Illumination Improves Telecentric Lens Performance

Machine vision systems that use telecentric lenses require a lighting method that complements these precision optics.

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Beleuchtung verbessert die Leistungsfähigkeit von telezentrischen Linsen
Bildverarbeitungssysteme, die telezentrische Linsen verwenden, benötigen eine Beleuchtungsmethode, die zu diesen Präzisionsoptiken paßt.

L'éclairage améliore la performance des lentilles télécentriques
Les systèmes de vision qui utilisent des lentilles télécentriques exigent une méthode d'éclairage qui complètent les optiques de précision.

Una corretta illuminazione migliora le prestazioni delle lenti telecentriche
I sistemi di visione artificiale che impiegano lenti telecentriche richiedono un metodo d'illuminazione specifico.

Machine vision uses a system of components comprising software, a high-resolution camera, optics and an illumination source. Telecentric lenses used in two-dimensional machine vision have an optical design that images objects anywhere in the depth of focus with the same size.

The difference between telecentric and conventional lenses is illustrated when measuring bore holes. Telecentric lenses show the front and back diameters in the same size because of the extreme position of the entrance pupil of the lens. Because it lies at infinity, the chief rays of the light bundles are parallel to the optical axis. The depth of focus of the system depends on the image scale and the aperture stop diameter, which defines the numerical aperture.

Most materials and surfaces require a lens and illumination adapted to the geometry, texture, colour and reflective behaviour of the object being measured. The precision of telecentric lenses requires object lighting of the same calibre.

The telecentric lens CorrectalT from Sill Optics GmbH is used with coaxial surface illumination and a retroreflector sheet.

The best method for measuring contours is through-light illumination, which places the light behind the object. When high precision is unnecessary, diffuse backlight illumination is usually sufficient. A flat panel backlight, for example, is simple to use and to align, and low cost. But the diffused incident light rays can cause reflections, which limit reproducibility.

As machine vision requirements increase, the inaccuracies from diffuse backlights become intolerable. Therefore, telecentric through-light illumination is recommended, because it uses only light rays that are parallel to the axis for illumination. Undefined reflections from the edges of the object will be stopped.

Homogeneous illumination

Telecentric condensers from Sill Optics GmbH comprise highly corrected collimation optics and a visible or infrared light-emitting diode (LED) as a point light source. The chief ray's angle deviation to a parallel of the optical axis of telecentric lenses, such as the CorrectalT series, is better than 5 mrad. To ensure a homogeneous illumination ratio at every field position, the performance of a telecentric condenser must be equal to that of the telecentric imaging lens. Otherwise, the light rays from the illumination system cannot pass through the pupil of the imaging lens, thereby missing the aperture. Using both telecentric illumination and imaging lenses precisely aligns their optical axes.

Partial diffuse telecentric illumination uses the advantages of telecentric lighting and minimizes adjustment. In this setup, an extended source provides a defined field angle.

To inspect bore holes and grooves or the surface structure

Illumination Sources

	Description	Advantages	Disadvantages
	Illumination box behind the object	• No alignment problem • Low price	• Disturbing light reflections • No flash mode possible
	Telecentric condenser behind the object	• High-precision measurement • Flash mode possible	• Alignment effort
	Ringlight directly in front of the lens	• Homog. illumination	• In most cases cold light source is necessary
	Illumination box beside the object	• Low price	• Inhomog. illumination
	Spot	• Local increase of density is possible	• In most cases cold light source is necessary
	Coaxial telecentric surface illumination	• Deep structures are illuminated without shadows • Polarization effect can be used	• For large object fields cold light source is necessary
	Coaxial telecentric surface illumination plus retroreflector sheet behind the object	• Quasi through light illumination with little need of space • Combined application of through light and surface illumination is possible	• For large object fields cold light source is necessary

of nontransparent objects, the light must hit the object from the side of the lens. This is called surface illumination.

There are two types of surface illumination: dark field and bright field. With dark-field illumination, an object is lighted from the side. With bright-field illumination, an object is lighted from above. A ringlight around the aperture of the lens provides a solution. To increase the ambient diffuse light ratio, illumination boxes are placed at both sides of the inspected object. With the help of spots, details can be illuminated.

To light the surface of an object, coaxial telecentric surface illumination is suitable. Sill Optics offers telecentric lenses with optional coaxial illumination, based on optical polarization. An integrated beamsplitter cube reflects light of only a single polarization. An extra polarizer blocks the other orientation to minimize stray light. The polarized light from the lens can be used for optical effects.

An LED can be used as a light source. When the intensity of light is insufficient, cold light can be guided to the object with a fibre bundle. An LED light source is a cheaper solution with a longer lifetime so long as the light intensity is sufficient.

A retroreflector sheet can increase the intensity without extra illumination. These sheets reflect in the incident direction. This has the same effect as through-light illumination, but it needs no space behind the object. The flat sheet is adhesive and easy to place. The intensity of the reflected light is so high that a charge-coupled device camera can see only the contours of the object, because the contrast between directly reflected light from the retroreflector sheet and diffuse reflected light from the object is extreme. A complementary metal oxide semiconductor camera can see the surface and, with its high dynamic range, even darker structures. Another solution is to reduce the intensity of the reflected light with a neutral density filter. □