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Machine Vision and Optical Metrology

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Computed Tomography
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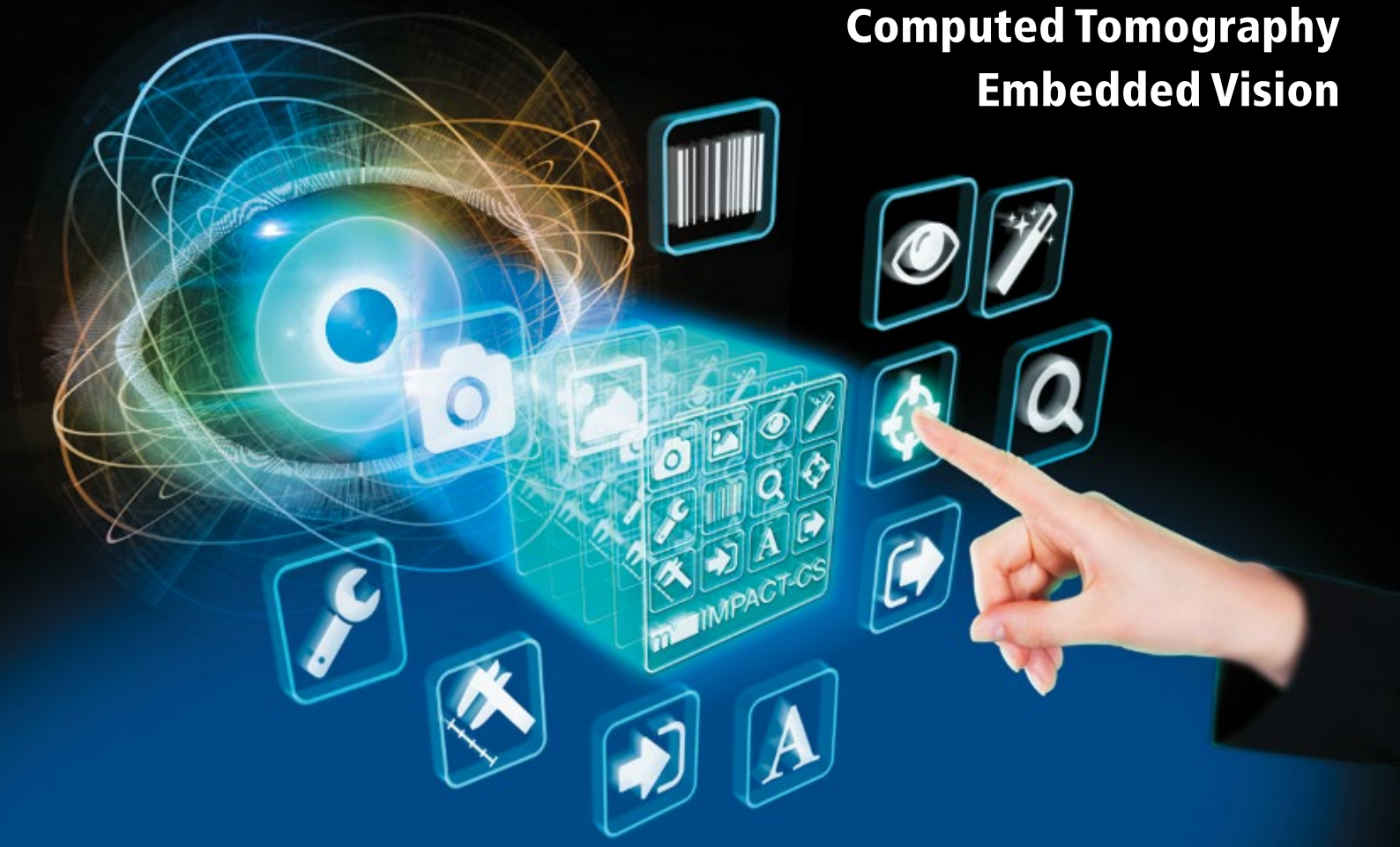

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inspect is international. Not only since the publication of this special issue, and not just because one third of the regular issues' readership is not domiciled in Germany. The same applies to our authors and the companies that advertise with us on a regular basis. inspect is a partner of international professional associations, and media partner of the most important international trade shows and congresses. It is therefore simply logical that inspect has been addressing the international market for many years as a cross-media platform: With the English online portal inspect-online.com, with international newsletters, with the European inspect Buyers Guide, and with the inspect application forum. With inspect international we are now putting it all on paper – from now on twice a year.

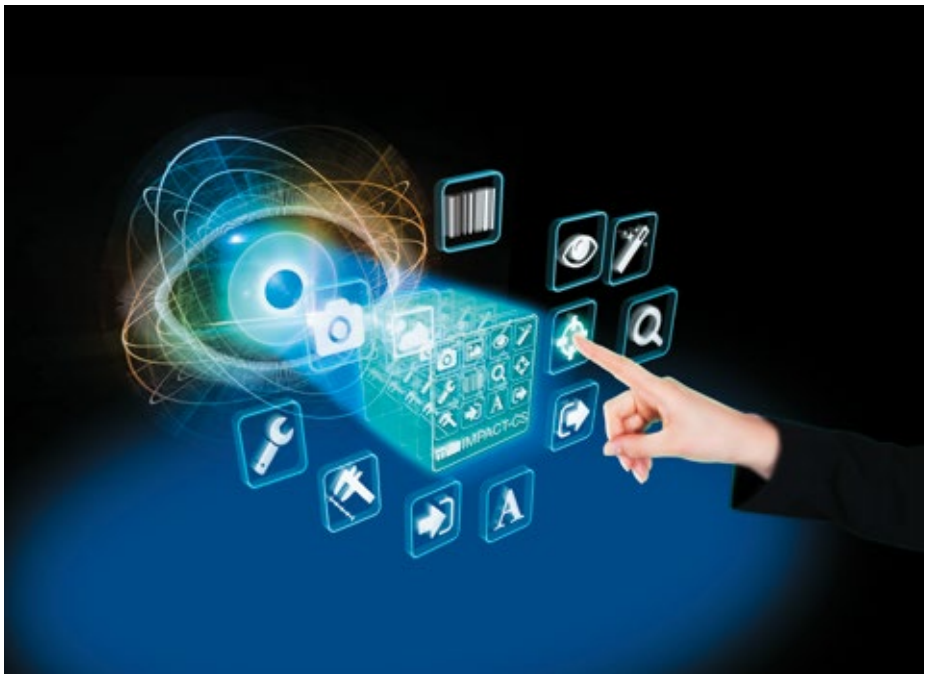
Joachim Hachmeister

inspect international does not only complete our international media portfolio. Moreover, we are striving to make our contribution to global knowledge and information dissemination across borders. Nowadays, technologies spread fast – and worldwide. The exchange between experts from companies and research institutes has to keep up and should not fail because of language barriers or restricted access to relevant technical media. With the articles in this international issue of inspect we would like to reach many new and interested readers in the numerous industries that already deploy machine vision technologies or optical metrology, and those that are working on their development and implementation.

Bernhard Schroth

The industry's development is moving forward in giant strides. Not just in Germany or in global enterprise's local subsidiaries. There is an amazing variety of nations that prove that expedient R&D knows no bounds. The trend does not stop at demarcation lines either – after all, embedded vision is the same anywhere in the world. With this in mind, we are hoping that the international issue of inspect can contribute to international understanding, and hopefully not only at a technical level. Eventually, Wiley is a global publisher and is committed to corporate citizenship – all around the world. As it were, for me it is an affair of the heart and a privilege that I had the opportunity to help shape this amazing special issue with 84 pages. I hope you enjoy reading it!

Sonja Schleif



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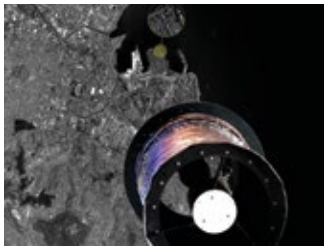
Elbit Systems' Space Imaging Systems Launched Onboard Satellites



Elbit Systems announced that two of its advanced space imaging systems, Jupiter and Venus, were launched to space on August 2nd. The high-resolution reconnaissance Jupiter imaging system for the Italian Ministry of Defense was launched onboard the IAI Optsat 3000 satellite.
The super spectral Venμs imaging system was launched onboard the French-Israeli Venus environmental satellite.
The Jupiter space camera provides spatial resolutions of 0.5 m resolution (PAN) from an altitude of 600 km and is Elbit Systems' most advanced light-weighted space imaging system developed for installation on micro and mini-satellites.
The Venμs space camera features 12 narrow spectral bands with 5.3 m spatial resolution from an altitude of 720 km. The Venμs satellite has been developed and manufactured as a joint effort between the French Centre National d' Etudes Spatiales (CNES), the Israeli Space Agency (ISA), Elbit Systems' Electro-optics (Elop) and Israel Aerospace Industries. Its Venμs imaging system provides multi-spectral high-resolution earth imaging.

www.elbitsystems.com

Teledyne Cameras Power University Aerospace Team

Teledyne Dalsa congratulates the University of Toronto Aerospace Team's (UTAT) UAV and Aerial Robotics Divisions on their recent success at Unmanned Systems Canada's national competition. Both teams were honored with awards for the design and performance of their custom-built unmanned aerial vehicles (UAV) which flew autonomous search patterns while capturing images at approximately 200 feet above ground.
Teledyne Dalsa provided two Genie cameras for the mission. The primary payload, a Genie TS-C4096 provided complete coverage of surveillance regions with high ground resolutions for effective target detection and characterization. A second and lighter weight Genie Nano C1940 model provided high-resolution color imaging from a multirotor. Teams were ranked for their ability to accurately report goose population attributes, including the geolocations of detected nests, the number of distinct goose species observed and a census count for each of these species. The UAV and Aerial Robotics Divisions placed 2nd and 1st in the design phase and 1st and 4th in flight operations respectively.

www.teledynedalsa.com

Creaform Now an ISO/IEC 17025 Accredited Laboratory

Creaform is pleased to announce that its Canada-based head office has received the ISO/IEC 17025:2005 accreditation from the American Association for Laboratory Accreditation (A2LA). The ISO/IEC 17025:2005 accreditation is an internationally recognized standard for testing and calibration. Laboratories accredited as per the ISO/IEC 17025 standard have demonstrated their technical competencies related to the calibration of its technologies. Creaform also follows the ASME B89.4.22 Standard for its acceptance testing and holds an ISO 9001:2008 certification for its quality management system.

www.ametek.com

Vision Engineering and Luxo Conclude Cooperation Agreement

Vision Engineering and Luxo, part of the Glamox Group and manufacturer of magnifying lamps and light solutions, announce a new strategic business partnership. Vision Engineering takes a wide range of magnifying lamps into its sales portfolio and will distribute them in Central Europe and North America under co-branding independently and through authorized distributors.

www.visioneng.de

Basler with Strong Growth and High Profitability

Basler presented final figures for the first six months of 2017. In the first six months of the fiscal year 2017, the group's incoming orders amounted to €100.4 million (previous year: €50.2 million, +100%) and were thus just below total incoming orders of the previous year. The group's sales of €78.5 million were 62% above the previous year's level (€48.5 million). The gross profit margin slightly increased and amounted to 50.3% (previous year: 49.7%). The earnings before taxes (EBT) for the group were positively impacted by economies of scale and amounted to €18.2 million (previous year: €5.3 million). The pre-tax return rate amounted to 23 % (previous year: 11%). At a slightly increased tax ratio, the result per share went up from €1.19 to €4.03.
Recently, the company raised its 2017 forecast and now plans within a group's sales corridor of €140 to 150 million at a pre-tax margin of 15 to 18%.

www.baslerweb.com

Hamamatsu Photonics Technology Days 2017

Hamamatsu has announced the 4th Hamamatsu Photonics Technology Days, a series of free of charge one-day events held across Europe that offer the opportunity to network and share knowledge with like-minded professionals. This year's theme is „Chasing Photons in X-ray and Infrared". The events will introduce participants to current and future technologies with keynote presentations from leading industry experts. In addition, workshops will be offering the opportunity to have hands-on experience with technology. The unique event has a limited number of spaces, so early registration is recommended.

www.hamamatsu.com

Positive End of a Business Year and an Era

Stemmer Imaging ended its business year 2016/17 on 30 June 2017 with a turnover of €88.7 million and an exchange rate adjusted growth of 6%. After 44 years, the company's founder Wilhelm Stemmer is handing the company over to proven successors.

Stemmer Imaging achieved turnover of €88.7 million over the 12 months of the business year that has just ended. After adjustment for exchange rates, this means a growth of 6% for the company, which is active in 19 countries. The biggest increase as a percentage was realised by branches in Finland, the Netherlands and Switzerland. The portion of turnover attributable to customer services has increased further in the preceding year.

The close of the business year 2016/17 also represents the end of an era: company founder Wilhelm Stemmer has sold his shares in the company with effect from 30 June 2017 and is retiring from the operative business. 75.04% of the shares are now held by Munich-based AL-KO AG, parent company of the internationally active AL-KO Kober SE. As part of the transaction, the proven management team acquired 24.96% of the shares.

www.stemmer-imaging.de

Nokia Smartphones to Feature Zeiss Optics

HMD Global, the home of Nokia phones, and Zeiss jointly announced the signing of an exclusive partnership that aims to set new imaging standards within the smartphone industry. This long-term agreement builds on the shared history and expertise between Zeiss and Nokia smartphones.

With a joint ambition to advance the quality of the total imaging experience on smartphones spanning the entire ecosystem from software, services, through to screen quality, and optic design, the partnership will see Zeiss and HMD Global co-develop standard-defining imaging capabilities and will bring the Zeiss brand back to Nokia smartphones.

The past collaboration saw Zeiss and Nokia phones driving technology innovations such as the world's first multi-megapixel mobile phone and many more standard-setting devices. This renewed relationship is a long-term commitment to build on that technology innovation over the years to come.

www.zeiss.com

Tattile Products Are Distributed by Framos

Tattile is pleased to announce a distribution agreement with Framos. With this new cooperation all Tattile hardware and software products are now available across the Framos sales network in Europe and North America.

"With Framos we are now cooperating with one of the strongest distribution partners in the machine vision industry. Both Tattile and Framos are very dynamic companies with impressive success stories in the last years," says Tattile CEO Corrado Franchi. He is adding: "Following the Framos approach 'From Sensors to Systems', the Tattile product line is a great match, enabling synergies for customers to bundle Tattile cameras, software and/or vision controllers with third party lenses and lighting from the Framos portfolio."

www.framos.com

Insights from 1000+ Industrial and Scientific Cameras

The online product selector Imaging.market has crossed the 1000-camera line. This is a major milestone on its mission to support faster development of better imaging systems at lower cost. The aggregated portfolio of 11 camera manufacturers constitutes a comprehensive cross section of the global market, which allows vision system developers to find a range of cameras from different suppliers for almost every requirement specification. At the same time, this portfolio allows for insightful analysis of the camera market, which shows a leading position of CMOS Global Shutter sensors, a 50% share of Sony sensors, and just 8% lag of USB 3.0 behind GigE.

Imaging.market is now hosting close to 1100 area scan, line scan and smart cameras as well as camera modules from the manufacturers Baumer, Flir Systems (formerly Point Grey), Kaya Instruments, Lumenera, Matrix Vision, Mikrotron, Pixelink, Smartek Vision, Sony, Tamron and Tattile.

www.imaging.market

Flir Systems Announces New President and CEO

Flir announced that James J. Cannon has been appointed President and Chief Executive Officer, effective June 19, 2017. Cannon will succeed Andy Teich, whose retirement after 33 years of service was previously announced on February 14, 2017.

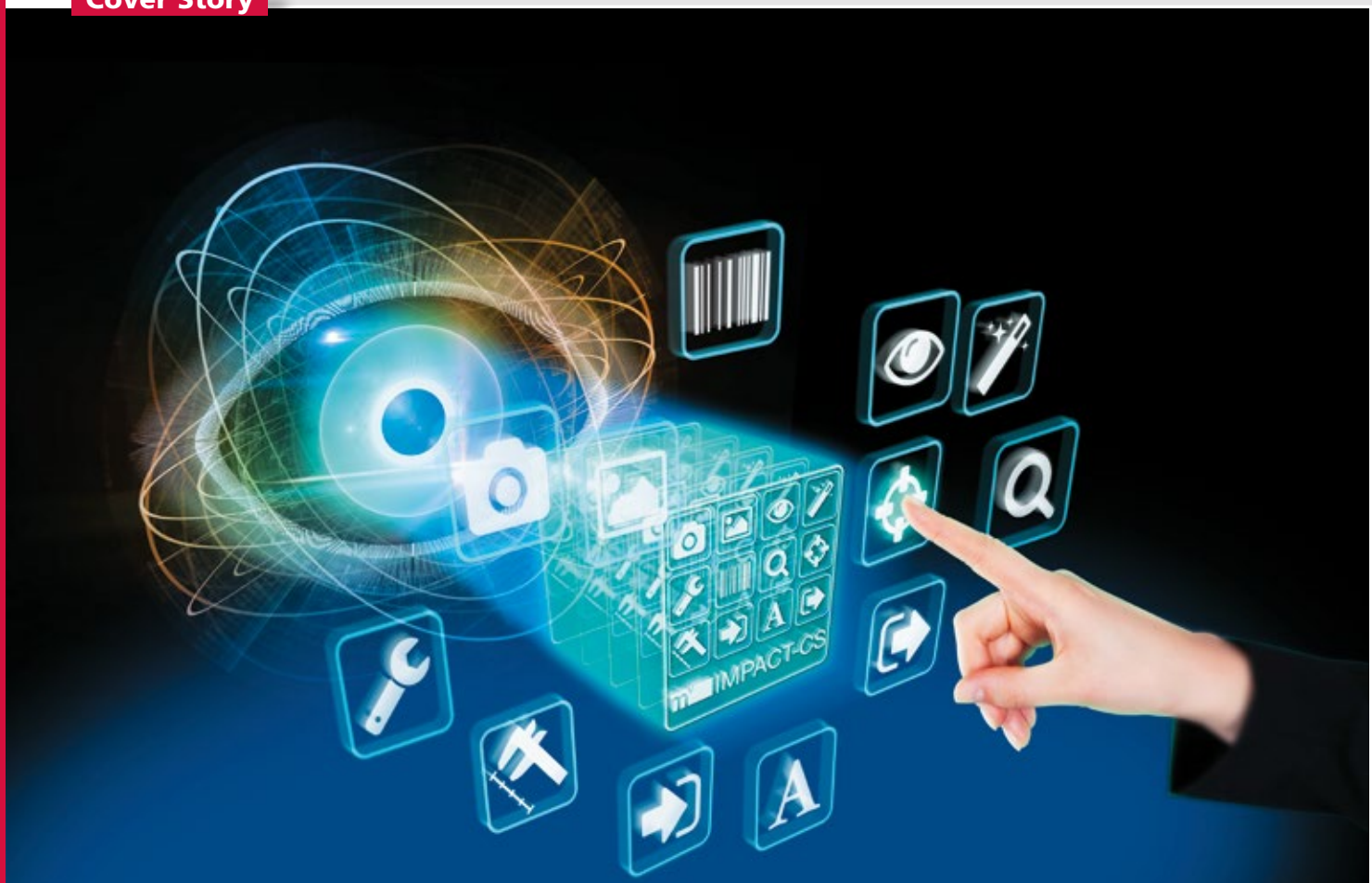
Cannon's extensive and varied leadership experience, together with his proven operational expertise and ability to adapt business strategies to meet evolving market needs, makes him ideally suited to lead Flir and its portfolio of innovative technology-based products and applications. He previously served for more than 16 years in a variety of senior leadership positions at Stanley Black & Decker, Inc., most recently as President of Stanley Security North America & Emerging Markets. Prior to that, he was President of the company's Industrial & Automotive Repair (IAR) business unit, first in North America and subsequently in Europe and Latin America, before then serving as President of Stanley Oil & Gas.

www.flir.com

Keith Bryant Appointed Global Director Electronics Sales

Yxlon International is very pleased to announce the appointment of Keith Bryant as Global Director Electronics Sales. Keith brings with him over 25 years successful experience at a senior level in Technical Sales, mostly in the x-ray field. He will be responsible for all channels to market, and develop our global sales team to be even closer to our customers, understanding their needs and reacting promptly.

www.yxlon.com



Help Yourself!

Intelligent Software Enables Automated Scene Analysis

Two of the buzzwords used in the field of computing are connected with the future of intelligent image processing: deep learning and cloud computing. Advanced software already enables the future today – without the need for special expertise.

There have been many publications recently on the subject of the future of intelligent image processing. Buzzwords such as ‚neural networks' and ‚deep learning' are uttered in the same breath as ‚cloud computing', heralding a rosy future for intelligent image processing. In this sense, the future has already arrived: With its mvImpact Configuration Studio, Matrix Vision is demonstrating the direction in which intelligent inspections are heading – neither specialist programming knowledge nor image processing expertise is required.

Deep Learning and Neural Networks

In an image processing context, deep learning refers to a learning process in which several, usually thousands, of good and bad images are used to train a system, which will eventually be able to decide automatically whether an image is good or bad. The computing time and storage capacity required for this is enormous. This is why neural networks are necessary to support the process. The neural networks will be generated by supercomputers and then used by the image processing application, or so the plan goes. But who pays the immense costs associated with the supercomputer? Another issue is the fact that nobody is able to follow what happens within neural networks and which aspects are decisive when it comes to deciding whether a part is good or bad. The following scenario, which is entirely feasible, illustrates the disadvantage of this lack of transparency: During the learning process, all of the good parts just happen to have a slight green tinge to them, which is then used as the basis for making the decision. This means that as soon as the green tinge is no longer present, even good parts will be recognized as bad parts. What is more, it is not possible to check why this is happening, nor can the incorrect behavior simply be corrected. Although you can try to use hundreds of these images to train the system to recognize good parts, you cannot be sure that the good parts will be accepted as a result.

Cloud Computing

As already mentioned a local PC cannot provide the huge storage capacity required by deep learning. For this reason, deep learning is often associated with cloud computing. This also raises a number of questions, however: Where is the server located? Who has access to the data? Who ensures the security

of the data? How quickly will security holes be patched? As production data is classififed as sensitive data, and security holes are frequently used to steal data, this is a point that cannot be taken lightly.

However, are such storage volumes and computing times really necessary? Is there not a more intelligent approach that will allow inspections to be carried out efficiently and learned by the existing hardware, which already performs sufficiently well? Yes, there is: with self-learning, intelligent software. And the best thing about it is that the technology is already available.

Intelligent Software

The mvImpact Configuration Studio software (mvImpact-CS for short) developed by Matrix Vision offers the simple operation known by vision sensors. This is due to the fact that it comes with its own digital image processing expert. The actual scene captured by the camera is automatically analyzed, then suitable algorithms are selected along with any required filters. For the filters, too, the software sets the right parameters - both immediately and automatically. The ‚mvImpact-CS expert team' that is integrated into the software is available 24/7. There is no need to pay a setup fee, or to conclude a maintenance contract.

The user can choose from a manageable number of tools whose names – such as ‚Setup camera', ‚Get image', ‚Read code', ‚Find object', ‚Measure object', etc. tell the user what they actually do. This means that the software uses the same kind of language as the user, who may well be able to describe what he requires, yet usually has no previous knowledge of image processing. The tools make it possible to carry out visual inspection tasks in just a few minutes: quickly and cost-effectively.

Operation Mode

The ‚Find object' tool, for example, provides a good illustration of operation mode and philosophy behind the intelligent software:

The Classic Approach to the ‚Find Object' Task

There are lots of image processing algorithms to find an object, including blob properties (blob = binary large object), numerous blobs and their spatial relationships, pattern recognition, edge-based pattern comparison, etc.. All of these basic algorithms have specific properties and limited scopes of application. An application developer involved in image processing will look at the image and decide – based on his experience – which the most suitable process for this particular object will be. The application developer will then implement the algorithm in his program or set parameters for the algorithm, assuming he is using a conventional, configurable camera. By means of tests and on basis of experience, the application developer determines and optimizes the parameters, whereof there can be up to 30 or even more.

Measurement of radii in the measure tool

An Innovative Solution for the ‚Find Object' Task

Choosing the right algorithms and deciding on and setting suitable parameters – all this is integrated into the new software, and it happens automatically with the help of a few sample images and a configuration assistant also known as wizard that interacts with the user. So, with mvImpact-CS, Matrix Vision is paving the way for automatic scene analysis – a task that had so far seemed impossible to achieve.

The ‚Check Object' Tool

The ‚Check object' tool uses a similar approach to deep learning, however only two to five sample images are required as opposed to thousands of good/ bad images. The tool does not use any non-transparent algorithms that make decisions as if by magic, but it uses well-established standard image processing algorithms instead. By way of example, the tool currently uses either an edge-based algorithm (are the present edges the same as those on the good parts?) or a brightness algorithm (are the grey values closer to those of the good parts or the bad parts?). Based on the images, mvImpact-CS automatically selects the appropriate algorithm along with the parameters. This is where it differs from other solutions in the market: No image processing expertise is required. What is more, both the process and the parameters are visible to everyone. First of all this means that it is possible to follow what is happening and why something is not working correctly and, secondly, that malfunctions can subsequently be amended by the user himself in order to influence the behavior.

mvImpact Configuration Studio demonstrates that the future of intelligent image processing has already begun - and that neither neural networks, nor cloud computing will be necessary for it. On the contrary: Everything takes place locally and the user has full control over the data – nothing leaves the system, and no external providers are required. In addition, the preparation of complete inspections is not restricted to a small group of image processing experts. Anybody can set up an inspection in a flash with the help of the wizard and the deep learning-style approach. Just like William Tell, who asserted his independence by taking things into his own hands.

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mvImpact-CS is paving the way for automatic scene analysis.

David Vitale, Director Photonics Department of Minalogic

> *Associations have to promote new emerging technologies.“*

The French Vision

The overall machine vision market is expected to grow from $8.12 billion in 2015 to $14.43 billion by 2022, at a CAGR of 8.15% between 2016 and 2022. We were taking a closer look at the European market, at France specifically, and spoke with David Vitale, Director of Minalogic´s Photonics Department, about the local trends and future growth potential, the importance of industry 4.0 in France, as well as drivers and opportunities.

inspect: Mr. Vitale, in which industries in France does machine vision play a special role? For example, is automotive (still) one of the most important markets for machine vision?

David Vitale: Camera integration has widely become popular here in France. Historically, it was rather dedicated to industrial control – with on-line inspection for quality control, and code scanners. But it has evolved considerably. Even if industrial control remains a strong field, machine vision systems are now penetrating the field of mobility with robotics, drones, and automotive in an accelerated manner. For example, automobiles integrate cameras to analyze the driver‘s level of attention, there are smart rear view mirrors, cameras for parking assistance and perimeter observation, for obstacle/pedestrian detection, the detection of traffic signs, trajectory analysis, and many more areas – moving slowly but surely from driver‘s assistance to the autonomous vehicle. All of these applications are possible thanks to the decreased cost of computational power and vision sensors, and due to increased integrated computing capacities.

inspect: Are there any industries for machine vision that you consider very important in France but not in the rest of the EU?

David Vitale: One of the areas that is developing strongly in France – but I am not sure whether this is specific for France – is farming, the agrifood market respectively. The same applies to the health and well-being sector. In addition, logistics is a very fast growing market, with a strong integration capacity: product monitoring, packaging optimization and control, assistance to operators and security, etc.

inspect: How strongly is machine vision being developed in France in the sense of the technology itself?

David Vitale: The value chain of machine vision in France appears to be complete. There is a decent amount of renowned providers and manufacturers of all necessary components, which are sensors, optics, light sources, and signal and image processing products. They are complemented by a variety of integrators, and backed by a number of research institutes/laboratories like Leti, a technology research institute at CEA Tech that pioneers micro and nanotechnologies, tailoring differentiating applicative solutions. The institute tackles critical challenges such as healthcare, energy, transport and ICTs. To ensure that France remains competitive and stays at the pulse of time, we also offer reasonable opportunities for industry-specific education, like at the Institut d´Optique, a top-ranking school of optical engineering that owns a research center and has close ties with the industry.

inspect: Is Industrie 4.0 a general topic in France, and if so, is it especially for machine vision?

David Vitale: The factory of the future is effectively a major topic in France, and machine vision has an important position in it. This applies to control and monitoring systems, authentication and/or identification methods for traceability, vision technologies for the immersion in augmented reality, vision for resource management (sorting, recycling) and so on. Today’s camera capabilities – being both smart and accessible - already offer solutions for the factory of the future, and they will offer opportunities to meet future challenges.

inspect: What are the technological specialties of your company Minalogic, and which industries are relevant for you?

David Vitale: Minalogic’s ecosystem is made up of industrial and academic players in the digital technology sector in France’s Auvergne-Rhône-Alpes region. The cluster supports the region’s leading innovators by facilitating networking, fostering collaborative R & D, and providing companies

with personalized assistance throughout all phases of business growth. Founded in 2005, Minalogic today boasts more than 376 members, including 325 companies.

The major domains covered in photonics are surface engineering, imaging, micro-nano-optics, lighting, energy, and displays. Our prioritized application markets are ICT, healthcare, energy, smart buildings, the factory of the future, mobility, and sports and outdoor.

The cluster has certified nearly 508 projects that have secured total government funding of €820 million of the more than €2 billion in total R&D spending these projects represent. The 67 projects completed to date have resulted in 56 products (either on the market or in the process of being prepared for market release) and generated €3.6 billion in revenue.

inspect: Where do you see future technology trends, in general, and in France especially?

David Vitale: For machine vision, the technological trends seem to be towards three major areas: The enrichment of the picture elements: Hyperspectral color, distance (time of flight), thermal, polarized, acoustic, etc.; the development towards the Internet Of Things: Remote monitoring and access, data centralization platforms, cyber-security; and the improvement of machine learning and its accessibility: Getting always smarter and easier to use (without particular expertise), being adaptable to complex environments and objects, and constantly evolving.

inspect: Where do you see future markets for machine vision in France?

David Vitale: Like I mentioned before, the market of agriculture and food products is growing in terms of technology integration. This is also true for the healthcare sector, especially for diagnosis and prevention. For example, the objective is to provide solutions for an aging population, or for guided surgery, and many other applications.

The French industry has recently brought forth some new key players in different areas. For example, there is Chronocam, a developer of biologically inspired vision sensors, or Irlynx who produce low cost infrared imaging sensors. Computer vision and machine learning are the field of Neovision who specialize in artificial intelligence, and Avalun offers a portable, communicating biological analysis device based on integrated lensless imaging technology.

inspect: What can associations do to support the industry?

David Vitale: First of all, associations have to promote new emerging technologies. Secondly, they must allow the industries to express their needs, and lastly they need to make the link between needs and solutions. (ssch)

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International Distribution

Issue 1: March 2018
Issue 2: September 2018

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EMVA Market Report „Machine Vision in France“

The machine vision markets across Europe are far from being homogenous. Having recognized this diverse landscape across Europe, the EMVA runs a series of country reports aiming to uncover the various market characteristics. After Austria, Italy, Ireland, Liechtenstein, Switzerland, and the United Kingdom the current market report covers the machine vision activities in France in detail. This article gives a sneak preview into the survey results.

Although the United Kingdom has surpassed the French economy in terms of GDP size, France is still considered the second largest industry nation in Europe. Dominant industry sectors in France are the automotive industry with renowned brands such as Renault, Peugeot and Michelin, the glass industry with Saint-Gobain at the forefront, the aerospace and defense industry with hotspots in Toulouse and Paris and its flagship companies Airbus, Thales and Safran, but also manufacturers of consumer goods such as Danone in the food sector or L'Oréal with cosmetic products. Also part of the French industrial backbone are the pharmaceutical and to some extent the electronics industry in the country, as well as the agricultural sector.

Machine Vision Market and Customers in France

A fact that is often described as a weakness of the French economy is the lack of a strong and sound SME structure as can be found in Italy or Germany, which is why machine vision players in France to a great extent deal with customers from industries mentioned above that are much larger in size and turnover than themselves. The French machine vision market is mainly served through imported components as there are only few relevant machine vision component manufacturers compared to the market size. There is, on the other hand, a high number of vision integrators active in France of which many may only be visible after a closer look at the market as they serve a limited geographic market region around their premises. Besides traditional factory floor applications machine vision is increasingly being implemented in non-industrial areas in France, ranging from ITS and security to medical, fruit sorting and the use of drones for example in agriculture, but also in entirely new computer vision applications. Steered by subsidies and governmentally supported clusters a lot of machine vision research takes place also within the companies; and the number of spin-offs of large research facilities is quite remarkable.

The detailed market descriptions in the EMVA report “Machine Vision in France” are complemented by a list of well over 300 names of all identified machine vision players domiciled in France, and their websites. This includes machine vision companies as well as research and academic institutes, and associations and clusters. More information on how to obtain a PDF copy of this unique market survey as an EMVA non-member is available at info@emva.org.

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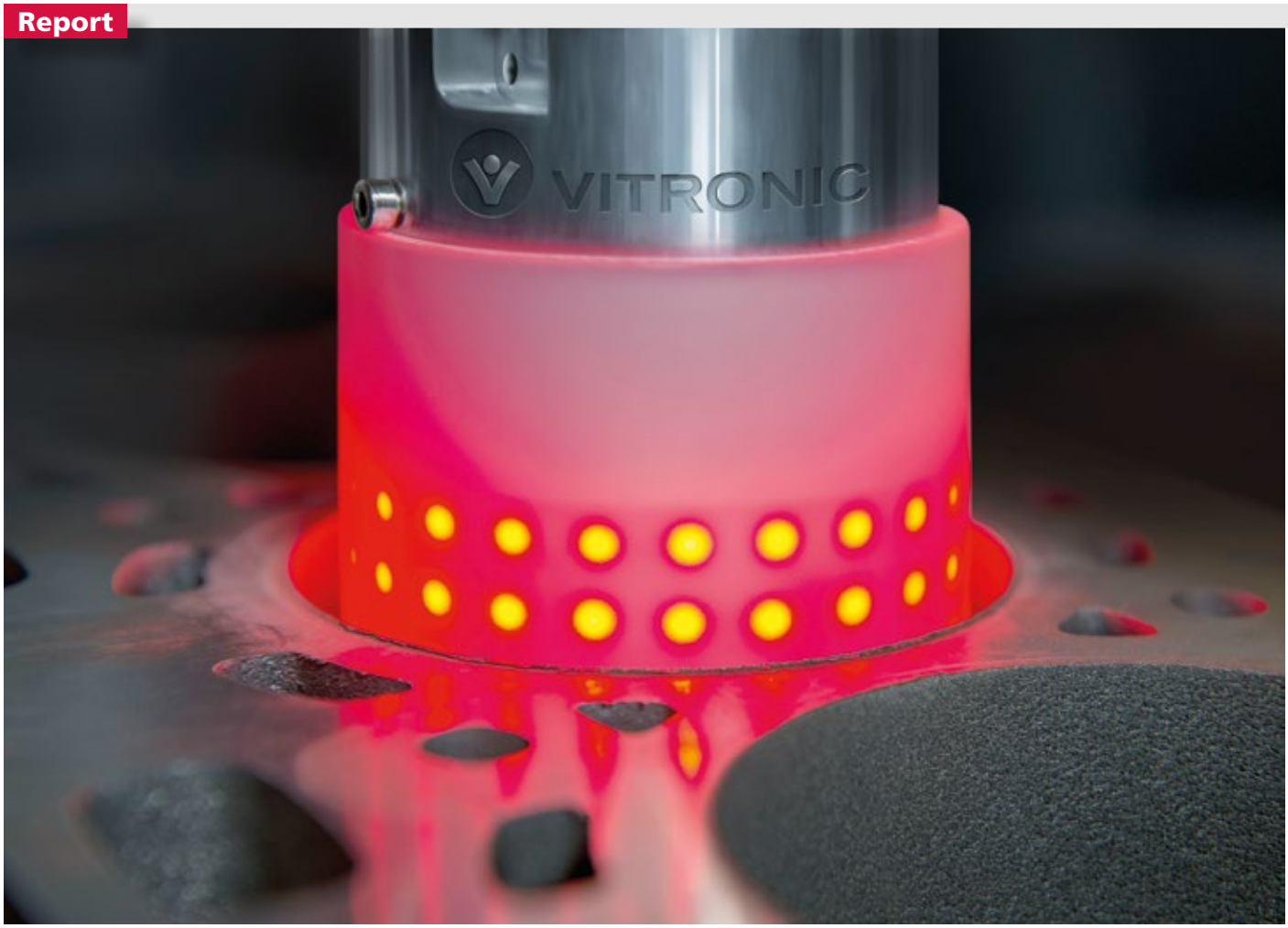


True All-rounders

Machine Vision in Europe – a Success Story

The development of machine vision has been spectacular. About 30 years ago, machine vision was mainly used in the research field, and even the pioneers in the field could not have foreseen its impressive development and widespread use. And today?

Machine vision systems can be found everywhere, be it in or beyond the factory environment. Optimizing traffic flows, the perfect swing in golf, training of medical doctors, checking moles, waste separation and recycling – we all benefit from machine vision.

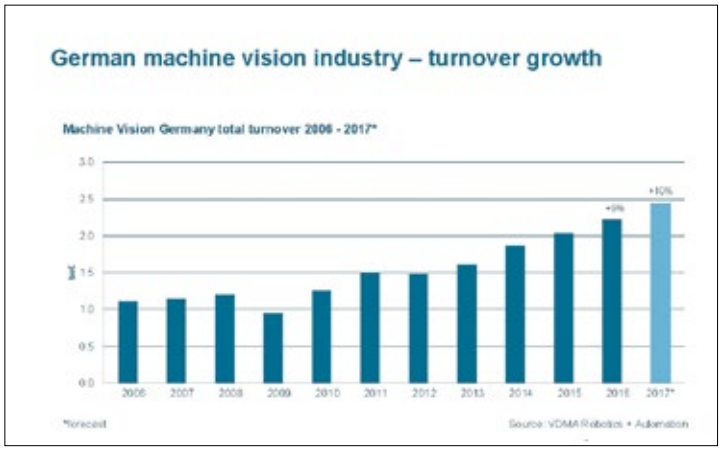
Machine vision systems have proven to be all-rounders. They check quality, guide machines, control processes, identify components, read codes, and supply valuable data for the use in production optimization. Industrial production without machine vision has become unthinkable, and what is more, it has conquered many other application fields beyond the factory. Improved quality, greater reliability, increased safety and cost effectiveness are benefits that are just as crucial in the non-manufacturing contexts as in the realm of industrial production.

A Growth Market

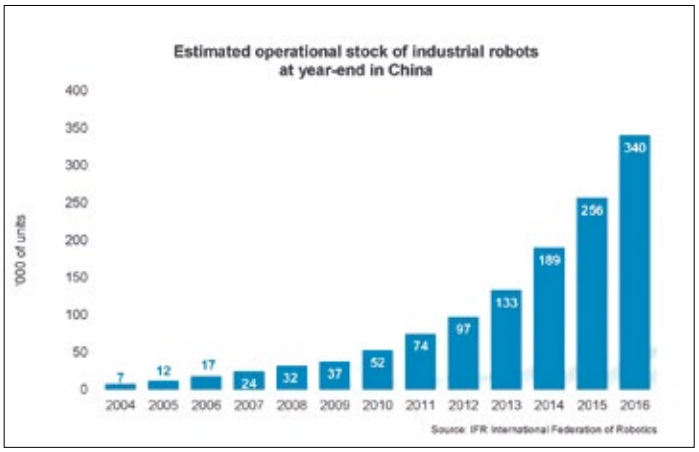
The machine vision industry in Germany and Europe has been reporting high growth numbers and record sales figures for years. According to the latest VDMA Machine Vision Market Survey, the turnover of the industry in Germany reached another record high of € 2.2 billion in 2016, representing an increase of 9% on 2015. For the European industry, total turnover grew even by 11 %, exports increased by 17% in 2016. In Germany, except for 2012, sales have been rising continuously since 2010. Between 2012 and 2016, the turnover rose by an average of 10% per annum. Sales levels of machine vision have almost doubled compared to 2008. Exports were the major growth engine in the past few years. The average growth rate of exports of the machine vision industry in Germany was 13% between 2012 and 2016, while domestic sales rose by 7%.

Asia and China: Gaining Importance

Not only for the European machine vision industry, but also for important customer industries as well as the mechanical engineering industry as a whole, the major growth stimuli have come from emerging markets – and in particular from Asia. In 2016, according to VDMA figures, the sales of the



Turnover of the Machine Vision Industry in Germany



Operational stock of Industrial Robotics in China up to 2016

European machine vision industry to China rose by 32 %, compared to 2015, reaching a new record high. Sales levels increased by an average annual 19 % between 2012 and 2016. China is well on the way to becoming the most important export market for machine vision originating from Europe. In 2016, China accounted for almost 11 % of the total sales and was again the third biggest market for machine vision companies, after Germany and North America.

China – Biggest Global Robot Market

Looking at the recent figures of the IFR (International Federation of Robotics), we can see that China already is the most important robot market. In 2016, 87,000 new industrial robots were installed, 27 % more than in 2015. China has rapidly become a global leader in automation. The operational stock of industrial robots marks the highest level in the world. The main drivers of the latest growth of robot sales in China are the electrical and electronics industry. Sales increased by 75 % to almost 30,000 units (2016). This remarkable demand will grow further in the future. Major contract manufacturers of electronic devices have already started to automate production. The semiconductor and the chip industries, for example, have strongly invested in automation. Large battery production facilities are being installed to meet the increasing demand for electric and hybrid cars. The automotive industry lost its pole position to the electrical and electronics industry, but is still a powerful driver for industrial robot sales. China has become both the world's largest car market and the world's largest production site for cars – including electric cars – with a lot of growth potential. China is the largest growing consumer market with increasing demands for all kinds of consumer goods. Consequently, various other industries have also started to expand capacities and automate production. From 2018 to 2020, an annual sales increase between 15 and 20 % on average is predicted.

Positive Outlook for Machine Vision

For 2017, companies expect a further growth of 10 % in Germany and 9 % in Europe. However, if you look at the development of the monthly VDMA incoming orders and turnover indexes, it is going to be more than this. Growth engines are Asia (China in particular) and North America. Moderate growth is expected in the domestic markets (Germany and Europe). There are high potentials for innovation and growth in non-manufacturing sectors, though industrial applications will dominate demand for many years to come. The worldwide trend for the automation and digitization of manufacturing is the overall driving force behind further growth. Machine vision is the trailblazer and key technology for interconnected production processes and its role, as well as demand of machine vision will continue to rise – in particular if machine vision systems will be easier to connect to production control and IT systems. In addition, embedded vision will offer new growth opportunities and will bring machine vision to the next level. VDMA Machine Vision has teamed up with the embedded world, the world's leading meeting place for the embedded systems community, to strengthen the embedded vision topic at the fair and the conference. The goal is to enter into dialogue and inspire the visitors – trend scouts, developers, project and product managers – who are looking for new trends and technologies. They will have the opportunity to experience that embedded machine vision has a lot to offer, namely a variety of interesting application options in almost every industrial sector and in everyday life.

VDMA 2017 Machine Vision Market Survey

VDMA has been conducting its market survey on machine vision every year since 1995. This primary research project directly surveys machine vision companies based in Germany and Europe. Both members and non-members of VDMA are included in order to make the results as representative as possible. More than 180 companies are constantly surveyed.

About VDMA Machine Vision

VDMA is the largest industrial association in Europe, and it has more than 3,100 member companies from the capital goods industry as well as from machine and plant construction. As part of the VDMA Robotics + Automation association, VDMA Machine Vision has more than 115 members: vendors of machine vision systems and components as well as integrators. The objective behind this industry-driven platform is to support machine vision with a wide range of activities and services. Activities include statistical analyses and the annual market survey of the machine vision industry, marketing and standardization activities, public relations, trade fair policy, as well as networking events and conferences.
www.vdma.org/vision

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Robert Edmund, CEO Edmund Optics

75 Years of Perspective

What started out as a shop that offered sets of 15 lenses for $1,50 in 1942 has become an innovative, globally operating company offering a catalogue that contains more than 28,900 optical components. We spoke with CEO Robert Edmund about the 75th anniversary of Edmund Optics, their history, current plans, and thoughts about the future.

inspect: Mr. Edmund, what exactly is your field of activity today? How did this evolve over the years?
Robert Edmund: Today Edmund Optics is a leading supplier and manufacturer of precision optical components, imaging lenses, and other subassemblies. The company's origin was in reselling recycled optical components to optics enthusiasts in 1942 and Edmund Optics later transitioned into a supplier of optics and other science items for hobbyist and educational use. The company then refocused on industrial optics during the mid-1980s when market analysis showed that demand for educational items had peaked and our motivation to address the industrial market and to impact rather complex projects had grown strong.

The next step in our evolution was to introduce internal manufacturing capabilities and to begin designing and producing precision optical components and sub-assemblies ourselves. Shortly after that, we also began designing and manufacturing our own imaging lenses. We are currently investing in R&D and precision laser optics to allow us to continue to grow and support the rapidly changing optics industry. In addition, Edmund Optics is focusing on expanding its technical expertise and resources to truly be a technical leader in our field, guiding our customers through up-and-coming technologies. Two consistent goals that have accompanied Edmund Optics throughout its entire evolution are to provide the highest level of service possible to our customers and to prioritize long-term thinking and investments.

inspect: Looking at your history, which is your personal most important milestone?
Robert Edmund: As a company, we were honored when one of our lenses went to the moon on Apollo 11 for coverage of the lunar landing in 1969. In a pinch, Jack Thompson of Westinghouse Aerospace realized that a ¢95 Barlow lens from Edmund Optics would fix a problem they were dealing with and was available immediately. The lens worked successfully for NASA and allowed them to save both time and money - opening up a new era in space exploration for just ¢95.

inspect: Which industry/technology area(s) are you currently involved in, putting energy in, respectively? What does this mean with regard to your product portfolio?
Robert Edmund: Edmund Optics is involved in so many industries, but two of our core application fields are life sciences and biophotonics. Many of today's innovations in medical instrumentation involve optics and lead to a reduction in healthcare costs and advancement in caregiving. To best serve these industries we have invested heavily in expanding our offering of specified optical filters and are now carrying more high quality filters that specifically address the needs of these application fields.

inspect: How do you see the development of the optics industry and the technology itself? What are your areas of investment into the future?
Robert Edmund: We are currently expanding our line of laser optics. Lasers and op-

Edmund Optics is continually adding thousands of new products each year from optics to optomechanics and intensifies its engagement in the field of imaging.

tical components have long been partners but there is a new technological push towards expanding the uses and applications of lasers. This is not just happening in life sciences or any one particular industry, but across the board. Laser World of Photonics 2017 in Munich was a wonderful example of the growing interest in laser optics. The show grew from around 30,000 visitors in 2015 to over 32,000 visitors in 2017.

There is also a great deal of development in imaging and machine vision as they are critical for many forward-thinking applications such as robotics, life sciences, and autonomous vehicles for transportation.

We are also moving into a period of significant improvements in optical manufacturing equipment and automated machines. To capitalize on this trend we have greatly expanded our capacity of state-of-the-art manufacturing machines.

inspect: What was the objective of your participation in Itos and what are the consequences for the company and the current European site?

Robert Edmund: Edmund Optics has been in business with Itos for some time and saw a great opportunity to offer their products and services globally to our customers. On top, Itos gives us a manufacturing foundation in Germany upon which we can build to further service our customers, both within Europe and abroad. The European region continues to be a great source of growth for Edmund Optics and we feel it is important to invest locally to further integrate into the industry. With the integration of Itos we anticipate to have a catalyst for further development of functions within Europe ranging from sourcing, to R&D, to precision optics manufacturing.

inspect: As a forerunner in the optics industry – how do you define embedded vision? How do you assess the topic: a new hype or a clear orientation?

Robert Edmund: Internally, we see embedded vision as a result of the expansion of imaging technologies in all aspects of life that has been originated by computer power and miniaturization. Imaging is integrated in a wide range of applications from productivity through automation, to advanced diagnostics and medical devices, to security and defense, to the automotive sector. Thus we do see this as a sustained long-term trend critical for solving the most fundamental problems of humanity. Embedded vision is a clear orientation for the future of imaging, not just a new hype. (ssch)

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The company truck that was used to deliver to Edmund Optics' customers.

People loved spending time at the shop, a real science emporium, where they could find lenses, many science products, telescopes and other components.

Robert Edmund follows in his father's footsteps and, after holding various positions in the company, became President in 1975.

The Chemistry Is Right

The Evolution of Industrial Image Processing

From monochrome imaging in the 60s and 70s to 3D imaging – image processing has made massive progress. Now, a new trend continues its evolution: The recognition, evaluation and processing of chemical material properties in the industrial process, and in real time.

In imaging, customer needs have increased constantly according to speed, resolution as well as for colour sensitivity respectively colour imaging in general. In recent years, numerous great inventions in the field of 3D imaging could be seen. However, a new trend has now been set by the machine vision users, virtually the next evolutionary step in industrial image processing.

The Needle in a Haystack

The basic technologies spectroscopy, hyperspectral imaging respectively, as well as chemometric and spectroscopic processing have been well-known for a couple of decades. The use of hyperspectral imaging enables the identification of the chemical properties of materials. Objects have a unique fingerprint, made visible through highly complex spectral information. But, if hyperspectral cameras provide such great advantages, why are they not yet being widely applied in industrial processes?

Hyperspectral data mainly consists of two spatial dimensions and one spectral dimension. Thereby an object pixel is described by a multiple number of spectral values. This information is often named the unique 'chemical fingerprint' of an object. In fact, a spectrum not only describes the 'chemical' information of a material, it also contains information related to the measurement setup, like reflections or morphologic information of the object's surface. There can also be optical and electrical variation depending on the acquisition method, and currently it seems a challenge for camera manufacturers to ensure precise and repeatable responses, even for products of the same batch. Furthermore, environmental conditions like humidity can be seen in the spectrum, or in the worst case they could mask the 'chemical' information of interest.

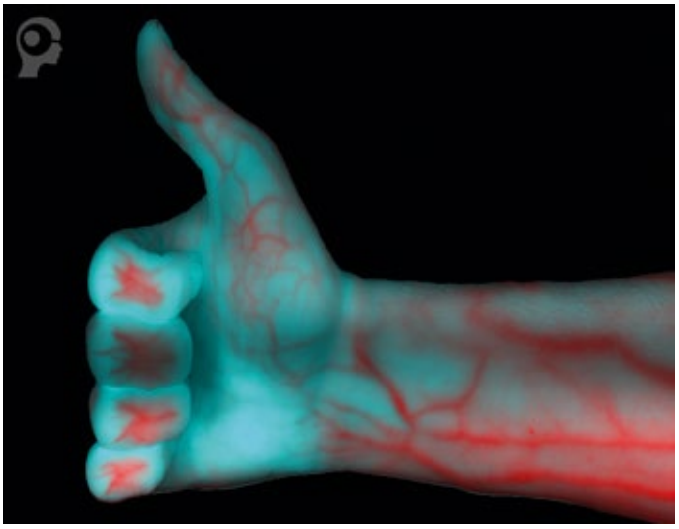
The search for the information of interest in hyperspectral data can be compared with the search for the famous needle in a haystack. Mathematically speaking, the search for information of interest in hyperspectral data is a multivariate problem. Every wavelength can be seen as a variable. N spectral points lead to a problem with N variables. This can be handled by multivariate data processing.

In order to allow the construction of serial machines, a hyperspectral application must also meet requirements on repeatability. Therefore, manufacturing tolerances of the complex hyperspectral camera systems must be taken into account.

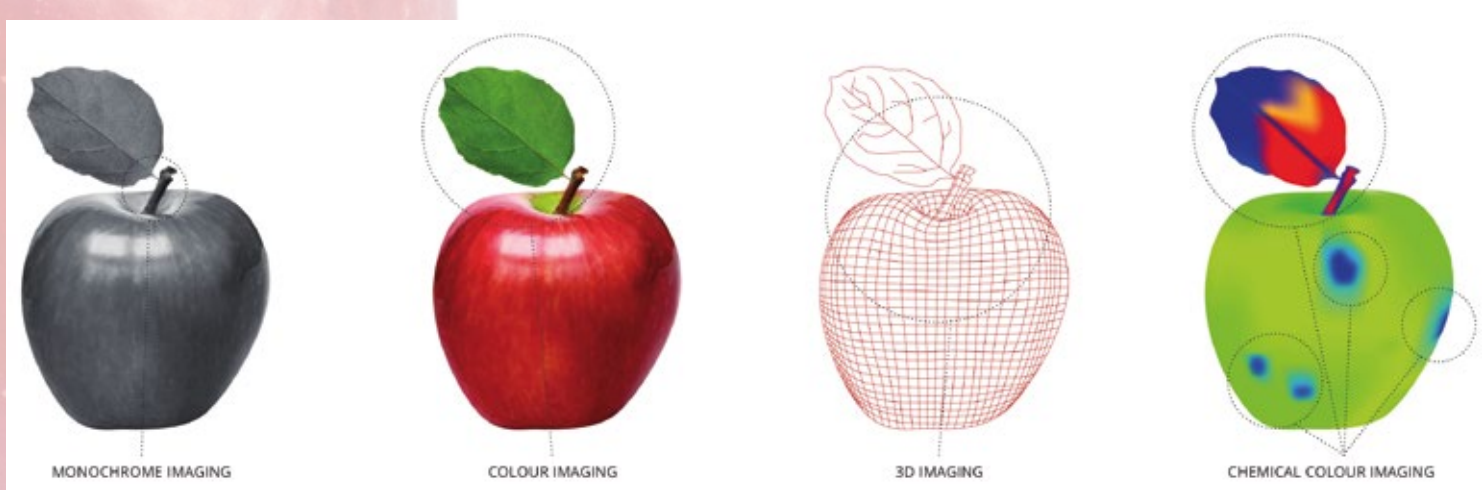
Hyperspectral technology not only offers numerous possibilities in the assessment of chemical material properties, but also a number of pitfalls. To bring hyperspectral imaging onto the factory floor, an enabling technology is necessary. Configuration concepts that allow vision related companies to easily integrate and handle hyperspectral cameras are needed. Chemical Colour Imaging (CCI) is such an enabling technology.

Chemical Colour Imaging

Chemical Colour Imaging (CCI) can be applied alongside existing image processing



CCI image of a hand and visualization of the vessels



systems, and it is designed to be a holistic approach bringing together the advantages of spectroscopy and imaging. A hyperspectral camera extended by CCI acts like a conventional colour camera, but the colours describe the molecular properties of an object.

The scientific analysis of hyperspectral data is a typical task for experts in multivariate data processing, chemometrics and spectroscopy. CCI encapsulates these technologies and provides a promising alternative suitable for industrial vision tasks. The user deals with spectral information in the colour domain and complex spectroscopic problems are solved based on the interpretation of image information. Since all workflows are based on those in machine vision, hyperspectral cameras using CCI can be applied like conventional vision cameras and allow numerous solutions to industrial challenges that had so far been inconceivable.

Industrial Application: Embedded CCI

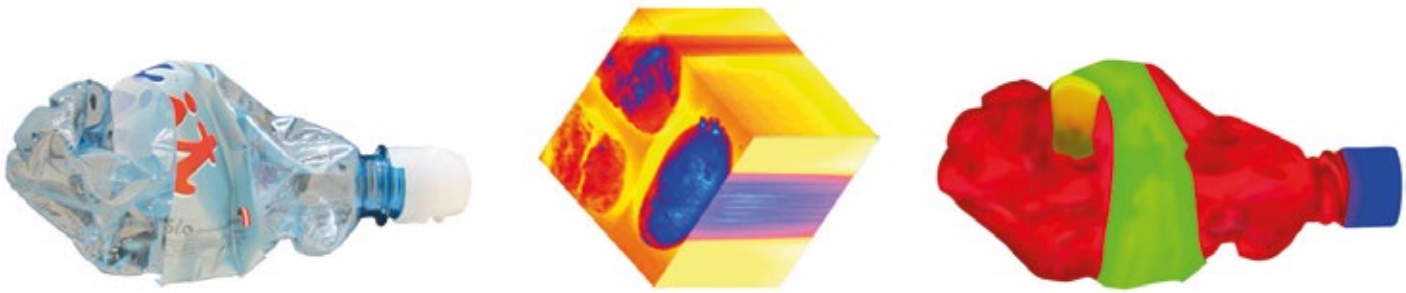
Chemical colour imaging is usually integrated into industrial processes. Most of these processes require real-time processing and high latency standards. Typical applications are sorting machines that are used to eliminate contaminants from a stream of foodstuffs in real-time, or the differentiation between various materials in recycling processes. CCI is also well established in the wood industry and the pharmaceutical industry.

In order to meet the requirements for the highest computing performance, strong graphic cards (GPU) that allow parallel data processing are used. Furthermore, GPUs offer great flexibility to implement new methods and algorithms at short notice. This is particularly important because of CCI´s broad field of application. In addition, GPUs are subject to very short development cycles. This means that performance is constantly increasing. GPUs are usually installed in 19“ industrial PCs.

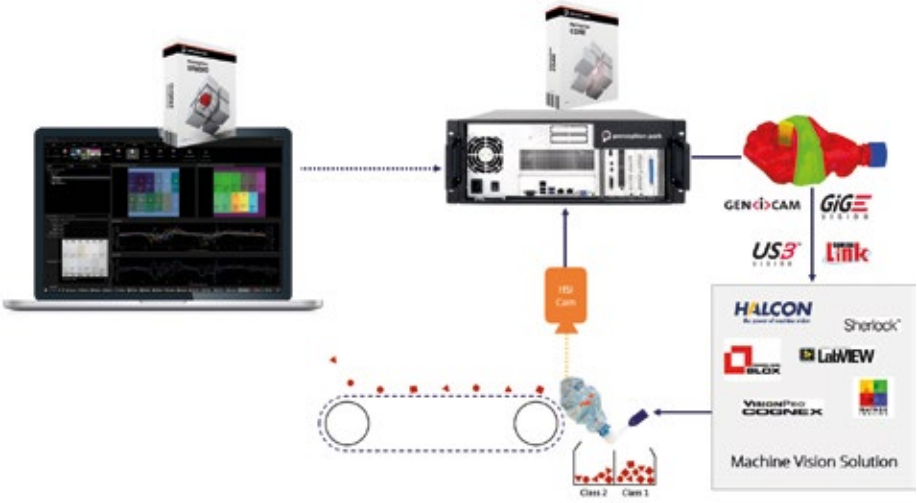
What if an application not only demands high performance but also compactness, robustness or low power consumption? For these kinds of challenges, manufacturers offer a System-on-a-Chip (SoC) that enables parallel data processing in a small form factor. One of these manufacturers is Nvidia that offers a high-performance SoC with its Tegra series. Due to its small size and minimal power consumption this SoC is ideally suited to enable Chemical Colour Imaging for very compact applications. The Tegra series addresses the automotive sector and the consumer markets. In addition to leading automobile groups, Google with its Pixel C tablet PC and Nintendo with its Switch console rely on the technology. Perception Park is already investing in Nvidia‘s Tegra technology, too, and presented the expansion of its product portfolio for the Tegra X1 and X2 at the leading conference for industrial hyperspectral imaging Chii 2017.

New Markets

Now that CCI is also available for SoCs, its application field has expanded dramatically. Not only industrial machines are now considerably more compact, the booming drones market is also experiencing numerous new opportunities, for example in the agricultural or in the forestry sector.



From the real image (left, ca. 1 MB) through the hyperspectral image (middle, ca. 400 MB) to the CCI image. (right, ca. 1 MB)



The figure shows an example of a sorting application using CCI. The Perception Studio is used to develop an application that distinguishes various plastics based on their chemical properties. Once the application is developed, it can be compiled for the real-time engine Perception Core. The Perception Core „translates" hyperspectral data into „chemical colour data" which can now be classified by standard image processing tools.

Since smart cameras occupy a very important place in industrial image processing, Embedded CCI allows the integration of Chemical Colour Imaging directly into the housing of a hyperspectral camera. In addition to configurable CCI systems, smart cameras that are tailored to a specific application can now be provided as well. Similar to a thermal imaging camera, „moisture cameras" or „sugar cameras" are now conceivable.

Hyperspectral cameras have become considerably smaller and lighter in recent years. This enables new mobile applications in many new fields, like geological field research, mine surveying, agronomy, environmental protection and food monitoring. If hyperspectral cameras will be further miniaturized at this rate, it will also be possible to integrate them directly into mobile devices in the near future. This way, CCI would become available for the broad consumer market. Just imagine everyone could investigate their food for „invisible" damages directly in the supermarket. However, the influence of CCI on tele applications will be much more important, for example in telemedicine applications where one could pursue the healing process of a wound or monitor skin diseases.

Core Challenges

Hitherto, the development based on hyperspectral technology has been very time and cost consuming. Even if the effort was taken, the challenge was the fact that industrial processes mostly require real-time processing. Hyperspectral data is often hundreds of times larger than conventional colour image data. This requires highly efficient and parallel data processing, in particular if there is the need to correct various disturbance variables. In summary, there are two core challenges when using hyperspectral cameras:

- find the application relevant information;
- apply the application in the field.

To meet these requirements, Perception Park has introduced a 2-component solution consisting of Perception Studio for the application development and Perception Core to integrate an application into industrial real-time processes.

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Need for Speed

Accelerating Machine Vision Applications

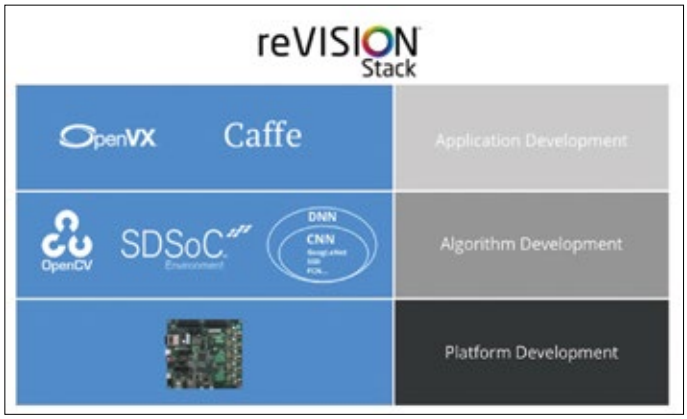
Designers of machine vision systems face various challenges, such as scalability, power efficiency, responsiveness and interoperability. While development around PC or GPU based architectures comes with both advantages and disadvantages, acceleration stacks address the challenges and satisfy the need for speed.

Embedded Vision systems are ubiquitous across the industrial landscape where they are often referred to as machine vision systems and can perform a range of applications from manufacturing line optical inspection to postal sorting. With such a wide range of possible applications, machine vision systems and their designers are facing several challenges:

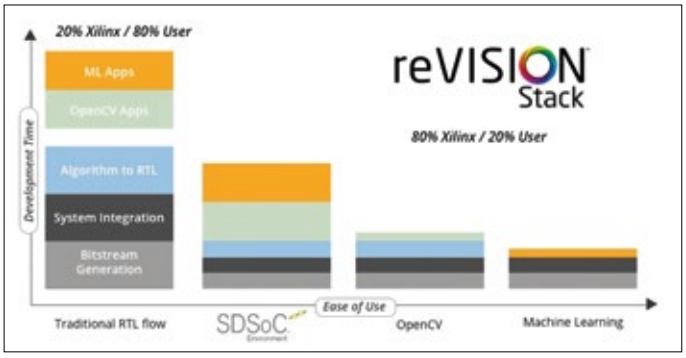
- Provide a responsive and power-efficient solution that is scalable with demand.
- Perform processing at the edge, often using embedded machine learning techniques to achieve the desired capabilities.
- Develop using industry-standard high-level frameworks and libraries.
- Ability to interface to a wide range of cameras and other interfaces including legacy and bespoke.

Challenging Traditions

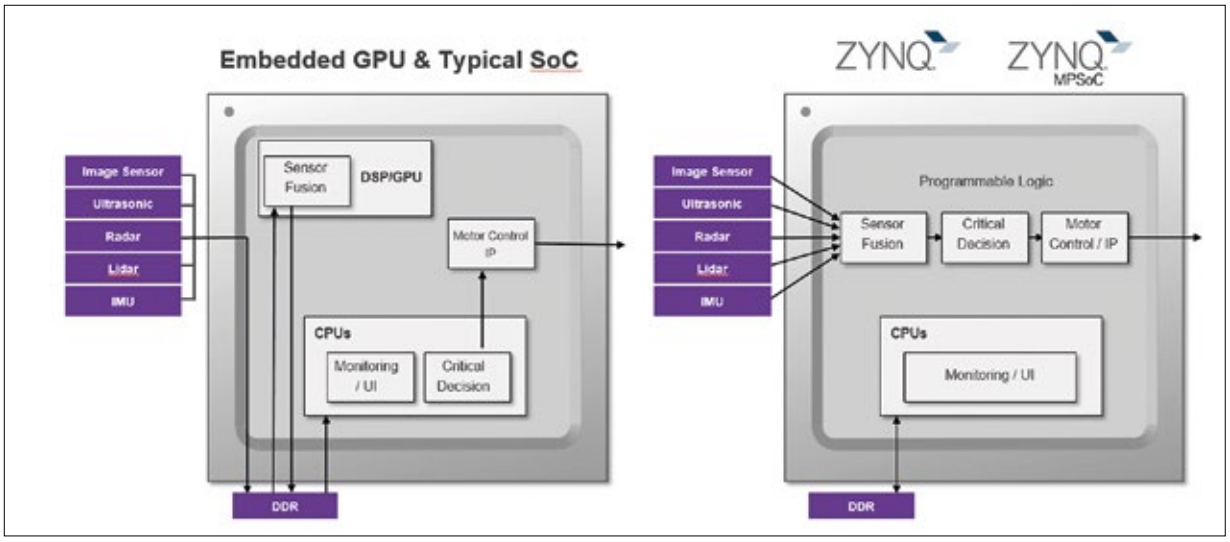
The traditional approach has been to develop machine vision systems around a PC based architecture due to the ease of deployment, the large ecosystem of software vendors, and the low cost of implementation. However, there are also several disadvantages: namely its low performance when compared with the alternate solutions, its large foot print, higher power dissipation and the fact that it is not easily scalable with demand. An evolution of the PC based approach is to use GPU acceleration within a PC architecture. This has similar advantages to that of a PC based application. It enables faster prototyping of the machine vision algorithms using high-level frameworks. However, it comes with an increase in power dissipation over and above that required by a PC based solution. It also requires expertise in the implementation of the algorithms on the GPU, and still presents the same issues regarding scalability. With both PC and GPU based approaches, it is difficult to implement a scalable, responsive and power efficient solution which enables processing at the edge, while providing the range of interfacing capabilities required.



The reVision Acceleration Stack



Development time reduction



Improved latency, determinism and power dissipation using Programmable Logic

More Responsivess and Power Efficiency

To address these challenges, machine vision developers utilise the Xilinx All Programmable Zynq SoC or Zynq UltraScale + MPSoC devices and develop applications using the reVision acceleration stack. These devices provide programmable logic coupled with high performance ARM A53 or A9 processors, forming a tightly integrated heterogeneous processing system, while the stack provides the ability to work with and accelerate industry-standard frameworks and libraries such as OpenCV, OpenVX and Caffe. This enables the inherent parallel nature of the programmable logic to be leveraged, allowing the creation of the image processing pipelines and machine learning inference engines, while the processing system implements higher-level decision making, communication and system management functions. When combined, this enables the creation of a more responsive, power efficient solution, while still being able to leverage industry-standard libraries and tools.

When it comes to interfacing, both MPSoC devices provide a range of industry-standard interfaces which can be provided via the processing system or the programmable logic. Legacy or bespoke interface functionality can be implemented using the programmable logic thanks to the flexibility of the IO structures, requiring only an external PHY to achieve the physical layer of the protocol providing any-to-any connectivity.

Performance Increase

The reVision acceleration stack enables developers to work with OpenCV, OpenVX and Caffe which are industry standards for the development of machine vision and machine learning applications. To enable more responsive solutions, the stack can accelerate several OpenCV functions including the OpenVX core functions into the programmable logic. It is also possible to accelerate machine learning inference engine layers including Conv, ReLU, Pooling and Detector & Classifier. Of course, with acceleration into the programmable logic also comes a significant increase in the performance for both machine vision and learning.

This acceleration capability is provided by SDSoC, a system-optimising compiler that allows software defined development for the MPSoC devices. This is made possible thanks to a combination of Vivado High Level Synthesis (HLS) with a connectivity framework, enabling seamless movement of functions between the Processing System (PS) and the Programmable Logic (PL). This ability facilitates the creation of the optimal solution with functions located in either the PS or PL to provide the best performance at the system level. Identification of which functions are causing performance bottlenecks and are therefore acceleration candidates uses SDSoC's inbuilt profiling capabilities.

Less Latency, More Determinism

In many machine vision applications, a low-latency and deterministic decision and response loop is of critical importance. One

such example would be production line inspection, where the response time is critical to keep the line moving, while identifying manufacturing defects in piece parts which need to be removed from the manufacturing flow. This improved response time is enabled by leveraging the parallel nature of the programmable logic to implement the vision processing pipeline and machine learning inference engine. Using programmable logic in this manner reduces system bottlenecks when compared with traditional solutions. With a CPU/GPU based approach, each stage of operation requires the use of external DDR, as the images cannot be passed between functions within the limited internal cache. A programmable logic approach allows streaming, with the internal RAM providing buffering as required. This removal of the need to store intermediate elements within DDR reduces not only the latency of the image processing but also reduces the power dissipated and increases the determinism, as there is no need to share access with other system resources or transfer image data off chip to and from the DDR memory.

Faster Time to Market

In benchmark tests undertaken by the manufacturer, combining reVision with their MPSoC devices has shown a performance increase, demonstrating up to 42x frames per second per watt increase for image processing or up to 6x images per second per watt increase for machine vision applications.

Developing using the acceleration stack also brings with it significant reductions in the development time when compared with a traditional RTL based development. This development flow would present a gap between the high-level embedded vision and machine learning algorithms and the RTL design implemented within the programmable logic, which would require the high-level algorithms to be recreated in RTL, increasing development time and cost. This would also bring with it a very rigid system segmentation between the PS and PL, removing the ability to relocate functionality. The stack and SDSoC remove this gap, enabling the developers to focus upon creating their value-added activity, achieving a faster time to market with a lower development cost.

Machine vision applications are facing several challenges requiring power efficient, responsive and scalable solutions capable of processing at the edge and interfacing with a wide range of industry standard, bespoke and legacy interfaces. The flexibility and capability provided by advanced MPSoC devices combined with a matching acceleration stack, enable machine vision developers to address these challenges, allowing the developers to leverage the capabilities provided by programmable logic without the need to be an HDL specialist.

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ARM Work

Embedded Machine Vision and the ARM Architectures

With over 100 billion ARM processors produced as of 2017, ARM is the most widely used instruction set architecture in terms of produced quantity. First developed in 1983, the ARM architecture is nowadays well-known for outstanding performance in embedded applications – and of course in embedded vision.

Imago´s family of ARM products

High-performance Architectures

Do you already know the ARM Cortex-A15 and Cortex-A72? They are the newest ARM architectures, offering impressive performance indexes for image processing applications. The Halcon Embedded benchmarks show their significant difference to earlier ARM generations. These CPU cores are used in Imago's newest products. The company's philosophy are the development and serial production of embedded vision computers using the latest technology. The deployment of state-of-the-art technologies enables device life cycles of partly up to 10 years, thus creating computer brains for long-lasting machine series. The camera and processor vision systems VisionCam XM and the variable OS boxes VisionBox Le Mans are available as ARMed family members.

Personalized Sensors

The VisionCam with optional Halcon Embedded addresses product developers who would like to develop their personal – in other words, equipped with an own app – sensor. Its processor by the industry CPU supplier Texas Instruments runs under Linux, and it is framed with CMOS sensors of up to 5 megapixels, optionally with fieldbus, Gigabit Ethernet, and of course I/O and serial signals. The VisionCam helps to succeed in migrating previously complex PC systems into a vision sensor. Up to now, Imago has received positive feedback from the developers who said: "My application runs as fast as on an i3 processor – fantastic." Or: "I still use MS Visual Studio for the development – the VisionCam deals with compiling and returning debugging information over the LAN – that is true comfort."

Multi-camera Connection

If the performance is not sufficient, or if multi-camera applications are required, that would be a case for the VisionBox Le Mans. Equipped with an 8-core processor by industrial CPU manufacturer NXP, the VisionBox provides the complete range of functions of Imago's vision technology. In the form of PCIe boards, they offer features like trigger-and-power-over-Ethernet (1-cable camera connection), faster or more powerful control of I/Os (with higher currents), encoder in- or even outputs (line scan application), LED lighting controls (regulated power source specifically for flash mode).

Four-camera System

As an example, in a four-camera system the user places four LED lighting heads in a suitable location, connects the four cameras with one Ethernet cable each, operates sensors and actuators, and has the vision system appear on the outside via Ethernet or fieldbus, just like a regular device. The HMI runs - as is common nowadays - on other control or regulation modules. In case service personnel requires to verify the computer's condition, an integrated status display informs them about what is going on. The box also suits new ideas of traffic engineering with characteristics like compactness and the ability to operate several cameras.

> *„The VisionCam deals with compiling and returning debugging information over the LAN – that is true comfort."*

Future-proof

The Le Mans processor offers an integrated 10 GigE interface. Thus, looking at the near future, it is already prepared for the 10 GigE cameras that are at the ready, and through the interface it allows scaling computers. One thing is clear: Two of today's computers with 16 cores in total will become the basis of tomorrow's new VisionBox generations.

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The Next Era

During the last decade, global joint standardization activities led by the relevant machine vision industry associations have been a major contributor to customer acceptance of machine vision technology. We spoke with Jochem Herrmann, EMVA President and Co-Chair of the Future Standards Forum (FSF), about the future role of embedded vision in the machine vision industry and the challenges embedded vision posts to existing and new standardization initiatives.

Jochem Herrmann,
EMVA President and Co-Chair of the Future Standards Forum

inspect: Mr. Herrmann, the work of the Future Standards Forum that is hosted by the G3 – and through this by all relevant machine vision associations around the globe - has massively influenced the development of the entire industry. Where does machine vision standardization stand today?

Jochem Herrmann: Indeed, what the industry has achieved in terms of standardization is a success story. I say industry here because we are all industry players, and the standards we are using today were developed by employees of machine vision companies that participated in the standard working groups.

This joint concentration on only a limited number of interface standards has not only prevented double development, but also encouraged faster acceptance by the market. It has also made it possible that the standards we are using today cover all current industry needs and focus on specific strengths, from high speed to long cable distances or the ability to use multiple cameras. In addition, the price and performance experience has constantly improved, together with the portability of application software. Yet, although low costs and small size have always been an important factor, the next era of vision systems will bring much different expectations in that respect.

> *„Embedded Vision will speed up and change everything."*

inspect: With ‚the next era' you are referring to embedded vision systems, a topic that has been discussed a lot in the recent past. Have these systems already reached market readiness, and what is your definition of an embedded vision system?

Jochem Herrmann: I believe that this process has begun and that it will be accelerating with the further implementation of Industry 4.0. It demands smaller and networked production cells with higher flexibility, together with a need for cost and size reduction. Integration plays an important role, and it can only be achieved with vision systems that are no longer standalone entities but integrated into the system architecture of the factory. These are

the requirements. In addition to that we see that a lot of innovation in embedded vision these days is driven by consumer electronics. When you take a close look at all the integrated – or in other words embedded – functions of the camera in your smart phone, you will understand what I mean. A combination of high-speed, low power, small size, and low cost is merging here. And this will have a strong impact on machine vision solutions: PCs will increasingly be replaced by processing platforms with embedded vision processors. These will be highly integrated, small-sized, cost-effective and powerful solutions that have the most relevant I/Os onboard. The cost, size and power of video processing will be minimized by the embedded vision processor – as it is today in our smart phones and tablets. Last but not least, the interface between camera module and the embedded processor will also be kept as simple as possible. This is where standardization comes into play.

inspect: What exactly do you have in mind when you say this?

Jochem Herrmann: We are coming from a low volume market where standards are crucial for the acceptance of our technology. In the future, our way will lead us to larger volumes by producing smaller and easier-to-use systems. This is required in the factories of the future, where it is all about more networks, smaller cells, more capability, easier to program, more flexible. It is obvious that size and cost are much more important there than in the `classic´ machine vision systems. So the question will be how much cost standards could add to the bill of materials of next generation embedded vision systems. To date, there is no clear answer to this question in the industry.

inspect: During last years' EMVA Business Conference in Edinburgh you set an emphasis on the MIPI standard. Is this still the strategy of the FSF?

Jochem Herrmann: I would rather see the broader scope. We are currently evaluating several options, and we are still in the phase of determining what exactly should be standardized and what should not. Bear in mind my argument regarding the bill of materials. This is why the EMVA has started a working group and invited all G3 members to evaluate the needs and layout of a future interface between the camera module and the embedded processor module for video data, control and power supply. Our thoughts go in the direction of creating what we are currently calling an Industrial Camera Serial Interface (CSI) that might use a MIPI standard, but also future standards that are better adapted to the needs of our industry. As to the MIPI Alliance, their standards are shaped towards consumer electronics, mainly mobile and mobile-influenced products. So the standard has a specific use case in mind whose needs are not congruent with those of our industry.

First of all MIPI is fast, but it is not the high speed that meets our industrial needs. Secondly, cable length is limited to centimeters, a measuring unit that often cannot be used in an industrial environment; and the standard does not tell the user anything about connectors or power. And thirdly, the MIPI standard is not particularly suited to interface to FPGAs because in their world they do not exist. There is a general misfit between the sensors that are using MIPI and the FPGAs our companies use.

The need for higher speed and at the same time the limitation of the number of I/O pins on CMOS image sensors will make suppliers of image sensors move to fast serial interfaces on their products. Sony is on the forefront here with the introduction of its proprietary interface standard SLVS-EC on the latest generation of fast CMOS sensors. The good thing about this standard is that it connects quite well to modern FPGAs that offer fast serial I/O. It can potentially run much faster than MIPI, and it can run a few meters of cable. So the standard is a pretty good fit for the requirements of embedded vision systems. Yet, the current downside is that SLVS-EC is still a proprietary Sony standard. EMVA and JIIA are in discussions with Sony to find out whether it could become an open industry standard.

inspect: Are there any other standards you are currently looking at?

Jochem Herrmann: Certainly an important initiative under the FSF is OPC UA, led by the VDMA. Their goal is to standardize the hardware and software connection between a machine vision system and its process environment. So the standard interfaces on a higher level will be giving answers to the question how to standardize and connect a machine vision system to the factory floor. The kick-off for this group was in spring this year, and a wider working group met in September. And there is GenICam, not to forget.

inspect: GenICam is going embedded as well?

Jochem Herrmann: This is the path we want to pursue. Until today, the beauty of GenICam is that one can have various cameras and different interface standards like GigE Vision, USB3 Vision, CoaXPress, and still the engineers that write software have a unified way of controlling the camera, acquiring images, etc. Embedded systems will change this, because the architecture the current GenICam 3.0 is based on assumes that there is some intelligence in the camera. In future, this will change because the simplest camera modules will be no more than a sensor plus some kind of simple interface. The processing that used to take place in the camera will be moved to the embedded processing module. A future GenICam 4.0 will aim to support both classic machine vision systems and machine vision solutions based on embedded systems, enabling the easy migration of solutions to embedded systems.

inspect: There seems to be quite some work ahead for the Future Standards Forum. Are there any other areas you consider important?

Jochem Herrmann: This is not only a question for the FSF, but also for the market. However, one thing I have in mind are lens-mount interfaces. When everything shrinks and goes embedded we need to ask whether C-mount and CS-mount lenses are still the right way to go. These standards have been around for a very long time, and they will limit the system's ability to become smaller.

inspect: So what are the Future Standards Forum's next steps in their embedded standardization activities?

Jochem Herrmann: The next milestone for everybody will certainly be the Embedded Vision Europe Conference from October 12 to 13 at the ICS Stuttgart, organized jointly by Vision and the EMVA. This will be the hotspot to discuss all open questions and work on roadmaps for the various standardization initiatives. I am very much looking forward to this outstanding new event. Basically, we are about to get ready for the next level of acceptance of machine vision technology. The FSF and events like the Embedded Vision Europe prove that the whole industry is working to achieve this. We only have to be aware that things around us are speeding up rather quickly.
(ssch)

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Healthy Crop

Converted Consumer Cameras and Unmanned Aerial Vehicles Assess Crop Health

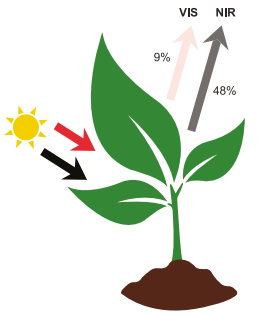
Triple Bandpass Filters are tools that allow us to go above and beyond traditional Normalized Difference Vegetation Index (NDVI) indicators to reinvent the way we monitor crop health and collect more information than ever before.

Traditionally, NDVI was used to determine plant health, which incorporates a camera with a red and near-infrared (NIR) filter—and the equation NDVI = (NIR – Red)/(NIR + Red). While this is a great tool, scientific advances have found that modifying this calculation can provide even more details about crop and field health. Similarly to red light, healthy plants also absorb visible blue light. And in addition to NIR light, healthy plants also reflect some visible green light. These facts enable us to assess crop health quickly, inexpensively and in real-time using converted consumer cameras and unmanned aerial vehicles.

New Triple Bandpass Filters

With this knowledge, MidOpt designed two innovative new Triple Bandpass Filters, which allow one camera to gather data results at all three wavelengths, making them an affordable, lightweight alternative to aerial surveillance applications that otherwise might require three or more cameras or sensors.

The TB550/660/850 filter takes the traditional red and NIR measurements to a whole new level by adding green. Green + Red + NIR wavelengths are used for applications where Chlorophyll Vegetation Index



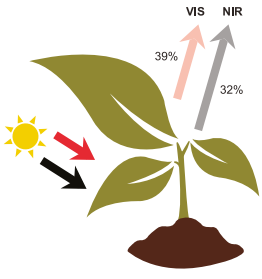


Image 3: Plants can be identified as healthy or stressed based on their NDVI value.

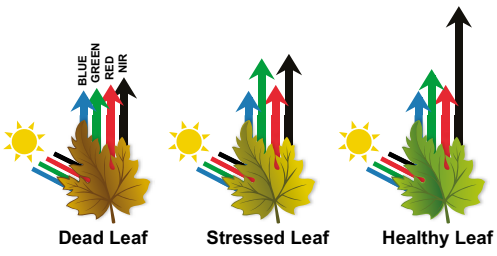


Image 1: Healthy plants absorb visible blue light and reflect some visible green light.

Without infrared camera device

With infrared camera device

Image 2: Object detection using infrared camera devices

(CVI), Normalized Green (NG) and other vegetative index monitoring is needed. Two of the calculations used are as follows: CVI = (NIR x Red)/(Green ^ 2) and NG = Green/(NIR + Red + Green).

Using the 475 nm, 550 nm and 850 nm wavebands differ from earlier calculations, since it uses Blue + Green + NIR light instead of the red-based method. It's recognized as the Enhanced Normalized Difference Vegetation Index (ENDVI), a technique that can provide more detailed information. ENDVI may better isolate plant health indicators and can generate results and false color mapping to indicate values as far down as the pixel level (see image 1).

It can also generate information about plant growth, water usage, soil type and topography. Because our eyes are unable to see many of these variations, advancements in surveillance technology are critical. ENDVI can also provide information on chlorophyll levels, help identify unwanted weeds and more. The ENDVI formula is as follows: ENDVI = ((NIR + Green) – (2 x Blue))/((NIR + Green) + (2 x Blue)).

MidOpt Triple Bandpass Filters are offered in various standard threaded mounts and custom mounts that are cut to fit any lens or camera size. Standard material thicknesses include 0.5 mm, 1.1 mm and 2 mm.

NDVI History

During World War II, the US military discovered that when looking through an infrared camera, vegetation appeared white, while a green object appeared dark (even though they both appeared green to the visible eye). Using infrared camera devices, the military could wash out vegetation and easily detect objects (see image 2).

Interested in the military's findings, scientists began working on using visible and infrared cameras to detect when vegetation was healthy or stressed. They found that when plants were stressed, their NIR reflectivity decreased before the plant's green color visibly changed, allowing for early detection that the plant may be suffering. A variety of mathematical formulas were developed to determine plant health, including NDVI = (NIR – Red)/(NIR + Red).

NDVI was formulated by Rouse et al. of the NASA/Goddard Space Flight Center in the early 1970s. The concept centered on the fact that chlorophyll in plants absorbs red light during photosynthesis, and healthy plants strongly reflect NIR light. Red NDVI is a number ranging between +1 and -1, with +1 indicating healthy plants and -1 indicating dead or extremely stressed plants.

As seen in image 3 on page 28, the healthy plant at the top absorbs more red light and reflects more NIR light to produce a larger NDVI value. The stressed plant at the bottom absorbs less red light and reflects less NIR light resulting in a lower NDVI Value.

Once it's recognized that a plant is stressed, further investigation can reveal what may be causing the issue. Identifying the cause of the issue early one increases the odds of being able to save that plant or plant community.

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Pig in a Poke

A Clarion Call for Lens Tolerance Standards

A major problem in the optical industry that is tripping up the best-intentioned engineers and their most-prized vision-system plans is the lack of lens-tolerance standards. As in many industries, experience is an asset that helps to overcome the latent challenges.

What do these sayings have to do with the workaday world of an optical engineer? Taken together, they point to a tremendous problem in the optical industry, namely the lack of lens-tolerance standards. How this turns out in practice is well explained by the example of an engineer at an aerospace firm who was about to pull the trigger on an important lens buy for an optical system designed to make measurements in space.

Distortion Does Not Equal Distortion

The data sheet listed a very low "distortion" metric, under 0.5 %, while a similar lens from manufacturer Schneider Optics listed distortion at 10 %. This seemed like a "no-brainer" in favor of the competitor's lens, but then the company´s team of experts noticed something the buyer didn't: the value listed was for a different kind of distortion. When the team pointed out the discrepancy – that the firm in questtion listed "TV distortion" while theirs listed "lens geometric distortion"– both the buyer and they themselves shared an `aha´ moment. "Of course," he said, "that's why their lens distortion value is so low. I didn't even notice!"

Spot the Difference

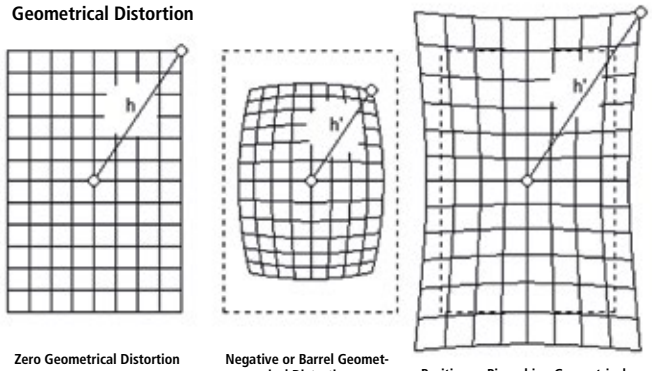
Have you ever looked at data sheets from Japanese, German, and U.S. lens manufacturers side by side? They have almost nothing in common. But the problem is not rooted in cross-cultural issues. Compare data sheets from three lens makers in the same country, and the result is the same. Each company uses its own format and nomenclature. Each company essentially is reinventing the wheel, but it is the buyer of the lens who, as can be seen, faces the prospect of a flat tire.

In order to help optical engineers and system designers view lens data sheets more critically, better circumvent traps hidden within, and ask the right questions of lens providers, we suggest focusing on the following key data-sheet parameters:

- modulation transfer function (MTF),
- focal length,
- f-stop.

MTF: A Convenient Way to Mislead

What most non-optical engineers and designers don't realize is that there are many different types of MTF, each with varying values that can artificially inflate an estimate of lens quality. Because there are no standards on how lens makers report MTF on a data



sheet, it is left to the buyer to ascertain which kind of MTF he or she is assessing. This quandary is made even more difficult by the fact that many vendors use the term MTF generically on their data sheets.

The generic use of MTF is a convenient way of misleading the reader. Used generically, MTF is commonly shorthand for "geometrical MTF," a value that does not take into account diffraction, and thus provides a higher, seemingly more attractive number. The most rigorous and useful type of MTF — one that is the best indicator of the lens' true performance potential in a vision system across wavelengths – is called polychromatic diffraction MTF.

Calculating polychromatic diffraction MTF is a better way to evaluate lens performance than geometric MTF because it better reflects how a lens will be used in the real world. Namely, it takes into account the physics of optics, which includes diffraction, something not accounted for in geometric MTF. Again, one can see from the calculations that polychromatic diffraction MTF is a higher number, and, to the untrained eye, that means "less good." Not so.

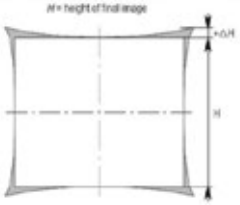
At Schneider Optics, we often answer questions from prospective buyers about why our MTF values don't compare favorably with various competitors. Nine out of ten times, they are shocked to learn not only that there are multiple kinds of MTF, but also that they haven't been comparing apples to apples.

Focal Length: When 100 ≠ 100

Even when there is an International Organization for Standardization (ISO) or Deutsche Industrial Normen (DIN) standard associated with a lens specification, many buyers are unaware of the standard and, of even greater consequence, the potential ramifications of that standard on their vision-design system. Lens focal length (f ,) provides a telling example.

For that company buying twenty 100 mm lenses for its web-inspection system, say for measuring defects over a large swath of material, the impact of the DIN standard for focal length is significant. It could mean that instead of buying twenty uniform 100 mm lenses, they are actually getting lenses of varying focal lengths, running from 94 to 106 mm (where the delta between what they buy and what they get = aggravation, extra work or rework, and, at its worst, a system failure, exposing the engineer's ignorance of the lens-buying process).). In practical terms, this would mean every single lens and camera would need to be set up at a slightly

Picture height distortion = △H/H



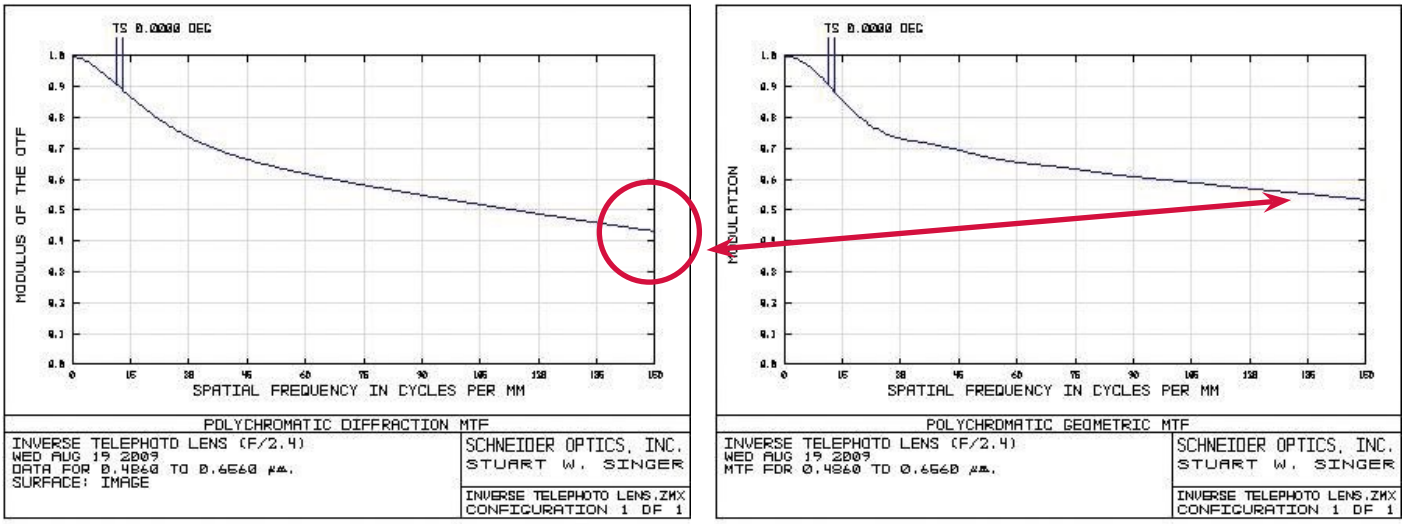
TV Distortion %age =

$$\left(\frac{\Delta H}{H}\right) \times 100$$

$$GD\% = \left(\frac{h' - h}{h}\right) \times 100$$

Geometrical Distortion %age

Diffraction MTF versus Geometrical MTF for the Same Lens



Diffraction MTF Polychromatic

Geometrical MTF Polychromatic

different distance to give all the same magnification and field of view.

F-number: Seeing the Light

Similar to focal length, the f-number (f/# or f-stop) – that controls the amount of light going through the lens – is addressed by an international standard, but, similarly, most buyers don't know the standard.

It is surprising to many what the ISO standard (ISO 517) dictates in terms of f-stop tolerances. When the f-stop is 5.6 or slower – for example, settings of f/5.6, f/8, f/11, f/16, or f/22 – the f-numbers need only be accurate to ± one-half a stop, or ±25% of the light. This is a huge difference. Imagine trying to set up 20 lenses in a row in a vision system with each turned to f/8, knowing they can all be off by ± 25%! And when the lens is faster, set to f/4, f/2.8, or f/2, the tolerance is ± one-third of a stop, or ± 16.6% of the light. One could drive a bus through these gaps, which certainly does not help when trying to set up multiple lenses in a row for a vision system.

Some might consider a simple workaround to these variances. For example, couldn't the f-number be adjusted slightly for each lens, so each had the same amount of light in the system? Yes, but remember what the lenses are being set up to do. The lenses would no longer be working at their proper f-number, affecting the depth of field and, consequently, the focus!

This topic of workarounds brings us back to our aerospace engineer mentioned earlier. The lens specification that tripped him up was distortion, another spec without a standard. The real distortion of the lens he almost bought would have crippled the system being designed, something that could have delayed the launch of a satellite and cost people their jobs. The error surely would have been detected downstream before a more catastrophic consequence, but this is not good enough. Engineers work in a world of exact values and need the means to get them before they buy.

> *„Not all modulation transfer functions are created equal."*

Learnings

Experience is a great teacher. Through many years of experience, Schneider Optics has learned a lot about the shortcomings of data sheets and the rules, or lack thereof that govern them. Here is a quick summary:

- Technical data sheets for optical lenses are not governed by standards, enabling every vendor to present the data he wants in the way it wants, which can lead to misleading performance claims and hamper apples-to-apples comparison.
- Even when specs are regulated by an ISO or DIN standard, the standards are often: a) not well understood by lens buyers; and b) typically wide enough to drive a bus through them. Efforts to bring industry players together to develop common standards have failed and been abandoned. This puts the onus squarely on the buyer to become better informed and more inquisitive. It also leaves it up to reputable manufacturers to move away from subterfuge and present their data in a clear way – calling out the type of MTF, for example. And where these two parties – buyer and seller – will continue to intersect is on the phone. Informed buyers need to ask the right questions, digging into the details behind key specs. In response, quality providers need to wow their buyers with a thorough knowledge of their lens tolerances and willingness to share them in a helpful and transparent way.
- Generic specification terms, such as MTF, often gloss over exactly what they are measuring and the variety of ways they are calculated, again leaving it to the buyer to do the detective work.

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Top Performance at a Top Price

For all those who want to purposefully detect weak points in the course of maintenance, Infratec offers a complete package with a handheld infrared camera of the premium class together with an efficient report software for just 14,950 Euros, plus VAT. The new Variocam HDx 625 is equipped with a large microbolometer detector. In combination with interchangeable high-speed lenses it provides images in superb quality as a basis for professional inspections, for example images of photovoltaic systems, or electrical and mechanical systems.
The camera with a light metal casing and protection degree of IP54 can be held safely in one hand. The concept for intuitive operation supports convenient use. The package is rounded off by the report software Irbis 3 report. Thanks to customizable templates in accordance with the VdS guideline, even high volumes of data can be documented easily as a report in PDF format.
www.infratec.de

Creaform Expands Its 3D Expertise to Aerospace Industry

Creaform will extend its expertise in non-destructive testing (NDT) to the aerospace industry. By expanding access to its inspection solutions, the company aims to better enable airlines as well as maintenance, repair and overhaul (MRO) service companies to more efficiently perform the evaluations of in-service aircraft safety while cutting costs and saving downtime.
To ensure that the solution matches aviation maintenance industry requirements and properly reflects the market needs, Creaform is partnering with major aircraft manufacturers for beta testing. The surface inspection solution dedicated to aerospace applications is set for release in October 2017.

Earlier this year, Creaform announced that the Handyscan 3D metrology-grade laser scanner had made its first major step into the aerospace industry. It was added to the Airbus Technical Equipment Manual (TEM) which is referenced in the Airbus Structure Repair Manual (SRM).
www.ametek.com

Positioning System with High Long-term Stability

In the semiconductor industry or in photonics applications, components often need to be precisely positioned for each single processing step and then reliably held in a stable position. The same applies to samples during X-ray examinations. PI (Physik Instrumente) now offers a practical solution for these types of and similar applications with the SpaceFab Q-845:
The extremely accurate parallel-kinematic positioning system can not only position loads up to 1 kg in six degrees of freedom with nanometer precision, but also keep them in a long-term stable position. The basis is made up of six linear stages, which are arranged respectively in three 90-degree-offset double stacks acting on a motion platform. This allows them to achieve a maximum travel range of ±7 mm in the X and Y directions, and ±5 mm in the Z direction. The rotation range of the three rotational axes are a maximum of ±7° (in θX, θY) or ± 8 degrees (in θZ). Piezoelectric inertia drives are the driving force for the linear stages. Thanks to their holding torque at rest no energy is consumed while holding at the target position and no heat is generated. This means that the positioning systems are also suitable for applications in a vacuum (vacuum compatible to 10^{-6} hPa). Mounting of the long-term stable positioning system is possible in any spatial arrangement.
www.pi.ws

Cost-effective CMOS Cameras

ISVI Corp. announces the release of the IC-C18N-CXP and IC-C18R-CXP, 18MP color CMOS cameras with a single CoaXPress CXP6, DIN-1 interface. They deliver 24 fps at a resolution of 4,912 x 3,684 pixels in 8-bit raw BayerGR format.
By combining the outstanding dynamic range characteristics (65.8dB) of the On-Semiconductor AR1820HS color sensor with a single CoaXPress interface, the cameras provide users with a very cost effective high-resolution solution for many single and multi-camera application areas such as 2D/3D metrology, AOI and SPI, 3D digitizing systems, wire bond inspection, LED/OLED inspection, robot vision, digital gel imaging systems and digital pathology.
The IC-C18N-CXP is a standard housed version with C-mount and additional power and I/O connectors, while the IC-C18R-CXP is a remote-head version with CS-mount consisting of the imager head, base unit and only a single DIN CXP connector. The standard cable length of the remote-head version from head to base is 20 cm but custom lengths are available upon request.
www.isvi-corp.com

High-speed Machine Vision Camera with Fiber Interface

Mikrotron introduces the first high-speed machine vision camera with a fully integrated fiber solution. The fanless 3 megapixel camera Eosens 3Fiber is capable of transmitting data up to a distance of 300 meters and runs up to 566 frames per second which are transmitted through the fiber interface. Based on a full resolution of 1,696 x 1,710 pixels the frame can be reduced continuously and allows frame rates up to 225,000 at smaller ROIs. The compact and robust MTP/ MPO connector ensures that the camera does not disconnect even during fast and sudden movements. The thinness of each individual fiber allows the bundling of all fibers into one cable that transmits the entire data.
Compared to copper-based solutions the overall system costs of the fiber solution are relatively low due to a lower cable price per meter and the fact that the fiber interface is both integrated in the frame grabber and the camera. In order to exploit the full capacities of the new fiber high-speed solution the camera can be equipped with a fiber grabber from KAYA Instruments.
www.mikrotron.de

New Series of Lenses

Kowa has released a new lens series for cameras with a 2/3 „chip size. The JC3M2 series has been developed for sensors with a pixel size of 3.45µm such as Sony IMX250 and IMX252. The series is available in six focal lengths from 8mm to 50mm. The new Kowa C-mount lens series is designed for use in industrial environments: the 2/3 „optics are compact, robust and temperature resistant. In addition, Kowa has launched a new lens series for Intelligent Transportation Systems (ITS). The JC5M-IR series is suitable for cameras with up to 2/3 „chip size. The new C-mount ITS lenses are IR-corrected, i.e. they minimize the focus shift when switching from visible light to IR illumination for night surveillance.
The series has a manual iris and is ideally suited for sensors with a pixel size of 3.45µm such as the Sony IMX250 and IMX252. The series is available with the focal lenghts of 16mm, 25mm and 35mm.
www.kowa.eu/lenses

Teledyne Dalsa Expands Its Xtium Frame Grabber Series

Teledyne Dalsa announced the expansion of its Xtium series with a new half-length CoaXPress frame grabber. Teledyne Dalsa frame grabbers combine industry-leading performance and feature sets, great value, and extensive camera support. The Xtium-CXP PX8 is fully supported by Sapera LT SDK and Teledyne Dalsa's Trigger-to-Image-Reliability platform. Like other models within the series, the Xtium-CXP PX8 takes full advantage of the PCIe Gen 2.0 platform using PCIe x 8 slots to deliver bandwidth of up to 2.5 GBs from four input channels (6.25 Gbps per channel). The Xtium-CXP PX8 is in full production now.
The Xtium series minimizes CPU usage and improves processing times for host applications by enabling maximum sustained throughput and ready-to-use image data. The Xtium family offers enhanced memory architecture to handle area and line scan, monochrome and color cameras.
www. teledynedalsa.com

Compact 48 Megapixel Global Shutter CMOS Cameras

Now offering the LX series also with CMV50000 CMOS sensor by Ams Sensors Belgium (previously Cmosis), Baumer opens the way to applications placing the highest demands on resolution, frame rates and image quality. The new LX cameras in compact 60 × 60 mm housing, deliver up to 15 fps at the full resolution of 7920 × 6004 pixels. Therefore highly-dynamic processes such as inspection of PCBs, wafers, surfaces and displays as well as track & trace applications can benefit from high-resolution images with reliable detection of even the finest details and the slightest deviation. Where previously several high-resolution cameras were required to fulfill demanding accuracy requirements, now a single 48 megapixel LX camera will suffice. This will reduce system and integration cost and increase system uptime. Series production of the new Dual GigE and Camera Link cameras begins in the fourth quarter of 2017.

www.baumer.com

Matrox Announces Major Update to Dot-Matrix OCR Tool

In a move intended to increase tracking and tracing efficiency, Matrox Imaging announced a major update to its dot-matrix OCR tool — SureDotOCR. The latest update brings with it optimizations that improve both reading speed and robustness. In general, the updated SureDotOCR tool can now read two times faster than before, which translates to a speed of over 2000 ppm when using an Intel Core i5-6500TE platform. In specific circumstances, read speeds have been increased by up to four times what was previously possible.

Introducing the possibility to specify the expected italicization and strings angles of dot-matrix text, this update further boosts reading robustness and speed; major throughput advances for those looking to provide dependable tracking and tracing in food, beverage, pharmaceutical and healthcare sectors. The update is available gratuitously to Matrox Imaging Library (MIL) users.

www. matrox.com

Support for New Labview 2017

BitFlow reported that a free software driver supporting National Instrument Labview for the CoaXPress standard has recently become one of the most frequently downloaded products from its website, www.bitflow.com, underscoring the rapidly expanding adoption of this interface by the machine vision industry.

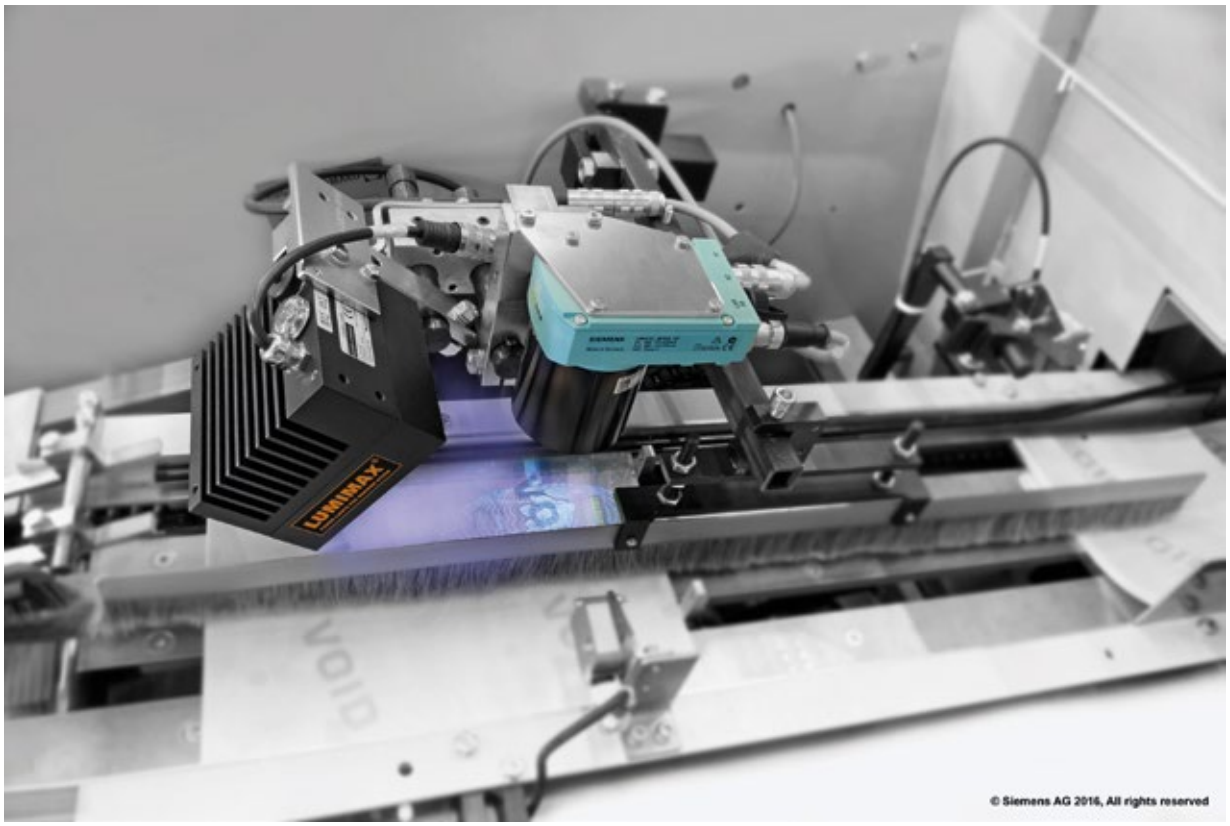
The company also announced the immediate availability of a CXP driver for Labview 2017, the latest version of the popular systems engineering software. The drivers are for use with BitFlow Aonnd Cyton CoaxPress frame grabbers. One of the many game-changing advantages of BitFlow drivers is that they support all of the company's current product families. As a result only one driver is required for any given application regardless of which BitFlow frame grabber is being deployed.

www..bitflow.com

Basler Ace L Enters Series Production

Basler is starting the series production of the 12 new Ace L models with the high-resolution sensors IMX253, IMX255, IMX267 and IMX304 with state-of-the-art global shutter technology from Sony's Pregius line. The 12 new Ace L models offer resolutions of 9 and 12 megapixels and frame rates of up to 40 fps. Featuring the high-performance IMX253, IMX255, IMX267 and IMX304 sensors, they offer the well-known brilliant Pregius image quality with a dynamic range of more than 70 dB and a high quantum efficiency over a broad spectrum of visible light into the NIR. The models stand out with their compact design size, which has a footprint of 30 x 40 mm to accommodate the new large-format sensors and thus ensures a simple integration.

www.baslerweb.com



Make It Visible

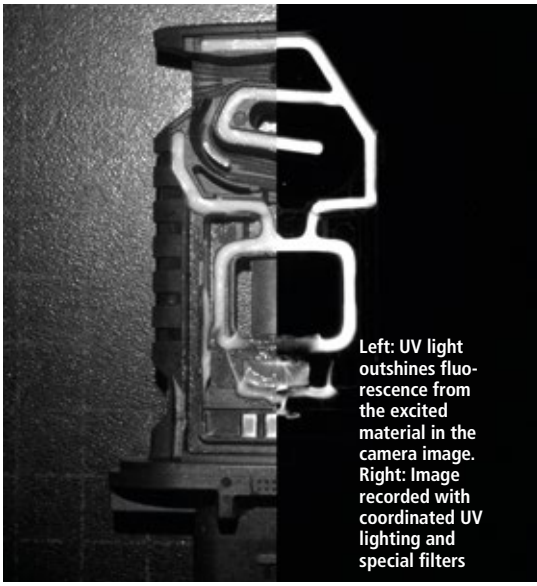
High-Power UV LED Lighting Detects Fluorescence

Fluorescence applications are used in many different areas within manufacturing, as possible uses of fluorescent materials in quality control and testing are extremely diverse. The use of UV lighting is necessary when features on test objects that are invisible in daylight need to be made visible.

The UV radiation produced by the lighting causes fluorescent materials to glow. This glowing is clearly visible both to the human eye and to cameras. By using high-performance LED lighting in conjunction with carefully coordinated filters, reliable solutions to a wide range of tasks and activities can be implemented. Fluorescent, low-contrast adhesives, paints and seals can be shown in high contrast with ultraviolet radiation. Presence and completeness monitoring is thus made easier for the camera. Product labelling that consumers would find distracting can also be applied with transparent, fluorescent ink. Under UV radiation, however, the labelling is easily visible for the purposes of testing. This aspect is of particular interest to the pharmaceutical industry, where track-and-trace is now an increasingly important factor.

Versatile Use

Fluorescence can also be used to make even the finest cracks visible – in cast parts, for example. UV lighting equipment is now also commonly deployed for residue and residual soiling analyses, and in forensic investigations. Another field of application is the inspection of security features and markings as protection against plagiarism and counterfeiting. IIM has worked with Siemens and passport machine maker BW Papersystems Stuttgart to develop a solution for this type of application. Advanced security requirements are now making passport manufacturing increasingly challenging. Here, the use of fluorescent materials has a particularly important role to play. To ensure that these invisible security features can be reliably detected and inspected during high-speed production runs, the machine manufacturer



Left: UV light outshines fluorescence from the excited material in the camera image. Right: Image recorded with coordinated UV lighting and special filters

The range of Lumimax UV lightings

used high-performance Lumimax LED lighting from IIM and 'teachable' optical readers from Siemens to develop a sophisticated testing system.

Verifying Passports

The unique challenge in this project was created by the mutual 'interference' created by the juxtaposition of two fluorescent security features on a Latin American passport. In this application, a numeric sequence printed using invisible security ink is scanned while the passport pages are being stitched together. When irradiated with UV light, however, this ink starts to fluoresce. The sequential numbers are also printed onto a special kind of paper that has been manufactured with the inclusion of fluorescent fibres as a further, 'passive' security feature.

After in-depth testing at the cooperating party´s sites, the scanning distance and trigger signal/flash duration timing were coordinated to ensure that the excitation of the fluorescent fibres in the paper did not prevent the scanning of the passport numbers. Despite a conveyor belt speed of 0.3 m/s during production, the powerful LED flash lighting is easily able to create a high-contrast image without any motion blur.

Inspecting Adhesives

Another interesting application scenario is offered by the inspection of adhesive as applied to a mass airflow sensor (MAF). While only a small component in a vehicle, the MAF can make its presence felt when it malfunctions, causing misfiring, problems with fuel intake and other performance issues. Before the mass airflow sensor is inserted into the assembly, an adhesive is applied that bonds the individual components together. The adhesive must not only be applied in the right amount – the shape and thickness of the application must also meet precise specifications. Only then is the long-term functional capability of the sensor in the vehicle assured. To provide a solution for this task, an LED UV Spot was used with a specially selected optical filter. This made it possible to eliminate both the light from the lighting system and the distracting light from the environment, which solves the particular challenge with industrial machine vision and fluorescence applications – namely that the emitted light (fluorescence) has less energy than the radiation required for excitation. For the human eye, fluorescence is easily and clearly visible, but the UV radiation from the lighting system is barely detectable. However, a camera is much more sensitive in the ultraviolet spectrum. In the camera image, the UV light outshines the fluorescence from the excited material. Accordingly, the image contrast is too low for reliable analysis.

Special Filter Support

To create a viable solution for tasks such as the inspection of the adhesive applied to the MAF sensor, the specialised UV lighting system therefore needs to be supplemented with carefully coordinated lighting/lens filters. This combination filter permits the exact separation of excitation and emission wavelengths. This works to suppress interference from UV reflections and extraneous light. As a result, the adhesive trace appears as a brightly lit line against a uniformly dark background in the camera image. This particular solution was achieved only by the specific, individual coordination of lighting, optical filters and the component. The UV application can now be deployed as a reliable process and error-free image analysis is now possible.

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The Iris M system offers the ability to make point measurements of absolute displacement of plant assets directly from images that can be used to quantify that motion.

Subtle Motion

Video Processing System Detects, Amplifies, and Measures Subtle Motion

A new non-contact video processing system employs a camera to detect, amplify, and measure the subtle vibrations created by machines.

The Flir 2.3M pixel Grasshoppper3 GS3-U3-23S6M-C camera, which is mounted on a Vanguard tripod, acquires monochrome image data at a default resolution of 1,920 x 1,050 and at a speed of 120 frames/sec.

All machines produce vibrations, some of which may be characteristic of normal operation and others which may indicate initial signs of failure. In the field of predictive maintenance, the detection of vibrational signatures is a key element of the diagnostic process that involves identifying and remedying problems before more serious events occur. A new system that is about one hundred times more sensitive in measuring displacement than traditional image-based measurement tools overcomes this challenge.

Improving a Tradition

Engineers at RDI Technologies in Knoxville, TN, USA have developed a revolutionary non-contact video processing system called Iris M that employs a camera from Flir to detect, amplify, and measure the subtle vibrations created by machines, eliminating all the drawbacks inherent with the use of earlier techniques.

Traditionally, the process was performed by deploying wired sensors such as contact accelerometers on machines in order to monitor the vibrations that are present. Once the data was acquired from the sensors, an operating deflection shape analysis was then performed on the data to render an animated model of the motion of the machine, thereby enabling vibration patterns to be visualized. The Iris M system employs a Point Grey/Flir 2.3 Mpixel Grasshopper3 camera mounted on a Vanguard tripod that acquires monochrome image data at a default resolution of 1,920 x 1,050 and at a speed of 120 frames/sec. Data from the camera is transferred over a USB 3.0 interface to a tablet PC where it is analyzed using the company's proprietary software to enable a user to visualize vibrational signatures in plant assets such as machinery.

No Progress without Drawbacks

According to Dr. Jeff Hay, the founder and CEO of RDI Technologies, the new tech-

nique does have its drawbacks. Not only is it time consuming to take measurements from more than a few points, it also requires access to the machinery or structures. This generally rules out its use where there is limited or no access to a machine, or where it is located behind barriers or glass. Furthermore, making such contact measurements often requires machinery to be stopped while the accelerometers are fitted, leading to expensive downtime.

Imaging Assets

In the Iris M system, the camera acts as the data acquisition device that collects the video imagery from which motion can be extracted and analyzed. The Flir 2.3Mpixel Grasshoppper3 GS3-U3-23S6M-C camera, which is mounted on a Vanguard tripod, acquires monochrome image data at a default resolution of 1,920 x 1,050 and at a speed of 120 frames/sec. Once acquired, data from the camera is transferred over a USB 3.0 interface via screw lock cables to a tablet PC, either a Getac F110 or Microsoft Surface Book.

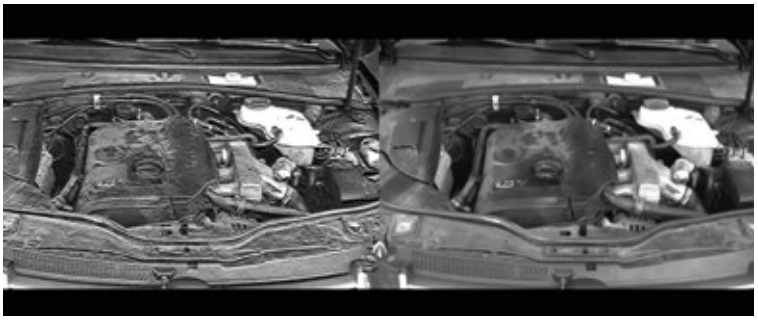
"A proprietary video processing algorithm called Motion Amplification running on the PC hardware then enables the vibrations of the machine to be visualized. To do so, it analyzes the pixels in each image on a frame by frame basis to determine which parts of the scene are moving. Next, it amplifies the periodic changes in the amplitude of the motion in a scene to a level that is visible with the naked eye. This reveals subtle motions that would be too subtle to seen by the eye alone, enhancing the understanding of the components and interrelationships creating any vibration," said Dr. Hay.

In-depth Analysis

Through the use of a graphical user interface running on the PC, a user can select numerous parts of the image for further analysis. Having done so, the system software will then display the time-dependent intensity data associated with those regions. Various mathematical functions, such as a Fast Fourier Transform (FFT) can then be employed to convert the set of time-dependent intensity data into frequency-dependent intensity data. The user is then presented with the absolute unamplified amplitude and phase of the vibration at different frequencies for those chosen sections of a scene. The new system offers the ability to make point measurements of absolute displacement of plant assets directly from images that can be used to quantify that motion, instead of interpreting point measurements to determine the types of motions and faults present.

Sensitivity and Scalability

Since its launch in the third quarter of 2016, the system itself has revolutionized the way people observe motion in the machine condition monitoring industry. Not only is the system simple to use, it returns easy to understand video imagery that the user can see to get a better understanding of the behavior of equipment.



According to Dr. Hay, the choice of the Flir Grasshopper camera has been one key reason for the success of the system. The 12-bit dynamic range of the camera enables it to capture small differences in pixel intensity between brightly illuminated and dark regions in the images, enabling the system software to extract more detailed changes than would otherwise be possible.

No less important, however, is the Motion Amplification algorithm itself. "Due to this unique algorithm, the Iris M is about one hundred times more sensitive in measuring displacement than traditional image-based measurement tools. Furthermore, the system offers the ability to make point measurements of absolute displacement directly from the image that can be used to quantify that motion when necessary, instead of having to interpret point measurements to determine the types of motions and faults present," he said.

Additional major benefits of the technology are the speed at which the data is returned, and the level of detail in the data. Unlike traditional contact measurement systems, it is also easily scalable, since the motion of all the assets in the field of view of the camera are measured simultaneously. What is more, it lends itself to being a good communication tool between a technical and non-technical user as the root causes of any issues with any assets can be seen directly in the video.

The new system has been deployed in a variety of practical applications. Aside from performing condition monitoring on industrial assets such as machinery, the Iris M system can also be use to analyze the structural integrity of bridges, buildings, and similar structures. In addition, it could also be used in biomedical monitoring applications for assessing the respiration of an individual.

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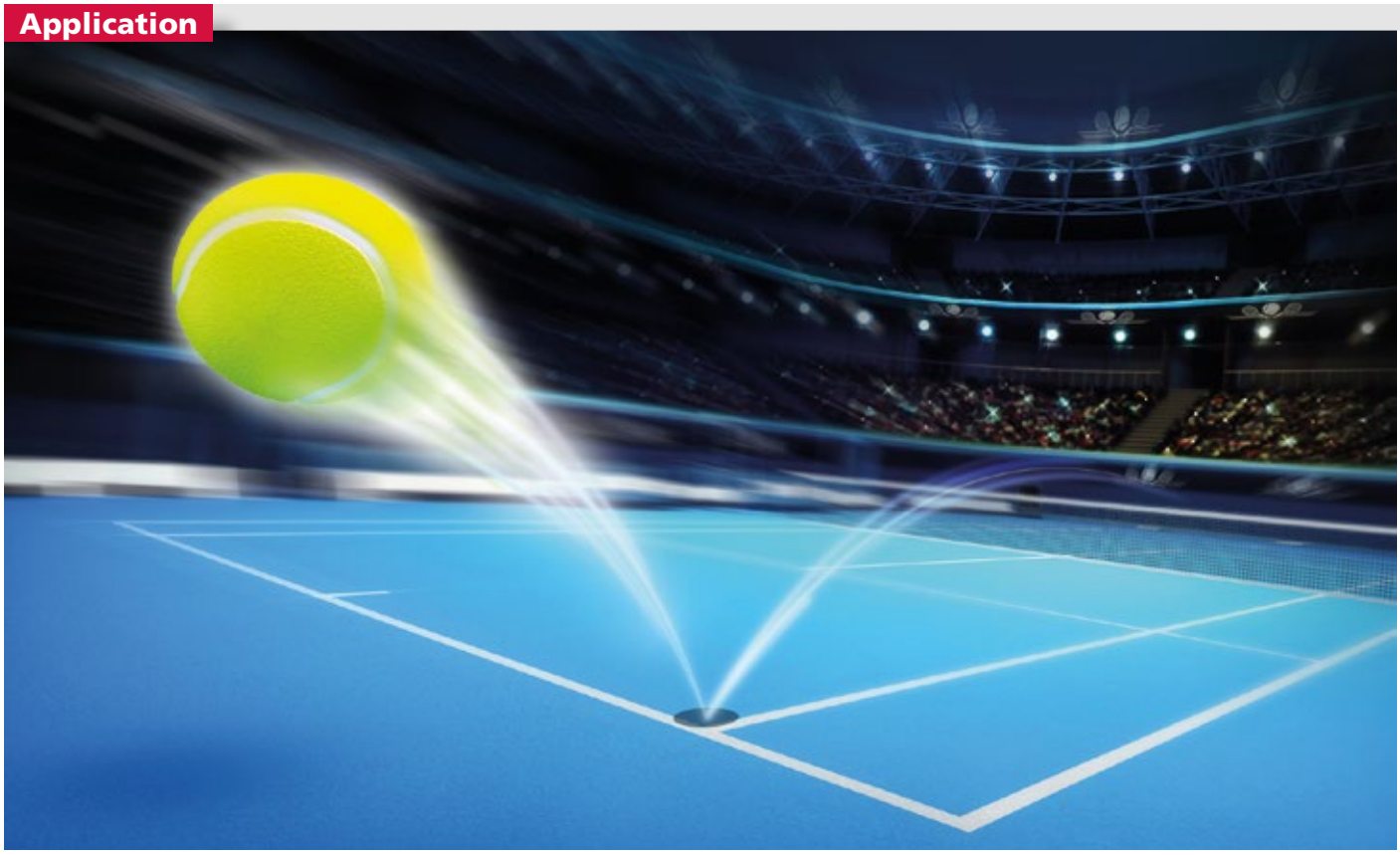


Fairplay

10GigE Camera Increases Fairness in Sports – Quick, Affordable and via a Single Cable

In sports and entertainment, 10GigE cameras deliver the necessary Full HD and 4K UHD resolution to support refereeing decisions and deliver slow-motion replays for the spectators.

Was the ball really in the net? Was the tennis shot out? What exactly did the baseball stroke look like in slow motion? 10GigE cameras are being used to answer these questions in sports and entertainment. The high-speed industrial cameras are more affordable and smaller than the classic broadcasting solutions and deliver the necessary Full HD and 4K UHD resolution. The main advantages of 10GigE cameras lie in the superb image quality and speed, the simplified cabling and reduced susceptibility to errors as well as the synchronization and data processing directly via a connected PC. The result: improved tracking options for sports event organizers and detailed, data-based reporting.

Goal Line Monitoring

It's the nightmare of every soccer fan and referee. The ball flies toward the goal, is almost in, but a quick defender kicks it out again right at the "goal-mouth." So did the ball cross the goal line or not? A visual judgment is often not enough to make a valid statement, TV cameras are positioned at the wrong angle, the goalkeeper says yes, the defender swears no – the referee often has only a 50/50 chance, at best, of making the right decision. This is where high-speed cameras can help, especially 10GigE cameras installed parallel to the goal line. They monitor the goal and the approaching ball with Full HD resolution (1,920 x 1,080) and, depending on the lighting conditions, at frame rates of up to 300 frames per second. The high resolution corresponds to television quality with high image sharpness. The high frame rates enable fast-moving scenes to be captured with fast time resolution and without the typical motion distortion. The instant replay and precise evaluation of the goal area immediately show whether the ball crossed the goal line, even momentarily before being kicked out again. This information can be passed to the referee almost in real time to ensure the game progresses fairly.

Fewer Cables, Fast Installation

Sports organizers and broadcasters who choose Camera Link or CoaXPress camera systems over 10GigE often must contend with piles of cables, additional interface cards and frame grabbers which increase costs and complexity. The systems were also prone to errors due to the integration of cables, cameras, frame grabbers and converters of many different suppliers, a large number of transfer points and connected components. A trained engineer is needed on site to get the system up and running and to repair it again in the event an error occurs.

When using 10GigE cameras, a single fiber optic cable with SFP+ connection is used to connect the camera to a PC fitted with a 10G network interface card (NIC). Without the need for additional frame grabbers, it connects the camera at the goal to the broadcast van or playback station over a typical distance of 1 to 2 kilometers. Distances of up to 10 kilometers are possible with an SFP+ fiber optic connection. Two 10GigE cameras, one for each goal, are sufficient for proper monitoring and evaluation. The costs of a 10GigE camera system are significantly lower due to the smaller number of installed components and fewer cables. The Ethernet solution can also be used with

other standard 10G network products, which are inexpensive to buy. As only one transmission protocol is used, the error rate is also significantly reduced. One on-site technician instead of an engineer is sufficient to maintain the system and fix any errors. The time spent commissioning and servicing the camera system is also significantly reduced. The large quantity of data generated by the 10 GigE cameras would exceed the processing power of commercially available PCs. Processing the data via the NIC cards integrated into the PC enables CPU usage to be reduced below 1 %. Small latencies of between 5 and 50 µs ensure flicker-free and instantaneous playback of the goal scene and in time-critical broadcasting applications.

Ball Tracking

In the same way that the soccer referee assesses the validity of a goal, in tennis it is the line judge who decides whether a ball is out or has landed just on the line. The immediate tracking of a ball and its exact position at a certain time is equally important for:

- the management of live broadcasts,
- the coordinated production of sports programs,

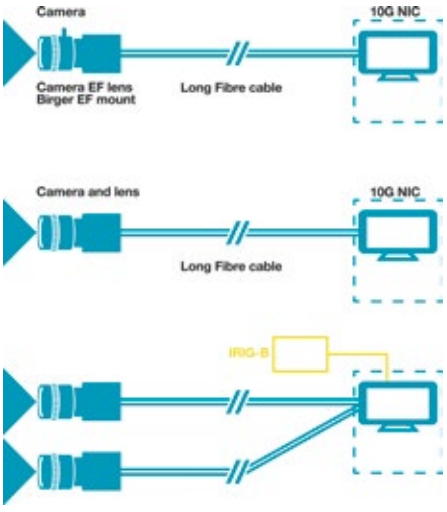
10 GigE cameras support refereeing decisions and deliver slow-motion replays.

- accurate video management,
- digital production for online reporting,
- coaching of athletes with motion analyses,
- evaluation of research trials on sports equipment in the development phase.

Timing and synchronization of the cameras are the main criteria for precise tracking of a ball and therefore decisive factors for building up the necessary multi-camera system. The ball never flies in a straight line, but creates arcs and angles. In order to calculate the exact shot, trajectory and speed, detailed motion data in combination with exact timing are essential. In typical 10GigE systems, such as those with 10GigE cameras from Emergent Vision Technology and the NICs, integrated IRIG modules provide a stable and steady time reference. With these time references, the NICs work as masters to trigger all connected cameras and add time stamps to the images taken before they are transferred to the PC with low CPU usage and very low latency. The IRIG standard has been used for the timing mechanisms over large distances since 1960. The dual sync NICs were originally developed for financial and stock exchange transactions and have a timestamp precision of 1,000 ns at a resolution of 500 ns. Thanks to minimized network delays, they are extremely accurate. IRIG modules and dual sync cards provide maximum synchronization precision when used in combination. The IRIG encoder renders previously required expensive switches obsolete and simultaneously eliminates a further source of errors. The usually pre-integrated IRIG encoder only has to be connected to the NIC for this purpose and can be used with all types and lengths of cable.

Precise Synchronization – Programmable and "from a Single Source"

The camera synchronization can be programmed and controlled via the camera SDK. The timing delays between the cameras are automatically corrected by the hardware and software. All cameras are therefore synchronized. When using several PCs, the standard network can be used for the transmission and controlling of the time stamp between the master and slave units. Combined with the various cable options, the IRIG referencing is the most flexible solution for synchronized high-speed applications such as Ball Tracking in terms of cost and performance.



The IRIG standard has been used for the timing mechanisms over large distances since 1960. Integrated IRIG modules provide a stable and steady time reference.

Compared to Camera Link and CoaXPress solutions, the advantage of 10GigE setups, such as Emergent Vision Technology cameras with NICs and integrated IRIG encoders, is that several cameras can be connected directly to the processing PC. Depending on the setup required, 2 or 4 cameras on a single NIC card and up to 4 NIC cards – i.e. up to 16 cameras – can be controlled by a single PC. The frame rates depend entirely on the performance of the camera and can be achieved with low CPU usage and very low latencies.

Bird's-eye View Broadcasting

The detailed observation of goals, lines or trajectories are important, but so too is the overall bird's eye view of the game. Monitoring whole pitches or wide overview scenes is often very complicated to control with conventional TV cameras. Remote control functionalities are not always available, meaning that additional hardware interfaces from third-party providers are usually required. That is expensive and poses the risk of additional sources of error. A camera operator also has to be present on site. Apart from these cost factors, 4K-capable television cameras are usually expensive and bulky. The 10 GigE cameras on the other hand are compact and can be installed permanently outdoors inside a weatherproof housing.

10GigE camera systems offer a simple remote control solution for an affordable price-performance ratio. To this end, the 10GigE camera equipped with a Canon EF lens with Birger mount is installed in an exposed position above the action, e.g. on the stadium roof. The 10GigE cameras with the newest generation of sensors, such as the Sony IMX 253 or IMX 255, achieve 4K UHD resolution (3,840 x 2,160) and the next-generation in TV quality. Settings such as trigger time points, frame rate, lens zoom, focus and aperture can be controlled remotely from the connected PC without the need for an additional camera operator. With up to 93 fps at 4K resolution, both time lapse and slow-motion playback are possible. The simple setup with camera including lens, cable, NIC and processing PC keeps costs low and need no further components or additional personnel.

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Automated Head-Up Display Measurement

Optical Measurement System for Efficient SAE Standard HUD Evaluation

The evaluation of automotive head-up displays according to the new SAE standard "Optical Metrology for Automotive HUD" requires a device or meter with NIST-traceable calibration to measure the real distance between the nominal eye center to an opaque monocolor paravan positioned at the perceived distance of the projected virtual image.

Head-up display (HUD) technology is one of the largest growth areas in the automotive market, with a key focus on increased passenger safety through improved vehicle operations and operator awareness. According to research, HUD technology has a compound annual growth rate (CAGR) of 21.67 %, and is expected to achieve a market size of USD 1.33 Billion by 2021.

All about Safety

The safety implications of HUD have guided manufacturers of automotive test and measurement equipment to partner with the Society of Automotive Engineers (SAE) Committee to define standard measurement criteria to assess the quality of HUDs and their compliance in accordance to standards SAE J1757-1 and ISO 15008. The new standard (SAE J1757-2 "Optical Metrology for Automotive HUD"), to be published in late summer 2017, provides a methodology for optical measurement geometries and requirements for measuring vehicle HUD performance. These measurements require an optical measurement device or meter with NIST-traceable calibration, which is to be positioned at several measuring points within the operator's eye ellipse area (to account for the scope of potential viewing angles), for measurement of the above criteria.

Referenced in the SAE J1757-2 standard as a primary solution for HUD testing, automated imaging photometers and colorimeters provide NIST-calibrated optical measurement technology to capture absolute measurements of luminance, chromaticity, contrast, object location, and distance. These solutions offer several advantages in the application of automated visual inspection to acquire the necessary data for SAE HUD compliance with greater speed and ease as compared to alternative systems.

Comparison of static POI manually drawn in the software and Auto-POI (Automatic Points of Interest) adapted to an object based on color tolerances

SAE Measurement Criteria Simplified by Automated Imaging Systems

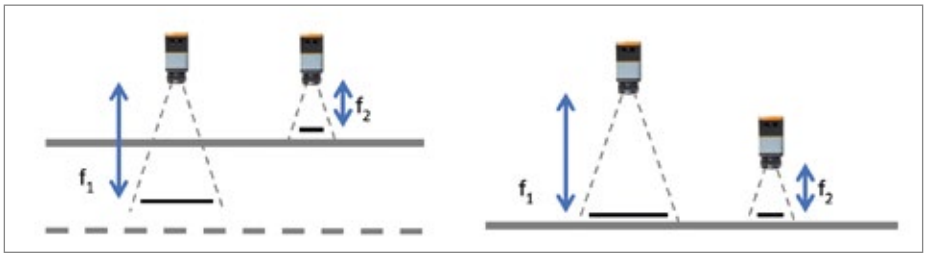
Calculating Object Distance and Location

SAE J1757-2 specifies that an optical measurement system for HUD evaluation must measure the "real distance" between the nominal eye center (the operator's nearest

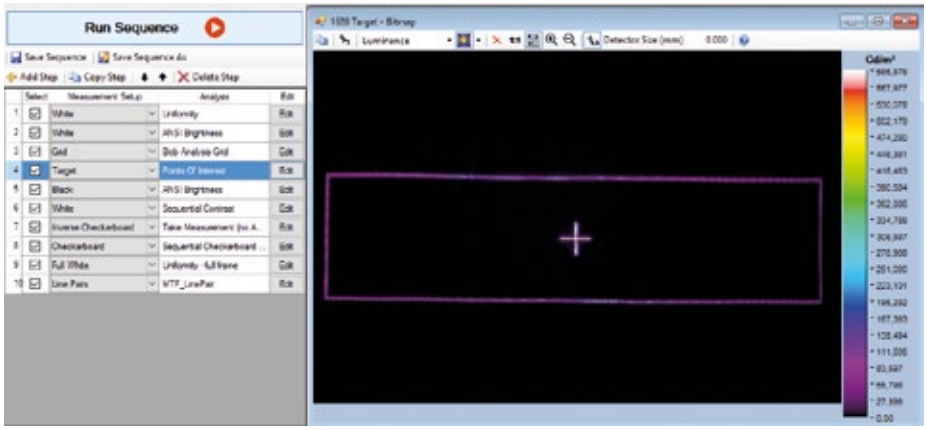
visual focal point) to an opaque monocolor paravan (surface) positioned at the perceived distance of the projected virtual image. In standard measurement systems, distance measurements from near to far are found using the camera's focal distance to evaluate the points along the horizontal plane where the camera can image objects in focus. The calculations required to convert focal distance to real distance units can be performed manually, but there are also measurement systems that can perform this conversion automatically. Such systems provide focal-to-real distance conversion using built-in software algorithms, enabling operators to display measurement data in real distance units in the system's software results.

Performing Multiple Measurements

To account for multiple potential viewing angles from the vehicle operator to the HUD projection, as well as to average out the margin of error, SAE J1757-2 requires that at least three measurements be taken at different locations on the paravan to determine the relative virtual image distance. Using standard fixed-lens measurement systems, the process of measuring multiple points is time-consuming and arduous. Alternatively, imaging systems with electronically-controlled lenses greatly improve the speed and accuracy of measurements at multiple angles, positions, and distances. These lenses can be remotely adjusted to ensure proper focus and aperture settings for image location at the paravan, or on an infinite plane, as shown in the examples below.



An imaging system with an electronically-controlled lens is able to remotely adjust aperture and focal settings for projected images, whether images appear at varying distances to the eye, or if the camera is positioned nearer to digital images within the HUD projection.



The test sequencing software above is programmed with ten steps, from uniformity to MTF line pair analysis, to perform multiple measurements of the HUD projection at once.

Measuring the Luminance Is Key

According to SAE J1757-2, minimum luminance thresholds must be achieved to ensure visibility of the HUD's virtual images superimposed upon the real-world environment in any ambient lighting condition (daylight or night). However, measuring the luminance of every virtual image in a HUD projection means accounting for a wide range of object shapes, sizes, colors, and locations. This process requires defining points of interest (POI) for each object to be measured.

Some advanced light measurement systems provide software capability that fully automates the process of POI-setting for multiple and even unpredictable objects in a projection. A software feature called Auto-POI (Automatic Points of Interest) in the latest imaging colorimeters, for instance, creates dynamic POI windows that automatically adapt to object pixels that fall within a defined color tolerance. A manufacturer may wish to evaluate the luminance of all red objects in a projection at once. For this measurement, the manufacturer would set minimum and maximum CIE color coordinates (Cx, Cy) in the software to encompass the range of red values represented in the target set of objects. Leveraging Auto-POI, the software would then "snap to" any set of continuous red pixels that match the defined criteria, creating accurate measurement regions regardless of object shape, size, or location.

Multi-Measurement Test Sequencing

Per SAE J1757-2, a HUD measurement system must perform luminance measurements on checkerboard images with alternating patterns to determine virtual image contrast for white and black projections in ambient light. The system must also determine luminance uniformity and non-uniformity of the virtual image, as well as chromaticity as compared to the target virtual image. Additional measurements must be taken to determine image distortion and aberration, as discussed above, to ensure accurate image shape and location as compared to the target virtual image.

The complete measurement process can be extremely time-consuming if the system runs only a single measurement at a time, or, if the system employs multiple software packages engineered for unique measurement applications. Alternatively, test sequencing software programs allow distinct measurement criteria, POI, and inspection tolerances to be programmed into a series of separate steps within one software environment and then run as a multi-part evaluation of the HUD. This allows luminance, chromaticity, location, and distance measurements to be performed to measure multiple aspects of the HUD automatically without reprogramming the measurement software for entirely new criteria or system replacement.

The Standard Ensures Competitiveness

With the finalization of the SAE J1757-2 standard coupled with the rapid growth of the HUD market, the demand for efficient measurement systems is destined to increase to ensure automotive manufacturers and suppliers achieve compliance and remain relevant and competitive in their industry. As SAE standard compliance becomes the baseline qualification for HUD selection, the competitive advantage for manufacturers will be the speed and efficiency to produce quality products that ensure optimal value of their technologies. Automated HUD measurement systems that include imaging photometers or colorimeters with advanced test sequencing software greatly reduce HUD evaluation time, enabling production-level measurement, ensuring compliance, and limiting cost and time to market.

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Quality Meets Quantity

Fast Feature Measurement on the Shop Floor

While the manual measurement with test gauges or callipers was time consuming and error-prone in the past, smart laser measurement systems do the work today.

Formerly, thorough quality inspection of gap and flush, radius, edge break and other features taxed people's patience: The manual measurement with test gauges or callipers was a task that required a lot of time and involved errors. Nowadays, these tasks are handled by smart laser measurement systems that are either user-operated or fully automated attached to a robot.

The optical profile measurement system GapGun from Third Dimension uses laser triangulation technology to measure forms and features (such as gap and flush, radius, edge break, burr, countersink, scratch, weld, seal, angle) fast and accurately, right on the shop floor. It automatically compares the measurement data against tolerance bands, and records it for statistical process control and traceability purposes. Manufacturers are provided with a fully auditable trail of every single product that is measured. The handy system can measure without ever needing to touch the surface. This maximizes accuracy and repeatability whilst eliminating potential surface damage and enabling the measurement of soft or unfixed parts.

Measurement Principle

The handheld measurement system projects a laser stripe across a part's surface to determine the measureable feature. Simultaneously, the integrated camera system takes images of this static laser stripe. As the angle is known between the camera and the laser projection, an algorithm can calculate the dimensions of the surface over which the laser falls and the camera sees. This measured data is then output to point cloud format to generate a digital copy of the surface.

Fully automated solution: Profile measurement integrated with robot.

With its high-speed data collection, processing and ability to output measurement data such as dimensional profile and deviation from nominal, the system improves the rate of response to component variation. This in turn helps manufacturers increase production volumes.

Minimum Training

Operating the handheld GapGun Pro is easy due to its ergonomic design and user-friendly interface: Once programmed, a graphical display guides the operator through the measurement process by showing both how and

where to position the system, as well as the point of the next measurement.

Additionally, to carry out analysis of a feature measured, images taken by the measurement system can be imported into Third Dimension's latest software development, Inspect. This enables the operator to easily and flexibly perform metrology checks using simple multi-section drag and drop tools to check whether the part has been built to the correct design specification. It is a tool for replacing old contracer and shadowgraph techniques and offers quick and simple digital inspection with only minimum training necessary.

Significant Reduction of Inspection Time

The system´s potential becomes obvious when looking at a practical use case: Trials by Leonardo Helicopters of the measurement system have reduced MRO inspection times for interior and exterior composite panels by almost 90 %, in early results. The military helicopter manufacturer has conducted the trial on servicing of Leonardo Merlin helicopters in the UK. GapGun has been used to measure the depth of scratches on helicopter panels and aircraft gearbox components. Operators have been able to establish on-site whether the depths of the scratches are within the 0.15 mm limit, and therefore determine whether the parts need to be repaired or replaced.

Keith Masterton, Leonardo's Merlin Depth Business Manager, said: "We recently did a check on a panel and, whereas the previous manual process using a depth gauge took two-and-a-half hours, the GapGun measures it in just 20 minutes. It gives us a very quick indication as to whether the damaged area, or perceived damaged area, is within acceptable limits. The system is so easy to use – after a couple of hours you're trained – and you can't misinterpret the reading. It is a much quicker process."

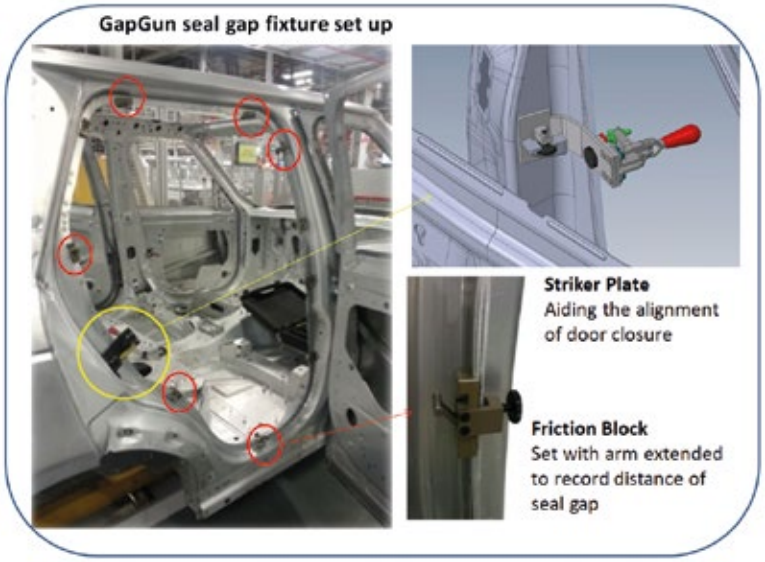
Previous inspection systems were more time consuming using a depth gauge with parts being taken away for inspection, often for days at a time.

Profile Check in Vehicle Production

Additionally, in the automotive industry, the systems have become an integral part of production: Many well-known manufacturers around the world use them to perform quality inspection, including Volkswagen, Audi, Ford and Toyota.

GapGun's areas of application cover the whole automotive production process including tool making, sheet metal working, body construction, and final inspection.

During assembly, the automotive manufacturer is in a position to identify and eliminate unwanted deviations arising during the actual production process at a very early stage. In this context, manufacturers favor the system for its ability to measure a variety of surface finishes, from bright machined edge conditions to very dark or metallic paint, and even chrome trims.



Seal gap measurement: Once the door has been closed on to the frame with the fixtures attached, the friction blocks are detached and the GapGun measures the distance between the friction block and the compressed arm.

> *"Previous manual process using a depth gauge took two-and-a-half hours, the GapGun measures it in just 20 minutes."*

Third Dimension have also developed a special method to use GapGun at the body in white stage to measure the seal gap between the car door and body. Using a custom made, patented fixture called a friction block, the system can provide accurate, repeatable and fast measurement data. It can measure seal gaps from 0 to 50 mm with a measurement capability of better than 0.2 mm. It allows for full control of tolerance bands of +/-0.5 mm and provides R&R scores better than 15 %.

Lastly, during the final inspection of a painted vehicle, visual aspects play an important role. Every single new car manufactured is expected, as standard, to show a perfect appearance for the car showroom and to its future owner. This goal can be achieved by inspecting the precision of gap and flush dimensions around the car body before it is approved for sale.

Integrated into the Manufacturing Process

If the data collected can be used more dynamically to influence a real-time outcome on the production line, mistakes can be corrected instantly. Therefore, GapGun can be connected and integrated seamlessly to existing production data systems using its Link software. This allows for efficient quality control during the production process: Immediate data comparison between the nominal data stored in the production system and the measured data can be used to identify geometric deviations. This real-time comparison enables quick decision-making for the optimization of production processes, all whilst the part is still on the assembly line.

Precision Automated Feature Measurement

At Control 2017, Vectro, an automated feature measurement system designed for fixtured or robotic integration, was launched. It is said to be simpler, faster, and to deliver increased levels of accuracy without operator interaction. It can be configured for use in several different ways, whether this be a robot moving the sensor around a part to take measurements, moving the part to a fixed sensor, or mounting it in a fixture. Thanks to consistent measurement positioning it is a solution that can be applied to deliver either fast throughput of production quality checks, application in high precision break sharp edge applications or offline metrology testing for research and development projects.

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Perfect Ambiance

Cameras Inspect Car Door Panels

A number of different cameras visually support the verification of completeness and quality of the interior configuration and ambiance lighting of produced door panels.

Red or blue ambient lighting? Cloth or leather? Functional design – individually arranged according to personal taste. What sounds like an interior designer's advertising slogan, represents a challenge for an automated inspection system used to inspect car door panels.

Choice versus Requirements

The combination of options a customer can select when building his own model, with the help of an online configurator, seem to be unlimited. High individuality and customer orientation equates to demanding tasks for automotive manufacturers. Due to varying feature details, the production of these automotive parts cannot be standardized. Each part must be set up separately. Simultaneously, industrial requirements have increased over the last few years: the automation and speed of production processes are expected to continue rising, as well as the required quality of processes and products. In addition, legal requirements like the traceability of goods and parts should be met. Thus, comprehensive documentation and visualization of production processes play an increasing role. Also, all this needs to be completed in both industrial and clean room conditions.

Visual Quality Control

The engineers at Ziemann & Urban are specialized in the field of inspection automation and quality control. They developed a tailor-made, end-of-line testing system that is capable of achieving 100 % control over produced car door panels. Before the door panels are sent to the factory for final assembly, the functionality and correctness of all produced parts must be verified: is the equipment a precise match with the ordered items? Does the interior, such as the color of fabrics, leather or seams, the decor trim, sound system, and function buttons, match, too? Are there any defects in the spotlighting, colors of the ambiance, and contour illumination?

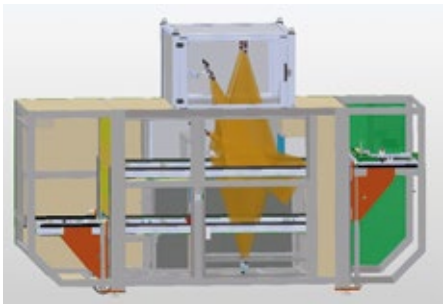
In the automotive industry, a combination of different metrology techniques is being applied most of the time. Visual inspection plays an important role. Depending on the special requirements of the inspected part, Ziemann & Urban sets up a fully automated end-of-line inspection system equipped with Allied Vision color cameras of different resolutions. Up to 17 cameras can be integrated in an end-of-line system, coupled with the necessary lighting. The cameras are placed above (side A) and beneath (side B) the inspected door panel.

Specific Cameras for Varied Inspection Tasks

The 5 Megapixel Manta cameras (Manta G-504) complete the attributive inspection and color recognition (for example the color of the leather, seam, seam contour, clips, rubber plug, function button). Complex and contorted systems often require the additional use of the ultra-compact Mako camera (Mako G-125) with its sugar cube housing sized 60.5 x 29 x 29 mm.

Several high-resolution 29 Megapixel Prosilica GT6600 cameras fulfill the task of checking the course and intensity of the line lighting in addition to the inspection of the surfaces. While covering a large field of view, the cameras deliver a resolution of 0.1 mm/pixel required by the automobile manufacturer. Fast data transfer and efficient drivers for Windows allow short testing time. The complete inspection (visual and electric) of all parts only takes approximately 23 seconds, thanks to deferred workflow steps. Universal holders and the high number of cameras allow the inspection of four different door panels (for example front, back, left and right, for a coupé, cabriolet or SUV model) in one single system. To ensure a fast transfer of high data volumes, only GigE Vision cameras are used.

5 Megapixel Manta G-504 for the attributive inspection and color recognition



Position of the cameras in the inspection cabin

The door panels are transported to the inspection station equipped with the cameras either manually or automatically by workpiece carriers. The parts are connected to a power supply via a docking system. Supplied with electricity, the functionality and correctness of ambiance lighting and other electronic components can be checked. To ensure proper illumination, it is analyzed whether the light intensity right and uniform, or whether there are there any hot or dark spots. The cameras capture images of the door panels from different perspectives. As a result, high-resolution inspection images are available not only for the special regions of interest, but also for those of non-inspected areas.

Analysis and Protocol

Ziemann & Urban developed an analysis software that applies special analytical algorithms. Based on the generated images, it delivers a visualization of the inspection results. A diagram on the screen shows where and which kinds of defects are occurring and which components are affected. Each part identified as defective is listed in a rework protocol. To meet the requirements of quality management regarding traceability and documentation, all analysis results (displayed as both graphical presentation and pure data) for each part are saved and indexed.

By now, different manufacturers of door panels in Europe, Asia and America benefit from this solution. Due to the automation and standardization of the inspection process they save time and costs despite the high individuality of parts. At the same time, automotive suppliers comply with the legal and economical demands of traceability and 0 % error rate while remaining competitive.

Andreas Ziemann, Managing Director at Ziemann & Urban is convinced of the benefit for the user: “Allied Vision cameras deliver high quality color images that make the automated inspection very precise and efficient.” As the request for even faster production processes and higher number of cycles coupled with the rising number of pieces continues increasing, the inspection experts are already working on a new system, equipped with the newest high resolution and high-performance GigE Vision Prosilica GT cameras.

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Automated optical inspection (AOI) helps to analyze a range of product defects, from simple mechanical errors to more complex failure mechanisms. While two-dimensional AOI is well suited for missing or misaligned parts and for finding straightforward defects, three-dimensional AOI adds the ability to incorporate volumetric data.

Let There Be Structured Light

Emergence of 3D Automated Optical Inspection Systems

Automated optical inspection is a powerful technique used in many manufacturing settings to provide real-time, decisive measurements related to part quality. AOI is a great tool for the analysis of product defects, from simple mechanical errors to more complex failure mechanisms. Identifying defective parts early in the line, and either reworking them or rejecting them, can save companies money and help build a stronger product-quality reputation.

2D versus 3D

Simple two-dimensional (2D) AOI systems have been around for many years and generally employ the technique of lighting the desired part, capturing an image and comparing that image to a known "golden" reference. This technique is well suited for missing or misaligned parts and for finding straightforward defects.

Three-dimensional (3D) AOI goes one step further and adds the ability to incorporate volumetric data. Introducing z-dimension data enables measurements of volume, flatness, lifted parts, and critical alignments or tolerances. When inspecting smaller or more complex products, 3D AOI offers fewer false fails and can measure geometries not captured by 2D AOI systems.

3D AOI Applications

3D AOI is most often associated with the inspection of electronic assemblies and printed circuit boards (PCBs). 3D measurements for solder paste inspection (SPI) are preferable because measuring the actual volume of solder paste deposited before component placement helps prevent solder bridging, shorts between pins and poor-quality solder joints. PCB manufacturing also leverages 3D AOI inline after component placement, reflow, final inspection and rework, as well as offline for custom inspections.

As 3D inspection capabilities become more widespread, several emerging areas are leveraging 3D AOI systems. Automotive production benefits from inline 3D scanning systems for body-part alignment accuracy and inspection at various assembly points. Figure 2 shows how a 3D scanning system can be implemented on a robot arm for automotive door panel inspection. Factories that build machined, cast or stamped goods also want to measure x, y and z dimensions for accuracy and quality assurance of their

> *The micromirrors on a DMD can enable 8-bit phase-shift rates greater than 1,000 patterns per second.“*

parts. For instance, companies may want to introduce a 3D AOI check for their finished goods, whether it’s a simple object like a smartphone chassis or something more complex, like a replacement hip joint.

Fast, Smart Light Pattern Generation

DLP technology is a micro-electrical-mechanical system (MEMS) and has been available in the industry for over 20 years. At the heart of every DLP chipset is an array of highly reflective aluminum micromirrors known as digital micromirror devices (DMDs). When combining DMDs with an illumination source and optics, DLP technology can power various display and spatial light-modulation systems.

DLP chips are commonly found in 3D machine-vision systems employing the technique of structured light. Structured light is the process of projecting a series of patterns onto an object and capturing the pattern distortion with a camera or sensor. The generation of a highly accurate 3D point cloud, once converted to computer-aided design (CAD) data, enables the analysis of an object’s features against the original CAD image.

Structured light is one of the top 3D image-capture techniques implemented in 3D AOI systems. DLP technology is prevalent in structured light systems, as it plays the role of a fast, flexible and highly programmable pattern generator. Structured light solutions using DLP chips are preferable for more detailed measurements, where accuracy in the millimeter or even micron range is required.

Integrating DLP Technology for Inspection Solutions

Whether trying to inspect common PCB failure modes or implementing a custom measurement for atypical alignments, 3D AOI equipment using DLP structured light capability can offer several compelling system benefits.

The micromirrors on a DMD switch very fast – in microseconds – and can enable 8-bit phase-shift rates greater than 1,000 patterns per second. This leads to high-speed data-capture rates to achieve real-time 3D AOI scans that are very useful for in-line data analysis. High-speed DLP chips also offer programming flexibility to select and reorder patterns on the fly. This helps ensure that the best pattern gets applied to specific parts or at a specific field of view, which helps extract the most accurate 3D information for analysis. Controlling pattern duration settings means that the on-time for each pattern can control the amount of light reflected from an object and maintain synchronization with the camera. With this flexibility, it is easy to see how a single 3D AOI design can inspect various object features at different assembly points in a production line.

DLP technology can be combined with various light sources and is compatible across ultraviolet, visible and near-infrared wavelengths. The flexibility to combine DLP technology with a broad spectrum of illumination and diverse camera options means that one piece of equipment can easily measure multiple objects. It makes sense that automotive production

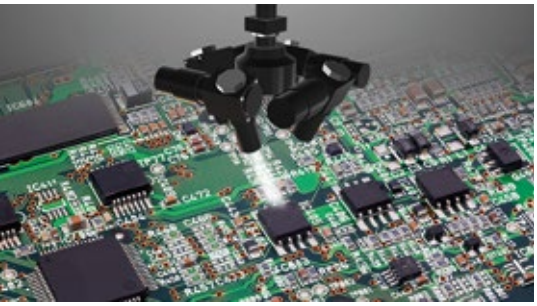
Inline Automotive inspection

lines, machine shops and modern 3D print factories are embracing 3D AOI solutions to inspect parts of various sizes and materials.

System integrators are able to innovate with flexible pattern control and new structured light algorithms when designing solutions using DLP technology. Optical architectures can also be optimized to match key resolutions and illumination requirements for inspection scans. Innovators can take 3D AOI systems to new levels using advanced programmability to control features in the spectral, spatial and temporal domains.

Future Trends for Cameras and Imagers

As I mentioned, a camera or sensor is a critical component in a 3D AOI system to detect structured light reflections. Today, for high-resolution systems, a 12-megapixel (MP) camera is typically paired with a 2 MP imager. A 2MP imager implies a 1,920-by-1,080-resolution imaging chip. In the future, the camera sensor market is heading toward 20 MP solutions. This has a few implications. First, the need for a 4 MP imager, or 2,560-by-1,600-resolution chip, will become necessary to optimize 3D AOI measurement quality. The good news is that the DLP chip portfolio is prepared for this increased resolution. Also, a 20 MP sensor means that more data can be captured. Processor solutions will also have to keep up in next-generation systems to manage the 5x step function of data points being gathered and analyzed.



3D PCB automated optical inspection (AOI)

Growth Ahead

Many companies ultimately depend on AOI systems to ensure that their products are built correctly. 3D AOI is increasing in popularity by introducing the z-dimension. In addition to the well-known inspection needs of PCB manufacturing, other emerging use cases embracing 3D AOI systems include automotive part manufacturing, machine shops and stamping factories. DLP technology is a predominant technology choice for 3D AOI structured light solutions because of its versatility to customize patterns at very high speeds, as well as its ability to pair with multiple light sources. These technology innovations, which help improve new inspection-system capabilities, will continue to fuel growth for the evolving 3D AOI market.

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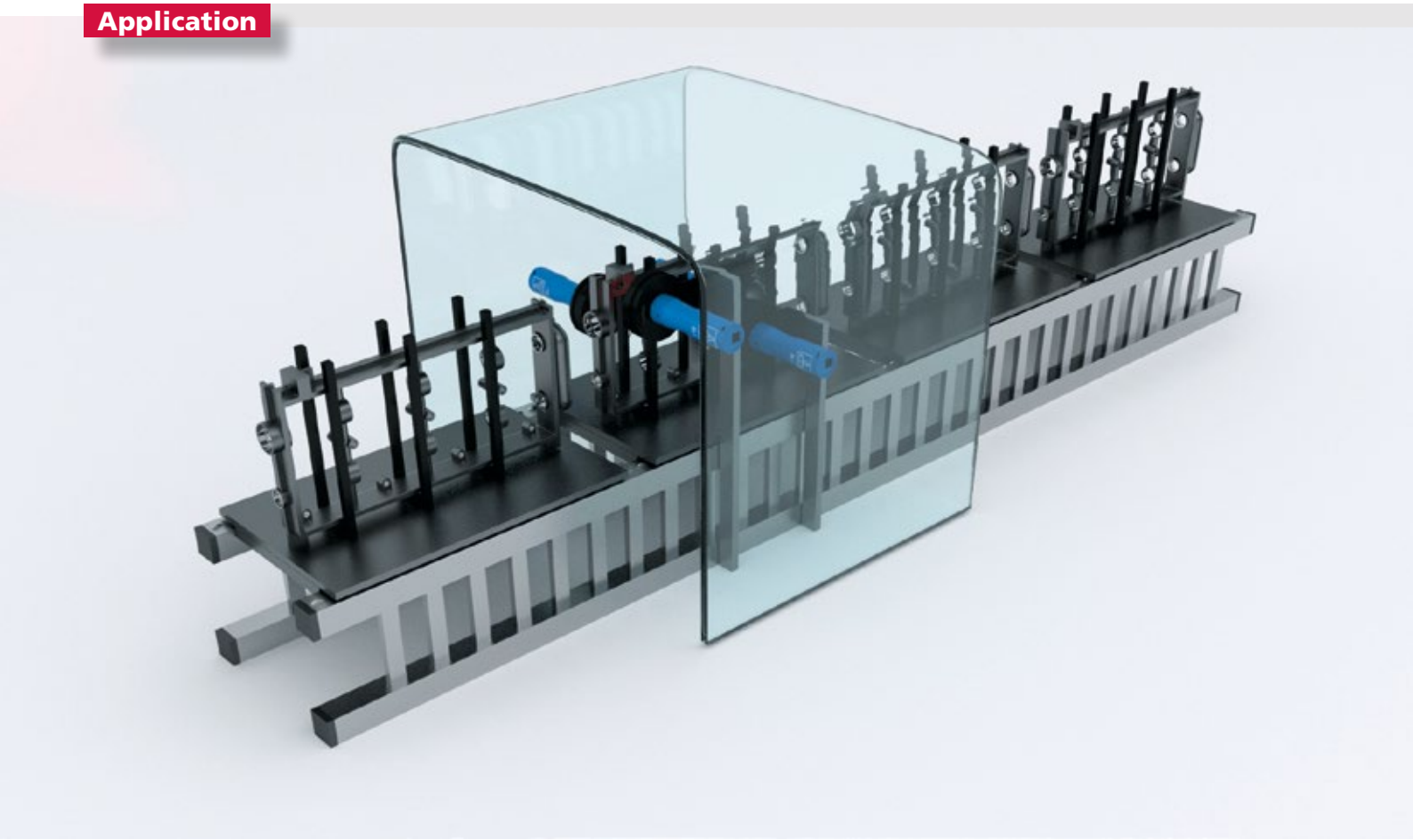


Hole-In-One

Bore Hole Inspection System on a Gear Frame

Control of bore holes, blind holes, cross bores and thread forming, or checks for remains from the drilling are challenges for the industry. A fully automated bore hole inspection system enables the checking of bore holes on various parameters such as threads, formings, and remains such as chips or foreign particles.

Manufacturers of turned parts, milled parts or plastic parts aim for a production based on zero-error principles. The three major causes for disruptions however are malfunctioning processes, the wrong tools used or the material itself. To match customer requirements for top quality usually 100 % inline or offline control systems are integrated.

Automated Control of a Gear Frame

A manufacturer of gear frames faced the challenge that during boring and automated reaming in some cases chips or similar remains got stuck in the holes. Since there are strict quality requirements for the automobile industry, every gear frame had to be checked before delivery. While watching a video on YouTube became aware of Pentacon's bore hole inspection system (BLI).

The bore hole inspection in detail

Designed as a modular unit, the bore hole inspection system may be integrated into existing testing equipment or can be used stand-alone as a manual test station. The bore holes or blind holes to-be-tested are inspected automatically on pre-defined parameters and then evaluated by a software. The evaluation, however, can only be by attributes because of the lens that was designed for this purpose.

Possible testing criteria are:

- thread run-in or thread run-out or its position toward an outer contour;
- the number of threads;
- chips between the threads or at the bottom of the bore;
- the presence of cross bores and the absence of burrs;
- the presence of blind holes.

The core of every system is a specially designed ento-centric lens suiting this purpose, plus lighting and a digital camera. The advantage of an entro-centic lens is the display of objects in closer distance. Objects in larger distance appear smaller, whereas closer ones appear bigger.

Adaptive Distance

Although not new to the machine vision industry in general, this new developed lens offers an unreached diameter-depth-sharpness ratio and an exceedingly good optical reproduction.

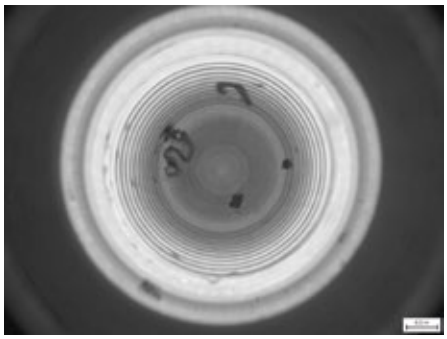
Depending on the shape of the part-to-be-tested, the distance between part and lens is adapted accordingly. It is important that the lens does not immerse into the hole and this way an easy automated part feeding can be realized. The whole bore hole inspection

system is either lighted by incident light or transmitted light. The incident light is arranged in a way that the light path runs along the optical axis. The system uses a modified lighting from IIM.

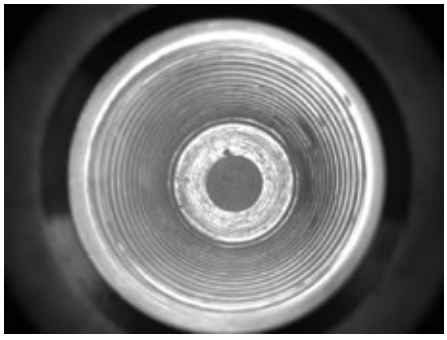
Evaluation Software

Attached to the ento-centric lens is a common 2 MP digital still camera hooked to a computer. The basic setup "Manual testing" offers an out-of-the-box viewer for the operator to manually evaluate the parts-to-be-tested. The advanced and automated bore hole inspection system features a software for evaluation and informs the operator (upon request) the results of the testing using a simple ample system. If the testing station is fully-automated (for example robot feeding and ejection), the system sorts the parts and transfers faulty ones outward. A software logs the results and may transfer the data to a CAQ system.

Bore hole inspection of cross bores (diameter 15mm, depth 40mm) with chip remains from the drilling process



Bore hole inspection of a blind hole with chips (M6 thread, depth ca. 14mm)



Bore hole inspection of a 4.8 mm blind hole with thread (M10 thread, depth ca. 25mm, cross bore diameter 4.8mm)

A Feasibility Study

During a feasibility study Pentacon's R&D engineers developed a solution for the provided gear frame. The following parameters had been pre-defined by the customer:

- 7 bore holes on the underside of the frame with a M6 thread;
- 2 bore holes on the underside of the frame with a M8 thread;
- 1 bore hole on the longitudinal side;
- 4 bore holes inside of the chain cover.

The gear frame is delivered to the customer as a pressured die-casting made of aluminum and will be processed afterward. The casting process occasionally produces cavities that need to be reworked but result in mechanical weakening of the structure. These cavities need to be detected and the parts sorted out.

Detection of Cavities

The classic approach of optical surface inspection is the use of dark field illumination. This method throws a slanting illumination toward the surface and results in a shaded image that can be evaluated. Due to the technological required milled surface (the sealing surface must not be even) this method cannot be applied. Instead a dome lighting is preferred, resulting in an over-modulated image for better evaluation images.

Detection of Bore Holes

The bore hole inspection system is placed right on top of the bore hole. The through bore is backlighted and blind holes are lighted with incident light. Both lighting concepts can be used in a single machine (see fig. on page XX).

Technical Implementation

The processing of the die-casted aluminum frames is done on two separate machines whereas the cycle time on the first machine is 18 seconds and 30 seconds on the second machine. Since both machines use the same conveyor belt, the average cycle time is 11.25 seconds. The parts are lined up unsorted but defined in orientation labeled with a Datamatrix- Code. These requirements were the starting point for the R&D engineers to design a bore hole inspection system fitting into the production process that guarantees the required cycle time and evaluates the pre-defined parameters.

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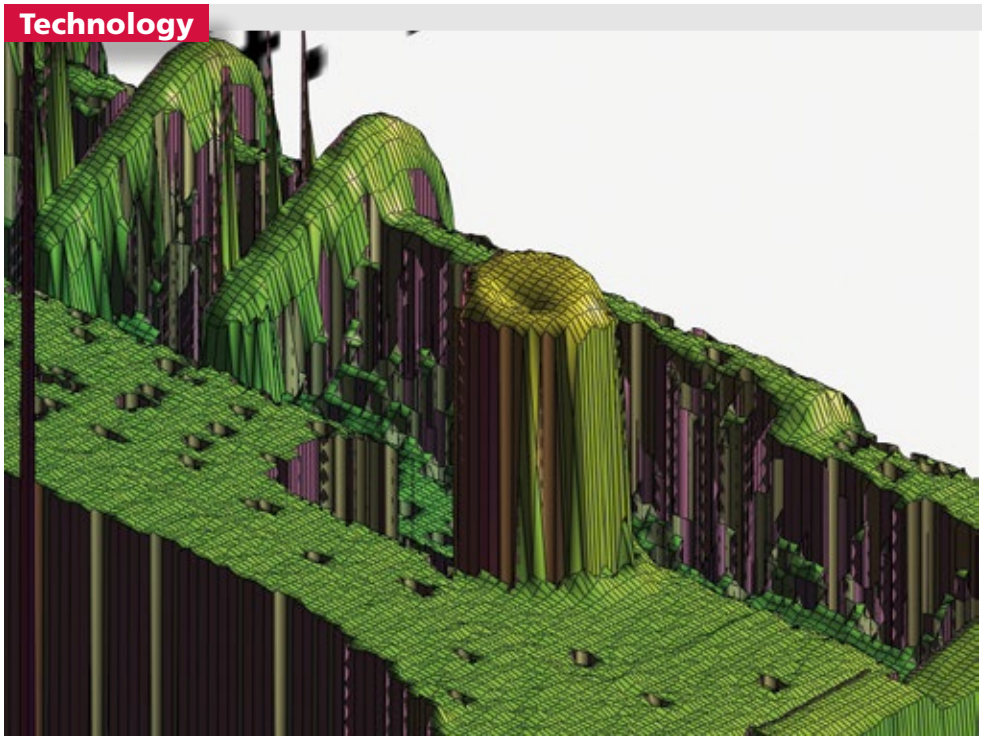
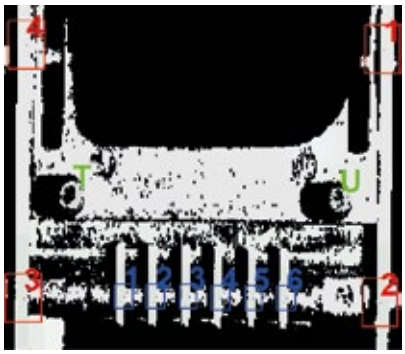


The system uses metal clips (1, 2, 3, and 4) on the connector to create a reference plane from which the system measures the height of the contacts. In addition, two posts (T and U) on the connector provide a datum for measuring the position information for each contact. ▼



Too Short?

3D Inspection System Examines Connector Pin Height

Advance could save connector manufacturers large sums of money and reduce recalls for automotive, aerospace, and other industries.

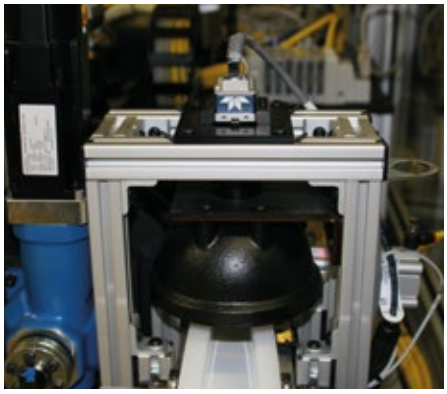
The global market for the Connectors industry is estimated to reach USD 80.3 billion by 2022, driven by the growing demand for reliable, fail-safe electronics in a wide range of industries, including automotive, aerospace, and defense/military. Faulty connectors buried deep within a major electronic subsystem in a car or an airplane can have catastrophic results. Failures in inspection systems can lead to loss of life and costly, massive product recalls. A new 3D inspection system could be the solution.

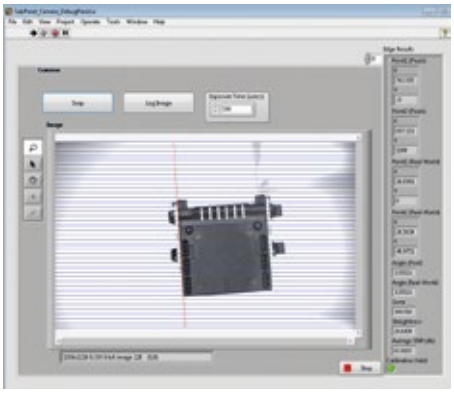
Save Lives, Reduce Costs

G2 Technologies, a test and measurement company with clients like Honda, 3M, BE Aerospace and Nascar, has developed a first-of-its-kind, customizable, automated 3D inspection system to catch flaws that previous inspection systems would miss. According to Craig Borsack, P.E., president of G2 and an industry expert, "Inspection historically has been limited to 2D and the human eye. Not anymore. With state-of-the-art 3D systems, companies can catch their mistakes before it's too late. That's important when lives and millions of dollars are at stake."

Borsack said if a tier-1 automotive supplier, for example, integrates a bad connector into an Engine Control Unit (ECU), and that ECU gets sold to an automotive manufacturer, is installed in vehicles and results in a recall, much of the associated cost will likely be charged back to the connector manufacturer.

In order to minimize the risk of faulty connectors making it into the supply chain, engineers at G2 Technologies have developed an automated connector inspection system. The system, built on the PXI platform from National Instruments combines a machine-vision based non-contact 3D inspection system, a cleaning station, electrical test and engraving stations.





Before connectors enter the 3D vision system for board-side scanning, they are inspected to verify that the correct part is present and that it's in the proper orientation.

Too Short?

"With contact inspection and the human eye alone, inspectors could see bent pins and missing pins all day long, but could easily miss a faulty connector with a pin that was just too short," said Borsack. "Now with this customizable application, they are able to use noncontact inspection and spot these faulty connectors that were previously making it through the process. This is a huge improvement and one that could save con-

nector manufacturers millions of dollars or more each year."

Short Takt Time

Borsack said that his company was able to achieve a 3.5 second takt time on each part. And G2 was able to develop a system that has the flexibility to inspect various connectors with pin counts ranging from four to 32, and deliver one-cycle rolling changeovers between parts. The inspection system is installed after stitching, a process that accumulates contact pins and inserts them into molded connector housings. Stitched connectors enter on an input conveyor and pass under a Genie Nano M1920 GigE Vision camera from Teledyne DALSA. An image of the connector is acquired with illumination provided by a DL 194 diffuse dome light from Advanced Illumination. The image is then analyzed to verify that the correct part is present and that it's in the proper orientation to proceed through the inspection process. If the part is not correct or is improperly oriented, the system diverts it into a reject bin.

Double-scanning

Parts deemed correct and that are properly aligned proceed to an orientation wheel that repositions the part board-side down, for the next station, which is board-side inspection. At this station, a Scancontrol 2650-25 laser line profiler from Micro Epsilon scans the entire board side of the connector. After board-side inspection, connector-side inspection takes place. Due to cycle time requirements, and the need to scan the part from both directions, inspection of the mating side of the connector is performed at two stations by two additional laser line profilers. "Two scans are required due to shadowing effects created by the connector shell as the part is scanned from one side," explains Borsack. "In order to get a complete 3D point cloud, the part must be scanned from both directions, then the images are combined to mask out the shadows."

> *"With contact inspection and the human eye alone, inspectors could see bent pins and missing pins all day long, but could easily miss a faulty connector with a pin that was just too short."*

The system scans from both sides and creates a plane based on a pad on the bottom of the mate side connector. This plane will be used to measure true position and pin height of the contacts.

After visual inspection, the connector goes to a cleaning station, followed by electrical testing, and finally, each connector goes through an engraving station. Passing connectors receive a date code and proceed to packaging. Failing connectors receive a reject code identifying in which station it was rejected and are moved to a locked reject bin to ensure that they don't get mixed with good parts. Borsack hopes connector manufacturers will consider exploring this for their companies. "It's a small price to pay when you look at the potential savings it offers. Not only can this inspection system help protect a manufacturer from being sued for millions of dollars in damages in a recall situation," Borsack said. "It could also absolutely save lives."

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Order Must Prevail

Machine Vision Ensures Orderliness in High-bay Warehouse

When thousands of completely different parts need to be stored in a high-bay warehouse, size and weight of the goods meticulously have to be matched with the available storage space. The customized combination of legacy equipment with high-end cameras and imaging software overcomes the challenge.

Kiefel, a company that develops and manufactures thermoforming machines and welding systems for the processing of plastics, stocks up to 14,000 parts in the new high-bay system at its site in Freilassing. The warehouse has a storage area of around 1,400 m² and a footprint of 120 m². A variety of machine vision components ensure that the company doesn't lose track of things.

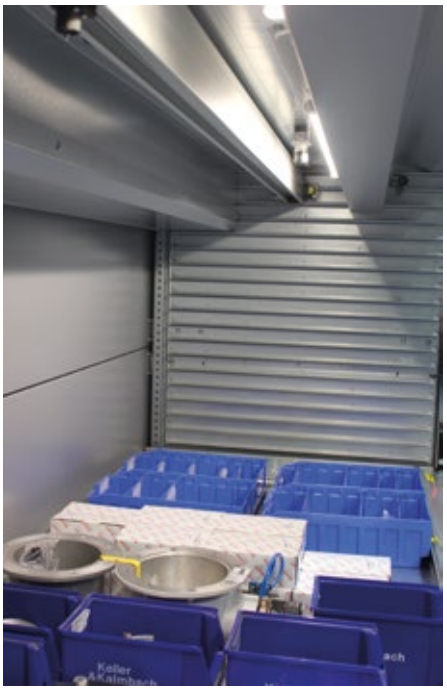
More Space, More Comfort

„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, describing the essential goals behind the change to a high-bay system, which was put into operation in spring 2017. Since then, twelve high-bay towers have provided sufficient space at the company's main plant for the tidy storage of up to 14,000 parts.

Weight Control

Among the challenges for the layout of the system, according to Hammer, was that the type and size of the stored parts vary a great deal and there are virtually no limits to the variety of the goods to be stored. „It could be anything from labels, small switches and other small parts through to tools, motors and bulk materials," explains the Logistics

The installation requires communication between the Kardex high rack controller (below) and the image capture system. © Stemmer Imaging



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

manager. When assigning them to storage, not only the size, but also the weight of the stored parts plays a role, because the maximum permissible load for each storage tray, of which there are up to 48 per tower, is 850 kg. „For that reason it's not enough to just find a tray with an area that is large enough when new parts are to be put into storage. The weight of the items that are already stored on each tray must also be available as information in order to be able to assess whether or not a selected storage place is suitable for the parts to be added. The employee can only put the part into storage if the space allows for it and the maximum load of 850 kg per tray is not exceeded."

Every tray´s present weight information is calculated by high-bay warehouse manufacturer Kardex's system via the current drawn by the motors that move the trays in and out. The difference between the maximum and the actual load is equivalent to the maximum weight that a new part may weigh when being put into storage. For simple handling, the currently stored weights are displayed to the operator in three traffic light colors, which he may define himself. The operator estimates the weight of a new part to be put into storage and then decides which tray he wishes to place it on.

„There is no standard system on the market that automatically recognizes free areas as well," Hammer explains. „At this point we developed a machine vision system with our partner the system integrator phil-vision, who helped us identify the free areas on the trays."

Always Up-to-Date

VIS.tray is the name of the resulting system that uses standard machine vision components from Stemmer Imaging. Phil-vision worked closely with Kardex on developing a system that integrates the optical systems in the high-bay towers in the best way possible. With the system, images of the present loading status of a tray are captured during the process of putting the tray into storage and the load weight is queried via the high-bay warehouse controller. These images and the loading information are stored in the database so that the warehouse worker can decide which tray has enough space to accommodate new parts simply by scrolling through the images.

If the sum of the already stored weight and the new parts to be added still lies below the maximum permissible load, the employee can request the selected tray simply by clicking on the input and output station on the connected touch panel PC, and then putting the new parts into storage. Shortly before the tray is put back into the high rack, a new image is captured and stored in the database, overwriting the previous image in

By scrolling the operator can find out quickly which trays still have space and weight capacity for the storage of further parts.

the process. This way the images are always up to date.

Standard Components for Image Capture

The selection of suitable vision components for integration into the output stations of the high-bay towers wasn't trivial, since on the one hand the entire width of the tray measuring 300 x 80 cm had to be captured and on the other the space for installing the camera was limited, and the distance to the objects was relatively small. „Our first idea was to fasten one camera to each tower on a mobile axis, but that would have been too mechanically complex, and the image capturing would have taken much longer," recalls Phil-vision's founder Philipiak. As an alternative, therefore, a system was created with two color cameras equipped with fish-eye lenses. The images captured with this system are distorted due to the lenses. Philipiak developed an algorithm for this that initially compensates the distortion of the two images and then combines them. „These stitched images then show, undistorted and in color, the complete storage area of the respective tray and it is then saved into the system," he says, further describing the procedure.

When selecting the vision components, he – as a former employee – placed his trust in the products of his former employer, who obliged him by lending him a few products for the initial tests. „Stemmer Imaging offers this service to some of its customers," emphasizes sales engineer Christian Berg. „This offer is used very frequently, and represents an advantage for our customers, who can put their machine vision systems through their paces before installation in plants or machines, and thus be sure that the selected composition completely fulfills the requirements."

In each tower, the systems installed at the customer´s site feature two GigE Vision Genie Nano cameras from Teledyne Dalsa, each with a fish-eye lens from Goyo, which were connected via GigE Vision to the embedded multi-touch PC from Vecow in the respective high-bay tower. Dedicated illumination was not required for this application as the light from the LED lamps integrated into the high-bay tower are sufficient to capture images in the necessary quality.

Philipiak chose the Genie Nano for several reasons: „This camera offers the required resolution of 1,280 x 1,024 pixels and the necessary speed to be able to capture the images within the 50 ms that lie between the signal to drive a tray in and the actual mechanical procedure. In addition, its compact design allowed it to be installed easily above the input and output station of the tray and it was attractive in terms of price." The lenses with the short focal length were selected as they had a very small working distance, and the embedded PCs meet all the requirements of the application with their performance and interfaces. In addition, he chose the imaging library Common Vision Blox from Stemmer Imaging for the software that corrects the distortion and stitches the images together.

Custom User Interface

The control between high-bay and machine vision system proved to be complex during the installation. Close co-operation was necessary between the integrator and the tower manufacturer in order to implement the system in accordance with all of the customers wishes.

The integrator put the finishing touches to the system with regard to its operation by creating a specific user interface conceived by Kiefel's logistics manager Hammer: „The clear representation of the space and weight conditions on the trays makes a huge contribution towards free storage space being found very quickly for new parts that need to be put into storage. That saves my colleagues a lot of time and is undoubtedly one of the reasons why the new warehouse system has been accepted very quickly by everyone involved."

A further advantage of the new system that Hammer mentions is the fact that the machine vision system offers a fast solution to problems caused by the potentially incorrect operation by the employees. If a part is put into storage by mistake without being scanned first, this part can be found again easily and quickly: instead of driving all the trays individually to the output station, they can now sift through the current images of all 48 trays per tower on the monitor to find the missing part.

In Use Throughout Europe

In addition to the twelve high-bay systems in Freilassing, the integrator has now put two further systems into operation at the customer´s subsidiaries in the Czech Republic and Slovakia. On account of the successful use, further applications are already planned in Austria, Switzerland and the Netherlands.

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Fully Integrated

Autofocus Barcode Readers with Fully Integrated Optics

Manufacturers often have to read tiny barcodes and symbols in challenging locations or at varying distances. A new imaging system with fully integrated optics facilitates this task.

The new MicroHawk Ultra-High Density barcode readers with Autofocus from Microscan ease manufacturer´s lives: Unlike other products that require special accessories to magnify small symbols, their UHD optics are fully-integrated within the imaging system and have been custom-designed to decode tiny symbols at very small distances. Tiny barcodes and symbols can be read even when situated in different locations or at inconsistent distances.

Less Complexity, Size, and Cost

The Autofocus cameras are equipped with a fully integrated liquid lens, and they can decode symbols where the x-dimension or barcode module of the tiniest bar is as small as 2 mil (0,0508 mm) at a distance of 40–150 mm in any environment. By integrating liquid lens Autofocus and UHD optics into the MicroHAWK, Microscan eliminates additional cost to the user, minimizes device size, reduces integration complexity, and lessens the need for additional optical accessories.

Fully Integrated Optics

With the addition of Autofocus to the barcode readers, the product is said to be the only UHD barcode reader with fully integrated optics that is currently available in the market. The new system reads and decodes tiny, difficult-to-read codes including very small Data Matrix symbols, and it includes a fully integrated true Autofocus system that automatically selects the optimal settings right out of the box, providing best-in-class performance. The reader's advanced imaging technology eliminates the need to spend time analyzing various configuration options before deployment. Setup time is minimal and does not require an investment in additional accessories.

Liquid Lens

Liquid lens technology was first offered by the manufacturer in 2009 with the QX Hawk Industrial Imager. Since the introduction of the MicroHawk platform for barcode reading and machine vision in 2016, Microscan has been setting the pace for high-performing miniature devices that can be easily embedded and configured. "We have designed MicroHawk UHD Autofocus to meet the needs of manufacturers requiring the ability to read tiny barcodes and symbols in difficult locations or at varying distances. Our new product is a very advantageous combination of high performance, flexibility and ease of use," stated Jason Dobbs, Global Product Manager at Microscan.

New User Interface

The new system is paired with a new release of the WebLink user interface, said to be the world's first setup tool that resides on the reader rather than on a PC. From the intuitive interface, users can enable and disable the Autofocus feature by clicking the Autofocus button in the toolbar. Autofocus causes the reader to search continuously for symbols at various focal distances within the field of view or to set fixed focal distances using spot focus functionality. Focal distance can also be adjusted by the user in WebLink. When enabling true Autofocus in continuous read or presentation mode, the barcode reader will automatically search for symbols, refocusing after every five no-read results. While in continuous read, triggered, or presentation modes, users can use spot focus to click anywhere within the live view captured by the reader to auto-set the focal distance for specific symbol locations.

The new barcode reader is offered in the ID-30 and ID-40 models with the SXGA 1.3 megapixel sensor, various lighting options, and with or without a polarizer. This offering is designed to read the symbols at a short range, a long-range version of the product is scheduled for release by the end of 2017.

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Optically Inspecting Printed Circuit Boards

Chromasens announces its 3DPixa 3D color stereoscopic camera for automated optical inspection of equipped and unequipped PCBs. By combining 2D and 3D visualizations in a single camera, the 3DPixa is suitable for PCBs with elevations of different heights. It features an optical resolution of 5µm for 2D color visualization and of 1µm for 3D image capture. High resolution is a basic requirement for the inspection of wire bonds with a thickness less than 1mil (1/1,000 inch = 0.0254 mm). The high-speed 3D algorithms developed by Chromasens for the 3DPixa clearly identify the wire connections in the generated stereo images, eliminating parallax errors and forming the basis to calculate precise connection heights. Defective soldering, foreign particles or possibly faulty positioning of components can also be automatically detected. Laser markings can be identified by using integrated dark field lighting.

www.chromasens.com

Coated Hypotenuse Right Angle Prisms with Tight Angular Tolerances

Edmund Optics introduces its new Techspec BBAR Coated Hypotenuse Right Angle Prisms. These broadband anti-reflection (BBAR) prisms feature a wide wavelength range from 350 - 2.200 nm and are ideal for applications that require a single axis retroreflector and optical systems with space limitations. The prisms provide a tight angle tolerance of ±15 arcsec, reducing ray deviation and eliminating the need for recalibrations of other parts of the optical system. The prisms are manufactured using an N-BK7 substrate and feature a high precision 40-20 surface quality, λ/8 surface flatness, and +0/-0,1 mm dimensional tolerance.

www.edmundoptics.eu

Easier than Ever

Testing is now easier than ever with the MidOpt NS100 Neutral Density (ND) Filter Swatch Kit. ND Filter Swatch Kits include all of the most popular ND Filters and allow you to stack multiple ND Filters to achieve a custom optical density. The NS100 is a great tool to have in the field or in a laboratory to test the effects of ND Filters, solve applications quickly and improve image quality. Neutral Density Filters are designed to reduce light intensity neutrally over a specific wavelength range without affecting image color or contrast. They also serve as a great solution for lens aperture control and reducing depth of field. ND Filters are available in both absorptive and reflective style options and can be used with monochrome or color cameras.

www.midopt.com

Mini-spectrometer for Color Measurement

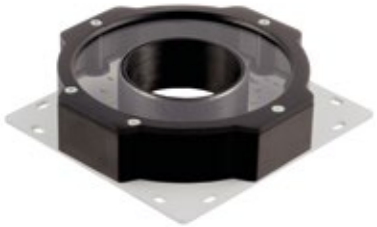
Hamamatsu Photonics introduces the new TF series mini-spectrometer for color measurement applications; the C13555MA. This USB-powered polychromator contains optical elements, a driver circuit and a built-in high-sensitivity CMOS sensor.
The 512 pixel CMOS sensor allows for low power consumption while retaining the sensitivity of a CCD; the trigger function within the device can be used for spectroscopic measurement of pulse emissions.
Spectrum data can easily be acquired and then transferred to a PC using the USB connection and an optical fiber to guide the measured light.

Free evaluation software is also included with the device and customers can use the disclosed DLL function specifications to design their own measurement programs.

www.hamamatsu.de

LED Lighting Series for Cost-saving Applications

The JustBright lighting series from MBJ Imaging was consequently designed to save costs. The 2mm aluminum LED circuit board also functions as base plate and heat sink thus ensuring optimal heat distribution. The case is 3D printed and can easily adapted to customized product designs. An innovative LED controller is already built in. The LEDs are operated for the first 20ms after the trigger in the so-called flash mode with up to 4-times higher current which is then automatically reduced to the brightness level for the continuous mode. Via the 0-10V analogue interface the lighting can be easily dimmed. The inputs are short circuit protected and a build-in temperature switch prevents overheating.



www.mbj-imaging.com

New Multispectral LED Line Light

ProPhotonix has announced the new multispectral LED line light Cobra MultiSpec that offers extremely bright and uniform illumination with discrete control of up to 12 wavelengths available. Wavelengths from UV to visible to IR are available. Cobra MultiSpec is designed to deliver multispectral tunable illumination allowing you to optimize your image acquisition. To enable rapid data acquisition and analysis, multispectral strobe patterns with up to four optically independent strobe lines come as standard. It is ideal for multispectral and hyperspectral imaging applications across a wide range of industries. This includes multispectral inspection of currency, food, semi-conductor, plastics and many more.

www.prophotonix.com

Measuring Technology for Large Coated Profiles and Tubes

With ProfilControl 7 DualVision XXL, measuring technology Pixargus has launched a new inspection system which is the first cost-efficient solution providing complete 360° surface inspection and shape measurement of large coated profiles and tubes. A newly developed camera system and a new calibration technique have enabled this leap forward in inspection technology. Conventional systems inspecting large profiles and tubes only check the main visible surfaces of the products. In contrast, ProfilControl 7 DualVision XXL (PC7 DualVision XXL) by Pixargus is the first system capable of providing complete inspection of all visible surfaces of large sections in a cost-efficient way.

www.pixargus.de

GigE Vision over NBASE-T Interface Hardware

Pleora's iPort NTx-NBT Embedded Video Interface is the industry's first product that brings the bandwidth and cabling advantages of NBASE-T technology to the vision industry. The NBASE-T specification defines a new type of Ethernet signaling that boosts the speed of Cat 5e cables well beyond the previous limit of 1 Gbps. NBASE-T technology is a natural evolution for high-performance imaging thanks to its increased bandwidth, low-cost cabling, and compatibility with existing GigE Vision software.

Pleora's GigE Vision over NBASE-T interface provides a cost-effective upgrade path for imaging device designers by supporting faster 2.5 and 5 Gbps transfer of uncompressed images over lower cost, flexible cabling. Leading X-ray flat panel detector (FPD) and camera manufacturers are designing Pleora's iPort NTx-NBT video interface into advanced imaging devices for medical and machine vision applications.

www.pleora.com

Ultra-compact Lenses for Precision Automation and Quality Control

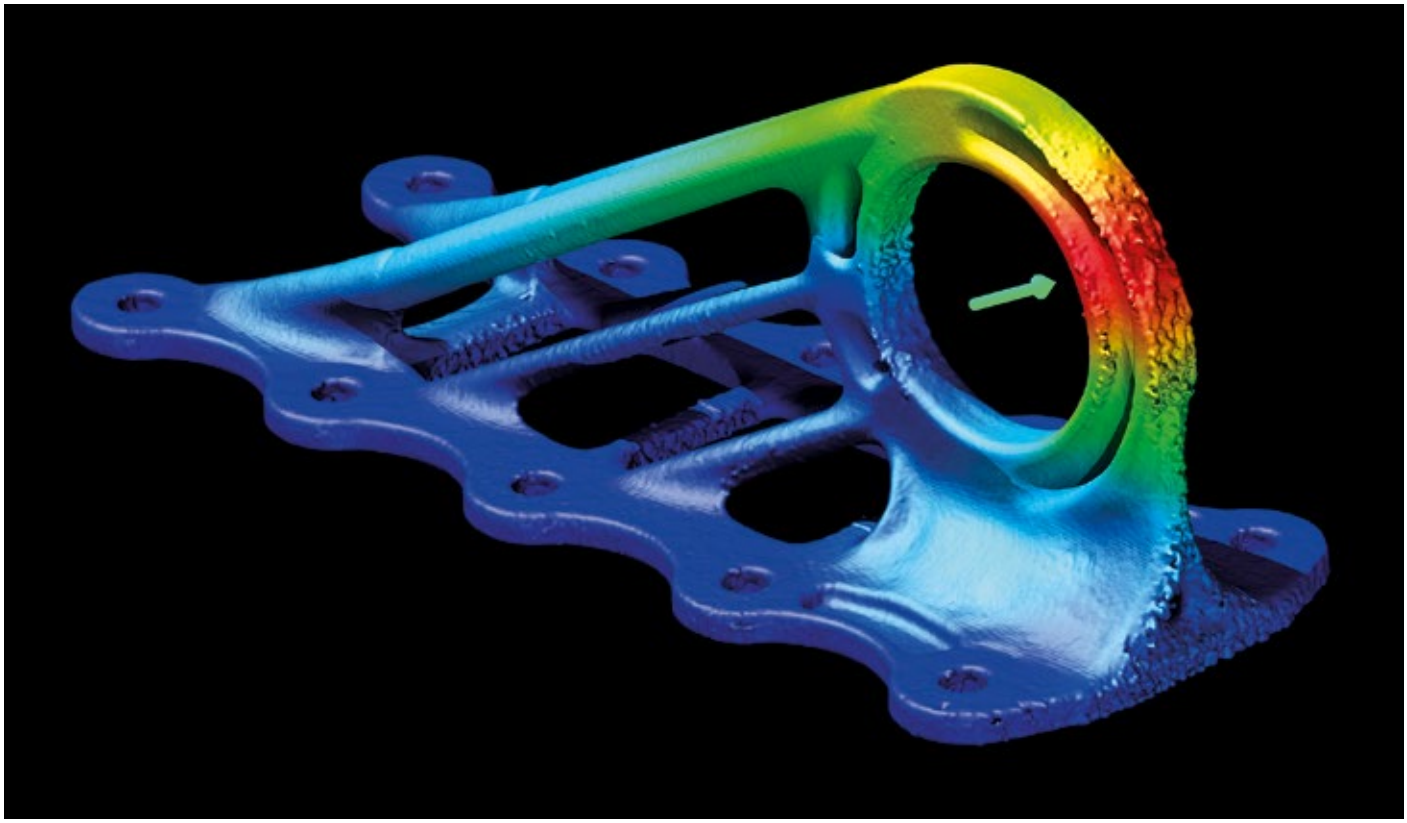
Tamron expands its portfolio with the M112FM series, seven ultra-compact high-performance lenses especially for high-resolution 1/1.2-inch sensors, such as the Sony Pregius IMX174 and IMX249. The new product line is particularly suitable for narrow areas of application where high precision and a highly detailled reproduction are required. The new series includes seven models with the focal lengths 8mm, 12mm, 16mm, 25mm, 35mm, 50mm and 75 mm. The M112FM series has been developed for the large picture area of 1/1.2-inch sensors such as Sony Pregius IMX174 and IMX249. These 2.3 megapixel sensors (1,936 × 1,216 px) with a global shutter have a 5.86 µm pixel pitch and are characterized by fast data processing, high quantum efficiency and an advantageous contrast reproduction. Tamron's new fixed focal lenses have been optimized to meet these requirements.They offer a high imaging performance free of vignetting and distortion. They are also suitable for the smaller 2/3-inch sensors with 3.45 µm pixel pitch.

www.tamron.eu/de/industrial-optics/

More Pixels, More Frames, Minimal Noise

Vision Components now supplies its small VC Z series smart cameras with more powerful CMOS sensors: Sony's IMX252 provides a 3.2 MP resolution (2048 x 1536 px) and captures 88 frames per second in this format. At lower resolutions, even higher speeds can be achieved. Like its predecessors in the same line, this new Pregius series sensor employs global-shutter technology. Users of previous-generation VC Z series cameras are very familiar with it and have come to appreciate its hands-on benefits over rolling shutters or CCDs: there is no bloom, smear, distortion, or overexposure in images captured with global shutter CMOS sensors. Despite its high resolution, the new sensor features a compact 1/1.8" footprint. It is housed on a 23 x 35 mm board and can be used with a wide range of lenses.

www.vision-components.com



Virtual Stress

Virtual Strength Tests Directly on CT Scans Increase Efficiency

In industries like die-casting, injection molding, and additive manufacturing, regular quality checks of manufactured parts made of a single material are indispensable. A new software goes deeper than just finding and analyzing parts: it enables a virtual strength test.

Wouldn't it be efficient to see whether a part would fail in practice directly on a computed tomography (CT) scan? Going a step beyond simply finding defects and analyzing them, a new software from Volume Graphics allows users to simulate the behavior of parts and thus test their strength virtually – and completely non-destructively.

In Detail

The optional add-on module „Structural Mechanics Simulation", which extends the VGStudio Max 3.0 software package, allows for virtual load tests directly on parts scanned using CT. A CT scan has the advantage of capturing every aspect of a part, such as porosities. The resulting voxel data allows for various material- and geometry-related analyses that take every detail of the real part into account.

This level of detail can also be seen in the simulation. Without time-consuming or lossy mesh generation, the software simulates the behavior of parts under force directly on the CT data. Thus the structural mechanics simulation provides results that help manufacturers accurately assess the suitability of the part based on its actual geometry as well as possible discontinuities in the material. The efficiency of this process is self-evident, as only those parts are sorted out whose discontinuities impair their strength.

Challenges of Additive Manufacturing

The structural mechanics simulation is a decisive step forward for the testing of parts that have been manufactured using die-casting or injection molding. An even bigger challenge than die-casted and injection-molded parts are additively manufactured parts. Additive manufacturing allows the produc-

The add-on module Structural Mechanics Simulation is available for the extendable high-end software VGStudio Max 3.0.

tion of every imaginable, sometimes highly complex, shape. A practical example is the delicate-looking Bionic Cabin Bracket of aircraft manufacturer Airbus, which – thanks to its organic structure – weighs 30 % less than its traditionally milled counterpart without compromising its performance.

Real Strength Testing

In order to check the quality of a part, it only needs to be scanned using CT. The voxel data set, which is generated during the scan, is then analyzed with VGStudio Max. Even before the introduction of the Structural Mechanics Simulation Module, the software already allowed for extensive tests such as porosity, wall thickness, fiber orientation, and more. However, since a part with many pores is not necessarily more prone to failure than one with fewer pores, a porosity analysis can only help so far in making judgements about the likelihood of the scanned part to fail in practice. The new module Structural Mechanics Simulation for VGStudio Max therefore subjects the scanned part to virtual stress tests. The results of the calculations help users to assess the stability of the part as a whole and, in particular, the effect of discontinuities on the stability of the part.

> *„The structural mechanics simulation works directly on voxel data, thus eliminating meshing as both a source of error and as a time factor.“*

Simulation without Meshing

The new software module is currently suitable for the simulation of linear-elastic static loads on parts made of a single material. The structural mechanics simulation works directly on voxel data, thus eliminating meshing as both a source of error and as a time factor. This is a crucial difference, since a conventional mesh generation – as is common in other software – can cause details that are smaller than the mesh cells to become lost. This is no small matter, as it is exactly these details that could cause defects in the part. If, on the other hand, all details, no matter how small, are taken into account during mesh generation, the models are often too large to be economically computed.

The new software´s structural mechanics simulation calculates and visualizes force lines, local displacements, and failure-relevant variables such as the von-Mises stress or the absolute maximum principal stress for directed force, torque, and pressure. The automatic hotspot analysis of the software identifies the most likely locations of failure. The color-coded result is displayed on the scan of the real part. In addition, the results obtained are available as tables and histograms.

Users can simulate both the real part with all its discontinuities and shape deviations as well as the CAD model, thus making comparisons between imperfect reality and the perfect CAD world possible.

Increased Efficiency

Regardless of whether one is dealing with additively or traditionally manufactured parts, the simulation directly on CT data increases efficiency and accuracy simultaneously. In the future, a discontinuity disqualifies a part only if it actually affects its strength. Until now, in the case of a defect analysis, experience and assumptions have been decisive factors in assessing a discontinuity. Now, users can use the results of the simulation to make their decision. In the ideal case, only defective parts whose discontinuities impair their strength are discarded. The more expensive the part or the smaller the number of parts or prototypes, the more important a correct diagnosis becomes.

At the same time, the structural mechanics simulation can be used to optimize the part and the production process. Even before production, the software can simulate the behavior of the part under pressure and optimize the geometry accordingly using the CAD of the planned part. In addition, critical areas in which little to no porosities should occur in the finished part can be identified.

In Practice

As an example, Volume Graphics analyzed generic tension rods and the previously mentioned bionic cabin brackets from Airbus with the structural mechanics simulation. For the tests, pores were deliberately inserted into both additively manufactured parts. They were then scanned, analyzed with the structural mechanics simulation, and tested destructively for comparison in tensile tests. The result: In the destructive tests, the parts actually broke at the points that the software had predicted.

A Key Dimension

The structural mechanics simulation expands the already extensive analysis possibilities with CT by a key dimension: virtual strength tests. Based on the holistic picture provided by CT, users can use the structural mechanics simulation to immediately check how discontinuities and other deviations from the ideal part affect the behavior of the real part under stress. Since the CT itself detects hidden and difficult-to-access surfaces and discontinuities, this works even on complex (additively manufactured) parts. It is thus possible to determine whether a discontinuity is really a defect and the part therefore scrap. Since this process allows only the actually defective parts to be sorted out, companies profit from an enormous increase in efficiency.

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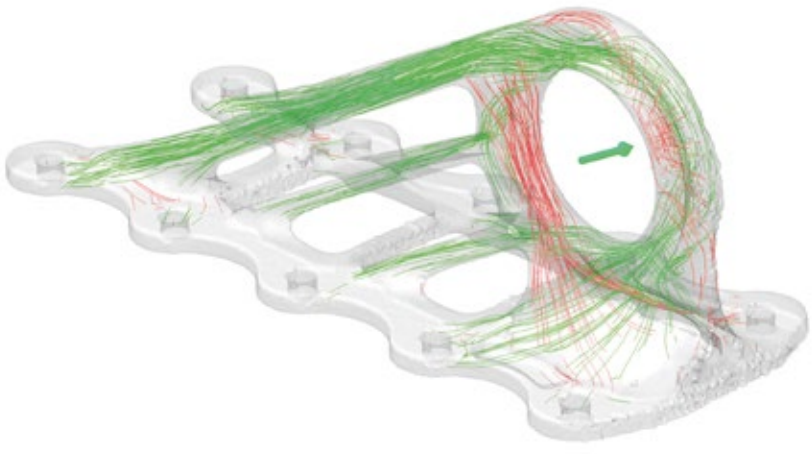

The cabin bracket with force lines drawn on the scan of the real part

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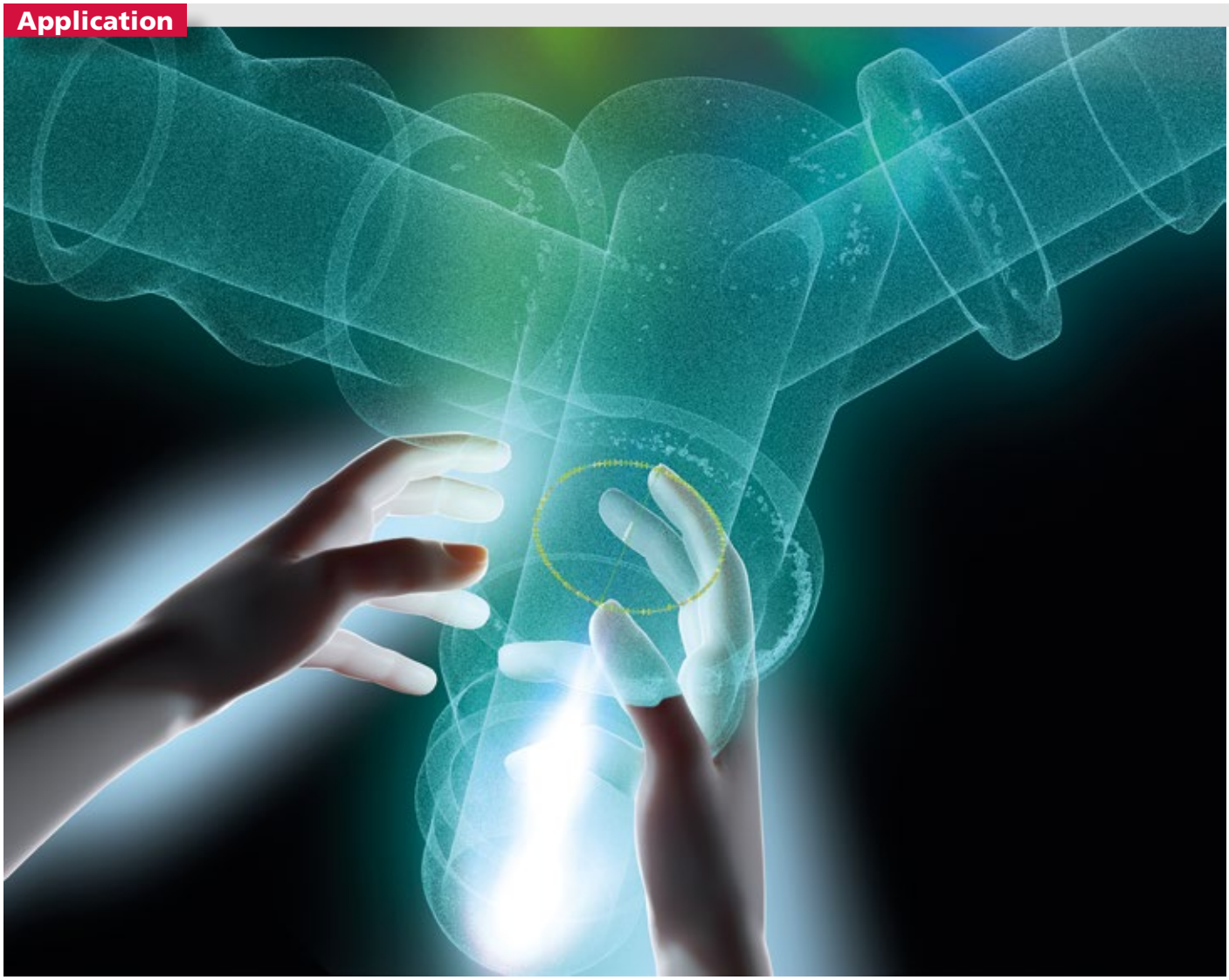


Light-Weight Quality

Quality Assurance and Metrology Using CT in Additive Manufaturing

While conventional testing and inspection methods frequently reach their limits within the framework of additive manufacturing processes, computed tomography gives us a non-destructive, three-dimensional view into the parts for further analysis.

Additive manufacturing (AM) is the term used to designate manufacturing processes in which component parts are built up out of an amorphous initial material on based on computer-generated data models. Additive manufacturing is particularly useful for meeting weight requirements, for example, in the aerospace, automotive, or medical industries. There are many manufacturing areas where cost effcient weight reduction are of great interest.

However, the high demands placed on quality in these industries calls for special attention to be paid to the topics of inspection technolgy and process control. Every part with relevance to safety – from the raw material to the final product – must be monitored end-to-end to ensure flawless accuracy. Conventional testing and inspection methods frequently reach their limits within the framework of additive manufacturing processes.

Additive Manufacturing

AM stands for a group of production technologies that are also referred to as 'generative manufacturing methods'. For example, instead of casting a workpiece or milling it out of a solid block, additive manufacturing builds up structural elements layer by layer out of the choosen material. This is the most distinct factor in differentiating additive methods from previously commonplace subtractive and reshaping methods for part manufacturing in industrial production.

Using additive manufacturing processes, throughput times can be shortened and, as a result, unit costs reduced, some to a substantial degree. Equally advantageous is the enormous freedom in design. Lattice structures or bionic design would not be producible through conventional methods wit-

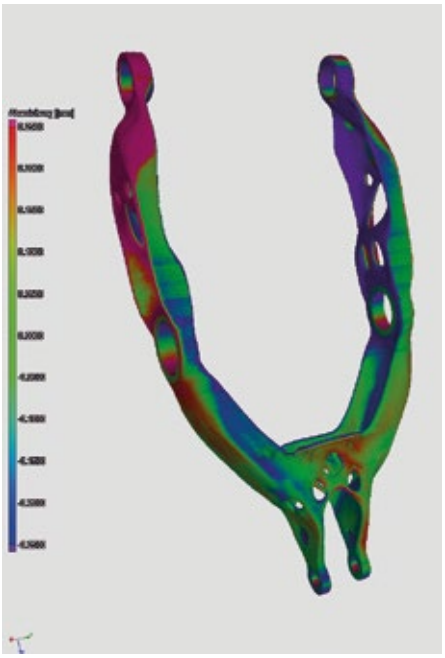
hout added expenditure. In contrast, additive production techniques allow highly complex parts to be economically manufactured.

Currently, selective laser melting (SLM), also known as 3D printing or powder-bed fusion (PBF), is the most common among the additive manufacturing methods for metallic materials. Parts originate solely from the targeted interaction of powder and laser light. A laser builds the workpiece layer by layer out of a bed of powder; a CAD/CAM model provides the 'blueprint' to accomplish this. A large number of metallic materials in powdered form can be used.

Quality Aspects

Due to their principle of layer-by-layer construction, AM methods provide new opportunities for ongoing process control. The production of each individual layer can be continuously monitored and depicted. On the other hand, the inherent advantages in AM, namely complexity and structure, result in new challenges as well. As per the current state of technology, it is not possible to ascertain or even prevent all relevant defects via online process monitoring. This, in turn, makes down-stream quality assurance mandatory, especially in the case of safety critical parts.

The layer-by-layer part 'build' means that most of these kinds of defects are correspondingly small and/or flat. The often complex geometry of the workpieces make an application of conventional non-destructive inspection techniques, such as ultrasonic or x-raying methods bearing a low resolution, not advisable. These methods are insufficient when it comes to determining defects such as cracking along with three-dimensional information (location parameters, dimensioning/size). This is where (µ)computed tomography comes in.



Measurements and analyses of the 3D CT volumes regarding deformations, symmetry, parallelism, coaxiality, perpendicularity and axial runout, including tolerances: variance analyses.

Illustration by courtesy of TU Hamburg Institute of Laser and System Technologies and Liebherr Aerospace Lindenberg

Computed Tomography (CT)

Computed tomography makes it possible to obtain a non-destructive, three-dimensional view into the part. CT creates a digital 3D visualization of the workpiece (volume), including all inner geometric and structural information necessary to assess the piece's quality.

All the data material that forms the basis for full-body part testing and inspection is generated with one single scan. Examples here include porosity, surface quality and deformation. Precise pore and wall-thickness analyses along with exact settings of shape and position parameters are possible. But that's not all: the tiniest deviations and part defects existing across all interior and exterior surface areas can be captured and localized.

> *„Among current methods of testing and inspection, the degree of detail from CT is far unrivaled."*

The scope of potential applications ranges from defect and assembly control all the way to the extraction of STL data and their transferral into the design process. A scope like this helps to optimize product quality, for example within the course of rapid prototyping.

In the production environment, the target/actual comparison assists in comparing the part quality required against the part quality achieved and in sorting out rejects at the right time. That saves time and helps in optimizing control variables relevant to production.

Application: Helicopter Bellcrank

A bellcrank used to hold the rotor blade was produced via additive manufacturing from a titanium-aluminum alloy, also termed selective laser melting (SLM). In this method, the driving factors were weight reduction without compromising the mechanical and structural attributes along with potentially lower production costs. Optimizing the design structures enabled the AM method utilized to achieve a weight reduction of around 30 %.

Quality control was mandatory here due to the part's safety importance. Factors to be considered as particularly crucial to quality were deformations of the bellcrank. For example, the parallelism exhibited by the crank arms and the diameter of the precision bores.

The high-resolution Yxlon FF35 CT computed tomography system is conceived for tasks like this. Optimization of the imaging chain enables the precise surface identification necessary for metrology down to the smallest subregions of the three-dimensional grid. Maximum stability for a high-precision positioning of the workpiece is achieved with a granite base and Heidenhain linear encoders. The climatized measuring chamber compensates for temperature fluctuations. In this applicaton, the water-cooled 225 kV microfocus reflection tube was used. The interaction of a granite-based manipulator, µ-focus tube, detector, FDD (magnification) and CT software algorithms results in the best image quality and accurate 3D data models.

As a method of non-destructive testing and inspection for additive manufacturing, computed tomography provides a data density and an information quality that optical or tactile methods are either unable to supply or only to a limited extent. Among current methods of testing and inspection, the degree of detail from CT is thus far unrivaled..

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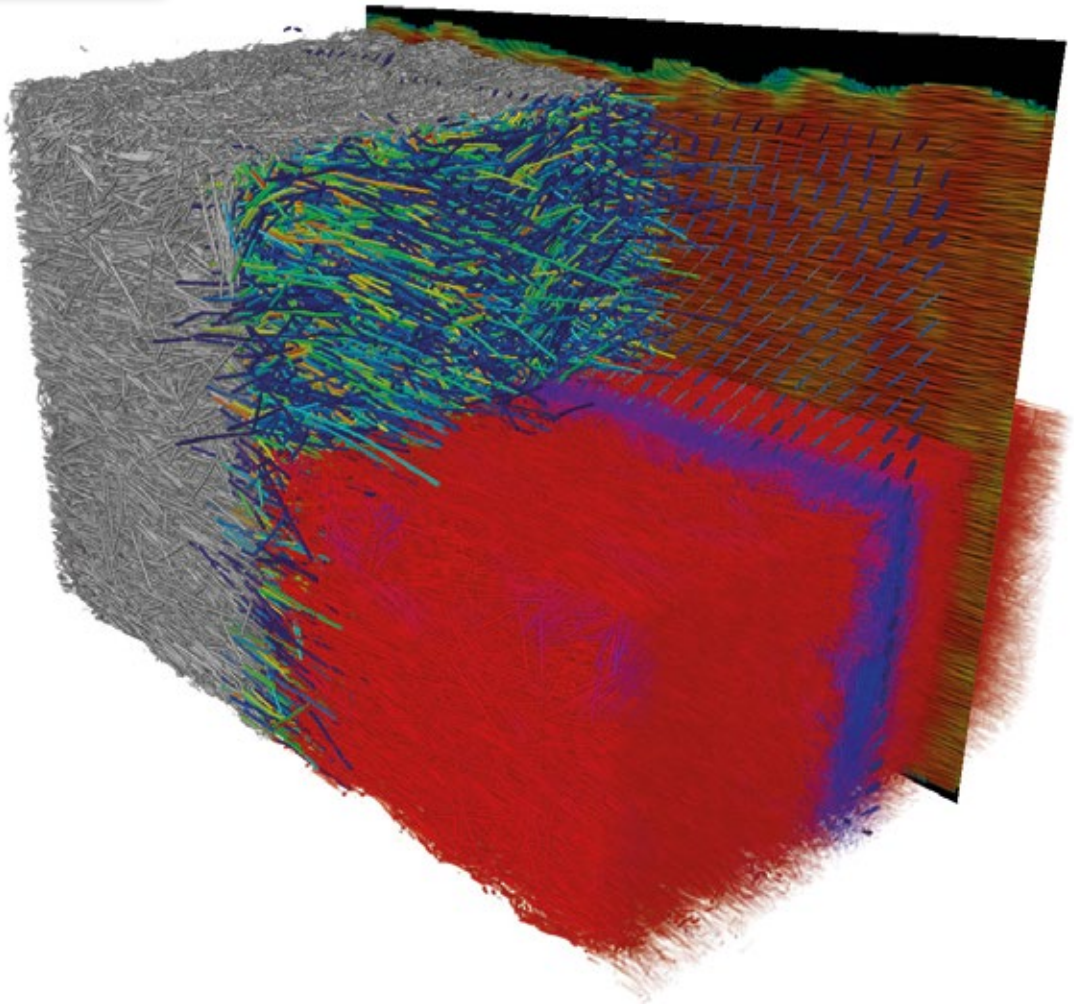

Courtesy of EMS Grivory

Tracking Fibers

Comparison of Fiber Orientation Analysis Methods

Computed Tomography (CT) is on its way to become the de facto standard in the field of materials science and material development, especially when it comes to the analysis of fibrous materials. To evaluate the distribution of fiber orientations within materials, different approaches that may operate at different resolutions are able to provide insight.

CT provides full 3D details of the inside of materials and enables the non-destructive analysis. This may be coupled with either in-situ experiments or numerical simulations to assess the physical properties of the materials. The current question in the industry is mostly about the compromise between image resolution and volume of data being analyzed, to extract accurate information allowing for the characterization of the fibrous material. When looking at the distribution of fiber orientations within the material, three different methods give insights about the fiber orientations.

Study of Estimation Methods

After presenting the three different methods in a first part, the data used for this study will be described. The described procedures will be applied to real data that has been acquired by a state of the art µCT system. There will also be an artificial dataset, generated with user-defined properties, that provides a gold standard reference against which the result methods can be evaluated. For both real and synthetic data, the behavior of the proposed approaches with respect to the scanning resolution will also be investigated, simulated by applying them to down-sampled versions of the same original images. The obtained results will finally be presented, allowing to draw conclusions on the respective merits of the proposed estimation methods.

Methods

Sub-volumes of materials of a predefined size are positioned without overlap along a regular lattice. The first approach (FFT) is based on the principal component analysis of the Fourier Spectrum. The second approach (GRAD) relies on the analysis of the local gradients. These first two approaches rely on the texture of the image to derive

estimates of the local orientation, and are expected to provide results even in the case of low resolution data where individual fibers cannot be distinguished. The third method (XFiber) consists of segmenting each individual fiber and extracting its centerlines. This gives immediate access to all statistics regarding the orientations of the fibers, but also about length, diameter or even tortuosity of fibers. The approach relies on a template matching stage and a specific fiber tracing algorithm. All three methods are implemented in Avizo 3D software for scientific and industrial data developed by Thermo Fisher Scientific (formerly FEI).

The methods are configured to operate on the same subdivisions of data to generate a tensor representing the local distribution of orientations in the corresponding subvolumes. This tensor is symmetric positive in all three cases, and its eigenvalue decomposition provides insights about the major orientation, and the dispersion of orientations. In the XFiber approach that relies on explicitly detected fibers the orientation tensor is clearly interpretable. It is defined as the outer product of unit vectors representing the orientation of fiber segments, weighted by the corresponding segment length L, and normalized such that they have unit trace:

$$A = k\sum L_i \vec{u_i}.\vec{u_i}^T$$

In contrast, the FFT and GRAD derive their tensors from image texture descriptors, making their interpretation less straightforward, and a direct comparison challenging. For instance, in the FFT approach, the major orientation corresponds to the direction where there is the least amount of high frequency variations, and thus to the eigenvector corresponding to the lowest eigenvalue. On the contrary, for the GRAD and XFiber approaches, the major orientation is the eigenvector corresponding to the largest eigenvalue.

Therefore, comparisons of the methods are preferably performed based on the statistical relationship between the estimated tensors, and on the estimated major orientation.

Data Sources

Generation of Synthetic Data

A synthetic distribution of non-overlapping fibers (straight cylinders) following a skin-core structure has been generated, such that the different methods for estimating the fiber orientations may be compared quantitatively against a known reference. The synthesis has been performed using a force-biased algorithm. The process starts with the insertion of fibers following prescribed random distribution laws for their position, length, orientation and diameter, within the volume of interest. Then, the algorithm iteratively translates and rotates fibers that are overlapping. The diameter of all fibers is also slightly reduced at every iteration to ensure the convergence of the algorithm. A fiber volume fraction around 10 % was obtained. The volume was discretized, including moderate gaussian noise and blurring, with a resolution such that the average fiber diameter corresponds to 5 voxels, and turned into a grayscale image of 512 x 512 x 512 voxels (see fig. 1).

Glass Fiber Composite

The methods are also applied to an actual µCT acquisition of a Glass Fiber Reinforced Polymer (GFRP). The polymer is charged with standard short glass fibers of 10 µm diameter on average, at a volume fraction measured around 17% in the considered volume of interest, which is roughly 2 x 2 x 2 mm³. The scanning resolution is 1.5 µm, which is sufficient to distinguish individual fibers (see fig. 2).

Results

The volumes are subdivided in cubic regions following a regular lattice, to perform local orientation analyses using all three methods. Both datasets follow a similar skin-core structure with orthogonal fiber orientations. The subdivision of both volumes is made such that most slabs of the data contain homogeneous regions in terms of fiber orientation with one clear major orientation (either X or Z), while other slabs contain a mixture of fibers oriented mostly along X, and along Z.

For both datasets, the local orientation was measured on the full resolution data, but also after downsampling by a factor 4, and 8, using Lanczos interpolation, to evaluate the robustness of the estimates with respect to imaging resolution.

Synthetic Data

For the synthetic dataset, reference orientation tensor is computed using (eq. 1), in other words the same approach as with XFiber, although on the true fiber segment (before discretization), whereas the XFiber measure is generated after generating a grayscale volume and performing the fiber detection on it.

Considering the whole volume, the different approaches show strong statistical relationships with the reference tensors, which seem almost linear. The coefficient of determination R^2 appears to be very strong, except for the diagonal component in the GRAD approach. This tendency is fairly well maintained when decreasing the image resolution, as shown in Figure 3(d). The off-diagonal component appears more difficult to estimate, and less robust. However, it must be noted that in the considered synthetic model, few fibers are actually significantly away from the two major orientations, making it more difficult to draw conclusions. It seems more interesting to note that - although the actual accuracy of the fiber detection of the XFiber approach considerably

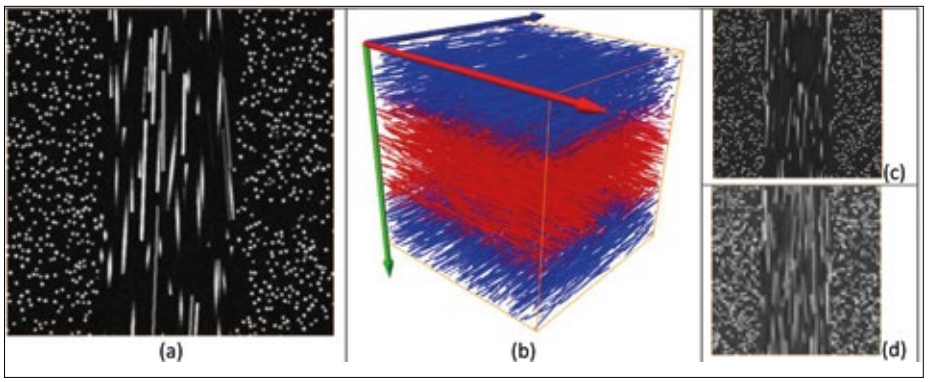

Fig. 1: (a) Slice through the synthetic volume, (b) 3D volume rendering of the synthetic volume, colorized according to the estimated major orientation (the red, green and blue axes indicate the color code), (c) slice through the synthetic volume, downsampled by a factor 4, (d) downsampled by a factor 8.

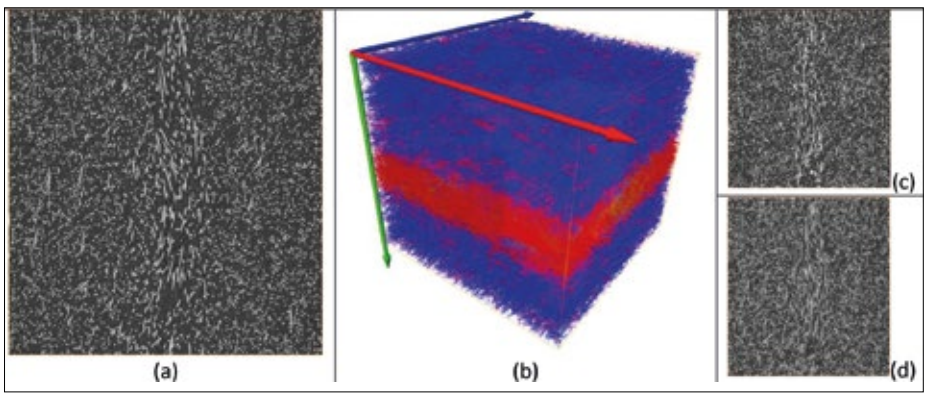

Fig. 2: (a) Slice through the GFRP volume, (b) 3D volume rendering of the GFRP volume, colorized according to the estimated major orientation (the red, green and blue axes indicate the color code), (c) image downsampled by a factor 4, and (d) factor 8.

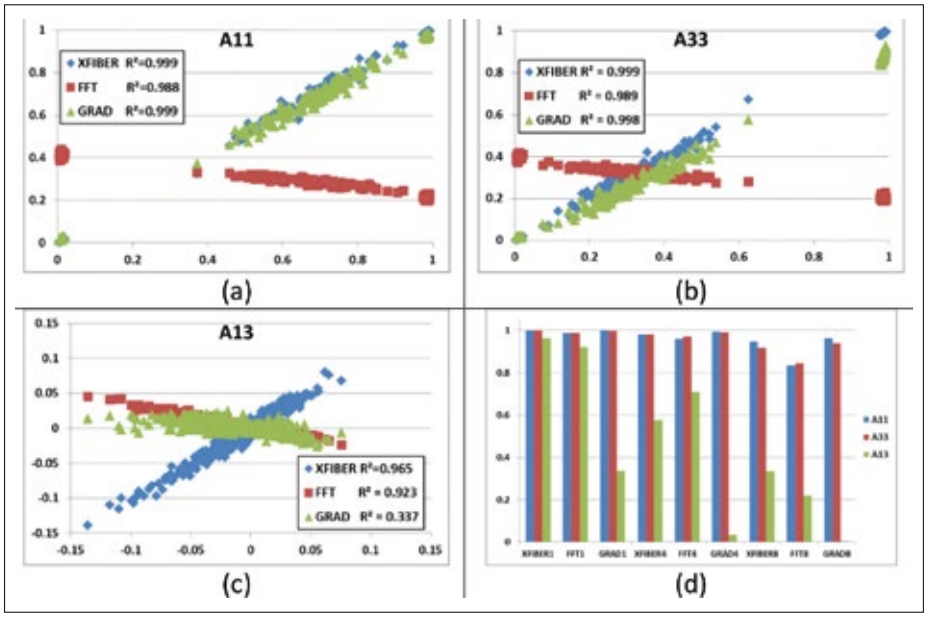

Fig. 3: (a), (b), (c) Scatter plots of the true vs estimated tensor components, respectively (a) A11, (b) A33, and (c) A13. (d) Corresponding coefficients of determination for the tensor components, estimated using the different methods at different image resolution.

drops at lower resolution, the results of the tracing still show high value in terms of orientation measurements.

Examining the results slab by slab, through the thickness of the data structure, allows the investigation of results in further detail. The subdivision of the data has been performed such that all slabs except slab 3 and 6 present a homogeneous population of fibers that are oriented either along the X (slabs 4 and 5) and Z (slabs 1, 2, 7 and 8) axes, whereas slabs 3 and 6 contain a mixture of fibers oriented in X and Z directions (about 2/3 of fibers are along X, and 1/3 along Z).

In homogeneous regions (all slabs except 3 and 6), the average angular error (angle between the true major orientation, and the estimated orientation) was very low for all 3 methods, with respectively 0.35, 0.48 and 1.26 degrees for the XFiber, FFT and GRAD.

On the other hand, in inhomogeneous regions (slabs 3 and 6), the estimation of the major orientation proved to be prone to significant errors using texture-based approaches, whereas the fiber tracing approach remained very precise. However, the estimation is significantly more accurate and robust with respect to resolution using the XFiber approach compared to the texture-based measurement methods GRAD, and especially FFT.

Glass Fiber Composite

A similar experiment and analysis was carried out on the GFRP sample. Since no ground truth orientation measurements are available in this case, we use the results generated by the XFiber method at full resolution as a reference. As with the synthetic dataset, and when considering volume-wise statistics, the different methods appear to be very strongly correlated. The coefficients of determination of the tensor components are very high, and the major orientation estimation remains within 5 degrees in homogeneous regions of the data, and still within 12 degrees after downsampling by a factor of 8.

However, the estimations from the different methods vary significantly when considering inhomogeneous slabs 4 and 7, which are at the interface between regions presenting orthogonal fiber directions. Although the XFiber approach provides estimated orientations that are relatively consistant across scales (< 10° difference for the major and second orientation at resolution factor 4), the other methods show considerably more deviations (around 20° or more).

Consistent Results

The three different approaches implemented in the Avizo software were applied on a skin-core glass-fiber reinforced polymer and on a synthetic dataset generated with a similar fibrous structure providing a gold-standard reference. The robustness of the estimates with respect to decreasing the image resolution was also investigated - as the typical practical tradeoff with CT acquisition is to choose between imaging smaller volumes at a higher magnification or using a coarser resolution but an increased volume of acquisition.

The results on both synthetic and real data suggest that the fiber local orientation tensor estimations are, overall, quite consistent for the different methods and relatively robust to a decrease of the image resolution. Interestingly, even if in terms of detection performance, the fiber tracing accuracy drops significantly when the image resolution reaches the fiber diameter. The results it generates are still exploitable and actually quite precise and robust to characterize the orientations in the sample.

The fiber architecture considered in this study allows the analyses of regions with a single population of fibers, all more or less oriented along the same orientation; as well as regions featuring two populations of fibres with two orthogonal preferred orientations. When a single orientation is present, although the fiber tracing approach is slightly more precise especially at finer resolutions, all considered methods behave accurately. However, when a mixture of orientations is present, the texture-based approaches show significantly decreased performances, whereas the fiber tracing approach remains precise, even at a relatively coarse image resolution. This is particularly interesting when considering fibrous materials exhibiting complex distributions of orientations, such as woven fibres, moulded composites, or more random distributions.

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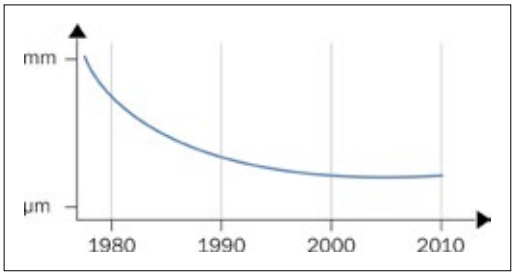
Making the Right Choice

Coordinate Measuring Machines Versus Portable Metrology: How to Choose the Most Effective Measuring Tool

Quality control managers have the delicate task of verifying and guaranteeing that manufactured parts meet customers' requirements, specifications, and tolerances. While coordinate measuring machines are usually their preferred choice, alternative metrology instruments are now available, enabling them to perform accurate measurements directly on the shop floor during the manufacturing process.

To carry out their mission critical tasks, quality control (QC) managers mainly rely on coordinate measuring machines (CMMs), which are the most precise and accurate metrology equipment available for quality inspection. Systematically choosing the CMM to perform all QCs can, however, affect the manufacturing process, inspection flow, and customer delivery because of its high accuracy, the CMM is widely used and, often, totally loaded by all types of QC. It might cause a bottleneck effect that clogs the manufacturing process. It might not be available to practise critical inspections, such as the first article inspection (FAI). Worst, it might generate critical delays in shipping the manufactured parts to customers. There are now several alternative metrology instruments available, enabling QC managers to unload their CMM and perform accurate measurements directly on the shop floor during the manufacturing process. The measurements obtained with these alternative solutions prove to be insensitive to external instabilities and, most important, very accurate.



Evolution: Flush and gap tolerances in automotive

Challenges

Better Quality Products

Over the past decades, the market's interest for quality products has increased significantly. The market now expects better quality products for both high-end markets and popular brands. To meet this demand, manufacturing companies must guarantee their products' performance and high quality by achieving more QCs and better inspections.

Tighter Tolerances

Tolerances that must meet QC standards are now increasingly sophisticated and optimized. To meet these tighter tolerances, QC managers need more accurate and better performing equipment.

More Equipment, More Resources

On the one hand, customers require more QCs; on the other hand, industry tolerances have tightened. This has a direct impact on the work of QC teams that experience more pressure because they are being asked to do more complete and accurate inspections in greater numbers and at different stages of the manufacturing process. To meet this demand, QC managers need more metrology equipment and more metrology staff to operate them. These two solutions are feasible in the short or middle term, but they require a large investment of time and money.

Purchasing new metrology equipment, such as a CMM, requires important capital investment. The new equipment will also permanently occupy valuable space in the laboratory, which must be controlled for temperature, humidity, and vibration.

Hiring more qualified personnel to perform more inspections involves time. It is not an easy task to find experienced metrology specialists. Training is, therefore, required to enable new employees to set up and manipulate sophisticated machines.

Although purchasing new equipment and hiring new staff are the ideal solution

to more inspections, the reality is different. Companies privilege using equipment to their maximum capacity and adding extra shifts before pausing, analyzing the situation, and considering different solutions. This reaction may have consequences that will impact the complete QC process.

Impacts

Bottlenecks

Bottlenecks happen when the manufacturing process is clogged by inspections waiting to be completed on the CMM. The major consequences of these bottlenecks are delays in deliveries to customers. To counter this, QC managers may decide to reduce the frequency of the sampling and/or inspections which means that only the minimum inspection is performed. No further investigation will be made to improve the QC process or to proactively identify issues before they occur. This may severely impact the products' quality and increase quality issues.

Pressure

QC managers might suffer from the pressure exerted by the production team to ship parts without delay. Part inspection must follow production to ship on schedule. Therefore, metrologists might be asked to make compromises in the execution of their work. They might no longer have the flexibility to perform QCs as they are used to. Inspecting parts as soon as they come out of production to ship them to customers immediately is the reality of many QC managers.

False Perceptions

Not All Parts on the CMM

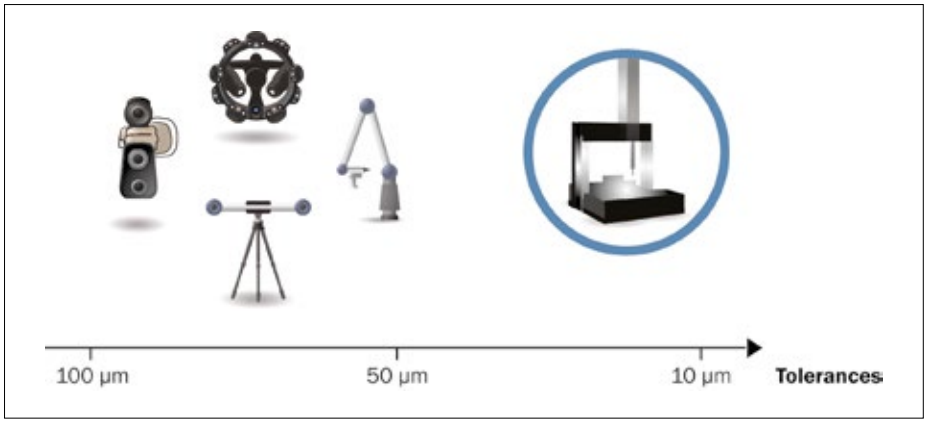
CMMs have undeniable advantages, but they also have clear limitations. For instance, it is certainly the most accurate measuring instrument available on the market. However, it requires moving the measured part and is often loaded by all types of operations. Therefore, a good way to optimize its key features is to use it specifically for highly accurate measurements, such as the first article and final inspections of critical parts. All other controls that do not require high accuracy do not need to monopolize the CMM. In fact, the high level CMM is an overkill for most intermediate and sporadic controls and for parts with looser tolerances.

A non-exhaustive study found that from a tolerance of 50 µm it is possible to use an alternative solution, such as measuring arms or portable technologies, and reach the level of accuracy required for the part's inspection.

CMM in action

Solution

Complementing traditional measuring equipment with portable technologies is the solution to increasing QC managers' productivity. Adding new tools to the common metrology kit gives more possibilities, including better use of the CMM, optimizing its use for more inspections, and allocating it for the most important controls.



A non-exhaustive study found that from a tolerance of 50 µm it is possible to use an alternative solution, such as measuring arms or portable technologies, and reach the level of accuracy required for the part and inspection.

Key Features

- Easy to use and simple to setup: Requires less-qualified staff and decreases the required time for every inspection.
- Portable: Gives the flexibility to address specific needs on the shop floor, in the manufacturing area, near or on the production line.
- Insensitive to external instabilities: Tracks any vibrations that could impact the measurement system.
- Flexibility: Enables measurement of different types of parts, materials, and sizes.
- Accuracy: Allows multiple inspections with a high level of precision which gives users confidence.

Benefits

Adding new tools to the common metrology kit generates two important benefits: It unloads the CMM and returns to an acceptable workload where all QC standards can be restored, and it lowers the level of expertise required to operate instruments.

Making the Right Choice

The CMM will always maintain its leading position in metrology labs. It is unquestionably the best and most accurate metrology equipment. This is why it should only be dedicated to specific, important, and accurate controls, such as the first article and final inspections of parts with tight tolerances.

Unloading the CMM by adding portable alternative solutions to the metrology kit should be considered. Since these technologies are specifically engineered to address external instabilities - due to their optical components - more controls on the production floor are possible. In addition, since these measuring instruments are easy to use and to set up, they can be operated by less qualified staff.

Finally, not only can QC standards be restored, but more inspections can be done, enabling the opportunity to improve the QC process, be more productive, and obtain better quality products.

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Coordinating Quality

Coordinating Measuring Machine Enables Inspection in Oil and Gas Industry

A large coordinating measuring machine enables the rapid, accurate inspection of large oil and gas components including huge wellheads.

Established in 1973, Express Engineering has grown from its origins as a precision engineering and tool-making company, to what is now a leading global Contract Manufacturing Group. The company supplies the global oil and gas market with a wide range of highly integrated precision machined components, kits of parts and fully assembled pressure tested products, including wellheads, christmas tree valves, manifolds, completions, tooling, flowlines and connections. A skilled workforce of approximately 300 people is located at the Tyneside oil and gas headquarters where it boasts 160,000 square feet of manufacturing space that accommodates more than 70 machine tools, including advanced CNC vertical boring, turning and milling machines.

Challenging Operation Environments

Given their critical nature and the environments they operate in, the quality of the products manufactured are of paramount importance to the enterprise. In addition to regular in-process, on-machine checks, the quality of the company's output is assured by comprehensive final inspection routines performed by a range of inspection aids, including Mitutoyo CMMs that are located strategically throughout the Gateshead facility.

Consequently, having invited quotes for an extremely large, very precise coordinate measuring machine with the volumetric capacity to enable the efficient measurement of the company's largest components, an order was soon placed for what turned out to be the largest Mitutoyo CMM ever installed in the UK.

Measurement of Oversized Components

This recently installed system is an adapted version of a large capacity Mitutoyo Crysta-Apex C, model 204020. To enable oversize components to stand upright when being measured, the CMM was modified by an extended Z axis and a 1.2 meter diameter hole bored through its granite measuring table. Riser plates were fitted to elevate the granite table and a lower component support was located beneath the hole. These modifications enable extra-large components such as 2-metre high, 4-tonne wellheads to be lowered by crane through the table and accurately measured at a single setting. The machine has a measuring volume of 2,000 x 4,005 x 2,005 mm.

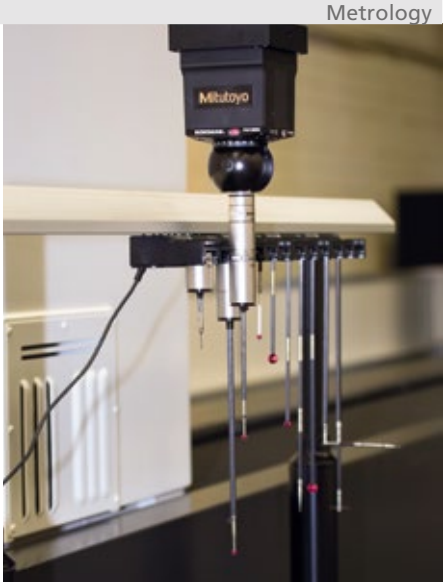
Express Engineering Quality Manager Bill Mole explained. "Our company is accredited to ISO 9001:2008 and aerospace standard AS9100; we maintain a quality management system which meets the requirements of both of these standards and other more extensive customer and industry requirements. Previous to purchasing our new Mitutoyo CMM, to inspect our increasing range of larger components with demanding dimensional tolerances, such as wellheads that stand 2 meters high, we would make a partial inspection on one of our larger CMMs, then reposition the component to complete the inspection routine. Although our previous inspection techniques were accurate, the volume of wellheads, and other large oil and gas industry components we now manufacture, meant that we needed to find a quicker, more efficient solution."

Tailor-made Solution

"As our existing seven Mitutoyo CMMs have proven very reliable, and given the service and back-up we have always received from Mitutoyo UK, we approached the manufacturer with our capacity needs and accuracy requirements. Although we enjoy an excellent relationship with them, and have been im-

pressed by our existing CMMs, in accordance with our policy of seeking more than one quote for capital equipment, such as machine tools, we contacted another manufacturer whose products also met our requirements.

In addition to the quote we received from Mitutoyo, for a specially adapted version of the company's large Crysta-Apex C 204020 CMM, representing the best solution, it also proved to be the most cost-effective option. Also, as our inspection staff are fully conversant with the software, and given that we replicated our previously used tooling racks on the new machine, the choice of this option has clearly helped us in terms of staff flexibility, training and continuity."



A specially adapted version of the Crysta-Apex C 204020 CMM ensures precise measurement of large component.

Challenging delivery times

"Given the challenging delivery times that are often required by the global oil and gas industry, we have made large investments in the best available CNC machine tools to help reduce our lead times and to ensure the best possible manufacturing standards. Now, in addition to further improving our large-component accuracy capability, our new CMM has enabled us to slash our inspection times on components such as wellheads. For instance, a comprehensive final inspection routine on a complex wellhead that previously took over 12 hours, now takes just four hours. Not only does our new CMM help us to adhere to the most challenging of component lead times, it is a good example of Express Engineering's continuing commitment to ensuring high standards of manufactured quality."

Robust CMM Construction

Mitutoyo's Crysta-Apex-C 204020 is a high-speed, moving bridge type coordinate measuring machine. The advanced CMM features a robust granite base that incorporates a Y-Axis guide way, whilst a unique design of self-adjusting air bearings on each axis provides excellent stability throughout high-speed movement and measuring routines. To further improve stability when measuring critical components, and to help provide excellent wear resistance, the CMM's moving bridge is constructed from low mass alloy. In addition, the external surfaces of the "X" Beam and "Z" Spindle are impregnated by an oxide coating process to create extremely hard surfaces.

The CMM's power drive is activated via a remote joystick unit for manual drive operation. Also, each axis can be locked and fine movement adjustment activated. Twin Joystick units are provided for precise control of 'X' and 'Y' axis movements and for 'Z' axis and optional rotary table control.

To provide a direct digital output of measured data and to ensure thermal stability, Mitutoyo SRD Linear Encoders are fitted as an integral part of the machine. A CMMCJ machine control unit provides full digital servo control for high speed, high accuracy positioning, with 3-axis vector drive and automatic computation of all acceleration and deceleration without operator input. Circular Path motion is also provided for continuous movement between relative positions.

The CMMs FCR25 flexible change rack unit provides three changer ports that can be configured to accept any SP25M system elements. SM25 scanning modules and the TM25-20 TTP module adaptor can be docked directly into the FCR25 ports.

User-defined Software

In addition to the hardware, the CMM uses Mitutoyo's popular MCOSMOS-1 software. It allows the generation of repeat part programs by automatically storing all commands. An intuitive operator interface displays easily identifiable icons to help support simple operation. The use of recognisable symbols removes the need for complex programming code, even when editing programs. Features being measured are automatically identified, calculated and in some cases automatically aligned, removing the need for operator intervention. Automatic Probe Calibration of motorised heads is also included as an integral part of the system

Particularly important for Express Engineering, due to the in-depth report requirements and traceability demands of the global oil and gas industry, is the user defined report generation software. Supplied as standard with all Mitutoyo CMMs, the flexible function allows reports to be created in a range of formats including PDF, HTML and JPEG.

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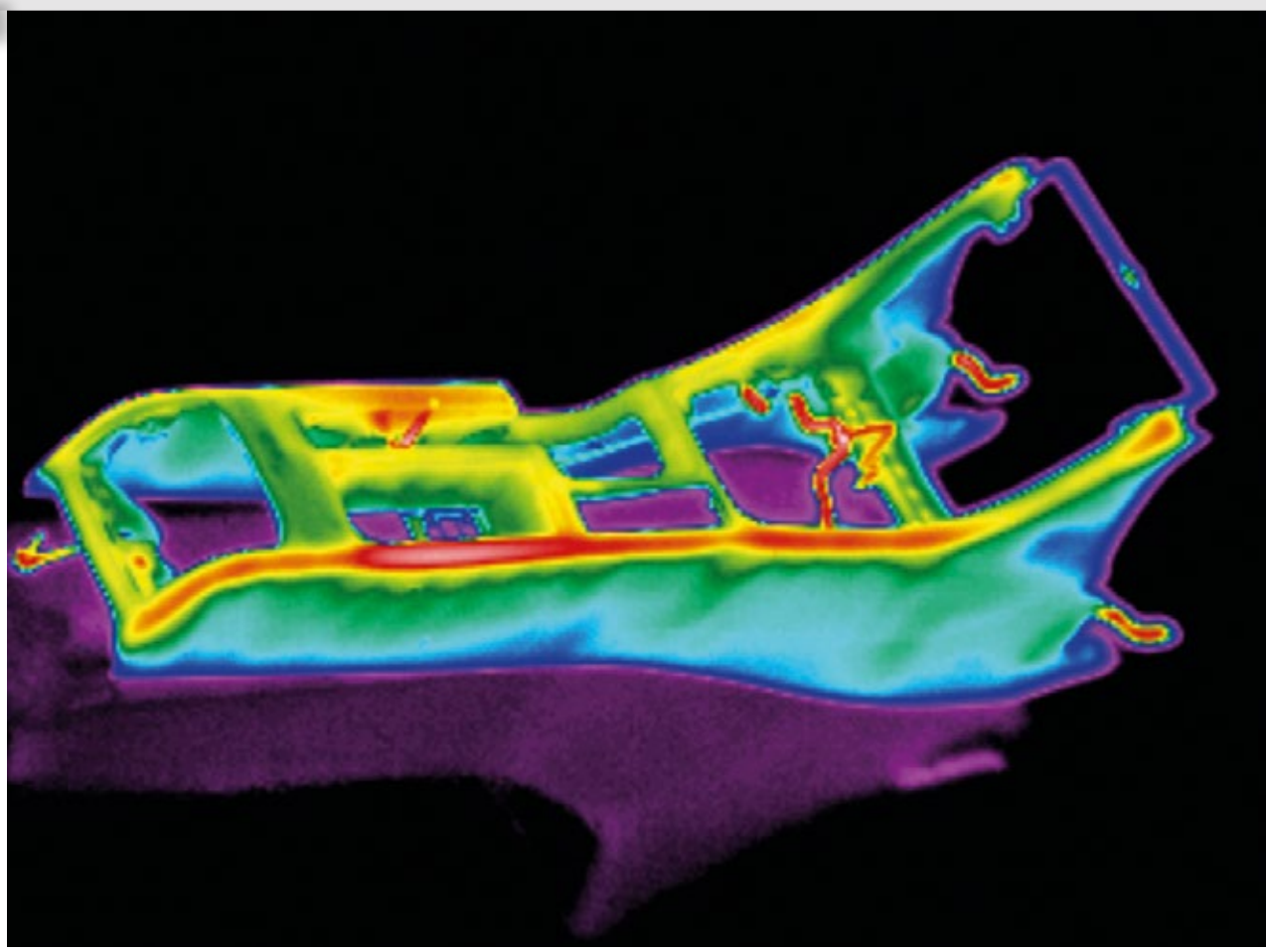


Dactylograms

The Thermal Fingerprint – Injection Molding in the Focus of Industry 4.0

In injection molding, the largest part of errors can be traced back to the tempering of the injection mold. Inline detection directly at the source can prevent errors, enhance quality, and consequently save money.

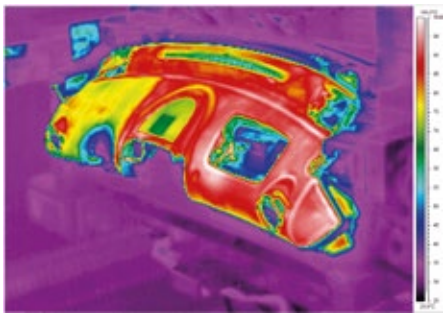
The most common thermal problems and their causes:

Appearance	Thermal problem classification	Most common cause
Dimensional problems, poor mechanical performance	Excessive temperature deviations in the mold wall	Asymmetrical cooling channel layout, insufficient heat dissipation, bridging of cooling channels
Molding warpage	Excessive temperature deviations in the mold wall, partially or over the entire molding	Asymmetrical cooling channel layout, insufficient heat dissipation, bridging of cooling channels
Surface markings in the form of shiny and matt patches, feathering	Thermal moldings of inserts and ejector pins, mandrels, retainers, ribbing and apertures	Insufficient heat dissipation, inadequate isolation of hot runner systems and hot runner nozzles, untempered molding lots
Excessively long cooling times/cycle times	Poorly configured tool tempering, significant pressure losses within the tempering system, hotspots on the molding	Blocked cooling channels, inadequate technical condition of tempering and cooling equipment, aggressive condition of water, untreated or insufficiently treated water

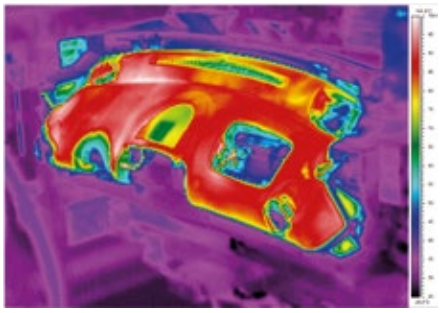
Uncontrolled and unstable processes are the most common financial drains in the injection molding process. The source of 60 to 70 % of all errors relating to moldings, which are responsible for inadequate quality and unacceptably long cycle times, is undoubtedly the tempering of the injection mold. The combination of infrared cameras and online quality control is a promising troubleshooter.

Inline Detection

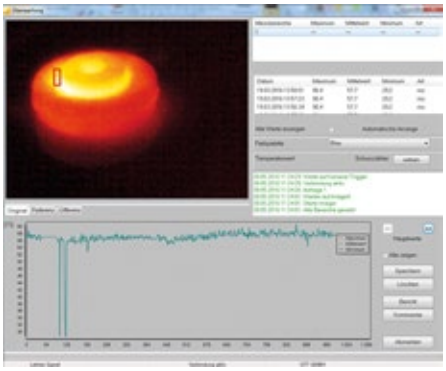
The use of compact infrared cameras by manufacturer Optris combined with the IR-ThermoControl online quality control system that was specifically developed for plastics processing by GTT Willi Steinko and Plexpert, thermal errors in the injection molding process can be detected inline, directly at the source. The data can be transferred to IR-ThermoControl using the PI Connect software. The software is the central element



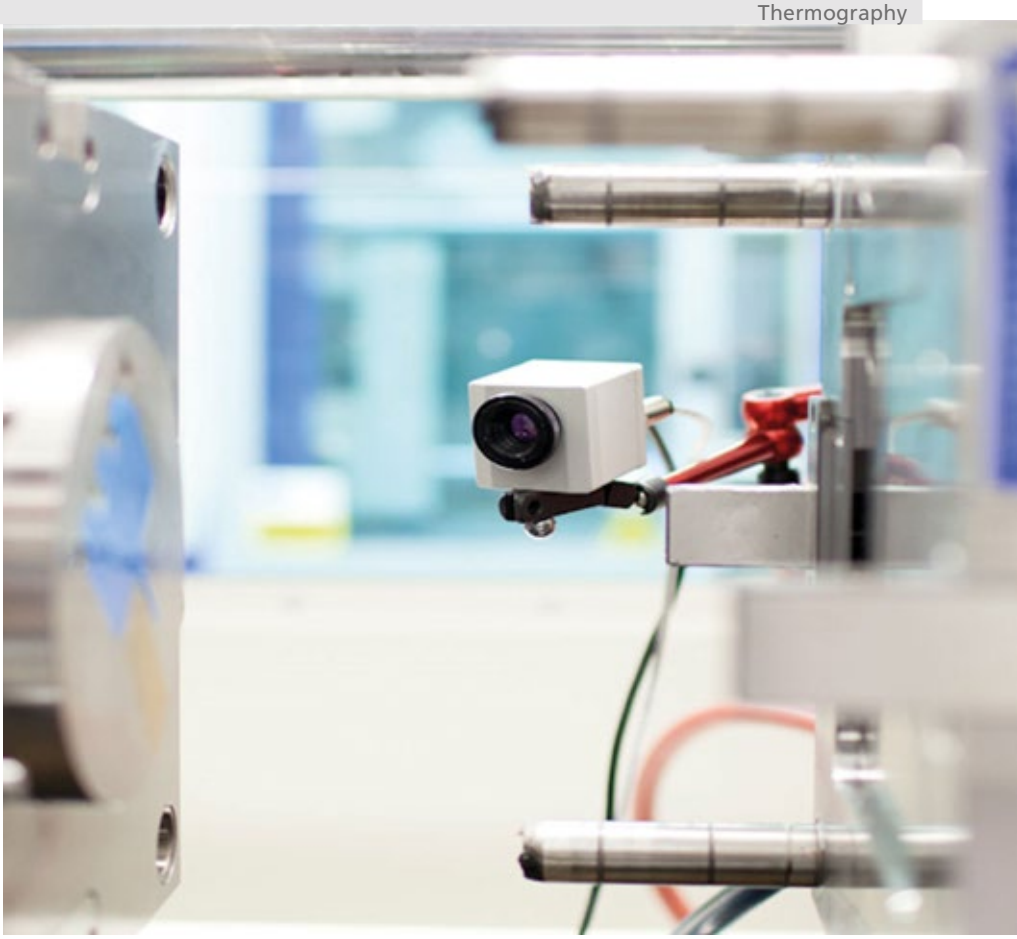
Before: clearly identifiable thermal weak points



After: thermally optimized component



The system´s analysis mask with IR-ThermoControl temperature graphic



The Optris IR cameras are a major component of the detection system.

that allows the fitter, process technician and quality leader to produce quality components in a quick, safe, and target-oriented way, and with the shortest possible cycle times. In order to take targeted measures, it is important to know where the causes of problems can be located.

Quick and Easy

This is exactly the important information the IR-ThermoControl system provides, and it even shows sporadically occurring effects and trends like, for example, a subtle temperature increase during serial production. The system can quickly and easily be installed on any given injection molding machine and it allows for increased flexibility and availability.

Reference Image System

The process-oriented user guidance facilitates the definition of control limits and automatically provides temperature deviations via a reference image system. This means that any differences that occur can be seen instantly. The IR-ThermoControl quality module creates an image of the molding in every cycle. A reference image is made of the first good part. Every subsequent recording is compared with the reference image. If there is a deviation at any given point an alarm is sounded. This technology is used in 2K injection molding as well as in combined foam/compact injection molding.

Process Optimization in Automotive

In an example from the automotive sector, any faults that occur in the process are immediately visible. The following application shows a thermal weak point occurring during production in which the zone depicted on the left oft he image displays a lower surface temperature than the one on the right (see image image top left of this page). Consequently, the length of the manufactured component was almost 2.5 mm shorter than specified. This dimensional deviation was caused by the fact that the required dwell pressure could not be reached. As a result, the tool tempering was adjusted in this zone and, in this way, was optimized (see second image from top left on this page).

A Look to the Thermal Future

The IR-ThermoControl "Plug and Work" system distinctly reveals thermal deficiencies. For example, excessively high temperature differences on injection molded components and tools are displayed in a clear manner. Production managers always need to keep an eye on quality and cost – a fact that this detection system supports by enabling the efficient and economic process monitoring and control. Manually touching the surface of a component or tool by hand to locate hot, warm, or cold zones is finally a thing of the past.

> *„Production managers always need to keep an eye on quality and cost – a fact that detection systems support by enabling efficient and economic process monitoring and control."*

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Paul Wilson, Managing Director of Scorpion Vision, is the Chairman of the UK Industrial Vision Association (UKIVA).

Since 1992, the UKIVA (UK Industrial Vision Association) – the association of industrial imaging in the United Kingdom – represents players from across the industry. In February 2017 the association elected its new Chairman, the CEO of Scorpion Vision, Paul Wilson. We spoke with him about the current market situation, the association, and his thoughts on Embedded Vision as well as the possible impact of the Brexit on the industry.

Appetite for Imaging

inspect: Talking history: how did the UKIVA evolve?
Paul Wilson: The UK Industrial Vision Association was established in 1992 so in 2017, we celebrate our 25th anniversary. The prime objective of the Association throughout its existence has always been to promote the use of vision in industry and it has done this over the years through educational seminars, newsletters, attendance at trade shows, technical advice, etc. This desire to educate has never been more prevalent than the establishment of the Association's first Machine Vision Conference and Exhibition, which took place in April 2017. This event attracted almost 300 visitors and featured a Conference with 58 presentations spread over 7 lecture theatres and an exhibition from 57 of the world's leading vision companies.

inspect: How are you currently organized?
Paul Wilson: UKIVA was originally administered by the PPMA (Processing and Packaging Machinery Association) from its formation in 1992 to the end of 1994 when it took over took over its own administration. In 2009, UKIVA rejoined the PPMA Group of Associations, which also includes BARA, the British Automation and Robot Association.

inspect: Paul, what is your history, how did you become UKIVA´s new Chairman?
Paul Wilson: I have had a varied career in many areas of technology and IT from providing flight technical support in the RAF through to machine vision. I established Scorpion Vision in 2006 to build a presence for Scorpion Vision Software in the UK and have grown it from a component sales business to a specialist machine vision integrator with a major interest in 3D imaging. I joined the UKIVA committee in 2011 and in 2015 was elected to be Vice-Chairman, with Ian Alderton from Alrad Imaging as Chairman. In January 2017, when Ian's tenure of two years was complete, I was elected to be Chairman.

inspect: Who do you represent, and with which intention?
Paul Wilson: UKIVA members fall into three categories:

- Vision Technology Providers – these are mainly distributors of machine vision products and technology;
- Vision Systems Integrators & Consultants – these are companies which specialize in designing vision systems to fit into existing and new manufacturing environment and
- Providers of Solutions That Utilize Vision Technology – these are companies that utilize vision systems within the equipment that they manufacture themselves.

Members cover a wide range of industries – most of the traditional industrial ones for vision such as automotive, food, pharmaceutical, packaging, electronics, etc., as well as many newer ones such as medical diagnostics, solar power, traffic and transportation and sport.

inspect: How do you assess the future market development in the UK, the EU, and globally?
Paul Wilson: The technological explosion that has occurred since UKIVA was formed has been the driving force behind the establishment of an industry that has enjoyed

spectacular growth as it became more and more established. There are estimates that the global machine vision market will be worth in excess of 14 billion dollars by 2022. There are strong indications that the UK market continues to be robust, as evidenced by the fact that there were nearly 300 visitors to UKIVA's recent Conference and Exhibition. Vision is a well established enabling technology which improves product quality, reduces waste and production downtime and helps to reduce costs. It will continue to make a massive contribution to the automation of manufacturing processes and will play an important role in Industry 4.0 applications. Vision is also expanding rapidly into many markets other than traditional manufacturing, including surveillance, traffic and transportation and sport.

inspect: To which extent is the Brexit an issue?

Paul Wilson: Although the value of sterling has dropped against the dollar and the Euro since the decision to leave the EU was taken, things have stabilized significantly. Vision components imported into the UK are now more expensive, but there are other mitigating circumstances. Firstly, many sales are not simply component sales but also involve technical input and support from the supplier, so the component cost can be a comparatively small part of the total. Secondly many organizations in the UK buy components in Euro or dollars so they are unaffected by exchange rate fluctuations. Finally, many OEMs using vision systems export them to Europe and the USA and will therefore benefit from the reduced exchange rates. So at the moment, Brexit does not seem to be having a major impact on the vision market in the UK. We don't yet know yet what will happen when we finally leave the EU in 2019, and whether we will be subject to higher import/export tariffs with Europe and of course that could potentially impact the vision market in the UK.

inspect: Do you have any international cooperations?

Paul Wilson: UKIVA does not have any direct relationships with other international vision trade associations, but at a personal level, the current PPMA Chairman and a former UKIVA Chairman, Mark Williamson, is a current board member of VDMA Machine Vision.

inspect: To which extent are you involved in the development and formulation of relevant industry standards?

Paul Wilson: The Association as an entity is not directly involved in the determination of industry standards. However, some of the companies who do sit on the various standards committees are also UKIVA members.

inspect: If you gazed into the crystal ball – what would be your outlook for the coming years, and which role would embedded vision play?

Paul Wilson: Judging by the comments of various UKIVA members and the impressive response to the UKIVA Conference and Exhibition, the appetite for vision in the UK continues to be strong, and the forecast mentioned above is a strong indicator that the global machine vision market is in good shape. However, for both the UK and the EU there is bound to be some future uncertainty as the Brexit negotiations evolve, and there could be adjustments depending on the deal that is agreed, since the UK is a major customer for vision components from the EU. From a technological point of view, embedded vision and Industry 4.0 are both 'hot' topics at the moment. Embedded vision is an obvious platform for large volume solutions where economy of scale can have a real impact. The availability of small, embedded processing boards based on either ARM or x86 instruction set architecture offers great potential for the development of embedded vision systems for industrial applications. The challenge will be to reduce the costs involved in developing the solutions in order to take full benefit of the low component costs. It is also likely that there will be an increasing use of SoC (System on Chip) processors. The full commercial realization of the smart factory concept of Industry 4.0 involves utilization of data provided by a wide variety of smart sensors, which will inevitably include cameras. Much effort is currently going into the interface protocols that will be needed to provide the necessary control and data access. Vision is already an enabling technology in automating industrial quality control processes, so it makes it an ideal candidate for incorporation into of Industry 4.0. As an enabling technology, industrial vision has, for many years, been having an impact in monitoring and controlling some industrial processes to improve manufacturing competitiveness. Product or components that are assembled into the final product can be inspected at multiple points in the manufacturing cycle to measure any variations in key parameters. Statistical process control techniques can then identify process trends to allow automatic process adjustment before acceptable product tolerances are exceeded.

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Chromasens

Chromasens GmbH, founded in 2004 and now part of the Lakesight group, designs and manufactures innovative image capturing and image processing systems "Made in Germany". Chromasens' development and manufacturing are located at the company's facilities in Constance/Germany. The companies' expertise is both in system and component development, the product range includes line scan cameras, 3D stereo cameras, multichannel cameras, line lights and customized camera systems. The Chromasens range of services is rounded off by intelligent software solutions for image correction, 3D metrology, color management and color measurement technology.
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Kolektor Orodjarna
Ljubljana, Slovenia
Tel.: +386 051 659 197
www.kolektorvision.com

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Even though M.I.T. GmbH has only been in the market for three years, it embodies almost 20 years of experience in the end formed tubes optical measurement and more than 30 years in the design of software for measurement and process control systems. M.I.T.'s main product is ZIMT, a very flexible optical measurement system for measuring end formed tubes. It can measure both metal and plastic tubes with high accuracy, and can be used both in production and in laboratory. The main feature, which is completely new compared to previous generations, is the ability to measure without creating the measurement "recipe". The software obtains the image from the camera, processes it and returns the measurements of all of the characteristics of the sample because it recognizes the shape of the object. M.I.T. also offers consulting services in the domain of measurement and software development and help in the design of machine vision or measurement systems and machines.

M.I.T. GmbH
Bellheim, Germany
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www.youseetheexcellence.de

Tattile

Since 1988, Tattile develops and produces sophisticated vision systems for different applications in the industrial, traffic and railway sector. Tattile is a part of the Lakesight group and a high-tech company with a strong international alignment, a remarkable innovation capacity and strong customer orientation. Its product range includes ANPR solutions for ITS (Intelligent Transport Systems) applications as well as a totally renewed catalogue of smart cameras, line scan cameras, digital cameras, vision software and multi-camera vision controllers for high-performance applications. Multiple technological partnerships enable customized solutions, made to respond to specific technical requests and to the needs of industrial OEMs from the most different industry sectors such as pharmaceutical, packaging, semiconductors, printing, ceramics, food & beverage, automotive, etc.

Tattile srl
Mairano (Brescia), Italy
Tel.: +39 030 970 00
www.tattile.com

Mikrotron

Established in 1976, Mikrotron GmbH provides a full range of high-end imaging solutions for challenging applications in industry, engineering, science and sports. Mikrotron designs, produces, and commercializes high-speed and high-resolution cameras, image recording cameras and systems, software and image processing components. Mikrotron's slow-motion recording enables customers to optimize manufacturing processes, improve product design, revolutionize quality management and analyze motion. Mikrotron is a member of the Lakesight Group and recently introduced the EoSens 3Fiber, the first high-speed machine vision camera with a fully integrated fiber solution combining high data rates with cable lengths up to 300 m and up to 566 frames per second. Based on a full resolution of 1,696 x 1,710 pixels the frame can be reduced continuously. The whole set of features makes the camera ideal for all application fields requiring high data/frame rates in connection with long cables.

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Unterschleißheim, Germany
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www.mikrotron.de

Tech B2B

Since 2006, Smart Vision Lights (Muskegon, Michigan, USA) has been one of the world's leading designers and manufacturers of high-brightness LED illumination products. Markets for these products include automotive, food and beverage, medical and pharmaceutical, electronics and semiconductor, traffic, and packaging inspection. Offering spot lights, ring lights, backlights, dome lights, linear lights, and custom illumination systems in both on- and off-axis configurations at numerous wavelengths in the ultraviolet (UV), visible, and infrared (IR), Smart Vision Lights provides systems developers with a single source for their illumination requirements.

"I am particularly proud of the technological achievements Smart Vision Lights has developed, the game changers in the industry," says Dave Spaulding, President. "All our products are supplied with universal internal current-control drivers that offer developers constant or OverDrive strobed operation, reduced wiring requirements, and, perhaps most importantly, a 10-year warranty."

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Tecnalia masters advanced technologies in areas like sustainable development and ICT. Tecnalia Corporation is a Technology Corporation set up in 2001 with the principal aim of contributing towards the development of the economic and social environment by means of the use and promotion of technological innovation through the development and dissemination of research in an international context.Our system Surfin Hot inspection performs real time detection and classification of surface defects (for example roll marks, cracks, etc.) on the hot steel long product manufacturing process of bars, tubes, billets, slabs, beam blanks or structural profiles. It detects defects at early stages in the production process, when the product is hot (>1,000ºC) preventing the unnecessary addition of value to it. In terms of speed the new architecture drastically cuts down the required computation time by 50%. The system is currently going through extensive validation at steel production line at Olarra Steelworks.

Tecnalia
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Tel.: +34 946 430 850
www.tecnalia.com

Euresys

Euresys is one of the leading manufacturers of image and video acquisition components, acquisition COTS boards and image processing software.
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Our products combine high performance software with hardware developments based on the latest microelectronics technology.
One of Euresys´ product highlights is the Coaxlink Quad 3D-LLE, a quad CXP-6 frame grabber with on-board laser line extraction for 3D profiling. It enables laser line extraction with zero host CPU usage, and the real-time generation of 16-bit 3D height maps. There is a choice of algorithms: Maximum, Peak, Center of Gravity (COG). The precision that can be achieved is up to 1/256 pixel (with Peak and COG algorithms), and the frame grabber has a performance of 19,000 profiles/s from 1024 x 128 images, and 38,000 profiles/s from 1024 x 64 images.

Euresys s.a.
Liège, Belgium
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First Embedded Vision Europe Conference in Stuttgart

In order to show the capability of hardware and software platforms, to present applications and markets for embedded vision, and to create a platform for the exchange of information the European Machine Vision Association (EMVA) and the trade show Vision will be hosting the first Embedded Vision Europe Conference from October 12 to 13, 2017 at the ICS International Congress Center Stuttgart next to Stuttgart Airport.
Florian Niethammer, team leader of the Vision show at Messe Stuttgart points out: „ In recent months we have increasingly observed how important the ´embedded´ issue has become. We are dealing with an overarching technology here that is of significant relevance in industrial as well as in non-industrial sectors. It is a logical step to organize a conference for developers and users of embedded vision systems together with our long-standing partner, the EMVA. The topic is booming, but up to now a professional platform in Europe has been missing."

Conference, Table-top Exhibition and B2B Meetings

The conference approach to cover the entire scope of embedded vision is reflected by the impressive list of speakers that have already confirmed their appearance: David Moloney (Intel), Dr. Harris Gasparakis (AMD), Paul Maria Zalewski (Allied Vision), Marco Jacobs (Videantis), Giles Peckham (Xilinx), Martin Wäny (Awaiba), Alexander Schreiber (Mathworks), Dr. Hans Ebinger (Espros), Jochem Herrmann (EMVA), Olivier Despont (Cognex) and Dr. Thomas Däubler (NET).
Since embedded vision is a key technology for a whole generation of new products from all areas conference participants are expected to come from a variety of industries, including robotics, agriculture, automotive, factory automation, security/ surveillance, logistics and retail, medical and healthcare, and many more. The accompanying special exhibition as well as the option to network and arrange business meetings already upon registration is an ideal platform to deepen the conference topics and business contacts.

www.embedded-vision-emva.org

European Vision Technology Forum Tour 2017

In October and November 2017, Stemmer Imaging and the European Imaging Academy will be organizing the third edition of the Vision Technology Forum at five locations all over Europe.
The tour will start on October 17 and 18 in Unterschleißheim near Munich. On October 24, the Scandinavian technology forum will be held in Stockholm, followed by events on November 7 in Eindhoven and November 9 in Paris. The final stop of the tour will be on the grounds of the famous Silverstone Formula 1 circuit, UK where the event will take place on November 15 and 16.
The focus of all technology forums will be on the presentations held by renowned imaging experts, and on the discussion of current developments in the field of machine vision technology. Since the lectures are organized in parallel sessions, the participants can select beforehand which presentations best meet their interests in order to optimize their individual agenda. Once again, the selection of sophisticated lectures will provide the participants with a comprehensive overview of state of the art technology and the latest developments. During all events of the five tour stops, leading machine vision manufacturers will present their latest developments in an accompanying table-top exhibition. The attendees will have the opportunity to discuss with numerous machine vision experts of various fields and gain a detailed insight, as well as have the chance to talk about their own projects. "Nothing can provide you with better and more concise information on the latest technological developments in the field of imaging and machine vision than this event", commented one of the participants of the previous Vision Technology Forum in 2015.

www.stemmer-imaging.de/technologieforum

Date & Location	Topics & Information
Oct. 9 – Oct. 12, 2017 Stuttgart, Germany	**Motek** The international trade fair Motek is a leading event in the fields of production and assembly automation, feed technology and material flow, streamlining through handling technology, and industrial handling. As such, Motek clearly focuses on all aspects of mechanical engineering and automation and on the presentation of entire process chains. www.motek-messe.de
Oct. 12 - Oct. 13, 2017 Stuttgart, Germany	**Embedded Vision Europe** The 1st edition of this brandnew conference will take place 12 to 13 October in the International Congress Center of Stuttgart nearby the international airport. The two conference days will also open the opportunity for companies to present their embedded vision competence with a table-top exhibition. www.embedded-vision-europe.com
Oct. and Nov. 2017 Unterschleiissheim, Stockholm, Eindhoven, Paris, Siverstone	**European Vision Technology Forum Tour 2017** The focus of the five technology forums will be on the presentations held by renowned imaging experts, and on the discussion of current developments in the field of machine vision technology. www.stemmer-imaging.de/technologieforum/
Nov. 13 – Nov. 16, 2017 Düsseldorf, Germany	**Compamed** Visitors can choose from the complete spectrum of products, materials and services within the medical industry. Visitors represent the key world markets, with high levels of decision-making expertise, www.compamed.de
Nov. 14 – Nov. 17, 2017 Munich, Germany	**Productronica** Future technologies, industry trends, growth markets. Investment decision-makers, industry experts. From around the world. At the right time and the right place. Productronica is the World's leading trade fair for electronics development and production. Now Productronica's new cluster structure makes it even easier for visitors to be in the right place at all times and to have a perfect overview of the entire value chain for electronics manufacturing at the same time. www.productronica.com
Nov. 28 – Nov. 30, 2017 Nuremberg, Germany	**SPS/IPC/Drives** SPS IPC Drives is the exhibition for electric automation technology. It covers all components down to complete systems and integrated automation solutions. The exhibitors – manufacturers of electric automation technology – present products and services from the most relevant sectors. www.mesago.de/en/SPS/home.htm

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Imprint

Published by
Wiley-VCH Verlag GmbH
& Co. KGaA
Boschstraße 12
69469 Weinheim, Germany
Tel.: +49/6201/606-0

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Bank Account
J.P. Morgan AG Frankfurt
IBAN: DE55501108006161517443
BIC: CHAS DE FX

Advertising price list
from May 2017

Circulation
10,000 copies

Individual Copies
Single copy € 16.00 plus postage.

Pupils and students receive a discount of
50 % at sight of a valid certificate.

Subscription orders can be revoked within
1 week in writing. Dispatch complaints
are possible only within four weeks after
publishing date. Subscription cancellations
are accepted six weeks before end of year.

Print
Pva, Druck und Medien, Landau

Printed in Germany
ISSN 1616-5284

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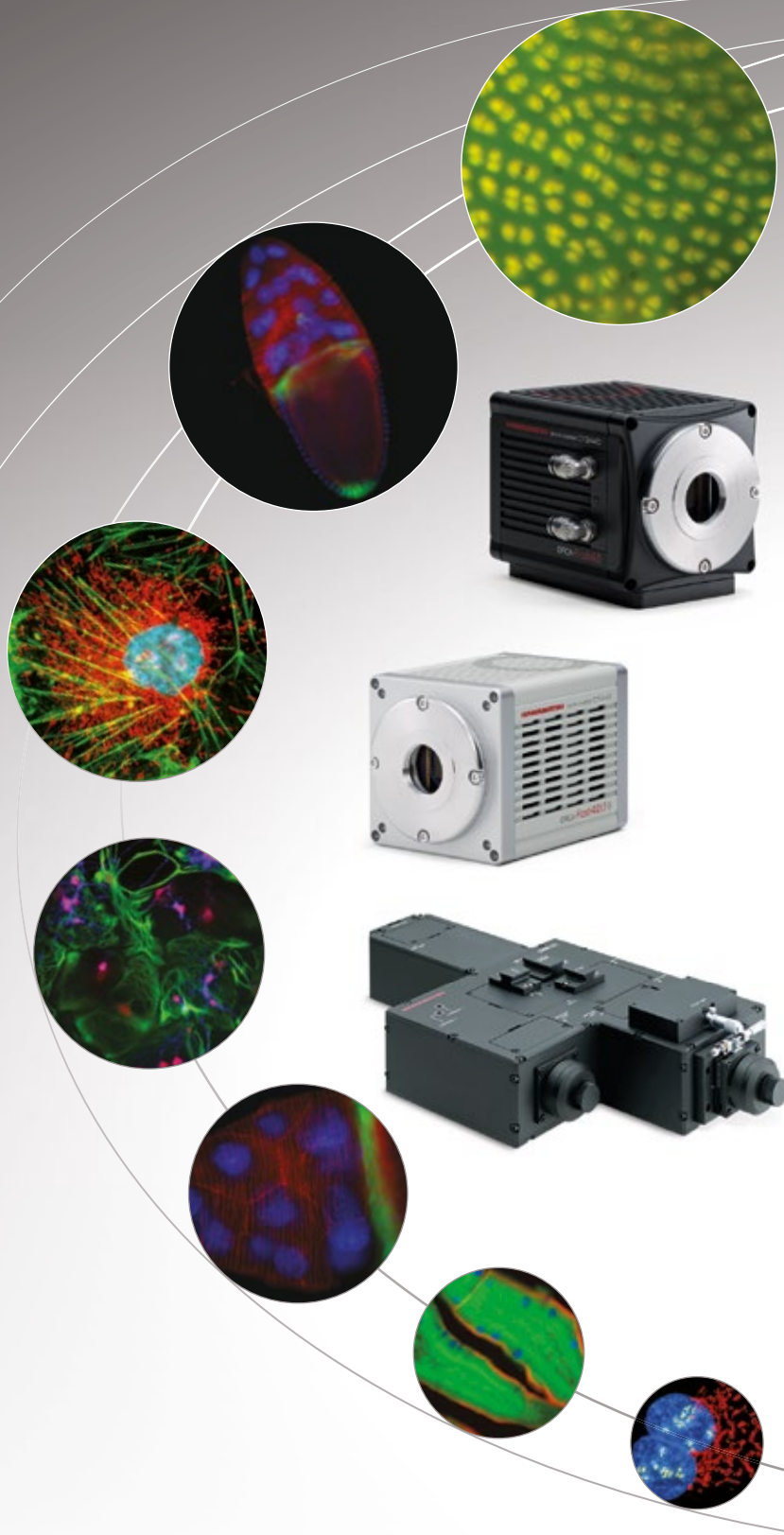

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