VOLUME 10
NOVEMBER 2009
11
D 30 122 F

VISION • AUTOMATION • CONTROL

INSPECT

Special: World of 3D

High Tech in the Cowshed

Review Vision 2009

A Passion
For Communication
Since 1969
40 Years GIT VERLAG
A Wiley Company
www.inspect-online.com

Brainstorming 1969

Do you know the difference between politics and physics? You don't?

Being a physicist you might have to wait for 40-odd years before you'll receive the public recognition for your achievements. In politics this public recognition is already given to the hope bearer supposed to achieve his goals in the first place. Admittedly, world peace is a goal that requires lots of hope and many a hope bearer, and audacity, which this year's winner of the Nobel Peace Prize has committed himself to. The goal of Messrs. Boyle and Smith, winners of the 2009 Nobel Prize in Physics, was much more down to earth: back in 1969 they were supposed to come up with a new and more efficient electronic memory device for their employer, the Bell Laboratories just outside of New York. What they actually did come up with was the CCD chip. After only one hour of brainstorming. And without even thinking about images or cameras. After another week or so, the first prototype of the chip was build, and only a year after thinking it up, Boyle and Smith were able to demonstrate the functionality for the first time inside a video camera. The memory device, originally contemplated, was long since forgotten. In 1972 the American company Fairchild constructed the first image sensor with 100 x 100 pixels, which went into production a few years later. In 1975, Boyle and Smith themselves then designed a digital video camera of a sufficiently high resolution to manage television broadcasts. It took another ten years before the first digital photographic camera entered the market, but ever since the trail of success for the digital camera with the Charged Coupled Device has been unstoppable; and the end of the era of photographic film was heralded.

This one hour of discussion between the two physicists led to generations of devices, technologies and processes ever since, and was the foundation for whole industry sectors. Among those is also the sector from which the INSPECT reports now in its 10th year.

A fluke? A lucky break?

For Willard S. Boyle the cause for their success was founded within the working atmosphere in the Bell Laboratories at that time. Creativity was explicitly encouraged. No business plan was required for starting a new project, not even a milestone plan, no budget for development needed to be asked for, and no profit forecast had to be provided. The management did not consist of "money bureaucrats," as Boyle phrases it, but they were scientists themselves. The leadership style was "Management by walking around," resulting in a very cooperative atmosphere bridging all hierarchy levels and leading to a continuous lively technical exchange. Even from today's point of view, looking back four decades, Boyle is still convinced that the reason for the joint success has always been the joy in working at Bell Labs, the high degree of freedom in developing new concepts and the possibility to gather experiences in many different areas. Boyle himself, for example, was seconded to the Apollo program once for two years, before returning back to his research lab at Bell.

However. Still. Is this not unprofessional? Maybe a fluke yet, a stroke of luck?

Up until today a total of 13 scientists have jointly won seven Nobel Prizes in Physics for work conducted at the Bell Laboratories. These are not bad arguments for creative freedom as basis for invention and innovation.

In any case, creative freedom is not a bad basis for world peace either.

Discover in this issue of the INSPECT what Willard S. Boyle and George E. Smith could not have dreamed of 40 years ago: what electronic images and machine vision meanwhile have become.

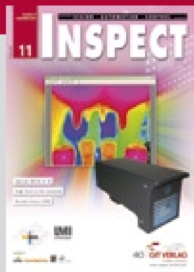
I hope you enjoy the discovery.

Gabriele Jansen
Publishing Director INSPECT

TOPICS

VISION

COVERSTORY



AUTOMATION

CONTROL

AIA, EMVA, JIIA Sign Cooperative Standards Accord

Leaders from the Automated Imaging Association (AIA), European Machine Vision Association (EMVA), and Japan Industrial Imaging Association (JIIA) signed an agreement on November 3 to cooperatively develop and promote global machine vision standards.

Up to this point, each association has developed industry standards on its own; these legacy standards will remain in place. Going forward, if the associations agree on an issue needing standardization, a lead association will develop the standard and then the group will mutually promote the result as a global industry standard. If there is no consensus on the global need of a standard, each association retains the right to develop standards outside the cooperative group.

"This accord will benefit machine vision users and suppliers alike by accelerating the pace of standards development, avoiding overlapping efforts, and creating more awareness of new standards," said Jeff Burnstein, President of AIA.

"This new cooperation in the field of machine vision standards development will play a decisive role in promoting machine vision technology in all markets. It will increase the global information flow during the standards development process and help the standards to become established internationally," said Patrick Schwarzkopf, EMVA General Secretary.

"We've worked diligently since JIIA first proposed this idea to prepare a global standardization process that will benefit the industry. It is especially rewarding that this agreement is now signed. We congratulate all of the machine vision players and look forward to further cooperation," said Shigeo Oka, Chairman of JIIA.

Machine vision, which accounts for more than US$5 billion in annual sales worldwide, is a critical technology for users in industries such as automotive, electronics, food & beverage, lab automation, pharmaceuticals, and security. New markets are rapidly developing in areas such as medical imaging, energy, entertainment, and other non-manufacturing sectors. AIA, EMVA and JIIA believe that new standards can help stimulate the growth of machine vision sales.

Representatives from the three trade groups said they hope to add leaders from other associations in the future as new groups emerge to represent the growing machine vision industry in countries like China and India.

www.machinevisiononline.org
www.emva.org · www.jiia.org

Cor Maas New EMVA Vice President

On October 1, the EMVA Executive Committee elected the new EMVA Vice President, Cor Maas (LMI Technologies), for a term of three years. Cor Maas has been a member of the Executive Committee since May 2008 and is in charge of EMVA standardization activities. He is co-founder of LMI Technologies Inc and serves as President of LMI's Vision Components Division headquartered in The Netherlands. As the EMVA Vice President his focus will be on the harmonization of global machine vision standardization activities and the further development of current EMVA standardization initiatives such as the GenICam and EMVA 1288 standards. "Harmonization of global machine vision standardization emphasizes the economic importance of machine vision as a key technology. It will also increase the benefit for all our members," Maas said.

www.emva.org

Coherent Acquires Product Lines from StockerYale

Coherent, Inc. has acquired the North American operations of StockerYale, Inc. in an asset purchase for US$15 million in cash. The company acquired all the assets and certain operating liabilities of the laser module product line in Montreal, Canada and the specialty fiber product line in Salem, New Hampshire. John Ambroseo, President and Chief Executive Officer of Coherent stated: "In acquiring these two product lines, we gain access to the machine vision market and expand our bioinstrumentation opportunities through the laser diode module business."

www.coherent.com

Michael Willis Joins Boulder Imaging as President and COO

Boulder Imaging Inc. announced that Michael Willis is joining the company as its President and Chief Operating Officer. He will lead the company in executing its goal of becoming the leader in Analytic Imaging solutions. "I am delighted to welcome Michael to Boulder Imaging," said Carlos Jorquera, founder and CEO. "This is an exciting time as we expand the company's product offerings and capabilities."

www.boulderimaging.com

Viscom Celebrates Anniversary

The Viscom AG celebrated its anniversary in October 2009. 25 years ago, in 1984, Viscom was founded as a private company for industrial image processing by Dr. Martin Heuser and Volker Pape. This places them among the pioneers in this new technology. The two-person business venture gave rise to a successful high-tech company. Viscom is now represented around the world, with branches in Singapore, the USA and France as well as international representatives.

www.viscom.de

Good Outlook for Control 2010

With its diverse and extremely valuable supplementary programme, Control trade show will once again emphasise its internationally leading role from of May 4 through May 7, 2010. Organized by the Fraunhofer Alliance Vision the special exhibition of vision systems and image processing technologies deserves to be mentioned, as does the complementary event forum offered by the IPA Fraunhofer Institute for Production Technology and Automation. In addition to this, internationally recognized, world-class expert seminars will be held again, and numerous exhibitors will present their latest developments at the exhibitor forum which is booked out on a regular basis. Thematically and structurally well equipped for the future, Control has every reason to look ahead optimistically.

www.schall-messen.de

Good Milk from Happy Cows

Time of Flight Imaging Enables Automated Milking

The output of worldwide agricultural milk production in 2007 has been 560.5 million tons with an 83.5% share of cow's milk. The biggest milk producers have been USA, India and China. In the European Community 150 million tons are produced annually, the E-15 is the biggest market for milk-based products. The production of milk is an industry, so it comes as no surprise that here as well automation technologies, especially in the area of automated milking, are in high demand.

Automated milking in dairy farms is rapidly expanding. The automated process not only frees up valuable time for the farmer, but also makes happier cows that produce higher yields of better quality milk. There are only a select few companies in the world who specialize in these technologies as this is a very difficult and demanding application of machine vision and robots.

A key enabling component in automated milking systems is the 3D sensor that identifies and locates the teat positions on the cow's udder as it steps into the milking box. The information derived from the sensor is used to guide a robot arm to attach the milking cups to the teats. The entire process of locating teats and attaching cups must be robust, fast, accurate and safe, without disturbing or stressing the cow.

Sensor Challenge in the Barn

GEA Farm Technologies, formerly GEA Westfalia-Surge, offers worldwide leading innovations and whole product solutions for dairy farming. When GEA decided to develop a new generation of automated milking systems, they approached LMI Technologies to create the vision guidance sensor. GEA recognized LMI as a leading edge 3D sensing technology solutions provider, with particular expertise in implementing sensors in challenging applications in extremely harsh environments.

One of the challenges in automating the milking process is reliably guiding the milking robot to attach the milking cups to the cow's teats. Cows are highly individual animals in both behavior and appearance. The sensor must cope with significant variations in target shape and colour, moving animals, in a naturally dirty environment cluttered with mud, straw, water and other uncontrolled objects that interfere with reliable operation of vision sensors. The sensor must also ignore sections of the 3D images caused by other components within the field of view, such as the cow's legs or swinging tails.

Ultrasonic ranging and laser triangulation techniques had previously been applied to provide robot guidance for automated milking applications, but had drawbacks, including the need for moving parts and/or laser safety concerns.

Unique Time of Flight Imaging Solution

LMI is one of only a few companies in the world that have expertise in successfully implementing machine vision technolo-

To survive in the harsh uncontrolled milking machine environment, the Tracker 4000 is housed in a sealed package

About LMI

LMI Technologies specializes in application specific 3D sensors for a wide variety of measurement, control and guidance applications. LMI sensor solutions are used in lumber processing, pavement inspection, molten metal pouring level control, automotive assembly, rubber and tire manufacturing, and many others. LMI's application specific sensing solutions are based on 2D or 3D sensing technologies, and in many cases effectively combine 2D and 3D sensing in a single sensor package. Founded in 1976, LMI developed much of the 3D sensing market, and holds over 100 patents related to 3D sensing technology.

gies for applications such as robot guidance in extremely difficult environments. Tasked with finding a better solution for guiding milking robots, LMI determined that implementing innovative time of flight 3D imaging would provide a unique and dramatically improved solution to this guidance application. The sensor based on this technology and developed by LMI in conjunction with GEA, is named the Tracker 4000.

TOF imaging cameras have a 2D array of pixels, with each pixel capable of returning time of flight information as well as intensity. The TOF information produces 3D images of a scene where the brightness of each pixel is proportional to the distance from the sensor to the object, creating an image similar to a topographical map.

TOF imaging provides many unique advantages when applied to guiding milking machine robots. The 3D image field of view includes the entire udder as well as the milking cups. The 3D image information from the sensor is analyzed to determine the position and angular orientation of each individual teat, as well as the milking cups. The location information is transmitted to the robot controller through Modbus over Ethernet. Use of industry standard protocols simplifies the integration effort for the machine builder.

The sensor currently operates at a frame rate of 8.3 Hz, with faster operation in development. Multiple images are taken as the cups are guided to the teats, which track movement of the cow during the attachment process.

Determining the locations of both individual teats and milking cups enable differential guidance, where the offsets to guide the robot to the teat locations are determined as the differences in location of the teats relative to the location of the milking cups on the robot. The result is improved reliability in guidance, as well as simplification of absolute calibration requirements for both the sensor and the robot over the full field of view.

3D Images with no Moving Parts

The TOF sensor is small in size and low in weight, allowing it to be easily mounted on the robot arm, so its position can be

The TOF sensor is small in size and low in weight, allowing it to be easily mounted on the robot arm

changed by the robot. This allows the viewing angle to be changed, very useful to obtain an unobstructed view of all teats, particularly if two teats are seen to overlap from one viewing angle. Obtaining 3D data from a single TOF camera provides a much smaller sensor package than would be required for two camera stereo imaging, which also requires extensive image analysis software to create a 3D image.

The TOF principle provides complete 3D images with no moving parts and no laser lines or spots. Traditional laser scanners require use of a mechanical scanning device to capture a full 3D image, which increases time required to capture an image, and adds complexity while reducing reliability.

The Tracker 4000 sensor is implemented with infrared LED illumination integrated into the sensor housing, which does not distract the cows in the milking station. Also, LED illumination eliminates laser safety concerns and related regulatory documentation, an issue with laser triangulation based sensing.

To survive in the harsh uncontrolled milking machine environment, the Tracker 4000 is housed in a sealed package, with a sealed watertight cable connector. The mounting bracket covers the top and sides of the sensor to protect from cow kicks and dirt.

The milking robot does not only free up valuable time for the farmer, but also makes happier cows that produce higher yields of better quality milk

Award-winning Teat Location

The Tracker 4000 is implemented with the field proven FireSync platform, developed by LMI to simplify the often complex task of integrating and synchronizing the many components of a 3D sensor system. FireSync is a synchronized, scalable distributed vision processing architecture for building reliable high performance systems. Real-time image processing algorithms running in the FireSync processor located inside the sensor use proprietary software to extract teat and milking cup locations in the images, ignoring other objects in the field of view, like a cow's leg or a swinging tail. The final result, coordinate positions for teats and milking cup locations in a predefined coordinate system, is delivered to the robot controller via an Ethernet connection. The FireSync platform is used in all of LMI's new products.

LMI's Tracker 4000 sensor is a technologically advanced device that will create significant improvements to yield performance and farm productivity, livestock well-being, enhance reliability, increased speed of farm operations and profitability, and improve product quality in the milking process. A short video demonstrating the Tracker 4000 sensor guiding a robotic milking machine to attach suction cups onto a cow's teats can be viewed at: http://www.inspect-online.com/en/webcasts/time-flight-imaging-enables-automated-milking.

In 2008, GEA Farm Technologies (GEA) was awarded the prestigious silver medal for "New Innovations" presented at the EuroTier 2008 tradeshow in Hanover, Germany for developing the innovative milking robot system with the LMI Tracker 4000 sensor.

This implementation of TOF technology is so unique that in February 2009, LMI Technologies was awarded US Patent 7,490,576 B2 from the United States Patent and Trademark Office for the use of Time of Flight sensors in livestock management.

▶ **Author**
Dr. Walter Pastorius,
Technical Marketing Adviser

▶ **Contact**
LMI Technologies Inc., Delta, BC, Canada
Tel.: +1 604 636 1011
Fax: +1 604 516 8368
info@lmitechnologies.com
www.lmitechnologies.com

Successful Partnership

Interview with Frank Grube, CEO Allied Vision Technologies and Christof Zollitsch, CEO Stemmer Imaging

INSPECT: Mister Grube, the integration of the Canadian camera manufacturer Prosilica that AVT took over in mid 2008 seems to be completed now: Prosilica has changed the company name, the cameras have changed color, and in early November the distribution channel for sales in Germany, UK, France and Switzerland has been changed to your long term partner Stemmer Imaging. Have AVT and Prosilica now really become one company?

F. Grube: Yes – Prosilica now is completely integrated into the AVT group. In the course of this integration it is just consequent to not only merge the product range but also push the fusion of the Prosilica and AVT organizations. Prosilica Inc., headquartered in Burnaby (Vancouver, Canada), will be renamed to Allied Vision Technologies Canada and will become part of the AVT group. With AVT Canada we will have a further AVT site in North America. AVT Canada will focus on independent developments and production within the AVT group.

Mister Zollitsch, the GigE camera product range has already been strong in your portfolio. What is the appealing factor of the Prosilica cameras and how do they distinguish themselves from the already existing products in your offering?

C. Zollitsch: Since November 1st of 2009, Stemmer Imaging has taken over the responsibility for the distribution of all AVT GigE Vision cameras. With this step, AVT bundles the distribution of their successful FireWire and GigE models on our company as a strong partner. For customers this guarantees that they will get the best consultancy and the optimum product for their individual task from one independent partner. Without any doubt we already have further well-known suppliers in our list of partners, such as Automation Technology, Dalsa, JAI and Mikrotron. These suppliers have strategically developed their own main focus in different areas of the machine vision market and have found their own positions. In case of overlapping products obviously the application has to be scrutinized in detail to choose the best possible product. With the extension to the Prosilica and AVT GigE product lines we now can offer a unique selection of cameras of that technology. Based on this diversity, our customers can furthermore rely on our technology consulting services.

Mister Grube, many other camera suppliers strategically have chosen direct sales for their products in important markets, and without any doubt, the German speaking area is one of those important markets. With the transfer of the Prosilica products you have again decided to distribute those by a partner. What are the reasons for that decision?

F. Grube: Eventually, AVT and Stemmer Imaging are the best proof that direct and indirect sales can perfectly complement each other. A competent imaging partner such as Stemmer Imaging mainly serves customer structures and requirements; this is something a pure component supplier can only do in a limited way because he is covering completely different core competences. All of our global partners offer an exquisite know-how in imaging that is requested by many customers. This service requires a local presence and availability – something that can hardly be covered by a manufacturer on his own. AVT has ascended to one of the biggest camera manufacturers worldwide very quickly – the AVT sales strategy surely was a key for this success.

Mister Zollitsch, Stemmer Imaging has been one of the most important AVT sales channels in terms of revenue in the past. What is the formula for your success?

C. Zollitsch: There are several reasons to be mentioned, and most of them are not only true for our cooperation with AVT. First of all and most important, our employees are crucial, as they are accepted partners of our customers, consulting them from the heart and with deep imaging knowledge. Another part of our success is based on our claim to serve our customers in the best possible way, offering the optimum comprehensive solution including illumination, lenses, cameras, cabling with the right interface to the processing system, as well as the application driven software solution. This is our promise, and we take the responsibility for that part. In combination with our core competence in software development and the production of small series of cabling and imaging computer systems, as well as with our competent consultancy and short response times we are the right imaging partner for our customers, guaranteeing fast reactivity, something that is essential to survive in today's global markets.

Thank you very much to both of you for this interview here at the Vision trade show 2009 and good luck for your future activities.


DRAFTFCB
OLYMPUS
Your Vision, Our Future
ERKUNDEN SIE DIE LETZTEN
WEISSEN FLECKEN DER NANOWELT.
Dorthin vordringen, wo noch niemand war: Mit der Olympus Dual Pinhole Technologie des neuen LEXT OLS4000 bezwingen Sie jetzt Flankensteilheiten von bis zu 85° – und entdecken so vollkommen neue Dimensionen im Bereich der optischen Messtechnik. Von hoch reflektierend bis hoch absorbierend – mit dem neuen LEXT präsentiert sich die Darstellung unterschiedlichster Materialkontraste in einem neuen Licht. Was immer Ihr Ziel ist: Mit überragender Auflösung und absoluter Messgenauigkeit ebnet Ihnen das neue LEXT den Weg zu den letzten weißen Flecken der Nanowelt. Wann starten Sie Ihre erste Expedition?
PIONEERS WANTED: WWW.MICROSCOPY.OLYMPUS.EU/METROLOGY
Olympus Deutschland GmbH | Tel.: (040) 2 37 73 46 12 | E-Mail: mikroskopie@olympus.de
OLYMPUS MIKROSKOPIE

A Dose of Vision

Optimistic Mood at the 22nd Vision Trade Show in Stuttgart

The 22nd Vision has ended. The three days of the fair were packed with the introduction of new products, presentations at the stands, with forum talks and discussions, special exhibitions and company highlights. The fair impressed both visitors and exhibitors. Read more on the fair's mood, the highlights of the supporting program and, above all, on the novelties introduced during the three days of Vision.

Vision 2009 in Figures

Shortly after our editorial deadline, Messe Stuttgart reported preliminary figures on Vision 2009: According to these a total of 5,900 visitors were counted on the three days from November 3–5. The percentage of visitors from abroad is reported to have risen distinctly from last year's 28 % to now 33 %. Also, say the organizers, the number of visitors with direct influence on investment and buying decisions has risen from 76 % in 2008 to 86% this year. It was also observed that visitors from the industry had well-defined project inquiries and concrete goals for their visits. 60 % of the visitors were planning new investments, an increase of 7 % over last year.

Vision, trade fair for machine vision and identification technologies, also in its 22nd year justified its position as the industry's leading trade show. This is substantiated by the figures given during the opening press conference by Thomas Walter, director of Industry & Technology of Messe Stuttgart: With 292 exhibitors, last year's level could be maintained precisely. Only the exhibition floor space shrunk by about 1,000 m². In times of turnover slumps affecting also machine vision companies, this constitutes a more than just respectable result.

A Brighter Future

Dr. Olaf Munkelt, since October 9th 2009 **VDMA's** (the German Association of Mechanical Engineering Suppliers) Chairman of the Board for the Department of Machine Vision, quoted prognoses given by the International Monetary Fund (IWF, Internationaler Währungs-Fond). According to them, the world economy would grow substantially in 2010. Present data of the Ifo Institute would indicate an ongoing improvement of the world economic climate, which, said Munkelt, meant an imminent recovery of the rate of incoming capital goods orders. This bright outlook is substantiated by the latest VDMA poll. Munkelt: "More than 70 %

Jochem Herrmann (center), representing the CoaXPress group of companies, accepts the 17. Vision Award

Representatives of machine vision associations AIA, EMVA and JIIA are pleased about the conclusion of the cooperation agreement in the field of standardization

of the machine vision industry's polled companies expect an increase of incoming orders in 2010; 20% even expect a distinct increase of more than 10%. Also, employment figures are expected to rise slightly." But Munkelt also warned that despite such optimistic prognoses it may take years to arrive at the record level of 2008.

Growth Booster Standardization

The VDMA regards standardization as the basis for further great growth potential, as standards simplify the use of the imaging technology, thereby facilitating wider applications and opening up new application sectors. In order to pave the way for global standards, the three big associations, Automated Imaging Association **(AIA)**, European Machine Vision Association **(EMVA)** and Japan Industrial Imaging Association **(JIIA)** on the first day of Vision entered into an agreement of cooperation for the common development and promotion of new standards in machine vision. As declares Patrick Schwarzkopf, EMVA's General Secretary: "This new cooperation in the field of machine vision standards development will increase the global information flow during the standards development process and help the standards to become established."

And the Winner Is...

One highlight of the trade show again this year was the announcement of the Vision Award. The award, which included a prize money of 5,000 €, was given to

CoaXPress, a group of companies, represented amongst others by **Adimec** Advanced Image Systems of the Netherlands. Jochem Herrmann, Adimec's CTO, presented the novelty and in the group's name accepted the award.

CoaXPress is endeavoring to define a new standard for high-performance camera interfaces. These would allow feeding supply as well as video and controlling data through conventional coaxial cables. The idea of combining the simple coaxial cable with the latest technology for the high-speed data transfer was considered prize-worthy by the jury. Fully configured, the system aims at a transfer rate of 6.25 Gbit per second over distances of up to 100 m. Japan's JIIA already promised to endorse the CoaXPress specification.

Sports and Leisure

According to VDMA future growth potential for machine vision can also be found in new fields of application outside production, fields like security, agriculture, medical technology and multi-media. This view is supported in numerous talks with exhibitors; they succeeded in cushioning the crisis by diversifying into new applications. Some companies have discovered professional sports as a new market segment. Roald van der Vliet, manager of InnosportNL reported a great demand from swimmers to record and analyze their movements under water. Van der Vliet equipped the swimming pool with 16 GigE camera by **Basler** and uses a **Norpix** software for movement analysis. **Cypress**, to cite yet another example, is now selling their sensors to system suppliers for analyzing golfers' movements. These make use of this tool to improve their tee off.

Imagine the surface of a table on which one may at will call up digital contents and enlarge, scale down, or shift them to-and-fro, alone or together with others. Encoded objects put on the table will cause pertaining information to appear, or presentations, or motion picture sequences. Two companies presented during Vision such futuristic interactive user interfaces. XDesk of impressx uses cameras of **VRmagic** for real-time gesture tracking. On the atracTable the infrared sensitivity of the **Sony** cameras is used for pattern recognition and tracking (http://www.inspect-online.com/en/webcasts/futuristic-interfaces-based-vision-technology).

Focusing on Picture Quality

Conquering new business fields, this is also what **Josef Schneider Optische Werke** are planning. During Vision 2009 the company initiated a study on to what extent customers are interested in customer-specific lighting systems. Depending on the outcome, Schneider will in the future extend their portfolio to include lighting solutions. This would allow conceiving lenses and lighting advantageously as one system with an optimum of mutual adjustment, the best prerequisites for good image quality.

The goal of producing high-resolution images in ever increasing quality is also pursued by the lens manufacturer **Kowa**. Thus, the company presented their 10-Megapixel series. **Sill Optics**, too, is broadening their product line, offering a 50 mm thermography lens with an aperture of 1.5. It functions, color-corrected, in a wave-length range in the far infrared from 8 to 14 µm.

Lighting in all Variants

Vision & Control are complementing their system of components by a new generation of coaxial lighting systems. Here, the diffuse incident light illuminates the specimen to be inspected in a homogeneous way without creating a shadow, thus making it highly suitable for the inspection of reflecting and mirror-finish surfaces.

CCS for the first time showed an LED at Vision producing a light similar to daylight. Its color rendering index is about CRI=98, compared to 100 of daylight. Conventional LEDs or halogen lighting will always produce color distortion; particularly in quality control jobs which are carried out manually, it is imperative to have natural light, as the company reports.

Pivot GigE Standard

Again, the GigE standard and products incorporating this standard were a dominant topic of the fair. In this vein the French company **e2v** introduced two new cameras with Gigabit Ethernet interfaces: the line scan camera DiViiNA LM1 as a low-cost camera and the more completely equipped model AViiVa 2 EM1. The latter is one of the first 4k-pixel line scan cameras equipped with a GigE interface. Its line rate is 28 kHz. The EM1 offers a dynamic range of 69 dB, a sensitivity at minimal amplification of 164 DN/(nJ/cm^2) and a PRNU (Pixel

Response Non Uniformity) below 3%. According to **Rauscher**, its distributor, these specifications ensure optimal quality when encountering short integration times or non-optimal lighting.

Beside the CameraLink interface the new 3CCD color cameras within JAI's AT series also have a GigE interface. The 3*1.4-megapixel and the 3*2-megapixel cameras are based on the experience of **JAI** in the field of prism technology and offer a larger sensor format and a higher resolution than all up-to-now available 3-chip RGB models, as reports the manufacturer.

Imago Technologies presented its VisionBox AGE, optimized for GigE cameras.

The DSP based computer has an adjustable computing capacity between 8,000 and 18,200 MIPS (mega instructions per second) in the shape of one or two integrated computers and its own network computers for Gigabit Ethernet. This way, full CPU capacity is available for image processing. Carsten Strampe, the company's managing director, reported a great demand for C++ programming at the fair, as many users wanted full command over the source code of their applications.

Dalsa now supplies a GigE Vision compatible version of the successful Spyder3 color camera. This color line scan camera is based on the successful monochrome double line scanning model of the Spyder3 camera. "The new Spyder3 color GigE camera with Dalsa's innovative double line design will deliver excellent color images with minimal image noise, flexibility as well as an excellent price-performance ratio", says Xing-Fei He, Senior Product Manager at Dalsa. "In addition, the GigE Vision compatible interface allows an easy integration with other components, a greater camera-to-PC cable length as well as cost reduction with our customers' machine vision systems."

Baumer, beside innovative cameras, also offers the critical network components for a GigE Vision compatible all-in-one solution, thus realizing the first true single-cable solution for GigE. In addition to multiport switches and PoE injectors, with which both standard and PoE cameras can easily be integrated into the network, the user for the first time may control simple processes via the network by means of the new Trigger Device. By using all network components, data and power can be transferred over a single Ethernet cable. Additionally, real-time triggering of the camera can be realized through the same Ethernet cable.

Components Express for the first time showed its Bit Maxx device, a Gigabit PoE+ splitter. This compact device enables the user to use cameras lacking a PoE connection in a Power-over-Ethernet environment. Both voltage and data will be transmitted via one single cable from the switch to the splitter. The camera is supplied with voltage by one cable from the splitter, the data being delivered by means of an I/O plug connection. The splitter may be directly connected to the most current GigE Vision cameras. The advantages, according to the company, are evident: No voltage connection is required in the camera environment itself and cable management no longer is a problem.

But not all the talk was about GigE Vision products. With its 5 Gbit/second, USB 3.0 represents a true alternative to currently used camera interfaces. In this context **Point Grey** showed the Grasshopper Express prototype with its new 3-Megapixel Sony IMX036 CMOS image sensor. The new interface promises a quantum leap as concerns speed of transfer and reliability at low cost and easy integration. The new Grasshopper represents an innovative supplement of the Canadian manufacturer's camera portfolio, offering already its FireWire, Camera Link and GigE Vision compatible products.

Small, Efficient and Intelligent

High capacity in the smallest space – this is what **Matrix Vision** presented with their new series of smart cameras. They incorporate high-capacity

processing units, the latest image sensors and an integrated hardware accelerator (H.264). The myBlueLynx-X family will yield new application possibilities for machine vision, surveillance and for medical and life science applications for OEMs and system integrators. For developing, there is a .NET compatible mono interface. This facilitates the platform-independent development of .NET based applications and using them on the myBlueLynx-X without cross compiling.

Vision Components, too, introduced its new Smart Cameras on the fair; these were expressly developed for limited-space applications: With 40 x 65 mm for the board camera VCSBC4012 nano and a 80 x 45 x 20 mm housing for the VC4012 nano these Smart Cameras range among the smallest machine vision systems available on the market. Vision Components could attain such miniaturization by equipping the

board on both sides. Thanks to the CMOS technology the small cameras are suitable for high-speed applications. With their 400-MHz processor and a computing capacity of 3,200 MIPS both cameras are efficient and easy-to-integrate vision systems, making an external PC superfluous.

Hitachi, too, ranges among the manufacturers of smallest cameras: The company extended its Mini-CameraLink series by 16 models. These cameras have a RAW data output. The KP-FRxxxSCL series comprises a total of 38 cameras with VGA up to 5 megapixel resolution. Beside

their small size they excel by their most easy handling. All models are available as PoCl (Power over CameraLink). They aim at applications in those fields of industrial imaging where fast data transfer between camera and computer is an issue.

That a wider functional scope in a camera does not necessarily mean a larger housing is shown by the new model USB uEye XS of **IDS Imaging Development Systems**. The USB 2.0 camera is packed full with smart features like face recognition and image stabilization, but measuring less than one cubic inch. The small housing, measuring only 22 x 24 x 24 mm, accommodates an 8-megapixel sensor and includes autofocus lens and DSP chip. The latter offers a wide scope of functions that are partly known with consumer products only. The new USB uEyeXS for the first time puts such capacity features in a professional USB industrial camera at the user's disposal; and what is more, theses features can easily be incorporated into the user's own applications by the supplied SDK.

Basler's already wide product portfolio contains as the latest development the model ace with a footprint of only 29*29 mm, profiting from the already five-year experience in GigE camera technology. Basler ace cameras fulfill the cost requirements of analog camera users, at the same time offering all the technical advantages of a digital camera. Thanks to their small size they may replace without problems analog cameras, USB cameras as well as IEEE 1394a and b cameras basing on the same footprint. In order to render replacement and integration particularly simple and cost-efficient, the Basler ace model is available with Power-over-Ethernet functionality.

Distribution Channels Extended

A distribution contract, signed shortly before the fair, put **Stemmer Imaging** in a position to appear at Vision with Prosilica's GigE cameras. **Allied Vision Technologies** had in mid-2008 taken over the Canadian company **Prosilica** and since that time is able to offer a considerable product line of GigE cameras, beside their well-proven FireWire models. The former

are now available since November 1 to all Stemmer Imaging customers.

MaxxVision, too, had news to announce: The company as of now distributes **Sony's** new GigE Vision cameras. These are available with a resolution of up to 5 megapixels and frame rates of up to 90 fps. A special feature of these cameras is a so-called package-resend-mechanism which prevents the loss of image data during data transfer. The camera is shock and vibration resistant; coping with 70g makes it well-suited for a rough industrial environment. A new group of products at MaxxVision are the **Gidel** accelerator boards. The high-performance boards, suitable to be reconfigured with up to

four Stratix III FPGAs of Altera, represent a good alternative where large amounts of data have to be processed in parallel. The sensor division of the company presents readily pre-calibrated, preprogrammed Plug-and-Play 3D Vision sensors. Based on the principle of laser triangulation, the FireSync cameras of **LMI Technologies** will guarantee highest measuring precision and scan rates also with unfavorable lighting conditions and surface properties.

Image Analysis News

With the introduction of Windows 7 the machine vision software requirements have changed. **Matrox Imaging** reacted, announcing during Vision their Processing Pack 2 for the Matrox Imaging Library. This Windows 7 compatible version has, in addition, been extended to include the function of adhesive bead inspection and an improved 3D laser distance measuring function. The technical adjustment of the camera laser was simplified, so that the laser no longer has to be aligned absolutely perpendicular to the surface to be scanned.

Optimally prepared for Windows 7 is also **Neuro-Check** with its latest version 6.0. The latest version of the well-known application software employs the modern Microsoft .NET framework and contains numerous new features. "All in all more than 2,000 suggestions from our customers and business partners were collected, systematically evaluated, and implemented in the new software version," says Managing Director Christian Demant.

The R&D department of **MVTec's** carefully and successfully tested the software package Halcon on the new Windows 7 platform. "That's why we are certain that the present Halcon Version 9.0.1 will run on Windows 7 without problems," says Christoph Zierl, Product Manager at MVTec.

A key function of the Scorpion Vision software of **Tordivel** is its ability to generate and process 3D images. Scorpion offers tools for localizing objects in 3D images, to carry out geometric operations in 3D images, and it operates in a genuine 3D reference system. With Scorpion, 2D and 3D technologies are combined.

The combination of fast 3D laser triangulation and proven 2D imaging was also to be seen on the stand of **Smart Ray** which had combined their laser scanner with hardware and software of **Eye Vision Technologies**.

The cooperation of **Aqsense** and **ImagingLab** resulted in an interesting application for 3D measuring: the 360-degree scanner for the slicing optimization of irregularly shaped bodies like ham, cheese or sausage is based on the 3D library SAL3D, integrated in **National Instruments'** LabView, and using three **Photonfocus** cameras.

Embedded Vision System: Faster Inspection

National Instruments presented its new Embedded Vision System. To production engineers and system integrators it offers the possibility to establish fast real-time systems for various applications, like e.g. sorting products, verify objects and inspecting packaging. The NI EVS-1464RT system is a multicore controller enabling the system to capture and process images of several IEEE-1394 and GigE Vision cameras. "In our industrial inspecting machines we prefer to use embedded devices with real-time operating system, as they are reliable and their starting-up does not require any support from the IT department," explains Ivan Meissner, CEO of **Qualimatest Technologies**.

Phytec Messtechnik, too, presented embedded solutions. The company's embedded-video idea is based on the requirement to integrate further electronic components beside image acquisition. Motor control devices, GPS receivers or audio I/O belong to that category.

Of course, there were many more newsworthy novelties to be discovered during the 22nd Vision in Stuttgart. Visit us at **www.inspect-online.com** to read about them, and look into the articles in our upcoming editions of INSPECT. In case you have missed Vision this year, why not mark your calendar already with next year's Vision date: November 9–11, 2010.

▶ Author
Stephanie Nickl
stephanie.nickl@wiley.com
www.inspect-online.com

Topics with Impact: All You Ever Wanted to Know About 3D

INSPECT Panel Discussion at Vision 2009

"3D technologies" is a generic term for a very wide field of methods, sensors, algorithms and applications. What is the benefit for the user, which technology is the best for which application, what is state-of-the-art today and what more can be expected in the future?

The INSPECT had invited six experts from industry and research to debate these and other questions during a panel discussion at the Vision trade show 2009. About 170 visitors came to the Industrial Vision Days forum on the second day of the trade show and followed the lively discussion.

The cost benefits of using 3D inspection technology for alleged traditional 2D tasks was discussed as well as the challenge to not only acquire high precision measurement data in ultra-short amount of time but to also compress these data to the core in a smart way to employ them as decision basis for process modifications.

It was unanimously agreed among the experts that the ease-of-use for 3D systems needs to be increased. Ideally the systems should be as easy to integrate into the production environment as an optical sensor.

To give you an impression of the panel discussion, we sampled some quotes out of the debate. You will read more about it in the editorial part of next month's Buyers Guide issue of the INSPECT.

Dr. Wolfgang Eckstein, MVTec: „Like in other industries we will need standardization here as well. This is the path to make the integration of the different 3D components quite easy."

Dr. Heiko Frohn, Vitronic: „Time-of-Flight cameras will probably change much more than the field of robot vision. They provide a possibility to open up entirely new applications fields, especially in security and traffic applications."

Dr. Mats Gökstorp, Sick: „3D enables the next step of automation and opens up new applications. The key for that is significantly increased ease-of-use."

Per Holmberg, Hexagon Metrology: „I think that you will see here in the next one, two, three years a series of new sensors coming out for different applications, much simpler than today, cheaper, and more flexible. "

Leonard Metcalfe, LMI Technologies: „The ability of using 3D to supplement, and use sensor fusion to bring all the different technologies together is going to make very robust products that can be installed by plant personnel and will work right away."

Dr. Christian Wöhler, Daimler: „The combination of different technologies – 2D, 3D – will be a great benefit for the applier because it will probably decrease the price and keep the accuracy at least constant."

Calendar

DATE	TOPIC · INFO
24.–26.11.2009 Nuremberg, Germany	**SPS/IPC/Drives 2009** Exhibition for electric automation technology www.mesago.de/sps
25.–27.11.2009 Milan, Italy	**Vision World 2009** First Mediterranean exhibition entirely dedicated to machine vision and identification technologies www.photonicaexpo.eu
02.–04.12.2009 Yokohama, Japan	**'09 ITE** International technical exhibition on image technology and equipment www.adcom-media.co.jp/ite/eng
02.–05.12.2009 Frankfurt, Germany	**Euromold 2009** World fair for mold making/tooling, design and application development www.euromold.com
20.–22.01.2010 Orlando, FL, USA	**AIA** Business Conference of the American Imaging Association www.machinevisiononline.org
23.–28.01.2010 San Francisco, CA, USA	**Photonics West 2010** The latest advancements in light-driven research and technologies http://spie.org
27.–30.01.2010 Hamburg, Germany	**Nortec** 12th Trade Fair for Manufacturing Technology www.hamburg-messe.de/nortec
16.–17.04.2010 Istanbul, Turkey	**EMVA** Annual Business Conference of the European Machine Vision Association www.emva.org
19.–22.04.2010 Moscow, Russia	**Photonica** Leading exhibition event of the Russian laser and optical industry www.photonica-expo.com
25.–27.05.2010 Boston, MA, USA	**The Vision Show** North America's leading showcase of machine vision and imaging components and solutions www.machinevisiononline.org
08.–11.06.2010 Munich, Germany	**Automatica** International Trade Fair for Automation and Mechatronics www.automatica-munich.com

Find these and more events with detailed information at www.inspect-online.com/en/events

World Coordinates under Control

Image Processing Basics: Camera Calibration

© Anetta/Fotolia.com

Applications of image processing in robotics or 3D metrology often call for the determination of real-world coordinates from the 2D data in the image file. The relationship between image coordinates and world coordinates can be described by a quantitative model of the image formation process. Geometrical camera calibration provides the values of these parameters by analysis of the images of calibration targets with well-defined reference points. The article describes the principles of this method.

Central Projection

A robot for a pick-and-place-application, supported by a vision system, needs the coordinates of the object to be picked and of the target area where the object is to be delivered. The control unit of the robot will be fed with coordinates in real space, so-called world coordinates, with reference to a fixed point in space. Let us first have a look at the somewhat simplified situation of figure 1, where the workspace is a plane and all points of interest are within this plane. An image of this scene taken with a standard lens will be formed in central projection, resulting in warped geometric objects due to perspective distortion. Scaling in such an image is difficult, since a single constant factor is not sufficient to transform distances within the image plane to corresponding distances in a plane in workspace. This becomes evident when the optical axis is tilted as in figure 2, where all the rectangular stones in reality have the same edge-length, of course, but appear more and more shrunken with increasing distance.

Coordinate Systems

The image formation process for a point from the workspace to the image plane of the camera can be described by a matrix transform, the so-called camera model. The image data in the memory of the host are pixel coordinates x_D and y_D, without any dimensional units. The known edge-length of a detector pixel, however, provides the connection with the sensor coordinates x_S und y_S of the image in the senor plane, measured in micrometers or other real-world units. The central projection of an object point to the sensor plane is described best in the camera coordinate system. In this system, a point has the world coordinates X_W, Y_W und Z_W, with the origin in the projection centre of the lens. In our pick-and-place-scenario, however, it will be more convenient to use world coordinates just in the working plane of the robot. The X- and Y-axes of this system are embedded in the plane, the Z-axis being perpendicular to the plane. The Z-coordinate of all points in this plane will thus be zero and will be known for all points in the plane. Figure 3 shows the different coordinate systems. The complete transformation from the world coordinates (X, Y, Z) of an object point to the pixel-coordinates (x_D, y_D) of the corresponding image point in the image data file may be mathematically described by a single matrix operation. This mathematical camera model contains a number of parameters, such as the six degrees of freedom for the orientation of the camera in space, the focal length of the lens and the distortion parameter of the lens. Once the numerical values of the model parameters are known, the matrix operation can be inverted, and world coordinates may be calculated from pixel coordinates. There is an important restriction, however: pixel-coordinates generally only give access to the ratios (X_w/Z_w) and (Y_w/Z_w), but not to the absolute values of X_w, Y_w und Z_w themselves. Since two points in space which are on the

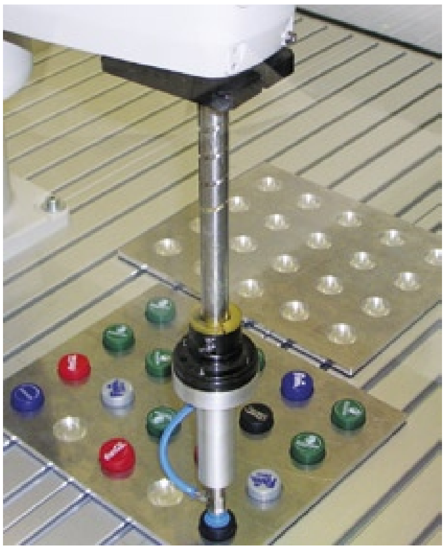


Fig. 1: Pick and place in a plane

same line of sight of the camera will inevitably be imaged to the same point on the detector, only the direction can be inferred from the pixel coordinates, the distance is lost in perspective. Whenever one of the three world coordinates is known, however, the other two may be calculated from the ratios.

Calibration

The transformation of the world coordinate system from workspace to the pixel coordinate system in the image data file is parameterized by 12 or more parameters, depending on the sophistication of the model. In general, these parameters, like the focal length or the distortion parameter, e.g., may be determined by separate and independent measurements. Common practice, however, is the calibration of the system by means of a calibration target. For this purpose, the camera in question takes images from an object with prominent, clearly visible features with well-known world coordinates in the coordinate system of the workspace. The positions of the corresponding points in the image are ex-tracted by the methods of image processing. After this operation, the world coordinates of the reference points in real space as well as the corresponding pixel coordinates are known. The link between both data sets is provided by the camera model. Since both sides of the matrix operation are known, the camera parameters may be treated as the unknown variables in the equations. With a sufficient number of reference points, there will be a system of equations which may be solved for the camera parameters. In our laboratory, we use a flat calibration target tailored to the pick-and-place-scenario of figure 1, which can be placed directly in the working plane of the robot. A suitable target is shown in figure 4. It contains circular objects with excellent contrast to the background, forming a regular mesh pattern with precise cell dimensions, well-known in absolute units. The origin and the orientation of the coordinate axes can easily be determined automatically. The huge circle in the centre defines the origin, and the small circle and the ring structure define the orientation of the X- and Y-axis, respectively. The Z-axis is directed perpendicular to the plane. The position of the circles in the image file is calculated as the centre of mass of the segmented objects after binarization and labeling of the image. The data for the positions obtained by this method are stable and have subpixel-precision. The requirements for homogeneous lighting are easily met with standard equipment.

Camera Model

The regular structure of the test pattern supports the automatic process of establishing the relationship be-tween the circles on the target with their well-known world coordinates in the system of the workspace and the corresponding centers of mass calculated from the image data. In figure 4, e. g., an array of six by six circles may safely

Fig. 2: Warping by central projection

be used to correlate world coordinates and pixel coordinates, resulting in correspondences for 36 well-known points in real space. The system of equations for the 12 camera parameters is thus significantly overdetermined and has to be solved with adequate numerical methods. The values for some parameters, the pixel dimensions, e. g., can be found in a data sheet with sufficient precision. For the remaining parameters, an optimized set of values will be determined by means of a least-square-fit. Suitable mathematical methods may be cumbersome, but are well documented and numerically stable. Nevertheless, the result of such calculations will be a set of parameters, which gives numerical access to the image formation according to the camera model. Since one of the three world coordinates is constant and known in the pick-and-place-plane of the robot, namely the Z-coordinate Z=0 for all points in the plane, the remaining two coordinates X und Y may now be calculated for every point in the plane from the pixel coordinates of the corresponding point in the image data file by means of the camera model.

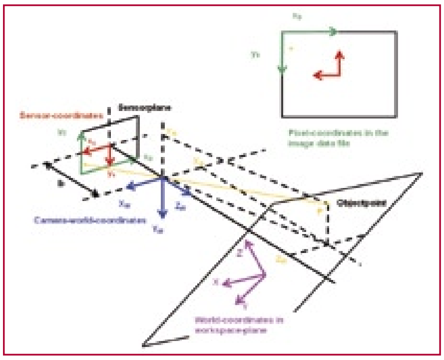


Fig. 3: Coordinate systems for the transformation of world coordinates from workspace to pixel coordinates in the image data file

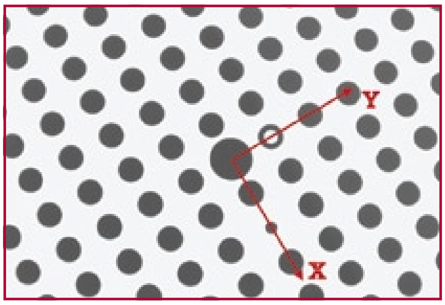


Fig. 4: Flat calibration target with X- and Y-axis of the world-coordinate system in the base-plane of the robot

Uncertainty

A simple test of the model is to try to reproduce the images of those circles on the calibration pattern, which themselves have been used for calibration. A proper figure of merit is the deviation for back-projection. The camera model with its parameters drawn from calibration is used to calculate the pixel coordinates of the reference points from their known world coordinates. These results are compared with the pixel coordinates taken as centers of mass from the real image. Usually, the data will not match perfectly, since the calibration is based on a regression of a huge set of data points with a small set of parameters. Both, the mean or the maximum deviation for back-projection are suitable measures for the uncertainty of the method. In our laboratories, we usually obtain back-projection deviations in the order of 1/10 to 2/10 of the edge length of a pixel for working distances in the order of 0.5 m with 8-bit standard analog cameras and off-the-shelf lenses. The uncertainty of the method thus is in the same order of magnitude as the uncertainty of the position of the centre of mass calculated for the reference objects from the image data. From this point of view, the method seems to be well suited. In fact, supported by a camera calibrated according to these principles, the robot shown in figure 1 precisely picks up the objects from the tray on the left and reliably places them in the moulds of the tray on the right.

The method described above, which utilizes a flat calibration pattern in a plane, by no means restricts the calibration to this plane. The camera is completely calibrated, as long as the orientation and position of the system remain untouched. In the calibration-plane, however, the three world-coordinates (X, Y, Z) may be completely and absolutely determined, since the Z-coordinate for all points in this plane is equal to zero by definition and thus known. Whenever one of the three world coordinates for an arbitrary point in the scene is known, the two remaining world coordinates may be calculated from the pixel coordinates of the corresponding point in the image. A certain point might hover 15 mm, e.g., above the plane where the calibration pattern has been placed. If the corresponding image point can be detected with good contrast, all three world coordinates can be calculated, since the Z-coordinate is already known, namely Z = + 15 mm. For the scene shown in figure 1 such a situation occurs whenever the robot is forced to pick up an object, since the top faces of these objects are not in the base plane of the robot where the calibration target usually is placed but rather pop up some millimeters – with interesting results when this particular fact is not taken into account.

The calibration procedure described in this article is based on the work of Lenz [1] and Tsai [2], published in 1987. It is remarkable that these fine methods needed 20 years to be generally acknowledged as a tool of the trade and have only in the recent years become commercially available. Meanwhile, camera calibration is a must for every notable image processing library and may well be classified as a basic method of image processing.

References

[1] Lenz, R., Informatik-Fachberichte 149: Mustererkennung 1987, S. 212-216, Springer 1987

[2] Tsai, R. Y., IEEE Journal of Robotics and Automation, Vol. RA-3 (4) 1987, 323-344

▶ Author

Prof. Dr. Christoph Heckenkamp
Darmstadt University
of Applied Sciences
Department of Optical Technology
and Machine Vision
heckenkamp@h-da.de
www.fbmn.h-da.de

Real-time 3D Reconstruction with GigE Vision

High Speed GigE Camera Used in Real-time 3D Structured Light System

In 2006, the University of Kentucky received a grant from the US Department of Homeland and Security to develop a method of range sensing for 3D surveillance cameras. The resulting product is a high-resolution, real-time 3D system that employs structured light illumination as well as high-speed reconstruction methods to form 3D images.

Structured Light Illumination (SLI) is the process of projecting a series of striped line patterns so that, viewed from a certain angle, a digital camera can reconstruct a 3D model of an object's surface based on the line distortions that occur on this object. The system consists of a high speed Prosilica VGA resolution camera with Gigabit Ethernet output and a projector. The camera was chosen for its fast frame rates (up to 200 fps at full 640 x 480 resolution) and plug-and-play attributes. Camera and projector are separated by 10° for optimum area scanning results, and synchronized to operate at 120 frames per second at 640 x 480 resolution using an external triggering circuit. The system is fully scalable and the camera optics, projector light brightness and viewing angle can be easily changed to adapt to a larger scale application.

The system uses a range of three to six different alternating linear patterns depending on the conditions (i.e. moving or stationary object). Each pattern contains 16 pairs of black and white stripes (periods) that are projected on to the target(s) in a pre-determined sequence of flashes at 120 fps. The University of Kentucky developed three new pattern strategies to ensure the quality and accuracy of the 3D reconstruction: A Period Coded Phase Measuring and a Dual Frequency Phase Multiplexing pattern that unwrap the high frequency phase without projecting more patterns or using complicated spatial unwrapping methods, and an Edge Pattern Strategy that increases the signal to noise ratio of the system.

While other systems generate 3D point clouds on a pixel by pixel basis, the 3D Imaging Lab has developed new look-up tables that replace the repetitive and constraining matrix process and allow the system to decode the phase video at the full 640 x 480 resolution and 120 frames per second rate. No recording or post-processing is used. The 3D point reconstruction technique is applicable to all triangulation-based 3D techniques including SLI, stereo vision, laser scan, etc. The 3D reconstruction software was developed in Microsoft Visual Studio 2005 with managed C^{++} using the Prosilica Software Development Kit.

The University of Kentucky's real-time 3D Structured Light System is fully scalable and can be adapted to perform in applications in the areas of human computer interfacing, biometrics and security, motion scanning and tracking, hand gesture, facial recognition, fast 3D modeling, and next generation multimedia. The system is available for licensing for use in commercial products.

▶ **Author**
Laurette Perrard, Marketing Specialist

▶ **Contact**
Allied Vision Technologies Inc., Newburyport, MA, USA
Tel.: +1 978 225 2030
Fax: +1 978 225 2029
info@alliedvisiontec.com
www.alliedvisiontec.com

3D Data from Time Delay Measurement

Time of Flight – How It Works

Time of Flight (TOF) cameras are based on the principle that each of the tens of thousands of pixels determines the distance from the camera to the corresponding object point via a highly accurate time delay measurement. Such cameras are capable of capturing the shape of their surroundings in three dimensions in real-time at up to more than 50 frames per second.

For each pixel, the time that light needs to travel between the camera and the object is measured. To achieve this, amplitude modulated light is send out from the camera onto the measured object, the reflected light is then collected by the lens and projected onto the image sensor – thus measuring the time delay between the emitted and the reflected light. The most important components of such a camera are the image sensor, the light source – most often working in the near infrared region – the control electronics and the optics. A multitude of camera designs and light modulation schemes has been developed by TOF camera manufacturers, each combination providing advantages for a given set of applications.

Advantages TOF

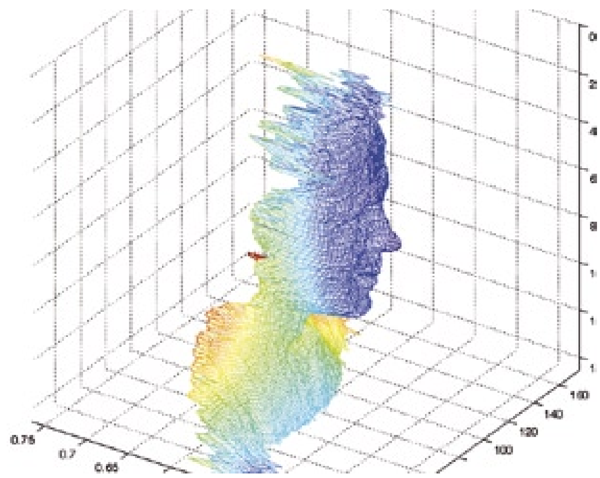
Compared to alternative 3D measurements techniques, TOF offers multiple unique advantages. The most important ones are the following:

- Measurements are neither dependent on external reference points nor on the presence of any contrast in the surface of the measured objects.
- Real time, video frame rate measurements are possible and are not dependent of scanning cycles or limitations imposed by computer processing power.
- The scene illumination is provided by the camera, and does not require any external illumination.
- The camera directly delivers depth values for each pixel, without the need for complex calculation algorithms. This results in faster, less computation intensive systems and allows for direct integration of application algorithms into the DSP of the camera.
- Larger objects can be measured easily without any increase in camera base length (as it is the case with stereo vision systems).

Those advantages have generated a multitude of new applications where TOF is better suited than alternative 3D imaging solutions. Many companies are considering TOF or have already started projects based on the TOF technology. Following this trend, several new companies have started activities in developing TOF cameras during the past year and some of them have even released new prototypes lately.

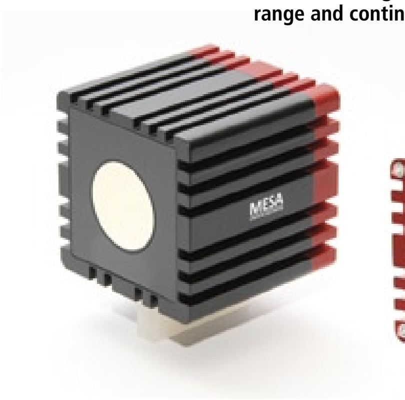
Technical Solution Remains Challenging

The introduction of a commercial-grade product took 17 years since the first theoretical approaches to TOF multi-pixel cameras were demonstrated back in 1993. First pixel designs came out in 1995 and have been implemented into first camera demonstrators around 2000. It took another nine years un-



TOF raw data are 3D point clouds of the measured scene which have to be post-pro-cessed to extract the information of interest

▼ The industrial grade SR4000 TOF sensor provides a high dynamic range and continually self-calibrates while in operation



▲ TOF cameras from the SR4000 product line are designed for the use in an industrial environment and are available for a measurement range up to 10 m

til first cameras with an acceptable reliability and which met industrial standards were brought to the market.

Mesa Imaging has been a pioneer on this long development road, and is now offering a camera that is suited for industrial applications ranging from parcel measurement for logistics, navigation systems for autonomous robots to people counting for security applications. This is a non-exhaustive list of applications that shows the diversity of industries in which TOF cameras are likely to be used in the coming years.

Nevertheless, it is important to realize that there is no universal camera that fits all these applications, and most often off-the-shelf cameras may need some customization to fit a given application – due to the fact that all camera parameters are extremely linked to each other, and often tradeoffs must be made in the optimization process.

Tradeoffs between Camera Parameters

A typical example is the tradeoff between the pixel density of the imager and its capacity of measuring fast moving objects, or its capacity of working in environments with high levels of background light. For a given chip size, increasing the pixel density will result in less charge storage capacity per pixel, thus less capacity to collect measurement signal. This will have the effect of decreasing the camera's capacity to suppress background light, of decreasing the camera's dynamic range and finally of decreasing the camera´s ability to measure moving objects precisely.

A second good example is the modulation scheme and the modulation frequency of the emitted light that is used by the camera. Not only does the modulation frequency affect the measurement range, it is also affects the accuracy of the camera: a modulation resulting in a longer measurement range will also result in lower measurement accuracy.

A final example is the tradeoff between field of view and angular resolution of the camera. For a given number of pixels, increasing the field of view will result in a lower angular resolution.

Standard Camera with Broad Range of Applications

These examples illustrate that a successful implementation of a TOF camera in a customer specific application resides in the choice of the best tradeoff between these interdependent camera parameters. Most challenging in finding the right camera configuration is to understand the minimal requirements for the given application.

Mesa Imaging, as a leading supplier of TOF cameras, can build on extensive experience gained in a multitude of TOF imaging based customer solutions. In order to serve the diversity of market needs, Mesa has meanwhile released four variations of industrial grade SR4000 TOF cameras, thus covering a broad range of diverse applications and customer requirements.

▶ Author
Christian Waizenegger,
Product Line Manager

▶ Contact
Mesa Imaging AG, Zurich, Switzerland
Tel.: +41 44 508 18 00
Fax: +41 44 508 18 01
sales@mesa-imaging.ch
www.mesa-imaging.ch

In the Spotlight

Lighting for 2D and 3D Imaging

To choose the right lighting specialists advise users to employ the experience and know-how of experts. Often, the user underestimates the importance of this crucial system's component. Actually, the quality of an image depends mainly on the selected lighting. The differences between LED and laser systems as well as their application areas are presented in the following article.

According to the experts of Laser2000 about 90 % of all illumination systems for 2D machine vision systems are based on LEDs. This is due to the fact that LEDs are available in many different colors, performance categories and designs. Furthermore, they are good alternatives to traditional illumination by short-lived halogen lighting, xenon sources or fiber optics. While LEDs are produced by the million, the possible light output that can be generated by the micrometer-sized semi-conductor chips is increased almost by the month. Thus, LED strip illumination can achieve extremely high values of up to 3 kW or several million lux. By now complete cinema projectors can be replaced by an LED cluster with the respective optical features and even a clearly increased signal to noise ratio at a projection over several square meters of homogenously lighted area can thus be obtained. For this high output, working with air convection alone usually does not suffice for cooling the electronic components and light sources. Active water cooling is required for this. However, it can usually be conducted within a compact internal circuit and is already included in the scope of delivery.

Strong Varying Standard LEDs

In the traditional lighting, standard LEDs – so-called T-Packs – are usually used. The low price for each individual LED fuels a company's wish to become their own lighting developer and producer. However, results often are less than perfect, because the LEDs have different wavelengths and therefore colors, and different output and radiation characteristics, even if they were manufactured in a single batch. Large companies may use suitable LED measuring stations to measure the values mentioned above and thus select the right LEDs. Companies that don't want to deal with this effort and the related five-digit investment can contact a specialist trader who is able to recommend suitable lighting from a large selection of different possible types of illumination independently of the manufacturer, and who also offers manufacturer's warranty for these products.

The characteristic LED data allow for an approximate estimation and comparison to traditional lighting. Unfortunately, the values stated in lux, lumen and sterradian are not really significant. On-site live testing is required to include environmental influences. Specialist traders usually offer this free of charge to help their customers choose the right lighting and to adapt this lighting where required.

Highlighting the right features of an object, a suitable illumination and the respective camera or filtering technique has to be combined. Depending on the application, homogenous lighting can be achieved through "coaxial lighting" or "dome lighting". In other cases, directed light may be used as incident light or in a dark field. Strip illumination is used to recognize the structure of band material or to conduct width and profile measurements.

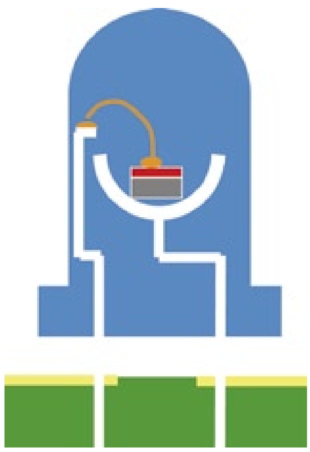
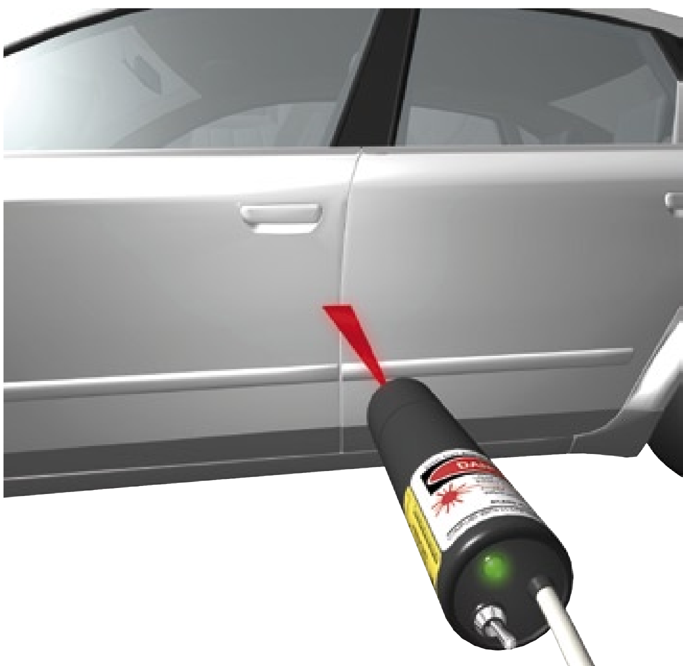


Fig. 1: Schematic section of a LED

▼ Fig. 2: The homogenous laser line is distributed evenly through contours and returns information about the gap width



Laser: the More Powerful Lighting

With a few optical tricks LED systems can be employed as strip illumination. However, due to the broad spectrum of light, efficient focusing is only possible for a limited range of distances and areas. While LED systems must be in the kilowatt range of light and power to generate a strip, lasers need no more than a few milliwatts for the same light output, reducing both cost and CO2 emissions.

In addition to the convincing result in total cost of ownership, lasers can be used efficiently as tiny light sources that can highlight features within a light section measurement on robot systems or in narrow working areas.

The homogenous laser line is distributed evenly through all forms, contours and profiles to return geometric information. Laser light can be used to determine distances (see fig. 2) and heights of edges (see fig. 3). Laser light is monochrome light that can be isolated almost completely from light generated by any other sources using band-pass filters. Different lasers directed at the same object can be analyzed separately when band-pass filters are used.

Monochrome wavelengths and light coherence permit focusing lasers on a strip section of a few micrometers. State of the art methods also permit creating telecentric strip illumination to see tiny features. Figure 4 shows this procedure used for inspecting soldering contacts.

Not all lasers are equal. Their differences become obvious where details are concerned. The core of any laser system is its light source: the laser diode. Laser diodes are produced by the million for different applications, just as LEDs. Batches vary to a great degree. Laser water levels or laser pointers never need to be active permanently. On the other hand, premium laser systems for machine vision are subject to more professional criteria than those developed mostly for applications centered on aligning and positioning. These low cost lasers are reasonably used in practice to position parts for different crafts, such as cloth for sewing, wood for cutting or to position patients in a CT or during surgery.

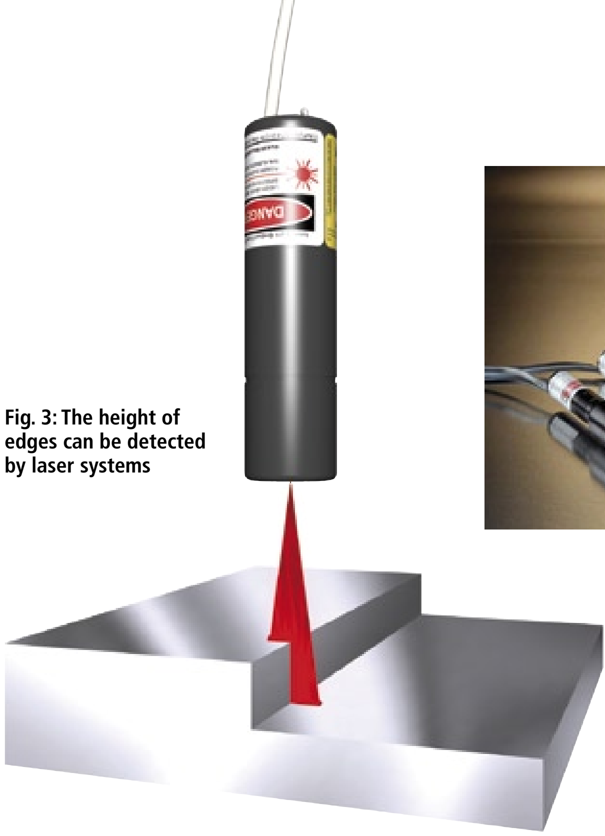
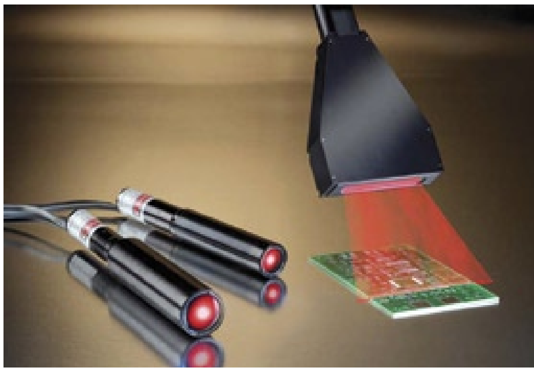


Fig. 3: The height of edges can be detected by laser systems



▲ Fig. 4: The telecentric strip illumination allows inspecting tiny features

Full Power till the End

Georg Powell is the inventor of the lens that bears his name and generates a homogenous line (see fig. 5). For premium lasers, each lens is still ground manually to adapt it perfectly to the laser diode. Laser diodes differ strongly according to the quality of their optical features. The beam width of laser diodes may vary by as much as 20 %. Because of this, molded optics, i.e. optical lenses pressed in large amounts, can never warrant consistent quality.

Not only grinding, but also a great number of other parameters must be taken into consideration for a laser that is supposed to retain its output over many years. While LED systems lose their power slowly, lasers that are set to a constant output will retain this output to the end of their live-span.

Beam stability is an important parameter; it determines how well the laser remains focused on one spot once adjusted. Premium laser systems can reach values of up to 10 µrad/°C. This means that, at a distance of one meter, the laser line moves by 10 µm per degree Celsius.

For example, if a simple standard laser with 0.1 mrad beam stability is used and the temperature varies between 17 °C and 32 °C, the strip projected at a distance of 2 m will deviate by 3 mm from the field of view. The problem is that this motion can never be reproduced, because it is subject to several parameters.

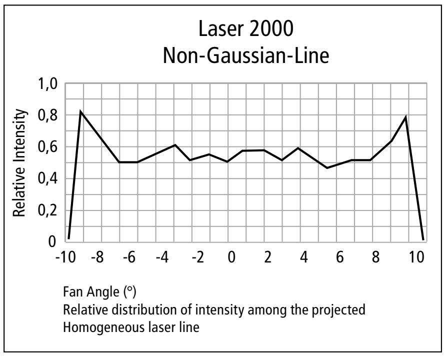


Fig. 5: Relative distribution of intensity among the projected homogeneous laser line

Laser 2000 gained decades of experience in the different areas of industrial lighting techniques. This knowledge is integrated into the company's products to ensure high quality lighting and support.

▶ Author
Thomas Rampertshammer, Key Account Manager

▶ Contact
Laser 2000 GmbH, Wessling, Germany
Tel.: +49 8153 405 0
Fax: +49 8153 405 33
t.rampertshammer@laser2000.de
www.laser2000.de

One Step Ahead

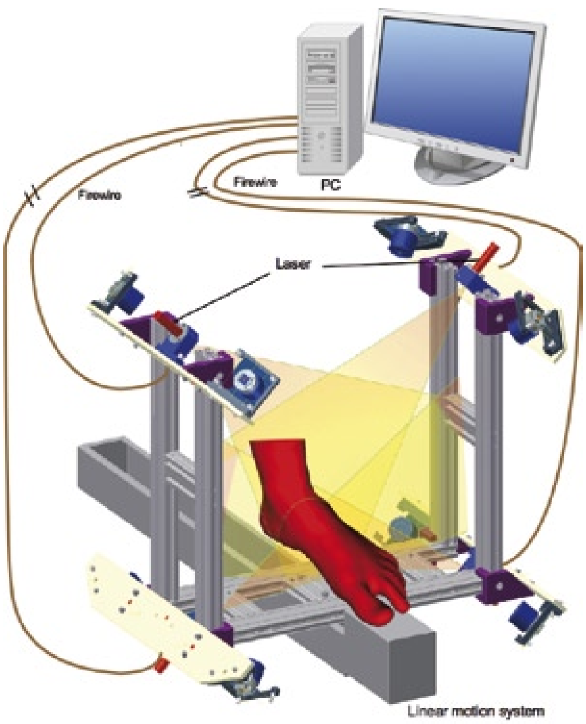
3D Scanner for the Custom-made Shoe

Orthopedists have traditionally relied on taking impressions or plaster casts of their clients' feet to manufacture foot orthoses. This method can lead to incorrect manufacture of the orthosis, since even tiny errors in measurement are magnified at each stage of the process. The elaborate procedure may also take up to 150 different steps until a perfectly fit "custom-made" shoe is ready.

In 2007 Elinvision, a Lithuania-based manufacturer of measuring and control devices, computer vision systems, and 3D scanners, launched a 3D foot scanner that uses laser scanning technology and the laser triangulation method to capture within seconds a 2D color footprint and 3D scan of a naked foot up to 40 cm long. The non-contact scanner is fast, precise, and more comfortable for the patient than traditional casting methods. The 3D "digital cast" provided by the system is accurate to within 0.25 mm, and a complete scan of one foot takes just up to 20 seconds, depending on the scanning accuracy.

Pictures from All Directions

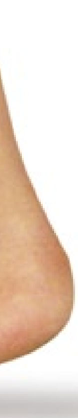
Laser scanning technology projects one or more thin and sharp laser stripes onto 3D objects. Elinvision's system is composed of the laser, the optical system, and the light sensor, and is moved across the object to digitize the surface. The 3D foot scanner uses four laser projectors and eight cameras for the 3D surface scanning and line-shape lighting and a color camera for the acquisition of the 2D color footprint. "A key advantage of using laser scanning is that it is not sensitive to ambient light," says Dr. Rimas Adaškevičius, Project Manager at Elinvision. "This means that special ambient lighting is not required, and the scanner can be operated in normal office conditions."



The entire foot shape is measured from below (for the sole) and from above (for the span) by taking pictures from all directions as the subject stands on a glass surface. The scanning unit, which is comprised of the laser projectors and cameras mounted to a linear motion system, moves along the length of the foot during the scan. Four high quality uniform laser lines are projected onto the human foot and its profile is digitized very accurately at 30 frames per second.

High Speed Cameras

Image capture is performed using Point Grey Firefly MV IEEE 1394a (FireWire) digital cameras, which utilize wide-VGA 1/3-inch global shutter CMOS sensors from Micron. The board-level Firefly MV's are equipped with M12 lens holders and Pentax TS412A 4 mm microlenses. "We selected the Firefly MV cameras by Point Grey primarily due to



their excellent quality and high speed in combination with the currently most affordable price in the market," says Dr. Adaškevičius. "Their extremely small board-level footprint was also useful for minimizing the size and weight of the overall system." The scanner uses monochrome cameras for the 3D scanning and color cameras for the 2D color footprint. The cameras simultaneously stream 8-bit raw uncompressed images over the FireWire interface to the host system, an IMBA-X9654 industrial computer board by IEI Technologies Corp. The host system is equipped with three Point Grey IEEE 1394a 3-port FireWire interface cards, allowing all nine cameras to be connected into a single PC. Image acquisition from the Firefly MV's is automatically synchronized by the cameras themselves. The interface board for motion and lighting control was developed by Elinvision.

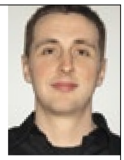
3D Shape Reconstruction

Images are received by the host system and processed using Elinvision's software, which creates a point cloud of geometric samples on the surface of the foot from eight different views, performs registration of the point clouds and meshing, and finally estimates the geometric parameters. 3D shape reconstruction is obtained by rectification and collation of the laser profiles from subsequent frames of the sequence. To get the full 3D shape without missing areas, including the small details around the undercuts of the human foot, the target is digitized from different aspects and reunited using an overlap automatic process. All processing of the raw scan data and foot shape reconstruction routines are performed on the scanner computer module. With the 3D foot scanner, the host computer with LAN interface is used for scanner control, displaying an accurate image and comprehensive measurement information in multiple views. The optimized final 3D model is created based on the 3D models of the foot. A CNC milling machine is able to produce a physical master of the final 3D model, which is used to produce the actual shoe.

3D Foot Scanners around the World

As a joint collaboration with Ortho Baltic, one of the largest manufacturers of orthopedic devices in Europe, custom-made orthopedic footwear can be ordered via the Internet. Digital casts can be e-mailed to manufacturers anywhere in the world, allowing the clinician to take advantage of the most attractive technologies, products and prices in a global marketplace. "Our 3D foot scanners are installed in orthopedic clinics around the world," says Dr. Adaškevičius. "This way, the perfectly custom-fit shoe can be on its way to the patients within just a few days."

▶ Author
Michael Gibbons,
Product Manager



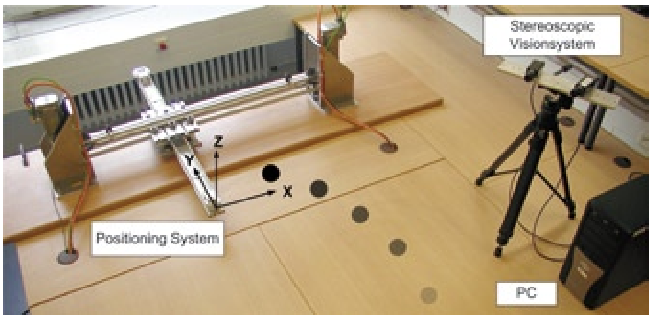
▶ Contact
Point Grey Research Inc.,
Richmond, Canada
Tel.: +1 604 242 9937
Fax: +1 604 242 9938
sales@ptgrey.com
www.ptgrey.com

The Force of Attraction

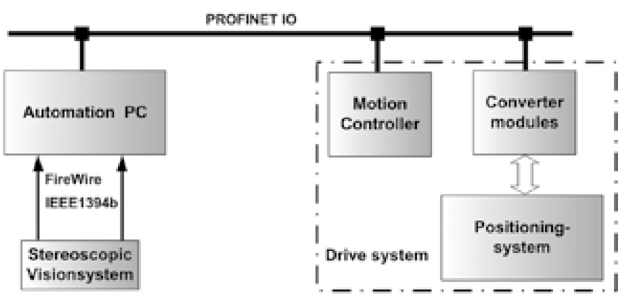
3D Object Recognition and Motion Control

The complex relation between machine vision and motion control is shown tellingly in trajectory prediction of flying objects based on stereoscopic vision and subsequent catching of these objects out of the air. To achieve this, detection system, vision software and motion controller need to be integrated into a superordinate system.

1686, Isaac Newton wrote the "Philosophiae Naturalis Principa Mathematica" and thus established the field of theoretical physics. In this book he also documented his law of gravitation. Newton was the first to formulate laws of motion being valid for both, earth and space. The gravitation determines orbits of planets as well as it is responsible for objects to fall. The trajectory of an object is calculated by using Newton's law of gravitation knowing the initial angle and speed. This is done now also with an automation system, even without knowing the initial values: Two industry cameras detect a flying object, the analysis software identifies its trajectory and calculates online the estimated position where the object will hit the ground. From this data, a PC determines the motion profile of a 2-axis positioning system, which moves to the target position at a high dynamic rate and then there catches the object. In machine vision mainly custom-built software is used, as it is also the case here for calculating the spatial trajectory data based on camera information. The integration into a superordinate system is usually difficult. The solution is LabView, a programming platform by National Instruments. By using this platform, engineers can design their own machine vision software based on LabView libraries and integrate these in a superordinate automation project. This way software developers are able to realize an all-purpose programming concept.



The test rig: A 2-axis positioning system catches flying objects using machine vision



The single components of the automation system communicate via Profinet IO

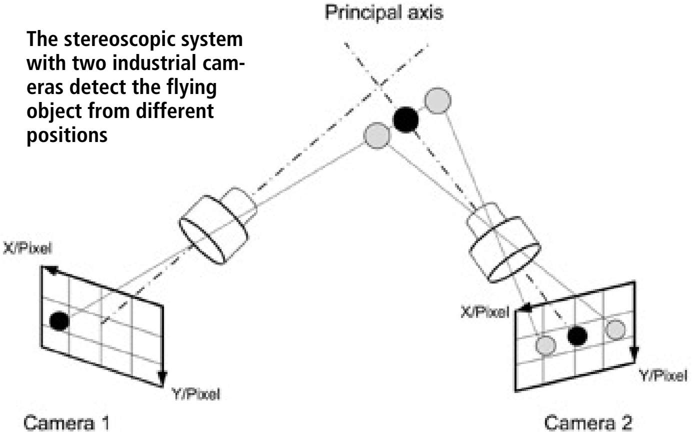
Machine Vision and Motion Control

The automation system for detecting and catching flying objects is set-up as a test rig in the Laboratory for Measurement Technology and Control Engineering of Fachhochschule Coburg. There, the engineers demonstrate the complex relation between machine vision and motion control. Automated guided vehicle systems (AGVs) in factories, handling applications using motion control, and vision-guided robots are only few examples for the increasing importance of machine vision to control autonomous motion sequences.

The test rig's stereoscopic vision system works with two industry-grade cameras capturing images consecutively. They are processed on a dedicated PC with high performance algorithms from the Labview Vision Development Module. From these processed data, the trajectory is predicted and the target coordinates for the 2-axis positioning system are calculated. The coordinates are sent to the motion control unit which actuates the converter modules for the two servo motors. All components communicate via the Ethernet standard Profinet IO.

Getting the Coordinates

If metric position data in three spatial dimensions are required of a vision system, simple calibration methods are no longer sufficient. An alternative is the stereoscopic image acquisition by using two



The stereoscopic system with two industrial cameras detect the flying object from different positions

different capture positions to identify the object's trace mapped on the respective image sensor. This mapping can be described mathematically based on the pinhole camera model. To merge the independent image data in one combined coordinate system the adjustment of both cameras to each other must be exactly known. Once this information is available the three metric spatial coordinates of the object can be calculated. In this way the target coordinates for the mechanical unit can be predicted unambiguously.

Several steps of image processing and data evaluation are necessary to implement this process. At first the moving target object must be separated from the static background. A subsequent particle analysis determines the centre coordinates of the object in the pixel coordinate system of the respective camera. These first steps can be done quickly using the LabView Vision toolkit. Merging 2D-center coordinates in a common 3D coordinate system as well as calculating the motion trajectory and determining the target position of the object must be implemented individually. Due to many powerful scientific functions of the standard LabView programming language this can be done in a compact and clearly structured graphical program. The processing time for the large volume of image data on a state-of-the-art multicore PC is down to only few milliseconds.

References

[1] National Instruments: NI Vision Concepts Manual, Texas 2008

[2] Hornberg, Alexander: Handbook of Machine Vision, Weinheim 2006

[3] Jäger, Edgar: Industrial Ethernet. Funktionsweise, Implementierung und Programmierung von Feldgeräten mit netX, Heidelberg 2009

▶ **Authors**
Fabian Bäz-Oberhäuser, Research Assistant
Benjamin Kolb, Research Assistant
Prof. Dr. Peter Schwarz, Measurement Technology and Factory Automation

▶ **Contacts**
University of Applied Sciences Coburg, Germany
Electrotechnics and Information Technology
Tel.: +49 9561 317 221
Fax: +49 9561 317 171
schwarz@hs-coburg.de
www.hs-coburg.de

National Instruments Germany GmbH, Munich, Germany
Tel.: +49 89 741 31 30
Fax: +49 89 714 60 35
info.germany@ni.com
www.ni.com/germany

Standard systems are going beyond themselves: With the new open UDC interface for integration of individual algorithms system developers are now able to adapt the systems faster to new applications. Furthermore, system integrators as well use the chance to customize the standard systems by enhancing the standard towards the application needs and the customer's wishes and thus offer their customers added value.

With a Special Flavor

Standard Machine Vision System Excels Beyond Standards

For more than 20 years now, Panasonic has demonstrated with its vision systems that many ordinary applications can be realized with standard systems. „Standard system" here refers to a vision system that is not only optimized for one particular task but rather comes with a multitude of universal algorithms that simply need to be configured by the application engineer. Based on this definition, the machine vision system P400 developed by Panasonic is at first glance a standard system. However, P400 has redefined „standard" by offering „some additional flavor."

The P400 systems are equipped with several PC-based controllers of various performance classes as well as with the corresponding software Vision P400. Hence hardware and software are sold as a complete system, meaning all components, from up to 12 cameras per controller to the software, are optimized to work together flawlessly.

The machine vision software Vision P400 provides comprehensive inspection methods from gray value edge detection via contour matching to OCR or 1D and 2D code readers. The inspection tools required for each application are simply drag-and-dropped into the images.

Adaptable

For various requirements, Vision P400 offers customizable interfaces that allow the software's basic range of functions to be expanded. These interfaces are not only available to Panasonic's own development team, but system integrators with experience in developing machine vision algorithms can access them, too.

The ActiveX interface has proven its worth already for several years. Many tasks can be handled via the ActiveX interface and could best be summed up under the term „customized interfaces". Such tasks might include implementing exotic robot protocols or sending e-mails automatically in correspondence with inspection results. On-site operators could take advantage of customized user interfaces, for example by adapting interfaces from other components with which they are already familiar, with any number of languages, or for purposes of corporate identity. In such scenarios a P400 is at work on the inside of the inspection systems without this being apparent from the outside. The ActiveX interface is a universal interface that can be used with practically all programming languages.

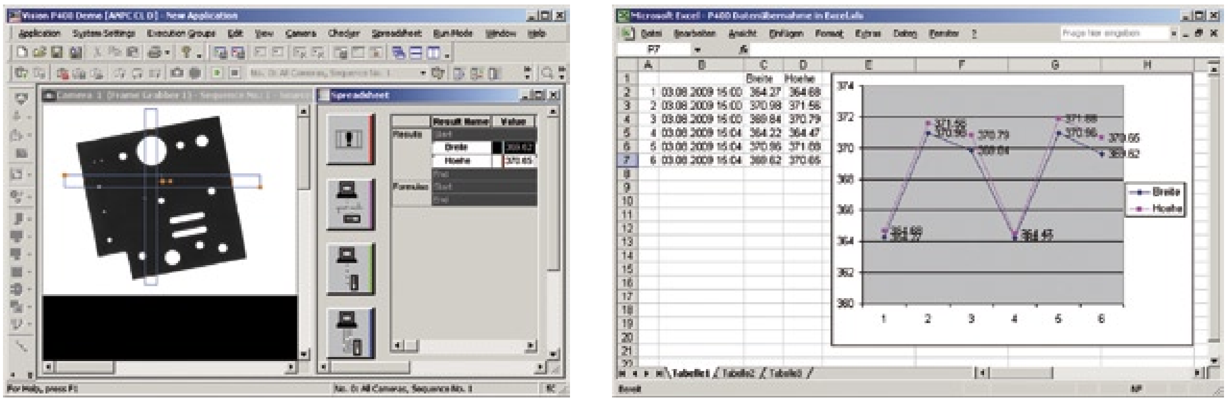


Fig. 1: The system Vision P400's measurement data are directly transferred in an Excel spreadsheet

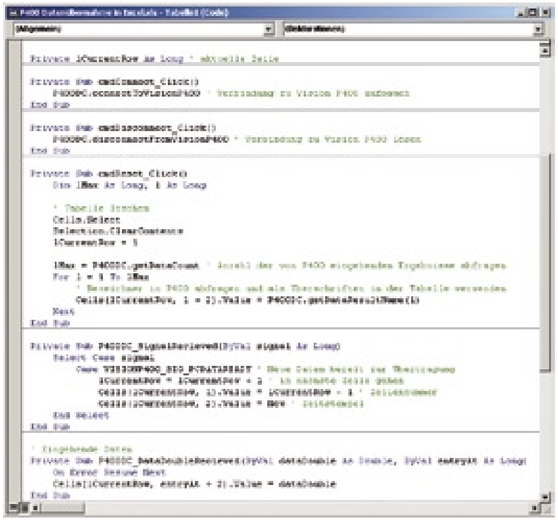


Fig. 2: The code lines which are necessary for writing the measurement data in an Excel sheet

Fig. 3: The customized user interface provides the on-site operator with the most important data of the running production process at a glance

Open Interface with UDC

Relatively new is the possibility to create own inspection algorithms for Vision P400. These „User Defined Checkers“ (UDC) were developed last year so that specialized inspection algorithms could be applied quickly without having to implement or maintain them directly in Vision P400. Originally this was intended to simplify the „customizing“ jobs of Panasonic‘s own development team. However, system integrators‘ interest was soon piqued by this open interface, of which they could likewise take advantage. Hence, custom inspection tools could be developed with little effort and integrated almost seamlessly into the P400 user interface. The complete hardware and all standard software features, which indeed control important functions such as image acquisition and interface output, can be retained without having to perform new system tests. This is an important cost-saving factor. Several custom applications were solved with P400 already during the development phase of the User Defined Checker that would have otherwise required much more expensive software solutions. Experienced system integrators are already making good use of the universal and flexible options the UDC offers.

Just like the software, the hardware also offers a good degree of flexibility, especially when it comes to cameras beyond Panasonic‘s standard product range. The standard type cameras are certainly the first choice since they have been tested extensively together with the hardware and software. However, customized applications that require thermal images, X-ray images or resolutions above 5 megapixels can be solved in this way. Line scan cameras have also been introduced with P400 while providing a customer with a customized solution.

Real-life Examples

Only a few lines of code demonstrate how easy it is to use the ActiveX interface. Vision P400 installs a so called ActiveX control element. This control element can be used by Microsoft Excel via VBA and macros. In this way, Excel can conduct machine vision operations. Figure 1 shows an example from the factory floor. At a semi-automatic work station for part measurement within statistical process control, all values from each part measured by P400 are written into a protocol and saved. The protocol can be formatted in Excel as desired to conform to ISO guidelines and then saved as a template. Machine vision operation is triggered at the push of a button, and measurement values determined by P400 are written directly into the Excel sheet via a simple VBA macro. Statistics, trend diagrams, etc. are displayed immediately. Then the document is sent to a printer and saved.

Vice versa, many parameters in Vision P400 can be set via the ActiveX control element. In this way the user program can load application data, receive image data, move inspection tools or request and set threshold values, for example. Hence, sophisticated machine vision applications can be customized with relatively little effort to be linked to optimized user interfaces for on-site operators. Figure 3 illustrates an application for differentiating molded parts.

Conclusion

Panasonic considers itself not only as a mere supplier of components but as a company that offers complete, comprehensive solutions. In the area of machine vision a development team works on customized solutions based on Panasonics’ own hardware and software. P400‘s flexibility for expansion and customization resulted from years of experience in the industry. What‘s new is that now system integrators have an interface at their disposal with which they can link the standard system to their individual program, which allows them to offer their customers a significant added value at comparatively little cost.

▶ Author
Christoph Kunz,
Senior Engineer for Machine Vision, Software Development, Automation Control Devices (ACD) Engineering, Technical Division at Panasonic Electric Works Europe AG

▶ Contact
Panasonic Electric Works Deutschland GmbH
Holzkirchen, Germany
Tel.: +49 8024 648 0
Fax: +49 8024 648 555
info-de@eu.pewg.panasonic.com
www.panasonic-electric-works.de

Vision Sensor with Motion Protocol

The SRV vision sensor from Schunk is capable of fulfilling a broad range of image processing tasks. The main task of the SRV is position measuring and determination of the orientation of a gripped object. In addition, components can be monitored for completeness and the presence of a particular feature as well as controlling assembly processes. The SRV combines not only camera and objective, but also LEDs and an on-board image evaluation unit, including software and interfaces, all in a compact housing. In the simplest scenario it is sufficient to connect the sensor to a power supply and teaching of the device is done directly on the device with two buttons. For more complex tasks, external yet efficient and intuitive software is available. The sensor offers a high resolution of 720 x 480 pixels. Three fixed working distances of 150, 300 or 450 mm are available as well as three different illumination colors: red, blue and infrared.

Schunk GmbH & Co. KG
Tel.: +49 7133 103 0 · info@de.schunk.com · www.schunk.com

High Resolution Vision Sensors

Cognex has added two new high resolution models to its award-winning line of Checker vision sensors. The new Checker 3G7 features 752 x 480 pixel resolution for better inspection of small features and high intensity white LED illumination for optimum image contrast. The Checker 3G7 can be configured as either a presence or measurement sensor and can detect and inspect up to 800 parts per minute. All Checker 3G models require no PC for set up, and can be configured in a matter of minutes using the SensorView teach pendant and One-Click Setup feature. The new Checker 272 offers the same resolution and lighting features as the 3G7 plus a ladder logic editor, encoder-based part tracking, and additional IO. The Checker 272 includes both Presence and Measurement sensors.

Cognex
Tel.: +33 1 47 77 15 21 · sales@cognex.fr · www.cognex.com

Schneider Kreuznach Employs New Production Technology

Schneider Kreuznach is using new, sophisticated production processes to achieve reduced tolerances and, for the first time, a real lenses resolution of 2 micron. These features enable the new Micro-Symmar 2.8/50 special lenses to offer outstanding homogenous image performance across the entire image field. The lenses have been enhanced for 3.5-time enlargement and have a 60 mm field of image. The proven V-interface guarantees smooth adaptation to a wide range of camera systems. The entire construction has been designed to meet the high demands of typical industrial applications to ensure reliably safe use, as well as a long lifetime. The high light intensity of f/2.8 allows short exposure times, while the short focal distance of 50 mm enables a compact system set-up for typical applications in flat rail inspection and micro measuring technology.

Jos. Schneider Optische Werke GmbH
Tel.: +49 671 601 0 · sales@schneiderkreuznach.com
www.schneiderkreuznach.com

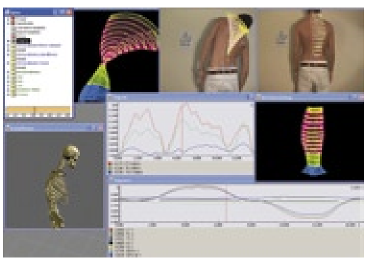
GigE and USB industrial cameras with new HDR sensor

The German machine vision specialist IDS announces the release of a newly developed HDR sensor for their USB and GigE industrial camera series. The monochrome HDR sensor uses a different functionality and applies a real logarithmic curve. This technology allows capturing images with ultra-high contrast and a dynamic range of over 120 dB, which is about 1,000 times more than conventional CCD sensors can provide. As a result, GigE cameras of the uEye HE series can read out and process the full 12-bit color depth, for example. The FX4 HDR sensor is 1/1.8" in size and captures up to 50 frames per second at a resolution of 768 x 576 pixels. The HDR cameras thus open up many new possibilities for applications that have very high brightness differences, such as traffic surveillance or industrial welding.

IDS Imaging Development Systems GmbH
Tel.: +49 7134 96196 0 · info@ids-imaging.de · www.ids-imaging.de

Makes Orthopedic Diagnosis Easier

With the aid of high-speed Pike cameras and SIMI Motion Software, doctors and scientists are researching musculoskeletal dysfunction and can already offer new therapies to patients, tailored to their individual needs. SIMI Reality Motion Systems provides innovative software and systems for motion capture applications, working not only with animation studios but also with competitive athletes, researchers and medical facilities who need precise tools for evaluation of motion sequences. With SIMI Motion, SIMI has developed a system for precisely evaluating a patient's sequence of movements within the framework of orthopedic or neurologic diagnosis and treatment. The system analyzes video data from one or more digital cameras and generates crucial data such as joint angles, accelerations, axle symmetries, and joint torque or stress. Data can be compared with standard values in biomedical literature to identify possible dysfunctions.

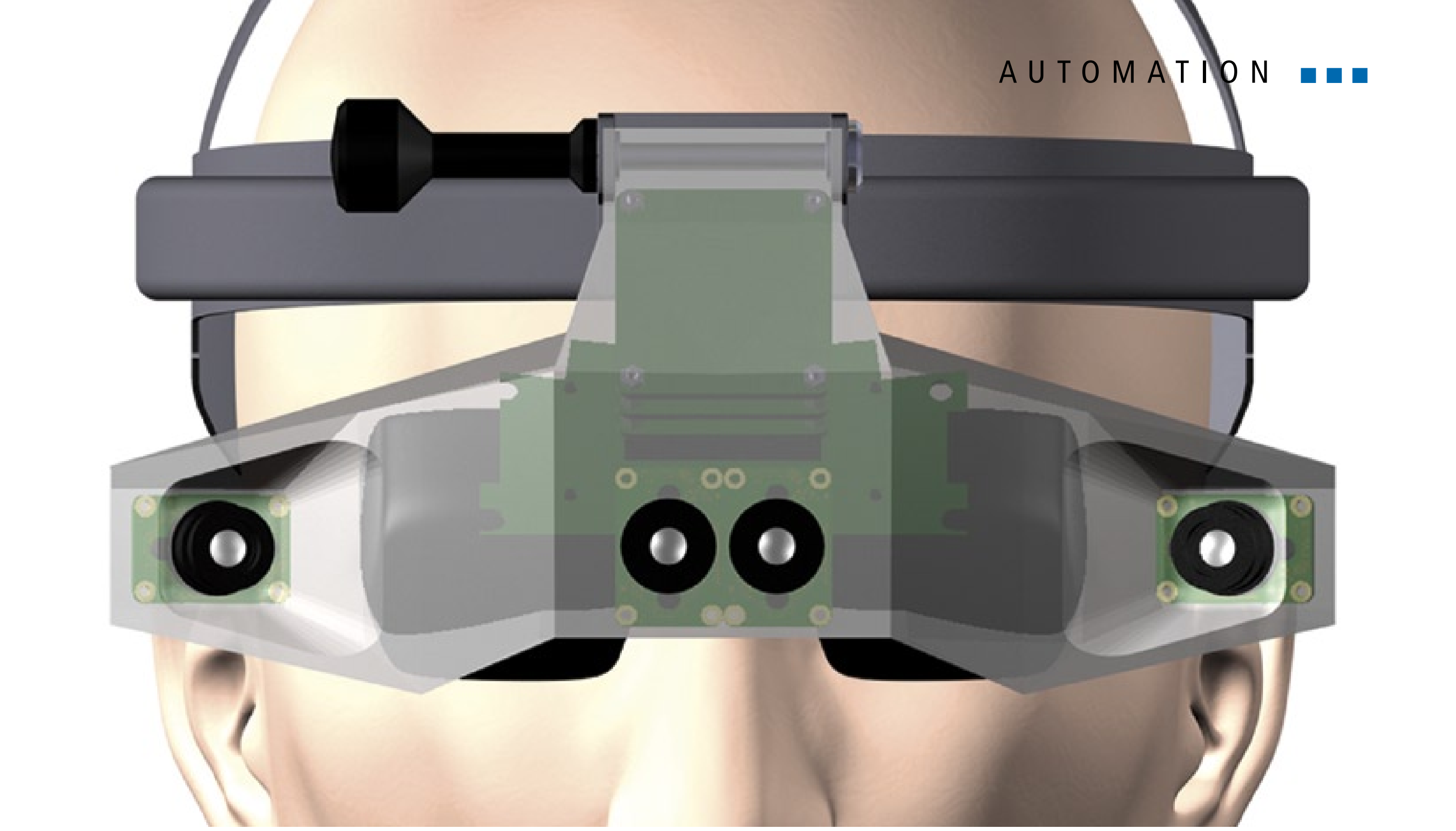


Allied Vision Technologies GmbH
Tel.: +49 36428 677 0 · info@alliedvisiontec.com · www.alliedvisiontec.com

Compact Gigabit Ethernet Camera

Matrix Vision introduces its newest member of the Gigabit Ethernet camera series: mvBlueCougar-X. The camera is full of extra features and design highlights. For example, the very compact and high quality housing is fit for industrial use and features lockable connectors. The mv-BlueCougar-X series will cover various applications with its wide range of highly sensitive CCD-/CMOS-color and gray scale sensors. C-Mount, CS-Mount as well as S-Mount lenses are supported. The camera series has a 14-bit analog-to-digital converter for highest dynamic range and a high signal-to-noise ratio. With its 32 MB camera memory, it is possible to acquire images and image sequences and to uncouple transfer from acquisition.

Matrix Vision GmbH
Tel.: +49 7191 9432 0 · info@matrix-vision.de · www.matrix-vision.de

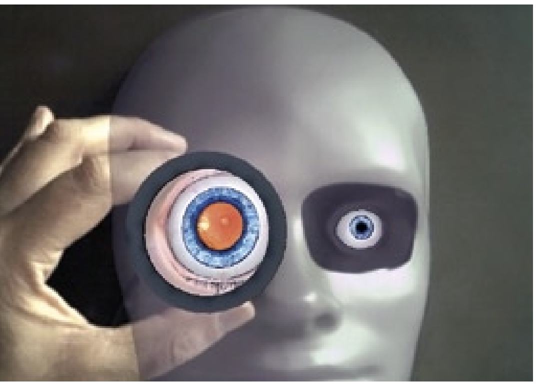


Augmented Reality Instead of Eye Drops

Optical Tracking for Data Eyeglasses of Medical Training Simulator

„Look up. Look up and to the left. Look to the left."… The ophthalmologist wears a light source and a binocular on a headband and looks through the pupil with a magnifying lens in order to examine the fundus of the eye. Anyone who has ever visited an eye-care practitioner will be familiar with this examination. Frequently, the pupil is artificially dilated with drops. As a result, the eyes will be uncomfortably sensitive to light for hours afterwards.

Ophthalmoscopy is a routine examination for registered ophthalmologists. Examination of the fundus is also used for diagnosis by general medical practitioners, e.g. in order to detect high blood pressure. For this reason, all students of medicine have to learn how to perform ophthalmoscopy. Handling of the ophthalmoscope and correct positioning of the magnifying lens require a good deal of practice. The ophthalmologist must first find the correct line of sight with respect to the pupil and must then position the magnifying lens at the correct distance between himself and the patient. To make matters more difficult, the image produced is upside down and inverted, so that the magnifier has to be moved contra-intuitively.



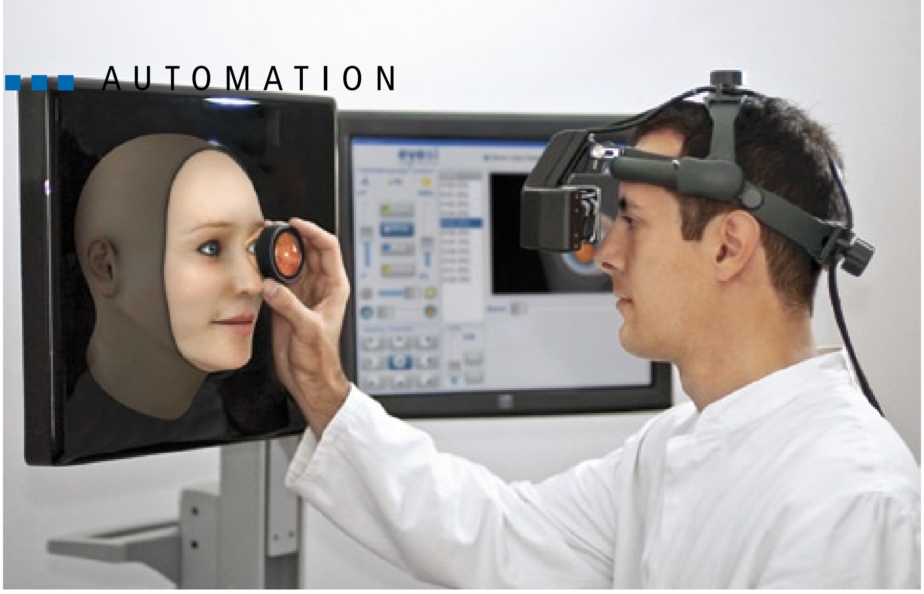
The augmented reality images for left and right eye are output to two separately controlled OLEDs

In cooperation with the Eye Clinic of the University of Frankfurt and the Department of Computer Science of the University of Heidelberg, the Mannheim-based company VRmagic has now developed an augmented reality simulator that allows medical trainees to practice both handling the ophthalmoscope as well as diagnosis of retinal diseases. Augmented reality means that computer-generated images are incorporated into real scenes in real time. For the user, the difference between the real and the virtual image levels is hardly perceptible.

The simulator developed by VRmagic consists of data eyeglasses – the so-called head-mounted display –, a patient model head, a freely movable magnifying lens and a PC with touch screen for system control. The user sees the genuine real-time video image with the model head and hand-guided lens through the head-mounted display. In addition, the virtual images of the visible part of the inside of the eye are displayed on the lens. "The handling and visualization of the simulator should be as close as possible to that of a real ophthalmoscope," says Clemens Wagner, Head of Virtual Reality Development at VRmagic. "A particular challenge of the technical realization was tracking freely moving objects. The magnifying effect of the lens resulted in very high demands for precision."

Multi-sensor Camera for Optical Tracking

Various conditions must be met so that the fundus area visible depending on the



Using a head-mounted display and a model head, physicians can train retinal examination procedures in the same way as with a real ophthalmoscope

position of the magnifier can be simulated in real time and so that the viewing person obtains an effect where the real and virtual image levels appear to merge. A basic prerequisite is optical tracking of the freely guided lens, which must be extremely precise on the one hand and also function robustly under different light conditions on the other. Powerful ray tracing algorithms and high-resolution stereo displays are required for image reproduction. The overall system must be capable of processing the complex data volume with a latency of significantly less than a hundred milliseconds so that users cannot detect the difference between the real environment and the simulation which then leads to the so-called immersion effect.

For the technical realization of this system, VRmagic developed a multi-sensor FPGA camera with four pixel-synchronous sensors, each with a resolution of 752 x 480 pixels (W-VGA). Two image processing paths are combined in this camera: 3D object tracking by two sensors, which track the position of the lens and model head, and a stereo see-through video camera. Only one USB signal is output. “Integration of the four sensors in one camera permits realization of a more compact design, better synchronization of the components and minimization of latency,” explains Wagner.

FPGA Tracking Cameras

The two tracking cameras are located as far apart as possible so that robust 3D reconstruction can take place from the 2D camera images. Infrared LEDs are used as tracking markers: There are three LEDS on the hand-held magnifying lens, which allow reconstruction of the position and orientation. Several markers are used on the model head to compensate for shadows. The LED markers are synchronized with the cameras via the strobe output. An IR low-pass filter is used so that the cameras record only the low frequencies of the IR markers. Preprocessing of the image data already takes place on the FPGA chip of the cameras. This includes binarization, removal of interference by an erosion filter and lossless data compression by run length encoding (RLE). The resultant significantly compressed data stream is forwarded to the PC. Blob segmentation, marker matching, triangulation and object reconstruction then take place here.

See-through Stereo Camera

The see-through stereo camera consists of two simple color sensors that forward the recorded image to a PC, where it is rendered into the augmented reality image as background texture. IR cut filters remove the infrared component in the environment and the tracking markers from the image to guarantee clean color representation. Since the tracking cameras require a short exposure time and the see-through cameras a long exposure time, an internal trigger ensures that the start of exposure is clock-synchronous for all cameras. Coordination of the image data takes place on the FPGA of the smart cameras. A 256 MB ring buffer is available for this purpose.

Real-time Ray-Tracing

The multi-sensor camera evaluates a new image every 16 milliseconds at the latest. In “low latency” mode, only packets of four images at a time are accepted at once in order to minimize the latency of the camera system. If a so-called frame drop occurs for a sensor, i.e. an image is missing, the images of the other three sensors are also discarded and processing continues only with the next complete four-image packet. The video images of the stereo see-through camera are incorporated as background texture in an OpenGL graphic image. In a second step, an image of the model head and lens is inserted. Finally, the simulated image of the visible eye area is rendered on the lens. Since it is necessary to simulate several optical refractions at the same time caused by the magnifying lens, cornea and crystalline lens, VRmagic developed their own real-time ray tracing method for the computer graphics. Rendering takes place on the graphics card. The refresh rate currently achieved is 35 Hz and it is planned to increase this to 60 Hz in the future.

Visualization

The calculated augmented reality images for the left and right eyes are output to two separately controlled micro displays in the head-mounted display. OLEDs from eMagin are used with a resolution of 800 x 600 pixels each (S-VGA). A prism optical system magnifies the image. In this way, medical specialists obtain the three-dimensional image impression that they are familiar with from a real ophthalmoscope. “The immersion effect is fascinating,” says Wagner, underlining his satisfaction with the end product. “The blend of real and virtual images is so convincing that our sensory system has absolutely no reservations!”

The augmented reality interface developed by VRmagic is a technology platform that is suitable for an extremely wide variety of applications in industry and science. The multi-sensor FPGA camera is also available as an OEM component. This camera is capable of producing pixel-synchronous images from several positions, as required for 3D reconstructions of moving objects, for example.

▶ **Author**
Meike Hummerich, Head of PR

▶ **Contact**
VRmagic GmbH , Mannheim, Germany
Tel.: +49 621 400 416 20
Fax: +49 621 400 416 99
info.imaging@vrmagic.com
www.imaging-vrmagic.com

Modern Warriors

Giving Robots Real-time 3D Vision for Dangerous Missions

An iRobot PackBot configured with a TYZX G2 Vision System in its payload for situational awareness and obstacle detection and obstacle avoidance

Robots are proving themselves to be fast, efficient, and reliable at performing dangerous missions for military personnel and first responders. Autonomous and semi-autonomous robots are being deployed for missions such as explosive ordnance disposal (EOD), HazMat detection, route clearance, structure mapping (surveying buildings for hazards), person-tracking and person-following, and long-term surveillance (sometimes called "persistent stare").

Robots do these jobs very well. The U.S. military finds that robots detect and disable roadside bombs five times faster and with more accuracy than humans.

The Requirement for Real-time Vision

To be able to perform these missions effectively, robots need to be able to see what's in front of them and make intelligent decisions about their surroundings. Visual awareness is needed for situational awareness, object detection and object avoidance (ODOA), person-tracking and person-following.

Providing robots with real-time vision is challenging. Robots need a vision system that is fast, equipped with high resolution cameras, is at the same time robust but compact, lightweight, and low-power, and is passive in the sense that it does not emit easily detectable signals.

Range data – determining the distance between the robot and a person, object, or feature of the terrain – is vital to all three visual categories: situational awareness, ODOA, and person-tracking and person-following. Robots need access to real-time range data in all kinds of lighting conditions.

TYZX 3D Vision System

The TYZX G2 Embedded Vision System (EVS) is a small embedded vision system with low power requirements that delivers high performance visual analysis at up to 30 fps in variable lighting conditions. The G2 EVS works at resolutions of a few centimeters or even millimeters, as required. It fits in small spaces and draws less than 15 Watts of power.

Performing advanced 3D calculations in silicon, the G2 EVS gives robots accurate, real-time range data in all three dimensions. TYZX ProjectionSpace primitives transform point-cloud data into efficient 2D or 3D geometric representations and rapidly segment a scene into relevant objects.

TYZX and iRobot

iRobot Corporation has chosen the TYZX G2 EVS for several military robotics research projects requiring real-time vision and depth-perception. iRobot has demonstrated the ability to integrate the TYZX G2 EVS onto its PackBot and Warrior platforms: rugged tactical mobile robots designed to perform dangerous search, reconnaissance and bomb-disposal missions while keeping troops out of harm's way.

Using TYZX EVS, iRobot military robots are able to achieve:

Enhanced Situational Awareness via 3D Visualization – 3D visualization provides depth perception and a more detailed view of the environment.

Person Detection and Person Following Capabilities – using the TYZX system for person detection, iRobot researchers are developing advanced autonomous navigation algorithms to demonstrate person-following capabilities.

Obstacle Detection and Obstacle Avoidance Capabilities for Increased Autonomy – TYZX G2 technology has enabled iRobot's SEER payload for its PackBot and Warrior platforms to support autonomous ODOA for complex vertical structures.

Tom Wagner, Vice President and Technical Director for iRobot, stated: "The TYZX G2 EVS provides our robots with the ability to sense and assess the surrounding environment. The G2's onboard processing capability, as well as its lack of moving parts, makes it a fitting sensor for our PackBot and Warrior platforms. Our robots are used in complex terrains, and the G2 system provides sensor data needed to enable advanced capabilities on our platforms."

The iRobot example demonstrates the effectiveness of the TYZX approach to real-time 3D vision for robots performing hazardous missions.

Two configurations of the TYZX DeepSea G2 Embedded Vision System

► Contact
TYZX, Inc., Menlo Park, CA, USA
Tel.: +1 650 282 4500
Fax: +1 650 618 1510
sales@tyzx.com
www.tyzx.com

Across Siberia

3D OCR Guarantees Traceability of Railway Wheels

Snow and Siberia's permafrost soil demand a great deal of the Russian Railway wheels' quality. Safety regulations claim the traceability of every single railway wheel. Therefore, a six-digit number on the wheel has to be read reliable at any time. This is the task of 3D reading stations equipped with laser triangulation cameras.

The Trans-Siberian railroad network is the main traffic artery of Russia. With a length of 9,288 km the route is the longest end-to-end railway connection in the world by connecting Moscow with Vladivostok, a city at the pacific. The Trans-Siberian Railway was originally built for freight transportation; today it conveys romance, adventure and the feeling of endless vastness to mainly western tourists. Every second day the train No.020 leaves Moscow's railway station and transits on its way the permafrost soil of Siberia. There, the temperature can reach values down to –62 °C. For withstanding these stresses and strains, the railway wheels must satisfy strict safety criteria. Therefore, the traceability of every single railway wheel throughout the production process from the first to the very last processing step is mandatory. Already in the red-hot state every railway wheel is marked with a stamped six-digit number on the side edge of the wheel. Before the first shape cutting, this number is read and thus, is linked to the production data throughout the entire further process. The scaled surface of the wheels and the dripping coolant complicate the reading process for any optical character recognition (OCR) process. The great range of fluctuation in the stamping also leads to a wide variety of shape and size. Ideally the characters are 12 x 6 mm high with a stamping depth of up to 7 mm on railway wheels with an outside diameter of approx. 0.7–1.3 m. The characters must be searched for around the whole circumference of the side edge, at a different radius depending on the respective type.

The stamped characters on the railway wheels are used for traceability

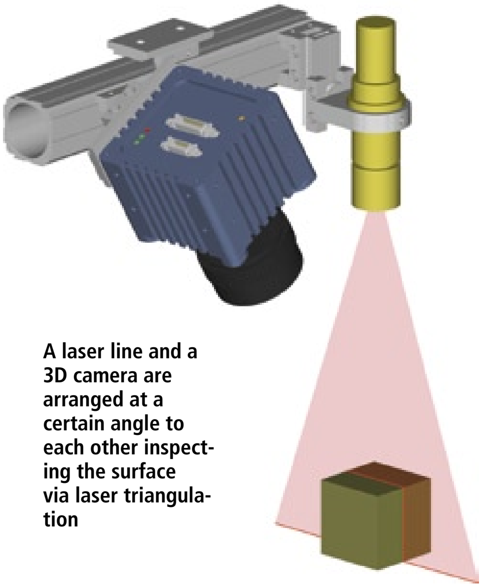
Reliable Character Recognition with 3D-OCR

Because of the high fluctuation range in the character contrast, a reliable solution with the classical 2D tools is not possible. No satisfactory results could be achieved with complex lighting solutions and sophisticated software tools either. In contrast, a 3D laser triangulation camera accomplishes the necessary reading reliability. Here, a laser line and a fast 3D camera are arranged at a certain angle to each other to scan the surface of the railway wheel. The local deflection of the laser beam at the wheel surface is a measure of the height or depth at the corresponding position. The camera determines the position of the laser beam in every single image and supplies the height data directly as 3D data for further evaluation. To scan the whole circumference of the railway wheel, either the wheel or the camera is rotated. Wobble of the railway wheel of ±10mm during rotation must not lead to impairment of the read results.

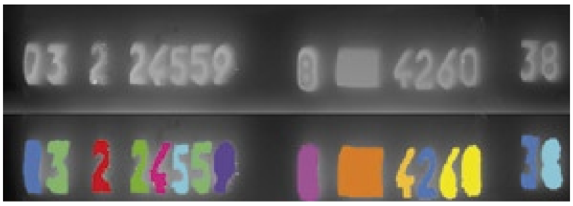
The different wheel diameters require the installation of the 3D camera on a linear axis which is moved type-specifically from the OCR station to the correct radius before the reading process starts. The 3D camera records up to 40,000 images per revolution of the wheel at an image rate of about 4 kHz. From these 3D raw data, the relevant regions which might contain characters are then searched for around the whole circumference. Then the individual characters are segmented in these regions by means of locally adaptive methods, i.e. the separation of the character characteristics from the background is achieved.

Character Recognition with Fuzzy Logic

In the next step based on statistical methods and fuzzy algorithms the character which best matches the corresponding pattern of the pre-taught character set is assigned to every segmented character



A laser line and a 3D camera are arranged at a certain angle to each other inspecting the surface via laser triangulation



The 3D raw data with height data coded as grey image at the top and at the bottom, the segmented characters

Any number of variants of a character can be set-up by the customer

region. The read cycle is finalized by transmission of the total result to the PLC via Profibus DP. The cycle time is mainly determined by the time for the 3D image acquisition, the actual reading of the characters is typically done in less than one second.

In order to cover the wide range of variations of a character, a statistical method is already applied during the teach-in of the character set which highlights the common features of a character in the 3D space. The system software does not limit the number of different variants of a character; any number of variants of each character can be set-up by the customer. However, practice has shown that a significant improvement of the read result is rarely achieved at more than 25 variants per character.

Reading Stations in Practice

The 3D reading stations are installed since 2004 in the railway wheel productions in Nizhny Tagil, Vyksa, Dnepropetrovsk and in Spain. The experience gained from these installations has lead to a standard 3D character recognition system of stamped and embossed characters for use in foundries. Castings such as cylinder crankcases, engine blocks, etc. usually have the specific production data (batch number, casting year, casting week and shift, casting tool and mould in the tool as well as a drawing number and sometimes an index) coded as embossed characters. To trace these parts the production data must be read automatically or entered manually in the first step of the process. This can be done best and most reliably with 3D OCR systems since the cameras are now available with a logarithmic characteristic and thus a high independence of the typical variations of the surface properties in this area is achieved. A Data Matrix Code (DMC) in which a consecutive number is additionally integrated is usually applied for further tracking of the parts in the next process steps. This coding can then also be read reliably with simple readers in the following stations.

The Octum 3D OCR systems can be used both for stationary parts (the camera is then moved on one or more axes) and for parts in motion. The 3D sensor (laser, camera, lens, Scheimpflug adapter) is designed application specific so that the best resolution, highest dynamic response and fastest scanning rate are achieved for the given surface. In practice that may easily amount to up to 5,000 3D images per second at a depth resolution of up to 10 µm. The process integration is also custom designed. For that, the common industrial interfaces are available. At present, the user interface is available in German, English, Russian and Spanish.

▶ Author
Horst Horvath,
Manager Marketing and Sales

▶ Contact
Octum GmbH, Ilsfeld, Germany
Tel.: +49 7062 91494 25
Fax: +49 7062 91494 34
info@octum.de
www.octum.de

Simply the Better Contacts

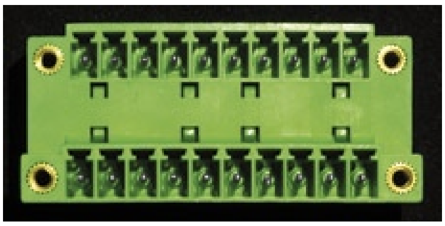
Inline 3D Inspection for a 100% Control of Plug Connectors

The requirements for high-quality parts like plug connectors confront the producers with significant challenges for quality management. The fully automatic 100% control through inline 3D inspection offers significant advantages here. The 3D inspection system Pulsar, developed by the company SAC, allows in combination with the industry-proven image processing interpreter Coake the elegant implementation of a 100% quality assurance strategy directly into the production line.

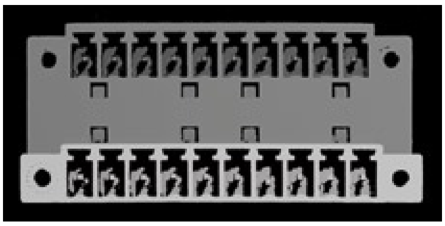
More often than not, debugging is frustrating and time-consuming, and mostly the small and simple components like cables and plug connectors are inspected at last. However, the quality requirements for especially security-relevant plug connectors are high. The key quality criterions are a precise fitting accuracy and the coplanarity of the connecting pins. If the connecting pins are too short, the electrical contact cannot always be guaranteed, which may lead to an unpredictable failure. On the other hand, if the connecting pins are too long, the housing might be damaged at the plugging. Finally, slightly bent pins usually cause that at the plugging these pins are not correctly positioned over the corresponding contact ports and will be completely bend.

3D Measurement Required

Three measurands have to be determined for the detection and evaluation of the described defects: dx (bending horizontally), dy (bending vertically) and dz (divergence pin height). For the determination of these three values, one needs to employ a 3D measurement system. One of the standard methods for fast and precise 3D measurement is the light-section method which registers the deviation of a laser line depending on the object geometry. But, this method is not suitable for the application at hand because the connecting pins are generally coated with gold or tin which leads to disruptive reflexions of the laser light. In addition, using coherent light on metal surfaces results in strong interference defects, so-called speckle pattern, which additionally distort the measuring result.



The classical 2D view of the specimen



Height profile of the specimen: darker areas are farther away from the camera

New Approach for the 3D Inspection

The new 3D inspection System Pulsar by SAC works decidedly more robust. Based on the method of projected fringes, the system offers high measuring accuracy at simultaneously short acquisition time. At the same time, the system avoids the light-section method's weakness and reduces the mechanical effort for the specimen's positioning many times over. Intelligent interpretation logic determines the measurement results for the quality grading of the specimen from the 3D data according to the respective task. The system is therefore suitable for a wide range of applications and allows the fast adjustment to new inspection tasks.

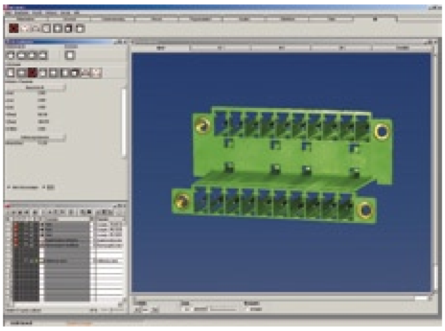
The core of the system is the pattern projection unit: Instead of coherent laser light, the measuring area will be illuminated with a LED light source. Thus, interference defects are eliminated right away. Modern LED light sources today achieve very high intensities of several hundred lumens. They are inured to impacts and vibrations and have in comparison with conventionally light sources an unexcelled durability of several thousand hours.

The different illumination patterns are generated by a spatial light modulator: In the process, several hundred thousand micro-mirrors, organized in a matrix form, modulate with digital precision the light source's beam path. One single mirror has an edge length of less than 20 µm. Spatial light modulators have switching times of below 100 µs, that results in more than over 10,000 switches per second, whereby very high pattern changing rates can be achieved. Also the semiconductor production has discovered the small light shaping chips for their purposes: Here they are used e.g. for the illumination of photolithographic masks.

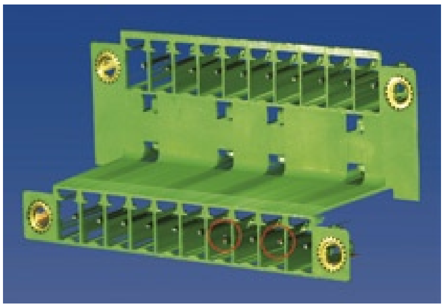
An industry-grade matrix camera captures the images of the coded light pattern. When using the projected fringes technology, the complete image is processed at once. In this way the amount of image acquisitions can be drastically reduced: Only 20 to 40 image patterns have to be processed. Dedicated high-speed chips are not required anymore and can be replaced by sensors with higher image quality. As a result this ensures a further degree of freedom for the inspection system's assembly, because optics and sensors can be chosen from a wide range of machine vision components for every case of application. Through the exact synchronisation between camera and projection unit, high image rates and therefore scan times of below one second can be achieved, which in turn enables reliable inspections within a short cycle time.

Under the Hood

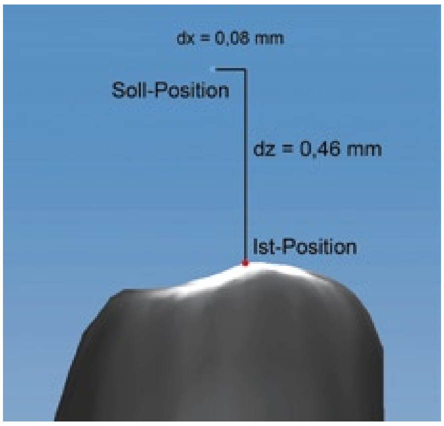
The captured light patterns will be transferred either via CameraLink or IEEE1394b to an image processing system, where the camera images will be decoded simultaneously to the acquisition. A pre-processing stage removes the image noise which every sensor produces, detects and revises any potential decoding errors, and generates a precise height-map of the measuring field based on the system calibration. Also image distortions, which are caused by the always existing lens distortion of camera and projection unit, will be revised and a linearization of the measuring area will be carried out. Additionally, the decoding stage provides a color-calibrated texture image, which allows for dimensional and color-metrical inspections with just one measurement. Since the color information is not captured through color filters covering the sensor, as it is usually the case, but rather by the variation of the illumination, the complete resolution of the b/w-sensor is available on all three color channels and the height channel. If the measuring data are optimally processed, the system generates a texturized 3D model of the specimen as single measuring points are adaptively connected with surface elements. The complexity of the 3D model is thereby automatically adjusted to the measuring data´s complexity, i.e. that also very high data amount can be reduced fast and without loss of accuracy. The pre-processing occurs of course fully automatically and without any user input. From the specimen to the complete 3D model, not more than a single mouse click is required.



User interface of the image processing interpreter Coake with a 3D model



The result of the automated inspection: two defects are marked red (left: pin bended, right: pin too short)



Front view: Detection of a too short pin through the determination of the height divergence dz

Quality Assurance per Mouse Click

As soon as the 3D model is generated, the industry-proven image processing interpreter SAC Coake proceeds with the evaluation. With the 3D functions especially adapted for industrial inspection tasks, the automatic measurement and evaluation of 3D models is possible without a huge time exposure: The user once sets the features that the system is supposed to inspect (pin height and pin positions) per mouse click or per specification of the nominal coordinate values. The permitted tolerances will be globally determined for all features or individually set for any specific features. An inspection program combines the single steps of the test procedure within one table and provides already during the teach-in of the inspection program a direct visual feedback: A green check mark signals a feature within the predefined tolerances (OK), the exceeding of the tolerance area will be shown with a red check mark (NOK). If during the inspection process just one of the inspection steps registers a negative result, the specimen will be classified as defective and a corresponding signal will be returned. This can be processed for instance as a 24 V control signal or via Profibus to the inspection machine, which can react correspondingly, e.g. by discharging the part from the production line. Through the graphical teach-in functions, it is possible in no time at all to adjust the system to new part types or to change the inspection tolerances. Of course, all measurement results can be logged and evaluated statistically. Thus, the production process will be transparent and process fluctuations can be immediately identified and located. Cost intensive recurring defects are thus a thing of the past.

▶ Author
Alexander Piaseczki, Research and Development

▶ Contact
SAC Sirius Advanced Cybernetics GmbH
Karlsruhe, Germany
Tel.: +49 721 60543 010
Fax: +49 721 60543 200
sales@sac-vision.de
www.sac-vision.de

Cost Optimization of Tube Manufacturing

Applying Cutting-edge Measurement Equipment to Improve Efficiency

"A penny saved is a penny earned" says a proverb. This is especially true when you are concerned with the success of your business. Therefore, reaching a high degree of efficiency is one of the main goals of a company. Manufacturing processes must be optimized continuously, and costs have to be reduced. However, where to start with cost savings? Businesses that produce tubes and pipes often mention four areas of costs that have a serious effect on total costs: gauge costs, material costs, storage costs and setup costs of bending machines.

Exemplary calculation of possible savings due to replacement of gauges:

Need of new gauges per year	5 pieces at € 2,000
Cost of maintenance and inspection	€ 500 per gauge p.a.
Potential savings in first year	€ 10,000
Potential savings in second year	€ 12,500
Potential savings in third year	€ 15,000

▶ The optical measuring system TubeInspect replaces cost-intensive mechanical gauges

In order to minimize these costs, it pays off to invest in modern measuring technology today. Based on the experiences of many tube and pipe manufacturers, especially the application of optical, tube-dedicated measurement equipment gives a good return. The camera-based measuring system TubeInspect, developed by Aicon 3D Systems from Germany, has been designed in cooperation with users from the automotive industry and accounts for the requirements of both manufacturing and construction departments.

TubeInspect measures a tube's geometry with high-resolution digital cameras in only a few seconds. For this, the tube to be measured is placed in the measuring cell. An illuminated measuring plate in the cell ensures that all parts of the tube are ideally visible. The digital cameras are positioned above the

Ralf Unger, taking care of the quality assurance at König Metall GmbH & Co. KG in Gaggenau (Germany), appreciates the fast and effective process control with TubeInspect

Since applying the optical measuring system, Serto AG in Switzerland has been able to reduce material costs significantly

measuring plate and acquire images of the tube from different directions. Evenly distributed reference points on the measuring plate guarantee for the correct spatial orientation of the cameras. Aicon defines their positions accurately to a hundredth millimeter during the installation of the system. The result display is easily understandable, also for users without technical background. Thus it allows for flawless evaluation of the measurement.

But how is TubeInspect able to reduce costs?

Elimination of Gauge Costs

Before a tube goes into series production, the prototype is changed many times with respect to its material and geometry until it will finally meet the requirements. Of course, also these prototypes have to come under scrutiny. This implies, when working with mechanical devices that an individual gauge has to be fabricated for each prototype. Depending on the tube, the costs for a gauge are between € 2,000 and € 4,000. Whenever a prototype is changed, the corresponding gauge has to be adapted, too. Including its final inspection by measuring the geometry, this can take up to two weeks. Yet not only causes the gauge adaptation a high amount of costs; it also leads to long delivery times that are often unacceptable for the customer. When using TubeInspect, it is possible to completely renounce to manual gauges. The operator simply types the new data (X-, Y-, Z-coordinates of bending points) into the data base of the measuring system – and after only a few minutes the measurement of the changed prototype can begin. TubeInspect works as a virtual gauge for any type of tube, and it can be applied in series production, too.

The possible savings in series production can easily be clarified with the following example: Due to five new products per year, a production facility has a yearly need for five new gauges at the price of € 2,000 each. Their annual maintenance and periodic geometry check amount for approx. € 500 per gauge per annum. When applying a flexible mea-suring machine such as TubeInspect instead of gauges, savings of € 10,000 are generated within the first year because no new gauges have to be acquired. In the second year, the savings account for € 12,500 as both the maintenance costs for the gauges of the previous year (five gauges for € 500) and the investment of € 10,000 in five additional gauges for new products are omitted. Accordingly, € 15,000 can be saved in the third year.

Reduction of Setup Times for Bending Machines

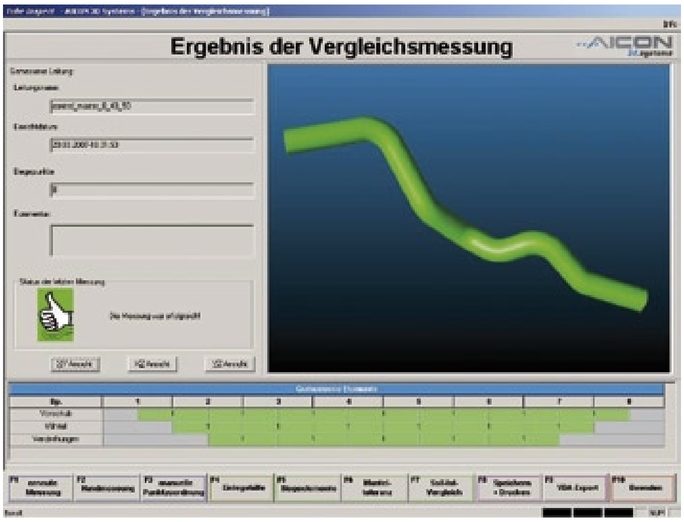
In production, a new setup of the bending machines is necessary e.g. whenever the product is changed. Very often, well-experienced staff members have to attend to the setup as it demands great skills. And even then it can take several hours in case of complex tubes. Meanwhile production stops. At this point, TubeInspect can bail you out: With the help of the measuring system, correctional data is generated within a few seconds and transferred to the bending machines. As a consequence, their setup will only last a few minutes. The attained savings can be clarified using the example of a typical tube manufacturing plant as it is common in the supplier industry:

The exemplary company disposes of a manufacturing capacity of four bending machines. Thanks to its flexible production strategy, it is in the

Exemplary calculation for savings thanks to shorter setup times of the bending machines:

Number of bending machines (BM)	4 pieces
Number of changeovers per day per BM	2
Time savings per change over	0.75 h
Costs of machine downtime per hour	€ 100
Number of work days per year	200

Savings p. a.
E = 2 changeovers x 4 BM x 0.75 h x € 100 x 200 work days
= € 120,000



Thanks to the clear display of the measuring result, the quality can be evaluated immediately

position to deliver products in small batches right away. Over a longer period, setup procedure and time were analyzed with and without using TubeInspect. During the observed period, every bending machine was changed over twice a day on average. With TubeInspect, the setup time could be reduced by 0.75 h. The cost of machine downtime is calculated with €100 per hour. This results in potential savings of € 120,000 in the first year under the assumption of 200 manufacturing days per annum.

This observation is also affirmed by Ralf Unger, responsible for the quality assurance at König Metall GmbH & Co. KG in Gaggenau (Germany) who has applied TubeInspect since December 2006. “With TubeInspect we are in the position to monitor our processes in a fast and effective way as the measuring system shows accuracy information for the bent tubes after only a few seconds. Therefore, the approval for production can now be given in record time. In the past, when the measurement was tactile, we had to wait for the approval for a really long time. Moreover we have reduced the setup time of our bending machines considerably. The gained free machine capacities mean hard cash to us.“

Reduction of Material Costs

Material prices increase steadily. Especially the high price for steel hits businesses where it hurts. Hence the reduction of reject parts gets more and more important. Thanks to the fast setup of the bending machines, TubeInspect also pays off in this issue. Joe Girtanner, Director of Production at the Swiss tube manufacturer Serto AG, reports about his experiences with TubeInspect: “The number of deficient tubes has been strikingly reduced. When a new production run starts, the second tube meets the requirements. And as we mainly manufacture tubes made of expensive materials, we clearly notice the strong decrease of costs in this area.“ Serto employs the material 1.45.71 for example (rust-acid-resistant, titanium-stabilized stainless-steel) in order to manufacture tubes for coffee machines. This material has, just as the whole stainless-steel market, experienced significant price increases in the last years. Due to the optimized material consumption, Serto can partially absorb the increased costs now.

Storage Costs

Particularly companies with a high percentage of in-house-manufactured components and with many active products have a huge need for storage because a measurement device must be at hand for every tube or pipe. Additionally, sample tubes are kept in order to be able to cope with follow-up orders quickly. Here, TubeInspect may also bring substantial benefits. Not only can the system work as a virtual gauge and measure the manufactured tubes so that the use and storage of gauges can be avoided. The system can also calculate the bending data of tubes that come without CAD data. For this calculation, the operator has to use TubeInspect’s function “master measurement” and measure the tube in two different positions. Thus TubeInspect can automatically generate the bending data. These data are then saved as nominal geometries in TubeInspect’s data base.

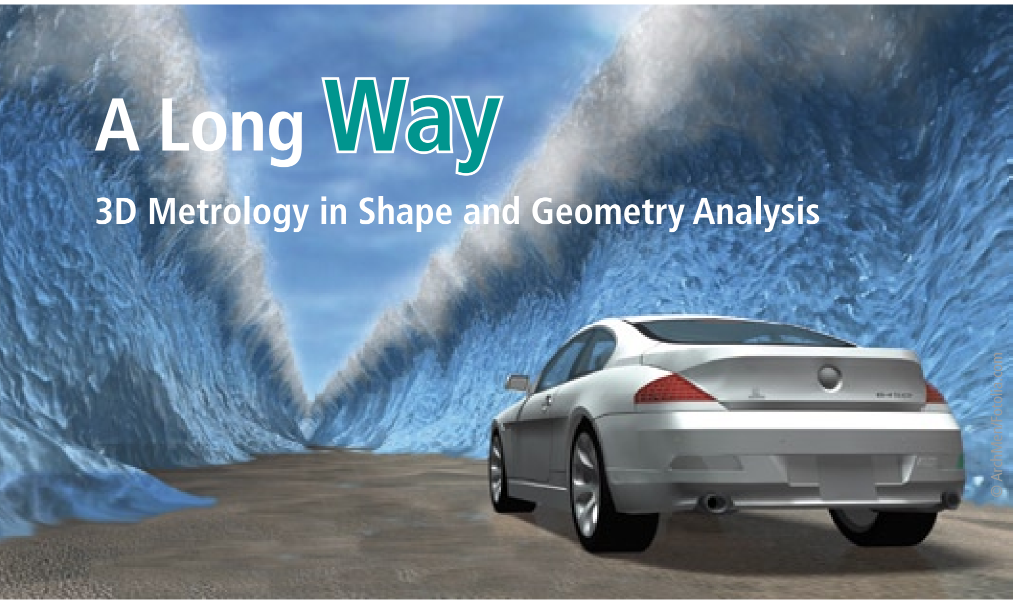
What are the advantages of the master measurement? Joe Girtanner explains: “In the past we had to store samples of every manufactured tube, no matter if the batch size comprised 20 or 10,000 pieces. This was necessary to handle follow-up orders rapidly. Today we are in the position to send back the sample tubes to our customers as soon as the data are digitally saved. As a consequence, we have been able to reduce the storage capacity tremendously.”

Upshot

Especially in view of the current economic situation and the increasing pressure of competition, it is worth to work hard on cost reduction. For a flexible measuring device such as TubeInspect, it is easy to calculate the return on investment. Many users realize after this calculation that an investment in optical measuring technology will amortize after only one year – and nothing is more convincing than bare figures.

▶ **Author**
Jutta Thiel, Marketing & PR Manager

▶ **Contact**
Aicon 3D Systems GmbH, Braunschweig, Germany
Tel.: +49 531 58 000 58 · Fax: +49 531 58 000 60
info@aicon.de · www.tubeinspect.de



A Long Way

3D Metrology in Shape and Geometry Analysis

From the idea to the automobile ready for mass production, it is a long way with lots of development work. Topometric inspection methods support the prototyping process in the automotive industry. Meanwhile, these methods are so advanced that they are applied for routine tasks in the production process itself.

In spite of advancing simulation techniques, design models for automobiles are very often still made of clay because the human imagination mostly cannot sufficiently cope with computer models in 3D. The clay models are prepared on a scale of 1:1 or 1:4. Once the design is agreed, the next step is to build the prototype, involving a lot of manual work. Result is that the tolerances required for the final production are not achieved. Therefore, the development departments request that any imperfections of the prototype are captured and compared with a CAD model. In close collaboration with a leading German car manufacturer, Breuckmann has developed a solution coping with these very demanding requirements.

Integrated Tracking

For capturing three dimensional surfaces, the method of optical triangulation is combined with structured illumination. A well defined sequence of linear fringes is projected onto the object, which are then recorded by one or two high-resolution cameras at different viewing angles. This way, lateral resolutions of approximately 25 µm and depth resolutions up to 1 µm can be achieved.

Due to the very tight time constraints of the car manufacturer, a preparation of the shiny parts prior to the scanning process, e.g. with an anti-reflection coating, is not an option. Measurement accuracy within a range of 0.2 mm was required; the measurement procedure should be predominantly automatic. The maximum processing cycle is limited to 20 minutes even for large sized parts. In order to fulfill these requirements – time constraints, accuracy, handling – a standard industrial robot is chosen, mounted with a Breuckmann white light scanner. A large turntable is integrated into the set-up for better part handling from all angles.

In order to compensate for the limited accuracy of the robot, an optical tracking system implemented in the naviScan^{3D} scanner verifies each scan position during the set-up procedure. These positions serve as basis for the actual measurement. Since the complete system configuration consists of independent sub-systems, their thorough calibration and co-ordination is essential.

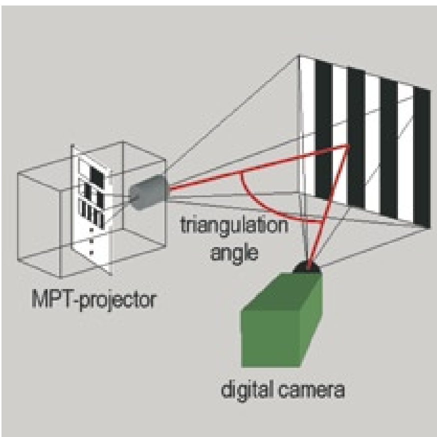


Fig. 1: The method of optical triangulation

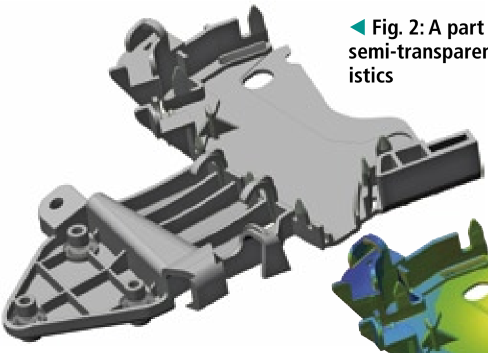
Thorough tests show that a more than satisfying repeatability and reproducibility have been achieved. In reference to a sphere of 30 mm in diameter, the probing error varies between 0.079 and 0.131 mm and the so-called sphere-spacing error is limited to 0.2 mm. All values are achieved in a measurement volume of 3 x 2 x 2 m^3.

Process Optimization

Also the tasks at the Wirthwein AG, a German manufacturer of plastic components, are characterized by their variety: first sample inspection, process optimization and quality control of various plastic components. Main requirements here are the analysis of geometry, shape and position tolerances and CAD comparison. Figure 2 shows a plastic component for a car door measuring approx. 20 x 14 x 3 cm. The material is semi-transparent and in particular to capture the important "clips" components at a very high accuracy is of essential significance. The Breuckmann stereoScan^{3D}-HE system with a camera resolution of 2 x 5 MegaPixel is in operation since beginning of the year. In this particular inspection example, a measuring range of 175 mm is used. The measurement raster is about 50 µm, the resolution limit in Z-direction is 4 µm and the feature accuracy is typically below 10 µm. Figure 3 illustrates the deviations from the CAD model as false color map.

Surface Inspection in the Production Process

The surface control of car body outer panels is traditionally done by human visual inspection. In case defects like blisters, bumps, dents or sink marks are not detected during the production process, they will only be revealed as shade formations after the painting stage. Obviously, this causes cost intensive correction work and considerable wastage. Therefore, the goal is to perform a continuous optical control during the production process. With this objective in mind, the INB Vision AG in Magdeburg, Germany, has developed an in-line inspection system which can automatically examine even very complex forms and shapes. The result is a digital "defect map" of the investigated region which clearly presents any defects on the sur-



◀ **Fig. 2: A part for a car door with semi-transparent surface characteristics**

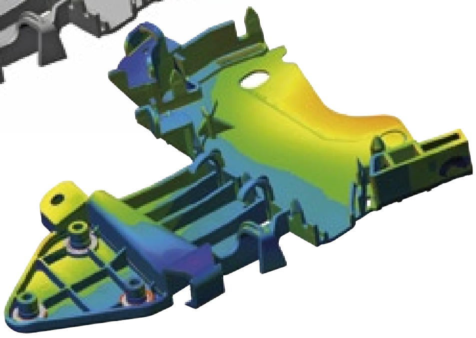


Fig. 3: The deviations between a real part and the CAD model on a defect map ▶

face. The faulty areas can also be projected back onto the actual object (fig. 4).

The configuration for a specific part is obtained in a short training procedure. On the basis of this training data, a special algorithm calculates a virtual reference model which is subsequently matched against the part being inspected. Meanwhile, these inspection installations are in operation at several German car manufacturers and components suppliers with excellent performance.

Fig. 4: Defects are marked optically at the surface inspection of a production process

Since April 2009, INB Vision and Breuckmann cooperate for this application area. Addressing a largely identical clientele, the companies complement each other perfectly. While Breuckmann specializes in geometrical measurements, INB Vision concentrates on 3D surface quality.

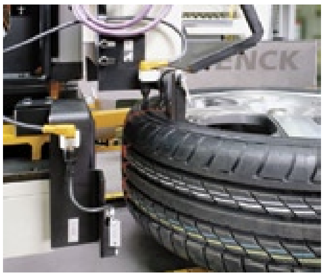
Industrial Maturity

The technique of optical, non-tactile recording of three dimensional surface data as well as the analysis of shape and geometry have reached a level of maturity, which not only allows resolving new, but in particular also routine tasks in the production process. Given the broad range of applications, the examples presented only demonstrate a very small, but representative selection of the complete production spectrum. It is foreseeable that topometric inspection methods will gain more and more importance in the future.

▶ **Author**
Harald Rein, Manager Sales & Marketing

▶ **Contact**
Breuckmann GmbH, Meersburg, Germany
Tel: +49 7532 4346 0
Fax: +49 7532 4346 50
info@breuckmann.com
www.breuckmann.com

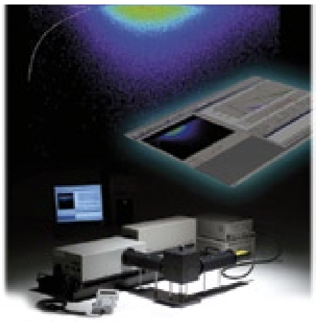
Laser Modules and Laser Projectors



Z-Laser presents the new product family ZM18. The advanced lasers for the vision, measurement, scientific, medical and alignment industries are available with wavelengths of red, green, blue and IR with output powers up to 200 mW. With these new lasers, the user no longer has to settle for a particular operating voltage as they feature 5-30VDC operation, with voltage, spike and reverse polarity protection. At any voltage within this range, the lasers can be modulated both analog and digitally simultaneously, at frequencies of up to 20 MHz. This allows the laser intensity to be varied whilst also enabling the laser to be synchronised with a camera or other equipment. Furthermore, the sophisticated electronics feature a built-in micro controller and serial interface facilitating the logging of temperature, operating hours etc.

Z-Laser Optoelektronik GmbH
Tel.: +49 761 296 44 44 · info@z-laser.de · www.z-laser.com

Fluorescence Lifetime Spectroscopy System



Since many years the streak technology is well established as the high-end method for time-resolved fluorescence spectroscopy. It is employed in a range of complete measurement systems Hamamatsu is offering. The brand-new C10627 streak detector is the successor of the well-known Streakscope detector. It offers two big quantitative improvements along the above mentioned themes: The streak sweep repetition rate is further improved by a full order of magnitude. This will give 10 times shorter measurement times in case of very weak samples. The maximum photon counting rate is improved by a factor of about five. This allows shorter measurement times in case of samples with stronger emissions. Both improvements extend the capabilities of these systems even further, allowing efficient measurements even in most demanding applications.

Hamamatsu Photonics Deutschland GmbH
Tel.: +49 8152 375 0 · info@hamamatsu.de · www.hamamatsu.de

New Microscope Stage

Newest technology integrated in the microscope stage for reflected and transmitted light applications in the field of microscopy: ITK presents the very compact microscope stage LMT100 with an absolute measuring system and controller on-board. Time-consuming reference measurements are not necessary anymore. The linear motor from ITK allows a very fast and precise positioning also in the nanometer area. Wear parts like bearings, spindles and end switches are not in the concept, because ITK will increase the stability, availability and lifetime of the whole system.

ITK Dr. Kassen GmbH
Tel: +49 6441 65005 12 · h.rausch@itknet.de · www.itknet.de

All-In-One Microscope System

Olympus has introduced the all-in-one FSX100 fluorescence microscope system to enable even the most inexperienced users to create high-end research images. The FSX100 microscope is designed to remove all of the complex steps involved in setting-up and using multi-channel fluorescence microscopes, ensuring that users can concentrate on the images and data without any prior microscopy expertise. By coupling high quality microscopy and imaging components with precision automation and advanced software, the Olympus FSX100 presents simplified workflows so that users can obtain high quality images and image series by simply: loading their sample; defining their observation mode and regions of interest (ROI); and then capturing their images: as straight-forward as Set-Select-Capture.

Olympus Life Science Europa GmbH
Tel.: +49 40 23773 0 · microscopy@olympus-europa.com
www.microscopy.olympus.eu

3CCD HD Microcamera

The new Panasonic GP-US932A version provides a range of new functions and improved characteristics that put the preceding version in the shade. Now with dimensions of just 37 x 47 x 54 mm, the separate camera head of the new GP-US932A is 6 mm shorter and now makes mechanical system integration easier. The video signal is digitized in the camera head with resolution of 3 x 14 bits. The entire digital processing chain provides true, almost loss-free color reproduction. Panasonic's new model 4 now comes with different optional cable lengths: 4, 6, 10 and even 20 m cables allow the camera head to be moved even long distances away 'loss-free', which therefore considerably increases the number of potential applications for the equipment.

Panasonic System Networks Europe
Tel.: +49 40 8549 0 · info-de@eu.pewg.panasonic.com · www.panasonic.de

ONLINE

We´ve researched the Web for you and found this:

http://www.brainguide.com

■ Do you need an expert for British Island´s tax law? Do you search for an insider from the food industry? BrainGuide provides access to thousands of experts from highly specialized knowledge areas. The portal offers a free-of-charge overview of each expert's competences as well as his or her company. The portal so far has a focus on Germany, UK, USA, Canada, India, Austria and Switzerland.

http://www.boardtracker.com

■ Boardtracker is a search engine entirely dedicated to message boards and forums, those areas of the web that are not as easily googled as, e.g., company websites. Messages can be tracked and instant alerts based on user criteria can be sent.

http://www.inspect-online.com

■ Company news, product data, white paper, webcasts, polls, Buyers Guide, event calendar, job search engine – everything about machine vision and optical metrology, in English and German language. Updated daily.

http://www.nasa.gov

■ Images, videos, podcasts, 3D animations, interactive games and much more about space, aeronautics and NASA missions. The website is as cool as the topic is, and it offers so much to discover and play around with that a rainy November Sunday afternoon is highly welcome for a change.

http://www.slideshare.net

■ SlideShare is YouTube for presentations, documents and pdfs. Individuals and organizations upload their presentations to SlideShare to communicate their ideas, get in contact with others and draw attention to themselves and their companies. The portal has about 17 million visitors per month.

http://smarthistory.org

■ To which era of cultural history does the Venus of Willendorf belong? Was Michelangelo an artist of the Renaissance or of the age of Romanticism? This portal answers your questions from art and history – and is a feast for the eyes.

http://www.slideshare.net/mzkagan/what-the-fk-is-social-media-one-year-later?src=embed

■ Share your views on Slideshare by posting presentations? Here is a neat example on the topic of Social Media: "Social media is like teen sex. Everybody wants to do it. Nobody knows how. When it´s finally done there is surprise that it's not better." Whatever else you might want to know about Social Media then follows on the other 80 slides of this presentation.

Let us know about your online favorites at contact@inspect-online.com

Interview with Johann Salzberger, Managing Director Micro-Epsilon

INSPECT: Mr. Salzberger, today Micro-Epsilon can look back on a company history of over 40 years and belongs to the most successful metrology companies in Europe. Since when is optical metrology part of the company's product portfolio and what is the importance of these products today?

J. Salzberger: Micro-Epsilon is today one of the most important companies in the sector of measurement technology by remaining true to measuring geometrical quantities and by trying to always offer the best possible solution to the customer. Therefore, we have continuously expanded our product range with new measuring technologies. In 1990, Micro-Epsilon decided to add optical measurement to the existing product range. As early as 1993 we launched our first digital laser sensor onto the market. Today, our product range covers a lot of different triangulation sensors, digital micrometers, laser scanners for profile measurement and confocal sensors. Our real-time compensation for changing surfaces (RTSC) is still unexcelled. For years, optical sensors play an essential role in our product range. A lot of measurement tasks can be best solved optically. Since the requirements from the market in this sector are very diverse, also customer-specific sensors are being developed.

Which products does Micro-Epsilon offer in the field of optical 3D metrology and in which applications are these products mainly used?

J. Salzberger: In the sector of 3D measurement technology, Micro-Epsilon offers various laser scanners for profile detection. Both, scanControl 2800 and 2810 represent the high-end solution for demanding measurement tasks. These sensors provide 256,000 measuring points per second. In order to serve all different market needs, the series scanControl 2700 and 2710 are offered at a mid-range price level. The compact design, the integrated controller and an excellent cost/performance ratio characterise these sensors.These laser scanners are mainly used for profile measurement in quality assurance applications. Among those applications are the use of the scanners in coordinate measurement machines for fast and non-contact scanning of surfaces and the inspection of adhesive beads in body-in-white production. In order to allow a 3D measurement a traversing of the sensor or the object is necessary. Therefore our laser scanners are often mounted onto robots. Even the software which enables a fast development of the requested solution for the measuring task, is developed by Micro-Epsilon in-house.

Together with BMW and Forwiss, you have developed a system for the 3D inspection of high gloss surfaces. Where is this system in use today?

J. Salzberger: The system reflectControl detects object surfaces by reflection of a striped pattern. Optical distortions of the pattern by bulges, dents or craters are reliably detected this way. In case of bigger or more complex objects reflectControl is mounted onto a robot which moves the sensor around the object. This set-up of the measuring system is in use at BMW. The system is applied here to inspect surfaces of painted car bodies. In case of flat geometries such as metal stripes or glass panes the system can be operated in linear mode. The system is applied for the inspection of all surfaces with sufficient gloss properties. A short standstill period is sufficient for the acquisition of several raw images which are used to generate a presentation of the surface –a result which can not be achieved by traditional 2D image processing technologies.

What is your expectation regarding the future development in 3D technologies? What are the trends that you foresee? What are your plans?

J. Salzberger: Requirements for 3D technology regarding speed and accuracy will definitely increase further. Reasons can be seen in the high quality requirements for the respective end products and the production process itself. Acquiring a new technology to increase quality always is initially a significant investment. However, considering how much can be saved during the production process, costs usually are amortised within a short time frame. As soon as this point is exceeded, higher quality products will be produced at less costs.

A trend can be seen that customers require complete solutions for their measuring tasks. The system is expected to reach the specified performance within a short period of time which often requires not only the sensor technology but also the mechanical construction and the metrology software. Micro-Epsilon offers some advantages in this regard due to our own on-site mechanical production and the internal software development.

Micro-Epsilon has grown into a 500 people strong multinational group of companies without any external help, and is up until today in private hands. What is the formula for success here? What are your plans for the future?

J. Salzberger: The success of Micro-Epsilon has a whole set of different reasons. We are convinced that on one hand our formula for success is the commitment of our people, many of them with the company for a long time already. They have a distinct sense of community which consistently results in exceptional solutions. An important role is also played by the "entrepreneurs" among the employees. These are the employees possessing work-ethics as if they themselves own the company. They scrutinize every decision regarding efficiency in reaching the overall business objectives of the company. On the other hand, Micro-Epsilon is known as an open-minded and reliable business partner since its foundation. This is shown by the continuous confidence and satisfaction expressed by our customers. Another reason for success is the above average number of developers working at the company as well as the high technical competence within our sales department which consists mainly of engineers and technicians with specific product know-how. Exceptional and unique solutions are developed by the combination of these teams.

We are firmly convinced that Micro-Epsilon will again grow above industry standard after the crisis is over.

Mr. Salzberger, we wish you success with this and thank you for this interview.

▶ **Contact**
Micro-Epsilon Messtechnik GmbH & Co. KG,
Ortenburg, Germany
Tel.: +49 8542 168 0
Fax: +49 8542 168 90
info@micro-epsilon.de
www.micro-epsilon.com

Preview

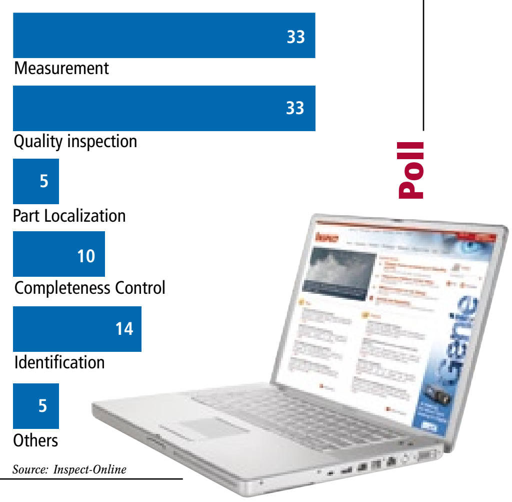
Look ahead to our next issue, the international INSPECT Buyers Guide 2010, published for the first time ever in cooperation with the EMVA (European Machine Vision Association).

Comprehensive, complete and concise: The INSPECT Buyers Guide provides you with the relevant information about product and system manufacturers, integrators and solution providers for machine vision and optical metrology.

The framework for company and product information will consist of a presentation of the global machine vision standards, the results of the annual camera survey and an insight into the possibilities for software benchmarks.

Poll

For which type of application do you use 3D vision/ 3D metrology most often?



IMPRINT

Published by
GIT VERLAG GmbH & Co. KG
Rößlerstr. 90
64293 Darmstadt, Germany
Tel.: +49/6151/8090-0
Fax: +49/6151/8090-144
info@gitverlag.com
www.gitverlag.com

Managing Directors
Dr. Michael Schön, Bijan Ghawami

Publishing Director
Gabriele Jansen
Tel.: +49/6151/8090-153
gabriele.jansen@wiley.com

Editors
Dr. Peter Ebert
Tel.: +49/6151/8090-162
peter.ebert@wiley.com

Andreas Grösslein
Tel.: +49/6151/8090-163
andreas.groesslein@wiley.com

Stephanie Nickl
Tel.: +49/6151/8090-142
stephanie.nickl@wiley.com

Editorial Assistant
Bettina Schmidt
Tel.: +49/6151/8090-141
bettina.schmidt@wiley.com

Scientific Advisor
Prof. Dr. C. Heckenkamp
Darmstadt, University of Applied Sciences

Segment Manager
Oliver Scheel
Tel.: +49/6151/8090-196
oliver.scheel@wiley.com

Sales Representatives
Claudia Brandstetter
Tel.: +49/89/43749678
claudia.brandst@t-online.de

Manfred Höring
Tel.: +49/6159/5055
media-kontakt@t-online.de

Dr. Michael Leising
Tel.: +49/3603/893112
leising@leising-marketing.de

Dirk Vollmar
Tel.: +49/6159/5055
media-kontakt@morkom.net

Production
GIT VERLAG GmbH & Co. KG
Christiane Potthast
Claudia Vogel (Sales Administrator)
Michaela Mietzner, Katja Mink (Layout)
Elke Palzer, Ramona Rehbein (Litho)

Reprints
Christine Mühl
Tel.: +49/6151/8090-169
christine.muehl@wiley.com

Bank Account
Dresdner Bank Darmstadt, Germany
Account No. 0171550100
Routing No. 50880050

Advertising price list from October 4st 2009

Printed in Germany
ISSN 1616-5284

The English language ePaper version of the INSPECT is mailed to 13,500 recipients worldwide.
The German language printed version has a circulation of 20,000 issues.


PicSight.com
PicSight® Smart GigE
becomes smarter!
OpenCV
HALCON
Leutron Vision
PicSight Smart GigE cameras now
with Halcon Embedded 9.0 and OpenCV