WILEY
SEPTEMBER
2019
2
76 963

inspect international

WORLD OF VISION

www.inspect-online.com

20 years inspect

SPECIAL TOPICS

Lighting & LED
3D
Spectrometry & Microscopy


eVe
embedded
VISION
europe
2019
24.–25.10.
EUROPEAN EMBEDDED
VISION CONFERENCE
ICS Stuttgart, Germany
EVE 2019 will give insights into the capabilities of hardware and software platforms; will present applications and markets for embedded vision and will create a platform for the exchange of information between designers and users.
www.embedded-vision-emva.org
Organiser
emva
european machine vision association
Messe Stuttgart
Key to Markets

Celebrating the Future

When a magazine has its anniversary celebration, the readers expect to read about how everything began, and what has changed throughout the years. inspect, World of Vision, is celebrating its 20th anniversary this year, and of course, inspect international extends warmest congratulations. In fact, the international magazine would not even exist if our "big sister" wasn't a forerunner in specialist literature for the vision market.

The past two decades have been marked by impressive technical progress in almost every industry, also, of course, in image processing. Computers have become smaller and more powerful, resulting in an explosion of integrated systems and a push towards automation. In addition, the developments in sensor technology have completely changed the way images are captured.

inspect has also seen a lot of changes over the years: the people behind the magazine, the layout.

»Everything is in flux in the machine vision industry.«

Martin Buchwitz, deputy editor-in-chief of inspect, will face a new challenge as Managing Director of Technologiezentrum Schwäbisch Hall from October. Many thanks for the creative and intensive cooperation. What remains are quality and the depth of content. And they will not change in the future.

Speaking of the future, we have collated a wealth of interesting articles that deal with the status quo, and the future of industrial vision.

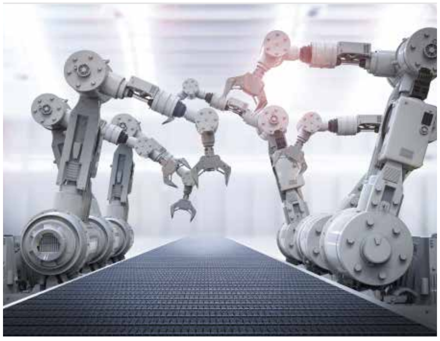
Computational imaging is one of the catchwords in this edition, along with 3D technologies and X-ray. Looking to the future, you will find articles about machine learning and the evolution of the OPC UA standard. Everything is in flux in the industry which can be seen in a preview of the Embedded Vision Europe Conference coming up in Stuttgart in October.

If you are fluent in German, I recommend reading the anniversary edition of inspect World of Vision, it is absolutely worthwhile. In the meantime: let's celebrate the future with inspect international.

Happy reading,
Yours,

Sonja Schleif

22 **Seeing the Unseen**



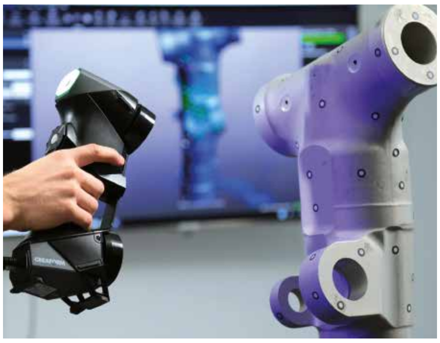
©Fotolia

24 **The Merging of Two Worlds**

40 **Behind the Scene**

Contents

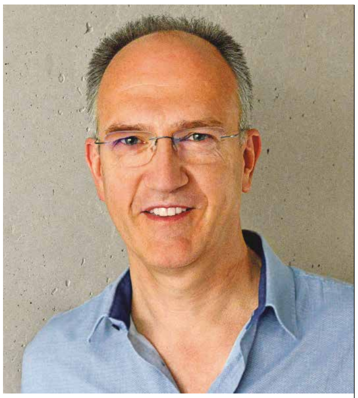
Cover: ©Serhii - stock.adobe.com



Future

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

News



Ximea Strengthens Management Team

In connection to the company's growth, Ximea GmbH strengthens its management by appointing Jürgen Hillmann as second managing director as of July 15, 2019. Mr. Hillmann, who has been COO of the company since 2012 and later on CTO, has managed various development and sales projects, is responsible for hyperspectral cameras and has represented the company externally as an authorized signatory.
In his new role, Mr. Hillmann will now lead the company in cooperation with Dr. Vasant Desai, who has held the position of CEO since the company was founded.

Michael Cmok, Technical Sales Director, also received power of attorney on July 15, 2019. www.ximea.com

Vision & Control Finds New Distribution Partner in China

Vision & Control expands its distribution network with a new partner in China, Eide Tech. Together with its parent Shanghai Xiangshu Europe Trade Mechanical & Electrical Equipment Co. Ltd., the Chinese partner is now taking over the distribution of all Vision & Control products in the Chinese market, in Hong Kong, Macao and Taiwan.

Eide Tech introduces itself as an innovative industrial company, which deals with project consulting and service for decades. It is mainly active in the automotive, electrical, iron and steel, energy, food and medical industries. His services and solutions are not limited to individual machine components, but focus on the entire industrial production line. It has knowledge in this area and maintains a network of worldwide partners.

www.vision-control.com

Stemmer Imaging Machine Vision Technology Forum

The fourth Stemmer Imaging Machine Vision Technology Forum will take place on October 8 and 9 in Unterschleissheim near Munich. The industry get-together offers attendees the opportunity to learn about current trends and technologies as well as gathering ideas for their own projects in a pleasant atmosphere.

In six parallel sessions, machine vision experts will give presentations on the latest trends such as industry 4.0, embedded vision, machine learning, 3D and spectral imaging. Basic lectures on a wide range of topics will provide newcomers with a perfect overview.

Parallel to the lectures, participants will have the chance to have discussions with numerous machine vision specialists within various fields in an accompanying table top exhibition.

An entertaining networking event on the evening of the first day will round off the forum.

www.stemmer-imaging.com

Successful CHII Academy 2019

Building on the success of the three previous chii conferences, the chii academy 2019 was held for the first time this year in Graz (Austria). More than 40 engineers and application developers from 11 countries discussed issues, problems and applications of hyperspectral imaging technology.

In four lectures and four interactive workshops, the participants gained a deep insight into the areas of image acquisition, image processing and data analysis for hyperspectral imaging. In addition, live demonstrations and applications with commercially available hyperspectral software were impressively demonstrated.

www.spectronet.de

Exclusively Embedded

Embedded Vision Europe Conference, Stuttgart, 24 to 25 October 2019

After a successful debut of the Embedded Vision Europe Conference two years ago, the second event, a cooperation of EMVA and Messe Stuttgart, will be held at the ICS International Congress Center at Stuttgart Airport.

The conference features high-quality presentations on the trend topics of embedded vision by renowned speakers, including keynote speaker David Austin, Senior Principal Engineer at Intel Corp. and further presenters from NVIDIA, Micron Technology, and Hacarus Inc. The conference is accompanied by a table-top exhibition.

Highlight presentations are, among others: "Using Sparse Modeling in Visual Inspection to Solve Issues Deep Learning Can't" by Takashi Someda, CTO at Hacarus. His presentation introduces sparse modeling, an AI technique that understands data like a human- by its unique key features. The agenda will include a presentation of the technique, a brief background and real-world examples of its use for image data in visual inspections. In conclusion, the presenter will provide a comparison with deep learning-based techniques and discuss advantages and weaknesses of using sparse modeling for visual inspection. Jagan Ayyaswami, Sr. Director of Mobile Architecture and Systems at Micron Technology, will be speaking about "Processor Architectures for Machine Learning": With the rapid advances in machine learning and various neural network topologies, we have made tremendous amount of progress in solving many embedded computer vision tasks. Face detection, face recognition, object tracking and identification etc. are but a few examples of the applications where we have seen signification improvement in performance by these techniques compared to the traditional computer vision algorithms. However, these new approaches use a different computational model to achieve these results. In this talk, Jagan will explore the various kinds of hardware implementations that are gaining popularity in these machine learning based embedded vision applications and discuss the relative pros and cons. "The challenges of deploying Deep Learning for visual quality inspection" will be presented by Pierre Gutierrez, lead machine learning researcher at Scortex. In this talk, we describe the challenges that we have been facing at Scortex and how we try to tackle them. The first one is the real time processing, because inspection in factories means meeting the cycle time. The second challenge is about machine learning, since to be of any use the performance of the system almost needs to match that of a human. ■

CONTACT
European Machine Vision Association,
Barcelona, Spain
Tel.: +34 931 807 060
www.emva.org

Dr. Olaf Munkelt, CEO of MVTec Software, Dr. Klaus-Henning Noffz, New Business Development of Basler, and Mark Williamson, Director of Corporate Marketing of Stemmer Imaging – Board members of VDMA Machine Vision.

Embedded Vision Expands Market Potential

VDMA Machine Vision Board Members Discuss Opportunities for the Use of Embedded Vision

The machine vision landscape has already changed considerably in recent years due to powerful developments in the field of embedded vision – and it will continue to do so. The effects of these developments were discussed during a panel discussion at this year's EMVA business conference in Copenhagen in mid-May. Three board members of VDMA Machine Vision, sector group within the VDMA Robotics + Automation association, participated.

"Embedded vision will affect us all and become so ubiquitous that there is no way around it". The experts were in full agreement on this key message of the discussion: embedded vision is already so important in the industry today that no machine vision company can afford to exist without this technology and corresponding products in the near future.

What at first glance sounds almost like a threatening statement, has enormous potential, as MVTec Software CEO Dr. Olaf Munkelt explains: "Embedded vision is suitable for a much broader range of applications than traditional PC-based image processing and its main field of application, the industry." For the existing market and the players active in it, the embedded technology thus represents a great chance to think beyond well-known application possibilities and to find applications in which the characteristics of embedded vision systems are completely validated. This includes, among other things, the peculiarity that the costs of individual components and complete embedded vision systems are considerably lower than those of traditional PC-based architectures, but that development costs are generally significantly higher. For this reason, embedded vision developments usually only pay for themselves from relatively high quantities.

Progress from the Consumer Sector

However, the profitability threshold of embedded vision systems is falling: the current focus for further development of the technology is on the system-on-chip (SoC) approach. To this end, the world's leading hardware and software manufacturers, located in Silicon Valley in particular, are constantly providing new ideas. Companies such as Sony and Intel are already adding more and more new functions to their products at the semiconductor level that can be used for image processing purposes. However, since the underlying technologies are usually developed for mass markets rather than for the machine vision niche, one of the key challenges is to identify these expanded opportunities and leverage existing strengths for effective deployment in appropriate user industries.

A well-known example of this phenomenon has its origins in the entertainment industry: the graphics card manufacturer Nvidia introduced GPU architectures a few


©Stemmer Imaging

years ago. These graphics processors were originally designed to improve the visual representation of computer games. Due to their extremely high computing power, however, these processors were also perfectly suited for the conversion and evaluation of extensive image data such as is available in image processing. Today, the use of GPUs in suitable vision applications is part of the standard repertoire of many developers.

Many experts expect similar effects from system-on-chip solutions, which are currently being developed for use in smartphones and could also be of great value for the image processing industry in the near future. "The development speed of the individual components required for the development of embedded vision systems remains enormously high," observes Dr. Klaus-Henning Noffz, Chairman of the Board of the VDMA machine vision division and CEO of Silicon Software. "Embedded vision has now reached a state of the art that already enables powerful, economical systems."

Embedded vision still requires a great deal of commitment and cooperation of leading companies in order to achieve a status comparable to that of the traditional machine vision industry in terms of standards.«

Expanding Expertise in Embedded Technologies

In many conversations and technical articles in the recent past, embedded vision has been praised as a kind of miracle weapon that will sooner or later challenge the raison d'être of traditional image processing technology. Participants in the panel discussion did not share this view. One reason for this is the fact that the functionality and performance of conventional vision systems is still increasing strongly at all levels: cameras, image acquisition components, lighting and optical products, software tools for image evaluation, and also the interfaces for data transmission are far from the end of their potential and are being raised to ever higher performance levels by many innovative manufacturers.

The human factor also has an influence on the fact that traditional image processing will be in use for a long time to come: Many programmers with years of experience are available to develop new and further PC-based systems and to create the necessary algorithms. Although the know-how for the creation of embedded vision solutions is growing rapidly, it is not yet available on the market to a comparable extent. One of the challenges for the further development of the embedded vision market therefore also consists in expanding the level of knowledge in companies, e.g. on Linux or Cuda for GPU programming, and transferring the existing application-specific know-how to the new technology. A helpful way of doing this would be to increase the standardization of embedded vision at all levels. In terms of standards, embedded vision is still in its infancy and still requires a great deal of commitment and comprehensive cooperation of leading companies in order to achieve a status comparable to that of the traditional machine vision industry.

Traditional Machine Vision Remains

The following statement by Dr. Munkelt illustrates the potential changes: "Classic machine vision will remain, as high-end solutions with corresponding cameras and frame grabbers are still in demand. However, many applications that were considered high-end a few years ago will probably soon be tackled with embedded vision." The limits for using the optimal technology are therefore shifting – but this does not mean the end of traditional image processing architectures.

It is undisputed that embedded vision systems are the perfect solution for certain applications. The experts mentioned the example of drones, which open up completely new possibilities in applications such as agriculture. PC-based image processing is not suitable for such applications simply because of its size and weight. Furthermore, as an extremely important field of application from an economical point of view, the panel addressed the automotive sector in which the arguments of low price and high volume are the main driving forces behind the development of embedded vision systems. Here, autonomous driving could develop into one of the decisive applications that are absolutely necessary for the establishment of a technology. There are therefore numerous opportunities for the use of embedded vision – it is important to track them down and use them!

Embedded Vision at the Embedded World Show: Success Through Collaboration

The embedded world exhibition & conference – 2020 in its 18th year – is the world's leading meeting place for the embedded community. At the embedded world, experienced developers come together to share their knowledge and to help others to turn ideas and innovations into real products. With over 2,100 participants in the conference and over 32,000 visitors of the show, the embedded world is a well-established platform and market place for embedded technologies in Europe, targeting developers, project and product managers that are looking for new trends and technologies – people you need to connect with, when approaching the topic embedded vision in Europe. VDMA Machine Vision has teamed up with the embedded world trade fair organizers. In 2020, you can again expect a panel discussion on embedded vision, a dedicated track on embedded vision at the conference, a dedicated award on embedded vision, and many exhibits related to embedded vision at the trade show. ■

AUTHOR
Mark Williamson
Director of Corporate Marketing
Stemmer Imaging and member of the
Board of VDMA Machine Vision

CONTACT
VDMA Robotics + Automation/
Machine Vision
Anne Wendel
Frankfurt/Main, Germany
Tel.: +49 69 660 314 66
www.vdma.org/vision

100 Years of Excellence

The German edition of inspect – World of Vision magazine is celebrating its 20th anniversary this year. A leading global company that has been in the market for five times as long is Olympus, this year celebrating its 100-year anniversary. We spoke with Senior Vertical Market Specialist Markus Fabich about the history and future of the microscopy division.

inspect: How would you describe Olympus' development in the industry – from Takeshi Yamashita's Japanese production of microscopes to a globally leading manufacturer of nondestructive testing and measurement equipment?

M. Fabich: Throughout our history, an Olympus microscope has been considered a mark of quality and trust – and this is something that remained the same through the years. What's evolved is Olympus' ability to get closer to the users' needs, striving for an ever-higher degree of excellence in specifications and delivery. A good example is the field number of a microscope; our field numbers have continually increased over the past decades, and we're continuing this trend. This means you can see more in high quality – not just through the oculars, but also on a camera.

Working closely with our customers has enabled us to successfully expand our portfolio and respond to their needs. Our CIX100 cleanliness inspection microscope is a good example. This microscope was designed based on a need for using microscopes to comply with industry standards, such as ISO standards. The CIX100 can be used to ensure compliance with 38 different standards in contamination control alone – and there may be hundreds of implementations of these standards in different industries.

Of course, our industrial portfolio has also expanded far beyond microscopy. Remote visual inspection (RVI), for example, has been with Olympus for more than 40 years. Even more recent additions such as ultrasound, eddy current and X-ray fluorescence have been part of Olympus for almost two decades. Many of these technologies came to us as a result of acquisitions, but after joining the Olympus family they have benefitted hugely from our world-leading optical expertise and manufacturing excellence.

inspect: What are the critical success factors for Olympus' development?

M. Fabich: First of all, every organization needs to have an area of expertise in which it excels. In our case this is optical engineering, design and manufacturing. And this is really where our roots are: that level of quality, not only in design, but also in manufacturing and the final product. However, as the company grew, focusing solely on lenses, objectives and other hardware aspects was not enough, so we've grown our business beyond just the hardware. We are now also a leading supplier of imaging software and advanced technologies in lighting.

We always work very closely with our customers, as we always have done since Olympus came here to Europe 60 years ago. We have always listened to what was needed and over the years, we've continuously reported back to the engineering teams, ready to start the next cycle of innovation.

inspect: The company's founder, Mr. Yamashita, was Japanese. To what extent is the Japanese company culture still a factor at Olympus today? How has the company's management style changed over the years and adapted to market requirements?

M. Fabich: Olympus was founded in 1919: the dawn of the 'roaring 20s' and a time of great prosperity and scientific advancement around the world. It's worth illustrating that the company thrived, innovated and grew from its

»Microscopes have been augmenting reality since they've existed … we've been doing this for more than 60 years!«

origins in this period. In terms of company values, customer centricity and integrity have been core values of the company from the very beginning – and this is of course important in Japanese culture, but also to us here in Germany.

Nevertheless, the company has of course developed into a global organization. This global identity is particularly noticeable in the scientific solutions division, which has two geographical strongholds: the headquarters for microscopy and RVI is based in Japan, and the analytical instruments and nondestructive testing businesses are based in the US. Influences from these different markets have clearly provided the best of both worlds for Olympus as a whole, contributing to its current, global identity.

inspect: Current hot topics in the industry are augmented reality and human–machine collaboration. What are your undertakings in these areas?
M. Fabich: Augmented reality is indeed a hot topic in the industry, but actually microscopes have been augmenting reality since they've existed. Especially with the range of illumination and contrast methods we have today, you could say that each of these methods augments reality in some way. Take interference contrast as an example. You can use it to see nanometer-level height differences in transparent materials in real time. So, this is basically analog, real-time augmented reality – and we've been doing this for more than 60 years!

When it comes to human–machine interactions, we have made enormous progress over the years. Microscopes have long moved away from being just a tool to get the job done. Instead they can guide you through the entire analysis workflow, from picking the right magnification, lighting and contrast method, all the way to helping you take the right measurements. All that complexity of helping the user each step of the way – that's our vision for human–machine interaction.

inspect: In the year of your anniversary you have launched the new industrial digital microscope, the DSX1000. How does this product relate to your anniversary? What are the microscope's unique selling points?
M. Fabich: Exactly 100 years after the launch of our first product, which was a microscope, we've moved to a completely new way of thinking about microscopes. This change is most obvious in terms of flexibility, versatility and user-friendliness. The DSX1000 offers a wide range of magnifications from 20 to 7000x and six different illumination methods. It also has the ability to image a sample from every direction without moving it, thanks to a rotating stage and headpiece. Furthermore, the microscope can generate precise 3D models in a matter of seconds and take measurements with guaranteed accuracy for compliance purposes.

When it comes to user-friendliness, the DSX1000 is designed with today's users in mind. Thanks to the intuitive operation and software, it requires little expertise to set up and operate. This means that its features are accessible to all users – even if they're not microscopy experts. That is a big plus for many industrial applications.

inspect: What are the typical applications for the product, and why?
M. Fabich: A key strength of the DSX1000 is its flexibility, which means it's designed for use across the industrial sectors. So it doesn't matter whether you work in the electronics, materials science, automotive or aerospace industry, the DSX1000 has got the answers. This versatility also extends to different tasks within the same industry – failure analysis, QA/QC, R&D, you name it!

The versatility and flexibility of microscopes like the DSX1000 highlights a change that has taken place in the industry. If you look at microscopes in the recent past, maybe only 20 or 30 years ago, imaging was the primary purpose of using a microscope. If you look at our customer portfolio for different types of microscopes now, measurement capabilities are crucial for many users. Taking beautiful images is great, but today's users expect more – and the DSX1000 does exactly that. ■

CONTACT
Olympus Europa SE & Co. KG,
Hamburg, Germany
Tel.: +49 40 237 73 0
www.olympus-ims.com

inspect award 2020: Nominees

Vote and decide who will receive the inspect award 2020

This year, it was especially difficult for the jury to make a decision: They had to pick the nominees for the inspect award 2020 from more than 40 entries. A few rounds of discussions later, the following candidates in the categories Vision and Automation + Control were chosen. Now it is up to your vote who will earn places 1 to 3. Cast your vote at: www.inspect-award.de

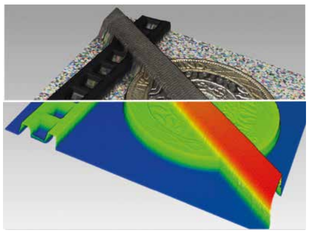
Vote now and win a tablet!

At www.inspect-award.de you can vote as of now until October 15, 2019. Your vote will automatically enter the prize draw for a high-quality tablet.

Recourse of the courts is excluded.

Category Vision

ICI: Simultaneous 2D and 3D Industrial Inspection

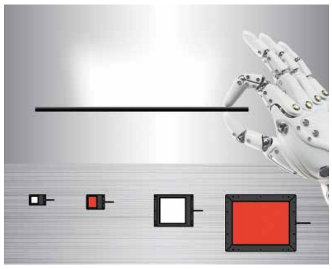


Inline Computational Imaging (ICI) is a new technology for simultaneous 2D and 3D inspection. The simple and compact ICI sensor system consists of an area scan camera, a lens and two illuminations. While the object moves in front of the camera, a stack of images is captured, with each image showing the object at a different viewing and illumination angle. The ICI algorithms calculate for each object a precise 3D model together with optimized color images such as all-in-focus or HDR images. ICI works largely independently of the surface properties and therefore for the first time enables the precise inspection of dark and shiny metallic objects simultaneously.

➔ **AIT – www.ait.ac.at**

OLF Series: Bright OLED Flat Light for Machine Vision

The OLF Series is an OLED panel light. It has a 3mm-thick, weightless design, and low heat generation. The organic molecules generate light across the whole emitting surface. The Lambertian radiation creates the same effect as a dome light. Using a tandem structure design of multiple organic and transport layers, the electron-hole pair will generate multiple photons to achieve twice the radiance of other OLED panel lights and conventional LED back lights. It also features lifetime prediction technology. The controller reads usage data recorded in the light's built-in IC-chip (operating time and operating current proportional to radiance) to estimate the remaining lifetime of the light provided that the usage settings remain unchanged.



➔ **CCS Group – www.ccs-grp.com**

Quality Intelligence Solution: Visual Inspection

Scortex transforms quality inspection by automating and applying intelligent detection and analysis, to improve accuracy and reduce defect rates. Manufacturers can dramatically reduce the total cost of quality, while having access to quality data in live manufacturing lines.

Innovation: Scortex is an automated defect detection and analytics platform for automotive manufacturers needing to more accurately identify defective products in real time while improving overall plant profitability. Scortex is the only deep learning quality inspection technology, capable of detecting defects in real-time to trigger targeted actions. The solution is shaped by each customer's quality specifications, combining edge compute hardware and machine learning software capabilities to continuously learn and improve the defect detection rate.

➔ **Scortex – www.scortex.io**

Digital Stereoscopic 3D-Display

A glasses-free, stereoscopic digital display system which enables you to see subjects in true 3D in full stereo HD resolution with outstanding depth perception. Essential for users who need three dimensional visualisation without the constraints and issues of VR headsets.
It is a patented technology and unique and there is no equivalent headgear or barrier free system currently on the market. The technology behind the system is called TriTeQ³ and is a unique, advanced digital stereo image presentation which provides fully interactive, real time, natural 3D visualisation. Innovation: It is the worldwide first true stereo digital 3D viewer. There is no other glasses-free system on the market! Besides the numerous ergonomic advantages of Vision Engineering's eyepiece-less microscopes, the DRV-Z1 offers users the first wide screen 3D digital display of subjects. It offers customers the opportunity to remotely view subjects on a second DRV where the remote viewer will see the same 3D image as the local user. This is ideal and increasingly valuable for feedback/communication up and down the supply chain.

➔ **Vision Engineering – www.visioneng.de**

Vision App-Based Industrial Cameras

IDS NXT rio & rome extend the vision app-based industrial camera platform IDS NXT. All IDS NXT models are fully-fledged standard industrial cameras whose range of functions can be extended and modified by the user as required thanks to vision apps. This way, they are cabable to solve a wide range of vision tasks. With IDS NXT rio and rome, even neural networks with self-learning algorithms can be integrated. With the IDS Smart GenICam app, the configuration, control and results of the vision apps can be made available to any GenICam-compliant third-party application via the camera's XML description file. The devices remain full-fledged standard-compliant industrial cameras that can transfer image data at full GigE speed.

➔ **IDS – www.ids-imaging.com**

Category Vision

VIS-SWIR Lenses

Kowa's VIS-SWIR lenses can cover a wavelength range from 400 to 1,700nm. And it's designed to minimize focus shifting through the whole wavelength. This is made possible by Kowa's original mechanical structure and special coating. The lens can even keep a transmission rate of 50% at 2,000nm and this will expand users' possibility in machine vision inspection. NIR/SWIR cameras and hyperspectral cameras are getting more important in machine vision applications. These cameras can accurately analyze the reflective properties of materials over a wide wavelength range. This is used in image processing e.g. for material testing, separation and sorting, etc.

➔ Kowa – www.kowa-lenses.com

Helios 3D ToF Camera Featuring Sony's DepthSense Sensor

Helios is a compact, high precision 3D Time of Flight (ToF) camera that uses four 850nm VCSEL laser diodes and features Sony's new DepthSense IMX556PLR back-illuminated ToF sensor. It features high NIR sensitivity, 10µm pixel size and high modulation contrast ratio. It can produce depth data at 60 fps with 640×480 resolution over Gigabit Ethernet. The camera offers superior depth precision compared to existing ToF cameras currently available in the market. The Helios camera has a precision of 2.5mm at 1m and 4.5mm at 2m. Helios performs on-camera depth processing which reduces system load on the host PC. It is compliant with the GigE Vision and GenICam 3D standard for ease of integration using LUCID's own Arena SDK or 3rd party software.

➔ Lucid Vision Labs – www.thinklucid.com

Linux-Based Smart Camera with New Event-Based Sensor

The new camera sensor reacts individually to the pixel and only on movement changes, which is how it highly reduces redundant data, for instance from the background. Every pixel can transmit movement changes up to the kHz area. Fastest movement analyses and classifications are thus possible and through the high data reduction, the smart camera already possesses enough computing power to run an entire application on the integrated Linux computer. Example applications like object counting, vibration monitoring or kinematic analysis are available on the SDK.

➔ Imago Technologies – www.imago-technologies.com

Universal Machine Vision Lens Series for 1.1" Sensors – without Vignetting

The Fujinon CF ZA 1S series with six fixed focal length lenses is the new, universal solution for industrial cameras with C-mounts and modern image sensors with an optical format of up to 1.1" and small pixels from 2.5 µm. The optics offer both the required high resolution and speed, as well as the necessary compactness, distortion-free imaging and the short minimum object distance (MOD) from 100 mm.

A small chief ray angle (CRA) of maximum 4.9° ensures a vignetting-free image illumination over the entire surface of the sensor. Fujinon's patented Anti Shock & Vibration design makes them more resistant to shocks and vibrations. Thanks to these specifications, system designers can use this one lens series in almost any industrial application.

➔ Fujifilm – www.fujifilm.eu/de

Category Vision

Alveo-U200-Multi-Channel-Frame-Grabber for AI-Enhanced Machine Vision

Configured as a smart frame grabber, the Xilinx Alveo U200 FPGA accelerator card can analyze multiple high-resolution, high-frame-rate camera channels to both accelerate industrial inspection and enable new insights into manufacturing processes. The card is capable of extracting intelligence from up to eight 10GigE (10 Gb Ethernet) high-speed, low-latency camera streams, greatly outperforming comparable single-input 10GigE frame grabbers. Alternatively, it can handle 96 individual GigE camera streams, compared to a conventional 4-input frame grabber. Performance benchmarks show 8x/2.5x advantage over CPU or P4 GPU respectively. Power efficiency is 42 images/s/W for GoogleNetv1(int8) DNN in low-latency mode versus 28 images/s/W for P4 GPU.

➔ **Xilinx – www.xilinx.com**

Lenses for APS-C-Sensors

The CA lens series is designed for the new APS-C sensors by Sony (31 MP) and e2v (67 MP). As a unique feature they offer a TFL-mount. The CA lens series is designed for the new APS-C sensor format with 28 mm diagonal. As a special highlight, they feature a TFL-mount. With an M35 x 0.75 thread and a flange focal distance of 17,526 mm, it can be considered as the big brother of the well-established C-mount for smaller sensor formats. Compared to other lens mounts, the TFL offers the following advantages: Especially when compared to the F-mount, the threaded TFL-mount is significantly more robust and stable, making it more suitable for industrial applications.

Also, TFL-mounts allow for designing more compact lenses when compared to F- or M42-mounts, which can also be used for large full frame sensors with 43.3 mm diagonal. Last, the TFL-mount is standardized by the Japan Industrial Imaging Association (JIIA). This enables system designers and integrators to use and combine components from multiple suppliers, without comparing technical details. ➔ **Edmund Optics –www.edmundoptics.de**

High-Power SWIR Illumination

Effilux's SWIR H.O.P. (High Optical Power) Technology is a powerful type of light source based on a proprietary material that emits SWIR light. It is designed to deliver high output power and the intensity achieved is 10 times greater than the standard SWIR LEDs in the market, making it possible to reveal invisible phenomena to SWIR cameras that usual LED systems could not. The H.O.P. technology retains all the advantages of LEDs compared to halogen or laser sources, with a huge improvement in power and the flexibility to create both highly focused SWIR beams as well as large area uniform SWIR illumination. In fact, one "chip" of the H.O.P. technology emits a luminous flux comparable to a 50W halogen source.

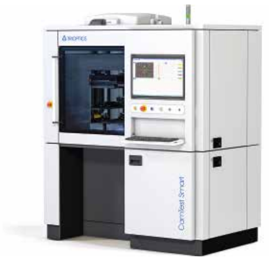
➔ **Effilux – www.effilux.fr**

Camera Line Combines High Resolutions with High Frame Rates

Ximea's CB654 model offers 65Mpix (9,344x7,000pix) at 76fps and as such utilizes the full bandwidth potential of its large format sensor (37.4mm diag.). PCI Express Gen. 3, 8 lane interface with standard iPass connectors reaches 64Gbit/s of data transport bandwidth. Effectively it provides over 7GB/s data streaming up to 100m via a fiber optical cable, including storage to non-volatile memory with selected PC and SSD configurations. High precision CNC milled full alloy body design with compact dimensions of 60x70x40mm makes it robust and improves heat dissipation. It allows the camera to be fitted into various environments with space constraints. Extremely low latencies due to no protocol overheads make it ideal for real-time applications. ➔ **Ximea – www.ximea.com**

Category Automation + Control

End-of-Line-Test-System for Camera Modules



CamTest Smart is an end-of-line test system that enables comprehensive testing of camera modules. With the help of focusing collimators, test chart and integrating sphere integrated in only one device, the end-of-line test can be realized. Along with common optical and opto-mechanical parameters such as MTF, SFR, defocus, image plane tilt and rotation, and distortion, the system also measures additional sensor parameters. Among others, OECF, dynamic range, white balance, relative illumination, spectral response are tested. The measurement process is fully automated and is particularly suitable for use in production of small and medium quantities. Due to its flexibility, the system is ideally suited for research and development.

➔ **Trioptics – www.trioptics.com**

Portable 3D Scanner

Creaform re-engineered its HandyScan 3D in order to launch the HandyScan Black patented third-generation metrology-grade scanner. The new tool meets the rising quality standards with its 4X superior resolution. Thanks to the unique and versatile combination of newly improved high-performance optics and multiple blue laser technology, the HandyScan Black now captures finer details and larger volumes. In addition, it performs more accurate and traceable measurements with an accuracy of 0.025 mm. This specification is based on VDI/VDE 2634 part 3 and ISO 17025 accreditation, ensuring that reliability and full traceability meet international standards.

➔ **Creaform3d – www.creaform3d.com**

TomoScope FQ

The TomoScope FQ (Fast Qualifier) coordinate measuring machines with computed tomography allow the evaluation of the measuring point cloud to be performed in real time. The measuring machines will be typically loaded by robots. In a cycle time of 30 seconds, geometrical characteristics of a machined aluminum workpiece are measured and an actual-to-actual comparison is carried out to check the workpieces for defects. A measurement in one run of multiple smaller workpieces results in a typical measurement time of 1.5 seconds per workpiece. In the WinWerth Scout user interface, a list of the measured workpieces can be displayed at all workstations in the network in order to check the measurement results.

➔ **Werth – www.werth.de**

Non-Destructive 3D Inspection of Components with Internal Structures

GOM presents a metrology CT that provides 3D data of internal and external part geometries in exceptionally high resolution. The GOM CT visualizes the finest details of the entire component, simplifying initial sample testing, tool correction and inspection tasks during ongoing production. Capturing complex components including their inner structures in one scan, the system provides the user with a complete digital replica of the specimen for GD&T analyses or nominal-actual comparisons. The computer tomograph particularly excels in digitizing small plastic and light metal parts. In order to achieve a very high detail sharpness during the digitization of parts, the GOM CT was built of perfectly matching components: The high-contrast 3k X-ray detector generates a very fine grid of pixels (3,008 x 2,512 pixels) and thus lays the foundation for high-precision part acquisition. The 5-axis kinematics with an integrated centering table makes it easier for the user to optimally position the part in the measuring volume, so that the measurement is always carried out in the best possible resolution.

➔ **gom – www.gom.com**

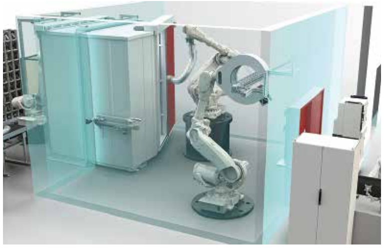
Mobile 3D Coordinate Measuring Machine

The XM series is a mobile and intuitive 3D coordinate measuring machine. A measurement is carried out with a handheld probe, which communicates via infrared signal with a special camera. The exact coordinates are detected via the infrared markers on the probe. The large field-of-view and the free handheld operation enable a big flexibility with 3D measurements. The all-in-one design allows users to integrate the system directly into the process. The XM can be used on a mobile table in the production, on a desk in the office or in the inspection room. A temperature-controlled measurement chamber is not needed. The measurement system XM uses software-based Augmented Reality and by this increases the user-friendliness. The technology of Augmented Reality connects the virtual world with actual movements of the probe and thus enables everyone to carry out easy and complex measurements. The user is guided through the measurement by the live image, which is captured with a small camera in the probe.

➔ **Keyence – www.keyence.de**

Category Automation + Control

Automated In-Line X-Ray System



The XRHRobotPipe is a fully automated system to inspect welded air ducts in a non-destructive (NDT) way. The titanium welds have to be fully inspected according to aerospace regulations to find inner defects like porosities.
The system autoatically recognizes the parts and performs the inspection without operator intervention. To achieve this VisiConsult used a variety of high-end vision components and industrial robots. Complying to demanding aerospace regulations the system is fully integrated in the customers production line. This allows to cut back the cycle time by factor ten. A system of this complexity and efficiency has never been seen in X-ray inspection before and provides a glimpse in the future of manfucaturing - Industry 4.0. The combination of vision components, robotics and X-ray inspection is a world novelty. The dual robot approach allows for high flexibility and process safety. An underlying artificial intelligence software developed by VisiConsult archives all the images to allow future automated image interpretation using AI. The system could also perform ROI Computed Tomography (CT) scans if required.

➔ Visiconsult – www.visiconsult.de

Smart Infrared Cameras for Industry 4.0

With the IRSX series of smart infrared cameras, intelligent, self-contained thermal imaging systems that are consistently designed for industrial use are available for the first time. As an all-in-one solution, the cameras combine a calibrated thermal imaging sensor with a powerful data processing unit and a variety of industrial interfaces in a small, rugged IP67 housing. A computer, special thermal imaging software, or external interfaces are no longer required. This considerably reduces system complexity, installation effort, and costs while significantly improving system stability. Thanks to the web-based configuration interface, the cameras can be set up for thermal monitoring tasks in no time without programming skills. Once installed, they communicate directly with the process control, providing an outstanding functionality for the practical implementation of Industry 4.0. A comprehensive range of software tools supports integration and use of the cameras, including standard APIs like REST, GigE Vision, MQTT, and OPC-UA as well as a growing number of application-specific apps. The IRSX series comprises a variety of models with different fields of view, resolutions, and frame rates, thus covering a broad spectrum of applications in all areas of industrial process automation.

➔ Automation Technology – www.automationtechnology.de

White Light Fiber-Coupled Module

Albalux is a novel white light module with precise fiber beam delivery. The structured light source produces highly-directional and brilliant white light up to 100x the intensity of LED.

Based on patented semipolar GaN laser diodes from SLD Laser, the sources use advanced phosphor technology providing minimal power consumption and a long lifetime with highly directional output.

How do you differentiate this product/system/technology from the next two closest competitive product/system/technologies in the market?

- Uniform and high contrast white light,
- enables long throw distance, up to 10x that of LED,
- sharp beam cutoff and high contrast light field gradients,
- luminance and long range will create new demand.

➔ Laser Components – www.lasercomponents.com

Customizable 3D Belt Picking SensorApp

The Sick 3D Belt Pick SensorApp is specialized for locating products on a conveyor belt. With this software installed, the TriSpectorP1000 programmable 3D camera turns into a belt-picking sensor. 3D vision allows for reliable detection and gentle handling. For each detected product, the camera reports location, height and orientation to the robot controller. The Sick AppSpace eco system opens up new possibilities for a system integrator to develop solutions. In Sick AppStudio, the SensorApp script can be opened and customized, e.g. to combine robot guidance with inspection. Then, the camera can also deliver quality info on the products, making is possible to monitor the manufacturing and packaging processes and correct them if necessary.

➔ Sick – www.sick.com

High-Definition Long-Reach Video Transmission

Options for High-Definition, Real-Time Image Acquisition over Cable

Maintaining image quality when receiving analog and digital video over extended distances has proved to be challenging. Various technology solutions and hardware have been explored and developed to address latency, resolution and cost issues. This paper will look at these options, and which solutions best address these challenges. It examines high-definition, real-time image acquisition using long cables and how it is possible to transmit video digitally over twisted pair cables up to 150 m and coax cables up to 700 m, with fiber optic offering the option of many kilometers.

Applications Using Long-Reach Video Transmission

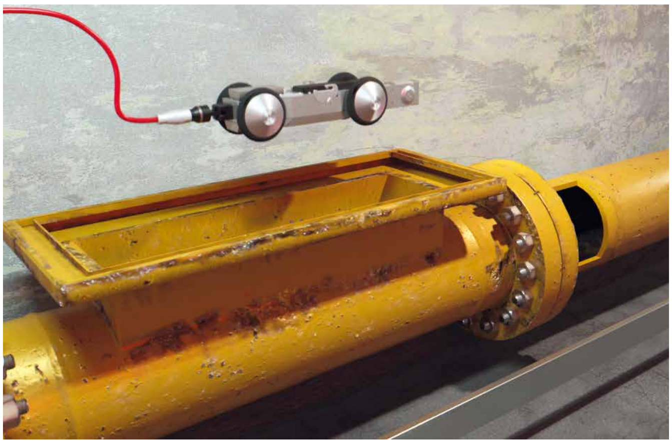
High-definition image acquisition for long-reach video is a particularly important aspect of pipe inspection, where small cameras are used in enclosed spaces, under limited lighting conditions. Applications include sewer inspection, pipe repair and industrial pipe inspection in the wastewater, energy, telecoms and manufacturing sectors. In pipe inspection, cameras are generally built into pushrod systems, which are mechanically operated, or pipe crawlers, which have varying amounts of remote control. These systems may include a number of slip rings, which allow cables to rotate in the pipe without twisting, and crawlers to turn or spin in excess of 360 degrees.

Clearly, it is important that images are of a suitable high resolution since operators are searching for tiny cracks and imperfections in the pipe structure. It is also imperative that pushrods and crawlers can operate at length to enable as much pipe work as possible to be inspected with the minimum amount of surface disruption.

Surveillance and security applications also benefit greatly from this technology. Defense systems, surveillance, ROVs and robotics all use compact cameras with long cables and/or slip rings to allow cameras to bend and turn, changing the direction of viewing.

Introduction to Long-Reach Video Technology

The optimum way to receive high-quality digital video is to acquire raw uncompressed data, but this of course, results in a very high data rate. Compressing the video to reduce the data rate can result in reduced resolution and/or image artefacts. High Definition (HD) video is normally transmitted at a serial data rate of 1.485 Gb/s or 2.97 Gb/s. While these rates work well over short cable runs, it is not possible to use these data rates over long cable lengths without significant cost.



Pipe Crawler inspecting a pipe and sending images via long-reach HD video

High-Definition Serial Digital Interface (HD-SDI) and 3G-SDI (2.97 Gb/s) are progressive scan formats which are typically transmitted uncompressed over a single coaxial cable. These formats benefit from low latency and can handle uncompressed data, but cable lengths are limited depending on the system hardware.

Historically, long-reach vision systems have been limited to SD analog transmission up to several hundred meters, often with supplementary amplifiers. However, requirements for long-reach video transmission in HD video applications are becoming more prevalent and new technologies are emerging to enable video transmission at lower data rates whilst preserving image quality.

IP Compression

One established method of transmitting high definition video is IP Compression using Motion-JPEG, or M-JPEG, format. In this process, each video frame is compressed separately as a JPEG image. The standard is common in gaming consoles and digital cameras developed for the consumer market. H.264, or MPEG-4, is a more commonly used standard as it allows a higher compression ratio but at the expense of latency and quality on a per frame basis. To cope with recent 4K video, this has been developed further, resulting in H.265, or High Efficiency Video Coding (HEVC), but this method currently requires additional hardware in the system to enable encoding/decoding of HEVC video. However, while these Ethernet solutions benefit from using mature compression standards that are widely supported, they incur latency, require large data storage facilities or bandwidth capacities, additional (often expensive) hardware and inevitably result in inferior image quality.

Alternative Technologies

- High-Definition Composite Video Interface, or HD-CVI, is an analog solution offering artificial higher analog image resolution by manipulation of the standard analog image signal. It

This board revolutionizes the transmission of digital video, allowing cable lengths not reached before.«

requires minimal installation requirements and is targeted at the mid to low-end surveillance market.

- High-Definition Transport Video Interface, or HD-TVI, was developed by Techpoint in 2012 and supports 1080p video resolution over cable lengths up to 500 m. It is focused at the high-volume surveillance market and provides limited support or information for the industrial sector.
- EX-SDI is a technology encompassing Visually Lossless CODEC (VLC) which can be encoded at both 270 Mb/s and 135 Mb/s; however, purchase of the encoder chips generally incurs a minimum order value. This, like HD-TVI, is also a solution for high-volume security customers with little support for industrial applications.
- Analog High Definition, AHD, supports 720p and 1080p over coax cables, connecting CCTV cameras to DVRs. Downsides are the limitation in camera compatibility and configurability, plus the quality degrades with distance, since it is not a digitally-based system. While cost is competitive, image quality is not as good as that available with other technologies.

These options are all viable over shorter cable lengths but have not proven to provide the high- quality image results required by many applications over longer cable lengths. Furthermore, hardware is bulky.

HD-VLC – a Preferred Choice

High-Definition Visually Lossless CODEC (HD-VLC) is an innovative technology, developed by Semtech Corporation, which works over cable lengths of at least three times that of HD-SDI products. This involves a unique CODEC which encodes HD data to the same rate as standard definition video, i.e. 270 Mb/s or 540 Mb/s serial data rate. The technology is easily accessible from a well-established supplier and is a dependable and consistent option. The advantages to using HD-VLC include:

- Ability to use coax cables up to 700 m, twisted pair cables up to 150 m and fiber optic cables over many kilometers.
- Hardware is compact, allowing the smallest possible components to be produced.
- No additional latency is introduced to the system, so images are transmitted in real-time.
- Superior image quality.
- Multiple slip rings can be used.

Cable type	HD-VLC 270Mb/s	HD-SDI 1.48Gb/s
Belden 1694A (RG6)	700m	230m
Belden 543945 (RG59)	550m	150m
KE-Link SYV 75-5	500m	140m
Canare L-3C2V	300m	80m
Cat-5e/6 UTP	150m	-

Solutions from Active Silicon

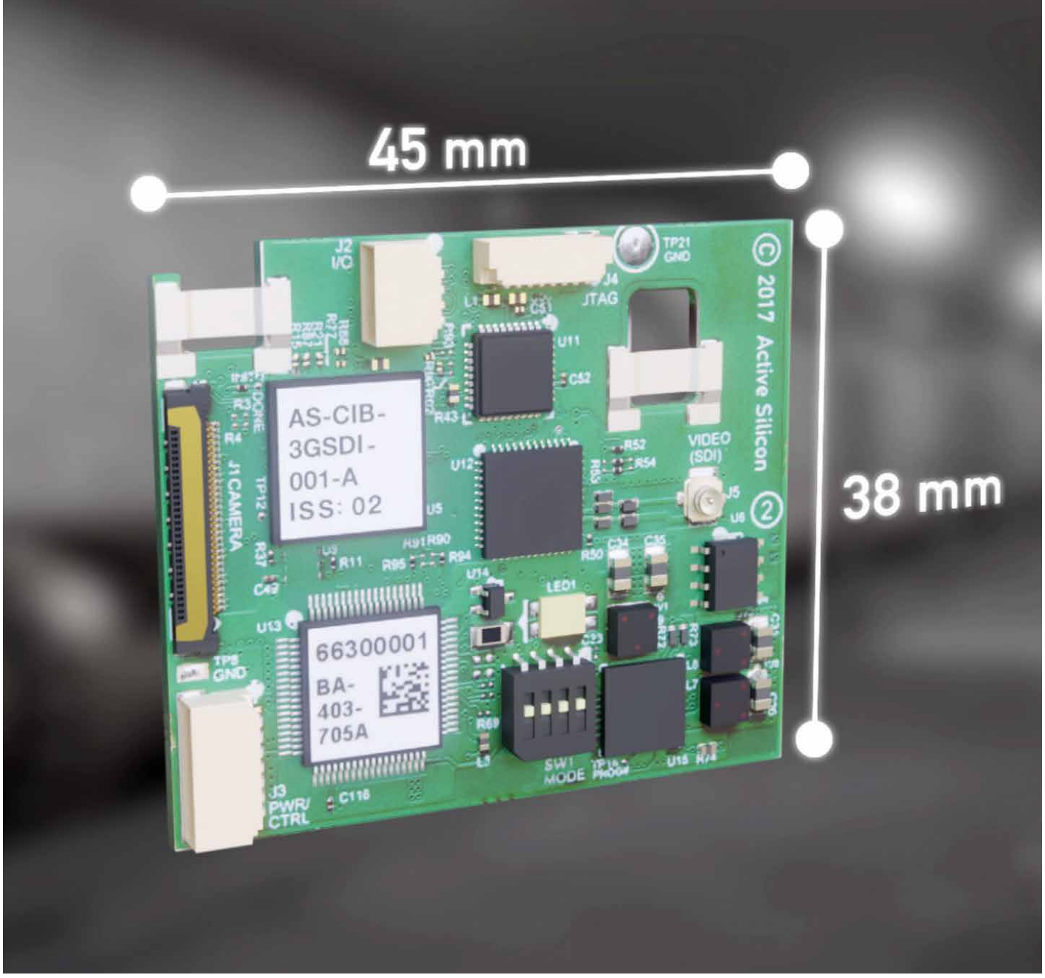
Active Silicon has developed an interface solution to support HD-VLC and enable long-reach high-definition digital video transmission. This solution has been tailored to the pipe inspection sector but applies equally to many other application areas.

The solution comprises the Harrier 3G-SDI Camera Interface Board (shown above), compatible with autofocus zoom cameras including the Tamron MP1010M-VC, MP1110M-VC and various Sony cameras, and the Harrier SDI Adapter (which provides options for conversion to USB 3.0 and HDMI).

Hardware has been tested using 75 Ohm coaxial cable and 100 Ohm twisted pair cable, as well as including a number of slip rings. Results are shown below (test results according to Semtech Corp.).

Harrier 3G-SDI Camera Interface Board

Active Silicon's new Harrier interface board provides a cost-effective solution to take full advantage of the high-definition digital video provided by the camera, connecting directly to the camera's digital output to provide



Harrier is the smallest and coolest-running board available on the market today.

AUTHOR
Natalie Ryan
Marketing Specialist

CONTACT
Active Silicon Ltd, Bond Close,
Iver, UK
Tel.: +44 1753 650 600
www.activesilicon.com

superior image quality and supporting all the HD-SDI modes of the camera up to 1.5 Gb/s and 3G up to 2.97 Gb/s. In addition, the interface board can provide simultaneous analog output in Standard Definition (SD) video in 720p50/60 modes and supports full screen 4:3 and 16:9 monitors.

Other features include a built-in test pattern which conforms to the SMPTE RP-219-2002 specification, and HD Visually Lossless Compression allowing much greater cable lengths. Additionally, it is programmed to enable activation of crosshairs and other application- specific overlays in the image data.

This board revolutionizes the transmission of digital video, allowing cable lengths not reached before, and complements our existing interface board and digital interface kit range. Harrier is the smallest and coolest-running board available on the market today.

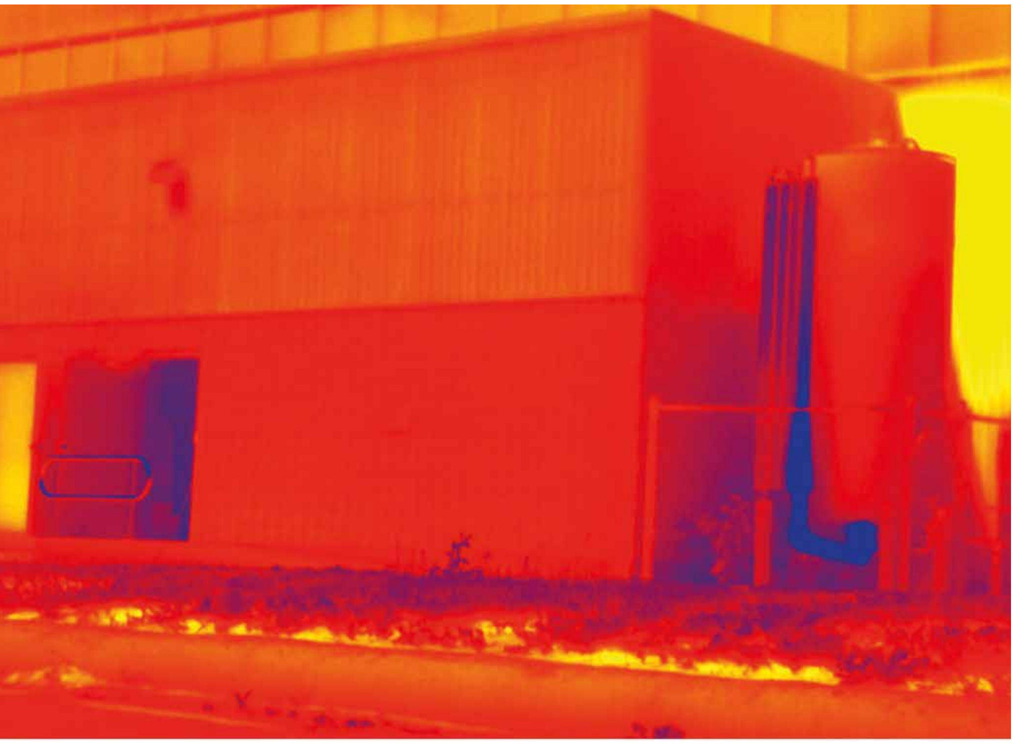
Harrier SDI Adapter

When using HD-VLC compression technology, the digital signal is encoded for long-distance, high-quality transmission. Active Silicon provides the Harrier SDI Adapter, which converts the signal back into HD-SDI, USB or HDMI, ready for viewing on a monitor or processing via computer.

Harrier 3G-SDI Series

Harrier allows crawler systems to transmit images over cable setups, including multiple slip rings, of up to 700 m and pushrod systems up to 150 m. It provides real-time imaging with low-latency, superior image quality and fits the smallest cameras available in the market.

Due to its compact size, the Harrier board is the only video interface board available to date which, in combination with small autofocus zoom cameras, can replace legacy Sony FCB camera systems without requiring any significant mechanical changes to the existing enclosure. Therefore, it is an ideal component in the replacement of Sony FCB modules which have reached end-of-life status. ■



Seeing the Unseen

How Infrared Cameras Capture Beyond the Visible

With infrared and thermal imaging, we are able to see what, in the past, was unseen. They enable us to analyze different levels of light and heat to better manage and understand our environment.

From the stars to our bodies, heat is everywhere. As long as atoms continue to move around, heat energy is generated and transferred via conduction, convection, or radiation. Heat energy transferred as an electromagnetic wave, similar to light, is known as thermal radiation, and while we can feel heat, we cannot see it.

Infrared cameras, also known as thermographic cameras, differ from cameras that capture images within the visible spectrum. In fact, infrared cameras can only capture images of objects that omit radiation in the infrared region, which can be well beyond our visible threshold of 650 nm.

Seeing Heat

Both thermal and infrared imaging allow us to "see" heat. So what is the difference between thermal and infrared? What we refer to as infrared is typically in the range of near infrared (NIR). NIR is the closest to our visible range, which radiates electromagnetic wavelengths of 650 to 1050 nm; whereas long-wave infrared (LWIR) ranges from 8000 to 12000 nm. While both bands of light can detect heat, a LWIR-sensitive sensor is able to detect heat as well as contrasting levels of heat between different objects – this is what is referred to as thermal imaging. In between these bands of the spectrum is short-wave infrared (SWIR). SWIR is just beyond NIR with wavelengths of 1050 to 2500 nm and is popularly used for moisture detection.

Imagine taking a picture of two identical mugs; one is holding warm water, the other holds cold water. You would not be able to tell the difference between the two without touching them both. With an infrared camera, you will see the contrast between what's inside of the mug and its surrounding environment. The infrared sensors inside the camera can detect the different levels of thermal radiation in the water and its distribution through the ceramic of the mug, which can be used to produce an image that shows a mosaic of different temperatures. It's not possible for warm-blooded animals such as mammals and birds to see infrared light because their own bodies release heat. However, several cold-blooded animals have evolved to see infrared light. Initially used by the military, thermal imaging has been adapted for various applications. From our homes to outer space, infrared and thermal imaging are used to analyze different levels of light and heat to better manage and understand our surroundings.

Home Quality Inspection

Energy consumption has a direct relationship with greenhouse gas emissions. It's become clear that if we manage our energy use, we can lower our gas emissions. According to Eurostat, European households account for 25% to 27% of all of energy consumption in Europe. Additionally, US household emissions account for 4% of global carbon emissions. Heating systems are costly for both the wallet and for the environment. Regular HVAC system inspections can provide necessary feedback to tell homeowners and businesses whether their buildings are energy efficient. About 70% of the heat produced by a boiler can escape through the roof, walls, windows, and doors because of cracks or lack of insulation. These areas need to be identified in order to prevent heat or air conditioning can escape.

HVAC professionals utilize thermal imaging to analyze spots where heat or air conditioning can leak out, such as faulty windows or cracks that need to be filled in – helping save time, money, and energy. Thermal imaging inspection during the winter months can help pinpoint areas of heat loss, whereas summer is the perfect time to find areas of heat gain.

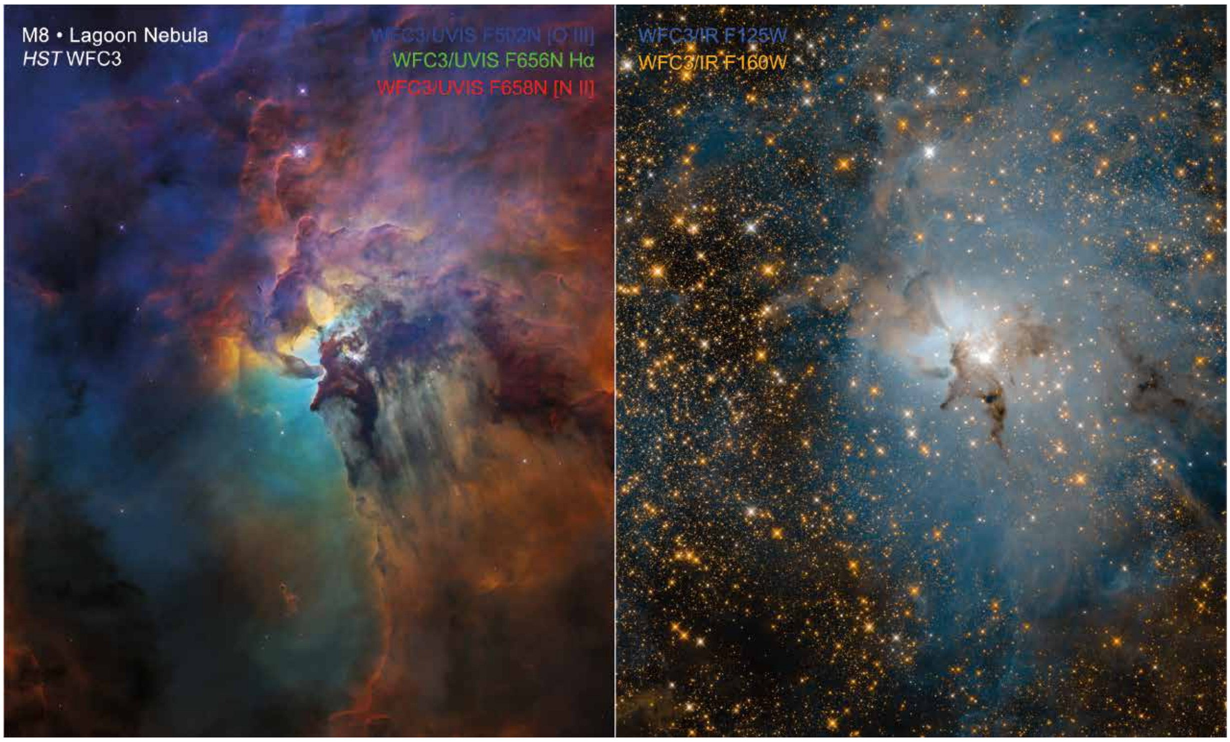
Businesses can also save a lot of money by ensuring their buildings are energy efficient. Small businesses in the US spend more than $60 billion a year on energy. Infrared imaging can map out areas of energy loss, especially with larger structures.

Fighting Fire with Heat

In cases of fire, the use of thermal imaging might sound counterintuitive since heat would be surrounding the entire area; however, thermal imaging cameras are capable of detecting differences in heat. Depending on how the camera is designed, thermal imaging cameras can detect differences as small as 0.01°C.

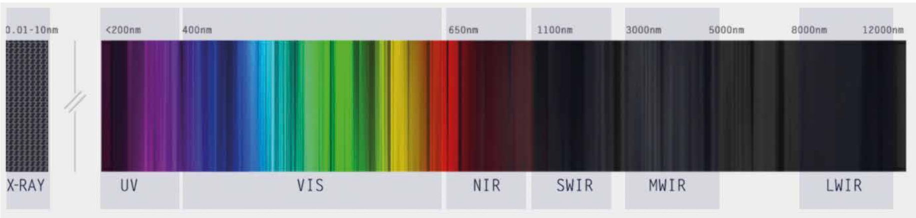
»

Being able to see beyond the visible spectrum improves the accuracy of inspection systems and helps to manage natural disasters.«



Source: NASA

Images captured by Hubble Space telescope of the Lagoon Nebula, a stellar nursery. The image on the left is taken in the visible, and the image on the right is taken in infrared.



The different color spectra

Firefighters often have a hard time navigating their way through a smoke-filled building. However, thermal cameras can help firefighters see through thick walls of smoke that would otherwise obstruct their view. It also enables them to detect burning surfaces and help distinguish a human amidst the heavy smoke and flames. Furthermore, infrared imaging can help first-responders map out the fire and help aid with navigation. Drones can be equipped with thermal imaging cameras and airborne sensors to fly over dangerous areas which responders cannot access. With this technology, emergency personnel have the ability to determine the size of the fire, the rate it's spreading, and to identify civilians that require rescue, as well as detect other hazards present during fire suppression. Thermal imaging can also ensure that all of the flames have been extinguished – the failure to extinguish smaller flames is a dangerous problem.

Seeing Infrared Outside of Our Planet

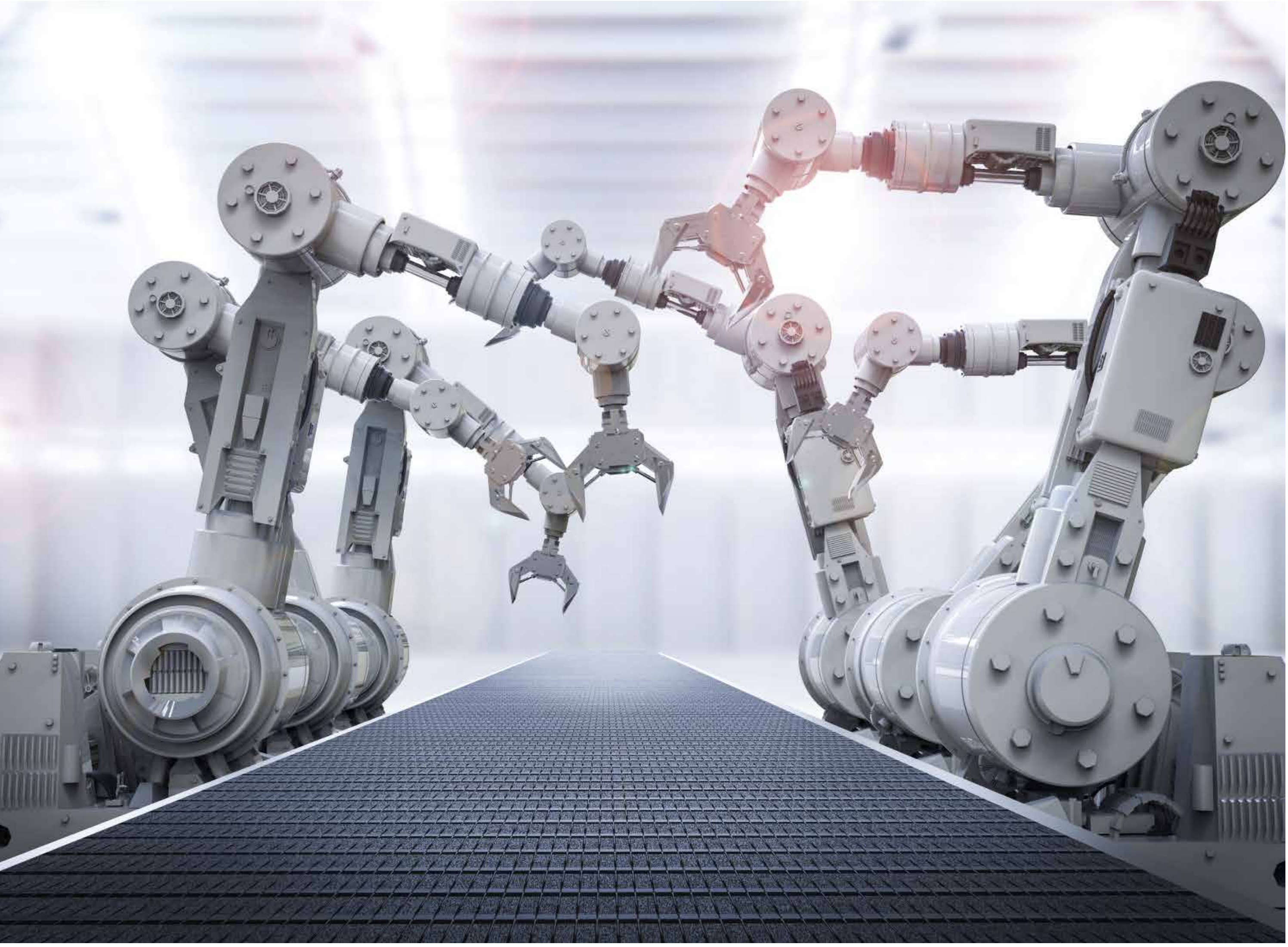
Infrared imaging also allows researchers to discover and observe celestial bodies both within and beyond our solar system. Planets, stars, galaxies, and other celestial objects radiate energy in the infrared spectrum, enabling scientists to capture images that would otherwise be obstructed by dust particles – a branch of astronomy known as infrared astronomy. Additionally, there are only certain 'windows' in the Earth's atmosphere where infrared radiation can reach telescopes, due to water vapors absorbing infrared radiation. To overcome this atmospheric obstacle, space-based telescopes were developed.

Space-based telescopes took off in the 1960s and have since enabled astronomers to discover new planets and stars outside of our solar system. They are also capable of conducting weather analysis when pointed toward Earth.

Launched in the 1990s and equipped with Teledyne Imaging's high sensitivity near-infrared sensors, the Hubble space telescope has made several astounding discoveries, from new planets to dark matter. The Hubble has also been used in the possible discovery of the first Exomoon, where researchers observed changes in the NIR exposure of the moon. From new galaxies to new molecules, advancements in imaging technology allow humanity to discover new aspects of our earth, and the universe. With thermal imaging, we are able to see what, in the past, was unseen. And in so doing, improve our understanding of not only our impact on our environment, but our response to environmental change. Being able to see beyond the visible spectrum improves the accuracy of inspection systems, enables the discovery of astronomical objects, and gives us the insight we need to manage natural disasters. ■

AUTHOR
Manny Romero
Senior Product Manager

CONTACT
Teledyne Dalsa, Waterloo, Ontario, Canada
Tel.: +1 519 886 60 00
www.teledynedalsa.com



©Fotolia

The Merging of Two Worlds

Integrating Automation and Machine Vision Through Standards

New technologies such as the IIoT require the integration of the different systems in process automation and machine vision. OPC UA, a framework that defines a common language for the communication between different system environments, paves the way.

Process automation and machine vision used to be two completely separate worlds. However, new technology and production trends such as Industry 4.0 (aka the Industrial Internet of Things) require that industrial value chains be more interconnected and consistent. Joint standards like OPC UA now ensure seamless integration and better interoperability between the two system environments.

The Need for Common Standards

The automation of industrial manufacturing and inspection processes has been around for a long time. Relevant technologies have been used and continuously developed since the 1960s and 1970s. They work with control and sensor systems that have become established and been proven over time. In most cases, proprietary applications are used that are difficult to integrate and have to be constantly reprogrammed and provided with modified interfaces for different use cases. In the context of automation, programmable logic controllers (PLCs) form the heart of mechanical manufacturing processes. Proprietary protocols like EtherCAT, Profinet/ Profibus and EtherNet/IP have been developed over a period of decades for use in this area. The many different standards generally don't permit direct, consistent communication between the different components.

Machine vision, on the other hand, is a comparatively new inspection and identification technology that is changing and developing highly dynamically. In the past, there were very few interfaces to PLCs and other automation technologies, which is why the two system environments have largely remained separated until now. However, Industry 4.0 is imposing entirely new requirements on networked production and inspection processes. All participants in the digital production process, including machines, collaborative robots (cobots) as well as automated handling and transfer systems, have to communicate with each other, exchange data and work together consistently. This requires common standards.

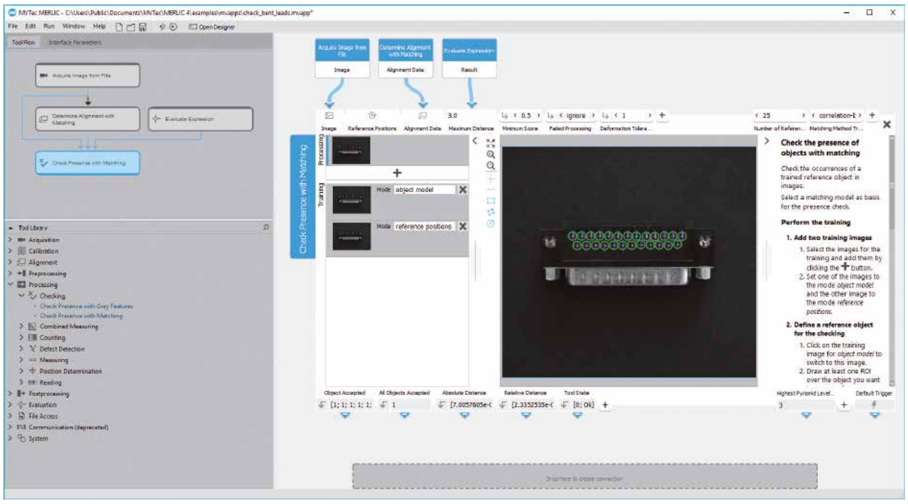
OPC UA for Consistent, Cross-Platform Data Exchange

Meanwhile, machine vision has become highly standardized. The GenICam (Generic Interface for Cameras) standard, which was launched in 2006, has led the way. It standardizes software-based access to all kinds of camera features used in machine vision. All current camera standards are based on GenICam, chief among them being GigE Vision and USB3 Vision, as well as high-speed standards like Camera Link HS and CoaXPress. Nevertheless, additional standards are needed to integrate machine vision seamlessly into process automation systems. The Open Platform Communications Unified Architecture (OPC UA) is of paramount importance here. It is a popular standard that ensures consistent data exchange between

»OPC UA is a framework that defines a common language for communication between different system environments. It can be used to integrate numerous industrial applications, such as those in robotics.«

different industrial components – independently of manufacturer, platform and operating system. The OPC Foundation, an international body made up of leading software suppliers and controller manufacturers, is at the forefront of this development.

Thus, OPC UA is a framework that defines a common language for communication between different system environments. It can be used to integrate numerous industrial applications, such as those in robotics. The foundation for OPC UA is a basic interdisciplinary specification that contains general guidelines for exchanging information. This specification is the basis for the "companion specifications" that cover the particular conditions of specific branches of industry. The OPC UA Companion Specification for Machine Vision (OPC Machine Vision for short) is significant for machine vision. It was developed by the OPC Vision Initiative of



MVTec Merlic makes it possible to create professional machine vision applications quickly and easily.

©MVTec Software GmbH

the VDMA (German Mechanical Engineering Industry Association). As a leading provider of standard machine vision software, MVTec Software is an active member of this body, through which it is working to promote the specification's widespread acceptance.

Semantic Description of Machine Data

Unlike other machine-to-machine (M2M) communication protocols, OPC UA not only permits the transport of information but can also describe machine data – for example, control variables, measured values and parameters – semantically. This context reference enables machines to read and understand the data independently. One of the objectives of OPC Machine Vision is the seamless combination of machine vision with PLC functions based on this semantic interoperability. For example, cameras and PLCs can be addressed in parallel via the shared standard. Uniform semantics can be implemented across all physical layers and field buses.

Standard Interface to Different Fieldbus Protocols

The integration of machine vision with process automation can also be simplified by means of hardware. Through its collaboration with Hilscher, for example, MVTec offers a uniform interface to different fieldbus protocols such as Profinet and EtherCAT. The API of the cifX family of PC cards from Hilscher provides a common interface for all PC cards. For example, it enables MVTec's standard machine vision software Merlic to communicate seamlessly with all common PLC technologies. Users benefit from a large number of drivers, form factors and network protocols that can be used with powerful imaging software.

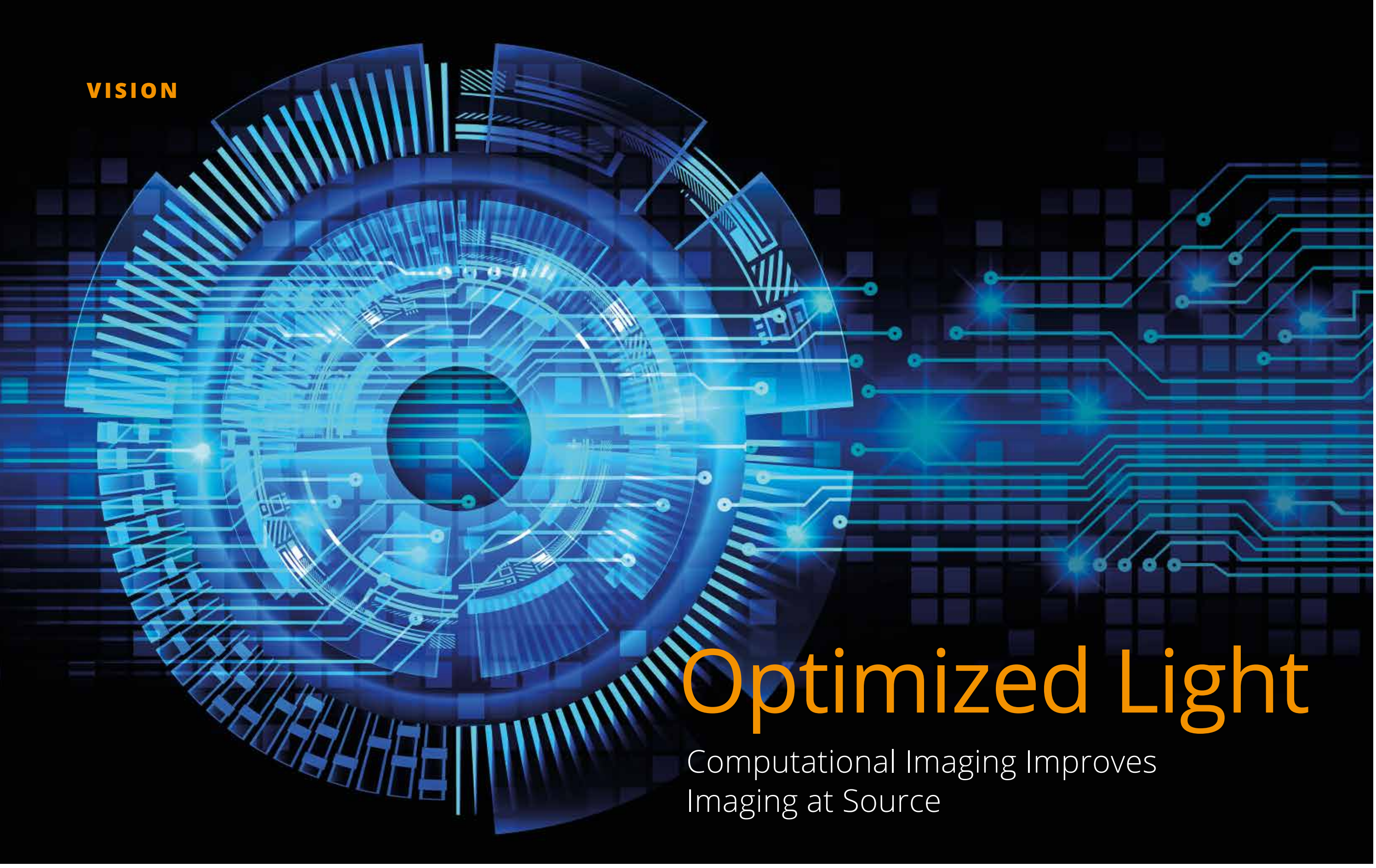
If the complete integration of machine vision and automation is to become a reality, the creation of complex machine vision applications must be made accessible to a broader range of users. MVTec Merlic provides support here as well. It's based on an image-centric user interface and contains intuitive, user-friendly tools that enable users to create professional machine vision applications quickly and easily, making complex program codes, command lines and parameter lists a thing of the past. For example, automation professionals who lack in-depth machine vision or programming expertise also benefit from this approach.

Summary

Process automation and machine vision are merging more and more due to the increasing establishment of standards such as OPC UA. This has many benefits, including the eventual, total elimination of proprietary interfaces. Tools from both environments can be better integrated and applications can be developed more quickly and flexibly, resulting in a shorter time to market. Thanks to increased interoperability, users benefit from more consistent processes and reduced effort for maintaining interfaces, as well as saving both time and money, while companies can meet the challenges of Industry 4.0 more successfully. ■

AUTHOR
Christoph Zierl
Technical Director

CONTACT
MVTec Software GmbH,
Munich, Germany
Tel.: +49 89 457 695 0
www.mvtec.com



Optimized Light

Computational Imaging Improves Imaging at Source

Computational Imaging (CI) uses data extracted from a series of images acquired under different lighting or optical conditions to create an output image containing the details that are most important to a particular machine vision task.

This approach offers powerful advantages over traditional one-shot imaging. It can improve the capability of a camera and reveal image detail not previously possible. Unlike traditional image acquisition, which often requires substantial post-capture image processing, CI is configured to directly output the required image, leading to more robust machine vision solutions.

Computational Illumination

A key requirement of CI is to optimize the lighting configuration and deliver a sequence of strobed images with different illumination for each frame. This might involve changing the intensity, angle or wavelength of illumination for each frame. By choosing from multi-segment, multi-spectral or multiple independent lights, a number of CI techniques are possible for applications such as image enhancement, image deblurring, geometry/material recovery, and others.

Typical CI techniques include:

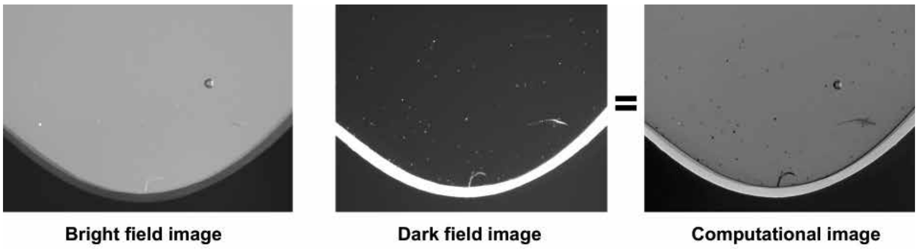
- high dynamic range imaging (HDR) – creating images with higher contrast ratios;
- ultra-resolution color (URC) – creating higher resolution color images with no interpolation artifacts;
- extended depth of field (EDOF) – improving measurements without losing light or reducing magnification;
- bright field/dark field – combining the advantages of two well-known lighting techniques;
- multi-spectral imaging – enhancing images with maximum contrast from multiple spectral bands;
- 360° object capture – panoramic imaging with singly triggered, multiple scene acquisition;
- PhotometricsStereo (PMS) – generating edge and texture images using shape from shading.

Illumination Kit

Machine vision lighting specialist, CCS Inc, offers a complete computational illumination kit for use with any machine vision camera and most smart cameras. This includes an extensive choice of 4-quadrant ring or bar lights, full color, multi-spectral or segmented full color lights as well as a 4-channel light sequencing switch, software and cables. Using an external system trigger, the light sequencing switch runs a pre-programmed sequence of lighting on the 4-channels and outputs a correlated camera trigger, automatically timing an external camera exposure to the programmed lighting sequence. The frame time and exposure for a sequence can be set as well as the strobe width for each of the independent channels. The system is fully compatible with leading machine vision software such as Sherlock from Teledyne Dalsa, where photometric stereo is already implemented.

Shape from Shading: The Trevista Process

One particularly important application of computational imaging is photometric stereo, or shape from shading. Inspecting shiny and curved surfaces or materials with variable brightness are extremely challenging tasks for machine vision systems. The patented trevista shape from shading method has been specifically developed to inspect the texture and the topography of the test specimen separately. The special technology offers fully automated, process-safe 100% inspection which can reliably detect even the smallest defects on such difficult surfaces. The object is illuminated from four different directions using domed diffuse structured light to reduce any interfering ambient light. It combines the speed of 2D image processing and the precision of 3D recognition. The shape from shading algorithms are integrated into the system software environment for automatic evaluation of the topographic images. The optical 3D shape measurement detects even defects down to a few microns which significantly increases inspection accuracy. The separate inspection of texture and topography leads to a minimum of pseudo rejects which significantly reduces related costs since real



Computational image compared with bright and dark field images

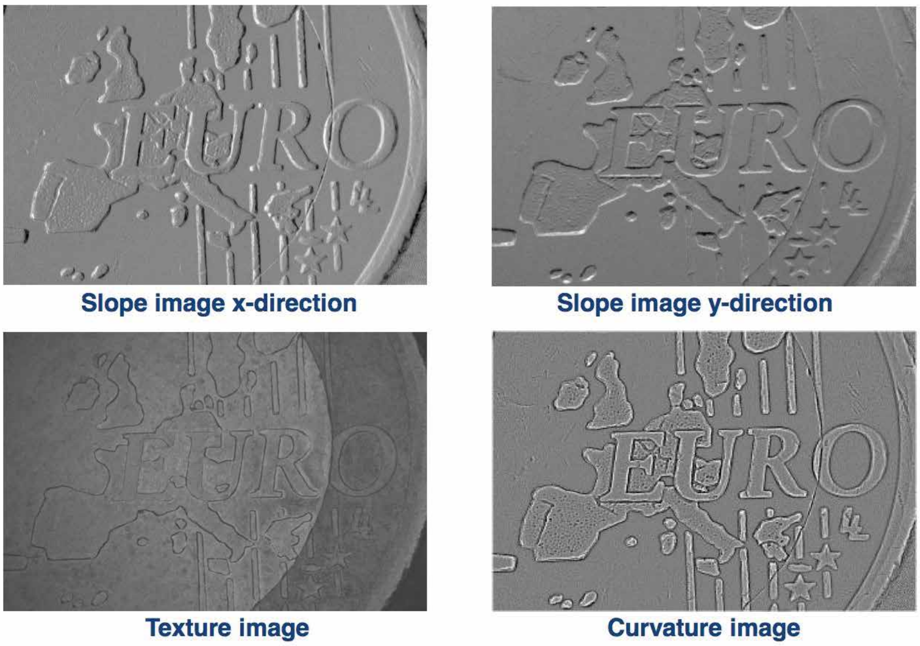


Image of the surface of a Euro coin captured with CVS trevista

defects such as scratches can be easily distinguished from supposed defects such as dirt on surfaces. With short cycle times inspection time can be reduced and productivity enhanced.

The Trevista Systems

Stemmer Imaging can offer a choice of dedicated trevista systems. The trevistaCam is a completely self-contained system that features an Adlink Neon 4-megapixel industrial smart camera and lens, preconfigured with either inspect Express or Sherlock measurement software from Teledyne Dalsa. The camera is integrated into a domed diffuse structured lighting trevista illumination system. The camera can readily be integrated into a manufacturing process with standard interfaces for higher level control. The two levels of software provide integrators with the option of a system that can be deployed without great image processing experience, or one that provides an advanced, rich set of tools and capabilities to solve more challenging applications. All shape from shading algorithms are included in the software. Applications include the identification of embossed data matrix codes and characters (or even raised braille text). Modular CVS trevista systems are also available which provide the flexibility of upgrading modules (such as utilizing a higher resolution camera) in order to react to changing requirements. Three CVS trevista variants are available. The surface system has a user-selectable area scan camera for the inspection of static parts with cycle times up to 200 parts per minute. The cylinder system uses a line scan camera for the inspection of cylindrical components, while the multiline system is designed for the inspection of moving or rotating components. This is perfectly suited to inspection tasks in production line processes and uses a freely selectable area scan camera which reads out the individual sensor lines. ■

»The patented trevista shape from shading method has been specifically developed to inspect the texture and the topography of test specimen separately.«

AUTHOR
Mark Williamson
Director Corporate Market Development

CONTACT
Stemmer Imaging AG, Puchheim, Germany
Tel.: +49 89 809 02 0
www.stemmer-imaging.de

Shed a Light

The Importance of Strobe Lighting Operation and LED Strobe Controllers for Machine Vision

LED strobe controllers allow machine vision engineers to achieve consistent light levels which are paramount to guarantee repeatable results.

Lighting is one of the most critical elements of a machine vision system and is key to achieve stable and repeatable results. Incorrect illumination and non-constant image brightness may result in extensive and time-consuming image processing or, in the worst case, in a crucial loss of information. There is no software algorithm capable of revealing features that are not correctly illuminated.

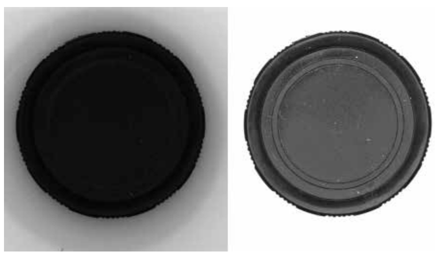
Most of the machine vision lighting products available nowadays are LED based. LEDs are in fact the ideal light source for machine vision applications: they can be switched on and off in sequence, turning them on only when necessary. Additionally, LEDs can be overdriven, i. e. they can emit more light only for a limited amount of time, which is usually necessary whenever the application requires an increased amount of light to image fast moving objects without motion blur. Furthermore, overdriving has many advantages, including the following:

- eliminate the influence of ambient light;
- preserve the LED lifetime;
- synchronize the on time of the light with the camera and the item to be inspected;
- reduce the power consumption of the whole vision system;
- decrease heat dissipation (no heatsinks or fans required).

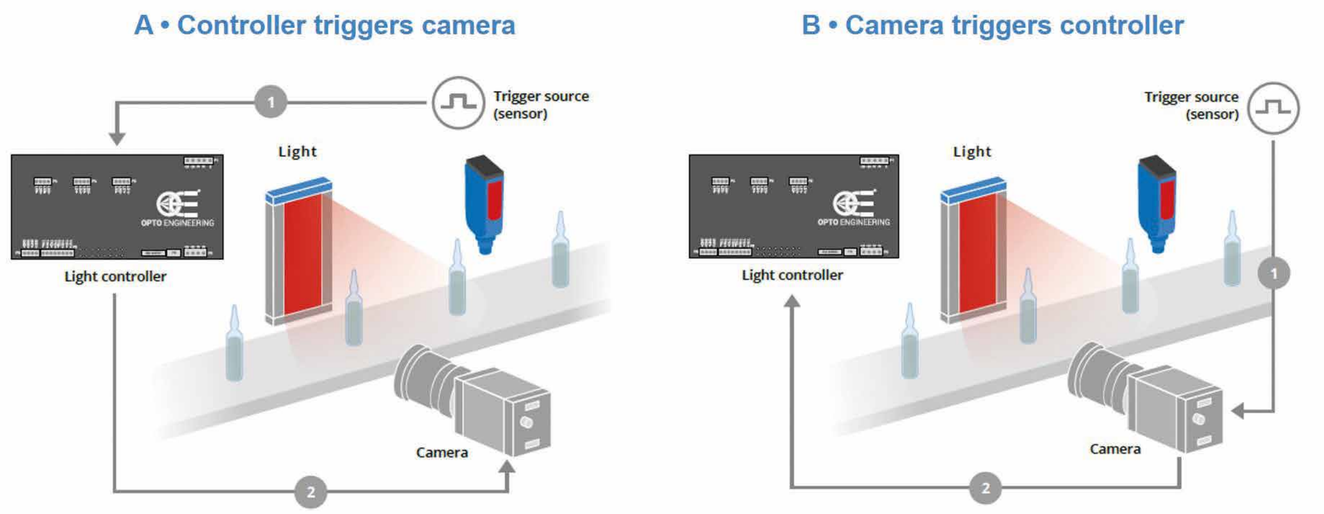
When inspecting fast moving parts, typical conditions include cameras set at short exposure times (to avoid motion blur) and optics set at high F/N. However, such conditions may lead to images that are too dark to be processed by machine vision algorithms. To get more light it is possible to either increase the camera gain or to lower the lens F/N. The first option will result in higher noise levels while the second will decrease the depth of field: both ways, therefore, will result in an image where fewer details can be distinguished.

In many cases it is possible to avoid this issue by increasing the amount of light. For this reason, Opto Engineering offers a wide range of LED lights designed to work in overdrive mode, specifically suitable for high speed applications, including high uniformity LED backlights available in many formats and wavelenghts (LTBP series), dome illuminators (LTDM series), low angle ringlights (LTLA series) and powerful LED pattern projectors (LTPRUP series).

When pulsing LEDs in high demanding applications it is, of course, essential to synchronize the on time of the light with the cameras and manage the timing in the most precise and repeatable way by controlling the pulse



Images of black plastic caps illuminated with dome lights. The image on the left cannot be processed by machine vision algorithms: the dome light used is not powerful enough. The image on the right with strobe illumination can be used for surface inspection.



A) Option A shows a triggering arrangement where the light controller is triggered by trigger source(s) (sensor positioned on the manufacturing line) and the lighting controller then triggers the camera(s). B) Option B shows an arrangement where each camera is triggered by a trigger source (sensor), the camera then triggers the light controller and starts its exposure.

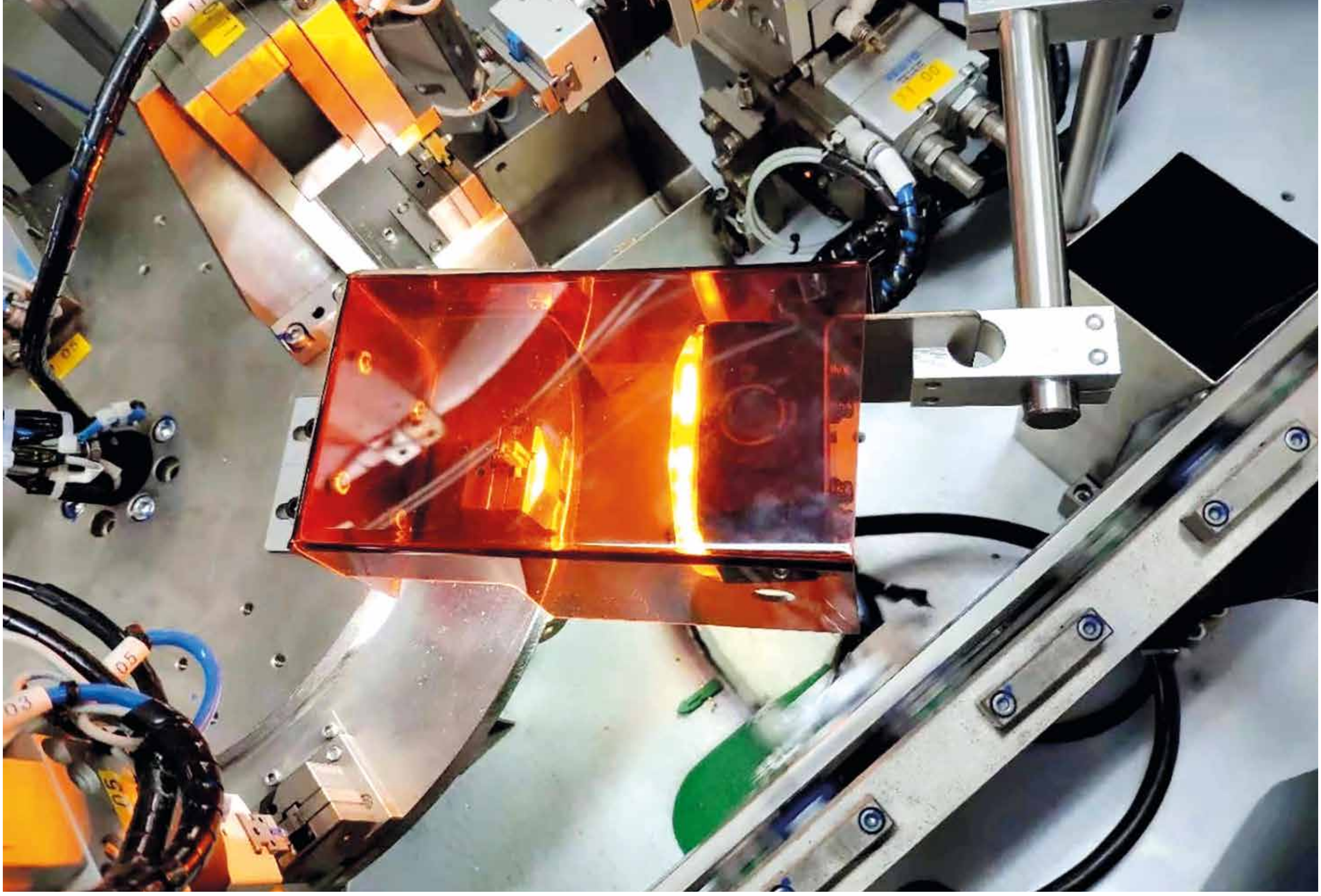
»With flashed LEDs in high demanding applications, it is paramount that the lighting is synchronized with the camera and the control is highly accurate and repeatable.«

duration, frequency and amount of current supplied to the LED: a LED strobe controller is required to do this, allowing machine vision engineers to achieve consistent light levels which are paramount to guarantee repeatable results.

Opto Engineering offers LED controllers with up to eight channels either with Ethernet and/or RS485 interfaces designed to accurately set current intensity, pulse duration and delay of LED illuminators (in steps a slow as 1 µs). The communication protocol is Modbus. In addition to a number of opto-isolated synchronization inputs, Opto Engineering high-performance controllers feature several synchronization outputs that allow the controller to be used as a master to the camera or to directly control an actuator on the line. ■

AUTHOR
Massimo Castelletti
Product Manager

CONTACT
Opto Engineering Europe Headquarters
Mantova, Italy
Tel.: +39 0376 699 111
press@opto-e.com
www.opto-e.com



Smaller and Simpler Choice for Inspection

Vision Sensors Enable Diversified Inspections

As there are various inspection requirements in the industry, vision systems are not always easy to build. Progressive vision sensors with integrated additional functions master the challenge.

The industrial camera is gradually becoming an indispensable part of the modern industry. However, it is still considered complicated to build a vision system for the inspection of presence/ absence, position, distance or angle, etc. A conventional PC-based vision solution requires a lot of materials including camera, lens, PC, light and redundant data cables. Is there a way to simplify the structure and the setup while maintaining the performance?

Vision sensors offer a solution to fulfill both needs. Compared to conventional PC-based solutions, the vision sensor features a compact structure and much easier setup. Meanwhile, the vision sensor provides more functions based on image processing than other industrial sensors.

The recently released Hikvision SC series vision sensor is such a product that meets the newest expectations. It features a wealth of built-in vision tools for diversified inspections, integrated lens and light, and a unique web-based HMI to improve the user experience.

What are the possible improvements when deploying a Hikvision SC vision sensors? Actual application cases describe them best.

Error-Proofing of Metal Part Assembly

In automotive industry, numerous metal parts need to be assembled. These parts are usually very small, transported with high speed on the conveyor belt. In addition, the same line is assigned to multiple types of parts, and the shift takes place quite frequently. Consequently, errors occur. To sort out the defective parts, an error-proofing inspection is required. The traditional solution composed of multiple photo-electronic sensors can hardly achieve the necessary multi-point check of the irregular metal parts.

The vision sensor has a built-in vision tool to measure the light intensity of multiple points in the FOV. All that is needed is to turn on the integrated front light. By checking the light intensity of predefined positions and calculating the illuminated area, the vision sensor is able to determine whether the metal part is correctly mounted or not. Only one vision sensor is needed in the whole inspection process, and the final result OK/ NG can be sent to the action part or PLC directly. Introducing the vision sensor to the sorting

»Compared to conventional PC-based solutions, vision sensors feature a compact structure and much easier setup while providing more functions based on image processing than other industrial sensors.«

system reduces the complexity of the system and the development difficulties, saving integrators the time spent on debugging with traditional vision systems.

Steel Inspection

A steel manufacturer needed to sort steels during the molding process to guarantee that different steels are sent to corresponding machines correctly. Besides, before sending steels into the punching machine, it was also required to check their positions to ensure that they could be shaped accurately. The accuracy is on centimeter-level.

The vision sensor can record the marking or pattern on the steel surface as a feature, differentiate steel types, and calculate the positions and angles by comparing the recorded features. Moreover, the built-in edge detection vision tool allows to measure the distance and angle between the two ends of a steel to check whether it is identical to the mold. The inspection result can be sent to the superordinate computer via multiple transmission methods such as Serial port, I/O, TCP or UDP.

Previously, the customer needed to employ several operators for sorting and aligning. Since the implementation of the vision sensor each production line has been saving an average of two workers.

LED Inspection

A power bank manufacturer needed to inspect LEDs on the power banks. Before, many integrators preferred to use color mark sensors to check multiple predefined positions on the power bank one by one to see whether there were LEDs blinking. Afterwards, all the results needed to be integrated with a PLC.

With the built-in vision and logic tools the vision sensor is able to check the light intensity of all positions at once. Then, all the check results of different positions are integrated automatically. Only one OK/NG signal will be output to indicate if the power bank is defective or not. It appears to be an easier and more logic way to perform this kind of LED quality inspection. The inspection efficiency and building costs are largely improved with the help of the vision sensor.

Liquid Level Inspection

A manufacturer of bottled mineral water recently introduced SC series vision sensors into its production lines for liquid level inspection. In the inspection spot, an area light panel is placed at the back of the bottle, and the vision sensor is fixed in front of the bottle. The edge detection vision tool is used to measure the distance between the liquid level and the bottle cap.

Before using the vision sensor, this process needed to be inspected manually by two operators. In addition, a much larger backlight panel was needed in case that the human eye couldn't follow the high-speed movement of the inspected objects. By virtue of its 60-fps frame rate, the vision sensor only needs a backlight panel that is slightly bigger than the bottle. No more worries about the movement speed of the conveyor.

Printing Characters Presence Inspection

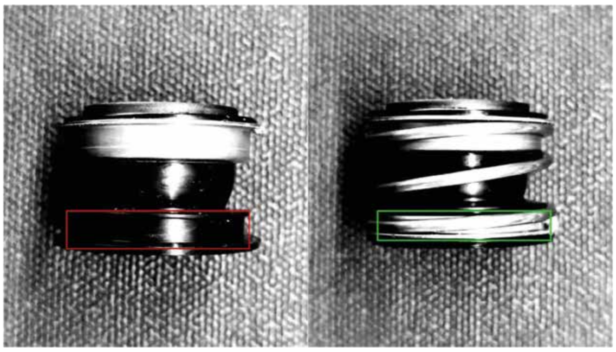
At the end of production, a thorough inspection on the packaging of each product is performed before the products are finally packed in batch. Among many items, the inspection of the production date is key.

After testing, it is confirmed that the surface with printed characters has an obvious contrast difference compared to the one without printed characters. The SC series vision sensor provides a contrast measurement function which realizes the presence/absence detection of the production date in the simplest way.

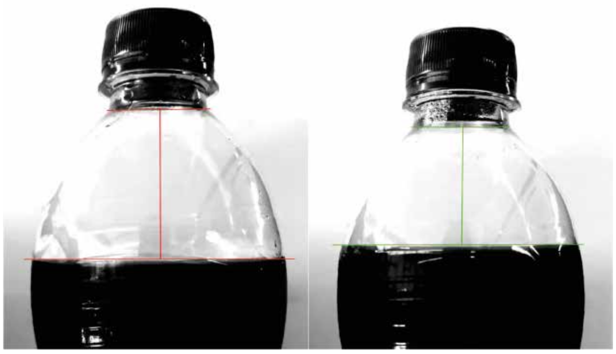
In the past, PC-based solutions largely reduced costs by replacing a part of human work. Today, the vision sensor simplifies the wiring, building and configuration process of a machine vision system.

We believe that in the future additional new technologies, like 5G and AI, will be integrated into machine vision products, including vision sensors and other smart cameras. The vision sensor will become even smaller, more powerful and easier to use. In the long term, more application scenarios can be expected. ■

Hikvision SC Series Vision Sensor



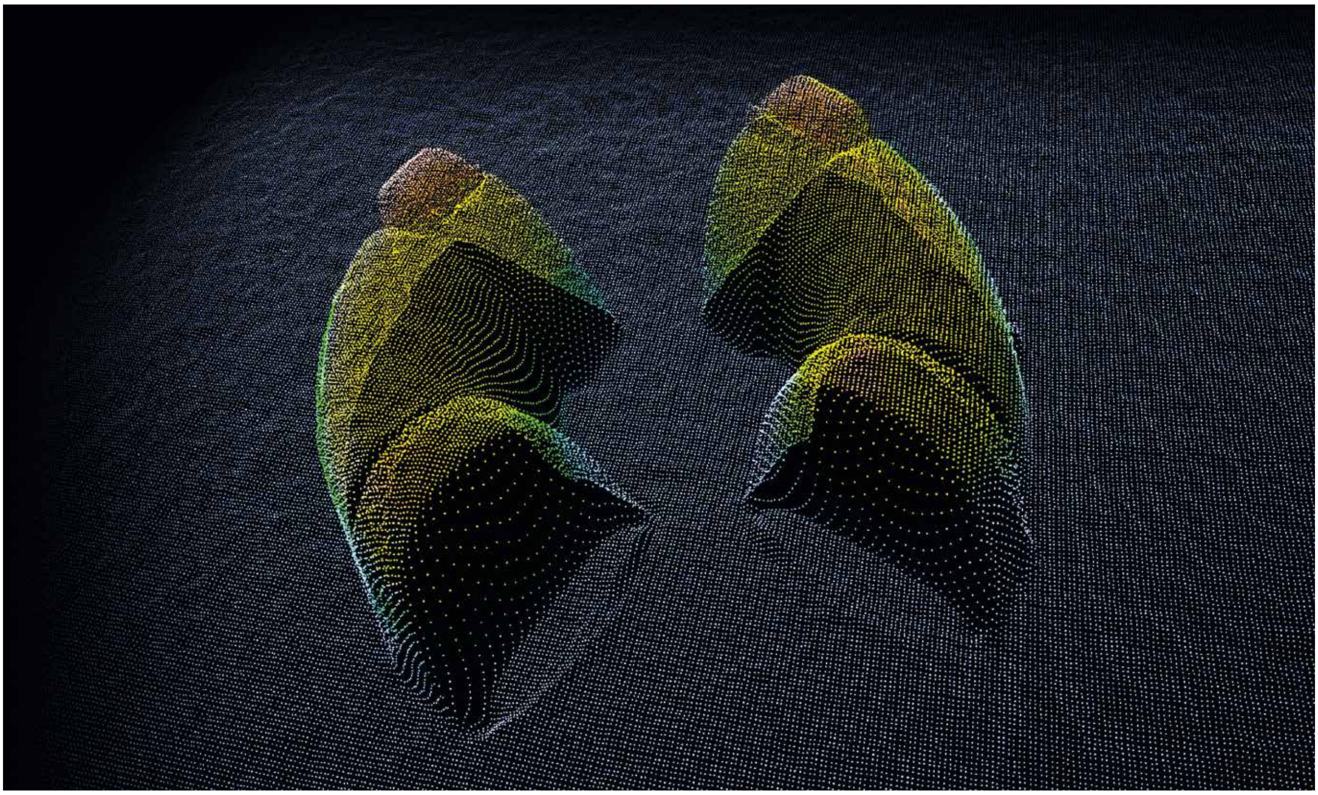
Metal Part Assembly Inspection



Liquid level inspection

AUTHOR
Kane Luo
Area Sales Manager – EU

CONTACT
Hangzhou Hikrobot Technology Co., Ltd.
Hangzhou, China
Tel.: +86 400 800 59 98
www.hikrobotics.com



Time-of-Flight on the Rise

3D ToF Camera with DepthSense Sensor

Time of flight technology offers multiple opportunities for developers of 3D imaging systems, eliminating the need for calibration, better robustness against different lighting conditions, relieving the PC, and saving cost.

Three-dimensional (3D) imaging applications are used in many different industries ranging from both industrial pick and place, palletization/depalletization, warehouse, robotics and metrology applications to consumer-based products such as drones, safety and security, and patient monitoring applications. No one specific type of 3D technology can solve all these different types of applications and the features of each must be compared as to their suitability for each application.

Passive Versus Active

3D imaging systems can be classified into both passive and active systems. In passive systems, ambient or broad fixed illumination is used to illuminate the object. Alternatively, active systems use various methods of spatially or temporally modulating light including laser line scanning, speckle projection, fringe pattern projection, or time of flight (ToF) scan 3D objects. In both passive and active 3D imaging systems, reflected light from the object being illuminated is captured, often by a CMOS-based camera, to generate a depth map of the structure and then, if required, a 3D model of the object.

Time-of-Flight

While surface height resolutions of better than 10µm are achievable using laser scanners at short working distances, other applications demand longer range. For example, applications such as navigation, people monitoring, obstacle avoidance, and mobile robots require working distances of several meters. In such applications, it is often simply necessary to understand if an object is present and measure its position to within a few centimeters.

Other applications such as automated materials handling systems, operate at moderate distances of one to three meters and require more accurate measurements of about one to five millimeters. For such applications Time-of-Flight imaging can be a competitive solution. ToF systems operate by measuring the time it takes for light emitted from the device to reflect off objects in the scene and return to the sensor for each point of the image.

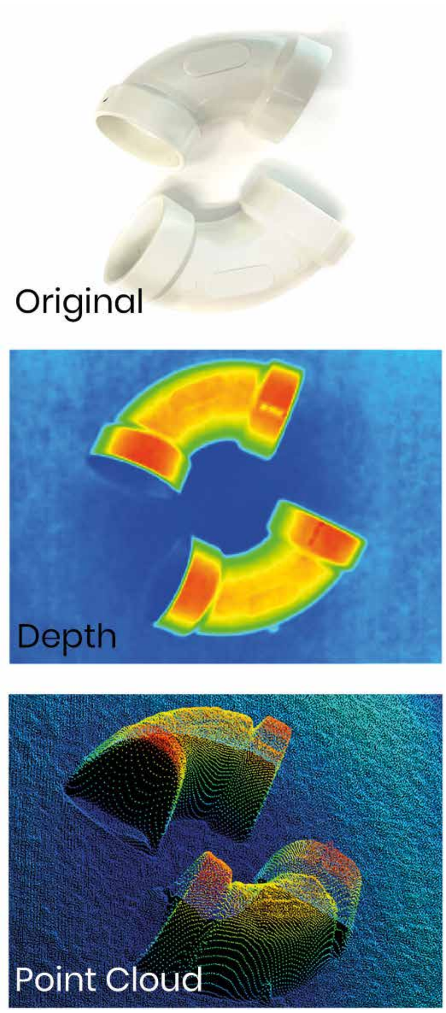
For applications such as automated vehicle guidance, Lidar scanners can be used to produce a map of their surroundings by emitting a laser pulse which is scanned across the device's field of view (FOV) using a moving mirror. The emitted light is reflected off objects back to the laser scanner's receiver. This returned information contains both the reflectivity of the object (the attenuation of the signal) and time delay information that is used to calculate the depth through ToF.

Pulsing or Waving

ToF cameras use one of two techniques, pulse-modulation (a.k.a. direct ToF) or continuous wave (CW) modulation. Direct ToF involves emitting a short pulse of light and measuring the time it takes to return to the camera. CW measurement techniques emit a continuous signal and calculate the phase difference between the emitted and returning light waves, which is proportional to the distance to the object.

Phase-based devices are available from several companies including Texas Instruments and Panasonic, with one of the newest

»With the release of GenICam 3.0, depth and amplitude data or processed point data can be read from cameras without any further data conversion required.«



Original, depth, and point data images of PVC pipes

sensors from Sony Semiconductor Solutions. Originally developed by SoftKinetics, now owned by Sony. The SoftKinetics technology features a Current Assissted Photonics Demodulation (CAPD) pixel structure capable of high-speed sampling with high efficiency. This ToF pixel technology is combined with Sony's backside illuminated sensor (BSI) technology to create the new DepthSense ToF sensor. The BSI technology provides better light collection efficiency in NIR wavelengths. The new Sony IMX556PLR is a ½ in sensor with 640 x 480 resolution, 10µm x 10µm pixels that runs at 60fps depth frame rate.

High-Precision ToF Camera Featuring Sony DepthSense

In June 2019, Lucid Vision Labs announced the series production of its Helios ToF 3D camera featuring Sony's DepthSense IMX-556PLR backside-illuminated (BSI) sensor. The company first demonstrated the Helios camera at Vision show 2018 and has seen great interest in this new camera technology since its debut.

The Helios camera can be operated at three working distances using light from four on-board 850nm VCSEL laser diodes modulated at different frequencies. The camera has a 59° x 45° field of view and an operating range of 0.3 to 6 m. At its highest modulation frequency of 100MHz the Helios camera has 2.5 mm precision and 5mm accuracy over its 0.3 to 1.5 m working range. The camera performs on-board processing producing 3D point cloud data that can be read directly from the device instead of having to be calculated off-chip. The point cloud data can be transferred over the camera's GigE interface and further processed using Lucid's Arena software development kit (SDK), which allows users to write custom programs interfacing with the camera in C, C++ or C#.

The Arena SDK includes easy to use controls for the Helios ToF camera. The ArenaView GUI can show the intensity and depth of a scene in either a 2D view or a 3D point cloud view, which can be manipulated and oriented in real-time. Additionally, settings can be adjusted and seen in real-time, including false color overlay and depth range.

In the past, camera vendors needed to supply drivers to their customers so that they could properly be configured and controlled by a host computer. With the introduction of GenICam, a generic programming interface for machine vision cameras, the camera interface is decoupled from the user's API, alleviating the need to write multiple camera drivers. Now, with the release of GenICam 3.0, depth and amplitude data or processed point data can be read from cameras without any further data conversion required. Since the Helios camera is GenICam compatible, it can be very quickly integrated with off-the-shelf GenICam software packages that are currently available.


The Helios camera features Sony's DepthSense sensor.

Conclusion

Time of flight (ToF) technology such as Sony's DepthSense sensor used in Lucid's Helios camera presents a new set of opportunities for those developing 3D imaging systems. First, because the system only uses a single camera, no calibration is required by the developer. Secondly, the system is much less affected by adverse lighting conditions compared to traditional passive stereo. Thirdly, the camera outputs point cloud data directly, offloading processing from the host PC. Lastly, the system is relatively low-cost being less expensive than high-performance active laser systems and comparable with projected laser light stereo systems. ■

AUTHOR
Jenson Chang
Product Marketing Manager

CONTACT
Lucid Vision Labs, Inc.,
Richmond B.C. Canada
Tel.: +1 833 465 82 43
www.thinklucid.com

Remotely Operated Walking Excavator

Remote Reality Teleoperation Project with Low Latency Multi-Camera Video System

With the technological advancement of wireless communication speeds to 5G networks and visualization technologies such as virtual reality, control units and sensors, it has become possible to train machine operators in a virtual environment as well as operate machinery from remote locations.

The technical university ETH Zurich is currently working on a project with the objective to deliver a precise and realistic experience to a machine operator, in this specific case that of an excavator. The operator will have access to all relevant information in the same form as if he was physically in the cockpit of the excavator. Furthermore, he can receive additional semantic data that is not available in the excavator, thus making his remote work more efficient.

Environment and Showcase

Some of the first use cases of the remotely operated excavator are trade show presentations and crane operator training in special laboratories. Outdoor trade shows have specific conditions, similar to an outdoor environment with changing sunlight and variable humidity. Menzi Muck AG, manufacturer of the walking excavator, in collaboration with ETH Zürich, demonstrated remotely operated excavators at Bauma Fair 2019. The demonstration consisted of a Menzi Muck simulator set for the training of operators connected to an excavator located in a different city. The operators were utilizing virtual reality goggles.

The excavator is equipped with a multi-camera vision system based on industrial cameras from Ximea. The cameras use a low-latency image processing solution provided by MRTech, and they are running on the Nvidia Jetson TX2 platform. Since it is an outdoor environment the exposure time of the cameras is dynamically updated with the changing conditions. There are many parts of this system that have to work in sync and are crucial to fulfill the highest requirements. In the following the components utilized for this complex application will be examined, split into several sections also covering reasons for particular solutions.

HEAP – Hydraulic Excavator for an Autonomous Purpose

The excavator used, called HEAP, is a customized Menzi Muck M545 excavator developed for autonomous use as well as advanced teleoperation. The machine has novel force-controllable hydraulic cylinders in the chassis that allow it to adapt to any terrain. Additionally, HEAP is equipped with sensors necessary for autonomous operation, i.e. Lidars, IMU, GNSS and joint sensing. The primary autonomous use is robotic landscaping/excavation which is investigated through a program of the National Centre of Competence in Research (NCCR) Digital Fabrication.

Embedded Remote Reality Streaming

The ETH team developed an actuated stereo video streaming setup in cooperation with MRTech, the official System Integrator of Ximea cameras for various projects. The collaboration originated from the strive to achieve

© Menzi Muck AG

Sensorized custom Menzi Muck M545 robot called HEAP

full resolution streaming from the cameras using the following hardware components:

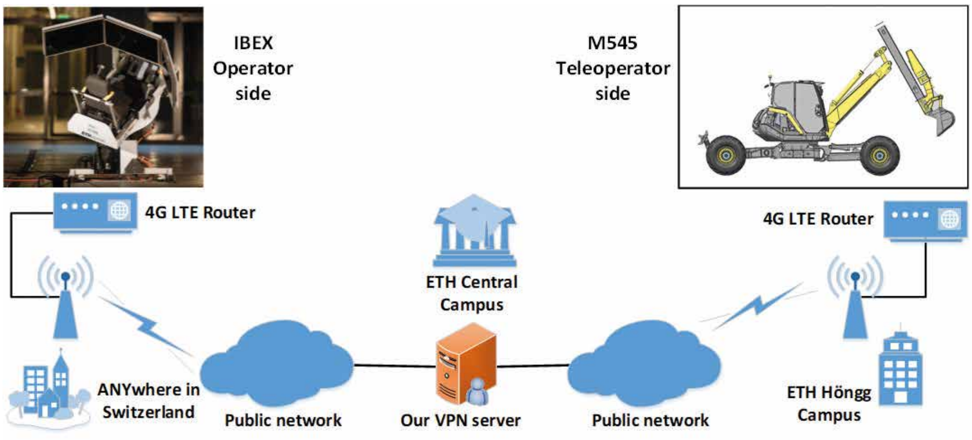
- Nvidia Jetson TX2 module with a carrier board;
- 2x PCIe xiX 3.1 Mpix (MX031CG) cameras with 2,064 x 1,544 resolution, 1/1.8" and 122 fps (218 Fps max) Theia MY125M ultrawide angle lenses (optically corrected fisheye ~150°);
- Gremsy T3 brushless pan-tilt-roll unit coupled with HTC Vive;
- Arduino nano for trigger control of the cameras.

This setup runs on Ubuntu 16.04 and employs the GPU accelerated image processing and video compression of currently H.264 on the stereo video stream. At the moment, the achievable resolution is 1,416 x 1,416 @40 fps or 80 fps with interleaved event. The resolution can be improved by choosing a camera model with a larger sensor. Improvemens of the framerate are possible by upgrading the Jetson to the AGX Xavier version in the future. The Gremsy gimbal is normally used for stabilized imaging, but ETH converted it into a position-controlled slave robot to mimic the motions of a human head. Initial tests show that the Gremsy unit is adequate for slow head movements, but for faster movements the operator can experience significant latency.

Multi-Camera Embedded System

MRTech has developed a modular multi-platform framework for image processing and machine vision applications focused on high dynamic range and lowest latency.

For this particular project, the following GPU-accelerated processing pipeline is implemented on a Nvidia Jetson TX2 platform with a carrier board used for interconnection. A switch to AGX Xavier will achieve even



Communication structure of the ideal mobile setup

higher bandwidth processing power and increase the Fps speed.

The current pipeline includes the following steps:

1. 8-, 10-, and 12-bit Raw image acquisition from the Ximea camera;
2. Black level subtraction;
3. Auto white-balance;
4. High-quality demosaicing (debayer);
5. Gamma correction;
6. Conversion to YUV format;
7. H.264/H.265 video encoding;
8. RTSP streaming;.

Steps 2 to 6 implemented the high-performance Fastvideo SDK that runs on the GPU.

In addition, the processing applies an asynchronous auto-exposure algorithm to adapt the camera settings in varying lighting conditions. Finally, when the two MX031CG cameras are acquiring simultaneously (with hardware synchronization), the system adds 15 ms latency for the above processing steps. Total glass-to-glass latency should not exceed 60 ms depending on the network parameters. The targeted communication environment is a 4G/5G network.

IBEX Motion Platform

Another part of the setup is IBEX which has been designed for HEAP in order to provide accurate motion and visual feedback. Particularly, it is a recreation of the HEAP's cockpit that sits on top of a 3-DoF motion platform. The movement of the excavator chassis and the movement of the platform are coupled in sync. This is essential, especially due to Menzi Muck's unique walking design in which operators heavily rely on their sense of motion to estimate whether all four wheels are in contact with the ground or not. In the initial design of IBEX, the visual feedback is provided via three 2D monitors that display live camera streams from three different perspectives – the front window and two side windows. As an extension, the monitors are replaced with a head-mounted display (HMD) using HTC Vive to completely visually immerse the excavator operator in a remote reality projection of the excavator's true surroundings. This allows the operator to experience the real sense of immersion, in fact, the HMD actually enhances the operator's perception of three-dimensional space. The image quality, visual acuity and field of view for the operators could even improve once the HTC Vive is replaced with XTAL, as described below.

Visualization

As mentioned, the current system works with an HTC Vive headset. For virtual reality, the XTAL VR headset from VRgineers is under consideration. It offers a 180-degree field of view with a crystal-clear picture. This is achieved by the combination of two OLED panels with a total resolution of 5,120x1,440 pixels, running at 70 Hz refresh rate. It is connected to a computer using one DisplayPort 1.2, one USB and one power cord.

At the moment, XTAL offers the following functionality:

- OpenVR support;
- NVIDIA VR works support;
- Testing eye tracking (30 fps);
- Hand tracking via embedded Leap Motion sensor;
- Support for AR Tracking, Lighthouse tracking, Optitrack tracking, StarTrack tracking.

In the near future the list will grow and include:

- Linux support;
- Fast eye tracking (120 fps);
- Nearside electromagnetic tracking (up to 2 meters – only suitable for seated experiences);
- Front facing cameras as addon module;
- Foveated rendering.

Compact Teleoperation Backpack Solution

Future requirements could be based on operating the excavator remotely without the use of IBEX. Then, the operator would wear all the necessary equipment to teleoperate the machine. This setup would also make sense for teleoperating smaller machines and allows integration of the camera system. Such a mobile operating station can also be considered for semi-/full-autonomous commanding using mixed reality.

The HP Z VR backpack computer can be worn as a standard backpack and has been tested with HTC Vive as well as with XTAL. It supplies sufficient performance and reliability coming together with exchangeable batteries and desktop docking station. Further specifications are:

- Intel i7 7827820HQ (2.9/3.9GHz);
- 16 GB RAM DDR4;
- Nvidia Quadro P5200;
- SSD 256;
- Ubuntu 16.04;
- SteamVR + OpenVR on Linux. ■

AUTHOR
Ivan Klimkovich
International Sales Manager

CONTACT
Ximea GmbH,
Münster, Germany
Tel.: +49 251 202 408 0
www.ximea.com

Products

New High-Speed Camera with 26.2 Mpix

Reaching a resolution of 26.2 Mpix (5,120 x 5,120 pixels) and up to 150 fps, the newly introduced CB262 from the xiB-64 series expands the product portfolio of Ximea. The PCIe3.0 interface allows image data to be transmitted at 64 Gbps (8 GB/s) – even over distances of 100 m via fiber optic connections.

The models of the xiB-64 series with selected Luxima, CMOSIS and GPixel sensors range from variants with 1.1 Mpix resolution and over 3,600 fps to 65.4 Mpix at 76 fps. The xiB-64 series combines high speed and high resolution in a compact package (60 x 70 x 40 mm). The ability to transfer image data directly into the PC's main memory (DMA) enables both high-capacity data storage and further processing of image data on graphics processors (GPUs). The range of applications extends from process monitoring, sports broadcasts and flow measurements (PIV) in the high-speed range to land surveying, medical technology and high-resolution spectroscopy. **www.ximea.com**

Up to 6Gpx/sec

Vision Research, leading manufacturer of Phantom high-speed cameras, introduces the Phantom S640 to their growing machine vision family. The Phantom S640 leverages the Phantom CMOS sensor used in the popular VEO640 camera and provides up to an astounding 6 Gpx/ sec (75 Gbps) of streaming data and images for machine vision applications.

The S640 gives demanding machine vision applications the frame rates they need, reaching 1,480 fps at full 4 Mpx resolution of 2,560 x 1,600 and up to 200,715 fps at lower resolutions. The S640 has many similar characteristics to the VEO640, including high image quality and high frame rates at 4Mpx resolution, but its output is not confined to the camera's RAM.

"We're excited to bring the benefits of the Phantom S640 to a wide variety of Machine Vision applications, especially those that need to access and analyze the high-speed data immediately and can't wait for downloading from the camera's memory, as well as those events and processes that run longer than standard camera RAM can manage," said Dan Hafen, Director of Business Development for Machine Vision Cameras at Vision Research.

www. ametek.com

Machine vision is used across the manufacturing industry to ensure product quality from the inspection of raw materials through product assembly to the final packaging stages. Currently, advances in lighting and imaging technology are driving innovative solutions to complex inspection applications in sectors such as SEMI, MedTech, and pharmaceutical.

Illumination for Computational Imaging

Innovative Use of Machine Vision Lighting for Multi-Shot Imaging

Computational Imaging

Producing high quality images with good contrast, focus, and low noise is essential for machine vision. Information that is not actually present in the image because of inadequate illumination can never be extracted using image processing. However, while it is important that the illumination has enough intensity to deliver good signal to noise, there may be more challenging factors in the application. These could be due to complexities such as curved or uneven surfaces, different textures and reflectivity, engraved or embossed characters (such as braille), or differing heights of inspected objects. Innovative approaches to the way lighting and optics are used, such as computational imaging (CI), can provide a solution. CI is a flexible multi-shot imaging method which uses data extracted from a series of individual images captured under different lighting or optical conditions. The resulting computed image contains detail or contrast not achievable using traditional single-shot imaging and can then be used for subsequent measurement and analysis using traditional machine vision methods. CI can create many different imaging solutions in many industries by producing better images or images with unique characteristics. Many CI tools have already been developed to enhance contrast, provide ultra-resolution color, extend depth of field, extract 3D surface information, remove glare, combine well-known lighting techniques, and generate multispectral information in a single image. For example, in the highly regulated medical device industry, vision systems are used to inspect the devices, associated components and packaging during assembly. One application is checking the labels and markings on packets and cartons which frequently include braille characters stamped into the carton so that they are superimposed on the printed text. The use of single-shot imaging makes it hard to obtain sufficient contrast on the braille characters in order for them to be read. The problem can be solved using photometric stereo methods, one of the many computational imaging techniques available.

Photometric Stereo

Photometric stereo imaging is also known as 'shape from shading' imaging and uses a sequence of images generated under different lighting conditions to separate the shape of an object from its 2D texture or surface coloring. Typically, it is used to highlight 3D surface features or imperfections in one image, known as the shape image, and remove glare from highly reflective parts, known as the texture image. In general, the object is sequentially illuminated from multiple directions, typically using a ring light with four 90˚

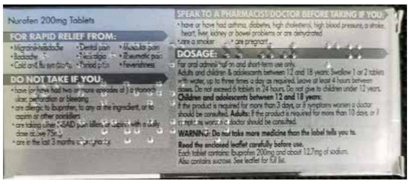


Fig. 1: Braille characters on a pharmaceutical carton

Fig. 2: 4 directional images for photometric stereo imaging

quadrants or an array of four bar lights or any other configuration that produces directional lighting. The shape from shading software processes the four images to generate the shape and texture images. The shape image is produced by removing all contributions from the source images that are the same, which leaves the differences created by shadow. This enhances 3D surface details such as scratches, dents, pin holes, raised printing, or engraved characters. It is especially effective on surfaces that have 3D structure but little to no contrast. The texture image is produced by removing areas in the images that are different (the light coming from each direction). This removes interference from the surface structure and removes glare.

In a braille character example, the carton is sequentially illuminated using a ring light with four 90° quadrants to generate four source images. Using photometric stereo software, the shape image of the carton is extracted to reveal the raised braille characters. These can be segmented using blob analysis to show the dots on a black background.

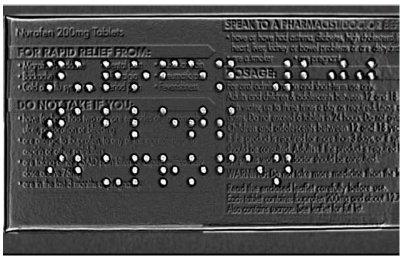


Fig. 3: Shape image of the carton

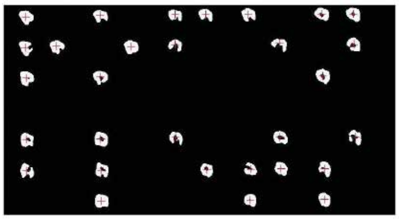


Fig. 4: Segmented image of braille characters using blob analysis

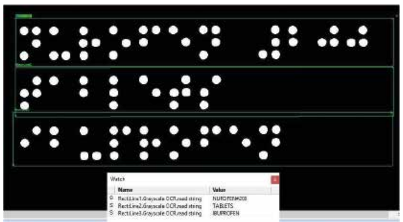


Fig. 5: OCR of trained braille characters

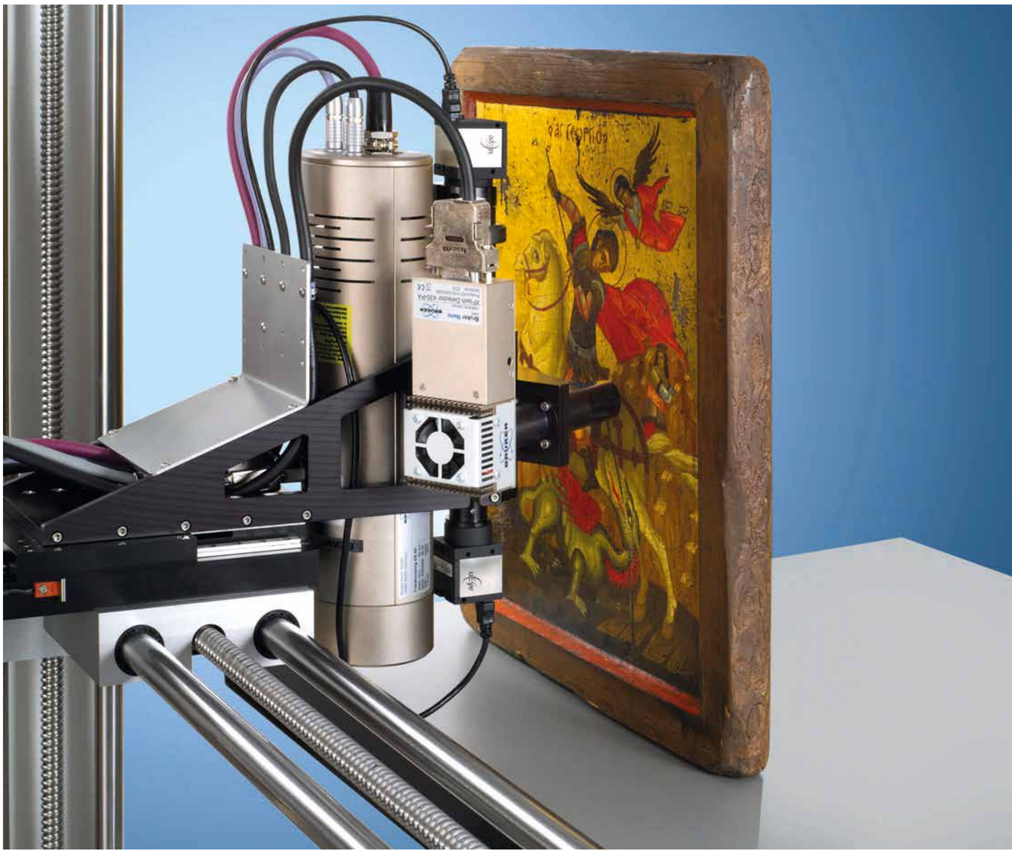
However, these dots are imperfect and may be difficult to train on and read reliably with optical character recognition (OCR). They are therefore further processed to produce perfect dots and the perfect dot characters are trained with OCR allowing the characters to be read.

Computational Imaging Technology

Computational imaging is a versatile technology which works on stationary or moving parts and can use any machine vision camera that can send and receive triggers. A programmable controller is needed to create and manage the lighting sequences for the image capture for all CI techniques. The LSS-2404 light sequencing switch from CCS Inc. is an excellent example of this. It can be used both with small precision lights or large, high output lights for large area inspections, covering all fields of view. It acts as a mini enhanced PLC and specifies one synchronous light pulse (or liquid lens refocus) together with an image acquisition in a single frame, allowing highly flexible and powerful sequencing. Multiple frames can be combined to form a sequence, and multiple sequences can be combined in a recipe or job file. Combining the multi-shot images created into a single enhanced image for subsequent analysis by the vision system is possible using commercially available software packages or a computational imaging SDK. ■

AUTHOR
Paul Downey
Marketing Manager

CONTACT
CCS Europe N.V., Sint-Pieters-Leeuw, Belgium
Tel.: +32 2 333 00 80
www.ccs-grp.com



Behind the Scene

How an XRF Spectrometer Reveals the Secrets of "The Night Watch"

With the aid of as X-ray fluorescence spectrometry, expensive paintings can harmlessly be investigated before restoration. This ensures sophisticated preservation of valuable art objects.

The Rijksmuseum in Amsterdam is carrying out the largest research and restoration project ever. Rembrandt's "The Night Watch", one of the world's most famous works of art, will be publicly restored. The Micro-XRF spectrometer M6 Jetstream is one of the most important instruments in this project used for analysis before restoration. The "Operation Night Watch" can be followed live on the internet.

"The Night Watch" is a really huge painting of 17 square meters. It is among the most prestigious exhibits of the Amsterdam Rijksmuseum, which has more than 2 million visitors every year. The aim of "Operation Night Watch," which started on July 8, 2019, is to understand Rembrandt's painting process and to apply the findings to the subsequent 26th restoration, a long-term preservation of this 17th century painting. The last restoration took place in 1975. The current restoration is preceded by the most comprehensive examination ever of this painting. The research team makes use of advanced imaging techniques, such as X-ray fluorescence spectrometry, to accurately investigate the painting. An entire year has been budgeted for this project.

Examining Color Alteration

Most paintings darken over time raising the question for the conservation and restoration of valuable historical paintings whether the dark colors are caused by contaminations or if they are due to changes in pigment chemistry. Colors alter, like all materials, so that the original appearance of a painting may not only have been brighter, but the colors may also have been even quite different.

X-ray fluorescence analysis (XRF) is a well-suited technique for the examination of paintings. It is based on the detection of the fluorescence induced after irradiation of a sample with X-rays. This fluorescence radiation is element-specific, therefore allowing to identify and quantify the chemical elements present in a sample. XRF is widely applied in the field of Art & Conservation, because it does not require sample preparation and does not harm the valuable objects.

The Micro-XRF instrument used for the chemical analysis of Rembrandt's masterpiece "The Night Watch" is Bruker's M6 Jetstream. This spectrometer allows large-format objects to be examined quickly and non-destructively. It was designed and developed in collaboration with the Technical University Delft (The Netherlands) specifically for the on-site analysis of paintings. If a painting can be inspected directly at the exhibition

»For each element, two-dimensional element distribution maps are created. They reveal the compositional variations in the complex art object and allow to understand Rembrandt's painting process.«

picture: www.rijksmuseum.nl

The M6 Jetstream Micro XRF Spectrometer was developed in cooperation with the Technical University of Delft (Netherlands) specifically for the fast and non-destructive on-site examination of large-format objects such as paintings in museums.

place, the transport is eliminated and therefore, also the associated safety and destruction risks and costs are minimized. Another advantage is the small spot size of the X-ray beam. It can be adapted in five steps without significant loss of excitation intensity to match the structure of the painting's surface and the desired spatial resolution.

Unique Components

The M6 Jetstream integrates a unique measure head positioning kinematic, special hardware components such as a polycapillary lens for focusing X-rays onto a small spot, high-performance detectors, and a comprehensive data mining software resulting in a dedicated instrument for the research field of art and conservation. The high excitation intensity and detection efficiency in combination with the maximum stage speed of 100 millimeters per second enable short measurement times. Translated into real world conditions, this means that, depending on object size and required spatial resolution, high quality measurements can be performed within a short time.

During "Operation Night Watch", the spectrometer is mounted on a mobile working platform directly in front of the unframed painting to scan the entire canvas. The transparent walls around it create a glass laboratory right in the middle of the Rijksmuseum. The painting does not have to be removed and is still available to the public during analysis. Not only the visitors on site, but practically the whole world can watch the painting being scanned millimeter by millimeter with an X-ray beam. A total of 56 scans of the entire canvas reveal the chemical elements that Rembrandt used in his colors 377 years ago. Due to the enormous dimensions of the painting, each scan takes 24 hours.

For each element, two-dimensional element distribution maps are created. They reveal the compositional variations in this complex art object and allow to understand Rembrandt's painting process. Depending on its energy, the X-ray beam penetrates into different depths of the painting's surface. This allows to examine different layers of paint and even detect corrections made by Rembrandt. It is already known today that Rembrandt lengthened lances or changed the positioning of figures in the picture.

Easier Data Evaluation

The visualization of the element composition and distribution facilitates the multidisciplinary data evaluation. Working together, art historians, conservation specialists and material scientists with their different perspectives can figure out what type of pigments were used, how they might have degraded, and which changes were made during or after the painting was created. This helps answering even the question if an object is an original or a fake.

In the past, Micro-XRF measurements already allowed to unravel hidden or lost paintings. Many other challenging scientific questions are currently addressed with the M6 Jetstream in museums and research institutes around the world: from the Palace Museum in the Forbidden City in Beijing to the National Gallery in London, from the Metropolitan in New York to the Vatican in Rome.

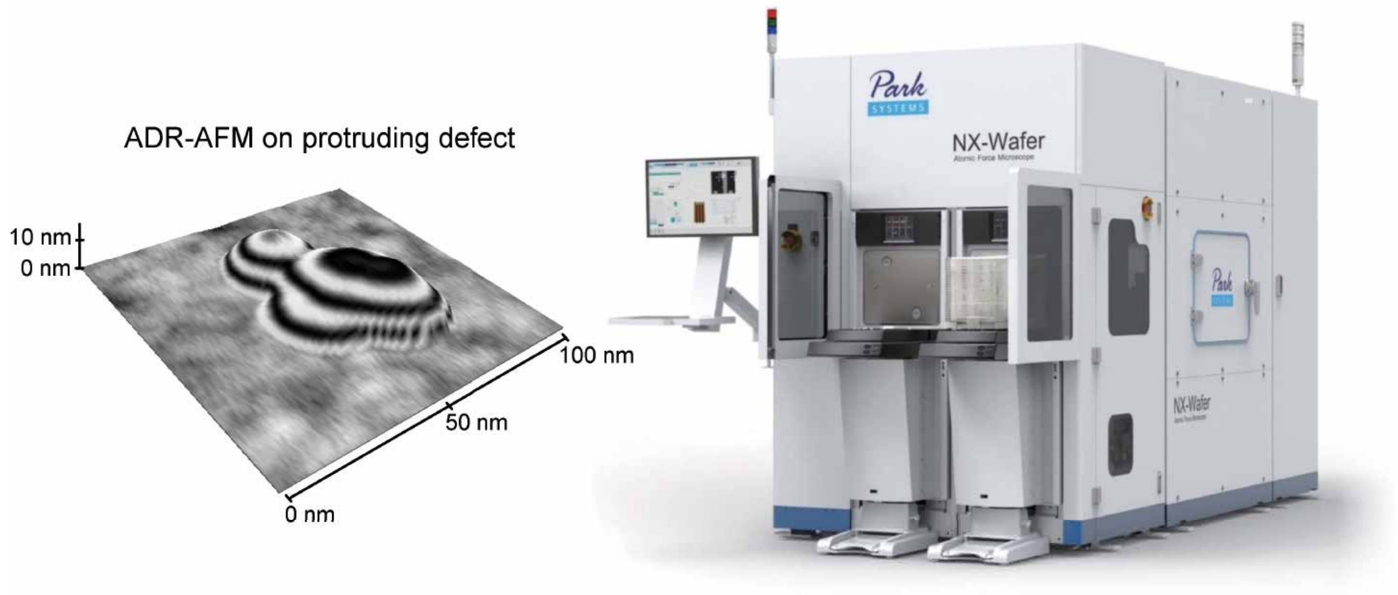
All applied research methods are the basis for a successful restoration in order to preserve old and world-famous art treasures, such as "The Night Watch", so that they shine forth in new splendor and continue to delight museum visitors for a long time to come. ■

AUTHORS
Dr. Daniela Habel,
Marketing Communications Manager
Dr. Roald Tagle Berdan and **Falk Reinhardt,**
Application Scientists for Micro-XRF

CONTACT
Bruker Nano GmbH, Berlin, Germany
Tel.: +49 30 670 990 0
www.bruker.com

Automatic Defect Review

Detecting and Classifying Defects via Atomic Force Microscopy



Automatic defect review with atomic force microscopy visualizes defects in three dimensions with nanometer-resolution and therefore qualifies as ideal technique for the semiconductor industry.

Advances in lithographic processing allow for the production of ever smaller semiconductor devices. With decreasing device sizes, nanometer-sized defects on the wafer substrates can already limit the performance of the devices. The detection and classification of these defects requires characterization methods with a resolution in the nanometer-range. Due to the diffraction limit of visible light, the conventional automatic optical inspection (AOI) cannot achieve a sufficient resolution in that range, which impairs quantitative imaging and consequent classification of defects. The automatic defect review (ADR) with atomic force microscopy (AFM), on the other hand, visualizes defects in three dimensions with the nanometer-resolution customary for AFM. Thereby, ADR-AFM reduces uncertainties in the defect classification and qualifies as ideal technique for defect review in the semiconductor industry.

Defect Inspection and Review

As semiconductor devices are getting smaller and smaller in accordance with Moore's law, the size of the defects of interest (DOI) decreases as well. DOI are defects that potentially reduce the performance of semiconductor devices and are therefore of interest to process yield management. The decreasing size of the DOI is a challenge for the defect analysis: Suitable characterization methods must be able to image defects non-invasively with high lateral and vertical resolution in a two-digit or single-digit nanometer-range.

Traditionally, defect analysis in the semiconductor industry is composed of two steps. The first step, called defect inspection, utilizes fast imaging methods with a high throughput but low resolution, such as scanning surface inspection systems (SSIS) or AOI. These methods can provide maps with the coordinates of defect positions on the wafer surface. However, due to their lower resolution, AOI and SSIS give insufficient information when characterizing nanometer-sized DOI and therefore rely on high-resolution techniques for the defect review in the second step. For this second step, high-resolution microscopy methods, like transmission or scanning electron microscopy (TEM and SEM) or AFM, image smaller areas of the wafer surface to resolve the DOI by using the defect coordinate maps from defect inspection. Utilizing the coordinate maps from AOI or SSIS minimizes the scan area of interest and thus the measurement time of the defect review.

While the electron beam of SEM and TEM potentially inflicts damage onto the wafers, AFM can scan surfaces non-invasively, if a non-contact measurement mode is employed. Furthermore, only AFM is capable to image defects with a high vertical resolution in addition to a high lateral resolution. Therefore, AFM provides quantitative three-dimensional information about defects required for reliable defect classification.

Atomic Force Microscopy

By mechanically scanning surfaces with a nanometer-sized tip on the end of a cantilever, AFM achieves the highest vertical resolution among conventional imaging methods. Aside from contact mode, AFM can be operated in a dynamic measurement mode, in which the cantilever oscillates above the surface. Here, changes in the oscillation amplitude or frequency provide information on the sample topography. This contact-free AFM mode ensures non-invasive imaging of wafer surfaces with high lateral and vertical resolution. Due to recent developments in automated AFM, the application of AFM spread from academic research to industry sectors such as hard disk manufacturing and semiconductor technology. The industry begins to focus on the versatility of AFM and its ability to non-invasively characterize nanostructures in three dimensions. Hence, AFM is evolving into a next-generation inline measurement solution for defect analysis.

Automatic Defect Review with Atomic Force Microscopy

One of the biggest challenges of AFM-based defect review is the transfer of defect coordinates from AOI to AFM. Originally, the user manually marked defect positions on an optical microscope in an additional step between AOI and AFM, and subsequently searched these positions in the AFM. However, this additional step was time-consuming and lowered the throughput significantly. The automatic defect review with AFM, on the other hand, imports the coordinates of defects from the AOI data. The import of defect coordinates requires an accurate alignment of the wafer as well as the compensation of stage errors between AOI and AFM. An optical analysis tool (e. g. candela), with a higher position accuracy than AOI can reduce the stage error in a quick intermediate calibration step. The following ADR-AFM measurement consists of a large-scale survey scan at the given defect coordinates, a high-resolution image of the defect, as well as the defect classification. Because of the automation, the user does not have to be present during the measurement and the throughput increases by up to an order of magnitude. To maintain the nanometer-range tip radius and thus a high resolution for multiple subsequent scans, ADR-AFM uses a non-contact dynamic imaging mode. Thereby, ADR-AFM in prevents tip wear and ensures a quantitative defect review.

Comparing AOI and ADR-AFM

The results of a defect review with AOI and ADR-AFM on the same nanometer-sized defects are compared in Figure 1. While AOI estimates the size of the defects based on the intensity of scattered light, ADR-AFM directly images defects by mechanically scanning the surface: in addition to their lateral size, ADR-AFM measures the height or depth of the defects and thus allows differentiating between protruding "bump" and indenting "pit" defects. The visualization of the three-dimensional shape of the defects ensures a reliable defect classification, which cannot be achieved via AOI.

When comparing the defect sizes determined via AOI and ADR-AFM, it shows that the values estimated by AOI strongly differ from the defect sizes measured via ADR-AFM. For bump defects, AOI consistently underestimated the defect size by more than half. This underestimation becomes evident especially for defect 4. Here, AOI gave a size of 28 nm – roughly one third of the size determined by ADR-AFM with 91 nm. However, the largest deviations between AOI and ADR-AFM were observed for measurements on the "pit" defects 5 and 6. AOI underestimated defects with sizes in the micrometer-range by more than two orders of magnitude. The comparison of the defect sizes determined with AOI and ADR-AFM clearly showed that AOI alone is insufficient for the imaging and classification of defects.

Comparing ADR-SEM and ADR-AFM

Instead of ADR-AFM, it is also possible to use ADR-SEM for high-resolution defect review. ADR-SEM conducts the automatic defect review based on DOI coordinates from the AOI data via an SEM measurement, during which a high-energy electron beam scans the wafer surface. While SEM offers a high lateral resolution, it generally cannot provide quantitative height information about the defects.

To compare the capabilities of ADR-SEM and ADR-AFM, the same areas of a wafer were first imaged by ADR-SEM followed by an ADR-AFM measurement (Fig. 2). The AFM images showed a changed wafer surface at the position of the ADR-SEM scan, visible in Figure 2a as rectangle in the AFM topography. Due to the visibility of the ADR-SEM scan area in ADR-AFM, Figure 2a illustrates that ADR-SEM missed a protruding defect, which was located just above the SEM scan area. Furthermore, ADR-AFM with its high vertical resolution exhibited a sufficient sensitivity to detect surface defects with a height as low as 0.5 nm. These defects could not be imaged by ADR-SEM due to the lack of vertical resolution (Fig. 2b). Additionally, Figure 2c highlights the risk of electron beam damages on wafers by summarizing examples of changes on the sample surface caused by the high-energy electron beam. The ADR-SEM scan areas can be recognized in the ADR-AFM images as rectangles surrounding the defects. In contrast, non-invasive imaging and the high vertical resolution make ADR-AFM ideally suited as characterization technique for defect review.

AOI		ADR-AFM		
Defect No.	Size in µm	Size in µm	Height/ depth in nm	Defect Type
1	0.018	0.076	11.75	Bump
2	0.018	0.074	16.32	Bump
3	0.022	0.038	6.25	Bump
4	0.028	0.091	2.39	Bump
5	0.029	6.909	-2.99	Pit
6	0.040	10.584	-8.47	Pit

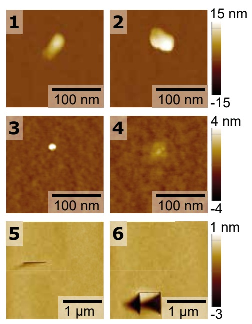


Fig. 1: Direct comparison of the defect sizes determined with AOI and ADR-AFM in the table on the left side. The according AFM topography scans of all six defects are shown on the right. Protruding defects are named bump, indenting defects are named pit.

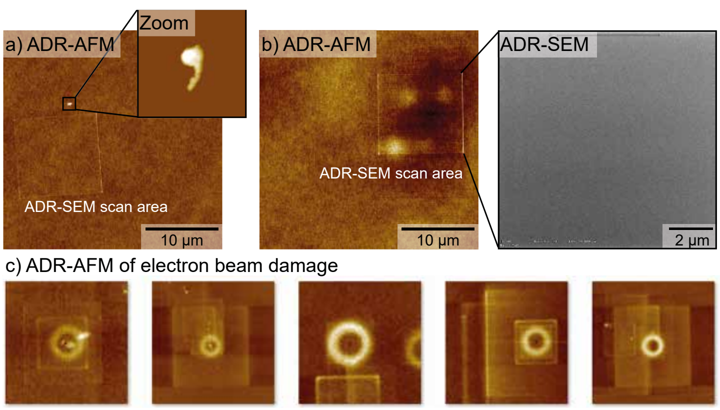


Fig. 2: Comparison between ADR-AFM and ADR-SEM, a) AFM image of bump defect missed previously by ADR-SEM. The ADR-SEM scan area is visible as rectangle in the AFM topography scan. b) Imaging of a defect with a low height (0.5 nm), which was not resolved by ADR-SEM. c) Examples of electron beam damage on the wafer-surface following ADR-SEM measurements, visible as rectangular areas around the defects.

Concluding Remarks

With the ever-decreasing size of semiconductor devices in modern technology, AFM gains importance in the semiconductor industry as a high-resolution and non-invasive analysis method for defect review. The automation of AFM measurements simplified and sped up the previously time-consuming workflow for AFM in the defect characterization. The progress in AFM automation was the basis for the introduction of ADR-AFM, in which the defect coordinates can be imported from prior AOI measurements and the subsequent AFM-based characterization does not require the presence of a user. Therefore, ADR-AFM qualifies as an inline methodology for defect review. Especially for defect sizes in the one- or two-digit nanometer-range, ADR-AFM complements conventional AOI, with the high vertical resolution of AFM facilitating a reliable and three-dimensional defect classification. The non-contact measurement mode ensures non-invasive surface characterization and prevents wear of the AFM tip, which guarantees that the high resolution is maintained in many consecutive measurements. ■

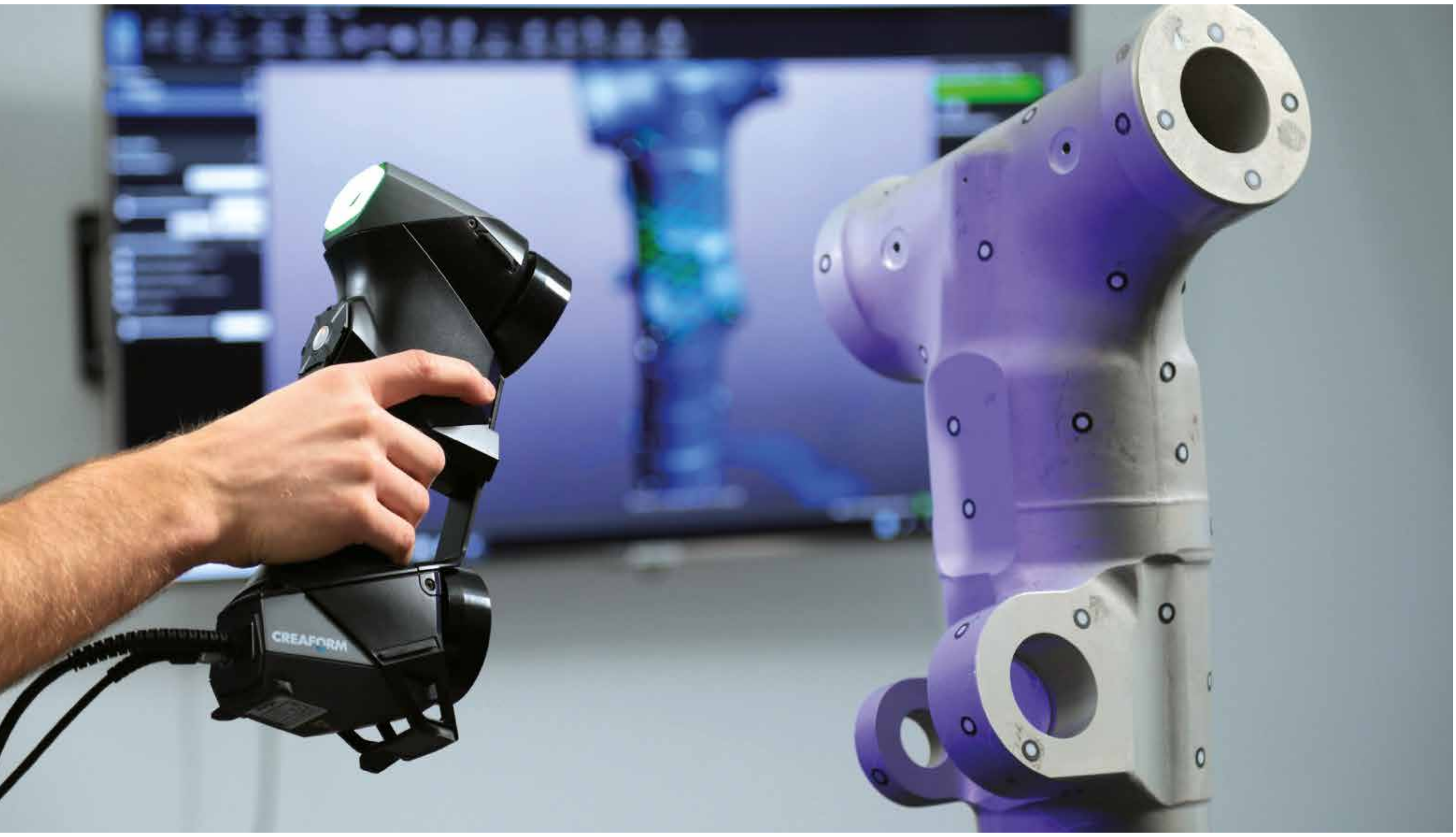
AUTHORS

Sang-Joon Cho, Vice President and Director of R&D Center

Ilka M. Hermes
Principle Scientist

CONTACT

Park Systems Europe GmbH,
Mannheim, Germany
Tel.: +49 621 490 896 50
pse@parksystems.com
www.parksystems.com



The New Standard in Portable Metrology

Versatile 3D Scanner for First Article Inspection, Quality Assurance, or Any Stage of the Product Lifecycle Management

A new metrology-grade 3D scanner, the result of several years of research and development, is aimed at offering manufacturing and engineering professionals the most effective and reliable portable and automated 3D measurement solution on the market.

Here, you can explore the broad lines that led to this new product introduction. You can understand the new capabilities that come with this innovation. You can visualize the size, material, finish, and complexity of the parts that can now be measured with this new and improved 3D scanner. You can imagine the speed that is needed to measure such complex physical parts within seconds. You can study the 3D scanner's features, which enable the capture of accurate dimensional measurements of physical objects — regardless of their size, material, finish, and complexity. Finally, you can examine the benefits of adding this new metrology-grade 3D scanner to your metrology tools.

Why Develop a New Metrology-Grade 3D Scanner?

Creaform is, of course, attentive to the needs of their users and always looking to provide them with the most cost effective and reliable tool on the market. Over the last few years, manufacturing companies in the aerospace, aeronautical, and automotive industries have seen their quality standards rise. The tolerances required by customers are becoming tighter, and the pressure to constantly meet these tolerances is increasing. In addition, the needs of manufacturing and engineering professionals continue to evolve. They must capture 3D dimensions of more complex parts, shapes, and free forms, which require more accurate measurements. Additionally, the time to perform measurements and quality controls is under pressure and must be optimized in order to prevent downtime or stalled production, which delay time-to-market.

During the research and development period, the company had in mind the needs of three engineering groups. First, product development engineers, who are under pressure to innovate, reduce the time to market of their new products, and work with complex shapes and designs to offer more competitive solutions. Second, quality assurance and production teams, who must optimize their manufacturing process, identify and fix production and quality problems, and manage downtime. Third, quality control people, who must validate if the customers' requirements have been met and confirm that the parts fulfill their purpose for the end users.

> **The portable 3D scanner is an essential device for process and production engineers, who can now accelerate the time-to-market by reducing delays in production.«**

Faster, More Accurate and Versatile Portable 3D Scanner

With these perspectives and issues in mind, Creaform developed the HandyScan Black, a patented third-generation metrology-grade scanner. First, the high-performance tool meets the rising quality standards with its 4X superior resolution. Thanks to the unique and versatile combination of newly improved high-performance optics and multiple blue laser technology, the 3D scanner now captures finer details and larger volumes. In addition, it performs more accurate and traceable measurements with a volumetric accuracy of 0.020 mm + 0.040 mm/m. This specification is compliant with the German standard VDI/VDE 2634 part 3 and is certified ISO 17025, ensuring that reliability and full traceability meet international standards.

Moreover, this new metrology-grade tool now has a larger scanning area covered by 11 blue laser crosses, which can take up to 1,300,000 measurements per second. Such a measurement speed – 3X faster than the previous version – ensures optimized acquisition time and data processing rate in order to provide users with an instant mesh. In short, the workflow from data acquisition to ready-to-use files has never been faster.

In short, the HandyScan Black is the jack-of-all-trades of 3D scanners. With its adaptative scanning area and limitless scanning volume, it can measure every part whatever its size, material, finish, and complexity. Also, because the resolution was quadrupled, in comparison with the previous model, the scanner is now the preferred choice for scanning small injection plastic parts or small sheet metal parts.

With its ISO 17025 accreditation, the HandyScan Black is the best choice to reach the highest accuracy and the finest level of detail to ensure full traceability of the measuring system. It is the jack-of-all-trades of 3D scanners that can be used in every step of the product lifecycle management (PLM) process, from concept and design to manufacturing and servicing. It also stands as the new standard in portable metrology for first article inspection (FAI) and quality assurance (QA).

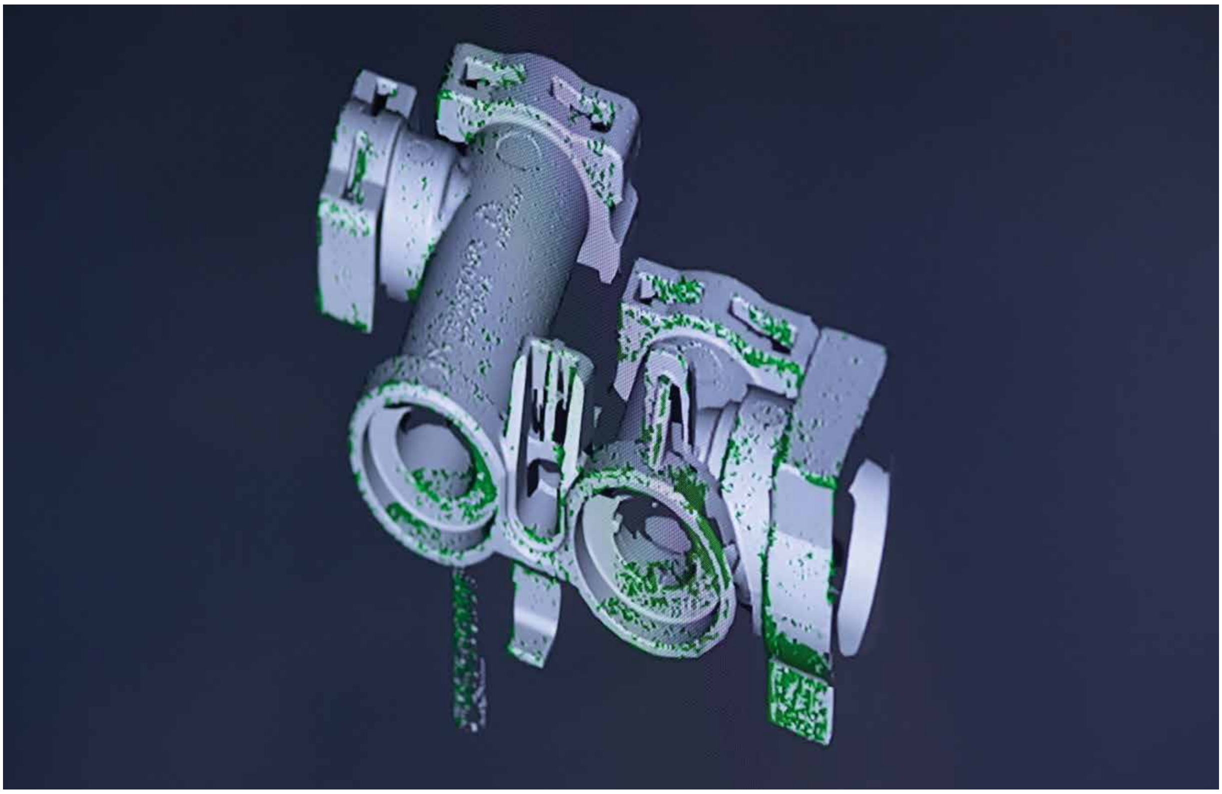
The new portable 3D scanner is an indispensable tool for product designers, who will be able to maintain a strong competitive advantage in designing new, complex, and innovative parts. It is also an essential device for process and production engineers, who can now accelerate the time-to-market by reducing delays in production. Finally, the HandySCAN BLACK is a fundamental instrument for quality assurance managers, who will now be able to reduce production downtime by quickly locating and fixing problems.

This new Creaform scanner combines high-performance 3D scanning, new and improved optics, multiple blue laser technology, and ergonomic design with the distinctive simplicity and portability advantages that are a staple of the company´s products. Their flagship portable metrology-grade 3D scanner sets the standard for the measurement of all kinds of parts, regardless of their size, material, finish, and complexity, within seconds anywhere. ■

The portable 3D scanner utilizes a unique and versatile combination of newly improved high-performance optics and multiple blue laser technology.

AUTHOR
Simon Côté
Product Manager at Creaform

CONTACT
Ametek GmbH – Division Creaform
Leinfelden-Echterdingen, Germany
Tel.: +49 711 185 680 30
www.creaform3d.com



Precision in Plastics

Quality Assurance of Injection Molded Parts

An optical 3D scanning system and coordinate measuring machine ensure high quality of injection molding processes.

Although Unika in Denmark is a medium-sized company, it has highly specialized knowledge in the production of injection molded plastic parts which is appreciated by customers all over the world. Even competitors buy there because of the unsurpassed quality. This is ensured by different Zeiss measuring solutions, including the optical 3D scanning system Comet.

It's four o'clock in the morning. Frank Fynbo turns on the light in the measuring room. It'll take four hours before the sun rises in Ans, in the middle of Denmark. First a sip of coffee, then the measuring lab manager opens the box that his colleagues from the night shift in the production hall up on Lyngbakkevej Street have put together for him. Included are various plastic parts and a complicated metal mold, an injection mold with which such plastic parts are produced.

While the wife and children of the Fynbo family are still sleeping, Frank is already working with Zeiss Comet, checking the first parts. "I like being here so early," says the 54-year-old, "in the morning it is more quiet and I can concentrate better on the measurements."

Precision As a Unique Selling Point

After a few minutes, the first plastic component rests on the turntable and shines in a deep blue violet. The 3D sensor of the scanning system projects structured light onto the component, its camera captures the light reflections and the software then uses triangulation to determine the position of each point on the surface - three-dimensional and accurate to a few hundredths of a millimeter.

Companies that produce plastic injection molded parts are common. But only a few of them reach the quality level of Unika. Precision is an important unique selling point; even competitors order here. Grundfos, for example, the world market leader for water pumps in nearby Bjerringbro, manufactures its own injection-molded parts. But for complicated parts, they also like to use the technical know-how of the molders and exchange measurement data, because Grundfos also relies on Zeiss machines for quality assurance.

After a short time, virtual 3D data of a water pump housing appears on the monitor. A few mouse clicks later, the false color comparison is available, which shows where the part deviates from the CAD design data provided by Grundfos. In the red areas the material is too thick, in the blue areas material is missing. Frank Fynbo clicks on some points in the 3D model and the software indicates the exact deviation for these points. The trained toolmaker, who has been working at Unika since 1989, nods satisfied. Everything is within the expected tolerances. Before purchasing the 3D measurement system, the company had to send the parts to an external service provider for inspection, which was expensive and took much longer.

Caution When Cooling Down

The measurement results are not always that positive. In injection molding, thermoplastic material at temperatures of up to 350 degrees Celsius is injected into a two-piece mold at pressures of up to 2,000 bar, and the injection mold can be held together by up to 1,500 tons in the largest injection molding machines at the molder. Water or oil flows through the mold, which lowers the temperature in a controlled manner until the component solidifies. When it is removed from the machine after one minute by a robot arm

Frank Fynbo at Zeiss Comet. The setup of the 3D scanner and the measurement only take a few minutes.

Frank Fynbo examines the casing of a water pump. Whether all measurements are correct, he can decide however only after the examination with the 3D sensor.

and placed on a conveyor belt, it is still so hot that it cannot be touched. Only after up to 24 hours it does cool down and reaches its final shape. Until then, it can bend or twist, in the worst case until it is unusable. The fact that this is rarely the case at Unika is due to the extensive process knowledge in injection molding as well as Frank Fynbo's meticulousness.

Frank does not rely solely on optical 3D measurement for critical parts, e. g. when series production for a new product begins. In his measuring room he also has a Zeiss Contura G2 coordinate measuring machine, which is used for tactile measurements. Sometimes Frank examines plastic parts here, and more frequently the metal injection molding tools that the company manufactures itself on modern machine tools. Any deviation in the mold would later reflect in the injection molding process and lead to rejects.

Machines in Tandem

Frank has been working with the Zeiss Contura since 2010, when Unika bought the system. His area of responsibility also includes one of the manufacturer's Duramax measuring machine purchased in 2014, which is used in the workshop for fast tool control. When the measuring tasks increased, there was no question that the next machine would also be from the same manufacturer. „Machine and software convinced us", says Frank, „and our largest customer Grundfos also works exclusively with Zeiss machines."

Thanks to its optical measuring principle, the Comet system perfectly complements the tactile measurements of the Contura. The company's colin3D software for the system is also compatible with Calypso, the software for all of the manufacturer´s tactile machines. The optical measurement data is saved as an STL file and loaded into Calypso. This offers options for superimposing the optical and tactile measurements and makes more detailed statements about deviations from target and actual values. All data is stored permanently and is available at any time as soon as a customer asks for it.

Small Part, Big Challenge

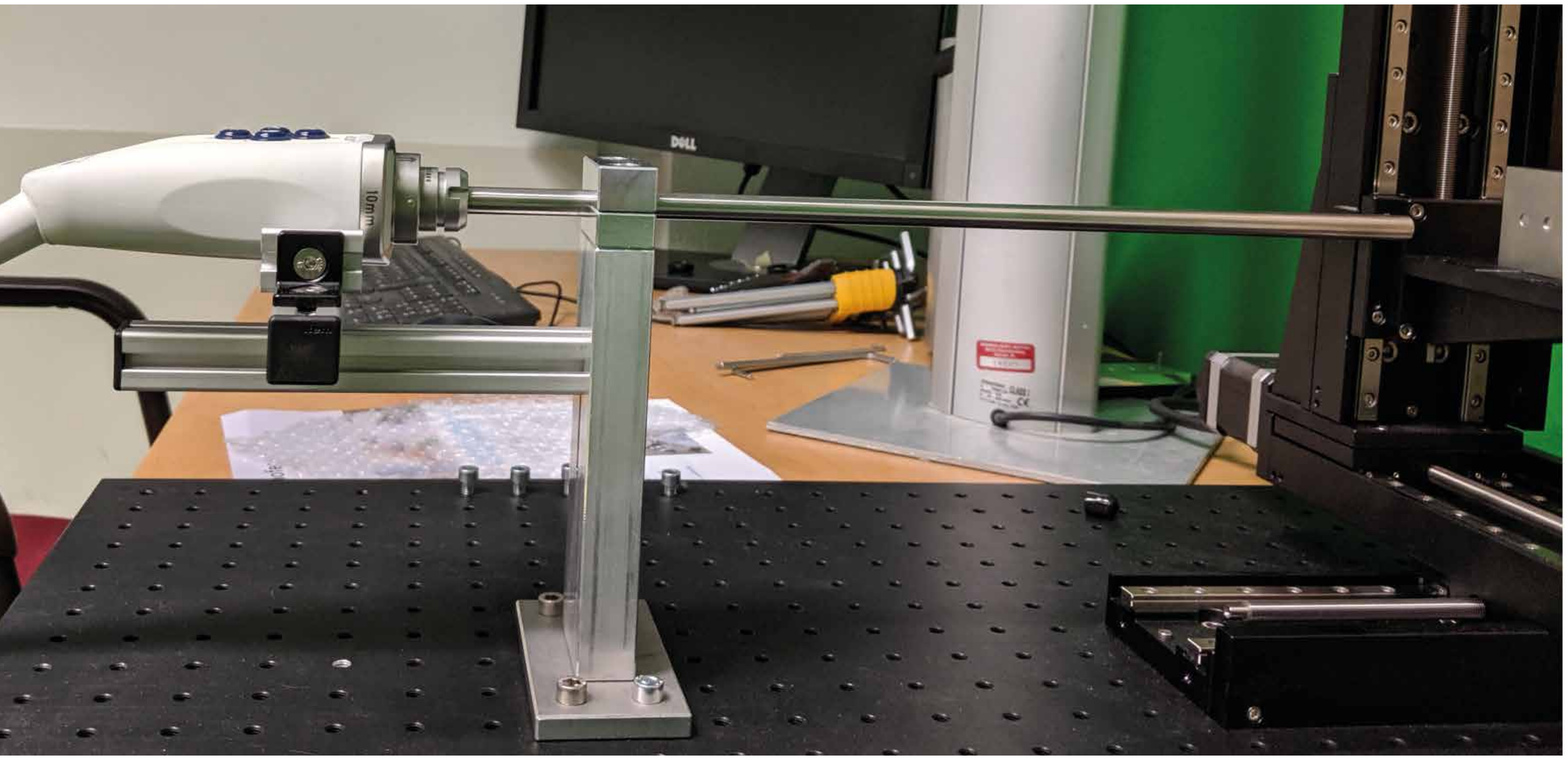
The 3D measurement system has been in operation since 2017. The component for which the machine was purchased is hardly larger than a pin head: a plastic pin for the hinge of a spectacle frame. „Because it's so tiny, I couldn't measure it on the Contura coordinate measuring machine," recalls Fynbo, „so we opted for the Comet 3D scanner." Today, of course, it not only measures pins for spectacle frames, but also a wide range of plastic parts or tools. Four lens sets providing different measuring volumes are available. In a two-day training course at the manufacturer´s premises, Frank Fynbo learned how to operate the 3D sensor. „I could start measuring right away, but of course I am still learning every day."

The The 3D measurement system also plays an important role in reverse engineering. Sometimes customers come with a part without CAD data, sometimes even just with a model made of wood, and the request, "Build it for us from plastic." Where design data is missing, the system can be used to generate it subsequently. This is partly automatic; the fine-tuning to the finished CAD file is done by Unika's design engineers. The rest of the process is then done iteratively. The tool is manufactured from the data, which is first measured with the Comet and compared to the CAD data. If everything is in order, the tool is mounted in the injection molding machine and some parts are made of plastic. These parts are checked again with the 3D measurement system. If there are deviations, the tool is reworked and measured with higher precision using Contura. Then the tool is mounted again, and the process starts all over again. Until everything is right in the end.

Frank Fynbo is currently discussing the acquisition of another coordinate measuring machine with Bo Johansen, the CEO and Steen Johansen the Chairman of the Board of Directors, both sons of the founder. This will be located in the upper hall where the injection molded parts are produced. There, work is carried out around the clock in three shifts, and the employees can then continuously check the quality. "And I could sleep longer in the morning," smiles Frank. ■

AUTHOR
Bernd Müller,
Freelance journalist

CONTACT
Carl Zeiss Industrielle Messtechnik GmbH,
Oberkochen, Germany
Tel.: +49 7364 206 336
www.zeiss.de/industrial-metrology



Remote Visual Inspection

Real-Time Image-Based Stereo Video Processing Chain for 3D Endoscopy

Non-contact measurement systems for remote visual inspection have special requirements. 3D endoscopy is ideal for the task, and a real-time image-based stereo video processing chain enables high-precision measurements.

Non-contact optical measurement methods are already used in many industrial areas, such as production monitoring of components or the generation of high-precision 3D models. However, these systems are used in controlled environments and the object to be measured is usually known. The methods work with active methods such as "Structured Light" or passive photogrammetric reference markers called fiducials. This is particularly impractical for remote visual inspection (RVI) during inspection and maintenance work, as visual inspection takes place in uncontrolled, inaccessible and unknown environments such as engines, piping systems or technical cavities. In contrast to optical in-line measurement systems, situations can arise at any time in which complicated instrumentation and poor lighting conditions make the measurement task even more difficult. This leads to special requirements for the non-contact measurement system. As an example, a real-time image-based stereo video processing chain for 3D endoscopy is presented, which enables high-precision 3D measurements. Furthermore, a first calibration and measurement setup is sketched, which should enable an objective evaluation of purely image-based measurement systems in the future.

Stereo Principle

The images are captured by a 3D endoscope (Fig. 1). The stereo data is recorded synchronously via two horizontally shifted optical beam paths. The horizontal offset determines the stereo base and the size of the so-called stereo-parallax, which is decisive for the 3D impression and the theoretically achievable measurement accuracy. The design of 3D endoscopes is therefore subject to different requirements. The decisive parameters are the focal length, stereo base and sensor size. This leads to three practical configurations for stereo systems: (1) For 3D visualization, (2) precisely measuring 3D systems and (3) hybrid systems, which are equally designed for surveying tasks and for 3D visualization. 3D laparoscopes from medical technology are a good example of such a hybrid system and can be used both for visualization and for surveying tasks. Figure 2 shows the schematic arrangement of an axis-parallel stereo system and names the parameters for determining depth information from stereo views using triangulation. The world point (Pw) is captured by both cameras and displayed on the respective image planes I_1, I_2 as p_1, p_2 in pixel coordinates. The disparity (stereo-parallax in pixels) can be calculated from horizontal pixel differences (p_1, p_2). Therefore, the depth (Z) for a world point is calculated from focal length (f), stereo base (b) and disparity ($d=p_1-p_2$) with $Z = (b * f)/d$. Especially for the practical evaluation of the measurement accuracy of stereo systems, three relevant parameters have to be exactly coordinated. (1) The stereo base (b), (2) the working distance to the measurement object in Z direction and the accuracy of the disparity from the calculated point correspondences. As a general guideline, the larger the stereo base (b), the higher the theoretically possible measurement accuracy. Furthermore, the influence on the measurement accuracy depends on whether the 3D endoscope is oriented orthogonally

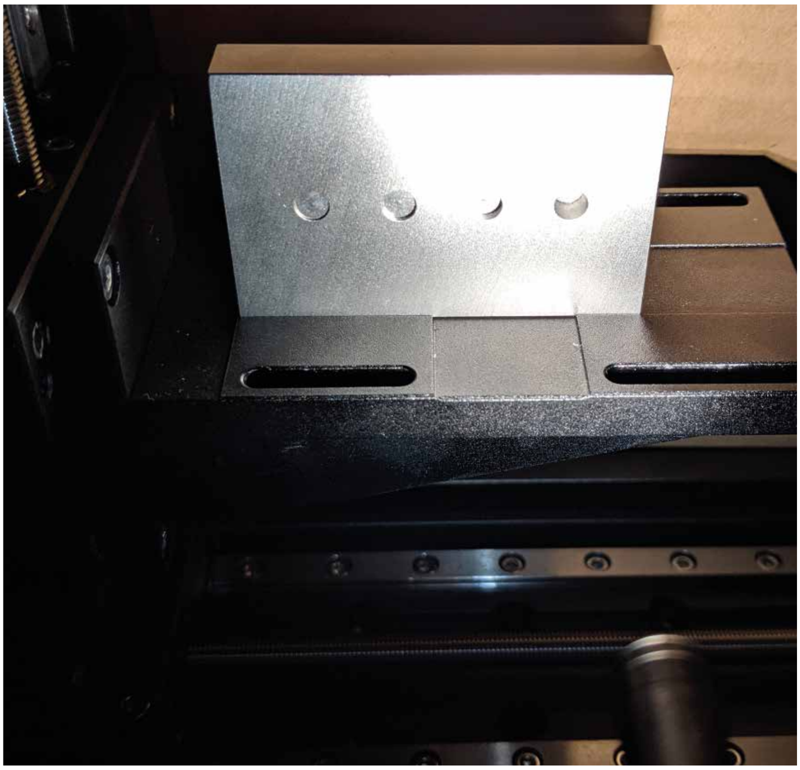


Fig. 1: (Left) 3D endoscope and holder. (Right) Measurement setup for a borehole specimen on a 3-axis motorized linear unit.

»With the presented approach, it is possible to evaluate stereoscopic measurement systems systematically in terms of measurement accuracy and measurement tolerances.«

or arbitrarily to the measurement object. For RVI, the evolution of the measurement accuracy in Z direction is of particular importance. Therefore, higher measurement accuracies can be achieved by guaranteeing sub-pixel accurate point correspondences.

Measurement and Calibration Setup

A calibration of the measuring system is indispensable for every image-based measuring method. This includes the determination of the distortion parameters, intrinsic parameters such as focal length and principal point as well as the estimation of the extrinsic parameters, i.e. the orientation of the two stereo cameras to each other (Fig. 2). An overview of common calibration methods is given in [3]. The measurement setup for validating the accuracy currently consists of three motorized linear units with a maximum measurement volume of 20 cm*20 cm*20 cm. The specimen can be positioned via a programmable trajectory in relation to the 3D endoscope to an accuracy of 600 nm. Besides the linear analysis, an extension of the system by two goniometers is planned to investigate the influence of angle dependencies on the stereo measurement.

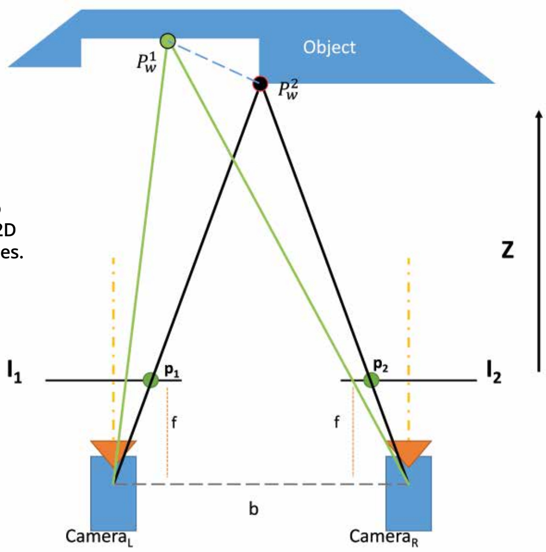


Fig. 2: Principle of triangulation for an ideal, axis-parallel stereo system for two corresponding 2D points (p_1, p_2) in pixel coordinates. The depth is calculated from

$Z = \frac{b*f}{d}$ *with* $d = p_1 - p_2$

Stereo Processing

For robust and real-time capable depth estimation, the stereo views must be pre-processed. This pre-processing is called rectification and ensures that the two stereo views are perfectly aligned, so that vertical offsets, keystone distortions, tilt angle errors, focal length differences and roll angle errors, which may be present due to design differences between the stereo channels, are eliminated. We calculate rectified image pairs by estimating a linearized F-matrix using corresponding feature points [1]. Based on the features correspondences a 3x3 correction matrix can be derived to calculate a homography between the two stereo views. Then, subpixel accurate disparity estimation (1/5 sub-pixel) [2] is performed on the correctly aligned stereo views and provides the input for the triangulation calculation.

Results

Figure 3 shows the results for the 3D reconstruction of the specimen and the continuous determination of the 3D trajectory along the optical axis of the endoscope. The measurement evaluation was performed with the Stereoscopic Analyzer [4] developed at Fraunhofer HHI. The measuring range was selected interactively in the live image with a real-time representation of the depth (Fig. 3). The measurement range is from 30 mm to 80 mm. The 3D reconstruction results shown

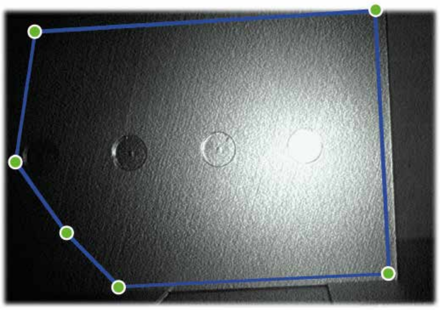


Fig. 3: Borehole specimen in uncontrolled environment with difficult lighting conditions at 70 mm working distance: Visualization of live selected 2D area used as input for 3D reconstruction pipeline.

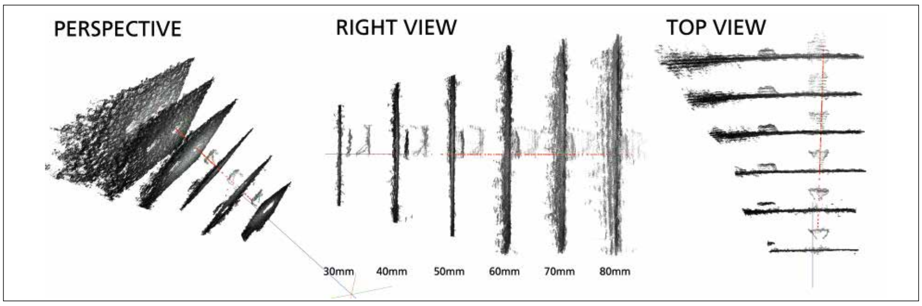


Fig. 4: Results of the 3D reconstruction for a borehole specimen. The drilling depths are 5mm, 2mm, 1mm. The 3rd borehole can only be seen for larger distances. The working range is 30 mm to 80 mm. The six measuring positions were approached in 10mm steps with a motorized linear unit. The 3D trajectory along the optical axis is shown in red.

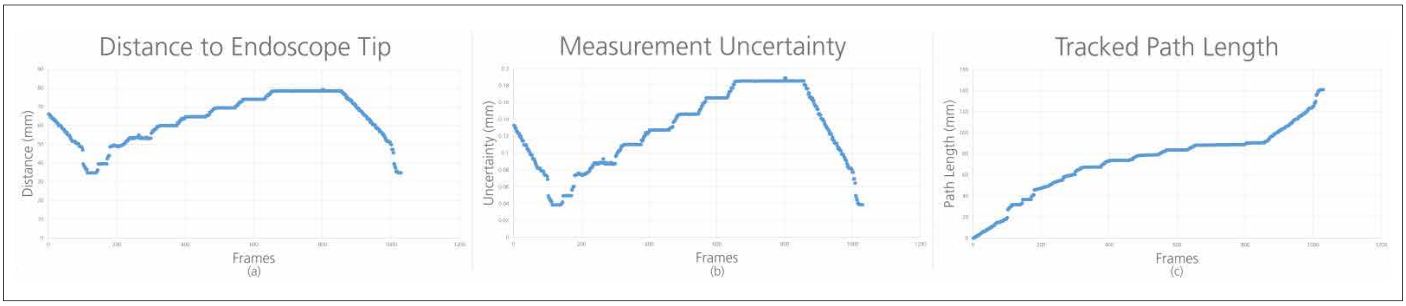


Fig. 5: Evaluation of the 3D trajectory along the optical axis of the endoscope. (a) Distance measurements, (b) development of measurement uncertainty, (c) "Target/Actual" comparison for the measured path length: 141.6/140.9 mm.

in figure 4 were calculated every 10 mm. The 5 mm borehole was aligned approximately to the optical axis. Figure 5 shows the results for the 3D trajectory. Table 1 shows "Target/Actual" evaluation for selected distances. It should be noted that for larger distances, the measurement accuracy decreases and the measurement uncertainty increases due to reduced depth resolution.

Conclusion

With the presented approach, it is possible to evaluate stereoscopic measurement systems systematically in terms of measurement accuracy and measurement tolerances. True-scale 3D models were computed based on stereoscopic "single-shot" reconstructions for six working distances as well as a high-precision endoscopic 3D trajectory was calculated along the optical axis. This results in new possibilities for inspection and maintenance tasks in uncontrollable environments (RVI) where metric information plays an important role. Furthermore, the aim is to transfer these procedures to minimally invasive surgery in order to determine the size of tumors intraoperatively.

A working live demonstrator consists of the following components: 1 x 3D HD endoscope, 1 xPC, Intel Xeon processor E5-2620, 2 GHz, 1 x HD-SDI capture card, NVIDIA GPU with 2880 CUDA cores. Currently, porting to OpenCL is being carried out. The metrological investigations and software development are funded by the Federal Ministry of Education and Research (BMBF) within the project "Compass" (Comprehensive Surgical Landscape Guidance System for Immersive Assistance in Minimally Invasive and Microscopic Interventions) [5]. We also thank Schölly Fiberoptic for lending us the 3D endoscope. The 3D measurement data for figure 4 and 5 can be downloaded at [6]. ■

References

[1] Frederik Zilly, Marcus Müller, Peter Eisert, Peter Kauff. Joint Estimation of Epipolar Geometry and Rectification Parameters using Point Correspondences for Stereoscopic TV Sequences, Proceedings of 3DPVT, 2010.

[2] Wolfgang Waizenegger, Ingo Feldmann, Oliver Schreer, Peter Kauff, Peter Eisert. Real-time 3D Body Reconstruction for Immersive TV, Proceedings of the 23rd International Conference on Image Processing (ICIP 2016), Phoenix, Arizona, USA, September 25-28, 2016.

[3] J.-C. Rosenthal, Niklas Gard, Peter Eisert. Kalibrierung stereoskopischer Systeme für medizinische Messaufgaben, 16.Tagungsband: Deutsche Gesellschaft für Computer und roboter-assistierte Chirurgie (CURAC), pp. 159-161, 2017.

[4] F. Zilly, M. Müller, P. Eisert, P. Kauff. The Stereoscopic Analyzer: An Image-Based Assistance Tool for Stereo Shooting and 3D Production, Proc. IEEE International Conference on Image Processing (ICIP), Hong Kong, pp. 4029-4032, Sep. 2010.

[5] https://www.hhi.fraunhofer.de/en/departments/vit/projects/compass.html

[6] https://datacloud.hhi.fraunhofer.de/nextcloud/s/L4cJErAX4iw8BrE

Table 1: Distance measurements for the 3D endoscope along the optical axis

	35mm	40mm	50mm	60mm	70mm	80mm
Distance measurement	34.73mm	39.57mm	49.22mm	59.93mm	69.38mm	78.45mm

AUTHORS

Prof. Dr. Peter Eisert
Head of Vision & Imaging Technologies Department

Jean-Claude Rosenthal
Research Associate, Vision & Imaging Technologies Department

CONTACT

Fraunhofer Heinrich-Hertz-Institut HHI,
Berlin, Germany
Tel.: +49 30 310 02 0
www.hhi.fraunhofer.de/en

Fraunhofer HHI is a member of the Fraunhofer Vision Alliance who pools the expertise of several Fraunhofer institutes in the fields of image processing and optical inspection and measuring techniques.

Products

Robust DPM Handheld Scanner

In production, many directly marked codes are read or checked daily with a scanner in order to guarantee product quality and traceability of the parts. With the new HS-3608 corded hand-held scanner or the new HS-3678 cordless version, Ioss offers and ideal scanner for reading directly marked codes (DPM). The scanner can be used flexibly in a wide variety of industries, including automation and automotive, as well as in medical technology. It is an extremely robust, industrial grade scanner that is perfect for capturing difficult-to-read 1D, 2D and DPM codes. The extended lighting module, including an integrated diffuser, enables reading on a wide variety of surfaces, e.g. reflective, curved or with low contrast. With the HS-360X scanner customers get a high-quality hand-held scanner at a reasonable price.

www.ioss.de

Advantages of Violet Laser Sensor Heads

Violet laser sensor heads use the shortest visible wavelength and enhanced software intelligence to lead the way in non-contact precision measurement. Violet laser sensor heads extend the range of materials which can be measured by Third Dimension's GapGun Pro and Vectro systems. Auto-makers now have a single tool for all inline gap and flush measurements, including light clusters, chrome headlights, tail lights, and all other common automotive surface finishes. GapGun Pro and Vectro systems replace manual, contact gauges for reliable data quality and traceability. Francois Froment, Third Dimension's Head of Sales, reports high levels of early interest in the product: "I have taken the Violet Laser to automotive customers in the UK, Germany, Sweden and Belgium. There has been tremendous interest, with quality managers and production engineers alike seeing the potential for saving time and improving their manufacturing processes. This is definitely the most efficient solution in the market today."

www.third.com

Compact Machine, Large Measuring Volume

The new coordinate measuring machine TomoScope XS Plus with computed tomography from Werth Messtechnik provides twice the measuring volume of the TomoScope XS. With Werth transmission tubes, high-resolution measurements are possible at high power in correspondingly short measurement times. The monoblock design of the tube, generator, and vacuum production makes the X-ray tubes nearly maintenance-free, providing extremely high uptime. The open design results in unlimited service life, as wear parts can be replaced if necessary. The other X-ray com-

ponents have also been optimized to ensure a maintenance cycle of one year for the entire machine, as is usual with conventional coordinate measuring machines. The tubes are available with maximum voltage of 130 kV or 160 kV, covering a wide range of applications for plastic and metal workpieces.

The new machine is also suitable for in-line applications. This is made possible in part by the reconstruction of the workpiece volume in real time, in parallel with the measurements, by the fast analysis software, and by OnTheFly CT.

www.werth.de

New Beamsplitters and Aspheric Lenses

Edmund Optics new Techspec Ultrafast Harmonic Separators, also known as Ultrafast Harmonic Beamsplitters, reflect second or third harmonic wave-

lengths from femtosecond lasers and transmit the fundamental pulse. The reflective surface is designed to be highly reflective and to minimize dispersion with a GDD of ±20 fs2, while the back surface is coated with an anti-reflection coating to maximize transmission. Manufactured from low wavefront distortion, 10^{-5} surface quality fused silica substrates, Techspec Ultrafast Harmonic Separators are available in two designs for separating harmonics of either 800 nm or 1030 nm lasers.

New Techspec λ/40 Aspheric Lenses feature a high numerical aperture design and a aspheric figure error of λ/40 or better, achieved via precision magnetorheological finishing (MRF). These aspheres are also available coated for specific Nd:YAG laser wavelengths as the Techspec λ/40 Laser Grade Aspheric Lenses. Each Techspec λ/40 Aspheric Lens is individually measured for 3D surface profile and test data is provided for each lens.

www.edmundoptics.de

Improved Inspection Thanks to Machine Learning

Image Recognition with Deep Neural Networks for the Inspection of Medical Products

A pilot setup of different machine learning technologies for the real-time identification of damaged medical containers puts deep learning for the classification of image contents in focus.

Seidenader GmbH is a manufacturer of high-quality inspection machines for a global customer base in the pharmaceutical industry. One of the machines´ application area is the visual inspection of medical vials containing freeze-dried pharmaceuticals. Seidenader's high-end machines are capable of performing a full-scale quality test of the packaging result at a rate of up to 10 vials per second. The test process includes a visual inspection of the vial with a line camera system and a subsequent real time image analysis with inspection software developed and validated by Seidenader's vision analytics group. In its current implementation this software relies on classical image analysis methods.

Further Improvement of the Inspection Performance

To keep its competitive technological advantage, Seidenader decided to assess in a systematic fashion to what extent state-of-the-art machine-learning methods can provide added value over classical image recognition algorithms during visual inspection. As a benchmark use case, the discrimination of acceptable and unacceptable lyophylisate containers with deep learning was identified. Evaluation criteria comprised the discrimination power achievable with machine learning approaches and the ability of the investigated algorithms to match the operational timing constraints – which are defined by the need to classify each vial within 100 milliseconds without requiring dedicated graphics processing hardware.

In order to ensure cost-effectiveness of the evaluation, the vision analytics team collaborated with an external service provider that could both provide the required professional and technical experience and ensure efficient knowledge transfer to the responsible in-house team after successful project delivery. D-fine was chosen for the task since their artificial intelligence group was able to bring in in-depth expertise on image recognition from both classical machine learning and modern Deep-Learning regimes and committed to deliver both a qualitative evaluation of different open source frameworks for the task at hand and a rigorous quantita-

© Seidenader

Fig. 1: Image acquisition of the medical vial is performed with a line camera while the vial itself is rotated at a defined angular velocity.

tive investigation of the different approaches.

1.Training and Evaluation of the Pilot System

To establish a pilot set-up and to assess its performance, suitable training and test data sets are required and quantitative criteria for the system's evaluation have to be defined. In this section we give an overview of both aspects in the context of the project.

1.1 A small but well-understood set of image data is key

The training data set used for the pilot system comprised 30 physical samples from the "accepted" and 30 from the "rejected" category. 15 images of each container were taken with line cameras thereby making use of the rotational invariance of the problem (i.e. by starting the image recording at different angular positions along the circumference of the vial).

The test data set was taken in the same way using 20 different physical samples from each class. This ensured that the training and test images were not only separated on a by-image basis but also on a by-sample basis.

Two typical images showing an accepted and a rejected physical sample are shown in Figure 2. They clearly differ in terms of size and interconnectedness of the cavities along the perimeter of the lyophylisate.

The total size of the training dataset is not very large on the usual scales of image recognition tasks and thus bears the risks of overfitting the system to the training sample. To avoid this, d fine applied a set of image augmentations to the training set. To increase the system's generalization capability, the images were translated by random angles and flipped by their symmetry axis. Furthermore, the total image brightness was changed and (de-) noising filters were applied.

1.2 Quantitative evaluation requires clear performance criteria

To evaluate the different setups in a quantitative fashion, the following benchmarks were used:

- The "Recall" of the system is the fraction of containers from the rejected class that were also rejected by the system. (This quantity can be viewed as the "efficiency of removal" of bad containers.)
- The "Precision" of the system is the fraction of containers rejected by the system that where indeed labelled as rejected in the test dataset. (It can be understood as the "purity" of the rejected images.)
- As an overall benchmark the "Accuracy" of the system can be used. It represents the total fraction of all containers that have been correctly labelled by the system.

A high Recall value is required in order to meet the high-quality standards applicable, in particular, within the pharmaceutical industry. A high Precision is desired in order to minimize false rejections and unnecessary removal of flawless vials. A perfect system would yield a value of 100% for all the above quantities.

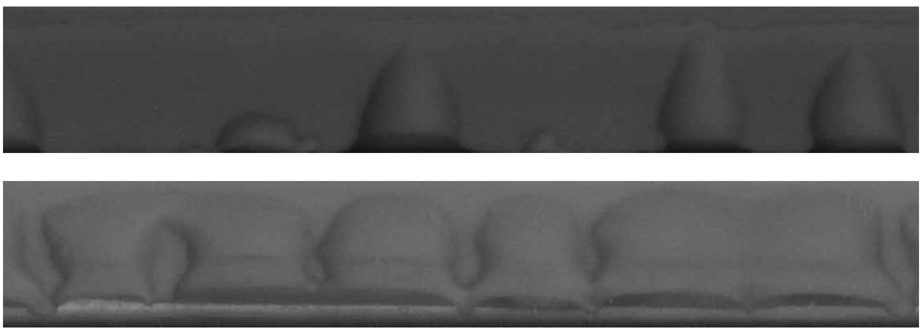


Fig. 2: Line camera panorama images acquired from an accepted sample (top) and a rejected sample (bottom)

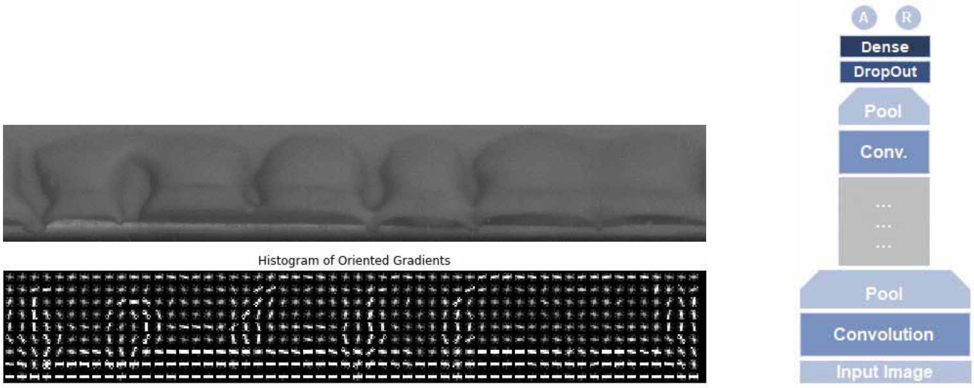


Fig. 3: During training and testing, images are either HOG-transformed and classified by a Support Vector Machine or – without a dedicated feature extraction process – are fed into a "shallow" Deep-Network with a few neural layers only.

1.3 Deep neural networks compete with classical machine learning

In order to set a quantitative benchmark for the Deep-Learning system, a classical image recognition setup was evaluated beforehand. A HOG transformation [1] was applied to the image data to transform the greyscale representation to a histogram of oriented gradients (a vector representation of the image with a substantially reduced dimensionality). Subsequent to this, a support vector machine was trained with the resulting lower dimensional feature vectors. Both steps where implemented with the Python scikit-learn package [3].

Based upon the qualitative assessment of different Deep-Learning packages, Seidenader and d fine opted for Google's TensorFlow framework [2] for the productive implementation of Deep Neural Networks (DNNs). There were a number of reasons for this: TensorFlow is well-tested, available free of charge, is continuously being developed further, not only by Google, but by a worldwide community of active users and is the basis of numerous successful artificial intelligence applications. Different network architectures can be easily defined and transferred to the productive application after completion of the training.

Different than classical image recognition technologies, deep neural networks do not require a dedicated feature engineering stage, but instead, learn for themselves what the discriminating features of an image are in a hierarchical fashion. An introduction to the underlying algorithms and a practical introduction into Deep Learning is provided in various literature sources [4].

One functional requirement – as described above – was to achieve a machine throughput of 10 decisions per second. To achieve this and to cope with the limited amount of training data available, D-fine opted for the evaluation of different bespoke network architectures each comprising only a few neural layers. Deeper architectures, which are commonly used for large scale image recognition challenges, were evaluated as well, but they did not show either superior classification performance nor deliver the required speed in this context. This corroborates the effectiveness of a customized network architecture matching a specific task.

2. Results

Classical ML and Deep learning were investigated applying different augmentation and training parametrizations. Below we summarize the most important results for both approaches.

2.1 The classical ML approach leaves room for improvement

After a systematic investigation of different combinations of image augmentations, a reasonable performance of the HOG/SVM system could be achieved. Table 1 shows the performance in terms of the benchmark quantities defined in section 2.

Already, the baseline setup achieves a perfect Recall, as all images from "rejected" containers are correctly identified as such. The system's Precision is however far from acceptable: 30 images (coming from two samples in the "accepted" test data set) are consistently misclassified as "rejected". After applying a de-noising filter to the images this situation was improved but was still found to be unsatisfactory.

2.2 Deep learning outperforms classical machine learning

Due to the economic layout of the TensorFlow™ networks, the entire quantitative investigation could be performed on a desktop system with a powerful graphics card and a sufficiently large memory. The evaluation of the recognition performance was done on the same system and is shown in Table 2: Using the Deep Network the number of classification errors was reduced to only one false

Table 1: Performance results of baseline setup: HOG-transformation & Support Vector Machine

Name	Number of classification errors	Accuracy (%)	Precision (%)	Recall (%)
HOG + SVM-baseline	30	95.00	90.91	100.00
HOG + SVM + denoising	10	98.33	96.77	100.00

Table 2: Recognition performance achieved with a TensorFlow™ based Deep Neural Network

Name	Number of classification errors	Accuracy (%)	Precision (%)	Recall (%)
DNN + Augmentations	1	99.83	99.67	100.00

» The results resolve the common doubt that high performance GPU hardware is required to put deep neural networks into operation.«

positive (i.e. one single image of one physical sample is falsely "rejected"). – A substantial improvement with respect to the classical approach.

Operational Usage

One constraint of the operational system to be deployed on Seidenader's machines was to facilitate real-time DNN-based image analysis with the existing hardware. Therefore, TensorFlow was compiled into a Windows-dll and linked to Seidenader's image analysis pipeline. The resulting processing speed was tested on a virtual machine with a standard CPU and a windows operating system. Due to the bespoke and lean network design, the throughput achieved with this setup was comfortably beyond the required level for real-time operational requirements.

Summary

Seidenader's inspection solutions distinguish themselves from their competition through a focus on cutting-edge technologies for particle and defect detection. To maintain this competitive edge, Deep Learning was evaluated as a tool for high performance real-time image recognition in their inspection machines. The build-up of the corresponding know-how benefited greatly from the collaboration with an experienced service provider who was able to not only deliver the professional insight into state-of-the-art machine learning and image recognition methods but was also able to speed up the development cycle substantially. Due to the know-how-transfer achieved in the project, Seidenader will be able to roll out the solution on a pilot system in the near future with minimal support. ■

Seidenader

The company constantly strives to integrate recent innovations into their image recognition technology in order to tackle even more challenging inspection tasks. In light of this, deep learning for image classification was naturally at the center of attention. D-fine, a supplier of mathematical and technological consulting services, has developed a pilot setup for Seidenader to investigate different machine learning (ML) technologies for real time identification of deteriorated medical containers. This collaboration enabled Seidenader to gain knowledge of the new technology, which can be difficult to master despite the availability of powerful open source software frameworks such as TensorFlow. Both classical ML methods as well as modern approaches – in particular Deep Neural Networks – have been systematically evaluated. The pilot system displayed excellent results with respect to the separation of intact and deteriorated medical vials – a classification task which is challenging for traditional methods. The quality of the separation is particularly remarkable as the available training data set comprised only 900 images taken from 60 physical samples – which is a relatively small amount of data compared to typical image recognition tasks. The algorithms can be deployed on productive systems without loss of throughput or upgrade of computing power. The results resolve the common doubt that high performance GPU hardware is required to put deep neural networks into operation. On the contrary, our results show that careful network design enables common industry-standard PC hardware to perform the relevant computations.

References

[1] Navneet Dalal and Bill Triggs: "Histograms of Oriented Gradients for Human Detection", IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 2005
[2] https://www.tensorflow.org/
[3] https://scikit-learn.org/stable/
[4] "Deep Learning with Python" by Francois Chollet, Manning Publications Co., 2017

AUTHORS
Patrick Hess, Seidenader
Dr. Patrick Sudowe, D-fine
Dr. Tassilo Christ, D-fine

CONTACT
Seidenader Maschinenbau GmbH,
Markt Schwaben, Germany
Tel.: +49 8121 802 0
www.seidenader.de

D-fine GmbH, Frankfurt/Main, Germany
Tel.: +49 69 907 37 0
www.d-fine.com

Visual Perception System Guides Robots

Bolt-on System Enables Intelligent Automation with Turn-Key Set of Hardware and Embedded Computing

An easy to integrate robot vision system with "eyes and brain" was developed by using the SGBM algorithm in a combined 3D sensing and processing unit and optimizing it for Nvidia Jetson embedded systems and real-time applications.

The perception abilities of industry robots and service robots alike need to be improved in order to enable man-machine collaboration in the smart factory and reach higher autonomy of unmanned service vehicles. However, integration of intelligent computer vision solutions into robots still poses challenges, despite major facilitations such as miniaturization of vision components. Therefore, the task is to develop an easy to integrate robot vision system which not only provides "eyes" to see anymore but also has "brain" to create visual perception. This was reached by using the renowned Semi-Global Block Matching (SGBM) stereo matching algorithm in a combined 3D sensing and versatile processing unit and optimizing it for the specific Nvidia Jetson family of embedded systems and real-time applications.

Complex Integration

Computer vision solutions have been famous for their development and integration complexity. Even today, many vision solutions, e. g. for robot applications, need specialized skills or expensive integration support to be deployed. However, in the context of Industry 4.0 and ever accelerating factory automation there is an increasing demand for standardized computer vision solutions which are affordable, easy to integrate and help to improve the perception abilities of an industry robot. In addition, such systems are also a prerequisite to successfully conquer new application fields outside the factory floor that are commonly gathered under the term service robotics. In this area progress has been visible over the last decade for instance with unmanned aerial vehicles (UAVs) and unmanned ground vehicles (UGVs) which have been reaching higher degrees of autonomy by deploying more complex algorithms and sensors. Integration of computer vision into these systems was further pushed by components becoming smaller and smaller, making embedded vision systems possible. Nonetheless, real life applications of "seeing robots" still post challenges to these systems, with obstacle avoidance being one of them.

Breakthrough in GPU Technology

In recent years, with the graphics processing unit (GPU) technology becoming more affordable and powerful, Nvidia's Cuda technology has been developed. It has opened

up new opportunities for versatile embedded systems which originally were not able to perform computationally intensive tasks in near real time. By using the Nvidia technology Lithuania-based pioneer company of mobile robotics solutions Rubedos, developed its 3D visual perception system Viper for free ranging vision guided robotics applications. As a result of several years of research and development, Rubedos has created and integrated algorithms, which provide essential environmental awareness for free-ranging robot navigation and can even detect 3D objects and classify them into categories.

The entire Viper system is a combined 3D sensing and versatile processing unit. It consists of a synchronized pair of commercial-off-the-shelf 2D sensors, the embedded GPU computing platform mounted on a custom engineered carrier board with low-latency ISP and all relevant industrial interfaces, and carefully matched foundation software which has been designed to be extended with standard or bespoke perception software modules (aka perception apps, available separately much like mobile apps for a smart phone). The latter is the powerful feature of the system, because a 3D image undergoes additional application-specific interpretation while it is still on-board of the system, which eventually extracts and outputs just the relevant insights to the host system. For example, the original 3D image can be analyzed and transformed into the laser scan signal for easy consumption on the robot side, thus converting user-defined segment of 3D volume image to a conventional 2D lidar signal representation on the fly. Or, in case of pallet pocket detection, the vision system can output just the 3D coordinates of the pallet after it has been detected in front of a self-driving forklift.

At the core of 3D sensing of Viper is a passive stereo camera which reads synchronized images with a certain offset and uses fast on-board computing to reconstruct a 3D image (also known as point cloud) of the environment. The stereo vision system with two 3.4 MP low light cameras continuously measures environment depth in 3D with a depth frame rate up to 40 Hz over range distances up to 50 meters. By virtue of being able to capture the extra third dimension data reliably, the 3D computer vision system is immune to the environmental factors adversely affecting 2D systems – the aspects of lighting, contrast, and variable distance to object of interest.

» The system is a stand-alone ingress protected industrial bolt-on 'eyes' and 'brain.'«

Integrated Machine Learning Methods

By handling all aspects of initial image disparity calculation, including real-time lens correction, camera rectification, correspondence searching, filtering, and error removal the system offloads low- and high-level image processing to the on-board processor. Moreover, it has enough power to locally run machine learning methods such as neural networks and processes stereo-image data on them. For instance, the vision system uses a similar approach to detect humans and calculate their relative 3D position, which can be used to enable smart functions on mobile platform, like follow-the-human or trigger an alarm when a human enters safety critical zone, such as a construction site. In order to enable the latter functionality, the user first activates one of the additional Viper extension modules, such as the 'Follow-me' perception app. The app then combines people detection capability (2D) and range measurement capability (3D) to inform the host system about any change in distance to the visually registered person so it can slow down, break or accelerate accordingly, thus achieving a virtual leash effect. In addition to people tracking, the app can track other types of objects or special tags, such as ArUco tags. The latter allows arranging a convoy of multiple UGVs that follow each other in succession, whereas the first UGV follows a human person.

Configurable Stereo Matching Algorithm

One of the notable developments within the system is the application of the renowned SGBM stereo matching algorithm that was optimized by Rubedos for the specific Nvidia Jetson family of embedded systems and real-time applications. Other specialized algorithms are available out of the box as well. Since speed is a crucial criterion in applying vision guided robotics the algorithm configuration concentrates on the speed aspect of stereo matching sacrificing accuracy where necessary. The vision system, however, allows changing the default speed-preference configuration or even replacing the default stereo matching algorithm with another algorithm of user's choice. This flexibility makes it an excellent stereoscopic vision research tool for robotic solution developers.

By default, the system is available as stand-alone ingress protected industrial bolt-on 'eyes' and 'brain'. In addition, an OEM Kit version is available for solution developers who intend to use the vision system to blend more seamlessly into their system designs. Weighing under 250 grams and consuming less than 10 Watts of power, the OEM Kit offers the same amount of environmental awareness as its stand-alone sibling, if only it is more suitable for smaller UGVs and UAVs such as professional drones, which often suffer from limited power and payload capacity.

With these features, the powerful and lightweight as well as easy to integrate Viper system enables intelligent automation with a turn-key set of hardware and embedded computing. It can be applied to a wide range of use cases to equip industrial and service robotics with visual perception. ■

AUTHORS
Linas Vaitulevičius,
Co-founder & CBDO of Rubedos
Andreas Breyer,
Vision Communications

CONTACT
Rubedo Sistemos, UAB, Kaunas, Lithuania
Tel.: +370 37 243 616
www.rubedos.com

Index

Imprint

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

Managing Directors
Dr. Guido F. Herrmann
Sabine Steinbach

Publishing Director
Steffen Ebert

Product Management/ Editor-in-Chief
Anke Grytzka-Weinhold
Tel.: +49/6201/606-456
agrytzka@wiley.com

Deputy Editor-in-Chief
Martin Buchwitz
Tel.: +49/15146185676
martin.buchwitz@wiley.com

Editorial
Andreas Grösslein
Tel.: +49/6201/606-718
andreas.groesslein@wiley.com

Editorial Office Frankfurt
Sonja Schleif (Editor)
Tel.: +49/69/40951741
sonja.schleif@2beecomm.de

Editorial Assistant
Bettina Schmidt
Tel.: +49/6201/606-750
bettina.schmidt@wiley.com

Advisory Board
Roland Beyer, Daimler AG

Prof. Dr. Christoph Heckenkamp, Hochschule Darmstadt

Dipl.-Ing. Gerhard Kleinpeter, BMW Group

Dr. rer. nat. Abdelmalek Nasraoui, Gerhard Schubert GmbH

Dr. Dipl.-Ing. phys. Ralph Neubecker, Hochschule Darmstadt

Commercial Manager
Jörg Wüllner
Tel.: 06201/606-748
jwuellner@wiley.com

Sales Representatives
Martin Fettig
Tel.: +49/721/14508044
m.fettig@das-medienquartier.de

Claudia Müssigbrodt
Tel.: +49/89/43749678
claudia.muessigbrodt@t-online.de

Production
Jörg Stenger
Claudia Vogel (Sales Administrator)
Maria Ender (Layout)
Ramona Scheirich (Litho)

Wiley GIT Reader Service
65341 Eltville
Tel.: +49/6123/9238-246
Fax: +49/6123/9238-244
WileyGIT@vuservice.de
Our service is available for you from Monday to Friday 8 am – 5 pm CET

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

Advertising price list from October 2018

Circulation
10,000 copies

Individual Copies
Single copy € 16.30 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 2567-7519

WILEY


WILEY
Good products are made
from good ideas.
© Alexandr Mitiuc / Hein Nouwens - stock.adobe.com
inspect
WORLD OF VISION
Buyers Guide
CAMERAS
OPTICS
ILLUMINATION
OPTICAL METROLOGY
CONSULTING
MORE THAN 500 COMPANIES
inspect international
X-Ray & Infrared
Optics & Illumination
Inspection & Identification
Vision 2.0: Wachstum und Reife
Industrial Computing
Robotik
Inline Messen und Prüfen

HIKVISION®

Finite Size, Infinite Power

SC Series Vision Sensor

- High performance hardware platform embedded in a compact and rugged structure
- Rich built-in vision tools for inspection of presence/absence, front/back, position, dimension, etc.
- User-friendly web-based configuration interface
- Field interchangeable lighting and optics

www.hikrobotics.com
hikrobotics@hikvision.com
Follow Hikrobot on in