pathology AI developers, PathAI and Ibex Medical Analytics, to develop embedded image analysis workflows that can be accessed via the cloud version of its uPath enterprise software, Navify Digital Pathology. Rivers is convinced AI algorithms will particularly assist pathologists in quantifying data.

'In a tumour micro-environment you often want to see multiple biomarkers at the same time... This can become difficult for the human eye to distinguish, but effective use of image analysis and AI to, say, convolute the colours, provide proximity analysis and other measurements of interest, could ultimately be very powerful,' he said.

As part of a digital pathology workflow, AI could also be used to prioritise a pathologist's caseload and allow an algorithm to perform the tedious task of counting cell division, or mitoses. Still, uncertainties exist around AI and the jury is also out on when fully digital workflows will

become mainstream. A few labs are leading the way but widespread adoption is probably several years away. As Rivers said: 'We'll see significant movement in the next five years and, in the labs that are already somewhat automated and are willing to invest, we're going to see a massive transition in the next decade.'

Beyond pathology

But as pathologists around the world get ready for the inevitable digital overhaul, many tech businesses are also developing new imaging-related devices and systems that promise to reduce analysis times in the lab. A case in point is technology consultancy, Cambridge Consultants, which has developed PureSentry, a contamination detection system for cell and gene therapy monitoring that uses an event-based sensor from French firm Prophesee.

As Cambridge Consultants' senior physicist, Josh Gibson, pointed out, he and colleagues wanted to develop a system that would cut the time and costs of arduous sterility testing in this sector. This process firstly demands a ten-day culture period followed by the actual sterility test, which can also take up to another ten days.

Gibson said: 'In the gene therapy market, each dose can cost around $500,000, and nearly one in 1,000 doses fail due to sterility testing, meaning seriously ill patients will not receive treatment. We realised that an automated system could cut the time taken to find failures – giving patients more opportunity to get their treatment – and reduce the labour-intensive steps in the lab.'

By chance, Gibson and colleagues came across Prophesee's Metavision event-based sensor around two years ago. They integrated

Roche

Viewing lung tissue using uPath software from Roche

it into an automated contamination detection system that operates in real-time, which ended up as PureSentry.

Inspired by the human retina, Prophesee's event-based Metavision sensor comprises 300,000 independent and asynchronous pixels that are responsive to low contrast, transient events. These pixels are essentially relative-change detectors, and activate independently according to any change in contrast detected in a scene. When activated, the pixels create a stream of time-stamped events in which their location within the sensor and the direction of the change in brightness - event-on or event-off - are encoded.

'We have software algorithms that mimic the way the brain leverages visual information... Each intelligent pixel is triggered by motion and decides when to activate,' explained Guillaume Butin, marketing director at Prophesee. 'One pixel activating is an event, and we only see what moves.'

'An automated system could cut the time taken to find failures and reduce the labour-intensive steps in the lab'

What makes event-based sensing different is that an output is only generated when the change in contrast exceeds a threshold. In comparison, conventional cameras will sample every pixel at a fixed rate. Such an event-based approach reduces power, latency and data processing requirements compared to frame-based systems, while achieving much higher dynamic ranges. Events can be recorded that would require conventional cameras to operate at 10,000 images per second or more. And critically, this approach makes label-free imaging a reality, even for low contrast targets, such as cells – spelling good news for cell and microbe monitoring.

'When we're flowing our cell culture medium past the microscope, we could be seeing only one bacteria among many millions of human T cells in our millilitre sample,' said Gibson. 'So what we really want to do is cut out all of the background and unnecessary data in a scene, and pick out what is important – event-based sensing is great for this as it only responds to fluctuations in brightness.'

As part of the PureSentry closed-loop system, an inverted microscope equipped with Prophesee's event-based camera captures data on cells as these and associated media are continuously pumped from a bioreactor through a microfluidic cell. Cell data is then sent to post-processing software including an artificial intelligence-event classifier algorithm and decision algorithm to determine if the sample is sterile or contaminated.

'The event-based sensor simply slotted into existing microscope setups – we could easily compare how this worked compared to standard cameras, and while doing this were able to develop our microfluidic rig,' said Gibson.

As the physicist pointed out, thanks to the large dynamic range of the sensor, the PureSentry system can use an LED light source rather than laser light, cutting overall costs and reducing the risk of photodamage to cells. The automation software for the system's hardware was based on Prophesee's Python APIs, while the Cambridge Consultants researchers developed post-processing software using machine learning recurrent neural network algorithms, which, →

‘We are providing widefield clinical imaging that is so much faster than classical staining’

→ as Gibson said, work well in an event-based sensing set-up.

‘We can see the cells flowing past the microscope and are only working with the data that we care about,’ he said. ‘[This means] the machine learning algorithms can more easily recognise if those cells are, say, T cells or something more unusual as we don’t have any other changes in the scene.’

So far, Cambridge Consultants researchers have used PureSentry to distinguish between *E. coli* and T cells in real-time, but the system – with its resolution of around half a micron – could be applied to other contaminants including *Staphylococcus aureus* and *Candida albicans*. ‘We’ve distinguished between *E. coli* and T cells based on size, but we’ve also seen these bacteria rotate and cartwheel as they flow through the system and should be able to distinguish contaminants based on how they move as well as shape,’ said Gibson. ‘We can also monitor the population of different-sized particles over time.’

Gibson is also adamant that PureSentry, with the Prophesee sensor, is set to make a big impact on contamination detection for cell and gene therapy monitoring, as well as other sectors. ‘We could look at yeast cells and contaminants flowing through beer or lactose, and contaminants flowing through milk,’ he said. ‘The prototype is in our lab and we’re looking for a commercial partner to take this forward with us.’

Researchers at France-based CEA-Leti have also developed a novel method that so far targets two key applications. In a similar vein to the PureSentry system, the setup can identify and discriminate between different species of bacteria. However, it can also bring down the time taken to detect cancer in tissue samples from days to minutes.

As scientific director, Dr Laurent Duraffourg, and research engineer, Dr Mathieu Dupoy, noted, for tumour detection, their label-free mid-infrared multispectral method can image a 1cm^2 tissue sample in minutes using four wavelengths. In contrast, the same sample would take several hours to image using FTIR spectroscopy, and around two days using today’s tumour-biopsy staining and immuno-histochemistry labelling procedures, which demand human assessment to confirm disease.

Roche

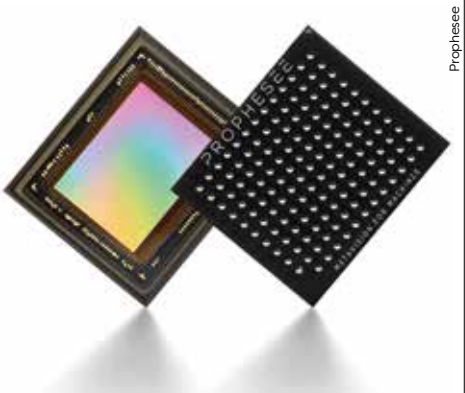
Roche’s Ventana 200 promises reliable, high-speed scanning of histology slides for digital pathology

‘This is a new paradigm for laboratories,’ said Dupoy. ‘We are removing the sample prep and shortening the analysis time – we are providing widefield clinical imaging that is so much faster than classical staining and labelling.’

Their multispectral method comprises an array of mid-infrared quantum cascade lasers, in the 5µm to 11µm wavelength range, and lensless imaging, with an uncooled bolometer matrix, comprising an array of heat-detecting sensors that are sensitive to infrared radiation wavelengths. The setup delivers biochemical mapping over a 2.73 by 2.73mm^2-wide field of view in a 20ms measurement time per wavelength.

The laser beams are directed at the tissue, with the infrared radiation transmitted from the tissue then detected by the bolometer matrix. As the infrared radiation is absorbed by a bolometer element, that element increases in temperature, changing its electrical resistance – this change is measured and processed into temperature values that are used to create a mid-infrared absorption image. Such images correspond to the vibrations of targeted chemical bonds, giving a biochemical fingerprint.

According to Dupoy, many of these images can then be combined to create a false-colour image, ready for classification and cancer detection. ‘From these images, you can see if the tissue is healthy or not and you can also get information on the spread of the cancer, if that tissue is cancerous,’ he said.



Prophesee

Prophesee’s Metavision event-based sensor

Perhaps not surprisingly, the experimental setup is coupled with machine learning algorithms to assist biological cell or bacteria classification in a fast and reproducible way. Indeed, the CEA-Leti researchers have developed machine learning algorithms to work with head and neck cancers, breast cancer, as well as microbial detection. And in recent tumour analyses on mouse tissue, which used 6µm and 10µm infrared wavelengths that are absorbed by endogenous markers (proteins and DNA), the method detected 94 per cent of cancer cells. Likewise, trials on 1,050 colonies of different *Staphylococcus* strains correctly identified 93 to 96 per cent of the species.

Given the results so far, both Dupoy and Duraffourg are convinced their method, in time, will be used in the digital pathology workflows of tomorrow. Neither CEA-Leti researcher knows of a lab that routinely uses infrared-based imaging in cancer tissue assessment, and are about to complete the development of a portable multispectral lensless imaging setup that can be easily transported to hospitals. Duraffourg is also heading up the launch of a start-up to commercialise the technology.

‘For now, tissues are analysed in our laboratory, but before translating this into a commercial product, we are building a robust, portable demonstrator that we will take to several hospital labs across Europe that we are partnering with,’ said Duraffourg.

Perhaps predictably, the researchers say widespread use of their technology in clinical settings is several years away. Still, their thoughts on industry demand surely echo those across so many life science sectors. As Duraffourg put it: ‘If you talk to clinicians that are also researchers, they really want to have new methods as they are good for science.’

How healthy is our woodland?

Greg Blackman speaks to **Dr Michelle Hamilton** at STFC RAL Space about mapping trees with spectral imaging

Four years ago, researchers from Fera Science and the Science and Technology Facilities Council's RAL Space flew a drone equipped with hyperspectral cameras over Big Wood in Suffolk. Now, the two groups, along with Newcastle University's School of Natural and Environmental Sciences, have received funding to fly the same wood again to see how things have changed.

The aim of the work is ultimately to model woodland carbon storage by identifying where trees are healthy and taking up carbon, and where they are unhealthy and could potentially die back and stop retaining carbon, because of pests, disease or climate change.

Part of this involves determining vegetation indices based on spectral signatures from plants. Dr Michelle Hamilton, a researcher at STFC RAL Space responsible for building the hyperspectral camera system for the project, explained that these indices can be used to differentiate between species of tree, as well as say something about the health of a tree – whether it's stressed or diseased, for instance.

She said there are indices that are regularly used and that can be calculated by imaging in certain wavelength bands, but that the team is using a hyperspectral camera to investigate other indices.

'Maybe you wouldn't want to fly a hyperspectral system all the time, but you could use that to work out which wavelengths... are important for identifying disease or stress or different species,' she told *Imaging and Machine Vision Europe*. 'Then make a simpler system that could be more easily deployed.'

Dr Michelle Hamilton

The hyperspectral drone camera was built by researchers at STFC RAL Space

Gary Battell

Paul Brown of Fera Science operating the hyperspectral drone camera at Big Wood, Suffolk

The hyperspectral system Hamilton and her team has developed uses two Ximea cameras covering 41 spectral bands in total: a visible camera with 16 bands, and one that images over 25 wavelength bands out to 910nm. These are snapshot cameras, taking images over an area, rather than the more traditional push-broom scanners. Snapshot imagers have fewer wavelength bands, but are less expensive, easier to calibrate, and don't need a controlled flight path.

Hamilton stressed the importance of calibration to get accurate results from the cameras. Measurements are made with calibration targets along with a downwelling light sensor, with which the team can correct for changes in light levels – if the sun goes behind a cloud, for instance.

It means images can be compared, from those taken minutes apart to images taken years ago. 'The calibration process is hugely important to get reliable data,' she said.

Measurements are currently taken with a spectrometer on the ground, but part of the project is to attach a downwelling sensor to the drone.

Hamilton said she'd like to image further into the infrared because there are a lot more chemical signatures in the shortwave infrared, but that cameras are more expensive.

> 'The idea is to see what's changed, in the ground coverage or the health of the trees'

'We want to see changes over time,' she explained. 'We flew these woodlands four years ago, so we can produce the 3D plots and a map of that woodland then. The idea is to come back and see what's changed, in the ground coverage or the health of the trees. That feeds back into the [UK's] net zero models.

'Carbon sinks and carbon sequestration models are really important at present, [as is] making sure these [models] have accurate data,' she added. 'We know we've got these trees over the UK and there's been an estimate of what they do. But if those trees and the woodlands are not well or not growing, then it does have an effect on carbon sequestration.'

Modelling how much carbon is stored in woodland isn't an easy task, Hamilton said. She also noted that picking up on the early signs that a tree is sick is really important to get a good picture of the health of a woodland.

Association news

Keeping European machine vision competitive

VDMA Machine Vision

As its new chairman, **Mark Williamson** sets out the priorities for VDMA Machine Vision

In October, the newly elected board met to identify the needs and challenges ahead for the European machine vision industry, and set the goals and activities for VDMA Machine Vision.

The board members are all aware that the machine vision industry is in a state of transition. In recent years, we have all seen many changes including company consolidations along with significant technological developments. New players have emerged, including start-ups, international corporations, and internet giants. The board itself reflects this, having representatives from start-up, multinational and consolidated companies, from component manufacturers and system integrators, all working together.

Vision is seen as a key technology in the trend towards digitalisation, both in and outside the factory, creating a lot of interest and offering many opportunities. Between 2013 and 2019, turnover in Germany alone grew by an average of 9 per cent per year. In 2020, while turnover declined by 4 per cent because of the pandemic, the decline was nowhere near as drastic as in many other industries, with good prospects for future growth. While the European machine vision industry is in an excellent position, it is important to strengthen this standing, to open up further growth markets in industrial and non-industrial environments, and to include new players.

Marketing and communication

The VDMA, with its 3,300 member companies in the mechanical and engineering sector, is well positioned for promoting machine vision within the industrial field, and for opening up new business opportunities. In Europe, VDMA Machine Vision is the conceptual sponsor of the Vision and Automatica trade shows. It also has activities at the Embedded World show to raise awareness among the embedded computing community of the expertise in the machine vision sector.

Meanwhile, through the VDMA's foreign department – with offices in China, India, Russia and Brazil – the association offers members advice, local support and networking opportunities, such as the VDMA Machine Vision pavilion at the Vision China Shanghai show, and the VDMA Robotomation symposium in India.

Technology and standardisation

Another focus of activity for the VDMA Machine Vision board will continue to be technology and standardisation. There is a lot of innovation, with new trends, technological developments and new players both inside our domain and across the wider industry having an impact on our members' future. For instance, how do developments such as data-driven business models impact the machine vision industry?

Luckily, the VDMA, with its 36 trade associations, offers a huge network and services to support the machine vision industry. It's the VDMA Machine Vision board's goal to make the membership aware of the challenges ahead, and to offer a platform to work on tackling them.

In standardisation, major efforts will continue in further developing the VDMA OPC Machine Vision initiative. The goal is to make machine vision fit for Industry 4.0 by defining standardised interfaces for machine vision systems to operate and be easily integrated into the wider factory.

With the VDI/VDE/VDMA 2632 series

'The board members are all aware that the machine vision industry is in a state of transition'

Plan projects early to accommodate delays

UKIVA UK Industrial Vision Association

By Neil Sandhu, UKIVA chairman

The lifting of most pandemic-related restrictions in the UK by July of 2021 heralded the opportunity for the UK vision industry to really kick on in earnest in rebuilding from the effects of lockdowns. So far this has been rather a rollercoaster ride, with the pent-up demand from industry to press ahead with vision projects tempered by supply chain issues that have significantly extended the lead times to fulfil orders. The increased demand for vision solutions across an enormous number of industries to address labour and skills shortages and changes in working practices resulting from both Brexit and the pandemic is very real. Many UKIVA members have reported significantly increased order books in recent months.

However, with some 90 per cent of vision components being imported from all over the world, the UK is very much reliant on the global supply situation. The extended lead times has led to frustrations for customers and vision system suppliers alike, but members report that the situation can be patchy, with noticeable variations in lead times depending on the components required.

UKIVA is an excellent resource for UK businesses wanting to implement new or upgrade existing machine vision installations. UKIVA members (who are listed at https://www.ppma.co.uk/ukiva/ukiva-members.html) include vision technology providers, vision system integrators and consultants, and providers of solutions that use machine vision. Between them, they not only have access to and use most of the global vision components available, but also provide the expertise needed to be able to offer solutions designed to minimise lead times. With many manufacturers predicting that the disruptions to supply chains will continue for a significant period of time, it is even more essential to begin the planning process for vision projects at the earliest

of guidelines, VDMA Machine Vision also supports the industry by providing a communication framework between vendors and users of machine vision systems, ensuring each project is well specified and delivered with a common understanding.

The group also continues to work toward worldwide acceptance of machine vision standards through the international G3 framework.

Market intelligence

Finally, VDMA Machine Vision will continue with its annual market survey. Sales by products, regions, and customer industries, as well as growth forecasts and trends are monitored. In addition, approximately 1,300 VDMA member companies participate in a monthly VDMA order intake and sales statistics for more than 40 VDMA groups – many of them customers of the machine vision sector. For machine vision, the data is separated into components and systems, and is ideal for benchmarking members' own company data, monitoring regional developments, and observing the trends in customer industries.

Together with the VDMA Robotics and Automation association, studies on important trends, such as battery production and a China competitiveness report, are undertaken. Thanks to the VDMA's good relationship with the China Machine Vision Union (CMVU), the VDMA Machine Vision membership receives an English translation of the Chinese machine vision market report.

The VDMA Machine Vision board's overarching goal in all that we do is to increase the competitiveness of the European machine vision sector, and ensure Europe maintains its technological lead.

VDMA Machine Vision

The board of VDMA Machine Vision; Mark Williamson third from left

Mark Williamson is managing director of Stemmer Imaging Ltd in the UK, and a member of Stemmer Imaging AG's senior leadership team. He was elected chairman of the board of VDMA Machine Vision at the end of September. Alongside Williamson, the board consists of: **Heiko Frohn**, Vitronic; **Martin Klenke**, Teledyne Imaging; **Hardy Mehl**, Basler; **Donato Montanari**, Deevio; **Olaf Munkel**, MVTec Software; and **Uwe Wiedermann**, Isra Vision.

possible opportunity to help accommodate these delays.

Another unwelcome consequence of manufacturing and transportation challenges for vision components is increased costs throughout the supply chain, which inevitably leads to increased prices for the consumer. This is somewhat of an unwanted adjustment in an industry that for many years has seen technology developments and economies of scale in manufacturing help drive down costs. While such price increases cannot be avoided, for the UK vision industry the impact may be somewhat mitigated since a significant proportion of UK vision revenue comes from vision solutions and integration projects. Here, the vision components can be a comparatively small proportion of the total project cost, and so increases in component prices will have less impact. Suppliers providing added value to the vision components, right up to full integrators, have much greater control of their own pricing structures, subject of course to any other inflationary pressures.

While the supply chain issues are slowing down the current roll-out of vision projects, the vision industry doesn't stand still. Even through the height of the pandemic new products continued to be brought to market, which was amply illustrated at Vision in Stuttgart. New image sensors with exciting capabilities have been developed; new illumination sources have emerged, AI capabilities have improved, image processing toolkits have been enhanced – the list goes on and on. UKIVA continues to be fully committed to informing and educating the UK industry as a whole as to the many benefits that machine vision can bring in order to facilitate even greater growth as supply chain bottlenecks diminish. The Machine Vision Conference and Exhibition, to be held at the Marshall Arena, Milton Keynes on 28 April 2022 (www.machinevisionconference.co.uk), will act as a focal point for the latest vision trends and technologies and their uses in real-life applications, as well as offering the opportunity to see a wide range of the latest vision products.

Brussels to host EMVA business conference

cge2010/Shutterstock.com

By Thomas Lübkemeier

The EMVA quarterly machine vision sales report shows a strong third quarter for this year compared to 2020. Sales grew by 16 per cent compared to the same quarter last year and by 2 per cent compared to the previous quarter. However, the sales outlook from suppliers representing the industry has weakened throughout the year. While in the first quarter of this year a big majority voted for future growth, the sentiment scores have become more diverse in the third quarter, with a tendency towards flat sales expectations.

Spotlight series

The second event in the EMVA Spotlight series took place in the middle of November, with market research expert Yole Développement giving insights on the market development prospects of machine vision over the next five years. The event highlighted both technology trends as well as the main drivers of customer industries and applications.

On 9 December the last event in the series for this year took place featuring Continental, with a focus on 'challenges and solutions for automotive end-of-line optical inspection'. Keynote speaker Nuria Garrido López spoke about choosing the right instrument from the toolkit of algorithm-based vision, robot vision and AI. The Spotlight series will continue in 2022, with the next topic to be announced soon. Further information and registration can be found at: www.spotlight-series-emva.org.

Business conference changes venue

The EMVA has changed the location of next year's EMVA business conference to Brussels in Belgium – the decision was made because of the low vaccination rate in the previous destination of Sofia, Bulgaria. Early Bird registration for the conference with reduced conference fees is available for a limited time on the EMVA website.

Meanwhile, the EMVA is inviting submissions for its Young Professional award, the winner of which will be announced at the conference.

The award honours the outstanding and innovative work of a student or a young professional in the field of machine vision or image processing. The work should apply the latest research and findings in computer vision to the practical needs of the machine vision industry. Applicants have until 31 March to submit an entry. For more details, see: www.emva.org/ypa2022.

On behalf of the entire EMVA team and the board of directors, I send readers of *Imaging and Machine Vision Europe* seasons' greetings and wish you all a good start to the New Year where we will hopefully meet in person at the EMVA business conference in Brussels.

Focus on lenses

Sponsored by Kowa

A look at the current market for lens technology and some of the latest products available

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Lenses are an essential component of any imaging system in order to focus the image of the examined object onto the camera sensor. They can be used to remove parallax or perspective error, or provide adjustable magnifications, field of views, or focal lengths.

Lenses continue to evolve in order to be able to accommodate the changing needs of imaging systems for a variety of applications and use cases, with consumer electronics driving demand for video capture. Other important markets include automotive, medical, security and manufacturing, with sensors being developed in different sizes and designs.

'Consumer electronics is driving demand for video capture'

This demand is driving growth in the lens market, according to the latest figures from market intelligence and advisory firm, Mordor Intelligence, which cited the value of the global camera lens market at $4.28bn in 2020. This is expected to reach $6.19bn by 2026, registering a compound annual growth rate of 6.5 per cent during the forecast period (2021 to 2026).

The report, *Camera Lens Market - Growth, Trends, Covid-19 Impact, And Forecasts (2021 - 2026)*, highlighted that technological improvements such as image stabilisation, faster processors for digital cameras, and an increase in storage device capacity and speed, have provided a push for the market to evolve.

Driving demand

Smartphones currently comprise a significant share of this market, which is expected to continue. This is because of the smartphone's evolution to become a device similar to a dual primary camera setup. Some manufacturers have even integrated triple, quad or more cameras →

agsandrew/Shutterstock.com

→ within a single device. These developments, said Mordor, have impacted the demand for lenses in the smartphone market. In addition, slow but steady developments in security applications, such as face recognition, are also generating demand for high-performance camera lenses in the smartphone sector.

However, the report also highlighted that demand in the interchangeable and changeable camera market is likely to experience slower growth, largely thanks to the aforementioned improvement in the smartphone camera market. This, in-turn, could have an impact on the camera lens market, with the demand expected to remain relatively static at around 10 million in interchangeable and 11 million in non-interchangeable camera lenses.

Commercial products

Vendors that offer lens technology include camera manufacturer **Basler,** which has its own range of standard and premium lenses. The standard product line is designed for fast cameras with a lower resolution. It has a good price/performance ratio, with lenses priced to correspond to the requirements of many cost-sensitive applications. The premium product line is available for more demanding applications, and the lenses offer high resolution, low distortion and low vignetting.

IDS is another example of a camera manufacturer offering its own lens line. The company's C-mount lens series provides resolutions of 5, 8 and 10 megapixels, as well as focal lengths of 4 to 75mm and different optical classes. The lenses cover sensor sizes

from ½-inch to 1.1-inch. The aperture and focus can be fixed mechanically if required, which ensures brightness and image quality remain constant, even if the lens is exposed to vibration.

Available from **Edmund Optics** is a range of imaging lenses for a variety of imaging needs, including telecentric lenses, liquid lenses, those with fixed focal length, zoom lenses, and shortwave infrared imaging lenses. A selection of imaging lens accessories is also available, including filters, and mounts or adapters for additional functionality.

Fujifilm offers a wide range of prime, zoom and telephoto lenses. Its most recent launch is the Fujinon GF35-70mm interchangeable lens for large-format cameras. Designed as a compact and lightweight zoom lens, it weighs around 390g, with a focal length range covering from 35mm to 70mm. The company expects the portable form factor to help broaden the scope of applications for GFX camera systems, equipped with a large format sensor.

Optotune's focus-tunable liquid lenses are designed to provide a versatile, compact and cost-effective solution to the challenge of keeping products in focus under the camera or quickly scanning various objects at different distances. Thanks to the absence of translational mechanics, these lenses can focus within a few milliseconds, ensuring robustness and reliability with a lifetime of billions of cycles for use in applications such as quality control, packet sorting, box filling, palletising, barcode reading, robot vision and 3D image stacking.

Resolve Optics offers compact fixed and zoom lenses for vision applications including parts recognition, precise component placement, automated alignment and placement, and automated inspection of manufactured components. The company recently reported how its custom designed high-contrast shortwave infrared lenses have been used for agricultural sorting applications by optimising both the resolution and imaging contrast achievable with the product.

Schneider-Kreuznach's latest addition to the range of Zirconia lenses is the Zirconia 3.3/90. Designed for line sensors, it has a common magnification 0.1x. The main fields of application are flat panel display and PCB inspection. It has a uniform imaging performance over the whole field of view and, like other products in the Zirconia series, it comes with a V48 mount.

Sill Optics provides a range of telecentric lenses for machine vision applications. The company offers products that include lenses with coaxial light coupling to entocentric macro and wide-angle lenses, and telecentric illumination. Its most recent additions are the S5VPJ0303 and S5VPJ0305 telephoto lenses, including a tunable liquid lens. They offer high-speed adjustment of focal length to compensate for working distance deviation.

Thorlabs offers a wide variety of C-mount camera lenses for machine vision, including standard fixed lenses, zoom lenses, high-magnification zoom lenses for macro applications, modular zoom lens components, and telecentric lenses. These lenses are compatible with all of the company's CCD and CMOS cameras. Thermal imaging lenses are available to focus infrared light without introducing spherical aberration, and the company can provide objective, scan, and tube lenses for use in constructing optical systems for machine vision applications.

Among its most recent developments in lenses, **Tamron** expanded its range of fixed focal length lenses for the machine vision market with the MA23 and MA111-VIR series. The MA23 series targets industrial inspection requirements with its small size and image quality optimised for shorter distances. The MA111-VIR series is optimised for larger sensor sizes and resolutions, with 1.1-inch sensor format and up to 24-megapixel resolution, addressing a large field of industrial and non-industrial high-resolution applications.

Products

More products now online at
www.imveurope.com/products

Cameras

SWIR imaging package

To optimise the performance of shortwave infrared imaging, Chromasens has introduced a package that includes its AllPixa SWIR line scan camera and the Corona II dark field illumination system with shortwave infrared LEDs.

The Corona II module offers a selection of LEDs at wavelengths of 1,100nm, 1,350nm, 1,450nm or 1,550nm. This module emits far less heat than halogen light sources often used with SWIR cameras.

The Corona II illumination system complements the recently introduced AllPixa SWIR line scan camera. Available with either GigE Vision or Camera Link interfaces, the camera uses an uncooled InGaAs sensor with 1k resolution and 12.5µm pixel size. It has a line rate of 40kHz. The camera has a C-mount lens interface and an FPGA that can be customised for pre-processing.
www.chromasens.com

SmartRunner Explorer 3D

The new SmartRunner Explorer 3D product family from Pepperl+Fuchs comes in two versions: stereovision and time-of-flight models. These are based on the same platform with the same housing, and standard user software and data output. The cameras are designed to keep integration costs down.

The stereovision version has two high-resolution cameras that produce a 3D point cloud. The time-of-flight version has VGA resolution and a measuring rate of 30Hz. Time-of-flight is suitable for applications with a larger measuring range, where short reaction times are required. The data can be used for applications such as controlling autonomous vehicles.
www.pepperl-fuchs.com

3D sensor for glass

SmartRay has launched a 3D sensor for glass inspection. The Ecco 95.025G sensor incorporates advanced reflection filtering algorithms to improve repeatability and accuracy when laser scanning transparent and highly reflective surfaces.

This sensor joins the Ecco 95.015G in the Ecco 95+ glass series; both are designed specifically to measure flat glass and specular surfaces. They use an optimised lens and optics, together with SmartRay's SmartX software optimisation tools.

The Ecco 95.025G provides a 28.5mm field of view to inspect larger parts or to reduce the number of scans. Its blue laser delivers a typical lateral resolution of between 13µm and 14.5µm, and a vertical resolution of between 1.4µm and 1.9µm. It can create a 3D profile with up to 1,920 points.
www.smartray.com/3d-sensors/

MvBlueCougar-XT cameras

The MvBlueCougar-XT camera range from Matrix Vision has been extended with new Sony Pregius S fourth generation CMOS sensors: IMX535 (12.4MP), IMX536 (8.1MP) and IMX537 (5.1MP).

The backside illuminated architecture of the Pregius S sensors mean they provide excellent image quality with a pixel size of 2.74µm.

The MvBlueCougar-XT camera range has a 10GigE interface and IP67 casing for industrial environments. Thanks to the high net data rate of 1,245MB/s, frame rates of up to 50.5fps can be achieved with a resolution of 24.6 megapixels.
www.matrix-vision.de

Phoenix GigE models

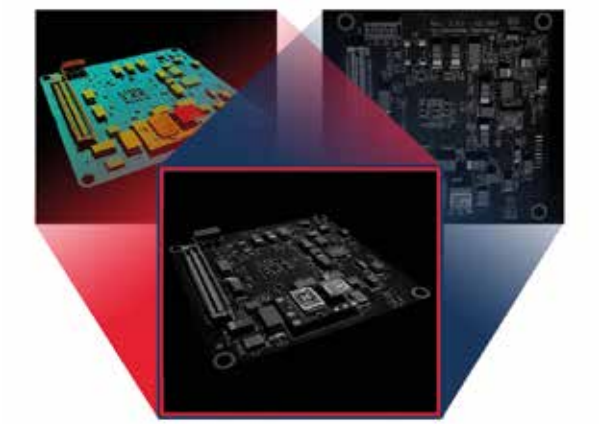
Lucid Vision Labs has begun production of its 5.0-, 8.1-, and 12.3-megapixel Phoenix GigE Vision cameras.

The three models are based on Sony Pregius S IMX568 (5MP, 22fps), IMX566 (8.1MP, 13.8fps) and IMX565 (12.3MP, 9fps) global shutter CMOS sensors.

The Phoenix GigE PoE camera module has a form factor of either 24 x 24mm or 28 x 28mm, and is designed for easy OEM integration. It has multiple lens mounts, body orientations, and Ethernet interface options.

All Lucid cameras conform to the GigE Vision 2.0 and GenICam3 standards, and are supported by Lucid's own Arena software development kit.
https://thinklucid.com

Cameras



C6 series

Automation Technology has equipped its C6 series of 3D sensors with new processing features. The MultiPart tool allows up to ten different features to be output simultaneously, regardless of pixel format or algorithm.

MultiPart gives data such as reflectance, scatter or confidence, in addition to information about different peaks (MultiPeak), which is often indispensable for suppressing secondary reflections from the laser line. This not only makes it possible to generate a photorealistic representation of the inspection object instead of a simple point cloud, it also makes it easy to implement 2D inspection tasks such as character recognition or inspection of QR codes.

The C6 series operates in accordance with the latest GenICam 3D standard and is designed to be plug-and-play. The benefits of the cameras are especially useful when inspecting electronic components.

www.automationtechnology.de

Vision Cam AI.go

Imago Technologies and Oròbix, both members of the Antares Vision Group, have collaborated on Vision Cam AI.go.

The embedded AI camera has features for easy implementation of image processing solutions based on deep learning. The device is designed to classify objects into two to five classes. No GPUs are needed, nor is sensitive data outsourced to the cloud.

If the task becomes more complex – if image classes are not easily distinguishable, or more image classes are needed – Oròbix offers engineering services.

www.imago-technologies.com

Falcon4-CLHS M4480

Teledyne Dalsa has begun full production of its Falcon4-CLHS M4480 camera, based on the Teledyne e2v Lince 11.2M monochrome sensor.

The camera has a CLHS interface that has been engineered for industrial imaging requiring high-speed data transfer. This latest model can reach a frame rate of up to 609fps in full 11.2-megapixel resolution, and multiple thousands of frames per second in partial scan mode. When using the sensor's

binning mode, it can reach a very large pixel full well capacity of 160Ke. The Falcon4-CLHS uses CX4 and fibre optic cables.

www.teledynedalsa.com/imaging

Illumination

Polarisers and diffusers for ring light

AutoVimation now offers polarisation filters and diffusers for its Meganova ring light for installation in Orca, Shark and Megalodon protective camera enclosures. The Meganova ring light with eight high-power LEDs, placed directly behind the enclosure front window, eliminates the need for external lighting.

The ring light design is matched to the enclosures for efficient heat dissipation. This allows for continuous operation at 200 per cent power and brightness under normal conditions.

Two linear, crossed polarisation filters eliminate light reflections into the camera lens. The solution consists of a polarisation ring placed over the ring of LEDs and a polarisation disc for the central lens aperture, which eliminates the need for a polariser on the lens. The ring and disc are simply attached to the lighting tube; then,

the outer ring, which polarises the LED light, is twisted against the inner disk until their polarisation directions are offset by 90°.

The Meganova diffusion rings for homogenising light distribution in the camera image are mounted in a similar way to the polarisation ring. They are available in two versions with strong and weak diffusion at light transmission coefficients of 45 per cent and 80 per cent respectively.

www.autovimation.com

Cobra HyperSpec SWIR line light

New from ProPhotonix is the Cobra HyperSpec shortwave infrared line light. This tunable line light is customisable and can be configured to a range of applications including textile recycling and quality control in the food industry.

Users can optimise the spectrum to maximise contrast, compensate for camera sensitivity, and deliver clearer, higher resolution images. Discrete control of each wavelength allows users to select the optimum wavelength balancing and relative intensities specific to the application needs.

For high-speed image acquisition, the platform's strobe capability can be configured to pulse all four strobe lines either simultaneously or sequentially with a combined delay and response time of less than 1µs. In addition, Cobra HyperSpec offers adjustable optics allowing users to select the optimum lens position for the application.

The line light is modular and is available in lengths up to 6 metres.

www.prophotonix.com

Wash-down spot light

Advanced Illumination has added a spot light to its UltraSeal Washdown lighting family. The SL316 light offers general purpose, high-intensity illumination.

Featuring an IP69K certification and crevice-free design, the UltraSeal spot light is ideal for hygienic inspection environments, aseptic manufacturing, and food and beverage applications.

The SL316 provides an intensity of 150klx at a 300mm working distance in continuous operation. It is available with narrow, medium, and wide lensing options, as well as a non-lensed configuration for high dispersion. The light is configurable in eleven wavelength options.

The spot light is built with an FDA-compliant nickel finish, making it resistant to corrosion. It is compatible with all Advanced Illumination inline and discrete control systems, and can be operated in continuous, gated continuous, pulsed, and adaptive pulsed modes, with dimming options for brightness control.

www.advancedillumination.com

Suppliers

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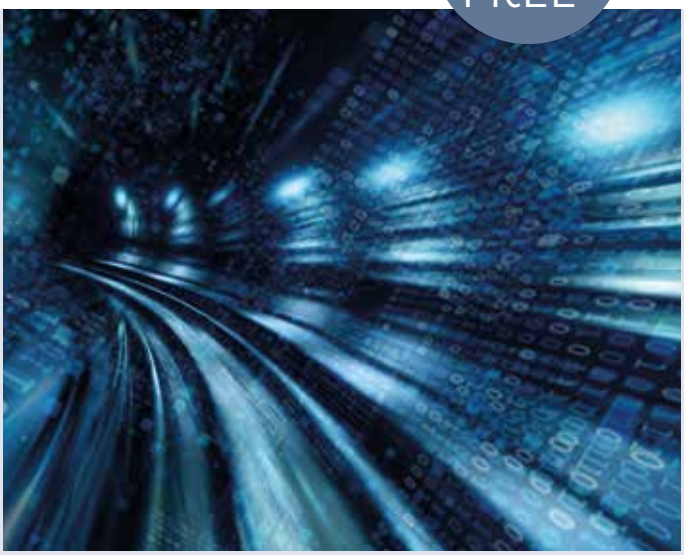
High-speed vision

Join us for a rapid tour through some of the fastest imaging equipment and technology out there, whether that's image sensors, cameras, or data transmission. Our speakers for this webinar were from Euresys, Optronis, Scorpion Vision and GPixel



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Speakers

Patrick Summ
Managing Director working for Optronis since 1989

What are the specific benefits of using the CoaXPress interface for high-speed vision applications? The presentation will highlight the pros (and cons) of using CoaXPress for high-speed cameras compared to other interfaces on the market

Marc Damaut
CEO of Euresys

CoaXPress-over-Fiber - a light yet significant extension of the existing CoaXPress specification to support transport over fiber optics.

Win Wuyts
chief commercial officer, Gpixel

This presentation will cover the latest (r)evolutions in high speed imaging with a strong focus on latest product and technology advance for industrial inspection applications achieving stunning 20 Gpix/s and 192 Gbps image data through put with low noise read out. Future outlook is provided too on novel technology concept of next generation products aiming to achieve 40 Gpix/s and 400 Gbps.

Jack Versey
Sales Applications Engineer

Presenting the benefits of the high speed camera that Scorpion has recently added to its product range

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