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Material Testing – Investment or Service?

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The 3D Experience

Have you ever watched a movie in 3D, wearing a pair of these ultra-chic glasses that make you feel like you had one too many beers when looking around? I recently took my kids to the cinema to watch a 3D movie starring dragons. Afterwards they said: "Mummy, this was really cool. Everything so huge. But it was also quite tiring."

It can be just as tiring not to have 3D in quality inspection. Simply because this could mean taking the manual approach to ensure 100% quality. On page 36 of this issue you can learn how smart 3D technology does the job: a built-in real-time data processing pipeline enables today's factories to achieve 100% quality control of manufactured parts, assemblies and finished products in an inline process.

Fundamentally, you might ask yourself whether to perform methods of non-destructive testing (NDT) inhouse at all – or employ them as a service. If so, our cover story "A guide to decision making for or against non-destructive testing as a service" is a useful tool to facilitate your decision-making process.

You might as well be thinking of buying a company that will bring the service – or any other technology – to your enterprise. Currently, the investment focus is on vision, and M&A transactions are becoming more and more popular. As it takes more than just money to guarantee the success of such transactions, you will find key insights on page 16.

» Currently, the investment focus is on vision, and M&A transactions are becoming more and more popular.«

NDT and many other inspection technologies can of course be found at Control international trade fair for quality assurance. Roughly 900 manufacturers and distributors from more than 30 countries will present innovative solutions for industrial quality assurance in Nuremberg from May 7 to 10, 2019. You will find many of the companies featured in this issue at Control 2019, and, of course, you will find our editors there, too. We're glad to visit your booth, too, just let us know whether you'd like us to come by. But for now, enjoy reading the first issue of inspect international in 2019!

Yours sincerely,

Sonja Schleif
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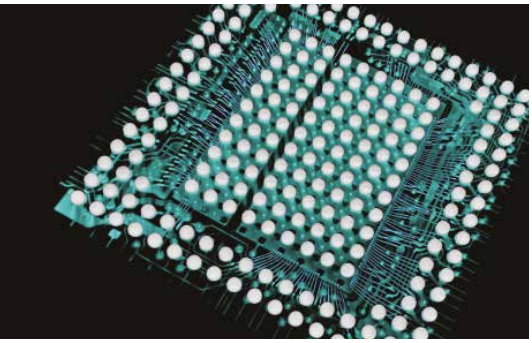

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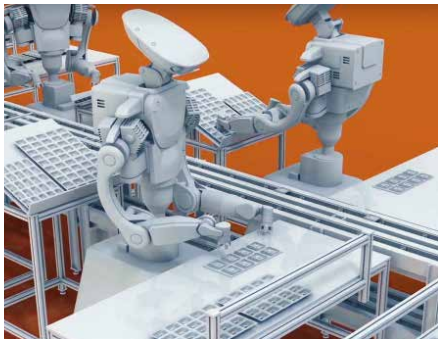

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Partner of: VISION, AUTOMATICA, Control, emva, VDMA, spectronet

News

Spectronet Celebrates Silver New Year

The SpectroNet innovation cluster was awarded with the Silver Label of the European Cluster Excellence Initiative (ECEI). In an audit, the SpectroNet cluster management led by Dr. Nick Leithold and Paul-Gerald Dittrich proved that the SpectroNet cluster meets the European-wide standardized requirements for excellent cluster management.

In the course of the realignment, the existing management processes were digitized and new innovative digital services were developed. These are adapted to the needs of the more than 45 cluster partners from industry, science and politics. The portfolio of cluster services was restructured and possibilities for efficient knowledge and information transfer were developed. **www.spectronet.de**

Edmund Optics and II-VI Cooperate

Edmund Optics has announced a partnership with II-VI to ensure immediate delivery of Zinc Selenide (ZnSe) optical components. Zinc selenide (ZnSe) planoconvex (PCX) lenses, zinc selenide (ZnSe) aspherical lenses, CO_2 beam expander, and lens tension tester are available now. This collaboration makes it much easier to acquire optical components for infrared applications throughout the design, prototyping and production cycle.

Zincselenide (ZnSe) Techspec plano-convex lenses (PCX) are developed by Edmund Optics and manufactured by II-VI using ZnSe material. They show a bulk absorption <0.0005 cm-1 at 10.6 µm and are available with broadband antireflective coatings, 8-12 µm or 3-12 µm. With an irregularity pass error of <λ / 20 at 10.6 µm and a surface roughness of <50 Å, it can be ideal for precision IR applications. Likewise, the aspherical lenses made of zinc selenide (ZnSe) are designed by EO and made from the same high quality ZnSe material. Zinc selenide (ZnSe) aspherical lenses have the same surface specifications and an 8-12 µm AR coating option as the PCX-ZnSe lenses.

www.edmundoptics.de

Dr.-Ing. Thomas Wenzel, General Manager Yxlon International and Takaaki Hattori, President Nagoya Electric Works Co., at Semicon China exhibition in Shanghai

Yxlon and Nagoya Electric Works Collaborate

Yxlon International announced a collaboration with the Japanese company Nagoya Electric Works (NEW). The collaboration includes the development and distribution of specialized X-ray systems for the semiconductor industry. Both companies are leaders in advanced Electronics X-ray technology. Yxlon bring their expertise in high-resolution X-ray tubes, image analysis, plus an excellent global sales and support network into the partnership. NEW are experts in automated X-ray inspection systems, offering accurate manipulation, extremely precise measurements and advanced software. The first products coming out of this collaboration are Yxlon FF70 CL, FF65 CL and FF65 IL. They were launched at Semicon China in Shanghai.

"This collaboration will help us to fulfill the growing demand of our customers from the semiconductor and also SMT industry, especially when it comes to analyzing continuously smaller features with high speed. We are excited to use the knowledge and experience of both companies to offer the best solutions for the market," said Eike Frühbrodt, Vice President Yxlon Product and Project Management. **www.yxlon.com**

New Distributor in Mainland China

Matrox Imaging welcomes a new Chinese addition to their global network of representatives. Attuned to the needs of their customers, Matrox Imaging stands by their five core advantages, ensuring customers benefit from a global network of distributors who offer complementary products and support, and integrators who build customized vision systems.

Beijing Microview Science and Technology Co., Ltd is a new distributor in the mainland China region. Headquartered in Beijing and with nine other offices across China, Beijing Microview has been in business for more than 20 years. Their sales representatives and engineers, including product managers, possess deep knowledge of the Chinese market as well as great familiarity with Matrox Imaging products.

www.matrox.com

Counting on Control

World's Leading Trade Fair for QA Systems Opens Doors in May

The Control international trade fair for quality assurance is highly esteemed by exhibitors and expert visitors, and it's always very well booked and visited. This year, the show's focus lies – among others – on technology transfer. Roughly 900 manufacturers and distributors from more than 30 countries will present innovative solutions for industrial quality assurance from May 7 to 10, 2019.

Exhibitors take advantage of the world's leading trade fair for quality assurance in order to present their new products to a broad-based audience. Initial prototypes are showcased here as trend indicators, as well as marketable, time-tested measuring technology which is refined to a greater extent each year. From optical measuring technology with augmented reality features and 100% monitoring of collaborative systems, right on up to the latest computer tomographs and tactile sensors, and above all industrial image processing – Control exhibits everything the users need.

A trend which is becoming plainly apparent is the closer intermeshing of quality assurance and production. Today, testing is conducted inline without losing any time. Manufacturers of measuring and test technology are tooling up for this trend as well: modular applications which are integrated into the shop floor are being used more and more frequently than separate, isolated test benches. Today's QA systems are incorporated into production and must be capable of withstanding adverse environmental conditions for this reason, and at the same time they must be able to process data rapidly. This is where industrial image processing comes in, on which the leading trade fair places great importance.

Control Is a Must for Exhibitors and Users

The offerings presented at this Schall trade fair appear to provide both users and exhibiting companies with added value, because exhibitors at the global quality event unanimously rate the industry meet as "important", "very important" and "of great significance." Amongst other things, they place considerable value on the fact that an overview of the latest developments in the field of measuring and test technology can be gained here in a compact format within a short period of time. And thus, Control is in a league of its own, because most exhibitors assess the trade fair as number one throughout the world as a trade fair covering all aspects of the key issue of quality assurance. The practicality of the exhibited modules and complete systems is a prerequisite for initiating dialogues with potential customers, generating interest, solving problems and finally landing orders. "This is one of the criteria which is essential for us when we compile the offerings and allocate presentation floor space," says project manager Fabian Krüger.

Exhibitor Forum: Transfer of Theory to Actual Industrial QA Practice

As is the case every year, the exhibitor forum is an additional crowd-puller for Control visitors and exhibitors. In 2019 as well, it will provide participants with the opportunity of transferring theory to actual industrial QA practice in an ideal fashion by means of technical presentations and best practice reports. Visitors will be able to derive solutions for their quality assurance tasks from the individual application cases introduced at the forum. ■

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Hardware and software manufacturers for embedded vision components must work together for the benefit of users in order to promote the effective use of this future-oriented technology. This was one of the conclusions of the VDMA panel discussion "Embedded Vision & Machine Learning: New architectures and technologies boosting (new) vision applications" during the Embedded World trade fair on February 27, 2019 in Nuremberg.

Success Through Collaboration

Embedded Vision at the Embedded World Show 2019

All 5 panelists - well-known representatives from both "worlds", the classical machine vision and the embedded community – agreed that the potentials of embedded vision in combination with deep learning are enormous. This impression seemed to be shared by the over 100 attendees in the discussion and could be seen at the trade show. Many of the demos showcased by the 1,170 exhibitors at their booths were vision related. Without any doubt, many future applications will be based on embedded vision: small, integrated image processing systems that work intelligently directly from devices and enable them to see and understand. Embedded vision is made possible by compact, high-performance computing platforms that also consume very little energy and, thanks to standardized interfaces to image sensors, can process an increasing amount of image data in real time. With artificial intelligence, image processing systems are becoming even more intelligent: they are learning for themselves.

PC-Based Image Processing Remains

According to the panellists, the embedded vision technology will not completely replace traditional, PC- or smart camera-based machine vision systems in the future, but it offers technically and economically extremely interesting solution possibilities in a multitude of application fields. The development speed of the individual components required, from sensor boards and a wide variety of embedded platforms to software, remains enormously high. As a result, embedded vision technology has now reached a level of performance that already allows the use of effective systems in suitable user industries, to sum up the results of the panel discussion.

An important and necessary step to make it easier for users to use embedded vision is, however, that the manufacturers of the required components cooperate with regard to standardization and platform building. If users have to laboriously assemble sensors, processors, software and other components individually on the way to a solution, the success of embedded vision will not reach the extent that is potentially inherent in this technology. However, various camera, embedded board and software manufacturers have now recognized this and are cooperating in the interests of users.

The technology receives a tailwind from continuous further developments, both in the field of processors and through innovative algorithms and methods such as deep learning or artificial intelligence. On the hardware side, ever smaller computers with multi-core processors and ever decreasing energy requirements provide sufficient computing power. Deep learning is becoming increasingly important in the use of embedded vision systems, for example to classify defects.

Statements of Participants

"Today's biggest challenge to apply efficient vision capabilities to embedded systems is the camera itself with all the integration efforts. New kinds of camera modules and technologies will help embedded engineers to lower NRE costs significantly. At the same time, users benefit from more image processing capabilities directly in the camera module, which improves the allocation of resources on the host side," said Paul Maria Zalewski, Director, Product Management, Allied Vision Technologies.

"Deep Learning on embedded devices is continuously gaining importance in the market. Yet, we do not see deep learning as a one-for-all solution, but rather as an ideal complementary technology for solving specific machine vision applications, e. g. classifying defects. By combining deep learning technology with other approaches, complex vision tasks including pre- and post-processing can be solved efficiently. Thus, a comprehensive toolset available for a broad range of embedded hardware architectures, such as provided by MVTec Halcon, is crucial to build embedded vision solutions in an efficient way and thus reducing time-to-market," explained Olaf Munkelt, Managing Director, MVTec Software.

"Given the continuous evolution of increased computing power at small sizes, low power advancements, and multi-core

» A comprehensive toolset for a broad range of embedded hardware architectures is crucial to build embedded vision solutions in an efficient way.«

processors capable of running multiple software applications, highly intelligent vision systems with centralized computing at the edge will enable a wide variety of volume applications that in the past were limited by the requirements and costs of dedicated PCs. Vision systems powered with serious analytics, using time sensitive networks, delivering real time performance will enable the next generation of products at a wide variety of market acceptable price points, and the value created will be from digitization of information," Jason Carlson, CEO, Congatec stated his opinion when asked whether the core component of an embedded vision system was the processor or processing board – as some doubt that small embedded boards with supposedly limited processing power could replace powerful PCs in demanding vision applications.

"It is not simple, but it is starting to do great things. These systems are the heart of new transportation experiences with autonomous driving. They are developing higher efficiency and better-quality manufacturing systems for in-line product inspection. It is simplifying shopping experiences from having no checkout lines to paying at vending machines with facial recognition. There is a lot more to do but real change is happening today because of improvements in imaging quality and advancements of artificial intelligence," said James Tornes, Vice President Systems and Software, Intelligent Sensor Group, ON Semiconductor when asked whether Deep Learning nowadays was really as simple and great as everyone says, or whether the expectations were exaggerated. ■

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Call for Papers: EMVA Young Professional Award 2019

Prestigious Industry Award Rewards Outstanding Work with Prize Money, Presentation at EMVA Business Conference in Copenhagen, and Free Pass for European Machine Vision Forum 2019

The EMVA Young Professional Award is an annual award to honor the outstanding and innovative work of a student or a young professional in the field of machine vision or computer vision. It is the goal of the European Machine Vision Association to further support innovation in our industry, to contribute to the important aspect of dedicated vision technology education and to provide a bridge between research and industry.

In this context, with the call for papers for the Young Professional Award 2019 the EMVA would like to specifically encourage students and young scientists from European institutions to focus on challenges in the field of vision technology and to apply latest research results and findings in computer vision to the practical needs of the machine vision industry.

Connected to the honor of the EMVA Young Professional Award and the publicity for the research work is a whole package of benefits. It includes a free conference pass and coverage of all travel costs to the EMVA Business Conference 2019 in Copenhagen plus prize money of 1,500 Euros and free entry to the European Machine Vision Forum 2019 taking place from 4 to 6 September in Lyon, France.

The winner of the award will be announced at the 17th EMVA Business Conference 2019 taking place 16 to 18 May in Copenhagen, Denmark, and will have the opportunity to present the awarded work to the machine vision industry leaders from Europe and abroad. This presentation will be covered by the international machine vision press leading to further publication options on an international level.

Applications shall be submitted by Email to ypa@emva.org. The criteria of the works to be presented for the EMVA Young Professional Award as well as more information can be downloaded on the EMVA website. ■

EMVA

Founded in May 2003 in Barcelona, the European Machine Vision Association currently has about 120+ members representing more than 20 nations. Its aim is to promote the development and use of machine vision technology and to support the interests of its members – machine vision companies, research institutions and national machine vision associations. The main fields of work of EMVA are: standardization, statistics, the annual EMVA Business Conference and other networking events, European research funding, public relations and marketing. To find out more visit the website www.emva.org.

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Hands on Vision

From Edge to Cloud: Fundamentals, Future Trends, and Hands on Training Classes at the Embedded Vision Summit

The annual Embedded Vision Summit will be taking place May 20 to 23, 2019, in Santa Clara, California. Visitors will be able to learn the latest applications, techniques, technologies, and opportunities in computer vision and deep learning with more than 80 talks and some 100+ demos together with more than 1,200 leading technologists and innovators in the fast-growing technology field.

This year's summit will feature four presentation tracks focused on computer vision trends, technologies and techniques, at the edge and in the cloud:

- Technical Insights presentations will focus on practical technical education and include techniques, trade-offs and case studies useful to vision product developers.
- Enabling Technologies presentations will highlight the latest vision-related products from Member companies of the Embedded Vision Alliance.
- Business Insights presentations will provide insights useful to business decision makers, including market and technology trends, business models, and case studies illustrating how vision technology is delivering value to consumers, businesses and other organizations.
- Fundamentals presentations will provide introductory technical tutorials on topics of broad interest to developers incorporating computer vision into products and systems.

2019 Vision Product of the Year Awards

Moreover, the 2019 Vision Product of the Year Awards will be presented at the summit, recognizing industry innovation and leadership: "Today, visual AI is being deployed at scale in thousands of applications, spanning industries such as healthcare, transportation and agriculture. In response, technology companies have stepped up their investments and accelerated innovation in new computer vision technologies," said Jeff Bier, founder of the Embedded Vision Alliance. "With the Vision Product of the Year Awards, we are proud to help the leading computer vision innovators gain visibility for their latest products."

> »Attendees will learn how to useTensorFlow 2.0 to create and train models for computer vision applications.«

Two Hands-On Training Classes for Computer Vision and Visual AI

An updated Deep Learning for Computer Vision with TensorFlow 2.0 training class and an all-new class on Computer Vision Applications in OpenCV (full-day, hands-on training courses) will be held May 20, 2019 in conjunction with the Embedded Vision Summit.

The TensorFlow course helps developers who are building visual intelligence into products. Attendees will learn how to use TensorFlow 2.0, the latest version of Google's popular, open source framework for deep learning, to create and train models for computer vision applications. The class has been updated to cover the latest features of TensorFlow, and is taught by Doug Perry, a Google Developer Expert who has led the development of the course material and taught earlier versions for the past two years.

The Alliance's new OpenCV class introduces developers to building real-world applications in OpenCV, the world's most popular open-source computer vision library. Attendees will learn how to use OpenCV to implement algorithms like image classification, object detection, face recognition, and more. The class is taught by Satya Mallick, the Interim CEO of the OpenCV Foundation and an experienced instructor. ■

Details and registration information on these trainings can be found at: https://www.embedded-vision.com/summit/trainings

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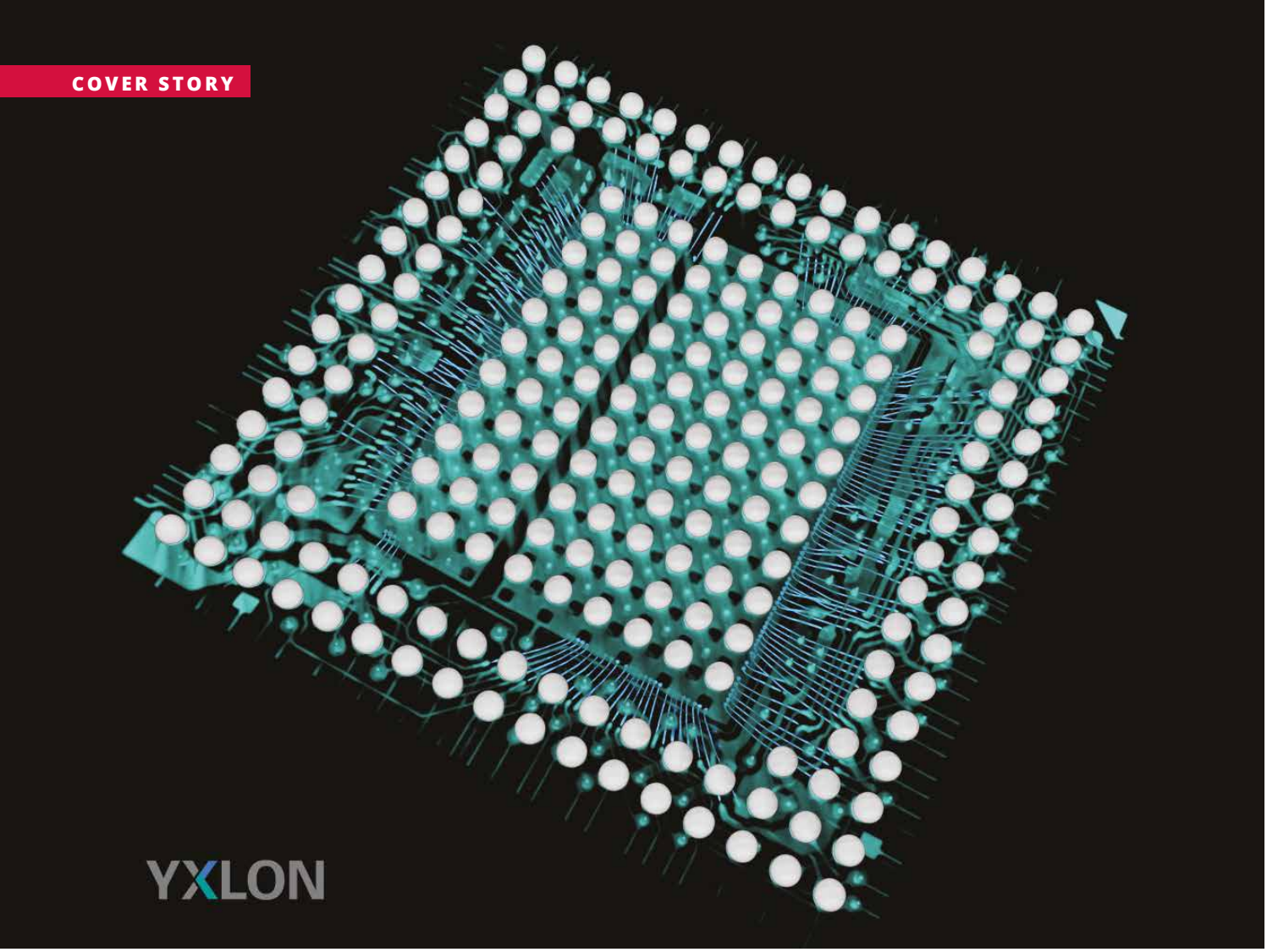

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Material Testing – Investment or Service?

A Guide to Decision Making if Using an NDT Inspection Service or Buying a System

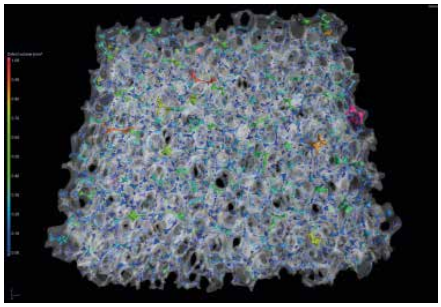
Virtually every manufacturer must perform some type of inspections to ensure that their products meet their own internal quality requirements, statutory requirements or the standards of their customers. The decision whether to deploy an in-house test system or use a service provider must be carefully weighed.

More and more industries are using non-destructive testing (NDT) methods to ensure safe, reliable and cost-effective operation of their structural and mechanical components. Because NDT does not change the test specimen, it can save money and time in product evaluation, troubleshooting, and research. Although there is a wide range of NDT technologies, the most common methods include ultrasound, magnetic particle, eddy current, visual and optical inspection, as well as liquid penetrant methods and coherence tomography. Due to their advantages over traditional X-ray methods, digital radiography, including computed tomography and metrology, are particularly popular because they are more time-efficient, use less radiation and do not require chemical processes. Moreover, the generated images can be digitally processed and transmitted.

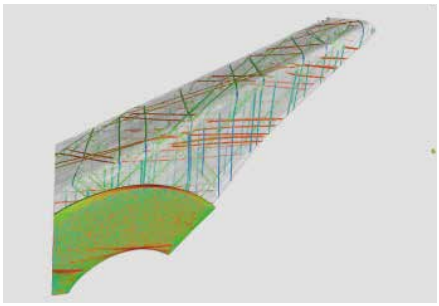
But regardless of which NDT technology you choose, the next consideration must be: Is the investment in a separate test system useful, or is it cheaper to commission a service provider? Before making that decision, some important questions should be answered.

How Often Will Inspections Be Required?

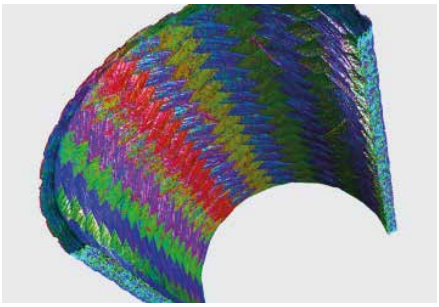
The inspection is only needed intermittently and is relatively time-independent, maybe because only a few prototypes need to be scanned to ensure that the internal specifications are met. Or a specific application only occurs seasonally. In that case, it certainly makes more sense to consider using an



Aluminum foam: pore analysis



Fiber reinforced helicopter wing scanned with laminography technology



Fiber analysis of composite material

inspection service than to invest in a system that will not be used most of the year.

How Large Are the Parts That Need to Be Tested?

If there is a regular need in your business to inspect larger parts, then purchasing a system optimized for large parts will be the most economical solution. However, if it can be safely assumed that only occasional inspections of larger, more unusual parts will occur, it might be best to buy a system tailored to the regular applications and to outsource the exceptions.

Are Shorter Delivery Times Becoming a New Challenge?

If a larger company plans to streamline its turnaround time to establish just-in-time manufacturing, then an in-house inspection system can make a significant difference in terms of delivery times. However, with sporadic demand for fast deliveries, an external inspection service may help stay on schedule.

Are There Any Plans to Introduce Products That Require High-Resolution Scanning?

In research and development, it is often necessary to scan parts in order to assess the impact of minor changes on a shape or design. A dedicated inspection system with the capacity to carry out dimensional and quantitative measurements inside the product would significantly accelerate the trial and inspection process and thereby reduce the time to market. However, if the requirements are low, using an inspection service will certainly be the better alternative.

Do Customers Expect New Production Standards to Be Met?

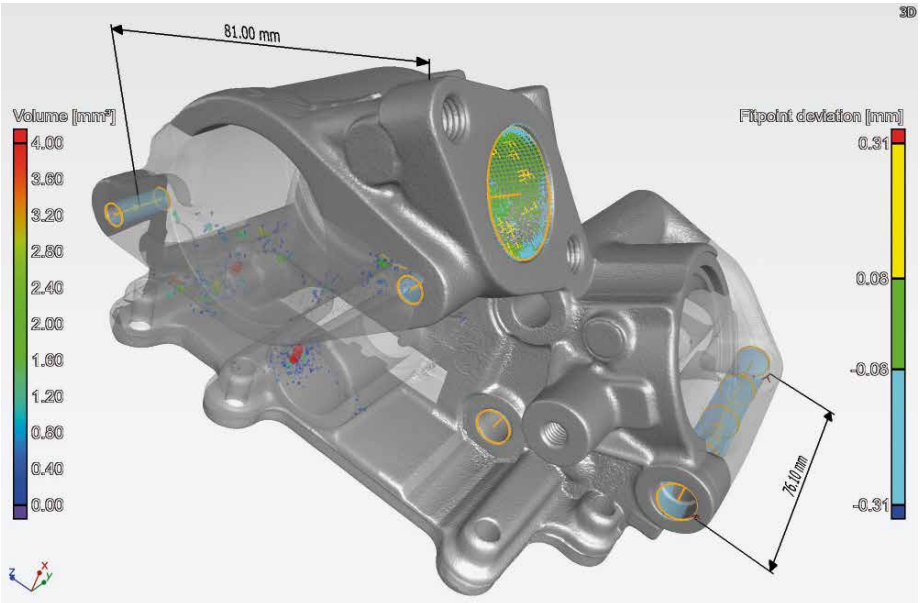
New standards can be the result of many factors, such as legal requirements, updated industry standards, a sudden emergence of recalled parts, etc. For example, several international standards for digital radiography for the aviation industry were issued by the ASTM (American Society for Testing and Materials). They were quickly accepted and are frequently referenced (such as ASTM E2736, E2699, E2597, E2698 und E2737). They cover topics ranging from long-term stability of digital detectors to guidelines on how to best implement this technology. The advantage of using external service providers is that they have these certificates and have experience in how to test for these standards.

Do the Service Providers Offer the Special Competencies Required?

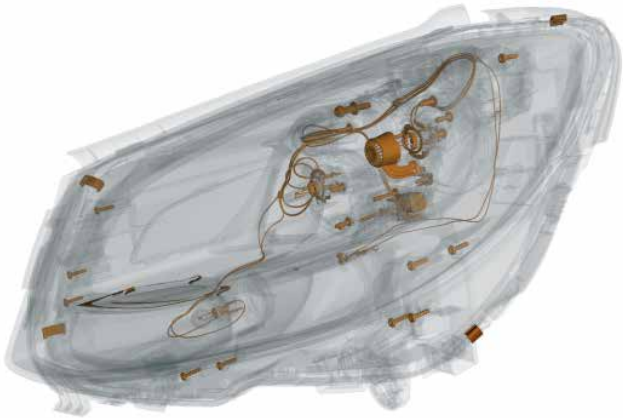
Not all inspection service providers can provide the same methods and qualities. Therefore, you always have to make sure that the service provider has the proper equipment and the qualified staff to meet the specific requirements, e. g. identification of defects and porosities, testing and assessment of internal structures, dimensional measurement or reverse engineering for 3D printing.

What Is the Service Provider's Experience with the Specific Objects to Be Scanned?

Computed tomography is often used for diverse parts like electronic components, castings, cultural or archaeological artifacts, aerospace components, rock and drill samples, implants, etc. It is also used in research, for example for the development of new materials. In order to obtain images with the best and highest resolution, the tester must be familiar with the type of test specimen as well as the test system and software that is most suitable for the particular task.



Aluminum exhaust throttle valve: porosity analysis and measurement tasks



3D volume of a car headlight

» The true differentiation of service providers lies in the quality of their testing system and the capabilities of their staff.«

What Level of Training Does the Staff Performing the Scans Have?

Although all service providers typically follow the same work standards as the International Organization for Standardization (ISO) and the ASTM, not all scans are performed in the same way. Image quality depends almost as much on the skill set of the tester as on the sophistication of the system. Most systems, regardless of the manufacturer, work with similar third-party software. This means that the true differentiation of service providers lies in the quality of their testing system and the capabilities of their staff. Although saving money plays an important role, it is useless if the end result is an image that cannot capture the features of the test specimen that need to be visualized.

Which Inspection Service Provider Delivers the Required Quality at the Best Price?

Proposals for the same project should be requested from several service providers who have the required skills. Selecting a test project for which the competing service providers have to perform scans of the same specimen allows you to properly assess the quality of the images that each service provider's testing equipment can deliver.

Just like no single digital radiography system fits every application, not every single service provider is suitable for every nondestructive testing requirement. However, careful research and targeted exploratory questions enable you to make well-founded decisions as to whether it makes more sense to invest in in-house test equipment or to hire an external service provider. ■

Control 2019: Hall 3, Booth 3303

Yxlon FF85 CT – today's most versatile CT inspection system

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Investment Focus Is on Vision

M&A Trends and Purchase Prices in the Vision Industry

In the prospering vision industry, M&A transactions are becoming more and more popular. Yet, it takes more than just money to ensure such transactions are successful. Munich-based Arthos Corporate Finance is giving insight into those market developments.

The vision industry is fascinating – not just in terms of technology trends and new product offerings, but also with regards to completed M&A transactions, and we are expecting more to come. Prices for vision companies have been increasing over the last couple of years and therefore we are often asked by investors how attractive companies can be convinced to listen to takeover offers and how investors can avoid overpaying in this market.

Growing Attractiveness

It is well known that the vision industry has become more attractive in recent years because, on the one hand, the industry has left its niche existence behind and, on the other, because annual growth rates of more than ten percent have been recorded in many vision market segments. Due to constantly improving technologies with availability of cheaper sensors, software and processors new applications are opening up, many in the field of Industry 4.0, but also in segments such as medical, logistics, agriculture or even mobility of the future.

This growing attractiveness of the vision industry has attracted many new investors who historically have not, or only to a limited extent, been active in the vision industry. This has created additional options for mid-sized companies that are considering a potential sale that were not previously available. We see this trend for the following types of investors:

- Financial sponsors,
- publicly listed industry holdings,
- strategic investors.

Financial Investors with New Type of Transactions

In November 2018, the financial sponsor Ambienta made headlines with the sale of the Lakesight Group to the TKH Group by attaining a purchase price of Euro 140 million. This result was achieved through the implementation of a buy & build strategy, i.e. the acquisition and bundling of several companies. It is interesting, above all, that with Tattile and Mikrotron companies were initially acquired which, due to their economic situation or their lack of fit with strategic investors, had not found a buyer for a long time. Another example is the acquisition of Stemmer Imaging by Primepulse (formerly Alko), followed by an initial public offering. Almost always, financial investors are actively influencing business development and introducing measures to increase profitability. In addition, the management structure of the acquired companies is often significantly changed. The two transactions mentioned above show impressively that the support of financial sponsors enabled new type of transactions that previously did not take place in the vision industry.

Listed Industry Holdings Increasingly Invest in Vision Companies

The publicly listed companies Ametek, Konica Minolta Holdings and Halma are examples of listed industry holdings investing in very profitable and strongly growing companies in technological industries. The business model and the management structure of the acquired companies are not or only slightly changed – the acquired companies retain a high level of independence because they are already economically very successful when acquired. Historically, these listed industry holdings have purchased in related industries such as the electronic equipment or photonics sector. However, because of the growing attractiveness of the vision industry, they are now also investing in this promising sector.

Additional Strategic Investors Are Showing Interest

Last but not least, during recent years many companies invested in the vision industry for strategic reasons that were not present in this segment before. Strategic investors are companies that integrate acquired companies into their existing business in order to achieve business synergies. Examples include Balluff, Hexagon and Flir Systems, which were previously players in automation, metrology and infrared technology, respec-

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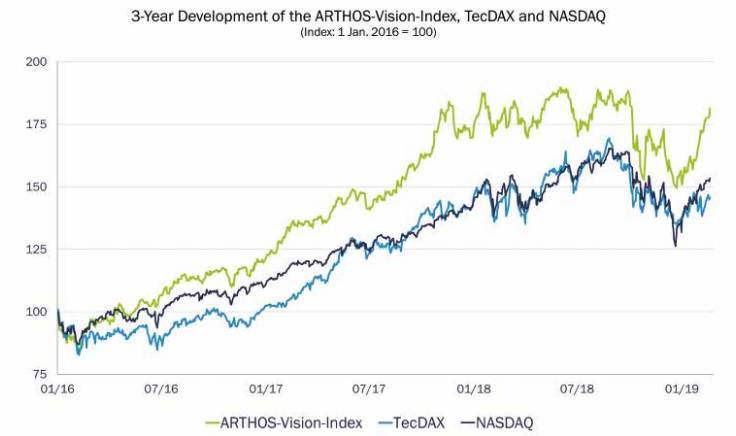

The high attractiveness of the vision industry is reflected in the good performance of listed vision companies.

Vision stocks have recently recovered.

tively. From the point of view of these strategic investors, machine vision competencies and technologies became key to their own future business development and thus the integration of the acquired companies is the main driver for strategic investors.

Vision Companies Outperform other Technology Companies at the Stock Exchanges

The high attractiveness of the vision industry is also reflected in the good performance of listed vision companies. Comparing the Arthos-Vision-Index – which includes the most important listed vision companies worldwide (e.g. Cognex, Teledyne, TKH Group) – with the performance of technology market indices, shows that the TecDAX as well as the NASDAQ were outperformed over the past three years. Furthermore, the recent recovery of vision stocks is due to growth expectations are once again above those of other technology companies.

Vision Companies Continue to Have an Attractive Valuation

A common valuation multiple for listed companies is the enterprise value (EV) divided by the EBITDA of the last 12 months (EV/EBITDA LTM). Since 2012, as visualized in the chart above the median EBITDA multiples of the Arthos-Vision-Index increased from below 8 to a peak of 18; after the recent market correction, at the end of 2018 the median came down to 12, which was still approximately 50% above its 2012 value. However, thanks to the recent recovery of vision stocks, the median rose back up to a multiple of around 14.5 in just six weeks.

Even though prices at the stock exchange fluctuate more than the purchase prices of small and medium-sized enterprises (SMEs), the long-term trends are fundamentally transferable, because SMEs operate in the same industry environment and the individual valuation of listed companies also affects their capability to pay higher or lower purchase prices for SMEs. However, it should be noted that M&A purchase prices of SMEs usually trade at a discount rate to stock market valuations due to their smaller size and the illiquidity of their company shares. According to our experience, during the past three years an average EBITDA multiple of about 10 was paid for vision SMEs with an annual growth rate and with an EBITDA margin of around 10%. In comparison, EBITDA multiples of around 8 are paid for SMEs in the electronics industry, which is roughly equivalent to the prices paid for vision SMEs three to five years ago. This shows that the valuation trend of the stock market for vision companies also had a positive effect on purchase prices for SMEs.

Despite the current correction in stock market valuations, we do not expect prices for SMEs in the vision industry to decrease considerably as the dynamic demand for vision products and services driven by applications for industry 4.0, mobility of the future and others will continue to keep the interest of investors in vision SMEs high.

It Takes More Than Just Money to Acquire a Vision Company

It is also interesting to observe that interested parties from various buyer groups often submit proposals with similar purchase prices in bidding processes. That means that the decision process between different offers is less a result of differences in the purchase price, and much more driven by the plans of the investors for the acquired company and what future role they offer the former owner.

In transactions with financial investors, normally former owners are offered the option to reinvest in a parent holding company at the time of the sale of their company in order to be able to participate economically in future development. In addition, often a non-executive director position is part of the package. Listed industry holdings, which in many cases are domiciled overseas, as well as many strategic investors often pay part of the purchase price as an earn-out, i.e. depending on the future economic success of the acquired company, sometimes even years after the purchase. From the seller's point of view, strategic investors can often offer the most promising packages, as business synergies can sometimes result in significant additional revenues for the acquirer as well as the acquisition target. However, the reality shows that some acquirers execute integrations better than others and adaptability to the interests of the seller, in particular, is sometimes limited.

Therefore, during the purchasing process it is not about developing a long target list and then approaching many to finally succeed with at least one, but more about offering interesting roles for the owner and the company they built up. Those acquirers who make people curious when approached and offer business concepts tailored to the seller's interests tend to be most successful. To avoid overpaying, focus on what is really needed, e.g. what is more important: excellent products or the sales channel? The right M&A strategy combined with a properly tailored approach certainly takes much more time and effort, but in return leads to a much higher success rate and ROI. ■

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Thanks to the enthusiasm that has developed in recent times for the term Deep Learning, the use of this technology for machine vision has now become popular on a broad basis.«

Automation and Machine Vision Move Closer Together

Automation technology and machine vision are increasingly merging. We discussed this exciting development with Peter Keppler, Director of Corporate Sales at Stemmer Imaging.

inspect: Mr Keppler, the merging of the control and machine vision worlds is a current trend in automation. What is the current situation, and do you foresee any difficulties?
P. Keppler: Amongst other things, the fact that leading controller manufacturers, such as Beckhoff, B&R and others, are pursuing the subject of machine vision with greater dedication than before shows that these two worlds really are moving closer and closer together. There is now a general conviction that "seeing" plants can do more than "blind" plants in many industry branches. As a supplier of machine vision technology, we naturally view this development as a logical and very positive step. Machine vision is now an established technology in the field of automation and with regard to Industry 4.0 it's completely indispensable.

As is so often the case, however, the difficulties along the road to user-friendly solutions lie in the detail. Important questions here are, for example, cross-manufacturer compatibility and communication between the controller and the machine vision system. There were no comprehensive standards for this topic in the past and that has unfortunately continually delayed the merging of the two worlds. Good standards aren't simply the "lowest common denominator," but must continue to allow differentiation between providers. In the meantime, there is growing awareness on both sides that the future lies in standardisation and compatibility. With the latest developments and the publication of the OPC UA Companion Specification for Machine Vision, we are currently at the dawn of a new era: this standard will considerably accelerate the interaction of machine vision and automation across all manufacturers and in this way make a big contribution towards making "seeing" plants an actuality according to the concept of Industry 4.0.

inspect: What new markets are arising from the merging of control and machine vision?
P. Keppler: I don't necessarily expect new markets as a result, but rather a much broader acceptance of machine vision in the existing application areas. In my view, the proven machine vision specialists remain responsible for "new markets". They are developing areas of application that have barely been opened up so far, among other things through the use of promising technologies, such as hyperspectral imaging (HSI), Deep Learning, 3D imaging, surface analyses and other approaches. Comprehensive consultation and intensive feasibility studies are still required for the implementation of successful applications in these areas.

inspect: Manufacturers of classic sensor components are increasingly offering imaging products. Why is that?
P. Keppler: The reason is clear: users are requesting them! Many current Industry 4.0 requirements can already be solved in an elegant way with quite simple machine vision solutions, whereas the classic sensors do not offer the

necessary flexibility. The selection and operation of these "vision sensors" is in some cases so simple that users can also be served efficiently through a sensor distribution network. However, I urgently recommend users to make use of independent consulting and training courses in order to ensure that they actually find the ideal solution for the individual task.

inspect: What effects does the merging of the two worlds have on their users?
P. Keppler: In my view, automation companies must concern themselves more with the subject of machine vision, as they will no longer be able to meet the requirements for Industry 4.0 in future without this technology. Machine vision systems must be simple to operate for this new group of users and must take into account their level of knowledge. However, this requirement is at the same time a big challenge, because the bandwidth of machine vision applications is very broad. On the one hand it is advantageous when more and more applications can easily be solved by machine vision devices that are simple to operate. On the other, focusing too strongly on "simple applications" also hampers the development of really innovative solutions with a unique character.

inspect: What ways of driving the use of machine vision into new task areas do you see?
P. Keppler: An important catchphrase for this at present is 'machine learning methods.' We have concerned ourselves with this subject for many years now and have already been able to successfully complete thousands of projects with technologies based on it. Thanks to the enthusiasm that has developed in recent times for the term Deep Learning, the use of this technology for machine vision has now become popular on a broad basis, even though Deep Learning – that means multilayer neural networks – is not ideal for industrial imaging in my opinion. With the right machine learning algorithms, however, we will soon see high-performance, flexible vertical solutions that will even run on inexpensive embedded systems, making extremely cost-effective systems possible.

Another way of simplifying machine vision, of course, is to use graphical user interfaces, from which programmers and integrators above all could benefit through fast induction and short time-to-market phases. However, I urgently recommend attaching importance here to vendor-neutral hardware support. In the field of camera technology, the established standards GigEVision and USB3Vision already offer a good basis for equipping oneself for most applications. Additionally, OPC UA will establish itself for independent communication with the plant controller.

inspect: Let's go back to the merging of automation and machine vision: how do you asses this development in summary?
P. Keppler: There has been a consensus of opinion for years that the combination of these two worlds offers considerable advantages for automation users and can create innovative possibilities. In the era of globalisation and Industry 4.0, the close connection of these key technologies is an important prerequisite for cost-effective automation solutions. With the current developments around the OPC UA standard, a large step has now been taken in my opinion towards the significant simplification of integrated solutions consisting of machine vision and automation in the interests of the users. We make an important contribution to the simple, risk-free entry into machine vision with our independent technology training courses for the planning and design of machine vision solutions. ■

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What Is Autonomous Machine Vision?

Giving QA and Plant Managers Complete Control over Their QA Processes

Autonomous Machine Vision has kickstarted a revolution away from complex, cumbersome and expensive traditional solutions installed by a systems integrator. Instead, manufacturers can accurately and affordably inspect products immediately – at any point in the production line. Yonatan Hyatt, CTO of Inspekto, the founder of Autonomous Machine Vision, explains the fundamentals of this new category.

In 1500, da Vinci designed a cart that could move without being pushed or pulled. Sometimes considered to be the world's first robot, the cart could move along a predetermined route, powered by springs under tension. Flash forward and we now have technology that can intelligently, not just mechanically, determine its own actions.

Robots on the Rise

Automation and robotics are now commonplace across manufacturing environments. According to the International Federation of Robotics (IFR), there will be a projected 630,000 industrial robots shipped to customers in the year 2021. However, automation has not been so quick to catch on in the quality assurance (QA) industry. According to the World Quality Report 2018-9, automation is the biggest bottleneck holding back QA and testing today. The report also found that artificial intelligence is becoming more important in testing, though 51% of respondents have experienced difficulty integrating AI with their existing applications.

What is Autonomous Machine Vision?

Autonomous Machine Vision gives QA managers and plant managers complete control over their QA processes. It requires little cost, effort and time to install and run. Importantly, rather than handing the reins of a machine vision project over to an external systems integrator to design and build a custom system for a particular point on the production line, manufacturers can do it in house.

In under an hour, the plant's own personnel can install an Inspekto S70 and begin assessing the quality of products on their production line. Because it is as simple as Plug and Inspect, the manufacturer can have complete independence and control over QA in the facility. Plug & Inspect is the first integrator-less technology for visual quality inspection, gating and sorting, which eliminates the costly integration and customised developments that characterised traditional machine vision technology.

Based on sophisticated artificial intelligence technology, Autonomous Machine Vision not only means that no external systems integrator is needed, but also that the plant's own staff require no additional skills or training to set it up or operate it. The system's algorithm can optimise the camera and illumination settings for the object and environment and then detect and locate the object without any input from the operator. The system only requires a limited number of good sample references and the system learns the properties of a gold standard product.

The system is ready-to-use, straight out of the box – the QA manager simply has to draw a polygon to mark the areas of interest on the object to be inspected. Once in operation, the system will compare each image with the gold standard, verifying both the shape tolerances and surface variations to identify any defects.

Autonomous Machine Vision therefore enables Total QA – visual quality assurance at every step of the production line.«

QA Is Everywhere

Autonomous Machine Vision therefore enables Total QA – visual quality assurance at every step of the production line. The manufacturer can identify a defective product at the exact stage that the defect was introduced. This improves yield and prevents scrap, by ensuring no further time or energy is wasted on a defective part and that it is not combined with a good part later to form a faulty product.

Total QA also enables the manufacturer to optimise their line. By performing root cause analysis using data that represents the full picture of what is happening, the QA manager can trace a defect back to its source. They can then take action to replace or perform maintenance on the equipment at fault and prevent defects from being introduced in the future. In this way, the manufacturer can optimise and streamline their plant, protecting their customers from defective products and protecting their facility from scrap and flawed manufacturing processes.

Total Control

Autonomous Machine Vision addresses the QA manager's true needs. Unlike traditional machine vision solutions, suited only to the integrator's needs, Autonomous Machine Vision gives the QA manager complete control of where, when and how visual QA systems are deployed.

The market has shifted since the World Quality Report was published. Autonomous Machine Vision has kickstarted a revolution away from complex, cumbersome and expensive traditional solutions installed by a systems integrator. Instead, manufacturers can accurately, affordably immediately inspect products at any point on the production line. ■

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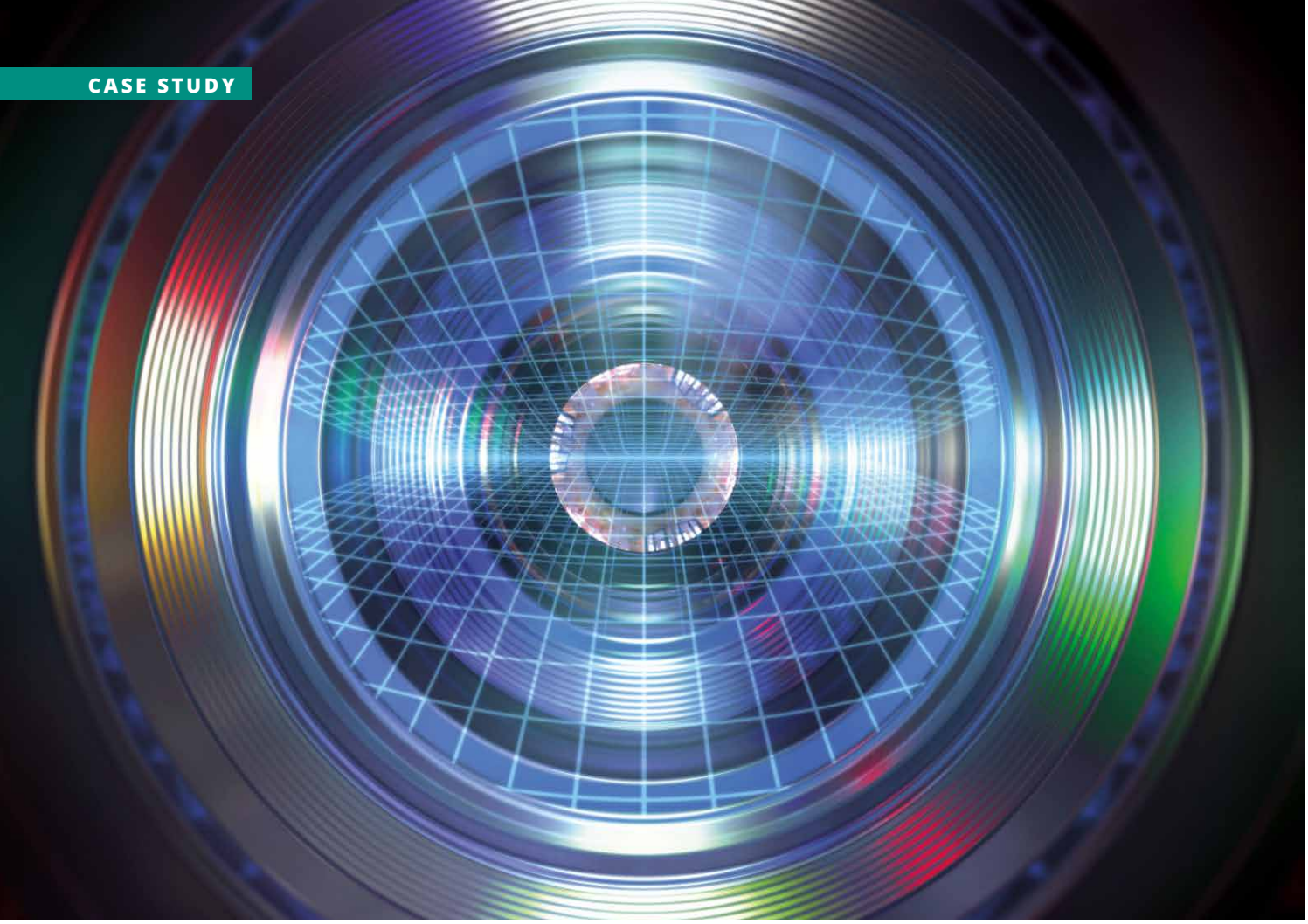
CASE STUDY



Machine Vision – Simple and User-Friendly

High-Performance Solutions Help Simplify Creation of Machine Vision Programs

The development of machine vision applications does not have to be complicated and time-consuming. With suitable software, it is now possible to generate such applications easily, quickly, and without any in-depth programming or machine vision expertise.

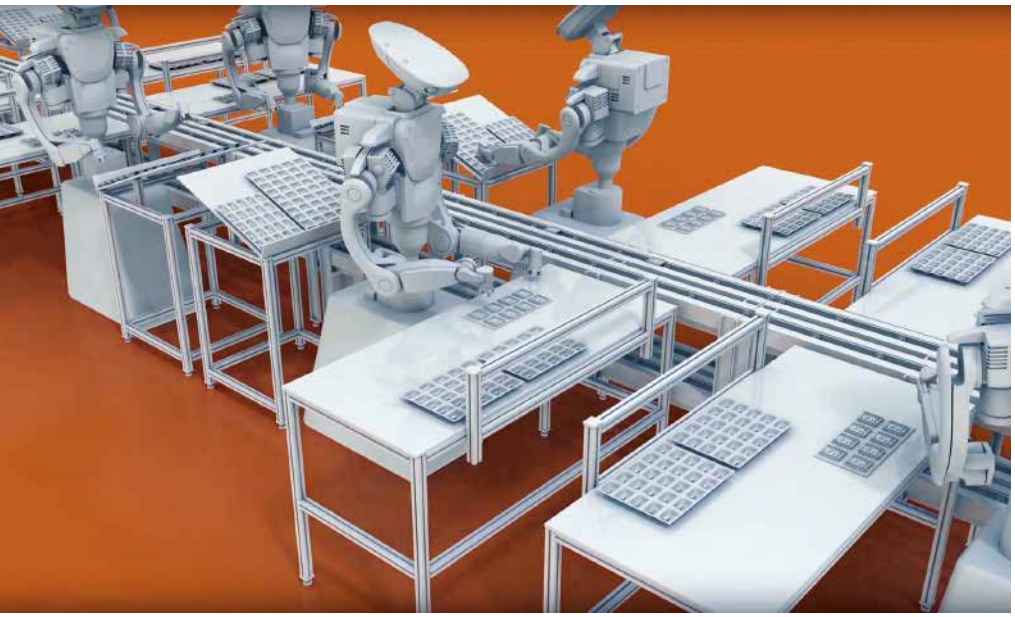
Technology trends such as the Industrial Internet of Things (aka Industry 4.0) and smart factory scenarios are profoundly affecting the value chains in manufacturing companies. Operations in assembly halls are characterized by digitalized, networked, and highly automated workflows. Technical components such as machines, robots, transfer and handling systems, sensors, and cameras communicate with and complement one another in the context of continuous production lines. At the same time, a new generation of compact, lightweight, and mobile robots, known as collaborative robots (cobots), is gaining ground. As the name implies, these cobots work seamlessly with humans, hand off parts to one another and work together to assemble entire components. Another advantage is that cobots can be quickly and flexibly retooled, enabling them to be used for a variety of manufacturing jobs.

In such scenarios, machine vision is of particular importance. As a key accompanying technology, it's often what makes highly automated processes possible in the first place. Using image acquisition devices such as cameras or 3D sensors, machine vision continuously monitors operations and functions as the "eye of production". The reliable detection of different objects makes handling processes safer and more efficient. Workpieces can be accurately positioned, and robots precisely grasp the right objects at the proper locations. Moreover, defect inspection can be automated as part of quality assurance. Low-quality products with visible defects can be reliably detected and removed before they enter the downstream process chain.

Quick and Flexible Setup of Cobots

Today's machine vision technologies must respond to the new requirements in robotics and, more particularly, support the work of cobots with sophisticated functions. It must be possible for mobile robots to be set up quickly and flexibly for changing production tasks. This requires that extensive machine vision programs for a variety of robotics applications can be created quickly and without a lot of effort. Modern, high-performance machine vision solutions help simplify the creation process and thus accelerate robot setup.

MVTec offers a practical solution with its Merlic standard software. The software allows professional machine vision applications to be compiled at a high level without the need for in-depth programming skills or machine vision expertise. Its key element



Cobots are being deployed more and more in Industry 4.0.

is an image-centered user interface that intuitively guides users through the entire process. The developer does not need any codes, command lines, or parameter lists, but can instead concentrate on the visual display of the machine vision functions, similarly to using a WYSIWYG (what you see is what you get) editor. In addition, the software includes a toolbox with standard tools for acquisition, calibration, alignment, measuring, counting, checking, reading, position recognition, and defect detection.

Detect, Mark and Select Objects with a Single Click

An innovative concept called EasyTouch also facilitates the building of applications. The user simply hovers the mouse pointer over an image, allowing specific objects to be immediately detected, marked and then selected with a single click. This means that it is no longer necessary to laboriously configure complex parameters, which saves a lot of time during development. An integrated designer provides numerous control elements that can be used to design a graphical user interface (GUI) in just a few steps using drag and drop.

The machine vision applications created can consistently communicate with PLCs (programmable logic controllers) via Merlic and can be seamlessly integrated into comprehensive automation solutions.

MVTec has further improved usability with its new Merlic 4 which was released in February 2019. This new version of the machine vision software includes numerous functions that make the development of machine vision applications even easier, more efficient and more user-friendly. For example, various tools can now be simultaneously processed and executed, thereby simplifying the implementation of multi-camera setups and allowing for a more efficient use of the system's computing power. This new feature is also reflected in the tool flow, rendering the user interface even more intuitive and making it even easier to use the tools to arrange and handle parallel strands.

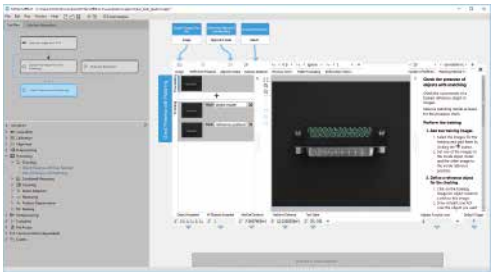
Integrated 3D vision tools that work on the basis of height images enable users, for example, to read embossed text and perform other 3D machine vision tasks. For this, the software includes four new tools that make it possible to prepare images from 3D sensors or 3D cameras so that inspections can be carried out using the existing 2D tools.

Integration of Machine Vision and PLC

Another novelty is the software's ability to communicate with common fieldbus and real-time Ethernet industrial protocols, such as Profinet, EtherCAT, and many others, via Hilscher PC cards. This further advances the integration of the machine vision and PLC worlds. In addition, "recipes" are now supported that permit a rapid changeover to other machine vision tasks.

Companies benefit tremendously from the much simpler handling. Consequently, complex machine vision tasks can now be assigned to a much larger group of people than ever before. Engineers from different disciplines can generate high-quality applications regardless of their current programming or machine vision expertise, thereby enabling professional developers to devote themselves to more complex challenges in the programming environment. Moreover, standard development processes can be significantly accelerated, and smaller projects implemented with less effort – which also applies, for example, to the creation of applications with cobots. This makes it possible to use machine vision technologies more cost-effectively in a variety of industries as well as to simplify processes and raise quality assurance to a new level.

»The developer does not need any codes, command lines, or parameter lists, but can instead concentrate on the visual display of the machine vision functions.«



The Merlic software simplifies the creation of machine vision applications.

More Flexible Production

In view of the growing requirements of digitalization, automation, and the Industrial Internet of Things, today's companies must design their production workflows more flexibly. In this context, it is important to simplify and accelerate the development of machine vision applications. Through the use of appropriate software, companies save time and effort and also improve the usability and flexibility of their setup processes. ■

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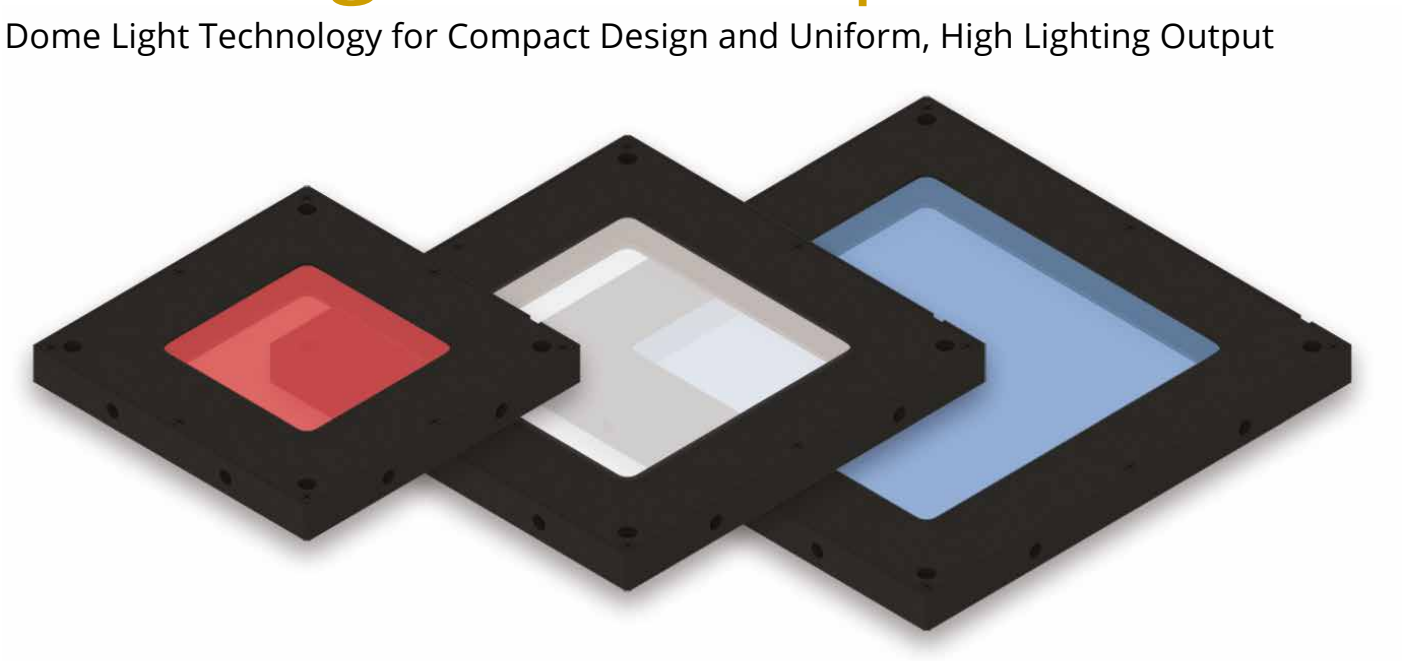
Avoiding the Dark Spot

Dome Light Technology for Compact Design and Uniform, High Lighting Output



Innovation in machine vision lighting technology is being driven by growing demands from users in areas such as more compact machine design, and inspection of surfaces which are uneven or highly reflective. Advances in flat dome lights are a good example of this trend. The latest developments from CCS in this field illustrate how leading illumination players are adapting to such market demands.

No Second Light Needed

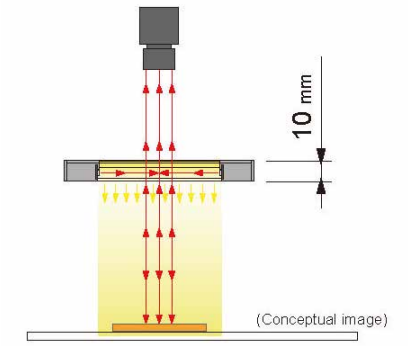
When you would like to remove surface irregularities from your image, you would traditionally deploy a dome light for its diffused output. However, because of the camera hole in the dome shell, the user must take into account that there will be a dark spot in the middle of their image. This can be overcome by adding a coaxial light on top, but this creates the necessity of a second lighting unit to be controlled individually, which can become a very space-consuming solution.

The flat dome technology from CCS has the same type of diffused output as a dome light. However, since this does not have a camera hole, it does not have a dark spot in the middle. This eliminates the need for a second lighting unit altogether and improves lighting uniformity in the acquired image. When moving the LFXV Series further away from the workpiece, you are also able to create parallel lighting output. This has much in common with a traditional coaxial light. The benefit compared to a coaxial light is that the light does not have to pass through a half-mirror of a coaxial light twice before it reaches the sensor. As such, light loss is kept to a minimum. Furthermore, the LFXV Series is only 10 mm thick. For applications where space-saving is absolute key, the LFXV Series offers the user an often-required solution.

Applications and Benefits

The LFXV Series is typically deployed in applications where reflections or surface irregularities need to be reduced. An example of this is when you need to read a code on a package. Because of the reflective nature of the plastic surrounding the package, this is difficult to do. However, thanks to the diffuse output of the LFXV, the reflections are removed, and the code is easily readable.

Another example is the codes printed on a capacitor. This is a very rough surface, which becomes clearly visible when using a ring light. With the LFXV Series however, surface irregularities are removed, and the code is easily readable.



The LFXV Series does not have a camera hole, and therefore it does not have a dark spot in the middle.

New Light-Guiding Diffusion Plate

CCS has recently released its new LFXV Series, this new series is the renewal of its industry-leading LED flat dome lights. Unlike its predecessor, the new LFXV Series uses a newly-developed light-guiding diffusion plate. The new plate uses a redesigned dot pattern, which is barely visible in the acquired image. The low visibility of the dot pattern enables the capture of much clearer images and allows for a much brighter field of view combined with higher uniformity, making the LFXV Series the ideal companion for high resolution camera sensors. The LFXV Series is available now in four different sizes (25, 50, 75, 100 mm). All sizes are available in red, white, blue, and IR860, with green available on request as a semi-custom product. ■

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What's New in the World of Ethernet?

2.5/5GBASE-T, Time-Sensitive Networking (TSN), OPC UA

Today, Ethernet is the most popular and widely used network technology in the world. GigE Vision provides a framework for transmitting high-speed video and related control data over Ethernet networks, making developer's lives easier.

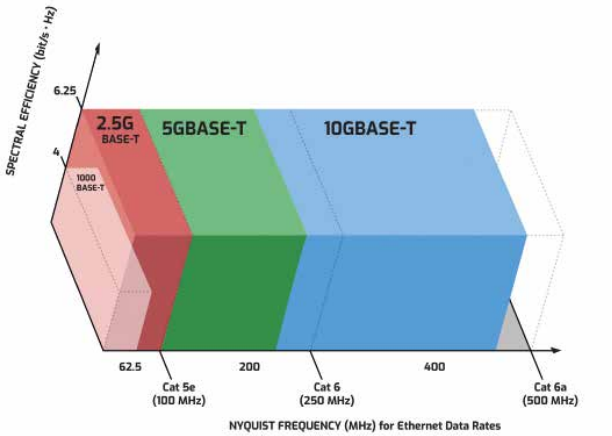
Since its introduction in 1980 and standardization in 1983 as IEEE 802.3, Ethernet allows computers to connect to other computers, servers, printers, scanners and other peripherals over single networks. These often use numerous switches that connect computers, printers and other wired devices to each other and are often wired to routers and models to allow Internet access. In office settings, Ethernet is now the most popular and widely used network technology in the world with millions of computers and peripherals linked together with the standard.

Data Rate Evolution

Like every other networking and interface standard, Ethernet has evolved from supporting data rates ranging from the now obsolete 10BASE5 (10 Mbit/s), through 1000BASE-T1 (1Gbit/s),10GBASE-T (10 Gbits/s), 25GBASE-T (25 Gbits/s) and 40GBASE-T (40Gbits/s). In 2016, recognizing the need to develop a lower power, more cost-effective version of 10GBASE-T (10 Gbits/s) over twisted pair networks, the IEEE standards board ratified the 802.3bz standard which encompass 2.5GBASE-T and 5GBASE-T.

While 2.5GBASE-T specifies speeds of up to 2.5 Gbits/s and operating at distances to 100 m over Cat 5e cable, the 5GBASE-T can operate as fast as 5Gbit/s at distances of 100m over Cat 6 cable.

Although 10GBASE-T operates at 10Gbits/s and can be used for camera to computer distances of 55 m (using Cat 6 ca-



Like every other networking and interface standard, Ethernet has evolved from supporting data rates ranging from the now obsolete 10BASE5 (10 Mbit/s), through 40GBASE-T (40Gbits/s).

ble) and 100 m (using Cat 6A cable), Power over 10GBASE-T is not currently supported. Thus, the use of existing cable combined with the lower power consumption and Power over Ethernet (PoE) has made 2.5GBASE-T and especially 5GBASE-T an attractive alternative, not just for communication systems, but also for manufacturers of machine vision peripherals such as CMOS-based cameras.

When compared with the fastest Camera Link Extended Full or Deca version that runs at a maximum of 6.8 Gbit/s over distances of 5 m maximum, the benefits of a 5GBASE-T interface are that it does not require an expensive PC-based frame grabber and custom cabling becomes apparent.

Fast Running 5GBASE-T Cameras

Recognizing these benefits, a few companies have now introduced cameras based on the 5GBASE-T standard. One example of such an area array camera is the latest Atlas 5GBASE-T camera from LUCID Vision Labs, one of the first companies to implement 5GigE in its Atlas camera series ranging from 5 Megapixel to 31.4 Megapixel. With an M12 hybrid connector capable of transferring 2.5 W of power and 5Gbit/s of data, the first model will feature Sony IMX342-based CMOS camera with 31.4 Megapixel resolution, 3.45 µm pixel size and can operate at frame transfer rates of 17 fps at distances of 100 m over Cat 6e cable.

Speed Specifications

There are many reasons why the machine vision market has embraced the 5GBASE-T standard. Many existing interfaces offer high bandwidth but at limited distances. Camera Link Extended Full version runs at a maximum of 6.8 Gbit/s over distances of 5m. USB 3.1 and USB 3.2 interfaces can transfer data at up to 10 Gbit/s and 20Gbits/s respectively, but are limited to camera-to-computer connection distances of 5m (USB 3.1) and 3 m (USB 3.2). Similarly, the fastest camera-to-computer interface, CoaXPress (CXP) can transfer data at speeds as high as 12.5 Gbit/s per CXP link and thus 50 Gbits/s using four links, cable length is limited to a maximum of 35 m at these data rates. However, using slower data links of 3.125Gbit/s, this can be extended to 100m.

System Cost

Like Camera Link, a relatively expensive (+$2,500) PCIe interface card is required to implement CXP-based systems. In some high-speed line-scan applications such as web inspection that demand low latency, low-jitter point-to-point interfaces, CXP systems must be deployed. 5GBase-T offers a lower cost alternative to Camera Link and CXP, capable of delivering high bandwidth performance at a lower price point.

Many 10GBase-T network interface cards, switches and hubs are backwards compatible at 2.5GBase-T and 5GBase-T speeds. Machine vision peripheral manufacturers have also introduced multi-port 2.5GBase-T and 5GBase-T network interface cards supporting Power over Ethernet. This greatly lowers the overall system cost for multiple camera systems.

Embracing GigE Vision and GenICam

GigE Vision provides a framework for transmitting high-speed video and related control data over Ethernet networks, making it easier for developers to build software. As part of the standard, GigE Vision's GigE Device Discovery Mechanism provides mechanisms to obtain IP addresses and an XML description file that allows access to camera controls and image streams that is based on the GenICam standard developed by the Verband Deutscher Maschinen- und Anlagenbau (VDMA; Frankfurt am Main, Germany; www.vdma.org).

While GenICam exposes features of a camera (such as frame rate) through a unified API and GUI, each feature is defined in an abstract manner by its name, interface type, unit of measurement and behaviour. The GenApi module of the GenICam standard defines how to write a camera description file that describes the features of a device, to be interoperable and a GenICam Standard Features Naming Convention (SFNC) that provides a common set of camera features, their names and their behaviour.

This is not to say, however, that out of the box, such 5GBASE-T cameras that embrace standards such as GigE Vision and GenICam provide a deterministic solution for industrial Ethernet-based applications. Business systems and office environments do not require such determinism since it is not critical whether data packets are correctly sent and received or whether they are sent and received during a known period of time. However, for industrial Ethernet systems where, for example, a machine vision system must inspect parts in a timely fashion, the opposite is true.

Such systems must be highly deterministic since any failure to transmit, receive and act on processed data at specific times in a guaranteed fashion is important since data loss or delay between process control equipment can result in unpredictable systems. Such determinism is therefore highly important and has been addressed by a number of specialized industrial Ethernet protocols.

Popular Protocols

Popular industrial Ethernet protocols include Profinet, EtherNet/IP, EtherCat, Sercos III, and Powerlink. Since there are major differences in the technical approaches taken by each of these protocols, supporting every one of them would be a Herculean software effort but for all of the largest manufacturers of industrial automation equipment. However, according to Kingstar, EtherCat offers both superior performance and market acceptance, delivering real-time, deterministic responses required by industrial machine controllers using low-cost network interface cards (NICs) and Ethernet cables.

To support this fieldbus, the OPC Unified Architecture (OPC UA - IEC 62451), an open standard developed by the OPC Foundation, can be used to specify the information exchange for industrial communication on

> With the emergence of the OPC Unified Architecture the OPC Vision Initiative and the IEEE 802.1 standards for time-sensitive networking (TSN) companies can use a single Ethernet network for both time-critical, deterministic applications such as image capture and less time-critical IT systems.«

Lucid's 5GBASE-T Atlas camera ranges from 5.0 MP to 31.4 MP capable of 600 MB/s data transfer rates over standard copper Ethernet cables up to 100 m. It features a TFL lens mount (M35) that is easily adaptable to F-mount and Active Sensor Alignment for superior optical performance.

computer-based machines, in-between machines and from machines to and from computers systems.

With OPC UA, developers can take advantage of OPC's data model and services to enables devices to exchange data with an agreed and shared meaning, rather than mapping data as byte streams. At the same time, the EtherCat Technology Group and the OPC Foundation's technologies complement each other with EtherCat being used as a real-time-Ethernet fieldbus for machine and plant controls and OPC UA as a platform for scalable communication.

Making Machine Vision Systems

While useful, such collaborations do not specifically address the needs of developers of machine vision systems wishing to leverage Ethernet-based systems on the factory floor. To do so, VDMA has collaborated with the OPC Foundation to form an OPC Vision Initiative to develop an OPC UA companion specification for machine vision.

While the OPC UA describes data, functions, and services of embedded devices and machines and data transport, for data modelling, OPC Vision allows industry-specific definitions of products such as cameras to be defined, similar to the GenICam Standard's Features Naming Convention. As well, the OPC Vision Interface can be integrated with fieldbus standards such as EtherCat to form a complete system model for real-time deterministic systems that can be integrated with OT production control and IT systems.

With the emergence of the OPC Unified Architecture the OPC Vision Initiative and the IEEE 802.1 standards for time-sensitive networking (TSN) companies can use a single Ethernet network for both time-critical, deterministic applications such as image capture and less time-critical IT systems. Since the OPC UA TSN standard can be applied to computer-based nodes on the network, including cameras, PCs, PLCs, and server-based systems, it will be especially useful in developing edge-based and cloud-based network applications.

Low-cost 5GBASE-T cameras coupled with standard off-the-shelf Cat 6 cable allows cameras to be easily located at up to 100 m from the host computer. Eliminating the need for relatively expensive frame grabbers lower the total cost of machine vision systems while still allowing 10Gbits/s image data transfer from the camera, fast enough to address a broad range of vision applications. Finally, when established, efforts such as the OPC Unified Architecture and the OPC Vision Initiative will ease the deployment of 5GBASE-T cameras in industrial Fieldbus-based Ethernet networks, and enabling an easy system integration. ■

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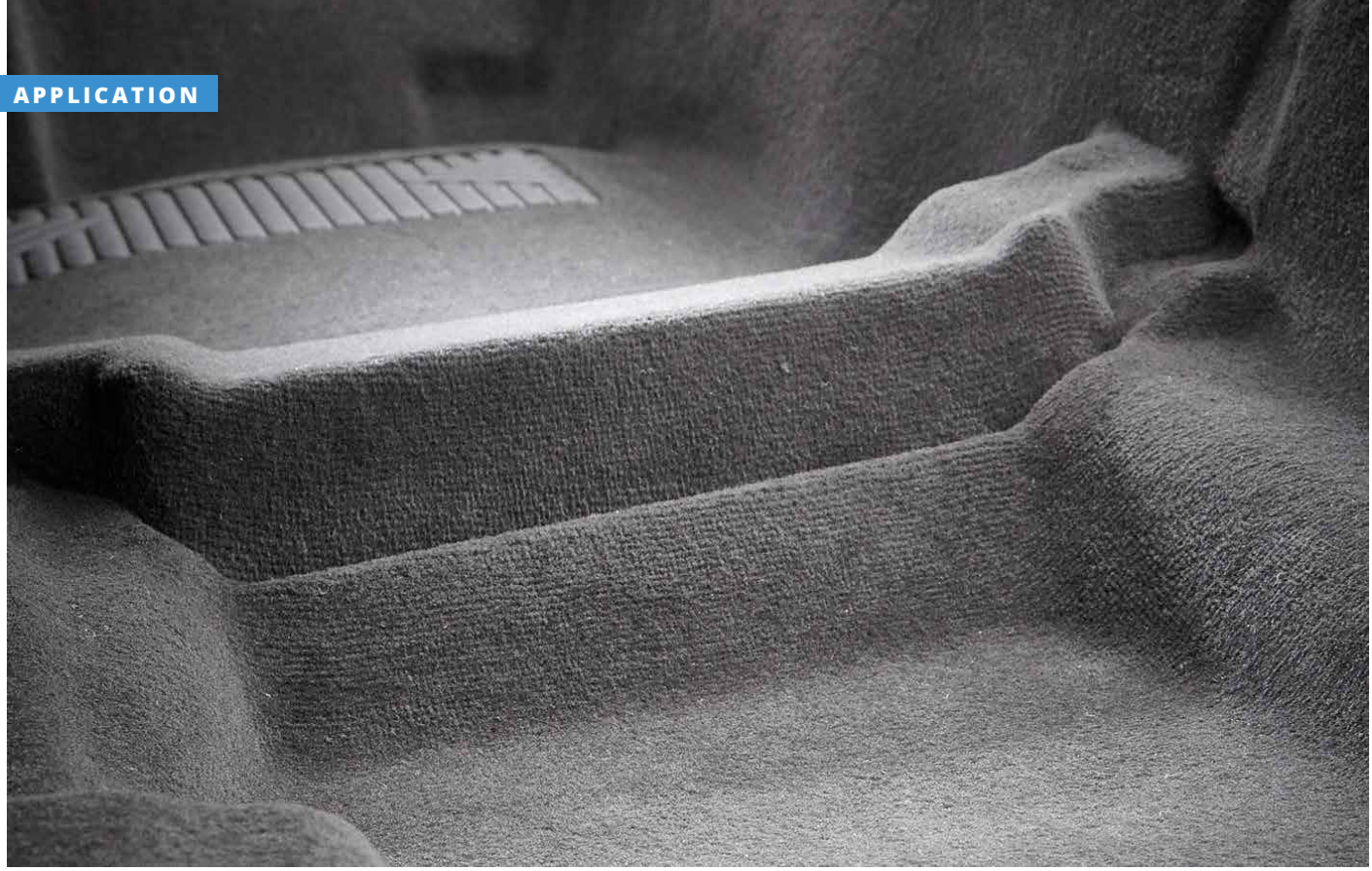


Real-Time Imaging

Adaptable Real-Time Vision System Increases Polymer Fleece Quality

Who would say no to better error detection in the manufacturing process? The improvement was enabled by the combination of line scan cameras, frame grabbers, and software into a tailormade inspection system.

Low & Bonar, headquartered in London UK, is a leading global manufacturer of high-performance materials that are produced in Europe, North America, the Middle East and China. They supply a wide variety of polymer fleece from various polymers they process in their factories into threads, fibers and coated textile items and composite materials. The manufacturing process consists of thermally bonding 350 fibers, each composed of 127 filaments, into fleece. The filaments in the material should open, making a stable product. The task of the image processing system is to find errors such as unopened yarn, dark spots, light spots, and a combination of dark and light spots. The unopened yarn algorithm is very processor intensive and is executed by a Silicon Software frame grabber together with the flat field correction. This could not be done on a PC in real time. The previous proprietary system could not detect unopened yarn errors.

Selecting the Right Components

Stemmer Imaging was contracted as the consulting, development, and implementation partner to choose appropriate solutions. They selected four monochrome Teledyne Dalsa Spyder 3 line scan cameras with 4K resolution, 8-bit image depth, and line frequency of up to 68kHz, as well as four programmable microEnable IV VQ4-GE frame grabbers from Silicon Software with GigE Vision camera interfaces. This system offered a good price-to-performance ratio, allowed 100 meter long cables to the host PC, guaranteed short implementation times and satisfied the hard real-time demands on image processing. Silicon Software's GenICam Explorer for the camera configuration and microDisplay for image acquisition control and preview aided rapid system implementation.

The software was developed in a joint approach, in a very short time: Stemmer Imaging did the programming of the microEnable IV VQ4-GE frame grabber using VisualApplets by the specifications of Low &Bonar.

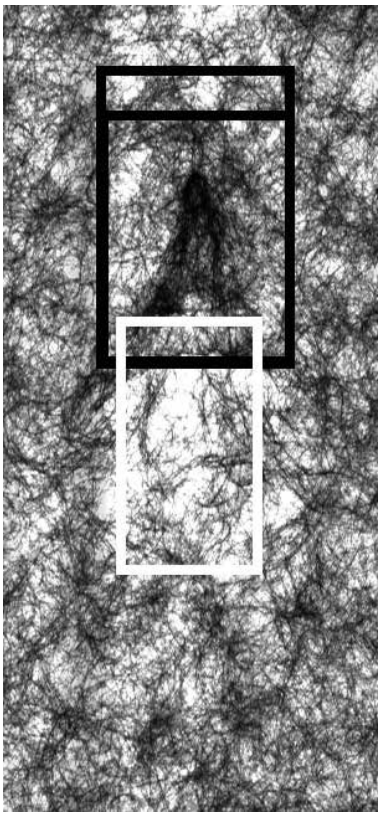
System Programmed and Put into Production in No Time

Using VisualApplets, Stemmer programmed a hardware applet for the FPGA for this special inspection task, along with a software configuration interface to the host PC for the applet. This contains a flat field correction al-

MicroEnable IV VQ4-GE frame grabber with four camera interfaces

> With the new image processing system, we are in a position to find more complex errors in the material at the same time.«

gorithm for line scan cameras and a multiple 9x9 morphological filter for precise, down-to-the-pixel analysis of filaments manifesting defects in their unopened state that compromise the material's tear resistance. Moreover, the applet includes a stitching functionality to combine the individual intermediary result images into a single entire image. They were able to have the new software available within a week – considerably faster than with conventional hardware programming. "The new hardware, the programmed applets, and the software could be implemented in a very short amount of time. We tested the entire system extensively in advance and had it up and running shortly thereafter," explained Dietmar Serbée, Managing Director of Stemmer Imaging. Even with the fiber material production line moving at a half meter per second, demands on bandwidth played more of a subordinate role.



Clumps of filaments or holes in the fabric can be identified with certainty.

Identification Certainty

In the first 1,000 lines of image acquisition, an original 8-bit monochrome image results, which is used to calculate the shading. The subsequent flat field correction generates yet another image of 1,000 lines. From this, using a multiple 9x9 morphological filter, the filaments' black-and-white transitions are analyzed, whereby once again a further 1,000-line image results. If a filament remains unopened, less light falls on that position and some areas appear darker than others. Using this method, unopened filaments and strands that are not connected are detected from various directions with certainty. Clumps of filaments or holes in the fabric can be identified with certainty as well.

The three images arising during the image recording chain (original image, flat field correction-improved image, and the 9x9 filtered image) are then finally merged via stitching into a single final image. Only four computers evaluate the final image. "We were able to reduce the number of computers particularly by integrating the large multiple 9x9 morphological filter using VisualApplets and without using software," reported Serbée. For the CPU-intensive 9x9 filter matrix calculation as well as the remaining image processing applications, FPGAs were used since real-time behavior could not be guaranteed with calculations on a normal CPU processor.

Tailor-Made and Flexibly Expandable

"With the new image processing system, we are in a position to find more complex errors in the material at the same time. We can alter the system at any time with VisualApplets and modify it for new requirements," underscored Gerrit Verbruggen, Project/Maintenance Engineer at Low & Bonar. "Further investments for this are not needed." When defects in the material are detected, a signal is sent to the machine that then marks the defective spot with a label. The material is usually completely fabricated and the defective spot is excised later. Polymer fleeces manufactured in this manner are tailor-made for different client requirements, and are implemented as stadium roof membranes, truck and sun protection tarpaulins, coverings, and flexible containers as well as for pools and boats, among other uses.

"The selection of appropriate GigE Vision frame grabbers, graphical FPGA programming of algorithms and applications solely with VisualApplets basic building blocks, the short implementation time and flexible system handling made this project a success. We are achieving better quality of our polymer fleece," Verbruggen emphasized. In future, flat field correction will be optimized further using higher dynamic ranges with the goal of inspecting darker polymer fleece error-free as well.

Using real-time image processing with hard- and software from Silicon Software, manufacturer Low & Bonar has achieved better error detection in their polymer fleece manufacturing. The solution can detect more errors as with other inspection systems that are available in the market. System conversion to GigE Vision frame grabbers and VisualApplets for the graphical programming of image processing applications, triggering, and peripheral connection proceeded seamlessly, thanks to consulting and implementation from Stemmer Imaging. The manufacturer is now set to use a tailor-made and yet flexibly modifiable system to deliver better product quality to its worldwide clientele in the process industry. ■

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The Genie Nano camera delivers big functionality in a small package.

Source: Teledyne Dalsa

Machine Vision Solution Manages Inventory System

High-End Cameras and Imaging Software Manage High-Bay Tower System

It is out of the question that managing an inventory of some 14,000 components is a challenge. A machine vision system including fast GigE cameras with CMOS sensor technology masters the task.

Kiefel, a company that develops and manufactures thermoforming machines and welding systems for the processing of plastics, keeps as many as 14,000 parts at its site in Freilassing, Germany. The company installed a new high-bay storage system to help manage this inventory, taking a warehouse with a 120 m^2 footprint and creating 1,400 m^2 of storage space. As a part of the upgrade to this more efficient storage method, they needed to include machine vision in the design to help keep track of the sizable amount of inventory. Twelve high-bay towers were installed in the warehouse, which is sufficient to neatly store 14,000 parts and maximizes the available space in the building.

"We wanted to achieve more storage space on a smaller footprint than we have up to now, and at the same time, make our warehouse more comfortable," says Robert Hammer, logistics manager at Kiefel in Freilassing.

The newly renovated warehouse with high-bay storage opened for operation in spring 2017. The company worked with systems-integrator phil-vision to design a machine vision system, including components from Stemmer Imaging and Teledyne Dalsa, to create a solution that ensures that Kiefel doesn't lose track of its inventory in the highly efficient storage system.

Challenge: Monitor Weight and Placement of Stored Inventory

In designing the new storage system, one of the main challenges was the large variety of parts, and the wide range in both size and weight of those parts. "It could be anything from labels, small switches and other small parts through tools, motors and bulk materials," explained Hammer. When sorting these parts into the storage trays, the company needed not only to note the size, but also the weight of each piece, because the maximum weight limit for each storage tray is 850 kg. With up to 48 trays in each of the 12 high-bay towers, keeping track of which parts are stored on which trays and how close each tray is to the weight limit is a major undertaking. When storing inventory, it is not enough to just find a tray with available storage area for a new part. Warehouse workers must also determine how heavy the items currently stored on the tray are to ensure that adding the new parts won't exceed the weight restrictions. An efficient solution for managing this complex task was required to make the high-bay system viable.

Each tray's current weight information is calculated by high-bay warehouse manufacturer Kardex's system via the current drawn by the motors used to pull the trays in and out. A warehouse worker can determine the acceptable weight limit for new parts to be added to a tray by checking the difference between the weight of the actual load on the tray and the maximum weight limit for the tray. To simplify the process for these workers, the currently stored weight of each tray is displayed to the operator. The operator can then estimate the weight of new items and decide which tray best has the capacity to take on new items.

There was no standard system on the market for managing the combined weight/space limitations. At this point, Kiefel worked with phil-vision, using components from Stemmer and Teledyne Dalsa to develop a machine vision system to identify free areas on the trays.

Fig. 1 Kiefel stores up to 14,000 parts in 12 high-bay towers.

Fig. 2 The system is very simple to operate via its customizable user interface.

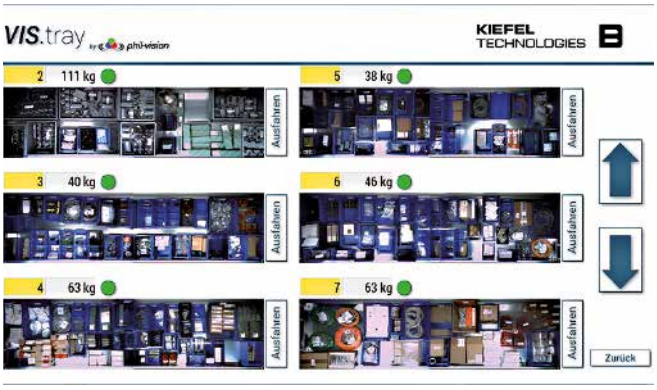

Fig. 3 By scrolling, the operator can find out quickly which trays still have space for further parts.

» The resulting solution integrated an optical system including Genie Nano cameras from Teledyne Dalsa in the high-bay towers for a unique and efficient solution.«

Solution: Genie Nano Captures Tray Images

The resulting solution, called VIS.tray, integrated an optical system including Genie Nano cameras from Teledyne Dalsa in the high-bay towers for a unique and efficient solution. This system captures images of the present load status of a tray while the tray is being put into storage. The load weight is determined via the high-bay warehouse controller. The resulting images and weight information are stored in a database so warehouse workers can decide which tray has enough capacity, both in space and in weight, to accommodate new parts, simply by scrolling through the images.

When a tray with available capacity is identified, a warehouse worker simply clicks on the input and output station on their connected touch panel PC to put the new parts into storage in the selected spot. Before the tray is returned to the high rack, a new image is captured and stored in the database, overwriting the previous image in the process, ensuring that images are always up-to-date with the most current information.

Spatial Restrictions

Selecting the right components for integration into the output station of the high-bay towers was a challenge since, on the one hand, the entire area of the tray measuring 300 x 80 cm had to be captured in images, but on the other hand, the available space for installing a camera was extremely limited, and the distance from the tray was relatively small. System integrator phil-vision originally considered attaching a camera to each tower on a mobile axis, but that would have been mechanically complex and would have increased the time needed to capture images. Instead they opted to use two color cameras from Teledyne Dalsa with fish-eye lenses. The resulting images are distorted but the system includes Common Vision Blox from Stemmer Imaging, software that corrects the distortion and stitches the images together. The result is an undistorted image, in color, of the complete storage area, which can then be saved into the system.

Fig. 4 Two Genie Nano cameras from Teledyne Dalsa, each with a fish-eye lens from Goyo, are used in each tower.

Kiefer installed two GigE Vision Genie Nano cameras, each with a fish-eye lens, all connected via GigE Vison to the embedded multi-touch PC from Vecow in each high-bay tower. The cameras were chosen for their lightweight, compact design and their ability to fit into tight spaces. They feature the latest CMOS sensor technology, producing high speed, low noise images, and also includes the proprietary TurboDrive technology, enabling the camera to deliver full image quality at faster frame rates that other GigE cameras. The cameras offer the required resolution of 1,280 x 1,024 pixels and the necessary speed to be able to capture images with the 50 ms that lie between the signal to drive a tray in and the actual mechanical procedure. Moreover, Genie Nano had the compact design that made installation easy for Kiefer's application. Its price point also made it attractive, as well as its speed, reliability and image quality.

Results: An Efficient Storage System That's Been Replicated at Other Sites

Thanks to the successful deployment of the high-bay storage system in its Freilassing site, Kiefer has now integrated two other high-bay systems in sites in the Czech Republic and in Slovakia. Due to the success of these sites in managing the extensive parts inventory, the company plans to deploy additional high-bay storage systems in Austria, Switzerland and the Netherlands. ■

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Products

Triton Camera Series Expanded

Lucid Vision Labs announced the addition of three new Triton GigE Vision camera models featuring Sony's global and rolling shutter CMOS image sensors.

The new 2.3 MP, 12.2 MP and 20 MP Triton camera models have now been moved into series production. These models include the monochrome and color versions of the 2.3 MP Sony Pregius IMX392 global shutter CMOS sensor, as well as the 12.2 MP Sony IMX226 and 20 MP IMX183 rolling shutter CMOS sensors featuring Sony's Exmor R Starvis technology. The 12.2 and 20 MP rolling shutter sensors use Sony's back-illuminated technology providing excellent low-light performance and a high quantum efficiency (85 % peak QE).

"We're pleased to complete our Triton camera portfolio and ship a full line-up of models offering a wide range of resolutions all the way up to 20 Megapixel" says Rod Barman, Founder and President at Lucid Vision Labs. "Featuring an extended temperature range, robust M12 & M8 connectors and optional IP67 protection, make the Triton camera the perfect choice for any industrial environment."

www.thinklucid.com

New 3-CMOS Prism Based Color Line Scan Camera

JAI introduced a new industrial color line scan camera in the Sweep+ Series. The Sweep+ SW-4000T-10GE is a prism-based color line scan camera equipped with three CMOS sensors and a 10 GigE interface including backwards compatibility to 5, 2.5 and 1 Gbps Ethernet standards. The 3-CMOS prism design features three separate imagers that simultaneously capture red, green, and blue spectral wavebands for very high color imaging accuracy.

The SW-4000T-10GE camera offers a maximum resolution of 4,096 pixels (4k) per channel/line, and in combination with the 10GBASE-T interface, the camera provides RGB output at a maximum line rate as high as 97 kHz (97,000 scan lines/second). YUV color data can be output at up to 145 kHz. Using sensor region-of-interest (ROI) the camera can output data at even faster

line rates. For example, by setting the ROI at 2112 pixels, the scan rate can be increased to as much as 183,400 lines/s.

Via integrated auto-negotiation technology the camera offers automatic backwards compatibility to NBASE-T (5 Gbps and 2.5 Gbps) and the traditional 1000BASE-T (1 Gbps output) for customers running vision applications on these lower-speed Ethernet standards. Therefore, the new SW-4000T-10GE color line scan camera covers multiple Ethernet configurations making it suitable for the slowest to the fastest running color line scan set-ups including applications in food sorting, plastic sorting, bottle/bottle cap inspection and high-speed color print/label inspection.

www.jai.com

31 MP CXP Camera with New Sony Sensor

Hikvision's MV-CH310-10XM area scan camera features the Sony Pregius IMX342 global CMOS sensor. In addition to a wide dynamic range, high quantum efficiency, and low noise, Pregius also improves pixel sensitivity and the quality of images taken under dim light. The 31 MP Hikvision camera has a resolution of 6464 x 4852 with a pixel size of 3.45 µm and can transfer up to 17.9 fps at full resolution.

On top of that, relying on technical accumulation in image algorithms gained over years, Hikvision has embedded ISP functions into the FPGA that improve image performance, on-board correction, excellent heat dissipation design, and power consumption control.

The camera supports the CoaXPress interface which enables users to apply the upgraded high-resolution camera in high-speed scenarios, capturing high-definition details frame by frame at super slow motions and precisely showing hairsbreadth differences in latency-free real-time applications.

AOI systems with continuous material feeding need cameras with extremely high frame rates that can help reduce cycle time per slice and boost system output through high FPS and low image transmission latency. The image performance of the MV-CH310-10XM perfectly fits the high demands of flat panel display inspection such as cell phones, tablets and TV display modules and SMT/PCB automated optical inspection and helps to make manufacturing processes more refined, automated, and efficient. It can also help to reduce system complexity by replacing a system with several low-resolution cameras by one single high resolution Hikvision camera. Other application areas include aerial photography, as well as high precision research which typically need sensors of high resolution, wide dynamic range, high quantum efficiency, and high sensitivity.

www.hikvision.com

New High-Resolution Cameras

Svs-Vistek adds to its extensive industrial camera range of high-resolution USB3 cameras with small-form factor: In the first quarter of 2019, the company has introduced ten new USB3 models of the EXO camera series (exo342, exo367, exo387) with resolutions of 31, 19 and 17 megapixels that are all based on the newest generation of Sony's Pregius 2 CMOS sensors. These new sensors with large, square pixels of 3.45 µm edge length are very light sensitive and offer an extremely high dynamic range.

The CMOS sensors of the EXO Series can be operated with numerous cost-effective lenses. With their front-panel section of 58 x 58 mm, the new product introductions ideally cover sensor sizes up to APS-C and Four-Thirds. For the new high-resolution models, one can also choose from variations in the EXO Series of the M42-Mount as well as the SVS-Vistek supported MFT-Mount for focusable lenses. The large pixel size of 3.45 x 3.45 µm works well with our wide-selection of excellent lenses from which you can choose to ensure the right optic for your application – enabling cost-effective solutions from a single source.

www.svs-vistek.com

Advanced Label Reader

Dutch-based systems integrator Prime Vision has launched its new e-commerce Parcel Reader to help postal operators overcome some of the major challenges associated with handling Chinese parcels.

Like most cross-border shipments, parcels from Asia vary in size, shape, and weight, making them difficult to position correctly for scanning in the automated sorting process. Chinese custom labels and barcodes are also often poorly printed with critical information missing or smudged. Add in the lack of standardization in address label format – which makes it near-impossible for common scanners to read – and the process becomes a daunting task for any sorting hub.

Prime Vision developed the e-commerce Parcel Reader as a viable solution to these problems. When used in partnership with any established optical character recognition (OCR) solution, it allows postal operators to convert highly labour-intensive Asian parcel handling into a profitable revenue stream.

Based on the company's award-winning OCR technology, Prime Vision has taken the capabilities of its e-commerce Parcel Reader to new levels by allowing data to be read across multiple labels including address labels, customs labels and recipient details.

www.newriver.co.uk

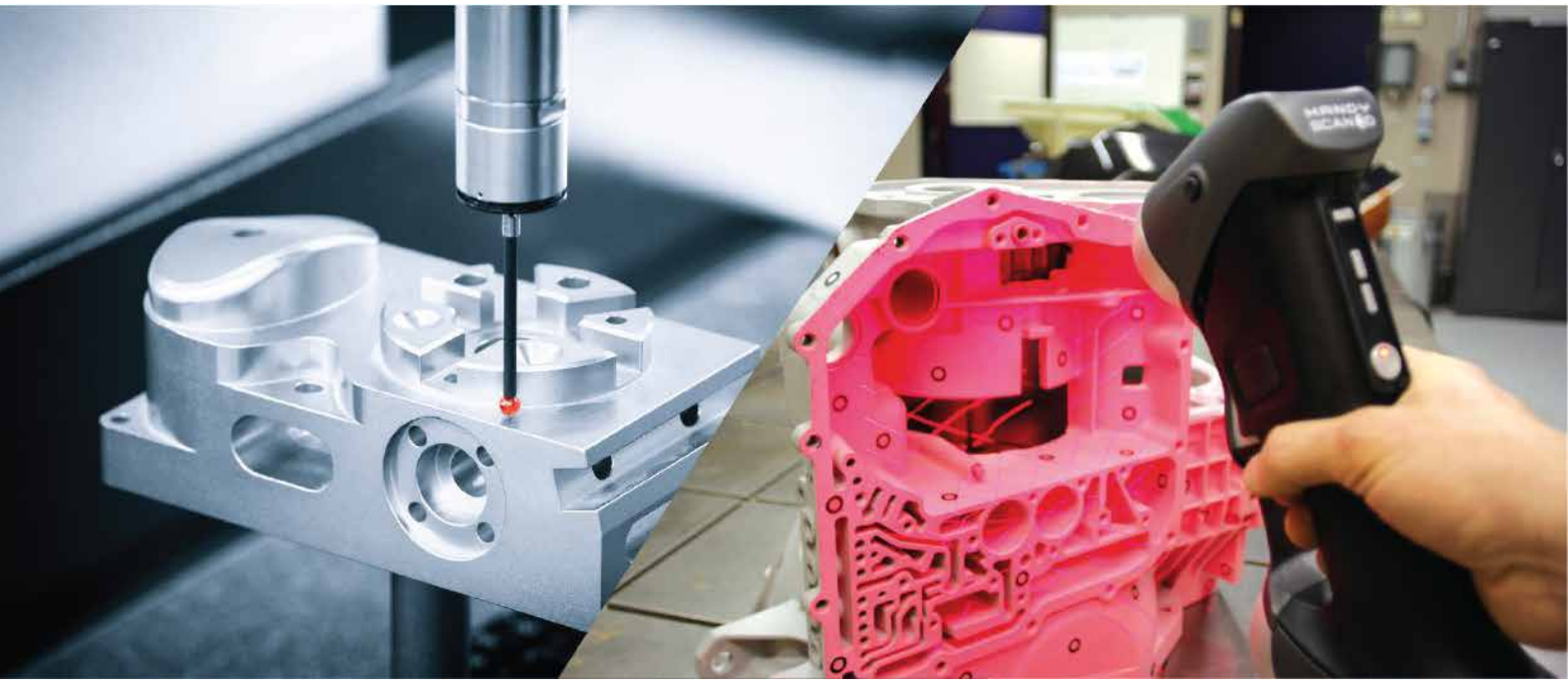
New Boards Supported

Besides the Raspberry Pi and Odroid, the EyeVision software now supports even more boards such as, for example: Asus (Tinkerboard), NVIDIA (Jetson), DragonBoard, Geniatech, HiKey, HummingBoard, MediaTec, MSC, Rock960, Ultra96, Voipac, etc. Therefore, the use of EyeVision is preferential for embedded solutions. It is also cost-effective, as the software offers an ideal cost-performance ratio, saving companies development and integration efforts, and therefore working time.

EVT offers trainings for beginners, and even with a short instruction the handling and programming of the software, which is based on a drag-and-drop function, is easy to learn. Additionally, EyeVision offers various interfaces. There is an interface for the machine instructor, which allows them to work fast and efficient. In case of necessary changes in the inspection program only the responsible developer of the company has access, so that there is no accidental interference into the production process.

EyeVision offers solutions for applications such as code reading, pattern matching, 3D inspection, OCR/OCV, object detection, Machine Learning (surface inspection and number plate recognition), color inspection, metrology, etc.

www.evt-web.com



Overcoming the Bottleneck

How to Reduce the Workload of a Traditional CMM and Solve Bottleneck Issues

While CMM used to be the means of choice for quality inspections in earlier times, 3D scanning has become a valid alternative. Which option between buying a new CMM or opting for a portable 3D scanner offers the best return on investment?

Bottlenecks at the CMM are a real challenge for manufacturing companies. They face pressure to optimize their production process, which is slowed down by pending inspections at the CMM. As a result, there are delays in manufacturing and delivering parts, and customers suffer from these delays. In the past, of course, the traditional CMM was the only tool for performing quality inspections. However, as the technological landscape has transformed, new measurement tools that meet the high level of accuracy and resolution required by the industry have emerged. 3D scanning has not only reached a level of accuracy that approaches probing methods, but it also provides quality control with more data, more details, and more information, which allows for the inspection of more complex parts. Consequently, today's industry experts now place their trust in 3D scanning and grant it a major role in quality control.

So, when dealing with bottleneck issues at the CMM, is it more profitable to buy a second traditional probing system or to get a portable 3D scanning device? This article aims to detail the costs and time associated with the functioning of a CMM and a 3D scanner. With these numbers in hands, we will be able to calculate the number of parts that can be inspected daily, to compare the time needed to program and operate the equipment, and, finally, to determine which of these options – A) buying a second CMM or B) getting a portable 3D scanner – offers the best ROI to reduce the workload of a traditional CMM and to solve current bottleneck issues.

Costs

First, the total costs associated with the acquisition of a second CMM are compared to those required for the purchase of a metrology-grade 3D scanner. Note that these amounts are listed in US dollars and that the analysis relates to the quality control performed on five models of car doors, in which 400 features must be inspected.

Purchase Costs

The CMM identified for this example has a purchase price listed at $ 200,000, while the price of a metrology-grade 3D scanner with comparable functionalities and measurement volumes is $ 100,000. In other words, the price of the probing tool is twice as much as the scanning tool. This difference is due to the CMM's unique ability to measure tight tolerances with a high level of accuracy. Nevertheless, out of the 400 features to be measured on the car door, only 10 % require a tight tolerance, making the 3D scanner an alternative option for the vast majority of inspections.

Infrastructure Costs

Infrastructure costs must also be added, since a CMM requires a floor space of approximately 14 m² ($ 300/ m² in an industrial environment) and must be positioned on a vibration slab, which costs $ 10,000 to install. Thus, $ 55,000 of infrastructure costs must be added to the purchase cost ($ 200,000) to house a second CMM. Meanwhile, the 3D scanner has no such costs, since the device is portable and can be stored in the most convenient free space.

Maintenance Costs

To make sure that both the probing and 3D scanning tools remain fully functional, a maintenance budget must be planned for calibration, hardware upgrades, and replacement parts. The annual calibration and maintenance fees for a CMM is budgeted at $ 3,000, compared to $ 5,000 for a portable 3D scanner.

Tooling Costs

The acquisition of an inspection tool, whether probing or scanning, is not limited to the

device itself. A fixture tooling is also required to check features other than those measured directly with the inspection tool. This fixture enables QC to verify that the part assembles correctly on its counterpart, to check the presence of each and every hole, to measure their diameters, etc.

As a result, the critical points, such as the attachment points, are measured directly with the CMM, while the other points are validated with a checking fixture. Moreover, since this tooling is dedicated to a single model, as many checking fixtures as car models must be purchased (in this example, that's five models at $ 20,000, totaling $ 100,000).

However, a checking fixture is not required for a 3D scanner. Instead, this equipment requires a holding fixture, which is more flexible because it does not need to be dedicated to a single model. Thus, even if a point or a position changes from one model to another, the holding fixture keeps the part in place, in the same position, regardless of the configuration. Consequently, a single holding fixture costs $ 4,000 for five door models.

Software fees have not been added to the cost comparison since it is generally the same data processing software that is used both in probing and 3D scanning.

In numbers

Total costs for the acquisition	
Second CMM	Portable 3D scanner
$358,000	**$109,000**

Time

Second, the total time required to perform an inspection – from the technician training to the programming, measuring, data processing, and report generation – is compared whether the inspection is made with a probing or a 3D scanning tool.

Training Time

CMMs are complex metrology instruments that demand more training than 3D scanners. Specifically, operating a CMM requires a 4-day training and three to four months of supervised practice, while operating a 3D scanner requires a 2-day training and two weeks of supervision before an operator becomes completely comfortable with the device. Thus, if a company wants to acquire trained and experienced talent, it might have to pay an additional $ 10,000 in salary for a CMM operator, raising salaries from $ 40,000 to $ 50,000 based on a $ 20 hourly rate.

Handling Time

Quality controls in the automotive industry regularly involve parts of large dimensions. Moving those parts from the production floor to the laboratory takes time – an estimated 30 minutes per part – and requires two technicians to perform the task. However, this handling time is not required with a portable 3D scanner, since it is the inspection tool that goes to the part rather than the other way around.

> **»In addition to being cheaper to purchase, 3D scanners also measure faster and require less training, handling, and programming time than CMMs.«**

Setup Time

Rigid measurement setups are essential to get accurate measurements on the CMM. Parts must be carefully fixed and positioned in order to enable operators to make measurements. The time to set up a CMM can be estimated at 15 minutes, compared to 5 minutes with a 3D scanner.

Programing Time

With a CMM, creating a program means establishing the probe trajectories for each feature, taking care to circumvent apparent obstacles. Thus, to measure 400 features on a car door, programing the CMM may take up to five days, while no programming is needed with a 3D scanner, since the trajectory followed for data acquisition is as simple as manual spray painting.

Measuring Time

With a CMM, the measuring time to get the full layout (400 features) is four hours. With a 3D scanner, the measuring time takes 30 minutes. However, 10 % of the features – those with high tolerances – must be measured with the CMM. Therefore, measuring these 40 features on the CMM will require four hours of programming and 25 minutes of extra measuring time, bringing the total measuring time to get the full layout to 55 minutes. In both cases, 100 % of the features are inspected.

In numbers

Total time to measure 1 part	
On a CMM	With a 3D scanner
4 hours (+ extra training)	**55 minutes**

Consequently, considering only the measurement time, four parts can be inspected per 8-hour shift with two CMMs, or eight parts can be inspected per 8-hour shift with the combination of one CMM and one 3D scanner.

Conclusion

CMMs are expensive metrology instruments that cost twice as much as 3D scanners. In addition, more time and money are needed to operate them. Therefore, it is strategic to dedicate only the most important and delicate inspections of high-tolerance features to the CMM and redirect all remaining controls to alternative equipment, such as a 3D scanner. This action not only saves on the acquisition cost of the second CMM, but it also helps to accelerate simple and daily inspections.

In addition to being cheaper to purchase, 3D scanners also measure faster and require less training, handling, and programming time. As demonstrated, the combination of a CMM (dedicated to inspections with high tolerances) and a 3D scanner makes it possible to measure twice as many parts in the same work shift. As a result, with the purchase of a 3D scanner, less specialized resources are required, less time is spent on each part, and less money is spent on the technology.

This analysis demonstrates that the purchase of a metrology-grade 3D scanner, which will complement the current CMM, is the best solution for offloading the CMM by reserving it for the 10 % of features that require critical accuracy. The 3D scanner enables QC to save both time and money while gaining efficiency and flexibility. This is how the alliance of the two technologies provides the best return on investment for quality control. ■

Control 2019: Hall 5, Booth 5102

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100% Inspection

Achieving the Ultimate Goal of 100% Quality Control with Smart 3D Technology

A built-in real-time data processing pipeline enables today's factories to achieve 100% quality control of manufactured parts, assemblies and finished products in an inline process.

There are three main types of inspection that occur in the factory today. These inspection types include the following: (1) Offline – First article inspection, (2) At-line – Random or reject sampling inspection, (3) Inline – 100% part inspection.

Of the three, 100% part inspection (i.e., 100% quality control) is the ultimate goal for manufacturers because it means every single part on the assembly line is inspected - and either verified to be acceptable or rejected. Inline inspection is usually accomplished using a laser line profiler scanning moving parts on a conveyor.

Offline: First-Article Inspection

When a machine vision system is slow, manufacturers are forced to use offline inspection methods. The intent with offline inspection is to verify first articles are manufactured correctly and assume that production equipment will behave within tolerances for long production periods. This method takes the first-article as a representation of the whole and is essentially blind to potential quality issues caused by dynamic process wear and tear on the production line.

At-line: Random or Reject Sampling

Using a faster inspection solution allows engineers to perform random spot checks on the production floor. At-line processes involve isolating random parts from the production line for inspection. In addition, at-line inspection is used to review rejected parts at a dedicated at-line measuring station in order to identify what step in the production process is faulty. While it cannot provide 100% quality control, at-line inspection detects quality issues during production and allows for the quarantine and rework of parts before they leave the factory.

Inline: 100% Part Inspection

100% part inspection becomes possible once inspection methods can achieve scan rates that match production speeds. Full automation can then be achieved with production optimized to minimize rework and error-proofing in place to monitor factory equipment performance.

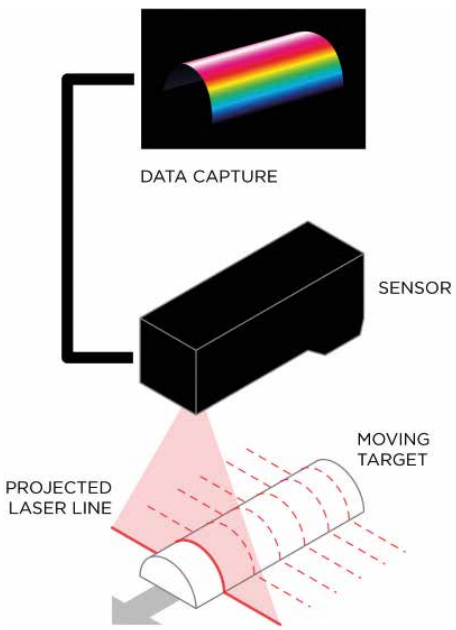
Commonly Used Technologies – Laser Triangulation and Structured Light

Today's most effective inline inspection solutions leverage 3D sensor technologies such as laser triangulation or structured light (fringe projection). Both of these technologies offer non-contact scanning of parts and generate the high-resolution 3D scans required for feature measurement and verification.

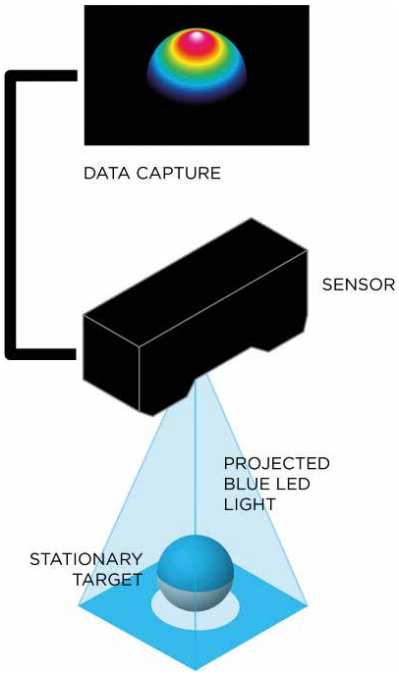
LMI's GoMax hardware solution achieves a magnitude increase in speed by leveraging a new breed of computing based on the NVIDIA TX2 Jetson module.

The Inspection Cycle in Context

A typical inline inspection process includes scanning, measurement, and control—all performed in a highly optimized pipeline of operations to keep up with factory speeds. Below is a summary of the critical processing steps in an inspection pipeline:



Laser triangulation process



Structured light process

Smart vision acceleration simplifies how factories achieve the increased inspection speeds required for today's inline systems.«

- A trigger causes a profile scan or area scan,
- high-density 3D point clouds are generated by combining these profiles,
- measurements are computed using built-in measurement tools,
- measurements are checked against preset tolerances,
- pass/fail decisions are communicated to factory networks and equipment.

The Advantages of Using 3D Technology for Inline Inspection

2D vision alone cannot achieve 100% quality control because it does not scan a part for geometry. Critical features related to shape are missed as a result. In summary, 3D offers:

- Volumetric measurement (X,Y, and Z-axis) provides shape and position related parameters,
- contrast invariant, ideal for inspecting low contrast objects,
- immune to minor lighting variation or ambient light,
- higher repeatability due to integrated optics, lighting, and pre-calibration,
- simpler to build multi-sensor setups for large object inspection.

Real-World Inline Inspection with 3D Smart Sensors

LMI's Gocator sensor is designed around a real-time data processing pipeline that includes triggering, 3D point cloud generation, part segmentation, part rotation, part sectioning, measurement, and pass/fail decision outputs.

This pipeline is fully implemented as a built-in capability of the sensor and is easily set up by a web browser-based user interface offering control over scanning (exposure, resolution, filtering, etc), measurement (anchoring, point and click feature-based tools, scripting) and control output (PLC, robot, Ethernet or direct I/O).

Achieve Even Faster Inspection Speeds

Smart vision acceleration simplifies how factories achieve the increased inspection speeds required for today's inline systems. LMI's GoMax hardware solution achieves this magnitude increase in speed by leveraging a new breed of computing based on the NVIDIA TX2 Jetson module. It is simply added to a single or multi-sensor network to reduce overall scan and inspect cycle times. Inside the hardware solution is a preloaded Linux OS with the Gocator Accelerator (GoX) runtime offering 3D point cloud generation and measurement tool processing optimized for execution on 256 CUDA cores.

GoMax comes in a small form factor and a low power usage of only 15 watts. Plus, setup is quick and easy. Just power up, connect via web browser, and activate acceleration for any Gocator 3D smart sensor to achieve increased inspection speed.

Leverage Sensor Networking

In the "smart" automated factory, a network of LMI's sensors may be required to scan large objects or capture multiple views from the same part. The pc-based application GoX is used to collect data from multiple sensors, stitch and generate a single 3D point cloud and then carry out micron-level measurement. Many such application processes may be run on many PCs to manage hundreds of Gocator sensors operating in a factory. This is the power of distributed "smart" processing brought to the factory floor.

Conclusion

With the built-in real-time data processing pipeline in Gocator and the ability to split this pipeline between the sensor and a PC using dedicated smart vision acceleration, today's factories have an effective inspection solution to achieve 100% quality control of manufactured parts, assemblies and finished products in an inline process. The ultimate goal is achievable with smart 3D. ■

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Trajectory Correction

Tailormade 3D Vision System Performs Quality Checks of Sensitive Air Conditioners

The quality check of objects with sensitive surfaces imposes a challenge to manufacturers. Where human intervention fails, tailor-made 3D vision systems can deliver an automated solution that is both more effective and economical.

A manufacturer of air conditioners was looking for a solution for a demanding quality control process. Heat exchangers are pressurized with helium and then undergo leak detection. A 3D Scanner scans the object from two different positions to ensure measuring accuracy and precision of both object localization and trajectory correction. The vision system captures the position of the heat exchanger in order to precisely lead the sniff detector along a fragile surface and detect a possible helium leak.

Daikin Industries' plant in Pilsen, Czech Republic, produces over 2 million air conditioning units per year. A lack of manpower and various attempts to minimize human error are the reasons why the company is focusing on process automation in fulfillment of their production plans, with continuous attention to high product quality. One specific bottleneck in the mid-assembly quality check process at one of their assembly lines required a new approach based on a high-quality 3D vision system: the testing of the integrity of heat exchangers. The major motivation to automate the sensitive test and the challenge per se had lied in a requirement for preciseness while inspecting the heat exchangers. They are made of fragile thin metal, so human errors in the preceding manual inspection process had come into play. The precision of robot guidance in the planned automation solution of the problem had to be ±1 millimeter.

Vision System and Robot in Co-Operation

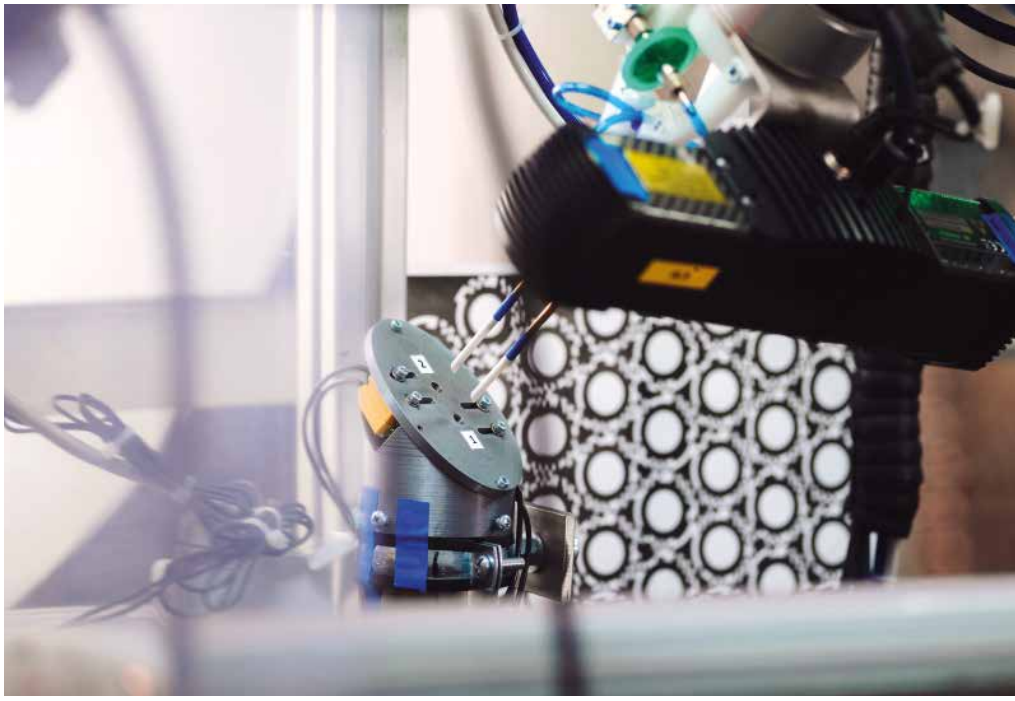
Daikin consulted Slovak developer and producer of sophisticated 3D machine vision systems Photoneo on the issue. "Following the successful testing, their team delivered the solution to our plant in Pilsen and made our production more effective and economical," said Jan Mirvald, Production Engineer at Daikin. While Daikin provided their input in the form of programmed trajectories for each type of heat exchanger, Photoneo implemented it to an adjustable program communicating with the UR5 robot the client chose for the application. Soon, the solution gained trust and popularity among both management and technical staff of the multinational Japanese corporation. Besides top performance 3D vision hardware like the award-winning PhoXi 3D Scanners and MotionCam-3D, Photoneo provides intelligent software solutions to automation challenges, often unprecedented ones. They include generic, versatile and easy-to-use applications like Bin Picking Studio or Locator, as well as occasional tailor-made systems. The Trajectory Correction Application (hereinafter TraCo) deployed in the Daikin factory in Pilsen belongs to the latter category.

3D Scanner Enables Exact Positioning

TraCo consists of PhoXi 3D Scanner, a tailormade application based on the Localization SDK and a robot-camera calibration software by Photoneo. The heat exchanger, first pressurized with helium, comes to a leak-detection cell on a conveyor belt, positioned randomly. In the cell, the PhoXi 3D Scanner scans the object from two different positions to increase the reliability of measurement and robustness of localization of the object and trajectory correction. TraCo

»

TraCo serves to detect the position of the heat exchanger, and accordingly, to adjust the predefined trajectory of the sniffing detector very precisely and carefully along a complex and fragile surface of the object.«



PhoXi 3D Scanner and sniffing detector

serves to detect the position of the heat exchanger, and accordingly, to adjust the predefined trajectory of the sniffing detector very precisely and carefully along a complex and fragile surface of the object in order to inspect its quality and notice a potential helium leakage without damaging it. Thanks to several measures in the cell, Photoneo's support team is able to investigate any however improbable issue remotely, within seconds. In addition, the company simplified its robot-camera calibration process to such an extent that a calibration can be affected by a trained end-user alone. It was the aim of TraCo's developers to decrease the potential resolution time and to keep up the high throughput of the production line at all times.

Adaptable to Product Changes

The entire solution is demanding in terms of working with glossy aluminium surfaces, configuration, precision of the scanner and localization software. Moreover, the component geometry of particular pieces on the conveyor belt is often not identical, so a robust logic had to be implemented to reflect this fact. The manipulation of the robotic arm with the detector as a tool has to be very gentle and precise, due to the formability of the thin metal material the parts are made of. The Photoneo team tackled the very limited work space of the leak-detection cell in the brownfield deployment. Last but not least, the solution was installed in a production line with a variable, just-in-time production plan. This means that different types of heat exchangers have to undergo quality check – not just one. The system is scalable, i.e. even after the initial setup for a certain set of heat exchanger types, new ones may be added and probed at a later stage. There is no programming involved then, and the change can be done by a Photoneo specialist in the configuration. The addition or alteration of the configuration for a particular type of heat exchanger does not affect the quality of service provided for the other existing types. The high resolution and accuracy of PhoXi 3D Scanners and MotionCam-3D allows them to be employed in areas that demand highest precision such as quality control applications and metrology. ■

Control 2019: Hall 6, Booth 6115

The Trajectory Correction Application improves the quality check of the heat exchangers.

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Safe and Reliable Product Handling

Software Turns Camera into 3D Belt-Picking Sensor

Working with 3D vision in robot guidance projects increases both the reliability of the picking process and the quality of the handled products, as the data is contrast invariant and includes the products' true height.

Vision systems guide the robots to pick the products from the automated conveyor line and place them into the desired packages. This ensures a consistent output quality both in primary packaging of food products, as well as in secondary packaging.

Robots nowadays more often do the repetitive and for humans potentially injuring motions needed in a packaging process. Vision systems guide the robots to pick the products from the automated conveyor line and place them into the desired packages. This ensures a consistent output quality both in primary packaging of food products such as cookies, candy pieces or prawns into the containers we consumers buy, as well as in secondary packaging of for example smoothie pouches, salad bags or tuna cans into the trays or boxes that are shipped to the grocery stores.

Challenges in Belt Picking Applications

When automating a packaging line for consumable products one important aspect is safe product handling. Customers tend to reject buying products that are not flawless, which means that they turn to waste. The robot picking process must therefore ensure that no products are damaged, something that presents an extra challenge if the product height varies.

Another important topic is to ensure maximum flexibility of the packaging line. Over the day, the products on the packaging line may change several times. To be economically successful it is important to keep the changeover time as short as possible, as well as to ensure that the equipment can handle products that vary in size, shape, height, color and graphic design.

While foods uniform in size and shape are easy to pick with a robot, products of a more free-form shape can be difficult. Consider for example a bag containing mozzarella in a liquid; the ball of cheese can be anywhere within the bag; and the robot needs the picking position at the highest point of the bag, not at the geometrical center, in order to adequately pick this product.

Changing product features and environmental conditions are challenges the vision system need to overcome. Over the days and weeks, the condition of the conveyor belt can vary due to contamination and wear. Also, wherever there are windows at the packaging facility, the ambient light changes.

More Reliable Product Detection

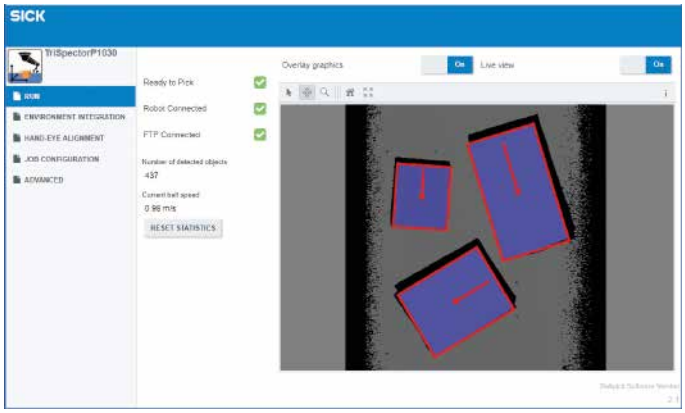
In many cases, 3D vision gives a more reliable detection of the products thanks to the technology's contrast and color independence. Detecting products by height instead of by contrast or color allows continuous picking, without reconfiguration of the vision system, also when the product design changes and even when the belt and the product have the same color. This means that the product design can be in virtually any geometry and color and still be detected.

More Gentle Product Handling

The programmable 3D camera TriSpectorP1000 from Sick is factory calibrated, which means that the true size and height of each product is included in the image data. With this information, the robot handling can be gentler; adapting the robot's motion to the actual products on the belt reduces product damage due to collisions or dropped products.

More Convenient Line Handling

The height information also means that the need for re-configuration is kept at a minimum. In pictures from a regular 2D vision



Web GUI with visualization of detected objects and their orientation

system, an object looks bigger when it is close to the camera than when it is further away, but in calibrated 3D data no such scaling is seen. Therefore, even when the product size and height differ among the batches handled on the packaging line, the camera can often work with the same settings.

The TriSpectorP1000 camera uses laser triangulation to capture the 3D data. As a product passes on the conveyor, the camera filters out the laser line projected on the product capturing up to 2,000 height profiles per second. The included laser lighting and filter reduces the sensitivity to changing ambient light conditions.

The laser, the camera and a processor for 3D image analysis all fit in one rugged aluminum housing, which is easy to integrate also in harsh environments.

Tailor-Made 3D Solutions for Flexible Automation

Sick AppSpace is an eco-system of software tools, and an expanding number of programmable devices based on technologies such as 2D and 3D vision, RFID and LiDAR. By using the application programming interface (API) functions so called SensorApps can be developed.

The Sick Belt Pick Toolkit is a SensorApp specialized for locating products on a conveyor belt. With this piece of software installed, the camera turns into a 3D belt-picking sensor, operating stand-alone. For each detected product, the camera reports location and height, along with orientation and optional features such as product volume and dimensions, to a PLC or robot controller. The web-based user interface is designed so that also an integrator with very limited vision skills can conveniently succeed with the integration and commissioning tasks.

Developing a Belt Picking Sensor

The team of application engineers at Sick in Linköping, Sweden has a long experience with robot handling in packaging applications. "When the new AppSpace programmable 3D camera was released it was a natural step to lift the previous solution to this new platform," says Anders Murhed, head of the team. "This meant going from a more guided step-programming environment to one much more flexible with a larger API, which requires a higher level of programming skills from the developer. For the robot integrator, however, the change was entirely positive, as the possibilities for making a tailored web-based user interface for commissioning are so much better now."

It is a simple step-by-step procedure to do the necessary settings in the interactive web user interface. In three different views the integrator can specify environment parameters like belt width and robot brand, align the camera's coordinate system to the robot's, and configure the camera to produce the required kind of pick positions for the products to be packed. Although the App is programmed in AppStudio, no programming is required to use it.

"We spent a lot of effort making the belt pick toolkit easy to set up and use," says Henrik Wolkesson, application developer at Sick. "No need to teach the objects to be recognized by the camera – just enter the size range of what should be picked, and you are done."

"And it works," says Sofia Nilsson, also member of the application development team. "Recently, we put our new ABB flex picker-based test line through some really tough trials. We literally threw anything we could find in the lab on the belt and the robot just picked it. Adapting the pick point to the actual object height means no mis-picks even when objects are varying greatly, size wise. By also measuring the volume of the object, you can adapt the picking process accordingly. In summary," she concludes, "handling varying and poor contrast scenarios as well as varying object height have never been easier." ■

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3D Visual Perception System for Robot Applications

New System Equips Robots with Eyes and Brain

While visual data processing is still the Achilles' heel of robots, a new 3D visual perception system can achieve it by continuously measuring environment depth in 3D and industry-specific object detection and classification.

Addressing the technological needs for next generation industrial and service robots, Lithuanian mobile robotics specialist Rubedos introduced its new 3D visual perception system Viper. Powerful and lightweight, the bolt-on and easy to integrate system enables intelligent automation with a turn-key set of hardware and embedded computing. It can be applied to a wide range of use cases to equip industrial and service robotics with visual perception.

On-Board Detection and Classification

Its stereo vision system with two 3.4 MP low light cameras continuously measures environment depth in 3D with a depth frame rate up to 40 fps over range distances up to 50 m. All object detection and classification tasks are performed on-board with the embedded NVIDIA Jetson TX2 computing unit using algorithms specifically designed by Rubedos. By doing this, the system offloads low- and high-level image processing to the on-board processor, reserving the robot's main computing resources for robot navigation.

"In the smart factories of the near future, intelligent robots will leave their safety cages. However, the lack of visual perception still is the sandbag of intelligent automation as these next generation robots depend on the ability to acquire, organize, and interpret surrounding visual data," said Rubedos Co-Founder Linas Vaitulevičius. "Our Viper system achieves this by continuously measuring environment depth in 3D and industry-specific object detection and classification."

Compact and Light Weight System

With its low energy consumption, a compact design of 246 x 98 x 35 mm and a light weight of 0.8 kg the system is particularly suitable for smaller robotic systems. It is auto-calibrated, IP65 ingress protected and physically connected to the robot with standard ¼" – 20 UNC, M4 mounting. Communication is supported via Ethernet at 1 Gb/s.

Rubedos

Founded in 2009, Rubedos has been developing mobile robotics solutions, develops 3D visual perception and navigation technology for free ranging vision guided robotics applications in various industries, including manufacturing and material handling. The company provides hardware, software and services to enable self-driving vehicle development, deployment and fleet operation; and enables to convert customer selected vehicle platforms into robotic systems. In the healthcare sector the company is well regarded for its FDA-compliant robotic precise tumor targeting solution designed for an image guided radiation therapy product of a Nasdaq Omx Nordic listed medical device manufacturer.

Perception Apps

Rubedos designed the Viper system extensible with a set of accelerated 'perception apps' built on top of NVIDIA Jetpack SDK. These application level software modules address standard factory floor tasks such as obstacle detection, a follow-me function, a safety volume guard to detect trespassing attempts, an object identification tool; and 3D vision based simultaneous localization and mapping. "On top of that, we develop perception apps adapted to tailormade applications," added Linas Vaitulevičius. "Overall, the new system provides high-density, low-power, long-range optical depth sense as well as visual perception in an on-board package. All these features make it a true value proposition for integrators and vision guided system manufacturers."

Since 2014, Rubedos has focused its R&D on development of 3D visual perception systems for robotics. Prior to that, the company had successfully developed a robotic tumor targeting solution for an image guided radiation therapy that passed the high hurdles of the US Food and Drug Administration (FDA). ■

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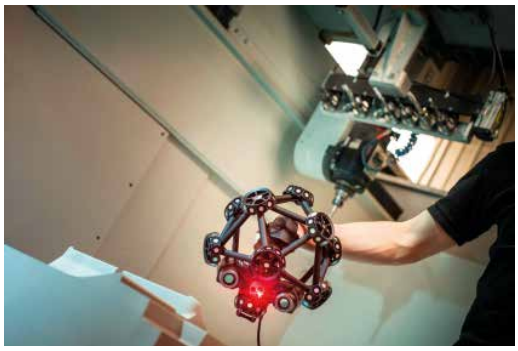
Products



New 3D Scanner

The accurate measurement of individual components (including entire installations) forms the basis for the reliable inspection and repair of large fans. The quicker and easier the measurement phase is to complete, the lower are the overall downtime and costs for the operator. Contactless analyses are ideal for minimizing stoppages and processing times without any deterioration in quality. Which is why the service team of the fan manufacturer Tlt-Turbo has been using a mobile 3D scanner for third-party machine parts since June 2018. The portable unit now allows them to measure assemblies with a circumference of up to 17 m³ – with an accuracy of around 0.064 mm.

"With this new, cutting-edge scanner, measured values are now available within a very short time and can be generated at any location," says Leif Heidingsfelder, Product Specialist at Tlt-Turbo. Reliability remains unaffected by black, multi-coloured or shiny surfaces. The device is compatible with all standard software solutions for reverse engineering, allowing CAD models to be created with no additional effort, based on the raw data collected. This in turn facilitates both continuous quality control during on-going production and the manufacture of spare parts for third-party fans, thereby guaranteeing consistent quality despite the process being accelerated. It is therefore possible for TLT-Turbo to reduce the overall downtime and costs for the customer. At the same time, the service team is much less dependent on location than before, meaning that appropriate actions can be taken quickly, even in emergencies.

www.tlt-turbo.com

PoE Light Controller

CCS announced the release of the new CN-PoE Series LED Light Controller featuring Power over Ethernet (PoE). Users can centralize their inspection system to a PoE hub for simplified system design.

With PoE, only a single LAN cable is needed for data connection and power for either 2 or 4 light units up to 10 W. The CN-PoE Series is compatible with a wide selection of over 350 models of CCS standard LED lights so that users can choose the optimal lighting solution. PoE allows users flexibility of installation, as it means that the controller can easily be set away from the control panel. The controller is also compact enough (W50 x D70 x H34.8 mm) to fit in tighter spaces within an inspection system.

The CN-PoE Series supports continuous and strobe lighting with 256 levels of light intensity. The controller provides accumulated values of controller power ON duration, light ON count/duration, and other operation data for more effective system monitoring.

www.ccs-grp.com

Apps for Digital Microscopes

With a digital microscope from Tagarno, the user can purchase apps specifically developed to improve quality control processes for their microscope. This gives the operator access to the latest technology without having to invest in new microscopes all the time.

Among the apps developed by Tagarno are:

- Image Comparison that allows the operator to compare a reference image of a golden sample with a recent sample from the production line;
- Focus Stacking that stacks images taken at different focus heights to create one ultra-sharp image with no blurred or out of focus areas;
- Tagarno Measurement application that enables the operator to perform on-screen measurements and add annotations and text to the image directly on the microscope;
- Watermark that allows the user to brand an image with a logo or confidential text. It is also possible to add date, time, field of view plus microscope name and serial number as an imprint on the image;
- Verification Lines that enables the operator to quality check an object by placing accurately calibrated vertical and/or horizontal lines as a layer on top of it;
- Capture and share images for improved collaboration.

www.tagarno.com

Speed Automotive Testing Challenges

Higher Speed Infrared Cameras Can Improve Design Phase Testing

In the automotive industry, missing defective components can be life-threatening and therefore cause costly recalls. Appropriate thermal measurement and testing including next generation camera technologies offer a valid solution.

Product research and development on internal combustion engines, brake rotors and tires, and high-speed airbags are just a few of the areas that truly benefit from high-speed, high-sensitivity thermal characterization testing. Unfortunately, traditional forms of contact temperature measurement such as thermocouples are not practical to mount on moving objects, and non-contact forms of temperature measurement such as spot guns – and even current infrared cameras – are simply not fast enough to stop motion on these high-speed targets in order to take accurate temperature measurements.

Without the appropriate tools for adequate thermal measurement and testing, automotive design engineers can lose time and efficiency, and risk missing defects that lead to dangerous products and expensive recalls. For example, US automakers recently recalled millions of cars, SUVs, and trucks due to faulty airbags with problems ranging from micro-cracks in passenger activation systems to defective inflators. These flawed systems are not only dangerous to drivers, but also harmful to the bottom line for manufacturers, who face lawsuits, fines, and loss of public confidence.

Next generation infrared camera technologies may offer engineers a solution. These cameras incorporate 640 x 512 pixels high resolution detectors that can capture images at a rate of 1,000 frames per second. Additionally, newer detector materials, such as Strained Layer Superlattice (SLS), offer wide temperature ranges with a combination of great uniformity and quantum efficiency beyond that of earlier MCT and QWIP detector materials. These new technologies, plus the ability to synchronize and trigger remotely, give engineers and technicians the tools they need to address the difficulties of high-speed automotive testing.

High-Speed Challenge

Measuring temperature on objects that are moving fast is challenging. Traditional forms of temperature measurement such as thermocouples are not practical for systems in motion. Non-contact forms of temperature measurement such as spot pyrometers lack the fast response rates necessary to take accurate readings on fast moving objects or to thermally characterize a high-speed target accurately.

Infrared cameras with uncooled microbolometer detectors are also unable to measure temperature accurately at extreme high speeds. These cameras have long exposure times which cause blurring in the thermal image. In order to visualize and take accurate temperature readings on extremely fast-moving targets, you need a cooled thermal camera with a short exposure time and fast frame rate. Let's explore both detector types to better understand the benefits and drawbacks of each as it relates to high speed thermal measurement.

Thermal vs. Quantum Detectors

The difference between thermal and quantum detectors comes down to how the sensor translates infrared radiation into data. Thermal detectors such as uncooled microbolometers react to incident radiant energy. Infrared radiation heats the pixels and creates a change in temperature that is reflected in a change in resistance. The benefits of uncooled microbolometer cameras include durability, portability, and low price. However, the drawbacks include slow frame rates – around 60 frames per second

Cooled thermal cameras with highest speed, sensitivity, and integration times will allow researchers to accurately track temperature shifts over time on high speed applications.«

The Flir A6750sc MWIR camera offers short exposure times and high-speed windowed frame rates.

– and slow response times (time constant). Because of this, uncooled microbolometers cannot produce a crisp, stop-motion image of a fast-moving object. Instead, the slow frame rate and response time lead to blurring in the image and ultimately inaccurate temperature readings. Slow frame rates also prevent these cameras from accurately characterizing objects that heat up quickly.

In comparison, quantum detectors made of Indium Antimonide (InSb), Indium Gallium Arsenide (InGaAs), or SLS are photovoltaic. The detectors' crystalline structures absorb photons that elevate their electrons to a higher energy state; this changes the conductivity of the material. Cooling these detectors makes them very sensitive to infrared radiation, with some able to detect temperature differences of less than 18 mK or .018°C. Quantum detectors also react quickly to temperature changes, with a time constant on the microsecond time scale, rather than multiple milliseconds. This combination of short exposure times and high frame rates makes quantum detectors ideal for stopping motion on high speed targets for accurate temperature measurement as well as proper characterization of how thermal temperatures rise over time on fast heating targets. These cameras are generally more expensive and typically larger than uncooled microbolometer cameras: factors some research teams may need to take into consideration.

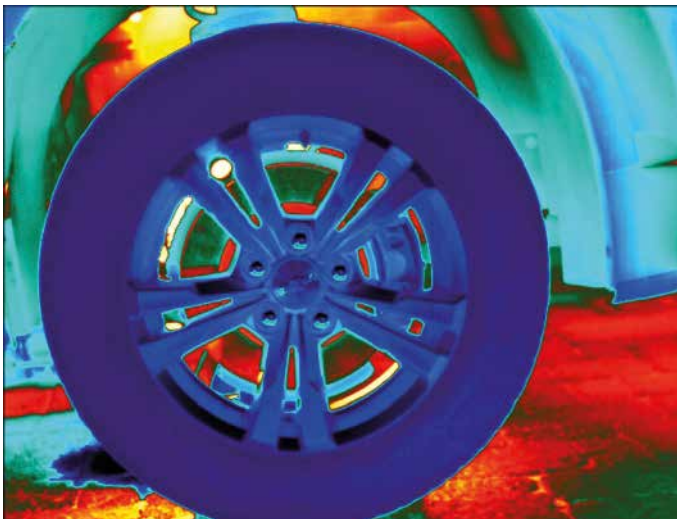
Fast Frame Rates Are Not Enough

As mentioned briefly before, the ability to record hundreds or thousands of frames per second is only part of what is required to stop motion. Another element of the equation is integration time, or how long the camera collects data for each of those frames.

Integration time is analogous to shutter speed in a digital camera. If the shutter stays open too long, any motion in the image it captures will appear blurred. In the same way, IR cameras with long integration times will record blurred motion. A bouncing ball, for example, will look like a comet – with a trail of motion behind it.

The number of analog-to-digital converters, or channels, a camera has, plus the ability to process pixels at high speed, are also important. High speed IR cameras typically have a minimum of 16 channels and have processing speeds – or pixel clock rates – of at least 200 MP/sec. Most low performance cameras have four channels and run at pixel clock rates below 50 MP/sec.

The temperature of your target can have an impact on integration speed and, ultimately, the digital count. The camera converts digital counts into radiance values used for the temperature readings on your target. Hotter targets emit more radiant infrared energy, thus more photons, while colder targets emit fewer photons. The challenge becomes how to accurately measure temperature on colder targets at fast frame



Brake rotor testing using high speed thermal camera at 1,000 fps

Brake rotor testing using high speed thermal camera at 60 fps

rates, because fast frame rates require shorter integration times.

Compounding the issue is the fact that older detectors – with previous generation Read Out Integrating Circuits (ROIC) – were non-linear at low well fills. This caused the Non-Uniformity Correction to break down, resulting in poor imagery and questionable temperature measurement accuracy. Now with the next generation ROIC designs, detectors offer linearity to low well fill, allowing for accurate measurements at high speeds (short integration times) on colder targets. This is why it is critical for high speed infrared camera to have a next generation ROIC with linear response to low well fill.

Getting the Timing Right

Another factor to consider is the camera's ability to synchronize and trigger to external events, such as synchronizing to a rotating brake disc or the ignition of a combustion engine. When a camera system is running on an internal clock, the detector's integration start point and data output are set by the clock. You could miss some of or the entire event if it doesn't happen to correspond exactly with the integration period. A separate triggering system can help you better synchronize recordings by strictly controlling the integration start time and the frame rate. Uncooled microbolometer detector cameras do not offer this capability because they have thermal resistive elements that cannot be externally controlled. This is another reason why a photon counting detector camera is essential for high speed thermal testing.

High Sensitivity Is Key

A significant advantage of cooled IR cameras is sensitivity. The cooled cameras can detect subtle temperature changes, as little as 0.02°C. Typically, uncooled cameras have a sensitivity of around 0.03°C. While a .01°C difference may appear small, it represents a 30% improvement in sensitivity. The cooled camera not only produces less digital noise, but the image it produces is more finely detailed. The ability to detect such subtle temperature changes helps you better detect small hot spots.

Longwave IR Advantages

The one advantage to uncooled microbolometer cameras is they detect longwave infrared in the 7.5-14 µm spectral range. More photons pass through the longwave band than shortwave or midwave, meaning it would take less time for a quantum detector to collect enough photons to create a charge. Specifically, a blackbody at 30°C emits nearly 10 times more photons in the 8-9 µm range than in the midwave 4-5 µm range. Typically, quantum detectors operate in the shortto midwave infrared. However, detectors made from Strained Layer Superlattice (SLS) detect longwave infrared in the 7.5- 9.5 µm spectral range. Because there are more photons to detect, SLS detectors have extremely short integration times, up to 12 times faster than InSb detectors.

They are more efficient than other quantum detectors at converting photons to electrons and offer more thermal contrast when imaging cold targets. The advantages of LWIR SLS detectors are much wider temperature ranges and much shorter exposition times, which can help if your target heats up across a wide band of temperatures or is moving spatially very fast.

Success Equals Safety

By including thermal imaging during the design and testing phases of automotive engineering, research and development teams can more readily identify weak points and improve overall product performance and safety. But the type of camera and its features can have an impact on imaging success. Choosing a cooled thermal camera with the highest speed, sensitivity, and integration times available will allow researchers to accurately track temperature shifts over time on high speed applications. These cameras will also provide crisply detailed stop motion frames, so researchers can accurately measure temperature and thermally characterize their products in order to identify the exact moment a problem begins. ■

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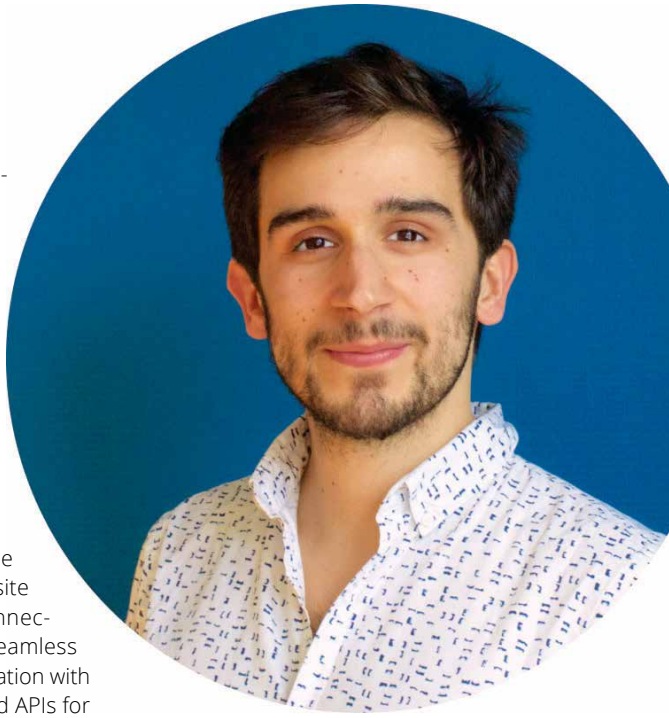
What Is Deep Learning?

With the buzzwords Deep Learning, AI and the likes all around we thought it makes sense to explain some of them a bit further. Therefore, we asked Aymeric de Pontbriand, CEO and Co-Founder of Scortex, to give us some insight from his point of view.



Inspect: Mr. Pontbriand, in your eyes, what is Deep Learning?
A. de Pontbriand: Deep Learning is a sub-field of machine learning, the study of algorithms that learn from data. In Deep Learning, the algorithms are called neural networks and are composed of a stack of internal representation of the world (hence deep). Deep Learning delivers state-of-the-art solutions for problems where this hierarchy exists, such as for Computer Vision (2D or 3D structures), Natural Language Processing (sentence structure) or more recently, planning and decision making.

Inspect: Considering this, what solution does Scortex offer?
A. de Pontbriand: Scortex is an automated defect detection and analytics platform for manufacturers who need to more accurately identify defective products in real time while improving overall plant profitability. It is a Deep Learning quality inspection technology, capable of detecting defects in real time to trigger targeted actions. The solution is shaped by each customer's quality specifications, combining edge computing hardware and machine learning software capabilities to continuously learn and improve the defect detection rate.

Inspect: Which kinds of users is your solution targeted at?
A.de Pontbriand: We are focusing on helping automotive and aerospace suppliers as well as consumer goods manufacturers to take control of their quality. Common applications include the inspection of plastic parts (injected or painted), metal parts (forge and foundries), plus continuous production processes including film coatings and welds.

Inspect: How exactly do you apply machine learning?
A. de Pontbriand: Aspect inspection requires human judgement based on images of the product. With the input from the operators we are able to train our algorithm to detect and classify anomalies as defined by each individual client. We have three distinct deep learning vision modules for segmentation, localization and classification.

Inspect: When it comes to installation, how is the solution deployed?
A. de Pontbriand: Scortex' solution is a combination of hardware and software comprising lights, cameras, autonomous computing and cloud connectivity. Our installations can be embedded into the production line. We provide real time inspection decisions on-site without the need for a cloud connection. There is a strong focus on seamless integration by providing communication with most of the industrial protocols and APIs for higher-level integration. Once the solution is deployed in the production line, the software enables data acquisition, application tuning and quality analysis. The solution is progressively tuned to provide the desired decision accuracy.

Inspect: What are the results users can expect from your solution, and can you give us a concrete example of an installation?
A. de Pontbriand: We have a strong impact on the overall cost of quality by reducing the cost of inspection, the cost of internal and external failure, and by greatly reducing the cost of quality data collection. Our solution enables a higher-level accuracy with an inspection standard that is more stable than a manual one. Automated inspection reports are generated for each part inspected giving unprecedented visibility of quality issues in real time. Since 2017, we have successfully delivered several automated visual inspection projects to tier 1 automotive suppliers mainly in France and Germany. We are currently expanding to the consumer goods and aerospace industry.

Inspect: Who are the people behind Scortex, your team, investors, partners?
A. de Pontbriand: Our 20+ experienced team members combine expertise in computer vision, machine learning, engineering and deployment in the industrial sector. Our industry-recognized investors are Notion and Alven, and we are glad to be partners of Microsoft (AI Factory and Scale Up Berlin) and SAP (Foundry Paris).

Inspect: Where can interested companies take a closer look at your solutions?
A. de Pontbriand: We are demonstrating our solution in action at the Microsoft Technology Center (near Paris, France), the Microsoft Retail Experience Center (in Redmond, WA, USA) and of course in our Headquarters in the center of Paris. Moreover, you can find us at Hannover Messe and at Control in Stuttgart. ■

Control 2019: Hall 7, Booth 7216

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Improved Efficiency

Tailormade Laser Modules Optimize Production Process of Thin-Film Solar Modules

In a fully integrated production line for the production of CIGS thin-film solar modules, laser modules play a decisive role in the surveying steps and help to optimize the production process. They ensure that the planned throughput is 100% controlled and that only defect-free substrates leave the plant.

In January 2017, Manz won the largest order by far in the company's history with a volume of 263 million euros for the following product: A joint venture of the Chinese Shanghai Electric Group and the Shenhua Group ordered a CIGSfab with a capacity of 306 MW and a CIGSlab, a research line with a capacity of 44 MW. Both factories are scheduled to start production in the summer of 2019. "We are absolutely convinced that the future belongs to CIGS thin-film solar technology in photovoltaics," emphasizes Bernd Sattler, Head of Vision & Metrology at Manz in Reutlingen. With CIGSfab, Manz is the only supplier worldwide of a turnkey, fully integrated production line for the production of CIGS thin-film solar modules.

50 Times Thinner Than a Human Hair

In a conventional crystalline solar module based on a high-purity silicon wafer, a large number of individual solar cells are soldered and mounted between a glass pane and a film. The individual wafers are up to 100 times thicker than the semiconductor layer CIGS (copper-indium-gallium-diselenide) on a thin-film module. This is vapor-deposited in a vacuum system, in just one process step, directly onto a glass pane. The use of expensive semiconductor material is correspondingly higher in crystalline technology. In addition, thin-film technology eliminates the labor-intensive and expensive multilevel process of the raw silicon, the wafer, the cell, and the module fabrication by direct application of the semiconductor to the glass substrate.

The advantage according to Bernd Sattler: "The CIGS absorber layer has a thickness of only approximately 2 µm and is thus 40 to 50 times thinner than a human hair. The positive effects on the manufacturing costs due to the material savings and fewer process steps are obvious."

The manufacturing process of the 600 x 1,200 mm solar modules at Manz therefore requires the highest precision. Bernd Sattler describes the essential steps as follows: "The carrier material is coated and structured in several process steps. The entire area has to be divided into smaller cells, as the whole area generates a high current. By connecting these small cells in series, the voltage can be

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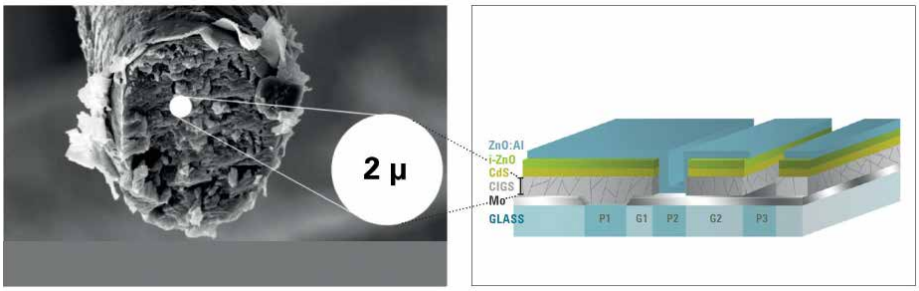
In the P2 structuring machine, two laser processing heads are operated in parallel, which is why two Z-Laser illumination lasers are used on one unit.



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The CIGS absorber layer has a thickness of only about 2 microns and is thus about 40 to 50 times thinner than a human hair.

increased from about 0.6 V per cell to, for example, about 80 V per module." This requires three separation steps, two of which are realized with one processing laser and one with a special engraving stylus.

Exact Measurement for Higher Efficiency

For the correct function of each module, it is essential that the structures for interconnecting the solar cell diodes are applied correctly. For economic reasons, it also makes sense to check these structuring lines after each of the three separation steps in order to recognize defect modules at an early stage, to take them out of the process immediately and thus not to cause unnecessary costs.

The measurements that have to be made include the widths and distances of the structuring lines, the so-called dead-area as well as structuring distances. Precise measurement results have a direct influence on the quality of the solar modules produced. The so-called dead-areas are required for structuring, but do not generate electricity. For that reason, the smaller these areas can be manufactured, the higher the efficiency of the entire solar module gets. With the measured results, the structuring systems are set and the distances are kept constant to ultimately optimize the efficiency.

High Demands

The structuring lines denoted P1 and P2 are generated by a solid-state processing laser in the infrared wavelength spectrum. Especially when applying the P2 line, the laser illumination is of particular importance: To minimize the dead-area, the position of the laser is actively controlled during the process of the second line (P2 structure) to produce this as close as possible and in parallel to the already existing P1 structure.

Sattler describes how his team solved this problem: "The processing laser for the P2 process is positioned using a very fast matrix camera. It measures the P1 line with a frequency of 1,000 Hz and an accuracy of less than 5 µm ahead of the processing laser. With this tracking data the position of the laser scanner, which writes a second line parallel to the first line, is directly controlled.

»The CIGS absorber layer has a thickness of only approximately 2 µm and is thus 40 to 50 times thinner than a human hair. The positive effects on the manufacturing costs due to the material savings and fewer process steps are obvious.«

In addition to accuracy and frequency, the main challenge, according to Sattler, was to safely separate the laser used for the illumination from the processing laser so that the processing laser would not damage either the camera or the illumination laser. "The entire integration into the optical path of the laser components could only be realized through a very close cooperation with our laser process group and the mechanical design," says the department manager.

Sattler also recalled that choosing the optimal laser lighting was not easy: "For this purpose the needed wavelength is above 1,000 nm because the transmission of CIGS layer starts at that point, and the suitable CMOS camera is still sensitive enough in this wavelength area to produce a usable image."

Specialized Laser Modules

During the design phase of the systems, Sattler and his colleagues used a proprietary prototype for lighting with a laser diode that offered the required characteristics. "When it came to series design, we looked for a partner who had more expertise in the field of laser diodes," says Sattler.

After reviewing various options, Sattler decided in favor of manufacturer Z-Laser: "Z-Laser's offer was the safest and most interesting option for us. The hardware costs were a bit higher than we calculated, but we were able to compensate for this by the fact that their modules were very precisely manufactured and pre-adjusted. As a result, the adjustment times in the machines were significantly lower than originally planned." At the beginning, the size also gave the Manz developers team a headache. "However, we were able to master this challenge with some good ideas in mechanical design."

Sattler mentions another important argument for working with the manufacturer: "We had specified the laser diode required for this measurement task very exactly. Our partner already had a laser module available in which this laser diode could be used with little effort." According to Sattler, the further cooperation went very well: "Even the first prototype and also the later series models that we received from Z-Laser worked very well right away. The learning curve typically associated with new suppliers and components was much shorter than usual. They quickly provided us with a solution to our demanding challenge."

Even when inspecting the quality of the modules after each of the three process steps, backlight laser modules ensure optimum illumination to enable perfect camera images. In a second measuring system at the final quality inspection stage, the entire substrate is scanned with a contact image sensor in order to ensure the completeness of the lines of the third structuring process and to detect any damage.

"Laser modules from Z-Laser thus play a decisive role in all three surveying steps and help to optimize the production process of the thin-film solar modules," explains Bernd Sattler. "Every CIGSfab uses several of the described systems. This is the only way we can ensure that the planned throughput is 100% controlled and that only defect-free substrates leave the plant." ■

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Power of the Wave

Wave Optics on the Rise

The transition from geometrical optics to wave optics opens up a new dimension in laser material processing. A thousandfold increase in productivity is realistic.

I still remember a bearded physics teacher drawing a ray of light and a mirror on the board and saying: "The angle of incidence is equal to the angle of reflection." Later on, we would discover that the whole light thing was a lot more complicated, but this seventh-grade perspective on optics has proved to be sufficient for laser material processing for decades: light is a ray, and a focus is a point at which converging rays unite. Frankly, that wasn't such a bad thing. In most applications - and for the purpose of designing optics - geometrical, or ray, optics gives you plenty of information, at least for the rectilinear propagation of light in a medium, reflection, refraction, shadow formation, and the path light follows in optical devices, such as focusing optics. If you are interested only in focusing light energy on a particular spot, then ray optics is a useful model.

Crossing the Threshold

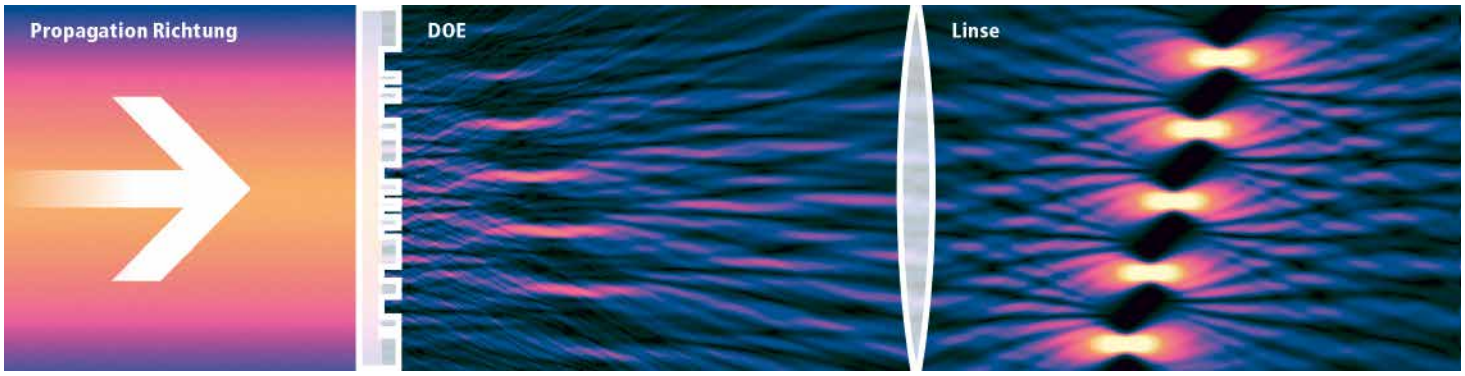
But there's a lot more you can do with light, so it's worth taking things a few more steps.

»The efficiency gains are huge: depending on the laser you're using, diffractive beam splitting can divide each focal point of the beam into between 50 and 1,000 foci without any loss of power, thereby increasing the processing throughput by a factor of 50 or 1,000, respectively.«

Even in well-established laser machining processes such as cutting steel with conventional optics, engineers often strive to optimize the focal point, which essentially means acknowledging that the focus is not actually a spot, but rather a spatial distribution of intensities. In order to calculate and optimize these intensity distributions, we need to picture light as a wave; we thus enter the domain of wave optics. Here, a focus is not a point, but rather an intensity distribution that extends in the x, y and z directions. That opens up a wealth of additional information about the focus. And, more importantly, it means it can finally be manipulated. In a big way!

A Thousand Times More Efficient

Targeted aberration of the laser beam enables us to tailor the focus to the requirements of a particular application. In glass cutting, for example, we can extend the focus along the direction of propagation in order to simultaneously change the structure of



Simulated effect of a diffractive optical element (DOE): in this example, the system generates six volume-distributed focus zones on the workpiece from a single beam using targeted aberration of the laser light. The different colors show the intensity distribution.

the material throughout the entire volume of the glass. Another option is to use diffractive optical elements (DOEs) to accelerate light. This method causes the focus to bend at a certain angle, so it looks like the letter C, for example. Laser beams with a C-shaped focus can then be used during cutting to give display glass the curved edges it needs without any reworking. Other DOEs split the focus and distribute it freely in space within a given volume. In Trumpf's advanced engineering department, we have already split a laser beam into 133 foci and freely distributed them in a different form within a volume of one cubic millimeter. This has enabled us to tap into new opportunities and efficiencies in the microprocessing realm. On this basis, it is perfectly conceivable that we could distribute them in other volumes, too, with the number of foci ascending to the hundreds of thousands. Metalworking applications could benefit from rectangular functions (flat-top distribution), which generate homogeneous intensity over a certain width, while the intensity outside the rectangle is simply zero. Instead of producing surface structures pulse by pulse, a focus with flat-top distribution can ablate the material in a single shot. The efficiency gains are huge: depending on the laser you're using, diffractive beam splitting can divide each focal point of the beam into between 50 and 1,000 foci without any loss of power, thereby increasing the processing throughput by a factor of 50 or 1,000, respectively.

High Computing Effort

As we can see, wave optics offers all sorts of new opportunities. But it's not just about shifting how we think about things; it also involves a lot of hard work! That's because switching from ray optics to wave optics means leaving behind a mathematically simple model and switching to a much more complex one. This transition affects not only mathematical modeling, but also computer simulations and the analysis of lab results. In the Trumpf advanced engineering department, we have performed pioneering work in all these fields. As a result, we can describe light in terms of wave optics along its complete path from the beam source to the workpiece. This also involves not only modeling the coherence of light waves from the light source, but also considering issues such as resonator modes in order to understand the field distribution within the focusing optics. It is not uncommon to be dealing with a billion pieces of information for a single laser beam within this kind of four-dimensional matrix (three spatial dimensions and one-time dimension). That requires correspondingly high computing and simulation capacities. What's more, the wave-optics model is different for each laser. For example, there is a huge difference between cw, short-pulse, disk and fiber lasers in terms of their wave optics.

Gateway to a New World

Wave optics are currently ushering us through the gateway to a new world of laser material processing. In the coming years, we will be operating with applications and achieving efficiency gains that will almost seem like witchcraft to users of geometrical optics. Yet the next threshold is already in sight. If we think of ray optics as a crutch, and wave optics as a pair of running shoes, then quantum electrodynamic (QED) optics may well seem like a racing car 30 years from now. But, for the moment, QED optics is difficult to calculate for macroscopic applications and yields far too much information, which we are incapable of using for optics design. Of course, that was also true of wave optics until recently. ■

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A New Telecentric Level

Telecentric Lenses and Complementary Software Make Measurement Systems Very Compact

While telecentric lenses are usually bulky, various industries have clear space constraints for their measurement systems. A newly designed combination of lenses and software for large fields of view masters the challenge.

With the advent and diffusion of the Industry 4.0 trend, automation is spreading in every manufacturing field and machine vision, in particular, is becoming more and more pervasive. The packaging sector is no exception as testified by an increasing number of tasks that are nowadays solved by automatic inspection and analysis, such as barcode reading, defect or scratch detection or gauging applications, in general.

Large Object Measurement

Speaking about the latter, for measurement applications telecentric lenses are commonly employed because of their characteristics of low distortion, fixed magnification and big depth of field. On the other hand, however, because of their design they result quite bulky in comparison to entocentric lenses – and this is a major problem, especially when large objects are imaged, something quite common in the packaging industry that must deal with almost every dimension of samples. In order to overcome this limitation, Opto Engineering designed the new Core Plus family of ultra-compact telecentric lenses and illuminators for large Fields of View (FOVs). Not only in order to exploit the full potential of the new lenses they also designed a dedicated software called TCLIB Suite that aims to take telecentric vision systems to a new level.

New Opto-Mechanical Design

The length and working distance of a telecentric lens strongly impacts the size of a vision system. This is especially critical when a large FOV telecentric lens is used with a telecentric illuminator as the overall system dimensions are doubled. The Core Plus series are large FOV telecentric lenses for area scan cameras and collimated illuminators with a novel opto-mechanical design that is ideal to measure large objects in a reduced space.

Both the working distance and the mechanical length of the lenses and illuminators have been optimized to make a measurement system as compact as possible: compared to any other telecentric lens and illuminator of similar FoV, the new lenses are up to 45% shorter.

A complete, large FoV telecentric system (lens + telecentric backlight) takes an important amount of space, considering that the front element of both the lens and the illuminator must be at least as big as the FoV. Therefore, with a standard design, the mechanical length of the lens/ illuminator is typically that of half the front element itself. The new lens series brings this back to an almost 1:1 ratio and the design, combined with the use of light materials, saves a lot on weight as well: up to 50% for the largest model.

The Core Plus technology combines a non-standard optical design with a very new way of using curved optical mirror elements.

Both the working distance and the mechanical length of the lenses and illuminators have been optimized to make a measurement system as compact as possible.«

TC Core Plus Series

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	Mag. (x)	1/1.8" sensor FOV (mm x mm)	WD (mm)	Lens length (mm)	Overall system height (mm)
TC12192	0.033	216 x 162	527	602	1129
TCCP12192	0.033	216 x 162	336	345	681
With CORE PLUS telecentric lens you save:	- -	- -	**191 (36%)**	**257 (43%)**	**448 (40%)**

TCCP12192 provides a 216mm x 162mm FOV with a 1/1.8" sensor (same as TC12192). Being 257mm smaller and having a 191mm shorter working distance, it allows you to save almost 450mm.

These two elements provide a mechanical length of the optics that is almost impossible to reach with traditional optical solutions. In comparison to Opto Engineering´s standard series the working distance was also reduced, allowing for even larger space saving. Moreover, the lenses feature a built-in mounting flange and standard aluminum T-slot profiles for easy mounting without additional clamps, making their integration easy and cost-effective.

Typical applications include, but are not limited to, measurement and/or inspection of large mechanical parts, bottles and vials, microplates, multiple parts in contemporary, glasses and batteries of smartphones.

Complementary Software Suite

Tclib Suite is a C++ based computer vision software designed to optimize the optical performances of a telecentric setup, typically used for measurement purposes. The use of both a .dll library and dedicated stand-alone tools makes it easy to take care of all aspects of a typical telecentric setup (focusing, alignments, distortion calibration) which, if not properly addressed, can negatively affect the results of measurements.

The software suite helps to improve the quality of the system, providing the best possible images for the chosen metrology software in order to obtain the best achievable measurement results. In fact, any edge detection, pattern matching, and calibration software will be more accurate and reliable if based on well-aligned, homogeneously backlit, undistorted images.

Tclib includes:

- dedicated tools to take care of the basics of a measurement system setup: alignment of telecentric lens and collimated light, alignment of the object plane, best focus (Tclip-App);
- a set of algorithms (C++ library) to calculate the distortion map of a system and correct in live mode every new image acquired by the system, plus all the functions developed in the app.

The stand-alone tools and the distortion calibration functions are used offline when the initial optimization and calibration of the machine is required. The distortion correction, on the other hand, is based on fast and reliable algorithms which allow the system to stream adjusted images in live mode.

The detailed functionalities of the graphical tools in the app are:

Aligning of Lens and Collimated Light Source

This tool assists the operator in achieving the most homogeneous illumination possible. Getting the best homogeneity of the illumination is the first fundamental step for a good measurement system, since this spec affects the reliability of any set of edge detection algorithms. The tool works in live mode, giving a visual feedback on the alignment. The FOV is divided in ROIs, each one having a color feedback regarding the alignment

Aligning the Object Plane

A good alignment of the object plane with the optical axis is essential. There are two main consequences of misalignment: In a backlighting condition we are looking at the object projection, not at its actual profile, hence the image might be affected by some compressions along certain directions. Also, some features might not be in the best focus at the same time, thus compromising the quality of the edge for the measurement.

Best Focus Tool

This tool gives a numeric index for every image, indicating the proximity to the best focus. It's based on two main algorithms, allowing the user to choose depending on the object features under inspection.

One of the most innovative tools in the library is the distortion correction function. This tool allows to eliminate the residual optical distortion from the telecentric lens – this value must be as close to zero as possible to achieve optimum results. From a single picture of a chessboard pattern covering the whole FoV (such as the Opto Engineering PT series), we receive all the information necessary to get rid of distortion.

The procedure is as follows:

- a single image of the calibration pattern is acquired (offline);
- from the picture a distortion map is created (offline);
- the distortion map is saved on a reference file;
- the distortion is eliminated on every new image acquired, recalling the saved distortion map (online).

Steps 1 and 2 are needed to calibrate the system, hence they have to be carried out only once. Step 4 is repeated on every new image acquired. All of the functions are integrated in the library .dll file and in a demo stand-alone software. The demo application can be used for test purposes or to obtain the distortion map, whereas for the actual online correction the integration of the .dll file is recommended. ■

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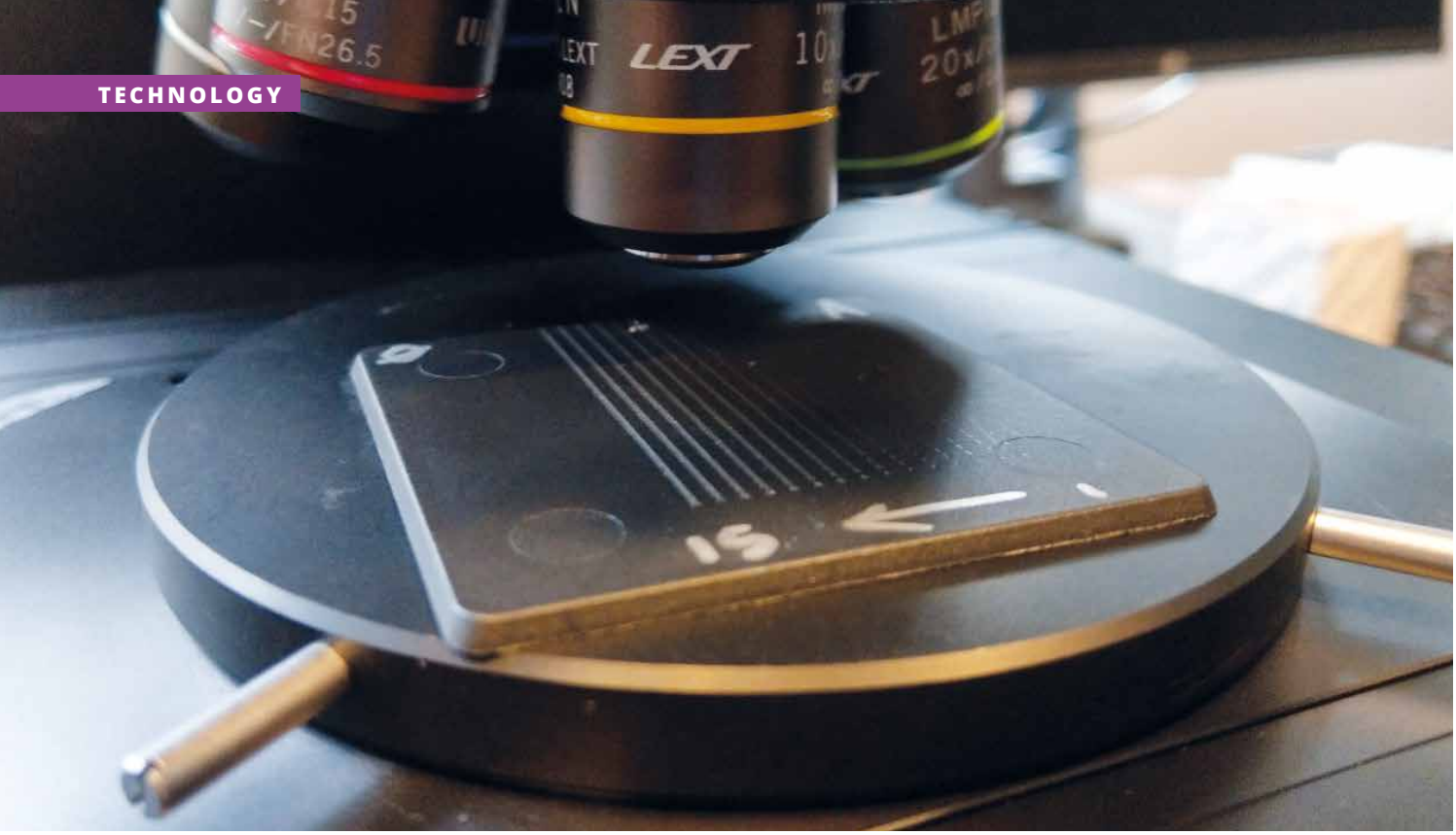

Surfaces: A Deeper Insight

Confocal Microscopy for Fast, High-Resolution Surface Measurements

Detailed surface measurements using confocal microscopes provide a reliable, quantifiable means of assessing surface properties in great detail – providing confidence in functionality and quality.

Surface properties influence both function and aesthetics in many products across different industries. Whether it's looking at roughness, patterns or scratches – surfaces matter. Products or components with the right surface properties can have longer lifespans, superior performance, or simply look better. Large surface features are obviously visible by eye, but most surface inspections require specialized equipment to see sufficient detail. Also, quantification of parameters such as roughness or the sizes of features requires a high-precision approach.

A Closer Look

A range of light-based techniques exist that can study surfaces and surface properties in a detailed, quantifiable way. Microscopy and interferometry are commonly used in many industries as part of R&D, manufacturing or QC.

Confocal microscopy is particularly well suited for surface inspection and measurement. It has the versatility to measure a range of different parameters in a fast, efficient manner. It also offers a high level of detail with the ability to measure to the nearest 10 nm.

What Is Confocal Microscopy?

Confocal laser scanning microscopes differ from widefield microscopes in that they offer a higher resolution and the ability to carry out precise measurements in 3D. The key difference is that widefield microscopes illuminate an entire specimen at once, whereas confocal microscopes use pinholes to detect light from a well-defined point in 3D and discard all out-of-focus light. With this method, samples can be scanned to create precise 3D maps that are well suited for a range of visualizations and measurements.

Scratch Testing at Croda

The following case study from Croda International clearly demonstrates the benefits that switching to confocal microscopy brings to a surface measurement workflow.

Croda International plc is a leading supplier of additives that improve scratch resistance in plastics. During manufacturing, these additives are mixed with liquid polymers in small amounts, typically up to 1%. When the polymer solidifies, the additives migrate to the surface and form a protective layer that helps to reduce scratch damage.

In the automotive industry, scratch resistance of injection-moulded components plays a key role in a car's appearance. Scratch-resistant materials contribute to cars retaining their value over years of use by minimizing the influence of wear and tear on the car's appearance. The precise composition of a material will determine its scratch resistance and detailed tests can reveal the level of scratch resistance of a specific material.

In a typical test procedure, the company's R&D team produced plaques of different compositions, which are then scratched using a standardized tool at defined forces of 1–20 N (fig. 1). This will leave a scratch and two mounds on either size (fig. 2). After scratching, they looked for differences between plaques, for example by studying depth, width and profile of the scratches.

Previously, the Croda team used two pieces of equipment for scratch measurement: a white light interferometer to show the scratch profile and measure depth, and a widefield materials microscope to measure scratch width. Although effective at measuring the necessary parameters, the method was also

Fig. 1: Sample plaques can be used to test the effect of additives on scratch resistance.

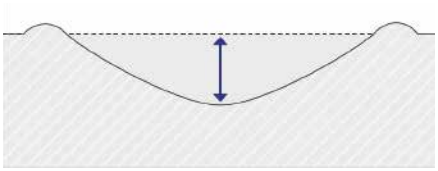

Fig. 2: Slice visualization of a typical scratch profile

Fig. 3: Olympus' Lext OLS5000 is well suited for measuring scratch parameters.

time-consuming, particularly the setup and data analysis of the interferometer.

When looking to improve the speed and precision of their test methods, the company's researchers at trialed the Olympus Lext OLS5000 confocal microscope in their testing lab. This measurement confocal microscope offers the opportunity to measure all relevant parameters with a single instrument. It also combines a fast scan speed with the ability to provide detailed, quantifiable data about a wide range of 3D samples.

Measurements that Are Up to Scratch

Switching to confocal microscopy led to enormous improvements in speed, precision, ease of use and operator variability. By using the microscope, researchers at Croda were able to measure scratch depth to the nearest 10 nm, an order-of-magnitude improvement in precision.

Even more significant improvements were made in the speed of the analysis: 10 scratches could be measured and analyzed in around two minutes – 10 to 100 times faster than the previous interferometry-based approach.

One of the challenges of interferometry measurements is looking at surfaces such as polypropylene. Its surface properties mean that the interferometer sometimes looks through the surface, which leads to spikes in the surface profile. When the same samples were measured using the Olympus microscope, researchers were able to obtain a smoother image of the scratched surface that provided an accurate representation of the scratch and facilitated measurement.

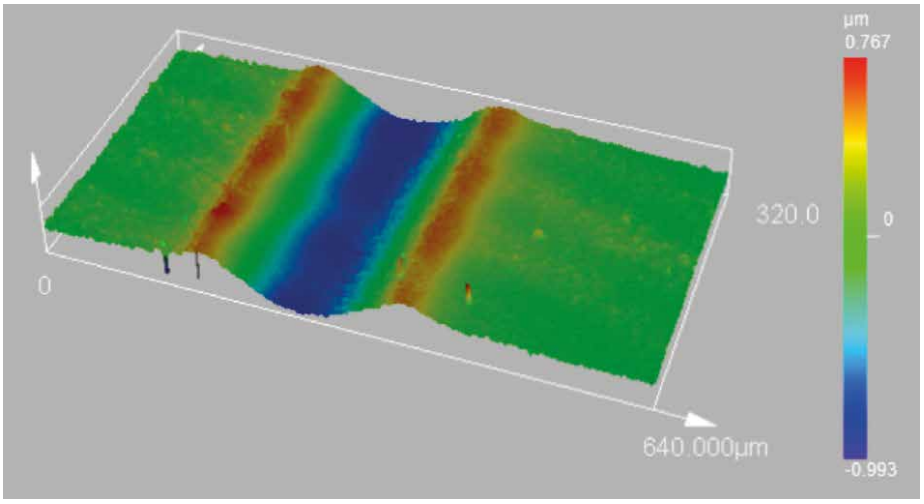

Fig. 4: A detailed 3D map without artifacts makes it easier to determine all the necessary parameters.

Interferometry also often suffers from variability between operators due to the complexity of the setup. As a result, different operators can get a different result from the same sample. Automated methods for measuring and analyzing a sample, as well as the easier setup, mean that confocal microscopy reduces the risk of human errors by making the workflow simpler and more standardized.

Scope(s) for Improvement

Surface measurements produce highly detailed, accurate data about the condition of surfaces. This information helps to assess a product's functional as well as aesthetic properties. Confocal measurement microscopes provide an excellent combination of precision and speed, making them well suited for high-throughput surface inspections.

The data from the Croda R&D team clearly demonstrates how Olympus' Lext OLS5000 confocal microscope helped to reduce operator variability and provided order-of-magnitude improvements in both speed and accuracy. These improvements resulted in better assessments of the positive effect of their additives on plastic products, which is key information, both internally and for customers. ■

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Featuring the award-winning design of the Flir T-series camera platform, the T840 features an ergonomic body, a vibrant LCD touchscreen, and a viewfinder to make it easy to use in any lighting conditions. The 464x348-resolution camera incorporates Flir advanced Vision Processin, including patented MSX image enhancement technology, UltraMax, and proprietary adaptive filtering algorithms to provide customers with enhanced measurement accuracy and image clarity with half the image noise of previous models. **www.flir.com**

AI Helps Sell the Original Sacher Cake

If you buy an original Sacher cake these days, you do not have to queue anymore. Thanks to sophisticated artificial intelligence, the patented end-to-end solution automatically recognizes all 60 available products from the Sacher product range and directly initiates the payment process. Sacher has specially crafted a pedestal, including red velvet upholstery, and equipped it with the latest technology from MoonVision. Via the platform, the integrated camera recognizes the respective product or its packaging size and automatically communicates the corresponding amount to the cash register system so that the customer can complete the purchase process completely autonomously.

With almost 100% accuracy, MoonVision's platform reduces the error rate across a wide range of applications, enhancing the quality management of industrial and manufacturing operations away from the retail sector. The solution is particularly useful where it can handle complex processes with absolute precision and no fatigue. Thus, the cloud software has learned within a very short time to recognize all 60 products from Sacher.

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"Adlink is taking embedded computing to the next level with GPU- and VPU-accelerated heterogeneous computing platforms. As an NVIDIA Quadro Embedded Partner with extensive experience in embedded applications, Adlink is uniquely qualified to bring NVIDIA Quadro GPUs with GPUDirect, NVIDIA Video Codec SDK, custom firmware and longevity support into embedded applications, enabling them to tap the power of embedded graphics and AI," said Edgar Chen, managing director of Adlink. **www.adlinktech.com**

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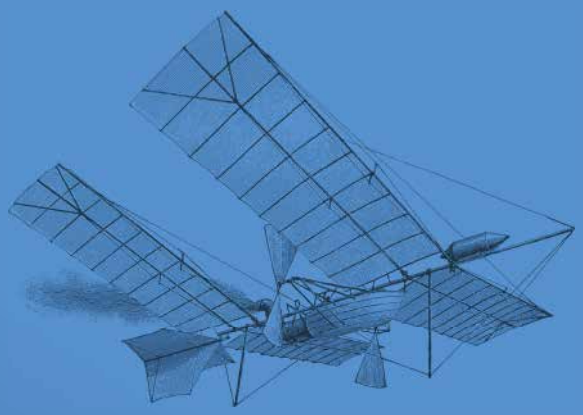

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