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Dear readers,

last year we celebrated the 25th anniversary of MVTec Software GmbH. In 1996, the year of our founding, we were one of the first companies to focus exclusively on software for machine vision. We are still sticking to our business model 25 years later. Apart from that, a lot has changed. In the meantime, MVTec employs more than 250 people. In addition, we are represented worldwide by our subsidiaries as well as by strong partner companies.

Outside the MVTec universe, a lot has changed as well. As the “eye of production”, machine vision software is playing an increasingly important role. Keywords of this development are increasing automation and digitalization. More and more applications are benefiting from the advantages of machine vision. Sectors besides classic industrial production are also increasingly relying on machine vision.

As a software manufacturer, however, we are only one part of the big picture. That is why we have always seen ourselves as an active member of the machine vision industry. The almost limitless possibilities of machine vision unfold especially in cooperations.

With “Machine Vision Insights” you are holding in your hands a publication that takes this fact into account. We want to bring you closer to our company, show you what is driving us, but also dare to see the bigger picture. Together with partner companies and the VDMA, we provide an overview of the industry, highlight trends and current technologies, and show exciting practical applications. I would like to invite you to join us on a journey through the world of machine vision. There are so many exciting things to discover.

Enjoy reading!
Olaf Munkelt
MVTec Software GmbH is founded in Munich by Dr. Wolfgang Eckstein, Dr. Olaf Munkelt and Prof. Dr. Carsten Steger as a spin-off of the Technical University of Munich and the Bavarian Research Center for Knowledge-Based Systems (FORWISS). Its managing directors are Dr. Eckstein and Dr. Munkelt.

April: MVTec starts working with its first sales partners. The basis for worldwide sales has thus been set.

June: The first version of MVTec HALCON hits the market. This powerful, comprehensive machine vision software already includes the option for 3D camera calibration – putting MVTec years ahead of the market. HALCON becomes the company’s flagship product.

Shape-based Matching and Automatic Operator Parallelization (AOP) are making their way into HALCON. Even today, machine vision applications benefit from these groundbreaking technologies.

MVTec HALCON is the first image processing software that is also available on embedded platforms. The technical term “embedded vision” has since been shaped by MVTec.

MVTec becomes a member of the VDMA (German Engineering Federation).

August: As of this year, part of the OCR (optical character recognition) technology in HALCON is based on learning networks, the precursor to deep learning.

MVTec establishes its first foreign subsidiary in the USA: MVTec, LLC, in Cambridge, Massachusetts.
MV Tec sends its software into space: Due to the unprecedented possibilities of 3D vision, NASA chooses MV Tec HALCON as the most suitable machine vision software for its humanoid robot R2, which was then sent to the ISS as a “co-worker”. Many other technologies from HALCON were also used in its work in space.

2014
The first version of MV Tec MERLIC is launched onto the market. With this software, machine vision applications can be created without programming knowledge.

2015
November: MV Tec cracks the mark: more than 100 employees are now part of the team.

December: MV Tec moves into new headquarters. The new office building is located right next to the Munich Hirschgarten park and offers plenty of space for further growth.

2016
MV Tec HALCON includes deep-learning-based OCR for the first time—its first technology to use artificial intelligence.

2019
The first version of the MV Tec Deep Learning Tool is launched. Users can use it to prepare their image data for deep learning applications.
2020

MVTec establishes its subsidiary in China: MVTec Vision Technology (Kunshan) Co., Ltd. near Shanghai.

2021

MVTec continues to grow: more than 200 employees are working for the company as of this year.

2022

MVTec is celebrating its 25th anniversary and has become the international technology market leader for machine vision software.
This is MVTec

- More than 250 employees
- More than 40% of MVTec’s management staff are women
- 50% of MVTec’s employees are software engineers
- More than 25 years of machine vision leadership

- From 22 countries
- Within 5 years, MVTec doubled its turnover and number of employees.
- 4000 customers around the globe
- 24 sales partners represent MVTec at 40 places worldwide

- MVTec members of staff speak more than 50 programming languages.
- MVTec has more than 75 image acquisition partners,
  which makes its “Image Acquisition Partner” program the largest of its kind.
- MVTec HALCON encompasses more than 2000 operators.

- Over 10000 free licenses of the HALCON Student Edition were given out in our MVTec on Campus program.
- Students in 36 countries use free HALCON Student licenses.
Some technologies are truly groundbreaking, changing the world and giving rise to completely new solutions. Technologies that have a major impact on how we live and how we address the challenges humankind is facing.

While some of these game changing technologies are the “talk of the town”, some remain somewhat hidden from view and do not quite make in into the mainstream media and public debate as much as they should.

Machine vision – one of the most powerful enablers we have at our hands – falls in this category. It is time to change that and make the wide range of application areas and unique benefits of “machines that can see” much more widely known.

Looking at challenges we face today, it’s obvious that machine vision is a real solution provider. Higher productivity and competitiveness

Automation is an essential key to success – especially for manufacturing companies in Europe. Only with automation Europe is able to sustainably secure its competitiveness. Not just since COVID-19 has it become clear that production needs to be increasingly carried out where consumption takes place, not least because of rising environmental and transport costs. When we think of automation, the first thing that comes to mind is a robot.

Not everyone knows that without machine vision, the robot can’t do much. It remains blind and dumb.

Recognizing changes and irregularities in production processes at an early stage is key to resource efficiency and cost effectiveness. Everyone is talking about Industry 4.0 and interconnected and data-driven production processes. For machine vision, this is ancient reality.

100% accuracy, infallible quality checks and complete traceability – this is what automation stands
Thanks to machine vision, companies are able to produce high-quality non-stop, 24 hours a day, seven days a week – avoiding costly product recalls, product liability claims and reputational damage.

Automation can relieve people of monotonous, physically demanding or even unhealthy tasks. Visual quality inspection carried out by humans is monotonous and tiring for the eyes, sometimes even too complex for the human brain. Monotonous and dull tasks are accomplished by a “seeing machine” supporting workers, ensuring a perfect human-machine interaction and resulting in a more advanced and satisfying workplace.

**Demographic change and sustainability**

The baby boomer generation will be retiring soon while birth rates remain low. This will massively reduce the potential workforce in Europe over the next 10–20 years. Increased automation can make a major contribution to solving this problem. Ensuring security, higher quality, and safety in and outside the factories, optimizing traffic flows, checking the stock level of shelves in the supermarket, monitoring moles at the dermatologist – machine vision makes life better for all of us.

We all agree: it is necessary to use resources efficiently. And, even looking beyond factory automation, machine vision contributes to environmentally friendly solutions. Sorting waste and recycling material, reverse vending systems for returning bottles in the supermarket, smart farming by applying fertilizer efficiently and sparingly. That’s machine vision.

Machine vision is a universal problem solver, not limited to the factory environment. And, the rise of machine vision (or computer vision as some refer to it) is far from being over!

**Machine vision is the real super star within automation!**

Let’s make sure it is in the limelight.
Machine vision – suitable for use (almost) anywhere

No, industrial image processing (machine vision) has nothing to do with Photoshop. However, its importance and range of potential applications are at least just as exciting.

Automation and digitalization are finding their way into ever more business sectors. Realigned supply chains, a skills shortage, and ever shorter product lifecycles are just a few of the issues that are encouraging their diffusion. Machine vision is increasingly becoming a key technology. It paves the way for extensively automating and optimizing processes along the entire industrial value chain.

Over the past few decades, machine vision has increasingly become an indispensable technology for companies from the broadest range of sectors. As the “eye of production”, machine vision constantly monitors all manufacturing and logistics processes. But what does machine vision look like in practice? What components are required, what exact benefits does the technology offer, and where exactly can it make best use of these? This article aims to answer these and other questions.

Let’s start with the basics: A machine vision application requires hardware and software components. In terms of hardware, we need what are known as image acquisition devices. These can be cameras or sensors positioned at various points within the production environment. The devices record processes and generate large volumes of image data. In a pictorial compar-

Mario Bohnacker
Director Customer Services at MVTec
ison to the eye, the cameras and sensors represent the lens through which events are perceived.

**Machine vision – the eye of production**
As with a human brain, the information captured has to be processed in order to be used. This is done by machine vision software integrated into the process, which processes the data and provides the results for further use. A number of methods and technologies are available to this end. In particular, deep learning, a form of artificial intelligence, opens up new and exciting fields of application. What makes machine vision special is that, like the human eye, it is able to identify the broadest range of objects and correlations and put them in the context of production. This opens up wide-ranging possibilities for uses in all sorts of different processes. For example, objects in the goods cycle can be automatically identified and classified. How? There are several possibilities. Firstly, this can be done on the basis of purely external features such as color, shape, or texture. Machine vision can also identify objects through the use of number or letter combinations printed on them.

There are also many other ways in which machine vision can be used in production. The Industrial Internet of Things and digital networking are key concepts right now – and machine vision is a key technology for these. Let’s take the example of quality assurance: Machine vision can be used to detect all conceivable types of errors on objects. And it can do this around-the-clock, seven days a week, and with greater reliability and precision than the human eye could ever do. But that’s not all. In the context of networked production, the products concerned can be automatically classed as rejects and removed before they get any further in the logistics process chain.

**Machine vision and robots – a dream team**
Machine vision can also be used for wide-ranging applications in the field of robotics. Classic and collaborative robots, i.e., robots that can work directly with humans without a protective device, use the technology to precisely grasp, process, and set down all kinds of objects. The robot’s added value increases as it can perform more tasks independently. This makes it possible to thoroughly automate production. One example of this is the use of robots in logistics, or to be more precise for loading and unloading pallets: Here, the robot arm is equipped with an industrial camera. Machine vision software is used to determine the position of the objects and send this information to the robot’s control system. This enables the robot to identify items on pallets as individual objects, to grasp them, and to set them down, for example on another pallet. In other words, the robot can “see”.

But even when not using robots, there are still many ways in which machine vision can be used in the fields of logistics and intralogistics. All objects are equipped with bar codes for identification purposes. As a result, they can be reliably identified by machine vision software and seamlessly tracked.
The “observation” of an object begins as soon as it is received. The warehouse’s management system automatically knows what contents have been delivered. Machine vision can also be used to check for quality and completeness as well as to identify free shelf spaces in the warehouse. In addition, the picking process is automated by identifying and picking the right items.

Where can machine vision be used? The question is more so: where can’t it?
Whether in the automotive industry, the machinery and plant engineering sector, or food and drink production, machine vision can offer support everywhere. Also, the electronics industry particularly benefits from the technology, for example semiconductor manufacturing. The many production steps and high levels of precision make this a particularly complex process, so it goes without saying that quality control is of immense importance. And this is where machine vision can naturally be used for the demanding inspection tasks.

Time is money
Automated inspection using machine vision is far quicker, the results are objective and reproducible, and there are no risks of the inspection quality deteriorating, e.g., due to tiredness or the monotony of the task. This makes machine vision particularly predestined for high-speed applications. As an example,

it takes less than 10 milliseconds to determine the position of any object with the utmost precision. In comparison, it takes 300 to 400 milliseconds to blink.

But that’s not all that machine vision can do. A whole range of application areas open up with regard to networked production or in combination with the cloud. For example, large quantities of image data can be used for predictive maintenance. Any necessary machine maintenance, for example as a result of wear, is now identified immediately, ultimately preventing machine downtime and reducing maintenance costs.
Anything is possible – with machine vision this is actually (almost always) true

Innovative machine vision applications are only developed in large companies? Not at all! Every day, the ingenious engineers at MSTVision show how companies can make profitable use of state-of-the-art technologies – even with a relatively small workforce, but lots of passion and creativity.

Small but mighty. Although perhaps not as hip as it used to be, this saying accurately reflects what has characterized MSTVision since its founding in 2016. As a small company, we are committed to using powerful tools and a wealth of ideas to develop efficient solutions for the broadest range of applications by customers, whether large or small, national or international. Machine vision provides lots of different tools, hardware, and software to this end. The challenge for us as a small company lies in finding the right tool and putting it to use in a way that ultimately achieves the best solution for customers. Creativity and passion are therefore very important to us. Our strength lies in our ability to diverge from the beaten track and always work with the latest technology. CPU solutions and programmable chips (FPGA) that enable us to push to the limits with our work are key factors. As part of most projects, we perform feasibility studies for our customers. These then enable us to optomechanically implement even complex optical structures as integrated solutions. A key part of our service is the transfer of knowledge to our customers. For example, we regularly offer training on MVTec HALCON, line scan cameras, optics design, VDI guideline 2632 and more. The examples below illustrate the kinds of projects that we implement in this way.

**Smart machine vision supports the development of advanced gene therapies**

DiNAQOR is a life science company that develops advanced gene therapies and enables in vivo gene editing solutions. One application example is the development of individual gene therapies to give patients with inherited diseases (e.g., cardiomyopathies) a chance to be cured.

To test the effect of such gene therapies, DiNAQOR relies on its (patient-specific) artificial heart tissues. MSTVision supported DiNAQOR in developing a new technology platform for evaluating the contraction of three-dimensional engineered heart tissues (EHT) generated from human induced pluripotent stem cells (hiPSC). Thanks to MSTVision’s improved approach, it is now possible to acquire 24 EHTs simultaneously and fully automatically without sacrificing accuracy. The new approach has eliminated the need for user intervention during measurement and the movement of the camera by an axis system. After the eval-

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Contraction analysis of artificial heart tissue
Advancing e-mobility – also thanks to machine vision

Many sectors and companies are working to advance e-mobility as there are multiple aspects that need to be tweaked. One of these is the production of batteries for e-vehicles. In particular, the coating processes within the scope of electrode production need to be closely monitored as these steps are key to the reliability of the batteries produced as end products. The extremely high resolutions required for this result in the increasing use of line scan cameras. MSTVision can support companies with many years of experience in this area.

Our established Multi-Channel technology makes it possible to use one or more line scan cameras to capture various surface properties in a single relative movement,

Simply and efficiently processed further with MVTec HALCON. Information from different image channels can be compared and contrasted without calibration. This technology makes it possible to perform the photometric stereo procedure, also known as Shape from Shading, with high-speed line scan cameras. This in turn enables the separate evaluation of the brightness (albedo) and the topography (inclination or curvature) of each pixel. Continuous surface inspection is a highly complex technical process. The underlying algorithm was therefore implemented in the FPGA of the framegrabber, an electronic circuit for digitizing analog image signals. As the procedure is suitable for both very light and very dark surfaces, it is often used to inspect lithium-ion battery foils, bipolar plates for fuel cells, and circuit boards for power electronics.

How high-speed machine vision helps reduce plastic waste

Another topical issue right now is the sorting of bulk materials. A few years ago, one of our customers commissioned us to modernize an outdated sorting system designed to detect black specks in white and transparent plastic granules. The difficulty lay in achieving the necessary performance data with regard to the optical resolution, high bandwidth, and low latency. To that end, MSTVision developed a proprietary technology platform, comprising line scan cameras, FPGA code, and its own electronic boards for precisely controlling the timing of quick-release valves. The performance data achieved are impressive: The FPGA-based solution can process 2.4 GBytes and more than a million objects per second, while also enabling reaction times of just one millisecond. The combination of the improved sorting accuracy and the higher throughput makes it far easier to waste less plastic. There are multiple potential uses for this technology. For example, the new system can be used in the recycling or food sectors by being easily expanded to include a multispectral imaging device (VIS and SWIR). Even the photometric stereo procedure in free fall is possible. In the future, it will also be possible to integrate customer-developed neural networks (deep learning).

Michael Stelzl
General Manager MSTVision
The realization that all areas of life are changing is nothing new. This naturally also applies to all economic sectors, and even extends to machine vision. But what are the challenges in this comparatively young industry? In which sectors will demand rise, and where will it perhaps decrease? What major machine vision trends are expected over the next twelve months? Dr. Maximilian Lückenhaus, Director Marketing + Business Development at MVTec Software GmbH, provides a forecast.

Dr. Maximilian Lückenhaus
Director Marketing + Business Development at MVTec Software

After all, in addition to automation itself, making technology easy to use is an important response from machine vision to challenges such as the skills shortage.

How do you think the importance of deep learning for machine vision will develop?
Providing it is implemented in an industry-compatible manner, deep learning will become increasingly important as a means of both supplementing and developing classic machine vision methods.
According to a recent study by the analysis company Gartner, deep learning is currently in a consolidation phase. In other words, the hype is dissipating, and companies are addressing the topic with greater realism.

One fitting example of this is the increasing use of AI accelerators. As deep learning places high demands on computing power, high-performance hardware components are required. Deep learning accelerators are small, energy efficient, and powerful chips designed to significantly increase the speed of deep learning processes. Thanks to their compact structure, the accelerators are now also enabling deep learning algorithms to be used in computing units with a small footprint, such as industrial PCs. This is an example of how deep learning can be used in a meaningful and appropriate way in a growing number of applications.

In which industries will machine vision gain momentum in the future?

From what we have seen, even today, machine vision is increasingly being used outside the traditional manufacturing industries, for example in the food, logistics, or pharmaceutical sectors. To take full advantage of the technology’s benefits, its use needs to be adapted to the requirements along the specific value-added chains. This can be illustrated by the following example: Customers from these sectors are increasingly asking for small, compact sensor devices. If machine vision functions are embedded into these “edge devices”, we refer to this as “embedded vision”. The key benefit here is that the results from these sensors cannot only be used locally, but can also be globally monitored and interpreted. For example, to centrally collect and evaluate quality specifications across many transported parts. For machine vision experts like us, the latter means that we also offer our customers cloud-based solutions.
A machine vision insight from South Korea

Keunho Jeong, R&D team lead, at MVTec’s long-standing sales partner Teknix Co., Ltd. from Seoul, South Korea, is stating his point of view on machine vision and its impact on today’s industrial landscape.

COVID-19, which is not over yet, has made us radically change our living environment. The impact of COVID-19 in Korea began in 2020. Due to this, the economy has greatly contracted, and it has caused great changes in the industrial field. Representative examples were the food service industry and the travel industry. However, conversely, as non-face-to-face consumption of purchasing products on the internet increased, the logistics industry greatly expanded, and while the restaurant industry decreased, delivery services at restaurants increased.

Speaking of another change: from 2020 to the first half of 2022, office workers had to work from home and students had to study via distance learning. Meanwhile, sales of home appliances (laptops, PCs, TVs, etc.) increased, and due to eco-friendly policies, increased subsidies have caused a surge in demand for electric vehicles.

**Machine vision in the packaging industry**

Let us examine one more example from the machine vision sector. While the packaged ready-to-eat food industry expands, the demand for packaging...
inspection via machine vision increases. And this is where – for one customer – we came in with the following application: Many ready-to-eat products include plastic and plastic wrap. If these products are not properly packaged, food may deteriorate. It is not easy to inspect this with machine vision. In terms of 2D inspection, it was not easy because there are various printings for each product, and in 3D, there was a lot of noise data due to the non-flat characteristics of vinyl. And, there was a limitation that the production speed was slower than 2D image inspection.

Therefore, 2D images were acquired by using a line-type laser. Using the obtained 2D image, a defect inspection was performed with deep learning. As a result, the existing defect detection rate has been greatly improved.

**Machine vision of high importance for semiconductor and battery production.**

The machine vision industry in the Korean market has a very high portion of the semiconductor and display businesses. Due to this environment, investment plans in the memory/non-memory semiconductor industry began to increase in the semiconductor industry. However, while the display industry, which can be regarded as another main axis, has moved to the China market, investment in the display industry has decreased significantly. In the display industry without facility expansion, machine vision inspection equipment makers were shocked. So, they attempted to overcome this situation with a new business field. As displays and secondary batteries have very similar manufacturing processes, battery production for e-mobility became this new business field.

So, it was much easier for display manufacturers than for other equipment companies to enter the secondary battery inspection equipment market, where demand is greatly increasing.

The most sensitive parts of semiconductor and secondary battery inspection are primarily the speed and accuracy of defect detection.
Of course, it is true that all machine vision is pursuing this. MVTec HALCON was optimal in these parts and showed greater power at larger image resolutions. Among the data structures of HALCON, there are “Region” and “XLD” types. Region has advantages in terms of speed, and XLD has advantages in terms of accuracy as a sub-pixel concept. With the combination of the two, it was possible to accurately detect foreign objects and measure objects at high speed. And, regarding the functional part as an example, HALCON provides a technology called photometric stereo. This enables data extraction of embossed or engraved data without using a 3D camera by combining 2D images obtained by using three or more lights at different locations.

This technology generally can be suitable for protrusion or dent inspection due to various pattern images in 2D images. In semiconductors and secondary batteries, this technology is widely used without using 3D cameras for chip and secondary battery surface inspection. It is also used for credit card OCR reading. And, additionally, deep learning is applied based on this data.

The numerous features offered by HALCON are not limited to a specific application. Depending on where you use these features and how you combine them with various ideas, the results can be beyond your imagination.

**Always keep an eye on new industry trends**

In the past, semiconductors and displays were the main pillars of the Korea machine vision market, and based on this, it has expanded to the electric vehicle (secondary batteries, camera modules, etc.) and logistics markets. We need to concentrate on the fact that business in a specific field becomes difficult, in other words, we will try to find a new business field. And in addition to this, it is very important to understand the industry trends around the world. We understood that the secondary battery field, along with electric vehicles, has been progressing gradually since 2018, and we began to prepare data by researching companies related to the secondary battery field, which had not received much attention in the past. The results have been very successful. From 2023, we must understand the new trend and prepare for the new market in advance. Today, the automation industry is a trend we cannot avoid. Vision sensors (including smart cameras) and robots are essential here. Furthermore, it is expected that the era of one robot in every household is not a distant future.

MVTec’s machine vision software with its features is already ready to enter the robotics and embedded markets. There are functions such as Hand-eye calibration, which is closely related to robots, various matching techniques (2D/3D), 3D processing, deep learning, etc.

If we understand the trend of the times, always think about how to utilize the available machine vision technologies, and respond accordingly, we will be able to preoccupy new markets before anyone else.
Deep learning

Deep learning in the field of machine vision – a game changer or a supplement to classic methods?

Everyone is talking about artificial intelligence (AI). In the field of machine vision, deep learning as a form of AI is of particular interest. The technology enables robust detection rates and paves the way for completely new applications. But is deep learning really the game changer people say it is or does its great potential actually lie in combining it with classic image processing methods?
From chatbots, to translation software, digital assistants, and even autonomous cars, artificial intelligence has become an integral part of many areas of life. It is also becoming increasingly widespread in industrial environments, for instance, in the field of robotics and with regard to the digital networking of machines as per the Industrial Internet of Things aka Industry 4.0. In the field of machine vision, a very special form of AI is becoming ever more prevalent: deep learning. The technology is based on convolutional neural networks (CNNs) and is regarded as giving machine vision a genuine boost.

Outstanding object detection results
One thing is clear: deep learning is achieving previously unseen results in the field of object detection. How? Like all AI technologies, deep learning is able to learn independently. This means that there is no need to program individual algorithms for each and every use case. The background to this is as follows:

Deep learning is based on neural networks. These can be trained, enabling the technologies to analyze large quantities of image data (big data) and thus detect certain patterns and correlations and apply these to new cases.

Machine vision takes advantage of this, for example by using deep learning to identify typical features that can be used to assign or classify the objects or defects to be detected with greater precision.

This results in a number of benefits: For example, the development work required in relation to machine vision processes can be significantly reduced as there is no need to manually define key features and object properties for the detection process. In addition, the technology opens the door for new applications that previously have not been possible to implement using traditional image processing methods.

A prime example of this is the new MVTec feature “Global Context Anomaly Detection”: Deep learning is used to understand the logical content of an image, making it possible to recognize completely new types of defects. For example, bottle labels that have slipped or been incorrectly printed, or missing components, for instance on circuit boards, can be detected as defects.

Deep learning has its limits
Although the benefits of deep learning for machine vision are clearly impressive, it also has its limits. The technology is ideal for the three classic fields of application of classification, object recognition, and semantic segmentation, and its benefits can be optimally used in these regards.

The “but” comes with the traceability of decision-making within the neural network. As a “black box”, the technology allows little insight into internal processes. Such insight can be hugely important in the industrial environment though, as is illustrated by the following example: If an engineer is responsible for the quality of a certain semiconductor component in electronics production, he requires detailed documentation of the entire inspection workflow. If this cannot be seamlessly tracked in the black box, the engineer is left in need of explanation in the event of an undetected defect. Classic image processing methods offer far more transparency in this regard as the image properties on which certain decisions are based are specifically and transparently described.

A high-performance hardware platform is required
A further constraint is that deep learning can sometimes involve a large amount of training, which requires an appropriately high level of resources. The production line also needs a high-performance hardware platform, which is not available in all industrial applications. The latter is especially true when AI-based machine vision technologies are used on embedded devices. Furthermore, deep learning is simply oversized in some areas of use, so the technology’s high performance and storage requirements – and thus its cost – are hard to justify. In such
cases, tasks can often be resolved more elegantly, simply, and cost effectively using classic machine vision.

So as not to miss out on the benefits of AI technology, the ideal solution is to intelligently combine deep learning and traditional, rule-based machine vision methods.

With this kind of hybrid approach, both technologies can make optimal use of their particular strengths for the application at hand. For example, classic methods can be used to perform preprocessing steps such as correctly orienting objects. The decision as to whether the object is a reject can then be efficiently made by deep learning using a smaller image area. Combining the techniques makes it possible to trace the specific decision criteria used to classify objects or defects more transparently.

Christian Eckstein
Product Manager and Business Developer at MVTec
Creativity is imperative for new technologies

The machine vision sector thrives on innovation. But how are new technologies created and how do they find their way into practice? Rebecca König, Research Engineer in the MVTec Software GmbH research department, gives us a tour of her workplace and explains the road from the initial idea to implementation.

It’s a wintry, Advent morning in December. We’re with Rebecca König in the kitchenette in MVTec’s head office in Munich. While the coffee flows into the mugs, we ask Rebecca what makes her job fulfilling. The researcher pauses briefly to think about it. She’s been working in MVTec’s research department since 2017, prior to which she studied mathematics at the Technical University of Munich. On completing her degree, she wrote her master’s thesis at MVTec and worked here as student trainee. Whilst the milk froth tops the cappuccino, Rebecca gives us her answer: “The best part is realizing that the software algorithms you’ve developed don’t just work during simulations but also in practice.”

Datasets as a basis for new methods

The approach taken by Rebecca and her ten or so colleagues is based on university research. They start with literature-based research, checking whether scientific papers or even datasets already exist for another similar case. Such datasets are large image files that can be used to test new methods and technologies. The datasets play an important role. If no datasets yet exist, MVTec therefore develops its own ones and provides them to the research community.

Customer feedback as a springboard for new developments

What attracts Rebecca to her work is also an important point for the machine vision sector as a whole. This is because the many minor and major innovations achieved by the company’s research and development team are what make the sector so dynamic. “Many of MVTec’s new developments result from specific customer problems. Here in the research department, it’s our task to find new approaches to things that can’t be resolved using existing methods,” explains Rebecca.

Datasets as a basis for new methods

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In fact, it is even one of Rebecca and her colleagues’ aims to support the entire research community with their own research work in the form of datasets and publications. “We provide the datasets in downloadable format and regularly attend specialist conferences to present our work as well as to network and exchange ideas with other researchers. This results in exciting new ideas for our own work,” she says. However, the primary goal of MVTec’s research department is to implement the latest research results in the company’s software products as quickly as possible. To do this, the department not only has ten permanent staff members but also employs doctoral and master’s students.

Customer feedback as a springboard for new developments

A change of scene. We’ve now arrived at one of Rebecca’s several workstations, the MVTec app laboratory, where we find several devices, camera systems, and even a robot. This is the place where applications are developed for trade fairs, practical use cases are simulated, and the aforementioned datasets are created. Depending on the case, a dataset for developing new methods requires around 2000 images. These need to be created. “We face particularly high real-world requirements, making a comprehensive dataset essential for developing robust methods,” explains Rebecca.

Creativity is required for new algorithms

We’ve moved to yet another area of the company and are now sitting at Rebecca’s office workstation. After creating the datasets, the actual work starts here. Our next coffee is also ready. “There was no way that the last practical inquiry we received could be resolved using existing methods. That means we need to create something new. Deep learning may help...”

Customer feedback as a springboard for new developments

The primary goal of MVTec’s research department is to implement the latest research results in the company’s software products as quickly as possible. To do this, the department not only has ten permanent staff members but also employs doctoral and master’s students.
“Global Context Anomaly Detection”, an evolved version of anomaly detection that can understand logical content and identify errors relating to the entire image.

For example, it can detect bottle labels that have slipped or been incorrectly printed, or missing components, for instance on circuit boards. The technology in this form is a world first.

Back to the current problem. Rebecca is in the process of developing a new deep learning network architecture. The algorithm programmed to do this, on which the network is based, will be subsequently fed with the dataset. In other words, the deep learning model will be trained using some of the data. The rest of the data will then be used to test and evaluate how well the algorithm resolves the problem. “There is more than one way to achieve a goal; creativity is required. For example, you can creatively achieve a goal by skillfully combining two complementary approaches in a single algorithm. This makes use of the benefits of both algorithms. Another example is to tweak various aspects of an algorithm to fully optimize every last bit of its performance. And that’s exactly what I enjoy about my work,” says Rebecca, adding: “Our team has intentionally given ourselves a great deal of free rein so that we can simply try things. We even undertake high-risk projects despite not knowing whether they’ll work. Failure is allowed.”

Integration of research results into MVTec software products

But how does a new technology bridge the gap from theory to practice? Once the new method is ready for the market, it’s about implementing it in one of MVTec’s software products. “To do this, we switch from the Research department to Development. We become part of the development team and help integrate the algorithm into the software,” says Rebecca. The new technology is then accessible to customers upon the next software release – and all that is left to do is await their feedback.

Our team has intentionally given ourselves a great deal of free rein so that we can simply try things. Failure is allowed.”
MVTec as an employer

MVTec works in the most effective manner for a modern, international software company: collegially and on the basis of flexible principles. MVTec collaborates with customers to forge new paths and is characterized by innovation, passion, and excellence. Our employees are proud of the informal team atmosphere and of interacting in an open, appreciative manner with a good dose of humor.

A few of these people report on their experiences over the next few pages.
Rebecca Wagner, Sales Support Expert

I’ve been part of the MVTec team for four years and am still really happy to be here: Our sector is extremely exciting and you learn something new every day, so I never get bored with my work.

Even before I started here, I’d had some contact with MVTec employees and was impressed with their spirit and solidarity. And this is still the case today: The way people interact internally and with sales partners is amazing. You’re part of a highly experienced team, the members of which have known each other for years and work fantastically together.

As a mom, a good work-life balance is extremely important to me – and MVTec is committed to providing this. Working hours are flexible and family friendly so you can even change your plans at short notice if necessary. The ability to work from home a lot is a major plus, not just for parents.

Dalia Al-Taan, IT Business Consultant

Here in the IT team, we work on lots of projects and systems that affect the entire company’s infrastructure and security. Specifically, I’m responsible for various management systems such as SAP as well as for the planning, organization, and implementation of updates and further system improvements. I also coordinate communication with our service providers and advise and support our employees in relation to IT issues.

Accordingly, I often collaborate with a very broad range of departments during my work and ensure that this interdepartmental communication is structured and fruitful. I really enjoy what I do and never get bored as there’s always something new to discover and learn. Experiencing new challenges and developing strategies every day – that’s what I love about MVTec.

We’re a very diverse team here in the IT department in terms of our skills and experience. However, we all have plenty of energy and enthusiasm when it comes to constantly learning more about new technologies and skills. This is extremely important for our work. We therefore support each other with advice and assistance and always work together as a team.

Peter König, Application Engineer

As an application engineer on the Customer Services team, I provide a direct interface to MVTec’s customers. My colleagues and I receive first-hand insights into the tasks that users want to resolve with our software and the difficulties they encounter while doing so. Specifically, we’re responsible for technical support, customer training, customer projects, technical videos, customer presentations, and building demonstrations for trade fairs. I love this diversity! The feedback that we receive from customers is also very interesting for many other teams at MVTec. This makes us an important internal interface. Our interactions are characterized by collegiality and pleasant communication.

Despite there being about 35 of us, we’re a very close team. Our everyday work involves a lot of interaction, whether because someone needs help with a specific support case, or to plan tasks. Essentially, the thing I value most about MVTec is the team spirit. It goes without saying that you can talk to anyone at any time and ask for help or advice. This open approach is fantastic.
We therefore support each other with advice and assistance and always work together as a team.

**Christian Eckstein, Business Developer & Product Manager**

As a product manager, you could say that I work with the “heart” of MVTec: our products. We Product Managers make strategic decisions about the business model and the alignment of the MVTec products, making us responsible for the long-term economic success of our portfolio. One part of the Product Management department is the Business Development unit. Our colleagues there are our pioneers, who work with partners to test new business models or product versions in new markets.

We have large networks of colleagues in both Product Management and Business Development. We also promote continual dialog with both our customers, to understand their needs, and our developers, to plan implementation work. It’s great that this interaction is encouraged by MVTec – including through our modern feedback culture.

In my work as a Product Manager, I can cooperate with various teams to create things that continually grow in value and sustainably resolve our customers’ problems. In particular, receiving great feedback from customers during personal interactions makes me truly proud of what we’ve achieved.

**Yuhui Chu, Marketing Expert**

I originally come from China and studied in Germany. I’ve therefore been influenced by both cultures. In MVTec, I have found an employer where I can make good use of this cultural background and even further develop it. For example, my duties don’t just involve coordinating Chinese trade fairs and online appearances as well as public relations and social media marketing in China, but also maintaining close contact with our Chinese branch.

With the support of my colleagues in China, I can organize events there with great efficiency. For instance, we can market and communicate the latest machine vision technologies from Germany in a manner that is fitting for the local market.

MVTec respects the unique features of every market and every culture. As such, a big part of my role also lies in acting as a translator and interpreter between the various cultural circles and promoting optimum communication and cooperation between our Chinese customers and our colleagues in Germany.

MVTec’s products are world renowned in the machine vision sector. That makes the work particularly enjoyable for me. Something else I really like is the friendly and innovative corporate culture – whichever country you’re in.
Why is customer proximity important to a software company?

1. Machine vision is complex and technically demanding. Most applications based on machine vision, as used by the respective customers, are unique. This flexibility accordingly results in a higher demand for support.

At MVTec, we place great emphasis on offering customers in-depth consultations from the outset in order to understand and resolve their problems and challenges. Furthermore, as a software manufacturer, we also want to know exactly how customers use our software and which additional functionalities they need. For example, we’ve identified geographical differences in how and which software products are used. Customer dialog is important to us as it enables us to better understand the market requirements in order to further develop products and services as well as to offer customers better advice and, ultimately, to grow with them. As such, internationalization is not an end in itself, but a means of further enhancing customer proximity. It is for this reason that we already have a presence in all markets thanks to our highly qualified sales partners and our branch offices around the world.

What different requirements do the individual markets have?

2. It’s hard to make sweeping statements in that regard. There’s generally a great desire for high-quality advice and customer support in all regions of the world. To offer these, we have to be familiar with the local conditions – from a technical, cultural, and linguistic perspective. Only so is it possible to optimally address customer requirements. The advantage we have is that we offer both powerful software products and high-quality support worldwide.

What does the increasing internationalization mean for MVTec employees?

3. Growth and internationalization offer our employees a wealth of opportunities. Lots of new jobs are being created – not just in Munich. Internationalization is creating multiple development opportunities, such as the chance to work in other countries or with colleagues or customers from different cultures. We deal with exciting topics that are becoming ever more varied and international. At the same time, internationalization is a challenge for our company, but one that we’re happy to face. For our customers and joint growth.

Martin Krumey
Vice President Sales at MVTec

MVTec goes global

3 questions for Martin Krumey
Vice President Sales at MVTec
Internationalization is not an end in itself but a means to be even closer to the customer.