Machine vision increases productivity, reduces waste

It is hard to find a component, subsystem, or system in a modern automobile that hasn't been tracked, assembled or inspected with the assistance of machine vision technology. Short lead times, lean inventories, complex supply chains that span continents and the OEM demand for zero defects have all combined to use machine vision technology throughout the modern automobile manufacturing plant.

Initially, the automotive industry used 2D machine vision technology to track parts on conveyors, measure gaps between body panels, and improve production visibility while increasing quality. Today, faced with increasingly demanding customer bases and a highly competitive global marketplace, the automotive industry is taking productivity to the next level—and machine vision to the next dimension.

A number of mature 3D machine vision technologies are helping automobile manufacturers bring new car designs to market faster while reducing tooling costs. Single-, dual- and multi-camera 3D machine vision technologies are helping robots become flexible production machines that can be re-deployed as production needs change. By adding an extra dimension to their machine vision automation systems, industrial engineers can enjoy all the traditional benefits and features of 2D vision while automating hazardous applications once considered too challenging for traditional plant automation, such as adhesive dispensing, painting and welding.

In short, 3D vision-guided applications are helping automakers to:

- Improve quality and prevent defects;
- Achieve compliance with new traceability requirements; and
- Reduce waste, increase yield and boost productivity.

However, in order to effectively develop and deploy 3D machine vision applications, automakers, their suppliers, machine builders and systems integrators need to understand where 3D machine vision technology can improve the automotive manufacturing processes, the challenges for each application and the potential benefits.

How is 3D machine vision technology used in automotive manufacturing?

- 3D robot guidance for flexible manufacturing
- Improving robot precision, repeatability
- Racking and de-racking (large parts)
- Pick and place (small parts)
- Palletizing and de-palletizing
- Automated dispensing
- Automated painting
- Automated welding
- Assembly verification
- Track, trace, SCM (supply chain management), MES (manufacturing execution systems)
- Kitting verification/packaging
- Worker safety, lockout systems
CASE STUDY: 3D Machine Vision in Action: KWD Automobiltechnik GmbH

To produce a car side panel in less than 30 seconds, KWD Automobiltechnik GmbH (Wolfsburg, Germany), a subsidiary of Schnellecke Group AG & Co. KG, developed a robotic welding station using Cognex’s intelligent VisionPro® 3D image processing software to guide Kuka robots with custom motion control from W-Plan. Under the leadership of KWD supervisory programs, the vision-guided pick-and-place robots collect constituent parts, weld the parts into the side panel, inspection the panel for accuracy and place the finished panel on the production line.

To accurately assemble the three constituent parts into a complete car panel, the welding robots need to know how each part varies in shape from the programmed part, including any warp or distortion in the sheet metal parts, and where each component resides prior to welding.

Precisely synchronized

To generate this geometric and location data, KWD’s workcell uses VisionPro 3D vision software from Cognex to recognize the part position and possible distortions of the side panels in the supply rack, and then forward the data to one of the two robots in the workcell. The VisionPro 3D software delivers 3D position data in real time using the PatMax® geometrical pattern search algorithm and built-in calibration routines.

Initially, one robot positions itself with the gripper and integrated vision system in front of the component magazine, which holds the car body parts stacked horizontally. The VisionPro 3D software analyzes the images from the various cameras and measures the position of the parts before directing the robot to the first part in the stack.

The gripping is done in two steps. First, the parts are suctioned by a vacuum, whereupon pins pass into fits and secure the sheets. Meanwhile, a second robot positions itself with its two-sided gripping system and integrated 3D vision technology in front of the transport rack, which holds the larger components for the car body panels. The second robot checks the position of the transport lock, measures the position of the parts, and picks up the components in the correct position. Subsequently, both robots move to a turntable and put down the parts in the correct position and in the logical sequence for welding.

Using data from the VisionPro 3D vision software, each robot controller can adapt the gripper path to the actual part position in real time. The result is increased product quality compared with manual welding and processing, allowing the operator to focus on the operation of the system rather than the correct loading and unloading of parts.

Complete traceability

After the welding process is completed by the spot-welding robot, the first and second robots perform an optical spot-weld inspection. The number and location accuracy of the spot welds are inspected. The 3D vision system checks whether the welds were placed in the predefined fields. Based on the parameters of the welding control, the system examines whether the roots of the weld points are correct. The data obtained from the testing is archived, and images are assigned to the associated parameters. In this way, KWD Automobiltechnik achieves complete traceability and a securely documented verification of quality.
In the final work step, the second robot removes the finished welded component and places it in the transport frame for finished parts. If the required number of finished parts is stacked in the transport frame, the signal is sent to transport logistics, which collects the full transport rack and delivers a new empty rack.

**Complete checking**

In addition to robot guidance for part acquisition, placement and welding, Cognex’s VisionPro 3D also inspects a number of initiators and end positions necessary for quality production and efficient operation, such as the tensioning levers of the welding station. The transport pawls of the containers are also checked to see whether they are open or closed.

Lighting proved to be one of the biggest challenges in the implementation of the 3D vision system. The individual components of the side panels do not have a defined position in the transport racks and can be twisted or tilted, which changes how the light reflects from the sheet metal. Workcell designers solved the problem by:

- Constructing an enclosure with white interior walls, through which white light is dispersed evenly on the metal parts with the greatest possible angle of incidence
- Using the VisionPro 3D robust pose estimator, which has the ability to detect outlier features caused by reflections and remove them from the pose estimation calculation

After a nine-month development and commissioning period, the new plant is running three shifts at full speed.

---

**What are the principal challenges associated with developing these applications?**

- Developing the appropriate specification and verifying the application’s feasibility before large capital investment
- Finding a strong integrator, preferably one that is part of a strong system integrator (SI) network associated with major machine vision hardware and software vendors
- Selecting appropriate 3D machine vision hardware (single-, dual-, multi-camera, time-of-flight ToF sensors; white, structured light; processor type; I/O and communications protocols)
- Selecting appropriate 3D machine vision software and image processing algorithms
- Developing a robust system that is able to overcome ambient light changes and changes in shift operators
- Achieving sufficient spatial and temporal resolution for object inspection, tracking, and motion control (Do final parts exceed minimum specifications?)
- Achieving the required throughput and accuracy requirements to meet production needs
- Collecting all the data you need to manage defects, suppliers, and production
- Assessing whether your application is easy to install across multiple locations (reduced supplier list, engineering costs)
- Determining if your application is easy to maintain (training, support)
How do Cognex products help automobile manufacturers succeed with 3D machine vision?

Cognex supplies a range of hardware and software for 3D machine vision applications in the automotive industry, including VisionPro® 3D software for robot guidance, part dimensioning, and quality inspection.

Cognex’s extensive product catalog and best-in-class global system integrator (SI) network means we can provide everything the automotive industry needs to leverage 3D machine vision technology—including sensors, lighting, image processing engines, and image processing software. By offering hardware and software that have been extensively tested for compatibility and ease of integration, Cognex simplifies system design and accelerates the customers’ return on investment. And should the design of your 3D machine vision system prove challenging, Cognex’s position as the world’s largest machine vision company means automotive customers have access to the world’s largest global integrator and product support network.

Cognex helps automobile manufacturers succeed with 3D machine vision in the following ways:

**CALIBRATION:** Calibration is critical to the success of any 3D vision project. Application performance is enhanced by high-precision Cognex calibration tools that adjust for optical distortion and camera position and synchronize cameras with moving elements like robots and conveyors.

**FEATURE DETECTION:** The second element in producing accurate and reliable 3D applications is accurately and reliably detecting the features of the part. Cognex’s patented geometric pattern matching tool, PatMax combined with SearchMax™ and PatFlex® tools, determines the precise location of features on the part.

**3D POSE DETERMINATION:** The final element in producing accurate 3D applications is using the detected features to compute an accurate and reliable 3D pose of the part. There are many ways to compute the 3D pose of the part in VisionPro 3D, including:

- Single-camera 3D
- Multi-camera 3D photogrammetry
- Two-camera short baseline (stereo) 3D
- Applications with a combination of fixed and robot-mounted cameras

**SAMPLE CODE AND APPLICATIONS:** VisionPro 3D software also offers sample code and a sample application to simplify image acquisition, calibration parameter setup, calibration, and validation. The sample code and application can be used in the lab or deployed on the factory floor.

What are the benefits of using 3D machine vision in automotive manufacturing?

- Improve quality, reduce waste
- Improve throughput
- Reduce the need for expensive hard tooling/fixtureing
- Reduce labor costs
- Add flexibility to the production line
- Cut CapEx through robot re-deployment
- Improve traceability (SCM, MES)
- Reduce product liability
- Improve supplier relationships
- Improve worker safety for hazardous operations
- Reduce line turnover time

---

**Americas**

- United States, East +1 508 650 3000
- United States, West +1 650 969 8412
- United States, South +1 615 884 6158
- United States, Detroit +1 248 668 5100
- United States, Chicago +1 630 649 6300
- Canada +1 905 634 2726
- Mexico +52 81 5030 7258
- Central America +52 81 5030 7258
- South America +1 909 247 0445
- Brazil +55 47 8804 0140

**Europe**

- Austria +43 1 23060 3430
- Belgium +32 2 8280 693
- France +33 1 4777 1550
- Germany +49 721 6639 0
- Hungary +36 1 501 0650
- Ireland +353 1 825 4420
- Italy +39 02 6747 1200
- Netherlands +31 208 080 377
- Poland +48 71 776 0752
- Spain +34 93 445 67 78
- Sweden +46 21 14 55 88
- Switzerland +41 71 313 06 05

**Asia**

- China +86 21 5050 9922
- India +91 20 4014 7840
- Japan +81 3 5977 5400
- Korea +82 2 539 9047
- Singapore +65 632 55 700
- Taiwan +886 3 578 0060

**Turkey** +90 212 371 8561

**United Kingdom** +44 1327 856 040

---

© Copyright 2012, Cognex Corporation.
All information in this document is subject to change without notice. All Rights Reserved. Cognex, In-Sight, PatMax, PatFlex, and VisionPro are registered trademarks of Cognex Corporation. All other trademarks are the property of their respective owners. Printed in the USA. Lit. No. VNEG2-201206