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3D Vision Options Drive Machine Vision Growth

by Winn Hardin, Contributing Editor - AIA

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People intuitively understand their three-dimensional (3D) world. But teaching a machine to navigate a 3D world using a camera that only sees in two dimensions (2D) is anything but intuitive.

Today, machine vision designers have a number of techniques for automatically generating 3D data for machine vision assembly and inspections systems, from checking the alignment of automobile doors against the body, to confirming pills going into a package by both shape and color.

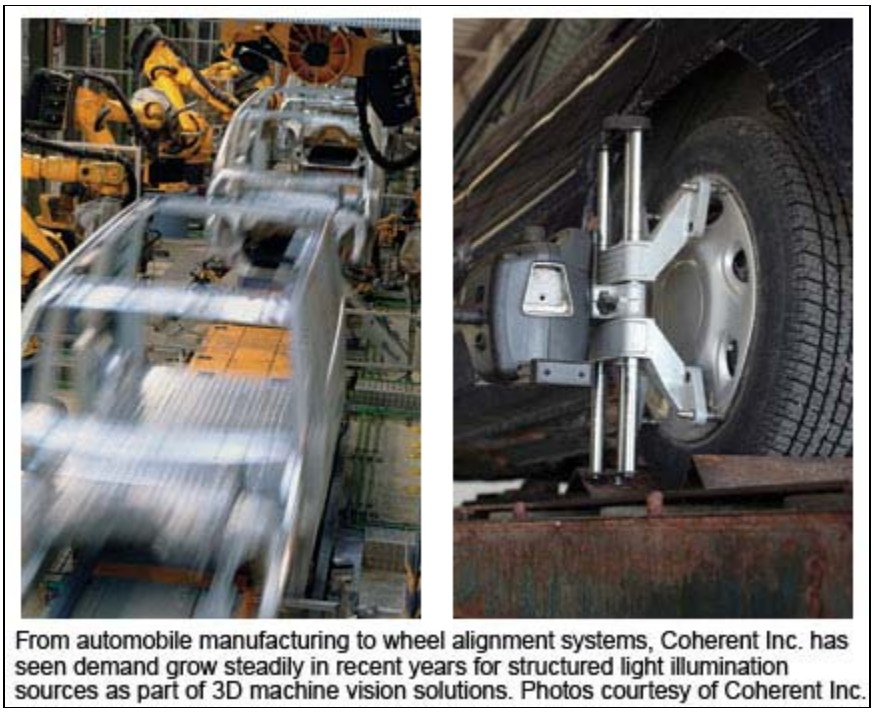
Low Cost, High Speed 3D

The human brain guides us through a 3D world based on slight differences in what each eye sees. However, using two cameras to mimic this approach adds cost to a machine vision system design and can add complexity to the software design and processing requirements. So when the benefits of a true stereoscopic vision system are not required, a more cost effective, high-resolution, and high-speed system will utilize a single camera.

New time-of-flight (ToF) cameras and cameras with structured light projectors are two ways to use a single camera to product. ToF systems can be very compact and cost effective, but are still evolving towards the higher resolutions and speeds required for many industrial applications.

Structured light solutions typically use a laser light source, and an area array camera to measure distortions in the projected line caused by height variations along the surface of the target object. Designers have a variety of illumination types to choose from depending on the application.

“The selection criteria are easy to understand when you consider the vision geometry,” explains Wallace Latimer, Product Line Manager for Machine Vision at Coherent Inc. (Santa Clara, California). “Most applications use some an array camera to image the pattern projected on to the test object. Simple trigonometry then enables the system processor to convert lateral pixel offsets in the recorded image line or lines into variations in height for example.”



From automobile manufacturing to wheel alignment systems, Coherent Inc. has seen demand grow steadily in recent years for structured light illumination sources as part of 3D machine vision solutions. Photos courtesy of Coherent Inc.

“So, a single point is used to provide single position height or offset information for objects on a moving production line,” Latimer continued. “A single line is used to produce a 3D map of a moving part. This is done slice by slice coordinated with the production line motion and/or by moving the laser line using some type of gimbal mount. In addition a multiline feature pattern is used to produce a 3D map of the same moving part but it can do this X times faster, where X is the number lines. A single line or multiline pattern is also used for 3D applications where it is the laser that is moving relative to a stationary object. Typical examples include a rail during a railroad wear survey where the laser is mounted on the underside of a moving car, or a road surface where the laser is projected from beneath a special van.”

In some cases, Latimer added, designers may choose to use a complex pattern of dots and/or lines to perform static measurements with a single shot. Here the customer is usually verifying the overall part shape or orientation, and is not targeting extreme dimensional accuracy.

Coherent offers a wide variety of laser solutions, including both illumination source and optics. The primary color for laser line generators remains red – due primarily to low cost, broad utility, and high quantum efficiency in that spectrum band from silicon-based image sensors. Designers will choose different laser colors when red does not offer sufficient contrast based on the reflectivity and absorption characteristics of the target object, said Latimer. Finally, Coherent always recommends that 3D machine vision system designers consider the use of filters to improve contrast and protect nearby workers. In nearly all applications, a narrow bandpass filter is used in front of each camera to block ambient light. Similarly, users are typically provided with goggles that are either based on cutoff filters or notch filters in order to block any scattered laser reflections from reaching their eyes.

Adding 2D to 3D Machine Vision

Humans intuitively see in 3D, but a human operator looking at a 3D point cloud on a machine vision system display may have difficulty understanding what they are seeing without other optical clues, such as colors and surface textures. “You can reconstruct a 2D image out of a 3D point cloud for the operator’s sake, but it takes a lot of computational power,” explains Donato Montanari, General Manager of Datalogic S.p.A’s (Bologna, Italy) Machine Vision Business Unit. “For this reason, Datalogic choose to use a stereoscopic approach to 3D using our MX embedded vision platform with multi-camera support. Using our Impact machine vision software, we can product high resolution 3D maps while allowing the operator to intuitively understand what they are seeing when they look at a product or defect on our system display.”

“Stereoscopic techniques have been widely used for larger area 3D inspection, such as for automotive assembly and inspection applications,” Montanari continued. “However, designers have typically used laser scanning for high-speed moving objects because of the potential to introduce blur into the image if the object moves during a

single camera exposure. We've overcome that problem with a custom illumination system with fast strobe capability coupled with frame-rate cameras. This allows us to use very short exposures on moving objects and create high-resolution 3D maps without concerns about blurred images. The MX embedded vision system makes higher levels of time synchronization possible among light sources and multiple cameras running short exposures because we control the hardware and software in a single platform. This level of synchronization wouldn't be possible using a PC host system. This also gives users the opportunity to use the same system to create 3D maps as well as locate 2D defects in traditional visible images."

According to Montanari, high-value or high-risk industries, such as the automotive and pharmaceutical industries, respectively, often request 3D vision solutions that can also output a 2D greyscale image.

3D Machine Vision Demand Grows

As with every technology, growing demand results in lower costs, with further drives demand. Machine vision solutions that use 3D techniques are no different.

"[3D machine vision] is currently a healthy and growing segment for Coherent," said Coherent's Latimer. "One important benefit of machine vision in this area is that it helps manufacturers to ensure greater cosmetic and aesthetic quality in their products, which enhances the overall perception of brand quality in the minds of their own consumers. This perceived quality issue is true whether we are talking about achieving better door and panel alignments in automobile bodies, or the quality of registration in bonded cases for smart devices. Simply stated, manufacturers of premium brands want better looking products and superior product consistency, and automated laser-based vision can help deliver this with 100% inspection, even for high throughput assembly lines. The other factor enabling our machine vision growth is product diversity. Just from these few examples….you can see that machine vision is characterized by incredible applications diversity, from inspecting a worn road surface to looking at the accuracy of case assemblies for smart phones."

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