Vision Yearbook 2022/2023

Business and technology trends for the year ahead

Coping with the chip shortage

Critical advice to help start-ups deliver

Shortwave infrared sensing heats up

Stories from the cutting edge of AI

Vision comes of age

New strategies for success in a maturing market

From the publishers of IMAGING & MACHINE VISION EUROPE

Agile and powerful

Matrox Design Assistant® X is a flowchart-based integrated development environment that takes the gymnastics out of vision application development. This powerfully agile software removes the need for coding and is equally well-suited for simple application development or solving complex vision projects. The same environment also enables communication with various automation equipment and enterprise systems as well as the creation of a web-based operator interface.

Field-proven Matrox Design Assistant X software is a perfect match for PCs and smart cameras. Get a leg up on development with an environment that delivers image analysis using deep learning, and provides traditional vision tools to inspect, locate, measure, and read in images and 3D scans.

Matrox Design Assistant X: Powerfully agile flowchart-based vision application development

www.matrox.com/imaging/design_assistant/imve

MATROX IMAGING

Vision
Yearbook 2022/2023

Editorial and administrative team
Editor Greg Blackman
Tel: +44 (0)1223 221042
greg.blackman@europascience.com
Head of content: Mark Elliott
Tel: +44 (0)7803 565092
mark.elliott@europascience.com
Technical writer Matthew Dale
Tel: +44 (0)1223 221047
matthew.dale@europascience.com
Senior designer Justin Zwierzanski
Tel: +44 (0)1223 221035
justin.zwierzanski@europascience.com
Head of Marketing: Vicky Stokes
Tel: +44 (0)1223 221033
vicky.stokes@europascience.com

Advertising team
Advertising sales manager Eleanor Waters
Tel: +44 (0)1223 221031
eleanor.waters@europascience.com
Art/production manager David Houghton
Tel: +44 (0)1223 221034
david.houghton@europascience.com

Corporate team
Managing director Warren Clark
warren.clark@europascience.com

Subscriptions:
Free registrations available to qualifying individuals. Subscriptions £180 a year for six issues to readers outside registration requirements. Orders to *Imaging and Machine Vision Europe*, 4 Signet Court, Cambridge, CB5 8LA, UK.
Tel: +44 (0)1223 221030.
Fax: +44 (0)1223 213385.

Imaging and Machine Vision Europe
is published by Europa Science Ltd,
4 Signet Court, Cambridge, CB5 8LA, UK.
Tel: +44 (0)1223 221030
Fax: +44 (0)1223 213385
Web: www.europascience.com
ISSN: 1745-5758

Cover: PureSolution/Shutterstock.com

EUROPA SCIENCE

FSC www.fsc.org MIX Paper from responsible sources FSC® C004953

Leader
Greg Blackman

When the chips are down

The chip shortage has been a thorn in machine vision's side for more than a year now, and the disruption it causes looks set to continue into 2023. Benjamin Skuse, in his article on page 14, assesses the crisis, asks how it is affecting vision firms, and finds out what strategies are being used to cope with it.

Supply chain issues are hampering growth in the vision industry, but, on the positive side, there's strong demand for automation and order books are full. The vision market is changing rapidly compared to 10 or 20 years ago, thanks to an influx of new technology and interest from larger companies outside of the traditional industrial vision space. Holly Cave examines the vision landscape in her article on page 8, and asks what it takes to thrive in this changing world. We also speak to Donato Montanari at Zebra Technologies on page 12, one of the newer vision providers, about why Zebra has chosen now to enter the vision market.

Two of the technology trends that have been making waves this year – and will continue to do so moving into 2023 – are machine learning and shortwave infrared imaging, both of which are covered in this issue. There are also articles on what it takes to be a successful vision start-up (page 22), and a new policy to protect IP in vision standards development implemented by the European Machine Vision Association (page 36).

The pace of change in the vision industry is accelerating bringing opportunities and challenges. Whatever happens, it will make for an exciting year ahead.

@imveurope

www.linkedin.com/showcase/imaging-and-machine-vision-europe

Supplier roadmaps focus on AI and SWIR

What new technology can vision users and integrators expect over the coming year? We round up some of the highlights

The vision industry has full order books. According to a VDMA market survey, sales in the European machine vision industry increased by 17 per cent in 2021. But supply chain disruptions are putting the brakes on growth, as camera makers struggle to procure semiconductor components in particular. Despite this, the VDMA is predicting the German machine vision industry will grow by 5 per cent and see sales of €3.2bn in 2022.

Need for speed

Speed of cameras continues to increase as sensors and processors get faster. A number of camera vendors are releasing models equipped with the GigE Vision 5GBase-T interface, an extension to GigE Vision with 5Gb/s data transfer speed.

Later in 2022, JAI will expand its Go-X series of cameras, featuring Sony Pregius S sensors, with an additional 12 models with the 5GBase-T interface. The additions will bring the Go-X family to 60 models, with resolutions ranging from 2.3 to 24.5 megapixels. All the new models feature 2.74µm backside illuminated pixels in compact sensor sizes and with small optical image circles, making all the camera models compatible with lower cost C-mount lenses.

Active Silicon has seen demand increase for its high-performance frame grabbers for industrial automation projects. The company's FireBird frame grabbers are designed to deliver fast image acquisition over Camera Link and Coaxpress interfaces, and can be integrated easily into new or legacy systems.

Active Silicon's 4xCXP-12 boards support up to 12.5Gb/s data rates on each link, enabling up to 50Gb/s in total, along with device power of up to 13W and device control of up to 42Mb/s, all on a single coax cable.

Camera Link options are GenICam-compliant and include up to 80-bit and dual

Active Silicon's FireBird frame grabbers

80-bit models, providing reliable and robust image transfer without CPU intervention. A software development kit, ActiveSDK, is provided. Camera and frame grabber control is delivered by the firm's front-end software, ActiveCapture. All FireBird frame grabbers support GPU processing.

Outside the visible

JAI's product release roadmap also includes a new four-sensor colour line scan camera in the Sweep+ series. The model – SW-4010Q-MCL – features an integrated prism that splits the incoming light onto four separate CMOS sensors. The camera is able to simultaneously capture images of visible red, green, and blue light, as well as a shortwave infrared image.

Also, a new 8.1-megapixel Pregius S sensor-based camera in the Go series – Go-8105M-5GE-UV – is on JAI's roadmap, and will provide vision system designers with high-resolution ultraviolet imaging capabilities.

Imaging outside the visible is another major trend happening in the vision industry. Emberion will release a GigE interface-based vis-SWIR camera soon, with frame rates of up to 400fps supported targeting optical sorting applications. Moreover, a megapixel vis-SWIR camera will be released and be available in 2023.

Emberion manufactures camera products made with its nanomaterial-based infrared sensors and in-house designed custom CMOS readout electronics, creating high value at affordable costs. The company currently offers a wide spectral range – visible to SWIR (400-2,000nm) – high dynamic range camera called the VS20. Variants of VS20 are being developed, based on the quantum dot nanomaterial sensors to meet different application needs, such as semiconductor imaging, defence, surveillance, automotive and medical.

Emberion's mission to broaden the spectral range of its sensors continues, and it is developing a mid-wave infrared (3-5µm) non-cryo-cooled camera, and ultra-wide tri-band solutions that can simultaneously image several wavebands (vis-SWIR-thermal), thereby opening up new application areas.

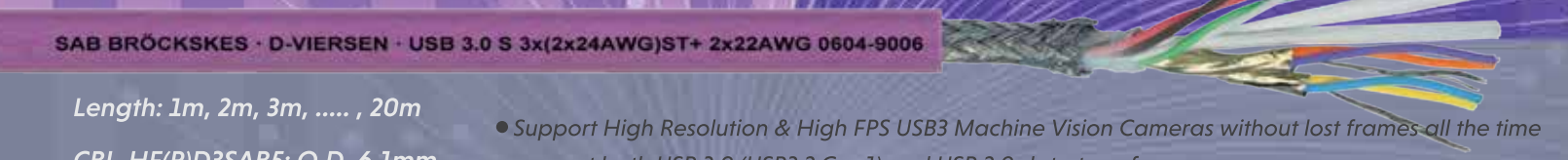
Sticking with shortwave infrared, the LED lighting manufacturer, MBJ Imaging, says it sees an increase in applications in the areas of infrared imaging, especially SWIR, along with systems capable of running multiple inspection tasks. MBJ Imaging says it is developing its portfolio to provide customers with target-oriented lighting in these areas to support efficient inspection systems.

Turning to the ultraviolet region of the spectrum, TPL Vision has launched a fluorescence imaging solution, which it claims is the market's first multi-UV wavelength dome light. The LED illumination product is designed for UV authentication and fluorescence inspection applications, as well as for users of visible spectrum cameras and entry-level code readers. Applications include inspection of glue seals in automotive and →

LONG DISTANCE CONNECTION

USB3.2 Gen1 MACHINE VISION CABLES

HI-FLEX



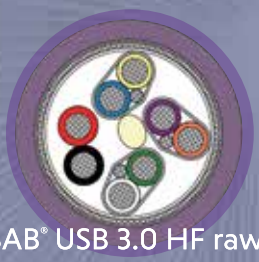
Length: 1m, 2m, 3m, ... , 20m

CBL-HF(P)D3SAB5: O.D. 6.1mm

CBL-HF(P)D3SAB6: O.D. 8.8mm

- *Support High Resolution & High FPS USB3 Machine Vision Cameras without lost frames all the time*
- *support both USB 3.0 (USB3.2 Gen1) and USB 2.0 data transfer*
- *USB 3.0 (USB3.2 Gen1) bus-powered, no external power supply needed*

L0604-9005	O.D.:6.1mm
3x(2x28AWG)ST+2x26AWG	
L0604-9006	O.D.:8.8mm
3x(2x24AWG)ST+2x22AWG	



SAB® USB 3.0 HF raw cable used

Fit for Cable Drag Chain Systems

Support USB3.2 Gen1 Type-C Cameras

Support USB3.2 Gen1 Micro-B Cameras

USB3.2 GEN1 TYPE-C CABLES

CBL-HFD3SAB6CS - 1m ~ 5m CBL-HFD3SAB6CS - 5m, 6m, ... , 20m

Angle Type-C

Left & Right
CBL-HF(P)D3SAB6CS - xmLRA

Up & Down
CBL-HF(P)D3SAB6CS - xmUDA

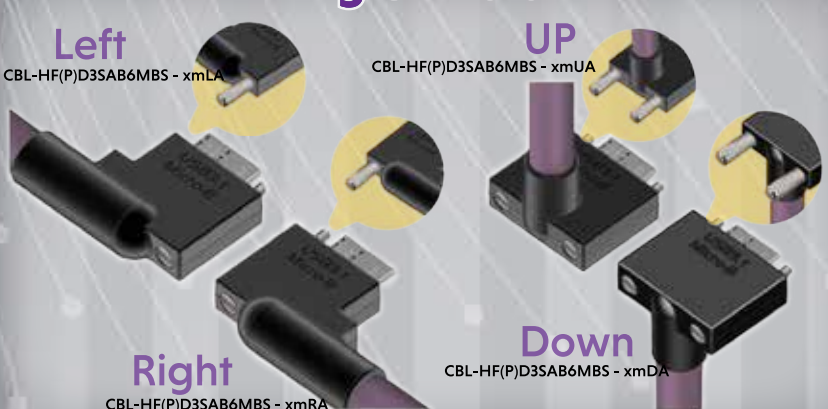
USB3.2 GEN1 Micro-B CABLES

CBL-HFPD3SAB6MBS - 1m ~ 5m CBL-HFD3SAB6MBS - 5m, 6m, ... , 20m

Angle Micro-B

Left
CBL-HF(P)D3SAB6MBS - xmLA

UP
CBL-HF(P)D3SAB6MBS - xmUA



Right
CBL-HF(P)D3SAB6MBS - xmRA

Down
CBL-HF(P)D3SAB6MBS - xmDA

JARGY® Mobile Computing®

JARGY CO., LTD. | jargy@ms17.hinet.net | +886-2-2662-5200 | www.jargy.com.tw

Made in Taiwan

34 years since 28th. 08 . 1987 34th Anniversary

Multi-UV dome light from TPL Vision

→ food industries, and UV security feature inspection in pharmaceuticals, electronics and luxury goods.

TPL Vision says it continues to develop illumination products for high-speed inspection and code reading applications, especially for the food and beverage, and pharmaceutical industries. It will introduce enhanced certifications, including an IP69K waterproof range of lighting products.

Harnessing AI

MVTec Software says its major goal is to make deep learning more flexible. This is in terms of ease-of-use and how easily the technology can be accessed by non-experts, particularly through its Merlic software.

The company will also enhance deep learning in its Halcon software library, where it will combine 3D vision with deep learning algorithms to make 3D applications, like bin picking, more robust.

In addition, the MVTec Deep Learning Tool will gain importance as a supplement to the company's portfolio. Firstly, the tool supports Merlic with its growing number of deep learning methods, and secondly, the tool provides features to check data

MotionCam-3D

quality, as this is an important parameter for improving the performance of deep learning models.

Photoneo has added colour information to its MotionCam-3D camera, which the company says is significant for applications using AI. MotionCam-3D gives high-quality scans of moving scenes, and combines 3D geometry, motion and now colour. The addition of colour means that AI algorithms can recognise products not only by 3D geometry, but also by colour features, which makes the output from AI models more robust.

Photoneo has also upgraded its robotic intelligence tool for automated bin picking, Bin Picking Studio 1.6.0. The new version introduces features to make bin picking easier to set up and run.

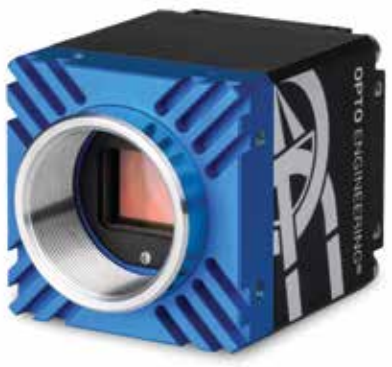
Pleora will expand the capabilities of its Visual Inspection System, which automates decision-support for manual manufacturing

Pleora's Visual Inspection System

tasks. The system integrates inspection apps that help reduce manufacturing quality escapes, and tracking and reporting apps that gather data from manual processes. Pleora is expanding its suite of apps, with new tools for machine vision and AI-based inspection, and customisable reporting for unique requirements.

With Pleora's inspection apps, the camera-based system visually compares products against a golden reference to highlight product differences and deviations. The apps require just one image to start inspection, with the AI model then trained based on the operator's initial decisions. After minimal training, the AI model will begin suggesting decisions to the operator.

Integrated tracking and reporting apps can be used for traceability, process improvements and inventory management, with data shared to a manufacturer's resource planning software.



Itala from Opto Engineering

Lens on progress

As already mentioned, GigE Vision remains a popular interface. Opto Engineering is releasing a series of GigE Vision industrial cameras with integrated liquid lens control. The Itala G. EL cameras offer resolutions ranging from 3.2 to 12 megapixels, and Optotune liquid lenses can be easily integrated, thanks to a built-in driver.

Elsewhere, Kowa has expanded its ultra-compact JC5MC lens series to include 35mm and 50mm focal lengths, adding to the 8mm, 12mm, 16mm and 25mm focal lengths already available. The lenses have a maximum length of 27mm and weigh 55g,

Kowa's compact lens series

making them ideal for use with smart and stereovision cameras where space in the camera body is limited.

The JC5MC series is optimised for five-megapixel cameras, with a chip size of 2/3 inches and a pixel size of 3.45µm. This makes them best suited to Sony's IMX250, IMX252, IMX264 and IMX265 sensors. The lenses are resistant to shock and vibration, and the series has good transmission from visible to near infrared.

This is a brief snippet of the technology that machine vision suppliers are working on, and doesn't even touch on the advances happening outside of the vision sector that will find uses in industrial automation. But with all this development work going into vision systems and components, and with the demand to automate processes, the future certainly looks bright for the vision industry.

COMPONENTS EXPRESS, INC.
CHALLENGING THE LIMITS OF PERFORMANCE

MADE IN U. S. A.

Total Solution Provider for Demanding Connectivity, Enclosure and Mounting Technology for Machine Vision and Industrial Automation

VISION

4 – 6 October 2022, VISION, CEI 10D55

Key Features:

- Industrial Machinery and Factory Automation applications
- Excellent mechanical and electrical characteristics
- Large selection of A, D & X Coded connector types to choose from
- Robust over-molded design and cable choices
- Multiple cable exit and connector orientations available
- Hard Anodized IP67 Rated Camera Enclosures
- Supporting camera sizes: 29, 38, 55 & 88mm

M12 - Cables

88mm IP67 Enclosure

Adjustable Swivel Mount

Light Bracket, Lens Covers & Accessories

ISO 9001 : 2015

1-630-257-0605
componentsexpress.com

SCAN HERE TO LEARN MORE
componentsexpress.com/qrm

Business strategies for success

The vision sector is changing rapidly, so how can firms thrive? **Holly Cave** speaks to some key vision suppliers

The machine vision industry witnessed record growth in 2021. As it grows and continues to mature, the vision sector has become a rapidly evolving landscape. Headlines report on the latest big mergers and acquisitions, but is conglomeration the only future for the sector?

Across the wider technology market, customers are typically far more aware of the variety of solutions and products available and are better able to assess which product meets their specific needs.

As Davide Ferrari, marketing communication manager for MaVis Imaging, a subsidiary of Framos, said: 'They know what they want to achieve and are looking for technology partners to supply custom or semi-custom solutions.'

Expect consolidation

While the routes to market are not changing that much, it is evident that consolidation through mergers, acquisitions and closer partnerships is a key trend in the machine vision sector.

Market competition and commoditisation – in which technologies are becoming more commonplace, less differentiated and thus more closely price-matched – is a driving force for consolidation and the domination of larger players.

Machine vision companies of a certain size are acquiring smaller companies with complementary technology to build up portfolios in certain areas. The conglomerate Teledyne Technologies bought Flir Systems last year in a $7.36bn deal. It also owns a large number of companies including e2v, Dalsa and Lumenera.

Such deals are likely to be the ongoing direction of travel, not only within the industry but also across the wider technology landscape, Ferrari suggested.

Zebra Technologies has moved into the market by buying up firms, most recently Matrox Imaging and, last year, Adaptive Vision. Another example is the chip maker Intel, which has already demonstrated its interest in the industrial 3D imaging market by building prosumer solutions that bridge the gap between personal consumers and a professional customer base.

'Whether this type of move becomes an interesting return on investment for leading technology industries across the board is another question,' added Ferrari.

Changing role for distributors

We are seeing manufacturers and distributors merge or team up, with the shared aim of reaching customers more easily and gaining greater insight into their needs. There is also a lot in this for customers, said Henning Tiarks, executive director, digital and software business management at Basler.

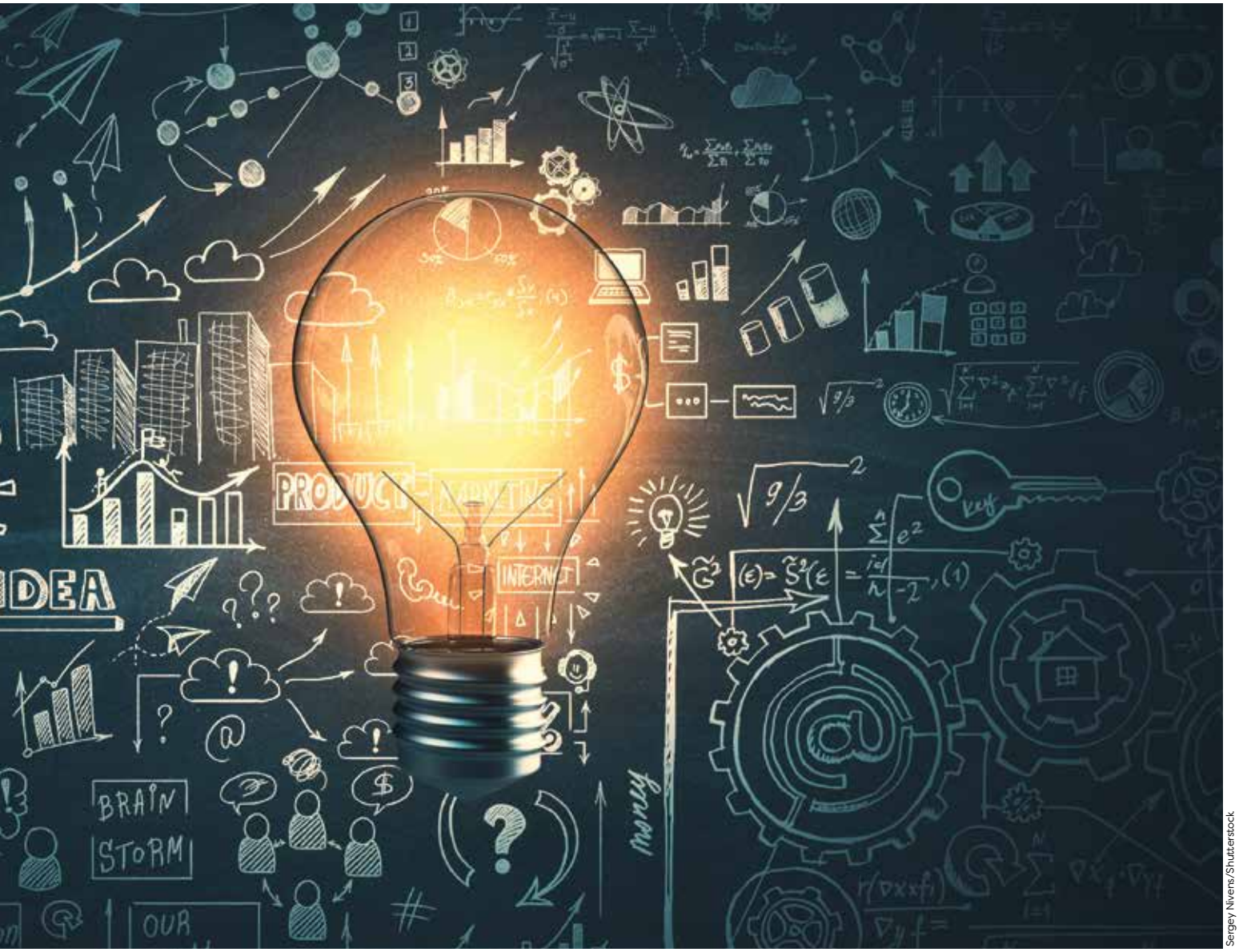
'By combining the unique competency of former distributors in helping customers solve all kinds of vision-related tasks with more direct access to Basler, this move will allow us to increase the value for the customer significantly. And as their hardware and software needs become much more transparent, we can create better products,' he said.

While companies such as Basler are buying their sales partners in other countries to develop direct routes to market – Basler bought its Italian sales partner Advanced Technologies and a stake in its French distributor i2S in May 2022, and its Beijing-based distributor in 2018 – stand-alone distributors in the current market are fighting to remain relevant. Is there still a place for them as stand-alone businesses?

Ferrari believes so, arguing that these companies have an important role as experts in managing expectations and delivery time frames within the image processing chain. 'In the past, there was a strong demand for next-day delivery,' he said. 'But as a result of the global pandemic, customers are now actually forecasting their requirements and scheduling deliveries.'

'[Vision companies] should adapt to new business models and define a certain, mostly new, role in the value chain'

Mark Radford, CEO of LMI Technologies, owned by the TKH Group, agrees that, with the increasing complexity and huge variety of products on the market, distributors are as important as ever. 'Customers come to distribution partners to have their challenges understood,' he said. While the space in most market segments or regions for purely reselling is rapidly



Sergey Nivens/Shutterstock

shrinking, there is a sizable opportunity for distributors to provide value-added services to end-customers, such as pre-sales support, application engineering and integration with other digital and electro-mechanical systems.

MaVis has also seen the industry shift towards faceless ordering systems, typically through webshop sales. But its view is that, so far, this is slow to be successful in Europe.

Online purchasing may represent part of the larger desire from customers to reduce the complexity of their businesses, or simply take advantage of their ability to do so. Why make three transactions when you could make one? This may work out well for distributors, said Radford, thanks to their large line cards and capability to advise on interoperability. 'Although it also speaks to the importance of machine vision brands producing broad portfolios with a wide variety of products,' he added.

Space for innovation

Although consolidation seems certain to continue, market growth provides room for new ideas and the potential for new players in niche or highly specialised areas to enter the market.

Radford reflected: 'This yields an interesting mix of greater acceptance of machine vision through the brand power of the larger, well-known players in the market, while innovation and new entrants force the evolution of products and services in a highly competitive market.'

Artificial intelligence, embedded processing, internet of things and cloud computing technologies have extensive potential for delivering innovation and breakthrough solutions. Tiarks is convinced these technologies will change the way machine vision products are built and will have implications on the technologies used to create machines in the future.

'All current machine vision companies need to master this in the coming years by deploying new technologies – be it from big technology firms or not – directly to the customer base,' Tiarks said. 'They should adapt to new business models and define a certain, mostly new, role in the value chain toward the customer. As a result, these companies will be sustainable and benefit from the changes in the market.'

Ferrari is less sure of the scope for the impact of innovation in these fields: 'Many applications still require very specific results from strictly defined inspection parameters, and so traditional image processing will still account for the major volume of applications,' he said. 'AI will help increase →

‘The market is moving towards more integrated imaging solutions that place machine vision into wider factory processes’

→ food and agri-tech applications though, with important implications for reducing the environmental impact of food production.’

Offering fuller solutions

The market is moving towards more integrated imaging solutions that place machine vision into wider factory processes – integrating robots, machinery and people to collaborate. ‘This is leading companies to diversify outside of their traditional technology sphere and take control of more aspects of image processing in the complete automation solution,’ said Ferrari.

Many companies in the machine vision sector are using their application and technical knowledge to specify, design, produce or select additional components that complement or expand their traditional product range.

Basler, for example, has been expanding from a camera manufacturer to a full-range supplier in the past few years. It now supplies a range of hardware components, including lenses, cables, interface cards and frame grabbers.

TKH now holds several companies under its TKH Vision umbrella brand, including Allied Vision, Chromasens, LMI Technologies, Mikrotron, Net, SVS-Vistek and Tattile. In 2021, it exhibited all those brands under a single exhibition booth at Vision Stuttgart for the first time. Individually, these companies have long histories within the machine vision market and, together, boast a broad array of technology components, technical expertise and application know-how in both the 2D and 3D spaces.

Backing up hardware with software

What is particularly interesting is that TKH Vision is building on its strong hardware product portfolio by putting an increased focus on the group’s software offerings. ‘We’re creating unique smart and integrated plug-and-play systems to fully round out an entire one-stop shop of solutions for customers, fully leveraging the group’s expertise,’ explained Radford.

TKH Vision hopes this combination of hardware, software and application expertise will make them the go-to supplier for machine vision solutions across a variety of industries and applications.

Basler is also developing its software platform with its Pylon camera software suite – a single tool designed to unify and synchronise the control and operation of all its hardware components. Functionality includes an integrated light-controller, the latest image analysis and processing tools, and harmonised CXP-12 cards and cameras. The interface and its integrated drivers are free to use until the design phase is done, explained Tiarks. ‘It can be downloaded and immediately used by everyone to create a vision system,’ he said.

The approach demonstrates how expanding into software brings benefits for hardware manufacturers. As well as offering a useful tool for Basler customers, the platform encourages them to access the webshop and drives them to guidance on the website, where they can be introduced to components and products they might consider purchasing.

The trends in business strategy happening across the sector look set to continue. While it is clear there is significant space for innovation, consolidation means that, in future, there is likely to be a handful of companies with wide portfolios across both hardware and software, which offer a ‘one-stop shopping experience for customers,’ said Tiarks.

Sergey Nivens/Shutterstock

COMITTED TO EXCELLENT LINE SCAN VISION PRODUCTS AND SOLUTIONS

CAMERAS.LIGHTING.CUSTOMIZING
2D.3D.RGB.MONO.UV.IR.SWIR
FAST.RELIABLE.STABLE

www.chromasens.com

THE LINE SCAN EXPERTS

chromasens
IMAGING FOR PROFESSIONALS

Follow us on

Visit us at TKH booth **10.F30**

VISION
World's leading trade fair for machine vision
04–06 Oct 2022
Messe Stuttgart, Germany

A TKH TECHNOLOGY COMPANY

New kids on the vision block

Zebra Technologies has made sizable purchases in machine vision over the last year. **Donato Montanari** reveals why the firm places so much value on vision

Zebra Technologies' acquisition of Matrox Imaging for $875m has been one of the biggest in the machine vision sector this year so far. It puts Zebra firmly among the leading machine vision providers, and is testament to the growing importance of vision technology, not just in manufacturing but also in areas like e-commerce.

Zebra announced its arrival on the machine vision scene in May 2021 when it introduced its own line of fixed industrial scanners and smart cameras, and acquired Adaptive Vision for $18m, the Poland-based deep learning vision software provider. At that time, Zebra also bought Fetch Robotics for $301m for its autonomous mobile robots.

But it was the Matrox Imaging deal a year later that cemented Zebra as a major machine vision player. 'Currently, without machine vision, around 40 per cent of Zebra's revenue comes from transportation, logistics and the manufacturing sectors,' Donato Montanari, Zebra Technologies' vice president and general manager for machine vision, told *Imaging and Machine Vision Europe*. 'They are markets we already know well; those are the markets where machine vision is important. We felt we had a strong right to play.'

He said there was also demand from Zebra's customers for machine vision products, which has helped the firm define its vision offerings, and that, from a technological standpoint, machine vision is similar to what Zebra already produces, namely optoelectronic systems. All of this makes the addition of vision products a logical step in the company's development.

Zebra Technologies' products include printers for track-and-trace, mobile computing, data capture, radio frequency identification products, real-time locating systems, and now machine vision. Its history dates back to 1969, when it was founded as Data Specialties by Ed Kaplan and Gerhard Cless. Its early products were handheld laser barcode scanners and barcode printers, and then later RFID handheld scanners. In 2014, it bought Motorola Solutions' Enterprise business for $3.45bn, and in the same year became the official on-field player tracking provider for the NFL in America through its RFID technology.

In 2021, the company generated net sales of $5.627bn; it has 9,800 employees in 55 countries, 128 offices, and more than 10,000 channel partners around the world.

The family of fixed industrial scanners and smart cameras Zebra introduced last year was designed as entry-level products. The acquisition of Matrox Imaging, as well as gaining more than 200 machine vision experts, adds high-end products, such as PC-based vision systems, 3D sensors and high-resolution – up to 16 megapixels – smart cameras.

'Having a very wide portfolio of products, both in the software and hardware domains, is critical,' Montanari said. Zebra recognises that an important aspect of machine vision offerings is the breadth of the portfolio, as most applications require specific hardware – one camera cannot fit all markets.

'We really saw this [Matrox acquisition] as an opportunity to expand our offering very significantly,' Montanari continued. 'Now we can go to large customers, to large end users, and say we are a player that can serve almost every machine vision need that you might have.'

Montanari said the pandemic drew 'a sharp line' between companies that were automated and those that were not. The growth in e-commerce, for example, accelerated by the pandemic and the shift in consumer purchasing habits, has had a big impact on

the track-and-trace part of Zebra's business, according to Montanari.

'We are very present in e-commerce, and the amount of automation with robotics that's happening in e-commerce is mind-boggling,' he said. He added that 'the single most important technology that matters to us is robot guidance.'

Vision technology is critical here and complements the robot technology Zebra gained from Fetch Robotics, although Montanari explained that Fetch's autonomous mobile robots would typically bring parts to a robot arm, which would then be guided by vision in pick-and-place tasks.

Full-range provider

Montanari said machine vision is a specialised sector and as such Zebra is competing with leading firms in the industry. But he added there is also a different kind of competitor looking at the machine vision market: the cloud providers – Google, Amazon, Microsoft and the like. 'They're looking at this technology [vision] as being critical to manufacturing and e-commerce,' he explained. Their approach is different, according to Montanari, and involves edge devices and processing in the cloud. 'It's an interesting dynamic,' he said. 'These are the competitors that we are very worried about, firstly because of their size and influence, and secondly because they have the cloud infrastructure.'

Along with growth in automation in e-commerce, Montanari pointed to the changes happening in automotive manufacturing – the switch to electric vehicles – as being another macro trend presenting an opportunity for machine vision suppliers. He said that Zebra is 'seeing a lot of traction in that market.'

In terms of technology, Montanari said 3D vision and deep learning both show great promise, and that 3D in particular will make strides in the coming years, benefiting from faster processors that will make it more accessible and less expensive.

Zebra plans to invest in both 3D and deep learning. The company will continue to bring together algorithms and products from Adaptive Vision and Matrox Imaging acquisitions, while also developing 3D products for robot guidance. 'You'll see something coming out in this domain [3D and deep learning] that we think will be very disruptive,' Montanari said. He added: 'You can marry those technologies [3D and deep learning] in the domain of robot guidance. If you do robot guidance in 3D you have a lot of advantages, and if you use AI for a specific part of robot guidance it becomes a very powerful solution.'

> 'The single most important technology that matters to us is robot guidance'

Montanari believes consolidation will continue to happen in the machine vision sector. 'Machine vision has been a relatively small market for a long time,' he said. 'Now it starts to be a big market, not just the size of the market but because of the technology – computer vision is now everywhere, from inspection to autonomous driving. That has caught the attention of large companies, Zebra included.'

There's also a generational change, where a lot of the pioneers of machine vision are retiring, with some looking for an exit plan.

Zebra has found machine vision ties in well with what it already provides and is putting a lot of resources into developing vision products. It will be interesting to see how its automation offerings progress, and whether, to bolster its vision products further, there will be more acquisitions in the pipeline.

naum/Shutterstock.com

Chipping away at the semiconductor crisis

With no end to the semiconductor shortage in sight, the industrial vision industry has had to adapt to a new normal, finds Benjamin Skuse

When US car makers like Ford and GM are making moves to bring computer chip production in-house, you know the semiconductor crisis is much more than a temporary blip.

Covid-19 hit during a natural downturn in semiconductor demand. As worldwide lockdowns and virus outbreaks halted global production and supply throughout 2020, demand rebounded dramatically thanks in large part to people craving electronic entertainment and devices to help them work from home.

Then, 2021 saw a host of extreme weather events and accidents affecting chip-making hubs in Japan, Taiwan and the US. Next, the Ukraine war began, placing further strains on the industry, given both Ukraine and Russia's importance as trade routes and their role in supplying key substances in chip production – neon gas and palladium, respectively.

When you add shortages in other key materials like silicon and rare earths, continuing disruptions to global supply chains, and the effects of the ongoing geopolitical conflict between the US and China, it is clear the semiconductor crisis will be with us for a long time to come.

Bullwhip effect

The mechanical manufacturing industry, including the industrial vision sector, has been hit hard by this worldwide imbroglio. Surveys conducted by VDMA – the mechanical engineering industry association, representing more than 3,400 German and European companies from the mechanical engineering sector – have found that almost all companies have suffered from the chip shortage.

'The current situation is partly explained by the bullwhip effect as a result of the pandemic: the surprisingly sharp and rapid recovery of demand in some parts after the global slump, especially first in China, and later in the EU, and the general aim to bring supply chains back into operation and build up stocks,' said VDMA's Sandra Engle.

The bullwhip effect is where each party in the supply chain gradually escalates an initially small spike in demand by adding additional products to their orders to act as a buffer. When – as has happened – the spike is larger and everyone in the supply chain does this, inaccurate forecasting, stock hoarding and out-of-stock products follow.

Speaking on the vision hardware company's blog, Phytec head of development, Marcus Lickes, delved into the consequences of this for semiconductor manufacturers: 'It starts with raw materials, goes to wafers, and ends with manufacturing and test capacity,' he said. 'So even if semiconductor manufacturers get the base material, they have to find free manufacturing capacity. Manufacturers with their own fabs are better off, but even their fabs are completely overloaded. This explains why there are hardly any components that can really be procured without problems.'

Even now, over two years since the pandemic began, VDMA reports that around 35 per cent of companies are still experiencing serious impairments in their supply chains, and 54 per cent see serious bottlenecks in electrical and electronic components. 'Not surprisingly, supply shortages are impacting the price structure of purchased inputs,' added Engle. 'VDMA expects no short-term relief due to long lead times for pre-materials and complex processes in semiconductor manufacturing.'

FPGAs and CMOS components

For companies working at the coalface, this situation has been a logistical

nightmare. The most challenging aspect of this nightmare for many industrial vision companies has been sourcing field programmable gate arrays (FPGAs), according to Zebra Technologies' vice president and general manager for machine vision, Donato Montanari. FPGAs are processors used in embedded systems that power high-performance, compact, industrial vision cameras. As the technology has been refined, they have been gaining favour as an image processor for industrial vision cameras in recent years.

'The fact that both the largest FPGA suppliers had been acquired [Xilinx by AMD and Altera by Intel] and are still going through integration is yet another difficulty to add to this perfect storm,' Montanari said. 'The availability of FPGAs, which translates into real new capacity coming online, is not going to happen until halfway through 2023.'

Another critical component in industrial vision cameras is the CMOS image sensor. One of the lead providers is Sony – the same Sony that serves tens of millions of iPhones. For very specialised industrial-only components, the machine vision industry does get priority and shortage of those components is relatively manageable, said Montanari. The problem is where there is overlap with consumer products like these CMOS sensors. 'That's where it gets really, really tough.'

Zebra Technologies has weathered the storm well. Designed for manufacturing

'The availability of FPGAs, which translates into new capacity coming online, is not going to happen until halfway through 2023'

and warehouse management applications, its VS-series smart cameras and FS-series industrial scanners were only introduced a year ago. 'We made a very conscious decision that instead of an FPGA for our fixed industrial scanners and machine vision solutions we were going to use very advanced microcontrollers with a GPU on-chip,' explained Montanari. Quite apart from the technological advantages in terms of deep learning and artificial intelligence this set-up has offered, it has also rather fortuitously meant Zebra has not had to compete with its peers for components.

'We are not fighting for the usual Xilinx FPGAs because our microcontrollers are actually built by NXP,' added Montanari. 'Demand has been through the roof and I think it's a combination of our products being new and innovative, and the fact that our competitors are not able to supply.'

Another factor in Zebra's recent success has been the shrewd acquisition of Montreal-based smart camera manufacturer, Matrox Imaging. With the two companies' product ranges sharing →

naum/Shutterstock.com

→ similar components from the same providers, and a mutual customer base containing top Fortune 100 companies, Zebra now has a lot more leverage to negotiate with semiconductor suppliers.

Other leaders in the machine vision space have been able to weather the semiconductor crisis well too, also in part because of their purchasing power. Basler, Stemmer Imaging and Cognex all posted strong revenue results for 2021, with Basler and Stemmer's sales up by 26 per cent on 2020, and Cognex's revenues exceeding a billion dollars for the first time, though Cognex shares fell by almost 14 per cent in May as a result of slowing growth. Basler and others have warned that challenges in procuring semiconductor components are expected to remain the limiting factor for growth in 2022, and possibly beyond.

Shifting mindsets

How are others in the machine vision space without the reach and resources of Zebra and its ilk coping? A key difficulty has been focusing efforts on R&D for new products. 'Many companies hardly find the time to deal with new developments,' explained Lickes on the Phytec blog. 'The effort required for rescheduling, design adjustments and procurement is simply too great in this crisis.'

Though they have released two new products this year, German machine vision pioneer, Matrix Vision, is one of the only companies to have openly talked about having to redesign some of its products to overcome component shortages. In a statement, the company announced: 'We have initiated a redesign based on alternative components with reliable availability as quickly as possible in order to ensure delivery capability.' Affected products are the GigE camera series MvBlueCougar-X and MvBlueFox3 series, though they retain the same product designations and mechanical properties as their original versions.

> 'No one knows if we will ever go back to that just-in-time scenario'

For most others though, product redesigns are not a viable option. They need specific components but find themselves at the end of a long queue. This is where distributors have been playing a critical role. 'The role of the distributor shouldn't be underestimated,' said Allan Anderson, managing director of UK-based Clearview Imaging, a machine vision component supplier. 'There's a myth, especially in Europe, that the only cameras that are available quickly are from Chinese manufacturers, but I think that does a disservice to well-run distributors who are making sure they have stuff on shelves.'

However, despite the best efforts of distributors, there is no getting away from the fact that shortages remain, and will continue to remain, a bottleneck to supplying machine vision products. As a result, all parts of the industry have had to shift their mindsets and expectations just to keep afloat.

'Just-in-time manufacturing pre-Covid meant that people expected a distributor or manufacturer to have any sort of quantity available instantly, or within a week,' said Anderson.

'No one knows if we will ever go back to that just-in-time scenario.' He went on to explain that the meaning of a long lead time has changed, from six to eight weeks pre-pandemic, to up to 12 months today. And this has been a hard pill to swallow for many. 'It's tough for a lot of customers,' he said. 'They find it very difficult to understand, at a macro level, how and why this is happening.'

For him, the key is planning and flexibility: 'I think the best customers are willing to work in an agile way.' The same applies to his own company, Clearview Imaging. Over the past two years, Clearview has optimised its forecasting and stocking formula and model, so they always have stock parts.

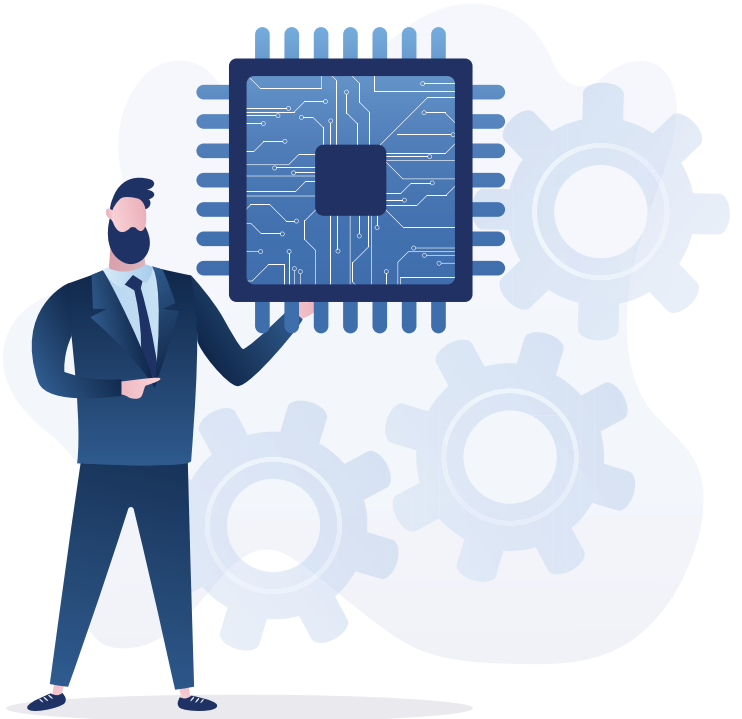
'We've always talked about being experts in machine vision, but we now have to realise we really need to push the boundaries of being experts in operations,' he added. 'This is about improving your processes, whether that means forecasting or purchasing or whatever – that's the challenge for any company working through this.'

Montanari feels the most important elements of riding out this storm, at least for Zebra, have been communication and transparency across the supply chain. 'There has to be real transparent communication across the whole ecosystem, where people are very realistic in expressing their demands, and suppliers even more realistic in communicating their abilities to supply.'

> 'There has to be real transparent communication across the whole ecosystem'

In his Phytec interview, Lickes also emphasised transparency and communication. He said his company identified five key areas to keep the wheels turning: close supplier relationships; intensive customer contact; flexible product designs and parts lists; transparent pricing policy; and consistent focus on the latest component generations.

But regardless of the approach to weathering the crisis, size of the company or position in the supply chain, all parties can agree on one thing: the semiconductor crisis has – and will continue to be – the ultimate stress test of their business.



naum/Shutterstock.com

EXCELITAS TECHNOLOGIES®

The most versatile **sCMOS** portfolio on the market

www.excelitas.com
www.pco.de

pco.
An Excelitas Technologies Brand

Adopting automation must be a priority

Robotics is key for UK productivity, a report has found. UKIVA's **Neil Sandhu** and **Allan Anderson** argue vision brings similar benefits

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 late in 2021 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, as of 2021, 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, 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.

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

Manufacturing Technology Centre

Robot solutions at the Manufacturing Technology Centre.

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 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.

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

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 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 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.

PPMA Best seeks to encourage young people to enter and develop a career in engineering in the processing, packaging, robotics, automation and industrial vision →

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 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 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.

Mike Wilson, the MTC's chief automation officer, 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 [UK government's 2017] *Made Smarter Review* identified that the application of automation and robotics in UK industry could contribute £183.6bn 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 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 that 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 bridge the gap between university research and of manufacturing solutions. The report can be downloaded here: **www.the-mtc.org/media/bdba0ls0/automation-and-robotics-research-paper-a4-pages.pdf**

→ 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 (https://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.

Manufacturing Technology Centre

There are lots of opportunities for automation in manufacturing

UK automation show to launch in 2023

The British Automation and Robot Association (BARA) has partnered with the UK Industrial Vision Association (UKIVA) to launch a new exhibition highlighting the importance of robotics and systems integration to the growth of the UK economy.

Automation UK, which debuts at the CBS Arena in Coventry from 20-21 June 2023, is intended to be the national automation and robotics show. It will be co-located with UKIVA's Machine Vision Conference, making it the largest annual event of its kind in the UK. Automation UK will feature the latest industrial products and services, robots, robotic systems, systems integration, automation control parts and systems, sensors and machine safety.

The exhibition's broad scope will target stakeholders from across the industrial spectrum, including manufacturing, retail and consumer, automotive, electrical engineering, aerospace and maritime, food and drink, logistics, transport and distribution, oil, gas and nuclear, and more.

Both BARA and UKIVA are part of the Processing and Packaging Machinery Association (PPMA) group, a coalition that spans the breadth of the automation and robotics sector. The PPMA represents and lobbies on behalf of suppliers of processing and packaging machinery to both the domestic and overseas markets.

Mark Stepney, managing director of Schubert UK and a PPMA board member, said: 'Despite headwinds, there is clear evidence that automation and robotics offer the fastest returns for businesses looking to improve their productivity and offset costs. There is also a strong desire among businesses operating in this sector to demonstrate their resilience to decision-makers and buyers and to highlight the importance of the automation and robotics sectors to the future growth of UK industry.'

The UK government has allocated £184bn out of £455bn via the *Made Smarter* industrial strategy specifically for automation and robotics.

Turning tech into business triumph

Vision start-ups are proliferating, thanks to AI and embedded computing. But what makes young companies successful? **Abigail Williams** reports

REDPIXEL.PL/Shutterstock

The machine vision sector is a natural home for start-ups. A lot of the now dominant players in the market began as technology start-ups, and while the industry has grown and matured, it's still an area where technical innovation can flourish.

Chris Yates, director at Vision Ventures, a company specialising in corporate transactions in automated imaging, machine vision and computer vision, said the vision tech sector provides tremendous opportunities for start-ups, and is an exciting market to be part of from a founder's perspective. There's also excellent investment potential, he noted.

There are new approaches to vision technology being developed and commercialised all the time, which can be applied to a vast array of automation and imaging tasks.

'The sheer scope of vision technology is probably one of the most unique aspects of the sector, and brings with it a wealth of opportunity,' Yates said. 'However, for both start-ups and investors, this breadth also creates a clear need to understand market structure and dynamics in detail to be successful.'

Changing landscape

One area that has had a marked impact on the vision start-up landscape in recent years has been the phenomenal development effort around neural networks and AI-based image processing. Over the last decade, this technology has moved from academic research labs to a topic that almost every company in the vision sector is addressing – a trend further enabled by powerful processors such as GPU modules, together with freely available neural network architectures and associated tool chains like TensorFlow and Keras.

'Both these points [AI and processors] have considerably lowered the barriers to entry for start-up companies to develop vision AI products for the market, and opened the way for many new companies to enter the space,' said Yates.

The combination of inexpensive, low-power computing, AI tool chains and high-quality image sensors means that extremely powerful vision systems can be built for many different domains. Whereas the need for a PC would previously have ruled out such applications, Yates pointed out that embedded vision is now providing value in consumer home goods, agricultural sensing, medical devices, waste recycling and many more areas.

'Vision has the potential to become truly ubiquitous, and it is an outstanding success of the vision industry that many companies are developing vision systems targeted at specific domains, while using the same fundamental technology building blocks,' he said.

Markus Lukasson, founder and CTO at Berlin-based Nyris, noted that a huge amount of new start-ups are applying machine learning to solve vision issues. Nyris launched its visual search engine in 2017.

'What is special about vision start-ups is that machine- and deep-learning is advancing so fast, and new opportunities to apply machine learning to solve a problem that has not been practically or economically solvable before pop up every day,' Lukasson said. 'Everything is changing fast and this speed creates challenges and opportunities alike.'

Lukasson added that it's become cheap to launch a software-based vision start-up, but that vision hardware requires significantly more investment.

Global awareness of the success of the vision industry has also changed the start-up landscape. Whereas, traditionally, start-ups in the vision sector often looked to organic growth based on dedicated internal expertise, Yates observed that, today, demand for vision technology by large end-user markets – and the major suppliers to these markets – has attracted many financial and corporate investors to vision tech.

'The availability of significant finance to early-stage companies has enabled them to develop products quicker and scale faster, as well as create more solution-based product offerings,' Yates said. 'Additionally, the continued growth in number and size of →

Factory Tough™ Cameras

Truly robust design for 24/7 industrial operation

IP67 Dust Proof, Water Resistant

EMC Industrial Immunity

Shock & Vibration Certified

PoE

100m Cable with Power over Ethernet

M12 & M8 Secure Connectors

Strong & Lightweight

GiGE VISION GENICAM | thinklucid.com/factory-tough

LUCID VISION LABS

→ vision acquisitions demonstrates this is a very attractive sector for start-up companies and their investors.'

Clear positioning is vital

Vision technology can be regarded as a horizontal sector serving different market verticals. There are many different product types, such as hardware, software, systems and services, and each requires tailored business models and separate channels to bring a product to market.

In Yates' view, one of the most important things for a new company entering the vision sector to consider is which part of the overall value chain it addresses with its offering. Clear positioning in the value chain can allow a company to identify the best partners to help with the go-to-market, whether these are key suppliers, or strategic or channel partners. Such an approach also helps companies to target the right customers with products that meet their needs, as well as identify those companies that are actual competitors.

'Particularly for new companies, this understanding can also help clarify additional customer needs, which may be important for scaling and growth,' Yates said. 'For example, the long-term support and maintenance requirements that are very important in verticals, such as factory automation, and sometimes not fully appreciated by early-stage companies.'

When it comes to the strategies and approaches machine vision start-ups adopt to address challenges, mitigate risks and exploit potential opportunities, Yates said many companies will go through a phase of market learning, often led by engagements with early customers and the adaptation of first products to a customer's specific needs.

'This can be a very effective way of mitigating risk by working on a clearly defined real-world problem, generating revenue, and also creating credible reference cases to help secure other customers, or for support in raising finance,' Yates explained.

Another interesting strategy Yates has seen evolving is the creation of well-defined innovation programmes by larger companies, either in the vision sector or in the wider automation market, specifically to address the interface to start-up companies. Here, the benefit to the early-stage company can be a better understanding of wider market needs through the interaction with an established player, as well as a potential valuable strategic partnership.

'For a larger company, these types of programmes provide a route to early validation and visibility of new technologies and products, without the risks associated with early-stage investment or acquisition,' Yates said.

For Lukasson, the most important approach for vision start-ups is to have a passion for the problem being solved. As long as this underlying motivation is in place, he believes there is a good chance the company can compete.

'Don't become a generalist,' Lukasson warned. 'Those general vision problems are being addressed by Google, Alibaba and co. Use your speed, speed is your major advantage as a start-up.

'Everything in machine vision is changing rapidly,' he continued. 'Things that were not possible three years ago are a commodity today. Enterprises can't change that fast, so their solutions are usually outdated when they are released. This is your opportunity!'

Multi-disciplinary approach

Alex Shulman, co-founder and CEO of Saccade Vision, made the point that, unlike many other sectors, machine vision start-ups tend to work across different technology disciplines. 'Even start-ups that develop pure software products often require understanding of sensor hardware, optics, physics, communication and integration protocols, as well as deep application-specific knowledge,' he said.

Saccade Vision, which was founded in 2020, launched its MEMS-based scanning 3D vision product at the 2022 Automatica trade fair. The start-up has completed a number of pilot projects with integrators and end-customers, and has made post-pilot sales.

For Shulman, one of the major challenges, and risks, for successful computer vision applications is the quality of data acquisition, especially since this often depends on an optimal hardware set-up for a specific task. Companies trying to solve a real-life problem need to avoid a garbage-in, garbage-out situation, he advised.

'The camera resolution needs to be sufficient, as well as the effect of illumination, processing power, optics and many other real-life factors – all must be considered,' he said. 'It is true that with powerful and sophisticated algorithms, sub-optimal imaging may sometimes be compensated. However, this will require significant software development efforts and eventually will affect the robustness of the solution. This is one of the reasons why computer vision start-ups often require a multidisciplinary approach.'

Understand your competitors

Looking ahead, Yates believes it is important for companies to focus on where the value is being created for the customer, and to capture that value in a way that is simple for customers to implement. Typically, a vision product fits into a larger ecosystem, whether this is an automated manufacturing line, a driver assistance system, or by providing data to a cloud platform.

'Making it easy for a customer to adopt a new vision tech product within an ecosystem they fully understand helps reduce barriers and shortens the time to achieve the first all-important market entry, from which the company can grow and evolve,' Yates said.

Yates also stressed the importance of understanding the real capabilities and true weaknesses of competitive solutions – especially since many applications in the vision sector have been addressed with solutions that have resulted from significant development efforts and a deep understanding of customer needs, not all of which may be visible to a newcomer.

'Early and objective analysis of competitive performance can significantly lessen the risk of failure or wasting precious resources within the company,' said Yates.

Over the medium-term, Yates observed it is also important to have a strategy for the growth and future of the company that matches the founders' and shareholders' desires. This can provide a helpful, underlying structure throughout the development of a company and support strategic decisions, such as when and where to raise finance, what company status would be most attractive to achieve before seeking an acquisition, or when to engage with strategic partners.

'Early and objective analysis of competitive performance can significantly lessen risk'

'Particularly if the company is thinking about a potential M&A project in the future, a professional review of strategic readiness can be a useful exercise to complete, to identify development options which can best position the company for a future strategic acquisition,' Yates said.

Shulman stressed the importance of quantifying the benefits for customers and proving fast return on investment. This can be by facilitating simpler and faster business processes for customers, preventing costly and dangerous processes, reducing direct costs, or by enabling improvement in the top line for customers.

Meanwhile, Lukasson's advice was: 'Keep your speed, this is one of your biggest assets.' He added: 'Don't forget you need a kick-ass sales and marketing team to sell your product. Technology alone will not get you anywhere. Finding good sales people is as hard as finding good developers or data scientists.'

Ultimately, as Lukasson stated, start-ups should 'be bold and be ready to pivot multiple times to find the right product-market fit.'

Harnessing machine learning's potential

Covision Lab's grand ambition is to be the leading industrial computer vision machine learning hub. Greg Blackman speaks to its CEO, Franz Tschimben

Getting the best out of advances in computer vision and machine learning is a daunting task, considering how much investment is being made in the area, but Covision Lab is bringing together academic research in computer vision with an industrial base to develop applied machine learning platforms.

The goal of Covision Lab, its CEO, Franz Tschimben, told *Imaging and Machine Vision Europe*, is to become the leading industrial computer vision machine learning hub in Europe.

With headquarters in South Tyrol, Italy, Covision Lab is a consortium formed in 2019 from seven companies. These founding firms cover various sectors, but there is a strong manufacturing presence, which is why one of Covision Lab's subsidiaries, Covision Quality, is focusing on manufacturing surface inspection.

Covision Quality won the start-up award at A3's 2022 Automate trade show in Detroit. Covision Quality was also among the leading start-ups as part of the San Francisco Alchemist Accelerator programme, which helped raise its profile in the US.

The research division of Covision Lab is headed by Professor Oswald Lanz at the Free University of Bolzano Bozen, where partner companies – Nvidia is one – can sponsor PhDs. Tschimben noted that the research branch of the company firstly pushes boundaries by publishing code for developers, and also, over the long-term, will help Covision Lab attract some of the best computer vision talent.

Covision Quality's technology is based on unsupervised machine learning, in that the software learns what a good part looks like and deduces the defects from anomalies in the image data. It is not trained with defects, just images of good parts, although often the manufacturer's CAD model is also used as part of the software pipeline.

Covision Lab has two offshoots, both based on the same unsupervised machine learning technology: Covision Media, which uses the algorithms for rendering sportswear as hyper-realistic 3D models for e-commerce – Gore-Tex uses the software, for example; and Covision Quality for manufacturing inspection.

Covision Quality came about through Alupress's involvement as one of the founding companies in the consortium. Alupress makes die-cast aluminium parts for the automotive industry. The focus at the moment for Covision is detecting surface defects, mainly on metals, plastics and packaging, although Tschimben said it plans to expand to inspect other surfaces in the future.

Covision Quality is targeting mid-size manufacturing companies – 2,000 to 15,000 employees – that typically don't have the specialised personnel to deploy traditional machine vision at scale. Tschimben said:

Covision LAb

Franz Tschimben, CEO of Covision Lab

'[Mid-sized manufacturing firms] can have 10 per cent of production lines equipped with machine vision, but they might have difficulties to scale to more because of programming legacy – developing non-machine learning-based visual inspection software is a lengthy, difficult task that requires specialised engineering personnel that is often hard to find and hire. Manufacturers therefore often work with third-party consulting companies. That's where we come in.'

The unsupervised learning approach means that specialised personnel isn't needed and the software doesn't need to be programmed. This makes visual inspection much more scalable, according to Tschimben.

One of Covision Quality's success stories has been with GKN Sinter Metals, one of the leading sinter metal companies in the world, with thousands of employees globally.

Covision Quality began by implementing its software at one GKN plant in Europe, inspecting a set of metal parts in real time at production speeds

'We have many companies reaching out to us already to start research collaborations'

of hundreds of milliseconds per part. From this assessment, GKN took the decision to deploy Covision software across multiple production lines at sites in Italy, Germany and the USA. One of the reasons was GKN calculated that Covision's technology would be 20 times faster at deploying new vision systems compared to traditional methods. Tschimben said it takes roughly a couple of hours to have its software automatically program a visual inspection system, which then can be deployed after going through various accuracy and reliability tests with the customer.

One pain point for customers using traditional vision technology, Tschimben noted, is that it's difficult to program a

classical machine vision system to inspect for every defect. 'Manufacturing companies sometimes struggle with traditional visual inspection systems and software, because they are hard coded on certain specific defects,' he said.
The advantage of Covision's software, according to Tschimben, is that it can handle varying inspection conditions and changing parts easily. 'In the long run, we help our customers be faster and more accurate,' he said.

The software is trained on around 100 to 200 images of mostly good parts. An operator then decides whether the predictions the software makes as to possible defects are accurate and retrains where necessary. Transfer learning can be used where the customer has similar defects, like dents, burrs, missing geometry, or changing colour. There's also a continuous learning approach, where the software learns to account for changes in the production process over time.

Along with finding defects, the system has an aggregate function to give high-level statistics on how the lines are running.

Tschimben said the system does not save large amounts of data, but that Covision installs workstations on the production site – on average, one workstation would cover four production lines – to handle the data generated by real-time requirements of running at speeds of up to one part every 200ms. Covision collaborates with Nvidia on the workstations.

At the moment, Covision Lab has two PhD students: Tsung Ming Tai, in collaboration with Nvidia, whose work is on video understanding and forecasting of actions and activities; and Cynthia Ugwu, who is focusing on anomaly detection for visual inspection. 'Most of the PhDs are working on shaping the status quo of research and solving large industrial challenges,' Tschimben stated. 'In the computer vision and machine learning space, research and applications are closely linked, as this year's CVPR 2022 has shown once again.' Tsung Ming Tai was awarded second place for one of the challenges at the Computer Vision and Pattern Recognition (CVPR) conference. 'This will benefit our manufacturing use cases in the long run,' Tschimben continued. 'We have many companies reaching out to us already to start research collaborations, beyond the mere use of our products.

'Our close collaboration with research departments at universities will guarantee we stay at the forefront of [machine learning] and continue to push the state-of-the-art ourselves,' he added. 'Our unsupervised machine learning approach to visual inspection is a very novel approach to machine learning… at industrial scale.'

Tschimben concluded: 'There's a high acceptance rate for machine learning at the moment, so the time is right [for Covision to grow].'

Young pioneer recognised for anomaly detection advance

We speak to **Karsten Roth** about PatchCore, anomaly detection AI technology that outperforms competitor methods

Karsten Roth, a PhD researcher with the Explainable Machine Learning group at the University of Tübingen, has won the EMVA Young Professional Award for work on a neural network for anomaly detection.

Roth was presented with the award at the 2022 EMVA business conference in Brussels.

PatchCore, which Roth developed during a research internship at Amazon AWS, is an automated visual anomaly detection method addressing the cold-start problem – that is, the model only has access to non-defective example images during training. The model can determine defects without having seen them.

The model offers competitive inference times while outperforming competitor methods for both detection and localisation. On the challenging, widely used MVTec anomaly detection benchmark, PatchCore achieves an image-level anomaly detection Auroc score – a metric for classifying a model's performance – of 99.6 per cent, more than halving the error compared to the next best competitor.

It's scalable and a lot more sample efficient too, according to Roth, and can match the previous state-of-the-art methods with as little as three per cent of the training data.

Roth presented the work at the Computer Vision and Pattern Recognition (CVPR) conference in June 2022.

Memory bank subsampling

One of the keys to PatchCore's performance is the subsampling method Roth used – coreset subsampling rather than random subsampling – to trim the memory bank. Coreset subsampling, unlike random subsampling, aims to retain overall coverage of the feature space in the memory bank.

PatchCore's network will generate a feature representation for different locations in an image, which it then dumps in a memory bank. The danger is the memory bank gets very large very quickly, and so subsampling is used to keep its size manageable.

The problem with random subsampling is there's the potential to drop rarely occurring feature sets. This is not the case for coreset subsampling. Speaking to *Imaging and Machine Vision Europe*, Roth explained: '[Using coreset subsampling] we are able to reduce the memory bank significantly with minimal drop in performance. This makes approaches that operate on this memory bank significantly – by orders of magnitude – quicker than ones that operate on the big memory bank, but without a drop in performance.'

EMVA

Karsten Roth (left) receiving the award from Chris Yates, EMVA president

Test images are then compared to the feature sets in the trimmed memory bank. If the feature is significantly different from the ones in the memory bank, it's likely to be a defect.

'The result is a method that has only ever seen normal data but, when you apply it to test data, it is able to very accurately detect defects for all kinds of data and products,' Roth said.

> **'It's very nice to receive this award… because it was research that was built around practical needs'**

The MVTec anomaly detection benchmark gives 15 different anomaly detection tasks, with the final performance as an average across all the tasks. For each of the 15 anomaly detection tasks, PatchCore achieves above 90 per cent Auroc with just five images of normal data; 15 images gives more than 95 per

cent Auroc. After that there's a diminishing return, in that the method needs a lot more to bridge the last few per cent. But even so, PatchCore's returns are a lot less diminishing than comparable methods, Roth said – the comparisons were made against SPADE and PaDiM.

Roth said the method has already been used in practice for anomaly detection on solar cell electroluminescence images. He also noted that the method has been replicated, meaning the concepts hold true beyond a specific implementation.

'It's very nice to receive this award for this work because it was research that was built around practical needs... instead of making the method complex and convincing from an academic point of view,' Roth told *Imaging and Machine Vision Europe*. 'We wanted something that works well in practice first, and then tried to convince the academic community of its merits.

'There tends to be some disconnect between what industry needs and what academia publishes,' he continued. 'We were able to find a niche by going from application needs first to academic publication.'

The fact the work was accepted for CVPR shows its academic merits too.

Roth said the code was written in a way that is scalable to the hardware the user has available. But, he added, 'if you have a GPU you can make use of it really aggressively.'

'We have extended PatchCore with a lot of computation tricks to run on a GPU, and if we do all of these tricks things are even faster,' he said.

Roth is still optimising the code base. He said he's looking to potentially develop the method for 3D anomaly detection.

The Explainable Machine Learning group at the University of Tübingen is part of the International Max Planck Research School for Intelligent Systems (IMPRS-IS) and the European Laboratory for Learning and Intelligent Systems (ELLIS). Roth is co-supervised by Zeynep Akata at the University of Tübingen, and Oriol Vinyals, a research scientist at Deepmind.

Roth completed both Bachelor and Master studies in Physics at Heidelberg University in 2021, and spent time in Canada as a researcher at the Montreal Institute for Learning Algorithms and the Vector Institute in Toronto.

The EMVA Young Professional Award honours outstanding work by a student or a young professional in the field of machine vision or image processing. The award encourages students to focus on machine vision challenges and to apply the latest research in computer vision to the practical needs of the industry.

The 2023 EMVA business conference will be held in Seville, Spain; the EMVA will celebrate its 20th anniversary there.

Design security into cameras, says consultant

As factories get smarter, cybersecurity in vision sensors is now more important than ever, writes Chainstep's Mark Hebbel

The security of IoT devices is always a last thought in new markets. It is important to get the functionality working first across the AI, the network connection, the processing and the image capture. Without this functionality, there is no point in having a secure system. But at some point the system is so functional that hackers are able to gain access to information owned by the company or their customers.

Unfortunately securing a modern-day system is a lot of work. In this article, I'll cover some of the misconceptions I sometimes hear from colleagues and friends in the industrial machine vision space when thinking about device security. I'll look at some of what should be considered when implementing IoT security measures – not an exhaustive list, but something that offers insight into the scope of the undertaking. I'll also touch on the future of security in industrial IoT (IIoT), namely through mathematically encrypted blockchain technology.

'I'm okay just using commercial software'

Often heard but it is not true! You cannot simply outsource the security topic without binding it into a concept (more about that later). A survey[1] of COTS vendors – well-known companies such as ABB, Arm, Bosch, Huawei and Intel – showed regrettable statistics: 25 vulnerabilities are detected per device; 60 per cent have vulnerable firmware and user interfaces; 70 per cent do not encrypt any communications at all; and 80 per cent fail to request a password for authentication that has a secure length: not a good basis for a secure system. Are these companies providing basic products that are then built into your products with more code and likely more vulnerabilities?

'No one can find my device'

One argument given to support not improving security on the device is that the device is not discoverable – security through obscurity. There are so many things connected to the internet, many people think their devices will be lost in the sea of other devices.

Unfortunately, this is not true. Shodan.io is known as the google of IoT. With it, you can quickly find any IoT device connected to the internet by searching for keywords. Try it out by searching for your own devices. You might be surprised by what you find and how much information is open to the world.

The classic machine vision architecture

The classic architecture of a machine vision system is normally a row of simple sensors feeding information to a central PC, which itself processes and then outputs to a database. The connections to the PC are direct and non-standard, and the connection to the database is usually one-way.

With only one hackable PC, the security requirements are straightforward: secure

VS148/Shutterstock.com

this one box. This is normally done by the IT department of the company installing the PC. But architectures are changing and the sensors are becoming smart and full of programmable components. This means each sensor must be protected as should, normally, the connecting protocols.

Modern architecture with firewall

Modern architectures often have smart sensors connected together in a network, with maybe several processing devices in the network. They often have a bi-directional connection to the cloud to send data and to receive software updates. All these individual sensors and processing devices can be hacked and have to be secured. With multiple devices, the chances of missing something goes up. In addition, the cloud connection has to be secure.

Often the entire system is inside the customer's firewall. Many people see this as justification for not having to do anything about security for individual smart sensors, as these are all hidden behind the firewall.

This is, of course, wrong. If the attacker manages to get spyware inside the firewall on any device – for instance, by using an automatic update running over an unsecure server in the cloud – then suddenly the entire system is accessible. In February 2022, the US government released a Federal Strategy implementing a 'zero trust' network as a security measure to stop this line of attack. The strategy states that all objects in the network must be secure in case the network firewall gets penetrated.

Building blocks of IoT security

For security to be taken seriously, hardware, software and data must be considered together. Hardware needs a secure boot mechanism, a trusted platform module and, of course, where possible, physical security. Software through the secure boot launches into a secure OS, with a secure communication stack, closed ports and a firewall. Data stored on the device and in transit must be encrypted and securely hashed to →

→ make sure it has not been tampered with.

Security for a decentralised system is much more complicated than for a single PC. Challenges include algorithmic complexity – the sheer number of units – audit trail and decentralised ownership. The list of challenges gets longer for IoT, with difficulties in implementing access control while keeping the usability, systems being optimised for time-to-market or cost, and a lack of accepted standard between manufacturers. On top of this, topics such as human safety in process control, data storage locations and industrial sabotage are all relevant for industrial IoT. The list of considerations is much longer and continues to grow.

This is not meant to demotivate, but to encourage you to see this as an ongoing design issue for a product portfolio, and not just an extra feature to shoehorn in somehow. I recommend building a cross-portfolio cybersecurity team for products. Getting this team to work with the experts in IT is also beneficial, although this can be tricky since, in most organisations, the IT department normally has nothing to do with the engineering department or those involved in building products.

The future and where machine vision is special

Most security measures rely on a unique ID. This ID is then used to generate a private/public key pair, which is then the basis of all encryption and hashing functions. This

> ‘I recommend building a cross-portfolio cybersecurity team for the products’

ID has to be unique and, if possible, only reproducible by a certain hardware function, so that the device cannot be replicated. This stops the attacker making a fake device with the same ID, finding a way to intercept traffic or producing fake traffic on the network.

One potential security measure in modern chips is the physical unclonable function (PuF). This hardware-based approach comes from quantum effects in the silicon of the chip, created during the production process. Another possibility is the sensor fingerprint from a vision sensor in a machine vision camera. These are created the same way as PuF and could be used as the basis of encryption. This provides extremely strong encryption for any vision-based system.

This ID can then be read out and distributed. Most proprietary systems for fleet management currently use hidden databases controlled by one company, which do not encourage distributed systems made up from the products of different companies. The concept of a globally decentralised identity brings blockchain technology to the rescue. With it, a globally accessible store of IDs and associated services can be produced, which is unchangeable thanks to high-end mathematical cryptography used in securing the chain. Such systems are being tried out by Chainstep in the Gaia-X research projects funded by the European Commission. The collaborative project involves large names such as Bosch, together with modern blockchain companies, including Iota and Ocean.

Conclusions

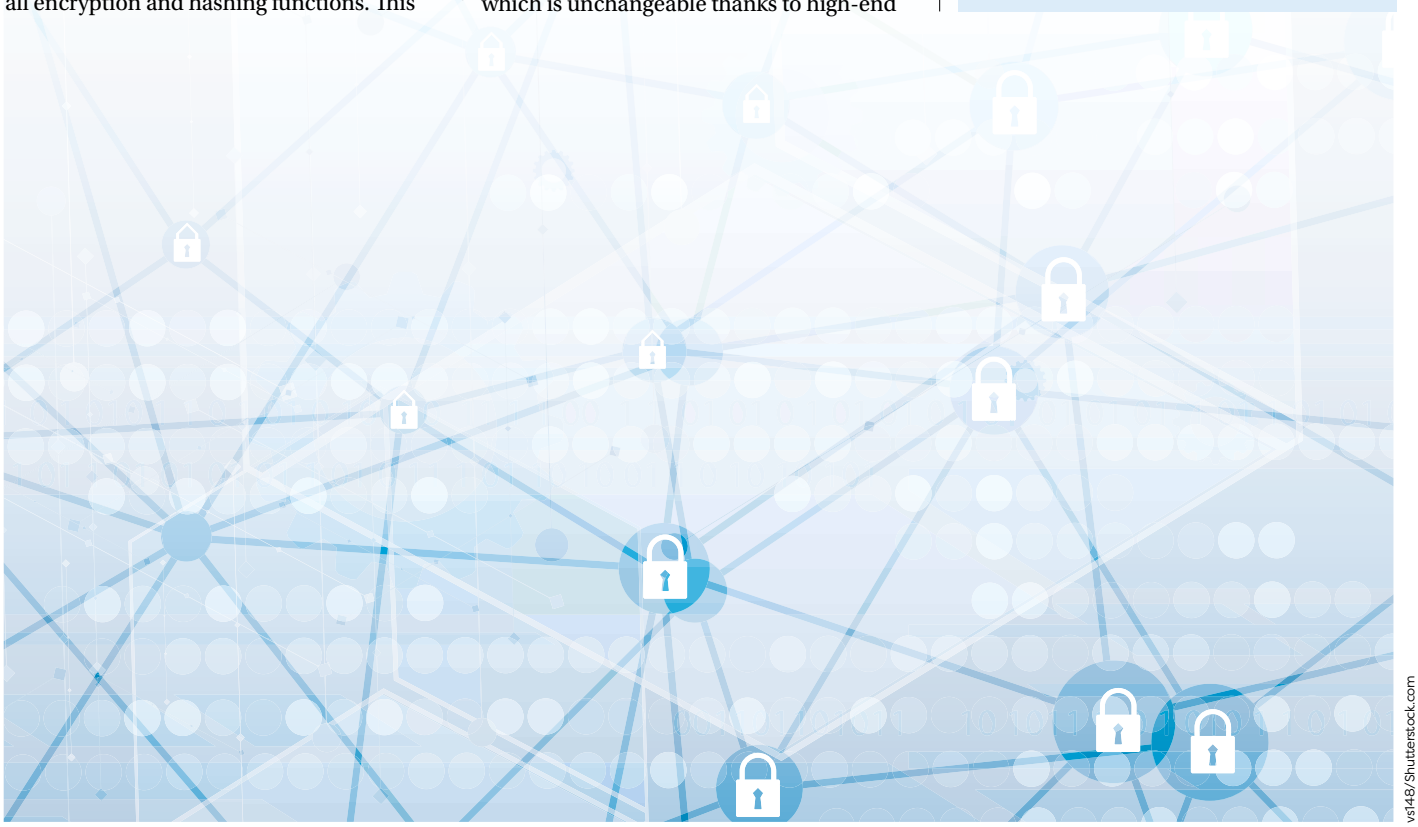
Cybersecurity is a topic that has become more important in a politically unstable world, where the number of ransomware attacks increases every year. IoT devices are also susceptible to attacks, and may be used in these attacks. An IoT device in a smart factory that is subject to an attack could paralyse production and cost the company dear.

In summary, cybersecurity is a race and continues indefinitely – just building in security as a feature is not enough. It must be continuously improved and updated for all products.

Chainstep, based in Hamburg, consults and builds trust, security and identity solutions with blockchain and self-sovereign identity technology in B2B. **Mark Hebbel** is head of consultancy at the firm.

Reference

1. Butun, I., Österberg, P., Song, H.: Security of the internet of things: vulnerabilities, attacks and countermeasures. IEEE Commun. Surv. Tutorials (2019). https://doi.org/10.1109/COMST.2019.2953364



vs148/Shutterstock.com

Quantum dots to spark new SWIR wave

Imec's **Paweł Malinowski** on the breakthroughs happening in SWIR imaging

Acquiring information in the shortwave infrared (SWIR) wavelength range has been for decades limited to niche applications. SWIR is used in the military, to identify targets in adverse lighting conditions, for instance; in machine vision, such as in solar cell inspection; and in scientific and space systems. These are typically high-end applications with a cumulative annual number of units sold in the tens of thousands globally.

SWIR cameras are traditionally based on focal plane arrays, with a resolution rarely exceeding 1 megapixel, and a pixel size an order of magnitude larger than what's found in CMOS image sensors (CIS) used in consumer devices – a typical pitch in a SWIR detector is 15-20µm versus sub-micron pixels for CIS. Imagers are made by hybrid bonding detector chips based on III-V materials – usually InGaAs, sometimes HgCdTe – to the readout chip using solder bump connections and die-to-die flip-chip techniques. All those elements in the fabrication process result in a very high price point for these sensors, easily exceeding several thousand euros per chip.

A recent innovation reported by Sony in 2019 uses Cu-Cu bonding of an InGaAs detector chip, which resulted in scaling down the pixel pitch to 5µm. The IMX990 and IMX991 chips are finding their way into more and more products, especially in machine vision, as they enable not only higher image quality, but also easier integration. Even with a premium price point, this sensor family opens up SWIR imaging to new use cases.

A technology that promises to lower the implementation barrier even further are SWIR sensors based on thin films, with quantum dots playing the lead role as a new type of absorber. The technology has been investigated for almost two decades; the first academic papers were published at the beginning of the 21st century by Professor Sargent's group at the University of Toronto, with pioneering work since then.

Now, the first products are being brought to market. Emberion announced its VS20 camera with a broad spectral range, from 400 to 2,000nm. Meanwhile, SWIR Vision Systems offers its Acuros series of cameras, with the highest SWIR resolution on the market (1,920 x 1,080 pixels). These are disruptive products in the infrared imaging field and prove the maturity of quantum dot technology is sufficient to deploy commercial products.

> 'ST's announcement… should reassure the industry that quantum dot image sensors are a credible technology'

In parallel, research centres such as Imec continue to explore the QD pixel stacks, readout architectures, and the integration process to improve performance and enable upscaled fabrication. At the same time, new application fields are opening up for end users that didn't consider SWIR imaging before because it was simply beyond their reach, in terms of cost but also size and complexity.

In 2019, Imec presented a 5µm pixel pitch QD SWIR image sensor, and in 2020 topped that with a 1.82µm proof-of-concept device – both state-of-the-art pixel density for SWIR image sensors at the time of introduction.

At the 67th International Electron Devices Meeting (IEDM) at the end of 2021, the tone-setting event for the semiconductor industry, STMicroelectronics announced QD image sensors. The 1.62µm pixel pitch sets a new record, and the external quantum efficiency of 60 per cent at 1,400nm inches ever closer to the values found in the incumbent technologies.

The most exciting feature is that these results come from chips fabricated using a 300mm wafer platform – this means that the QD technology has made significant strides in making it ready to manufacture. Upscaling to a wafer-level process promises extraordinary throughput and thus cost evolution. New sensor products based on this process will disrupt the market further, and act as a critical enabler for SWIR imaging in applications that never considered it before, including consumer products.

Imaging in the SWIR range offers features such as improved eye safety for devices using laser light like lidar – eye sensitivity to radiation at wavelengths above 1,400nm compared to 940nm is around six orders of magnitude lower – as well as for low-light imaging and cameras that can see through adverse weather conditions.

Looking forward, there are still technological challenges to address. Moving away from lead sulphide-based QDs to lead-free material systems will encourage more players to accept this type of sensor. Improving deposition throughput of the quantum dot layers by going to one-step coating – instead of the standard layer-by-layer coating used currently to achieve the desired final thickness of the absorber – will significantly increase the takt time in volume production.

Moreover, thorough investigation of reliability metrics according to industry standards will set further iterations of QD improvement to optimise long-term stability, and enable even the most harsh applications such as those demanded by the automotive sector.

STMicroelectronics' announcement in this space should reassure the industry that quantum dot image sensors are a credible technology with excellent potential that can be upscaled to manufacturing in semiconductor foundries. This should fuel further investment in research of these fascinating devices, and spark a new wave of applications for more accessible SWIR camera systems.

Paweł Malinowski is program manager at Belgian R&D institute, Imec. He has more than 10 years' experience in developing photonics technologies, and is currently working in the thin-film electronics group of Imec.

Industry puts faith in quantum dot SWIR

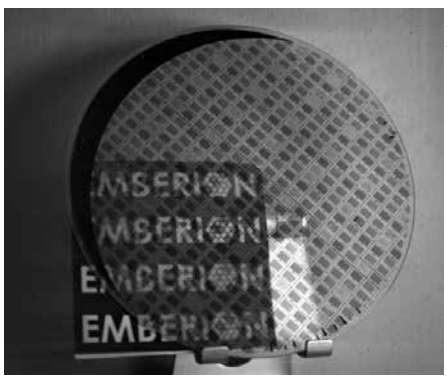
What does the future hold for nanomaterial SWIR sensors? We ask Emberion's CEO and CTO, **Jyrki Rosenberg** and **Tapani Ryhänen**

Emberion's CTO and co-founder, Dr Tapani Ryhänen (left)

Why is there so much excitement about nanomaterial SWIR imagers?
Rosenberg: 'We're pleased with the faith the industry has put in us [through €6m funding Emberion raised at the start of 2022]. Our investors see this technology as having wings and really being able to change the market. There are two main reasons: one is that [nanomaterial SWIR sensors] provide better performance than traditional technologies like InGaAs in terms of having, for example, wider bandwidth range – our imager is sensitive from 400nm to 2,000nm, but future generations will go beyond that. Secondly, we can do it at an affordable cost.'

Ryhänen: 'The reason why this technology is so interesting is that it's highly scalable. You are really able to create a different type of device – one with small pixels – with a colloidal quantum dot image sensor. That leads to low-cost, high-resolution devices. In addition, the technology can create imagers that can be produced in high volumes. That is where current III-V semiconductor InGaAs sensors have their limits – the technology is harder and more expensive to scale.

'We have a fabrication site in Cambridge, UK, based on semi-automated production, and will be investing in that to scale up production.'



Emberion

A silicon wafer, which is transparent in the SWIR region, captured with Emberion's VS20 Vis-SWIR camera

Where are you seeing most interest in your technology?
Rosenberg: 'We have chosen to focus mostly on industrial machine vision and surveillance at this time, and that's where we see the greatest demand from our customers. Medical imaging and self-driving cars are other potential areas.

'In the industrial space, we've had interest from customers involved in plastic sorting, and recycling more broadly. Food inspection is another area that benefits greatly from SWIR imaging, and we're getting lots of interest from customers across the food production value chain.'

> **'We're already at the point where the market will start to shift [towards buying quantum dot SWIR sensors]'**

What performance gains can you get with this technology?
Ryhänen: 'The performance of an image sensor is the sum of many different things; noise performance and sensitivity are one element of that. At the moment, characterising our device performance, we can say we have extremely good image quality and we have very high dynamic range compared to InGaAs, which means we can get good signal-to-noise ratio for dark objects in the image while also seeing bright objects. The images look really good compared to InGaAs images.

'We are on a par with other quantum dot SWIR imagers on the market in terms of quantum efficiency (QE). QE depends on the wavelength you're working at; when you extend the wavelength range you get lower QE. We have more than 80 per cent QE for visible light, but the same sensor will give a bit over 20 per cent QE at 1,850nm. It depends on the wavelength at which the sensor is working.'

Why are these sensors more affordable than InGaAs?
Ryhänen: 'InGaAs is built from two different devices, a CMOS ROIC and a pixel array. When you build the photosensitive part, you start with an expensive indium phosphide wafer; then there's an expensive process of building the different layers with molecular beam

Emberion

Surveillance image taken with Emberion's VS20 Vis-SWIR camera


Emberion

epitaxy. Plus, these two wafers need to be aligned and bonded together, and this bonding process is extremely complex and there are yield issues. It's a complex process that's very expensive.

'What we do, we take a CMOS wafer with all the electronics and we monolithically add material on top, using thin film processes and spin coating. We have just one substrate on top of which we layer the material. The starting point has a cost benefit compared to InGaAs, but also it leads to scalability; we can scale the pixel area and we can fabricate smaller or larger pixels with greater ease depending on the requirements of the customer.'

What will you be working on in the near future?

Ryhänen: 'Firstly, we are investigating nanomaterials to extend our wavelength range. We are working on midwave infrared sensing technology, to add that to the visible and SWIR imagers already in our portfolio. That's one area of investment. And all the time when working with the material we are targeting higher performance, such as higher quantum efficiency.

'A second area is further developing our integrated circuits. Here, we have a clear roadmap towards higher resolution, to megapixel devices.

'Thirdly, we are working on lower cost and miniaturised packaging that will enable new types of application. At the moment we package the device in a robust way so that it's reliable and tolerates rougher environmental conditions. But new packaging will open up new use cases.'

Rosenberg: 'We have shipped products to customers that have started testing and evaluating, and we expect further demand from them. We want to be ready this year to increase production capability to meet this demand.

'We're investing in scaling up production, commercialising our current imagers, and continuing to develop future generations of devices. We do see adoption to be further increased by extending the capabilities of the devices. However, we're already at the point where the market will start to shift [towards buying quantum dot SWIR sensors].'

Dr Tapani Ryhänen is CTO and co-founder of Emberion. Before establishing Emberion he led Nokia's research and development of sensor and material technologies. He has also worked at Vaisala Technologies, the Technical Research Centre of Finland (VTT), and at Aalto University.

Jyrki Rosenberg, CEO of Emberion, has more than 20 years' experience in the technology sector. He led F-Secure's B2B cyber security product business, was the CEO of a digital music service, and held a number of senior roles in sales, marketing, product development and general management at Nokia.

Legal framework to shape interpretation of standards

The European Machine Vision Association has written a new set of policies for machine vision standards, designed to protect IP among other aspects. EMVA's standards manager, **Werner Feith**, explains the changes

Werner Feith

How is the role of standardisation changing?
Allow me to open with a general remark that the main motivation for all standardisation efforts in any industry is to create a benefit for the end user. This is the reason why, in machine vision, even fierce competitors decided two decades ago to work together on standards. This has been an enormous success and standards have laid the foundation for the adoption of machine vision in so many verticals.

Since then vision technology has matured. In addition, technical developments are now often triggered from outside of the core machine vision community: 'AI' and 'embedded' are the most prominent examples. The EMVA has realised that, over the past 20 years, standardisation has grown organically, but a legal framework has not kept pace with standards development.

How has the EMVA reacted to this?
Intellectual property is an important aspect of standards development within the EMVA and the working groups, where many experts contribute know-how, code and maybe even patents to create the final standard. It is important for companies involved in developing a standard to have a clear legal basis for contributions. Similarly, companies that hold relevant patent IP should not have their rights reduced through participation in a standard's development.

The EMVA's new set of policies provides a clear legal framework for all contributions to a standard, together with any reference- or standard-testing implementations. At the same time, the policies clarify the rights and responsibilities of the working groups hosted by the EMVA.

Additional important aspects of the new policies include the commitment to ensure companies that contribute to standards and which hold necessary patents for the standard are prepared to issue Royalty-Free, Fair, Reasonable and Non-Discriminatory (RF-FRAND) licenses to users of the standard. This ensures that company IP is protected without creating barriers to adoption. The new policies suggest a nominated group, representing both the EMVA and the working group, manage and licence the IP encapsulated in reference implementations, to protect the IP of the parties involved.

What other aspects play a role in designing these new rules?
There is also a political aspect. It is important to understand how the evolution of global standards development could affect the industry, while also seeking practical approaches to ensure the successes of the past continue. This is particularly important in a European context, as EU companies have had a lot of advantages over the last few decades – the Made in Germany label, for example, is still recognised for innovation and reliability all over the world.

It's in this context that the role of standardisation in machine vision is entering a new period of evolution. Key commercial concerns such as liabilities, IP rights and protection, and ownership of contributions to standards, as well as keeping standards free of potential licence fees, should be addressed in a professional licence framework.

Additionally, standards play an important role in an increasingly connected world, and leadership in standards development is playing a more geopolitical role. One example that occupies the standards community is that China has published a standards 2035 roadmap, which outlines a strategy to make the country a leader in standards development, including building its own set of standards in key technologies. This could be a potential threat to all common global standardisation activities and build market barriers to outsiders that want to do business in China.

As it stands, a large number of national standards in China already have no reference to international standards. This is something we as a relatively small machine vision community have to take into consideration. We have to protect contributors, users and EMVA IP rights,

while at the same time doing everything to maintain market access for European machine vision players to all parts of the world.

What is the background behind users of the EMVA 1288 standard being asked to relicense?
This is part of the new set of rules, but also, with release 4.0 of EMVA 1288, the EMVA granted a transition period of one year for relicensing that expired in June. Therefore, since 21 June, datasheets in which data is designated as EMVA 1288-compatible and marked with the EMVA 1288 logo may only be published if the new EMVA 1288 licence has been applied for and approved by the creator of the datasheets.

I want to point out that use remains free of charge under the new licence, as it has been for the last 17 years. The aim is to have control over how the standard is used such that only those parties using the standard in the proper technical and legal sense are guaranteed by the licence.

Do you require something similar for GenICam?
Not exactly. The general conditions for participation in the GenICam standard working group have changed within the new legal framework, which requires a re-registration for all participating company representatives. Being the host association of the GenICam working group, the EMVA adjusted the conditions to those already established in standard working groups hosted by other associations. This involves a small fee for working group members. However, use of the GenICam logo, as well as the reference implementation, remain free of charge under the new licence, as it has been for the last 19 years.

All necessary application forms for relicensing can be found in the standards section of the EMVA website. These two measures for EMVA 1288 and GenICam are part of the implementation of the new standards development policies. In the forthcoming period, all current members of hosted working groups will reapply for working group membership and, through this action, will be protected by the newly adopted development policies. And there are more actions to come.

Can you specify these actions?
One major benefit of having standards is the compatibility of the services and products among those who use the standards. As such, it is the responsibility of the hosting institution to keep and maintain the compatibility level. The longer a standard is used in the market and developed, the more important this issue becomes. For GenICam we intend to implement a GenICam validation framework, where every user is validated to reconfirm the standard criteria and thus the technical compatibility of the product. This validation process will be implemented later in 2022 and through the next GenICam meetings.

Last year, the EMVA and the Khronos group joined forces to develop an open, standardised embedded camera API. How has this progressed?
A very interesting aspect of this collaboration is that two different communities have been brought together. While many machine vision companies have a strong background in industrial automation, the Khronos group represents platform players, chip providers, as well as companies operating in diverse areas such as consumer devices, medical, AR/VR, and automotive technology.

We are happy to announce that an exploratory phase has been completed and a standard working group has been established with Khronos. Currently the working group consists of 71 people representing 43 companies and institutions. The cooperation between EMVA and Khronos will continue throughout the design phase, as a formal joint initiative of the two organisations. Importantly, this means the EMVA is able to participate directly in the working group, as well as influence design development and contribute to the new standard.

This entire process represents a major new direction for standardisation in embedded vision through cooperation between leading associations and their members. The EMVA has paved the way for its members to take part in the biggest effort on embedded vision standardisation of the last decade.

sutadimages/Shutterstock.com

Suppliers' directory

A pick of the key suppliers of vision-related products and services
www.imveurope.com

Alkeria

Via Giuntini, 25 int. 36
I-56021 Cascina (PI) – ITALY
Tel. (+39)050-778060
Fax (+39)050-769112
www.alkeria.com

For more than 20 years, Alkeria has been developing and manufacturing high-performance USB3 machine vision cameras for life-science and industrial applications. Our expertise gained with OEM projects continues today within our camera range: long-time experience with image processing; great competence on motion control and vision synchronization; continuous and direct customer support. All these values allow Alkeria to offer a wide range of performant and versatile machine vision cameras, also tailored to our customers' needs.

➤ Accessories ➤ Cameras

AT – Automation Technology GmbH

Hermann-Bössow-Str. 6-8
26843 Bad Oldesloe, Germany
Tel. +49 4531 / 88011 0
info@automationtechnology.de
www.automationtechnology.de

AT – Automation Technology is a global technology leader in the field of special imaging sensors. We develop and produce intelligent infrared cameras, high-precision 3D sensors and unique sensor components that are used in industrial process automation, monitoring and inspection tasks worldwide. With over 20 years of application experience in a wide range of industries we offer innovative products that are optimally tailored to practical applications and are reliable to the highest degree.

➤ Cameras ➤ Complete vision systems ➤ Sensors
➤ Lasers for machine vision and inspection

Basler AG

An der Strusbek 60-62
22926 Ahrensburg, Germany
Tel: +49 4102 463 500
sales.europe@baslerweb.com • **www.baslerweb.com**

Basler is a leading international manufacturer of imaging components for computer vision applications such as cameras, lenses, frame grabbers, software as well as embedded vision solutions, customized products and consulting services. The products are used in a variety of computer vision markets, including factory automation, medical, traffic, logistics, retail, and robotics. Founded in 1988, the Basler Group employs approximately 1000 people at its headquarters in Ahrensburg and other locations in Europe, Asia and North America.

➤ Cameras ➤ Frame grabbers ➤ Complete vision systems ➤ Accessories
➤ Illumination ➤ Lenses ➤ Software

BitFlow, Inc.

400 W Cummings Park,
Suite 5050,
Woburn MA
01801 USA
Tel: +1 781 932 2900
Fax: +1 781 933 9965
sales@bitflow.com • **www.bitflow.com**

Since 1993, BitFlow has been developing industrial frame grabbers and software for machine vision. We specialize in interfacing to cameras with very high data/frame rates; working in environments with complex triggering and I/O requirements; and running in applications where every CPU cycle is precious. Choose the best. Choose BitFlow.

➤ Accessories ➤ Frame grabbers ➤ Software

Chromasens GmbH

Max-Stromeyer-Str. 116
78467 Konstanz
Germany
Tel: +49 (0) 7531 876-0
sales@chromasens.de • **www.chromasens.com**

Chromasens is part of TKH Vision group and a leading and innovative line scan technology expert with strong customizing capabilities for machine vision solutions. Chromasens high performance cameras and lighting systems are built on a fully customizable modular line scan vision platform and are used for image capture and image processing systems in 2D, 3D, mono, RGB, UV, IR and SWIR for acquisition, analysis, reproduction and measurement purposes in high speed inspection applications.

➤ Cameras ➤ Complete Vision Systems ➤ Illumination

Components Express, Inc.

10330 Argonne Woods Drive, Suite 100
Woodridge, IL 60517-5066
Tel: +1 630-257-0605 • **Fax:** +1 630-257-0603
info@componentsexpress.com • **www.componentsexpress.com**

For over 30 years Components Express, Inc. has continuously – Challenged the Limits of Performance, as a leading manufacturer of cable assemblies, IP67 rated camera enclosures and accessories for Vision and Industrial applications. Industrial M8 / M12 cables that are UL / CE compliant along with IP67 rated camera enclosures, mounts and accessories are the latest products to join the CEI's family. Camera enclosure accessories include: lens covers, air-curtains, light mounts, sun shades and pneumatic window shields. CEI's Vision cables for: Camera Link, GigE Vision, CoaXPress, USB3.0, Analog I/O, and Power Supplies. CEI is an ISO 9001 : 2015 certified organization.

➤ Accessories

Edmund Optics

Unit 1, Opus Avenue, Nether Poppleton,
York, YO26 6BL, UK
Tel: +44 (0)1904 788600
Fax: +44 (0)1904 788610
sales@edmundoptics.eu • **www.edmundoptics.eu**

Edmund Optics is a leading global manufacturer and supplier of precision optics, optical assemblies and imaging components. EO provides complete imaging solutions with a large product line, technical expertise, manufacturing capabilities, technical support, and assists customers to maximize the performance of their imaging system. From stock items in the catalogue to customized versions from design, development to serial production of imaging lenses: "EO - Your Partner in Imaging Optics!"

➤ Accessories ➤ Cameras ➤ Illumination ➤ Lenses

Euresys SA

Liège Science Park
Rue du Bois Saint-Jean, 20
4102 Seraing - Belgium
Tel: +32 4 367 72 88
sales.europe@euresys.com
www.euresys.com

Euresys is a leading and innovative high-tech company, designer and provider of image and video acquisition components, frame grabbers, FPGA IP cores and image processing software. Euresys is active in the computer vision, machine vision, factory automation and medical imaging.

➤ Frame grabbers ➤ Software

Excelitas PCO GmbH

Tel: +49 9441 2005-0
Fax: +49 9441 2005-20
info@pco.de
www.pco.de

PCO - "Pioneer in Cameras and Optoelectronics"

With over 30 years of expertise and experience, Excelitas PCO GmbH has positioned itself as a leading specialist and innovator in digital camera technology used in scientific and industrial applications worldwide. The company's innovative and competitive strength is continuously enhanced through constant development of the proprietary hardware and software.

➤ Cameras

Frankfurt Laser Company

An den 30 Morgen 13
D-61381 Friedrichsdorf, Germany
Tel. +49 (0) 6172 27978-0
sales@frlaserco.com • **www.frlaserco.com**

Frankfurt Laser Company (FLC) is a world leading supplier of FP, DFB and DBR laser diodes, SM individually addressable and broad area laser diode arrays, VCSELs and Quantum Cascade lasers and incorporating these products into- laser diode modules free space and fiber-coupled, diode-pumped solid-state frequency-doubled lasers and OEM modules. Our products cover 266nm to 12µm wavelength and 5mW to 750W power range. FLC supplies superluminescent diodes in visible and IR from 650nm to 2300nm and mid-IR LEDs in 1.2µm-4.0µm range. To complement the main line of products FLC can also supply SMT laser diode drivers and collimator optic, line generator optic, laser diode headers and caps, laser diode die.

➤ Lasers for machine vision and inspection

JAI A/S

Valby Torvegade 17, 1st Floor
DK-2500 Valby, Copenhagen
Denmark
Tel: +45 4457 8888 • **Fax:** +45 4491 3252
camerasales.emea@jai.com • **www.jai.com**

For more than 50 years, JAI has supplied industrial area scan and line scan cameras for machine vision, traffic imaging and life sciences applications. JAI has a long, proven track record of delivering cameras with innovative engineering, high-end quality, and long lasting operational reliability and durability. The camera range includes a wide selection of single sensor cameras from two to 45-megapixel resolution as well as a series of prism-based multi-sensor cameras for simultaneous visible, NIR and SWIR imaging.

➤ Cameras

JARGY CO., LTD.

3F, No. 266, Sec. 3, Pei-Shen Road,
Shen-Keng District
New Taipei City, Taiwan
22241, R.O.C.
Tel: +886-2-2662-5200
Fax: +886-2-2662-9162
sales@jargy.com.tw • **www.jargy.com.tw**

Established in 1987, Jargy has been devoted to the development / manufacture and export of connector (s) & cable and USB Hub / Card Reader / keypad assemblies for PC and Mac use. Excellent quality,compact design, timely delivery,competitive pricing and value-added services are the main factors for our success in the toughest market in the world.

➤ Accessories

Kowa

Fichtenstr. 123
40233 Duesseldorf
Germany
Tel: +49 211-542184-0
Fax: +49 211-542184-10
lens@kowaoptimed.com
www.kowa-lenses.com

With more than 70 years of experience in manufacturing state of the art optics Kowa has established itself as a maker of high quality machine vision lenses. Kowa has been gradually expanding its portfolio of multi-megapixel C-mount lenses, telecentric lenses and large format lenses. For specific cases in which the requirements go beyond standard lenses, Kowa offers customized solutions.

➤ Accessories ➤ Lenses

Laser Components (UK) Ltd

Tel: 01245 491499
Fax: 01245 491801
info@lasercomponents.co.uk
www.lasercomponents.co.uk

We are a global, family-run company employing about 280 people in three manufacturing sites worldwide. Our range includes components for the creation, guidance and detection of light - everything optoelectronics-related at the components level. We serve a range of industries such as the laser industry, medical, military, machine vision and automotive. As a manufacturer and distributor for our partner suppliers, we specialise in delivering custom solutions.

➤ Accessories ➤ Illumination ➤ Lenses
➤ Lasers for machine vision and inspection

LUCID Vision Labs GmbH

Renntalstraße 14
74360 Ilsfeld, Germany
Tel: +49 (0) 7062 97676 12
Email: sales.emea@thinklucid.com
Web: www.thinklucid.com

LUCID Vision Labs, Inc. designs and manufactures innovative machine vision cameras and components that utilize the latest technologies to deliver exceptional value to customers. Our compact, high-performance GigE Vision cameras are suited for a wide range of industries and applications such as factory automation, medical, life sciences and logistics. We innovate dynamically to create products that meet the demands of machine vision for Industry 4.0.

➤ Accessories ➤ Cameras ➤ Lenses ➤ Software

Macnica ATD Europe

2 - 6, rue Emile Pathé
Espace Lumière, Batiment 2
78400 CHATOU - FRANCE
Tel : + 33 (0) 1 30 15 69 70 • **Fax :** + 33 (0) 1 86 39 00 22
sales@atdelectronique com • www.atdelectronique.com/macnica

Following the acquisition of ATD Electronique by Macnica Inc. we now operate under the new name Macnica ATD Europe. Our team continues to provide the long established ATD services of image distribution and technical advice. Macnica ATD Europe offers image sensors (CCD, CMOS, InGaAs, Thermal), optics, interface circuits, imaging processors, cables and M-OLED displays. As Macnica ATD Europe we look forward to continue our trusted distribution partnership with key players in the machine vision industry.

➤ Consulting Services ➤ Illumination ➤ Lenses ➤ Sensors ➤ Software

MATRIX VISION GmbH

Talstrasse 16
71570 Oppenweiler, Germany
Tel: +49 7191 94320
Fax: +49 7191 9432 288
sales@matrix-vision.com
www.matrix-vision.com

Since 1986 MATRIX VISION GmbH develops components and customized solutions for industrial image processing and is one of the leading companies in this field. The focus is on the distribution of digital, smart and 3D cameras for various sectors of manufacturing and non-manufacturing industries. By belonging to the Balluff family, customers benefit from a global sales and support network and, first and foremost, from the synergies of two market leaders.

➤ Accessories ➤ Cameras ➤ Consulting services ➤ Illumination ➤ Lenses ➤ Software

Matrox Imaging

1055 St-Regis Blvd. Dorval,
Quebec, Canada, H9P 2T4
Tel: +1 800 804 6243
imaging.info@matrox.com • www.matrox.com/imaging

Matrox® Imaging is an industry-leading developer and trusted supplier to top OEMs and integrators in the machine-vision market. Innovative products consist of 3D sensors, smart cameras, vision controllers, I/O cards, and frame grabbers, all designed to provide optimum price-performance within a common vision software environment. Their vision offerings are tailored for automotive manufacturing, factory automation, food and beverage production, semiconductor and electronics manufacturing, medical imaging, and pharmaceutical production, among other industries. Committed to offering cutting-edge technology, comprehensive technical consulting and integration services, and the highest manufacturing standards, Matrox Imaging's track-record assures customers their needs are always met—now and in the future.

➤ Software ➤ Cameras ➤ Sensors ➤ Frame Grabbers

Navitar

200 Commerce Drive
Rochester, NY 14623 USA
Tel: +1 585-359-4000
Fax: +1 585-359-4999
info@navitar.com • navitar.com

Navitar has been designing and manufacturing imaging lens systems and custom OEM solutions for over 60 years. Our years of optical and mechanical design experience, manufacturing capabilities, modular product lines and customer-centric approach set us apart from other imaging technology solution providers. From high resolution, large format zoom lenses to low magnification fixed focal length lenses for factory floor inspection, Navitar works with every customer to turn their idea into reality.

➤ Lenses

Opto Engineering®

Opto Engineering S.p.A.
Strada Circonvallazione Sud, 15
46100 Mantova – Italy
Tel: +39 0376 699111
press@opto-e.com • www.opto-e.com

Opto Engineering® has evolved through the years, releasing hundreds of new, diverse products and developing multiple areas of expertise. Today we can say that we specialize in OPTICAL IMAGING TECHNOLOGIES. Our focus is to build and provide every single component needed to solve imaging applications: starting from the optical know-how and going through competence in lighting, we can supply the best combination of tools available on the machine vision market: optics, lighting, cameras and software.

➤ Accessories ➤ Cameras ➤ Illumination ➤ Lenses ➤ Software

Sill Optics GmbH & Co. KG

Johann-Höllfritsch-Str. 13
DE-90530 Wendelstein, Germany
Tel: +49 9129 9023 0 • **Fax:** +49 9129 9023 23
www.silloptics.de

Sill Optics is a specialist for quality and innovation in the field of photonic technologies. We have established ourselves internationally in both customer-specific development and portfolio solutions and are one of the leading companies in this field.

The product range focuses on telecentric imaging lenses, portfolio lenses and telecentric condensers for illumination. In addition to high quality and flexibility, Sill Optics convinces with its own production and individual services. Sill Optics is often first choice for customized products, prototypes and small series.

➤ Lenses

Smart Vision Lights

5113 Robert Hunter Drive
Norton Shores, MI 49441
Tel: +1 (231) 722-1199
sales@smartvisionlights.com • www.smartvisionlights.com

Smart Vision Lights is a leading designer and manufacturer of high-brightness LED lights for industrial applications, including machine vision. The products come with universal internal current-control drivers, offering constant or strobed operation, reduced wiring requirements, and easy installation. Smart Vision Lights products are the safest on the market thanks to the company's in-house IEC 62741 light-testing laboratory, guaranteeing conformity and compliance for your lighting systems.

➤ Illumination

Subscribe for free*

IMAGING & MACHINE VISION EUROPE

Do you design and build imaging systems?

Read Europe's only dedicated magazine for design and production engineers working in the scientific imaging and machine vision markets

Do you subscribe?
Register for free now!
imveurope.com/subscribe

Also published by Europa Science

Subscribe for free*

Fibre Sytems – The leading publication for the optical communications industry
fibre-systems.com /subscribe

Electro Optics – The number 1 pan-European optics and photonics publication
electrooptics.com/subscribe

Laser Systems Europe – The magazine for integrators and users of laser systems
lasersystemseurope.com/subscribe

*Registration required

Theia Technologies

29765 Town Center Loop W Suite 4,
Wilsonville, OR 97070, USA
Tel: +1 (503) 370-3296
info@theiatech.com • **www.TheiaTech.com**

Theia Technologies delivers high-performance precision optics to meet the exacting requirements of machine vision, automation, robotics, intelligent transportation and other industrial imaging applications. Theia's patented Linear Optical Technology® lenses provide an ultra-wide field of view without barrel distortion, correcting distortion optically, without the use of software. Theia's 4k resolution lenses come with manual and motorized options for a variety of image formats and mounts. Theia's compact, multi-megapixel telephoto lenses are selected by companies worldwide for ANPR, LPR and ITS applications to provide high image detail in visible and NIR light. Theia also provides optical engineering and custom design services.

➤ Lenses ➤ Accessories ➤ Consulting Services

The Imaging Source Europe GmbH

Überseetor 18,
28217 Bremen, Germany
Tel: +49 421 335910 • **Fax:** +49 421 3359180
info@theimagingsource.com • **www.theimagingsource.com**

Established in 1990, The Imaging Source is one of the leading manufacturers of industrial cameras, video converters and embedded vision components for factory automation, quality assurance, medicine, science, security and a variety of other markets. Our comprehensive range of cameras and other innovative machine vision products are renowned for their high quality and ability to meet the performance requirements of demanding applications.

➤ Cameras ➤ Consulting services ➤ Frame Grabbers ➤ Lenses ➤ Software

TPL Vision

Unit 1, 2 & 3 Breadalbane Terrace, Perth PH2 0FD
Tel: +44 (0)1738 310 392
www.tpl-vision.com • **contact@tpl-vision.co.uk**

At TPL Vision, LED illumination is our world - and it's ALL we do. Our dedicated team combines imaging and design expertise with specialist application knowledge to help you easily identify the best lighting for your application, leaving you free to focus on your projects. Our LED illumination solutions feature in-built product modularity and flexibility for easier product selection and enhanced yet simplified user experiences.

Ideal for machine vision, robotics and traceability applications, TPL Vision's range includes illumination dedicated to the logistics, food & beverage, pharmaceutical and automotive markets. With headquarters in the UK, manufacturing & shipping from our modern European factory, and tens-of-thousands of installations around the world, TPL Vision is the perfect partner to select for your next machine vision project.

➤ Illumination

XIMEA GmbH

Am Mittelhafen 16
D-48155 Münster, Germany
Tel: +49-251-202408-0 • **Fax:** +49-251-202408-99
info@ximea.com • **www.ximea.com**

XIMEA designs and produces leading-edge, high-performance cameras with the fastest speeds and the smallest footprint, as well as highly optimized cameras and imaging solutions for volume OEM applications.

The portfolio is targeted towards industrial, hyperspectral, X-RAY, scientific-grade and high-speed applications as well as Multi camera systems.

The plethora of models are offered with CCD, CMOS and sCMOS sensors using USB and PCI Express (PCIe) interfaces in board level or housed versions, including cooled and customized options.

➤ Cameras

Suppliers
by industry sector

Accessories
Alkeria
Basler AG
BitFlow, Inc.
Components Express, Inc.
Edmund Optics
JAI A/S
JARGY CO., LTD.
Kowa
Laser Components (UK) Ltd
LUCID Vision Labs GmbH
MATRIX VISION GmbH
Opto Engineering®
Theia Technologies

Cameras
Alkeria
AT – Automation Technology GmbH
Basler AG
Chromasens GmbH
Edmund Optics
Excelitas PCO GmbH
LUCID Vision Labs GmbH
MATRIX VISION GmbH
Matrox Imaging
Opto Engineering®
The Imaging Source Europe GmbH
XIMEA GmbH

Complete vision systems
AT – Automation Technology GmbH
Basler AG
Chromasens GmbH

Consulting services
Macnica ATD Europe
MATRIX VISION GmbH
Theia Technologies
The Imaging Source Europe GmbH

Frame grabbers
Basler AG
BitFlow, Inc.
Euresys SA
Matrox Imaging
The Imaging Source Europe GmbH

Illumination
Basler AG
Chromasens GmbH
Edmund Optics
Laser Components (UK) Ltd
Macnica ATD Europe
MATRIX VISION GmbH
Opto Engineering®
Smart Vision Lights
TPL Vision

Lasers for machine vision and inspection
AT – Automation Technology GmbH
Frankfurt Laser Company
Laser Components (UK) Ltd

Lenses
Basler AG
Edmund Optics
Kowa
Laser Components (UK) Ltd
LUCID Vision Labs GmbH
Macnica ATD Europe
MATRIX VISION GmbH
Navitar
Opto Engineering®
Sill Optics GmbH & Co. KG
Theia Technologies
The Imaging Source Europe GmbH

Sensors
AT – Automation Technology GmbH
Macnica ATD Europe
Matrox Imaging

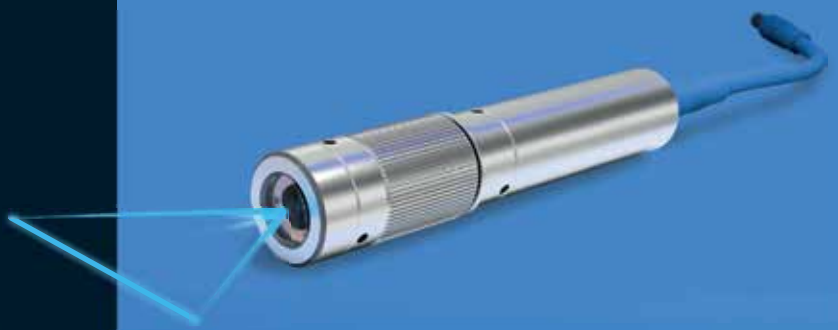
Software
Basler AG
BitFlow, Inc.
Euresys SA
LUCID Vision Labs GmbH
Macnica ATD Europe
MATRIX VISION GmbH
Matrox Imaging
Opto Engineering®
The Imaging Source Europe GmbH

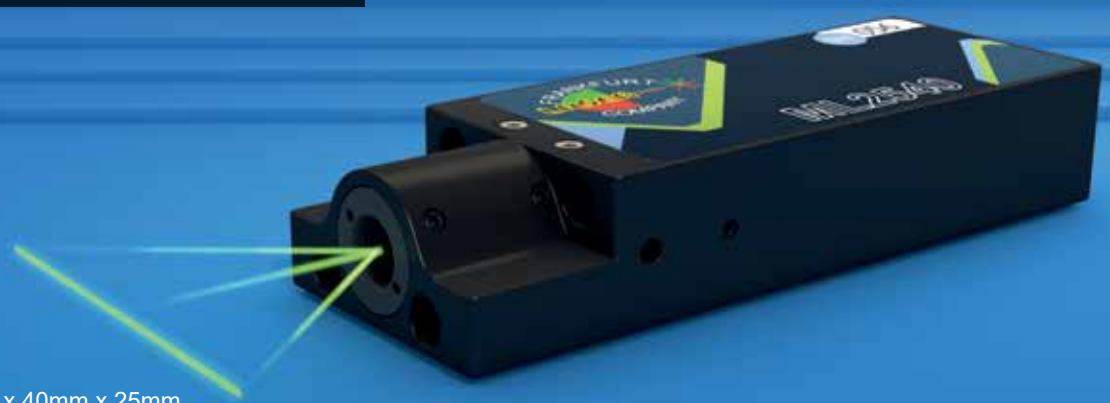
FRANKFURT LASER COMPANY

Line Laser Modules for Machine Vision and Laser Triangulation

HAML-F

Uniform Line Laser Diode Module
Wavelength: 405nm – 1060nm
Output power: 100mW – 200mW
Line uniformity: up to +/- 10%
Industrial protection: IP67
Easy manual focus adjustment





ML2540

High Power Line Laser Modules
Wavelength: 405nm – 1060nm
Output power: 0.5W – 2.0W
Temperature stabilized
Industrial protection: IP67
Market smallest footprint: 130mm x 40mm x 25mm

HSML-E

Ultra-thin Uniform Line Laser Diode Module
Wavelength: 405nm – 1060nm
Output power: up to 50mW
Line width: 10 µm
Line uniformity: up to +/- 10%
Industrial protection: IP67
Separate electronic driver to use in limited space devices

See technical details on
frlaserco.com