Lenses for Machine Vision

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ALRAD IMAGING
ALRAD INSTRUMENTS
ALRAD - Company Profile

• **ALRAD** are a Distribution company for Imaging, Electro Optic, Analytical Components and Instruments including:
  – CCD and CMOS cameras
  – Frame Grabbers and Digital Acquisition Cards
  – LED and Laser Lighting for Machine Vision
  – Imaging and Image Processing Software
  – Optics, Lenses
  – Linear and Area Sensors
• Trading since 1970, 40 years in business.
• Two divisions – Imaging and Electronics
Lenses for Machine Vision

General Considerations

Popular Lens mounts for video cameras

- C - mount
- CS - mount
- S - mount aka M12
- F - mount

Common sensor formats and resolutions

<table>
<thead>
<tr>
<th>Sensor Format</th>
<th>VGA</th>
<th>XGA</th>
<th>SXGA</th>
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<tbody>
<tr>
<td>1/4in</td>
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<tr>
<td>1/3in</td>
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<td>UXGA</td>
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<td>2/3in</td>
<td>SXGA</td>
<td>QSXGA</td>
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Visible Light Applications

The majority of machine vision applications cover the Visible region of the EM spectrum, from about 380nm to about 700nm. Silica “crown” glass is the material of choice for most optical components for visible light applications, and **BK7 glass** is the typical grade used. Various coatings are usually applied to limit reflection losses on the surfaces of elements of compound lenses, as well as to optimise performance at particular wavelengths.
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UV Applications

The UV region of the EM spectrum is generally considered to cover wavelengths from 50nm to the limit of the visible light at c. 380nm. The vast majority of UV applications fall between 200 and 300nm, and most UV lenses are optimised for that region. High purity Quartz is the preferred optical material. Typical applications include medical, fraud detection (e.g. banknotes), materials testing and analysis of transparent materials.
Lenses for NIR / SWIR (900 – 2500nm) applications employ special coatings. Typical uses are for InGaAs sensor cameras, for applications such as: perimeter surveillance, border & port security, food sorting, road monitoring, aerial imaging, food sorting, quality control, and art conservation.

NAVITAR offer 1” format fixed focal length lenses (25, 35 and 50mm)
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LWIR “thermal” Applications

Long Wavelength Infra Red, usually considered to be 8 – 14 microns region of the EM spectrum is utilised by “Thermal” cameras using, e.g. microbolometer sensors. The lens material is usually high-purity microcrystalline Germanium with various coatings applied.
Machine Vision Factory Automation Lenses

A number of Manufacturers offer a vast range of lenses for a huge variety of general and specialist applications.
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New developments in board lenses

1MP 1/3" IR CORRECT BOARD LENSES

- Up to 1MP Image Quality
- IR Correct To Over 900Nm
- Suitable For 1/3" and 1/4" Cameras
- Five Focal Options 6/8/12/16/25mm
- F1.6 Fixed Iris
- Compact Size
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New developments in board lenses
“Megapixel” lenses offer high resolution of at least 100 lp/mm over the entire FOV. With the increased sensor resolutions, new classes become available from various manufacturers, currently 1.5Mpix, 3Mpix, 5Mpix and 10Mpix.

Focal lengths are usually between 5 and 50mm and are predominantly designed for the 2/3” format sensors.
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Low Distortion Lenses

Low distortion lenses, available in C-mount and M12 mount, are ideal for high precision applications such as inspection, measurement and OCR.
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“High Speed” Lenses

Lenses with wide apertures, typically F0.95, are typically required for low-light applications, such as fluorescence and research, often for use with ICCD and EMCCD cameras.

A small number of manufacturers offer a limited number of models, usually with 17, 25 and 50mm focal lengths.
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Lenses for 3CCD cameras

3CCD cameras are typically used in applications which require very high colour fidelity, e.g. biological and medical imaging. Each sensor images the whole FOV in one colour (usually R, G and B).

This requires a sensor arrangement where 3 image sensors are combined with a prism and filters. The sensors tend to be 1/3” format (sometimes 1/2”) and because of the prism geometry, require a specific construction restricting the protrusion of the rear element.

A few manufacturers offer a limited selection of lenses, in the focal range from 4 to 50mm.
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Macro Zoom Lenses

For specialist applications, e.g. laboratory and instrumentation. Manufacturers offer modular multi-component systems, which often includes a motorized option. Benefits include high resolution, wide FOV range, long WD and compact size.
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Lenses for Line Scan Sensors

Line Scan cameras tend to require a large image circle, typically 20 – 70mm in diameter. Lenses for these application usually feature high resolution and low distortion. F-mount is a frequent requirement.
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Telecentric Lenses

These lenses are used mainly for highly accurate measuring applications, often used as a high magnification macro lens if small dimensions are required.

VST offer a wide range of telecentric lenses, mainly small to medium diameter, fixed iris, with axial illumination option.
OptoEngineering is a optics company specialising in Telecentric Lenses and Systems, as well as other specialist optics. Their bi-telecentric range covers a wide range of sensor compatibility (up to 2/3” format) with high resolution and low distortion.
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Telecentric Lenses

Some measurement applications using Telecentric Lenses

On the left: an image of an internal spline on a cylindrical object taken with a telecentric lens (top) and the same object viewed by an ordinary lens (bottom).

On the right: an image of two identical machine screws 100 mm apart, taken with a telecentric lens (top) and an ordinary lens (bottom).
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Telecentric Lenses

vicotar® optics serve all these perspectives and more ...
Lenses for Machine Vision

Telecentric Lenses

vicotar® optics

Influence of the optics on the image produced

Distorted and distortion free image
Strong perspective / perspective-free image
Perspective and reflections / without both.

Precision and robustness is one of the most important features of vicotar® objectives.
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One object – different perspectives to image

- **entocentric**
  perspective centre is in front of object
  nearer objects are larger, distant objects are smaller

- **telecentric**
  perspective centre is at infinity
  nearer and farther are the same size

- **hypercentric**
  perspective centre is behind the object
  nearer objects are smaller, farther objects are larger
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vicotar® optics – general features & decisive differences

- **model variety**
  a vicotar lens for every task.
  optimized lengths and working distances
  large range of accessories

- **robust design**
  tough to deal with harsh industrial conditions
  well defined mounting methods, lockable adjustment elements

- **high quality imaging**
  ensures simple and reliable test programs.

- **telecentric imaging**
  freedom from perspective in the image
  for stable measuring, independent of working distance
  difficult test objects can be inspected
  wide spectrum from micro to macro.
vicotar® optics – general features & decisive differences

- **new designs**
  
  introduction of telecentric lenses to the market at the beginning of the 1990s

  other innovative Machine Vision developments:
  
  wide-field lenses
  
  inspection of machined holes by non-invasive optics

  hypercentric lenses
  
  lenses with extreme perspective properties.

vicotar® lenses have made possible the use of Machine Vision in application areas which have previously been inaccessible.
Lenses for Machine Vision

**vicotar® entocentric objectives – application**

- monitoring work, presence checking, attributive tests, colour checking
- measuring possibilities are extremely limited

**tempered steel drill:**

*at different working distances it has different widths but the same tip angle of 49°*

Different classes of entocentric lenses.
Due to its lightweight construction with plastic lenses telecentric wide field objectives can also be used in industrial environment.

inspection of 85 mm deep car catalytic converter with approx. 10,000 channels (0.8 mm); left: with entocentric lens, right: with telecentric lens