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A Flexible Approach

Modular Laser Triangulation Enables 3D Vision Applications in Automotive and Other Industries

Manufacturers across many industries are continuously striving to maximize product quality and performance, while also improving yields. This is driving a "3D explosion" in machine vision, and laser triangulation is now often the preferred technology to quickly verify fit, form and function in a cost-effective way. For example, in the lumber industry, laser triangulation delivers increased yields and reduced scrap. In the automotive and consumer electronics sectors, the main benefit is often improved cosmetics, i.e., perceived increased quality. In this article, we briefly explain how a single camera can deliver 3D information by clever orientation of the camera and the laser projector, and review some applications from the automotive industry.

Why Laser Triangulation?

Modern manufacturing is characterized by increasing use of automated methods. This enables companies to deliver higher product functionality, consistency and quality while minimizing manufacturing costs. The automotive industry is a standout example of this, where robotics and techniques like laser welding have long replaced intensive use of manpower on continuous production lines. A critical component in most automated processes is feedback, often in the form of some type of quantitative machine vision. And since most products are three dimensional objects, the vision metrology system typically must provide three-dimensional capabilities. Laser triangulation is a simple and proven method of deriving three- dimensional metrology data with the advantages of high speed and non-contact measurement. Moreover, laser triangulation is very flexible, which also makes it cost-effective. Specifically, modular systems are streamlined to deliver just the data needed for process feedback. With clever use of structured laser light patterns, such as arrays of dots, straight lines and grids, systems typically only require a single camera to simultaneously generate up to several pieces of critical dimensional measurement data.

The earliest, and still the most common, laser triangulation architecture is the single straight line projection geometry. Here, simple optics fan out the laser beam so that it forms a straight line of illumination on the part. When viewed by a camera from an angle different from the projector, the line is distorted by the surface of the part – see figure 1. The system controller converts distortions in the two dimensional digital image into three dimensional information using trigonometric algorithms. Individual installations differ greatly but nearly all are variations based on just four basic geometries commonly referred to as Standard, Reverse, Look-Away, and Specular, as shown schematically in figure 2. Advantages of the Standard geometry are speed and simplicity of calibration. The Reverse geometry is often preferred for planar objects. The Specular geometry may be preferred where height resolution is a primary consideration or where low object reflectivity (i.e., image brightness) is an issue. And conversely, the Look-Away arrangement is sometimes used where high object reflectivity is a challenge.

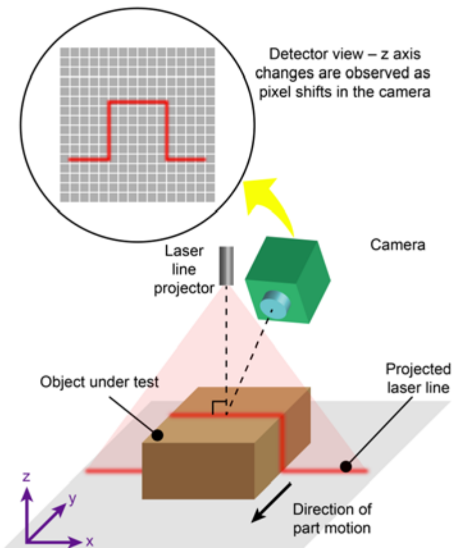

Figure 1. A projected laser line appears distorted when viewed from perspectives other than that of the projector.

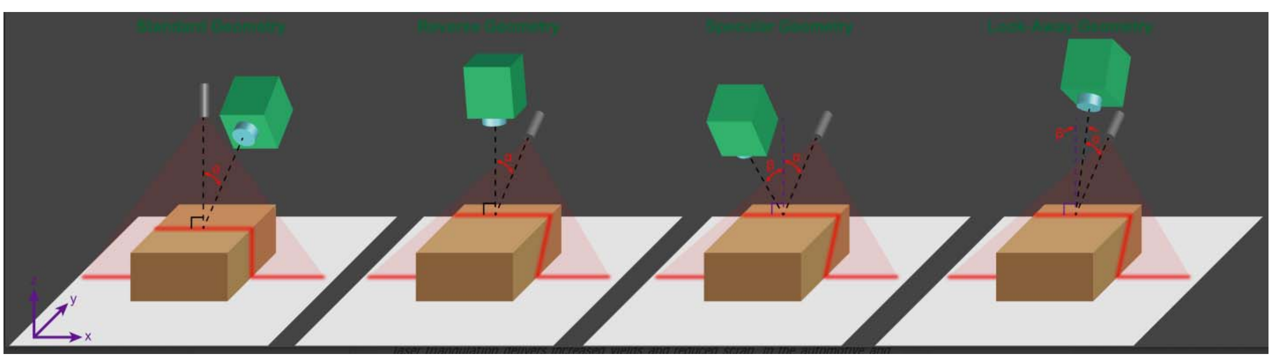

Figure 2. The most common implementations of laser line projection are based on the Standard Geometry, Reverse Geometry, Specular Geometry, or Look-Away Geometry.

Even for modules producing a single line projection there are many variables that impact performance and cost of the machine vision system. As a result, manufacturers like Coherent not only offer modules with a range of power levels and choice of several wavelengths, we also use different types of optics to spread the beam, in order to provide each application with a line that delivers the requisite intensity uniformity, linearity (straightness) and depth of focus needed for successful implementation in the most cost-effective format.

Some Applications from the Automotive Industry

The automotive industry is one that continues to make extensive use of laser triangulation in order to support its increasing reliance on robotics and automated assembly. Windscreen installation, tire manufacturing (and installation), side panel installation and alignment, and component-level inspection (clutch plates) are just some examples where laser triangulation plays a critical role.

Tires arguably represent the most expensive mass-produced "consumable" in the automotive industry: over 1 billion vehicle tires are produced worldwide annually. Each tire is built up on a drum from multiple components, starting with the inner liner followed by various fiber and rubber layers. A key step is the application of the tread, which is made in a long continuous strip by extrusion, and whose pattern and composition is optimized for long life, or sport handling, etc. The extrusion is monitored using a single laser line projection in the standard geometry described previously. The line is projected at 90º to the extrusion direction, across the outer (i.e., tread side) of the continuously extruded strip so that the entire tread area (depth and profile) is sequentially sampled. This application has traditionally been serviced with red lasers, but we are seeing growing interest in blue and green wavelengths which will improve contrast, and possibly resolution.

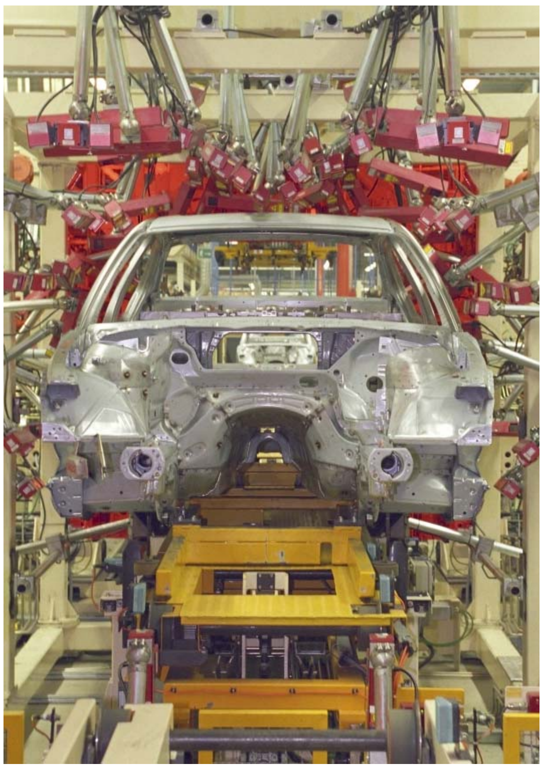

Figure 3. The contemporary automotive production line features an extremely high level of automation, including robotic actuators and supporting machine vision systems.

Another long-established application at the component level is inspection of clutch plates for contour and dimensional accuracy, including height changes and surface irregularities. In this relatively simple application, a single line projection spans the diameter of the clutch plate as it is rotated. Triangulation of the line image then provides a high resolution scan of the entire plate. As seen in figure 3, laser triangulation is also widely used to provide 3D feedback in automobile body assembly – for example to check the orientation of body panels prior to welding and to correctly position the windscreen prior to bonding. Consistent gaps are required for correct function, e.g., rain sealing, lower wind noise, as well as for cosmetic perceived value considerations. Here a line is projected across the gap between body panels or perpendicular to the edge of the windscreen. To increase speed of measurement by threefold, many of the body seam applications use three parallel line projections, rather than a single line for each of the four edges of the windscreen.

Summary

Laser triangulation is a flexible approach that is often the best solution to the growing need for 3D vision for process monitoring in numerous industries. Laser manufacturers support this market with a range of projection modules which enable system integrators and end users to get the optimum combination of performance and cost for each specific application.

Autor(en)

Petra Wallenta, PR / MarketingCommunications Manager Europe

Kontaktieren

Coherent (Deutschland) GmbH
Dieselstraße 5 b
64807 Dieburg
Telefon: +49 6071 968 0
Telefax: +49 6071 968 499