Vision Sensors Information

Vision sensors (a.k.a. machine vision or vision systems) are products consisting of a video camera, display and interface, and computer processor to automate industrial processes and decisions. These are commonly used for measurement, pass/fail decisions, and other observable characteristics relating to product quality. When the camera has an integral processor, it is called a smart camera.

Vision Sensor Operation

Machine vision systems provide data interchange between a video camera and computer-based software. The images captured are compared against criteria specified by the operator to determine subsequent actions. This criteria can be based on barcodes, blot/stain detection, sizing and alignment, and a variety of other characteristics that can be determined solely by non-contact examination. Vision sensors are particularly helpful when multiple features must be inspected on the product. There is usually some degree of tolerance for each article. Vision sensors are considerably quicker and more accurate than humans employed for the same task.

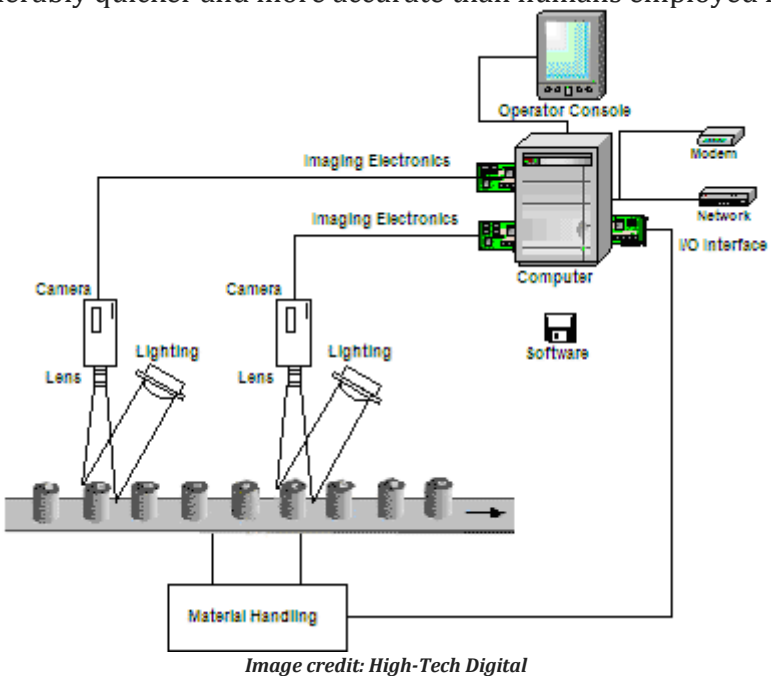

Image credit: High-Tech Digital

Tasks of machine vision systems include, but are not limited to, the following:

- High-speed product inspection (quality control)
- Measurement
- Counting

- Sorting
- Locating
- Decoding
- Robot guidance

Multiple jobs can be performed simultaneously and are commonly achieved by the software's identification of one or more of the following when placed in the camera's field of view.

- Shape, pattern, or color
- Object detection, including object geometry and assembly
- Alignment
- Barcode or alphanumeric symbol recognition (OCR)

Quality imaging of the processes is essential for accurate analysis. Lenses, mounting and lighting are important, unless the camera selected is designed to overcome some environmental shortcomings (e.g. low light cameras). For certain applications 3D, infrared, linescan, or ultraviolet imaging may be required.

Microscan Systems, a machine vision systems manufacturer, has produced a video series in regards to machine vision. Their section on the components of vision sensors and their influence on machine accuracy is particularly informative.

Video credit: Microscan Systems / CC BY-SA 4.0

Vision Sensor Disadvantages

While the benefits of machine vision sensors are substantial, the disadvantages of machine vision can be prohibitive. Machine vision systems are unable to cope with unforeseen circumstances and input. While ultimately cost-saving, high development costs can be expected for installation and personnel training. Constant levels of appropriate illumination can be difficult to maintain, and cameras can have difficulties isolating products in congested environments.

Vision Sensor Features

Vision Sensor Mounting

Cameras in vision sensors are exposed to the production process, and are susceptible to damage or corruption. Hardened camera cases and lens are available to protect cameras from loss. Most cameras in vision sensors are mounted permanently to ensure the camera records the proper field of view. Brackets, arm mounts, and vibration resistant mounts are all acceptable means of camera placement. Typically, two connection points are sufficient between the camera and the support.

Computer workstations for a manufacturing environment are kept away from machinery to reduce risk to the expensive interface. These include dust-resistant designs, translucent acrylic or polycarbonate housings, and lockable cabinets. Connectivity between the camera and computer is facilitated by wired links like Camera Link, FireWire, USB, Ethernet, or composite cable. Wireless connections are supplied via the Internet, or other type of LAN (e.g. ZigBee).

Camera Options

These specifications are often optional on video cameras, but depending on the implementation of the vision sensor they could enhance image quality in atypical recording situations.

- **Anti-Blooming**: Saturation occurs when the light that is sensed exceeds a pixel's capacity to emit electrons. Excessive charge can bleed into adjacent pixels and cause bright spots or streaks to appear on the image, a condition known as blooming. Anti-blooming gates remove excessive charge and can significantly reduce blooming, but often at the cost of reduced sensitivity.
- **Auto-Lens**: Auto-lens operation is a mode in which the lens iris automatically adjusts to maintain a predetermined level of light on the image pickup device. With unattended vision sensor cameras auto-lens ensures a focus field-of-view at a permanent distance.
- **Board Mount**: Camera optics are mounted directly on a printed circuit board (PCB). PCBs are useful in sensor operations with little clearance for camera mounting, but these may prove insufficient for some high-quality imaging requirements.

- **Cooled Sensor**: Sensors are actively cooled by a Peltier element or other method. This is essential for some CCD image sensors, as cooling reduces "dark current" noise and improves sensitivity.

- **Dome**: Cameras are enclosed in a protective dome made from materials such as acrylic or polycarbonate. Typically, these materials are optically-corrected for accurate image capture. This can create a tamper-proof and damage-resistant housing common for security and factory conditions.

- **Gamma Correction**: Gamma is the nonlinear relationship between the video signal level and the subsequent image element brightness. Gamma correction compensates for this nonlinearity in order to render the image true in color while providing intensity to the original object.

- **High Definition**: High definition is a video standard that has higher picture sharpness, larger picture, more colors, and higher quality sound than regular video standards. The low-end threshold for HD video is considered 1,280 x 720 pixels.
- **High-Speed Camera**: High-speed cameras record images at a higher frame rate than a typical camera. After recording, the images can be played back in slow-motion for close study of actions that may be ephemeral. This is particularly helpful for scientific study, but has a wide variety of other uses. Almost all modern high-speed cameras are digital in design and capable of recording over 1,000 frames per second. Too many frames per second sacrifices area coverage while also producing a large, unwieldy file. In conjunction with advanced vision sensor systems, high-speed cameras can provide super-fast product inspection.
- **Low-Light Camera**: These are meant to be used in dark situations where an otherwise suitable camera will not reach an exposure level capable of capturing an image. The cameras contain image sensors that are exceptionally perceptive of subtle light sources. Automatic gain control is a common way of providing surplus low-light imaging capabilities.

- **Outdoor Rated**: Outdoor-rated devices are designed to withstand outdoor temperature variations, rain, snow, and other weather conditions. This can be important in lumber mills and other natural resource-dependent industries.
- **Pan/Tilt**: These devices have integral or optional mounting features enabling side-to-side (pan) and up-and-down (tilt) controllable motion.
- **Progressive Scan**: This is a CCD design that allows acquisition of both even and odd fields at the same time. Each pixel contains information from one complete frame. This technology allows high resolution without the use of a mechanical shutter. Progressive scan cameras are used for image acquisition of rapidly moving objects and accurate dimensional measurements.
- **Radiation Hardened**: Devices are designed to withstand high levels of radiation. These cameras can be used in nuclear facility applications, or in scientific research that will expose the device to radiation.
- **Underwater Rated**: Devices are designed to work when completely submerged in water. This feature can be added with an aftermarket housing, and is also a versatile solution for general outdoor use.
- **Zoom**: Cameras are designed with a feature that allows the device to closely focus on distant objects. Optical zooms offer better resolution than digital zooms.

- **3D Recording**: The camera has the capability of recording images in three distinct directional planes. This is helpful for multiple features in machine vision systems.

Vision Sensor Applications

The advantages of vision sensors are considerable, and many processes that involve a human inspection can utilize vision sensors to maximum efficiency. Industries already employing machine vision systems include food packaging and beverage bottling; automotive, electronics, and semiconductor assembly; and pharmaceutical companies. Common tasks for machine vision include robot guidance, pick-and-place processes, and counting. Railroad companies use machine vision for hi-rail automated rail inspection. Children's toy manufacturer Lego® produces toy kits that utilize low-power vision sensors for scale-model machine vision capabilities.