As machine vision technologies improve, providing more data more frequently, new uses for inspection during the manufacturing process are emerging.

Bruce Morey  
Contributing Editor

The automotive industry might represent the ultimate challenge to providers of machine vision equipment used in robotic guidance and material inspection. “The automotive industry is a microcosm of the entire industrial world,” explained David Dechow, staff engineer for FANUC (Rochester Hills, MI). “Every potential industry is represented, from raw metal to electronics to wiring to machinery and everything in between.” Machine vision—electronic imaging for inspection, process control, and automated guidance—provides unique benefits in practically every facet of the industry.

FANUC is one of just a few robotic automation providers that have also developed their own integral robotic vision products. These are used in both guiding a robot to perform a task and inspecting parts and processes to ensure quality. He views robotic guidance as a fast growing field, using machine vision that provides 2D or, increasingly, 3D data. “These applications are starting to mimic human material processing.
by picking up individual objects that are randomly placed and posed, moving them and replacing humans in complex but repetitive tasks,” he said. One example is FANUC’s R-2000iB bin picking robot that uses a laser-based 3D sensor.

“However, inspection is the largest market segment for machine vision in automotive, and is likely to remain that way,” he said. Inspection requirements vary widely by application, from a simple check for part presence or absence, to high-resolution metrology that follows complex GD&T rules. What is enabling the growth of machine vision used for both inspection and guidance are better sensors, faster processors, and better algorithms. Vision engineers are learning how to better use the data from sensors and exploit the growing power of computers.

However, the wide base of applications in the automotive industry requires expert matching of technology to application.

Smart Cameras, Smart Applications

Kris Bierbaum, global account manager for Cognex (Natick, MA) has a unique insight into the industry. Cognex is a provider of the basic elements of machine vision equipment, the building blocks of integrated solutions. “In the automotive field, the driving forces for using machine vision are quality and productivity,” he said. He listed a number of widely different inspection applications employing machine vision that do not need the precise measurements of metrology to a GD&T standard.

Bierbaum believes these applications provide the best value when the product is moving—in process—and engineers are looking for a specific quality or feature. “I have seen applications using our equipment where...
they are looking for the visual quality of a seam in weld joint, cracks or flash in die cast parts, or the presence of holes with tapped threads in engine blocks," he said. "These are not metrology applications, which I think of as static, precise measurements, but more qualitative in nature."

While demand is important, what is driving growth is the evolution of the vision technology. "Once upon a time, looking for the presence of holes in an engine block was once an expensive science project," he said. Advancements in pixel resolution and accuracy, algorithms that are tolerant to lighting, and speed have made such applications reliable and commonplace.

The step change in the industry was the introduction of smart camera vision that combines vision software, optics, lighting and communications in the same device, Bierbaum said. This made applications much more affordable, easier to use, and easier to install. An example is the Cognex In-Sight line of vision systems. The In-Sight 7000 includes autofocus and lighting along with the on-board processor. Embedded communication protocols that talk with controllers such as Allen-Bradley, Siemens, or Mitsubishi devices are an important feature. "Smart cameras are the fastest growing segment of machine vision," he said.

Bierbaum also predicts more 3D applications as well, enabled by laser-based displacement sensors such as the Cognex DS1000 series of smart sensors. Cognex also offers vision controllers, vision hardware, and vision software as well as their VC5 Vision Controller. This connects to Cognex industrial GigE Vision cameras and Cognex 3D laser displacement sensors. It connects up to four area scan, line scan or 3D displacement sensors.
“Suppliers must comply with very stringent standards from automobile manufacturers. So, they are being asked to deploy more and more vision systems to make sure the product meets the expected quality,” said Roberto Baccega, US sales manager for Matrox (Dorval, Quebec, Canada). Matrox is also a supplier of component-level solutions such as cameras, video capture cards, and software. They supply these to various integrators as well as knowledgeable end-users. Such components need to be robust and easy to use such as their Iris GT line of smart sensors. These come with their Design Assistant software that uses simple flow charts for programming, eliminating the need for end-users to know programming languages. They also supply a Matrox Imaging Library (MIL) for easy image analysis. “Engineers use our tools to build custom vision systems,” he said.

**Distributed Vision for Complete Coverage**

Baccega sees a trend in automotive from sampled inspection using statistical process control (SPC) to 100% inspection. “That is a big push in recent years. For example, if there is a recall, they want to narrow down the source to a specific part, a specific lot that was manufactured at a certain time.”

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He also is seeing a trend towards more coverage, with installations employing more vision to cover multiple points and views. “Smart cameras may be more costly in certain vision installs,” he said. This is why integration hubs, like the Matrox 4Sight GPm is important in the field. This integration hub includes an embedded PC using an Intel i7 chip equipped with their Design Assistant software. It integrates up to 4 GigE cameras.
and 4 USB 3.0 cameras. “GigE and USB 3.0 cameras are inexpensive because they do not have the processors built into them,” he said. Instead, these are controlled by the single 4Sight device. “This is more cost-effective for multipoint or multicamera solutions than an equivalent number of smart cameras,” he added. The device can control not only 2D sensors, but 3D sensors such as laser scanners as well, which is becoming an important tool.

One reason lasers are so effective is their robustness in industrial settings. “Lasers offer better reliability because they are less sensitive to changes in ambient lighting than photogrammetry or stereo vision,” said Najah Ayadi, president of Bluewrist (Markham, Ontario, Canada). “Lasers are used to acquire accurate measurement results as well as being robust,” said Glenn Hennin, manager for LMI Technologies (Delta, BC, Canada) and Bluewrist’s supplier of 3D laser machine vision tools and software. “Measurement accuracies are 50 microns 3 sigma,” he said.

Bluewrist is a supplier of industrial automation solutions, including dimensional measurement, inspection and robotic guidance. “Bluewrist provides of 3D laser machine vision tools and software. “Measurement accuracies are 50 microns 3 sigma,” he said.

Perceptron has married its Helix programmable laser scanner with a collaborative robot, which uses a self-teach mechanism to recreate automatic measurement tasks.

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ment system for automotive assembly lines [FlexiSight] that can be used for body-in-white, frames and motor compartment measurements,” said Ayadi. FlexiSight employs a robot to move a sensor around parts and assemblies, taking discrete snapshots of features such as holes, slots, surface, edges, studs, clips, gap and flushness.

Bluewrist also offers PreciScan3D, a product designed for in-line scanning of parts for automatic defect detection and dimensional measurement. PreciScan3D provides point clouds that are automatically aligned to a CAD model. “We collect data at 100 mm per second,” said Mr. Ayadi. “Using the point cloud data for feature extraction is more reliable today because computers are more powerful. We can collect data and extract features in real time enabling 100% inspection of parts as they are being built, in-line. “It takes milliseconds now to extract features,” he said.

3D Vision Improvements

There is room to improve sensors as well. A prime example is the Helix laser-based programmable 3D sensor from Perceptron (Plymouth, MI) that exploits microelectromechanical systems (MEMS) technology. Rhex Edwards, director of business development for the company provided Manufacturing Engineering magazine a unique look at a MEMS chip that is at the heart of the Helix sensor. Backed by 140 patents, according to Edwards, a tiny solid-state mirror on the MEMS chip is responsible for rapidly directing a point-source laser beam, whose reflection is then measured using triangulated cameras. “In comparison to our older line scan technologies, the point source gives us more capability to look into corners and crevices,” he explained. “At the same time, we can [reprogram] the point into a line at a 100 kHz or scan to collect a 3D image.” This Intelligent Illumination package essentially customizes the sensor to collect more where needed to capture fine details in challenging measurement applications.
The Perceptron MEMS chip means no moving parts that can wear out or require recalibration. “Thermal and vibration issues are two of the biggest headaches with metrology,” said Edwards, which does not affect the MEMS chip. Perceptron offers the Helix in a range of sizes, starting with the H200 model with 175-mm depth of field to the H1400 with a depth of field of 225 mm, all with 50 µm of accuracy at 2 Sigma. A new model in the lineup released in March 2015—the 200HDR—is a high power laser model. Its power range is adjustable up to the maximum permitted for a Class 3R laser, according to the company. The higher power targets more complex measurements, for example highly reflective metallic surfaces such as machined aluminum castings.

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Essentially a smart sensor, the Intelligent Illumination package performs feature extraction from the measured point cloud using the company’s Vector software. According to information from the company, the sensor also includes an embedded accelerometer to determine real-time sensor orientation, useful for when the sensor is attached to a robot for movement around parts for more complete inspections, such as in another of the company’s newest product releases that exploits collaborative robotics. Their Autoscan Collaborate-Gage and Autoscan Collaborative-CMM metrology solutions are designed to allow the robot and operator to perform tasks simultaneously during manufacturing operations.

Prescribed Automation

An often complementary 3D technology to lasers are triangulated machine vision cameras that exploit structured light to accurately measure surfaces for use in metrology. For ex-
ample, the ATOS 3D scanner available through Capture 3D (Costa Mesa, CA) projects fringe patterns across a part’s surface and as the patterns rapidly shift during each scan, two triangulated cameras capture the displacement to calculate the 3D coordinate measurements. This form of machine vision is for high-accuracy metrology applications. For example, the ATOS Triple Scan 16M provides 16 million points per scan (PPS) and a single scan is capable of capturing point spacing down to 34 µm with a 170 x 130 mm² area and up to 166 µm within an 810 x 610 mm² area. Each scan takes a few seconds and multiple scans are taken to capture the entire object. The intelligent algorithms automatically align scans into coordinate position. “The newer Triple Scan technology has helped with shiny and complex parts and is better able to capture holes, slots, and trim edges with faster throughput and fewer scans,” said Marc Demarest, sales engineer for the company. While useful for reverse engineering applications, Demarest notes that today 90% of their sales are for dimensional inspection. ATOS software is able to analyze point clouds for GD&T, Trend/SPC, 2D and 3D comparisons with color maps comparing to CAD nominal in addition to CMM-type reports.

Like any sensor, the ATOS can only look at a part from a single point of view, requiring either the sensor or the part to move. Enter automation. To reduce the cost and improve repeatability of integrated sensor and movement systems, Capture 3D has created a series of pre-defined commercial off-the-shelf inspection cells they call ScanBox. The smallest ScanBox is aimed at smaller parts and components, such as pistons or bearing housings while the largest is a double robot cell designed for entire body-in-white assemblies. The advantage is all of the engineering for robust, safe, yet mobile systems is done already. The ATOS Virtual Measuring Room (VMR) software has automatic sensor positioning so offline and online programming is fast and easy. This makes setup plug-and-play and shortens ramp-up time. Additionally, the company has a multiaxis motion control system called MC-XL to address both small and medium-sized parts, and also offer custom robotic cells for specialized inspection projects.

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Demarest reports an installed base of “several hundred.” Capture 3D’s automated solutions are especially useful for inspecting automotive body panels for flush and gap, as well as interior assemblies.

“Fifty percent of our sales are automated systems and I think that is going to increase in the next few years,” Demarest said, noting that customers include automotive OEMs as well as Tier One and Tier Two suppliers. While the vast majority of applications are for offline inspection supporting SPC, a popular growth application is combining a ScanBox with automated material handling for inline inspection, Demarest said.

Hexagon Metrology (North Kingstown, RI) has also automated its Cognitens WLS400A structured light system specifically for automotive body-in-white gaging and process control with its 360° Smart Inline Measurement Solutions (360°SIMS) solution. The cell configuration combines robot-mounted Cognitens sensors and skids for fast, inline measurement of parts from stampings up to full bodies-in-white, according to Scott Everling, product manager for Hexagon. The system also delivers quality control data, including SPC. While the structured light Cognitens is the main sensor for measurement, Hexagon also offers fixed measurement systems, such as lasers and 2D cameras for use on installed systems as well. The company has provided systems that specialize in body-in-white, chassis, and clo-

In a broad trend to make machine vision for inspection and guidance easy to use, Matrox like other companies provides an easy-to-use interface for manufacturers to set up vision and inspection tasks.

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Combining a 3D laser scanner on a robot to move a sensor around parts and assemblies, taking discrete snap shots of features such as holes, slots, surface, edges, studs, clips, gap and flushness is a growing application, such as this LMI sensor on a BlueWrist robotic installation.

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sures, according to Everling. While accuracy is dependent on the production application, the overall accuracy is 250 µm to 2 σ, and static accuracies are down to about 50 µm to 2 σ, according to the company. “Our customers are not asking for more accuracy, what they want is more data faster,” he said.

Why develop this now? “A number of our customers expressed the need for real metrology not only near-line, but inline during production,” explained Everling. “Demand in the marketplace coupled with technology opportunities led to this fast, inline measurement system.” Flexibility in data coverage is a key feature. “You can run both the more limited number of checks that one has traditionally done, but also run a full body inspection similar to what you used to on a CMM” during the startup phase and the PPAP process. “But you are not taking it offline, checking it on a CMM and waiting for the results—it’s embedded online and they can ramp-up faster.” During regular production, they can scale back the number of checks needed to ensure process stability. “However, if problems arise they can take more data for troubleshooting and continue to solve problems online.”

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