The Right Choice

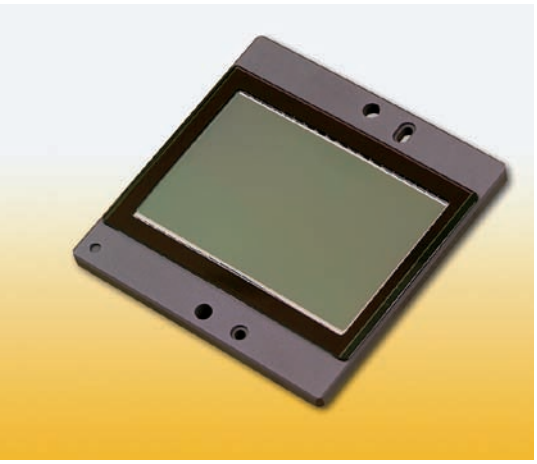
Key Questions for Camera Selection

Evaluating camera choices by examining base sensors such as this 16-Megaixel pixel Kodak KAI-16000 quickly leads to a tradeoff maze that can be simplified by first understanding key application requirements (Source: Eastman Kodak)

The camera is a key element in machine vision systems that replace humans in industrial tasks such as inspection, metrology, and sorting. Many factors go into camera selection, however, leaving developers with a bewildering array of options to consider. Answering a few key questions about the specific application can help focus the search and speed selection, but they may not be the questions you expected.

Approaching camera selection by looking first at technology can quickly become overwhelming as many factors interact, forming tradeoffs that require careful consideration. Camera resolution, for instance, seems like a simple parameter with first reactions saying that the more pixels the camera provides the better. But pixel size can also be important. For a given pixel count, small pixels provide finer detail but a smaller image field, while large pixels offer wider exposure latitude.

Even pure pixel count has its tradeoffs. One that, in general, the more pixels a camera has the longer it takes to download the image for processing so frame rate (pictures per second) drops. In many industrial applications the camera frame rate can limit a system's production speed, hence manufacturing revenue, while highest resolution may not be required. As a result, camera vendors such as Imperx offer products with a wide variety of pixel counts to allow optimum matching of speed and resolution to the application. The Imperx Bobcat series, for example, ranges from VGA (640 x 480) resolution at 250 frames/second to as large as 16 Megapixel at five frames/second.



When selecting cameras for industrial imaging applications, avoid technology-centric evaluation and consider implementation needs, instead (Source: Imperx)

CCD or CMOS

Other technology-based camera evaluation approaches can also quickly become confusing. Much has been made of the differences between CCD and CMOS imaging sensor technologies, for example, but what seem like benefits can quickly become liabilities with improper implementation. Because CMOS imaging uses the same base technology as digital logic, it offers an opportunity for creating compact designs through system-on-chip (SOC) integration. Yet the heat from the additional logic can also generate thermal noise in the image sensor, reducing image quality. And clever engineering using CCD sensors can achieve the kind of compact design that SOC integration promises without the thermal problems. The Imperx Bobcat cameras up to 5 Megapixel resolution, for instance, use 2/3-inch CCD sensors yet achieve a size of only 45 x 45 x 39 mm.

Application Requirements

Rather than approach camera selection by examining the various technology options, then, industrial system developers should explore the application in depth. One of the first questions to ask is 'What is the vision system looking at?' The answer to this question can go a long way toward determining the camera's resolution requirements as well as camera size and lens design. It also helps determine whether or not color imaging is required and if linescan-type cameras are feasible. Linescan cameras require either the object to be imaged or the camera to be moving at a steady rate in order to form a complete image, so lack of movement in the application can quickly narrow the field of choices.

Another key application area to explore is the operating environment. If the camera is to operate in an environment where vibration, moisture, or temperatures are excessive, a ruggedized camera may be required, further narrowing the field. The space available for the installation can also reduce choices. Developers should even understand object illumination characteristics such as wavelength, intensity, direction, and the like. A camera that works exceptionally well under controlled lighting conditions may perform poorly if dependent on natural illumination. Infrared or ultraviolet illumination may make key elements of an image more visible, but will require specialized cameras.

Once the camera acquires an image, what outcome or decision must arise? A simple pass/fail or sorting decision may only need a basic image that is within a simple camera's ability to provide. A metrology application that matches an image to a template may require a more sophisticated camera and the higher the metrology's precision needs the greater the resolution the camera must offer. Sophisticated quality control applications looking for subtle variations that can indicate the type and amount of process adjustments required often re-

quire high-performance cameras.

Processing Backbone

Another area to consider is the vision system platform with which the camera must work. Does the system have to be mobile or is it in a fixed location? Will it connect to a laptop PC or to a dedicated image processing host? Where is the frame grabber (image storage) for the image processor? Is the image processing to provide real-time decisions and metrology or is the image stored for later analysis?

With real-time image processing requirements, where is the processing to occur? In many cases a smart camera that provides some image pre-processing before delivery to the system can have major advantages. The Imperx Bobcat series, for instance, can perform tasks such as automatic exposure and gain control, white balancing, and other global enhancements in real-time to offload those tasks from the vision system and speed throughput.

Interfaces

The camera's connectivity is another important system issue to settle before making the camera selection. Camera-Link and Gigabit Ethernet are common camera interfaces and each has its strengths. Ethernet uses inexpensive cable and interface cards and allows the camera to be as far as 50 m from the image processor. It is bandwidth limited, however. While a Gbit/second sounds impressive it is relatively easy for a camera to exceed that data rate. A 2 Megapixel high-definition camera at 32 frames/second with at 12-bit dynamic range on the image already exceeds what the serial Gigabit Ethernet can sustain. Next-generation cameras will be offering 14-bit resolution.

CameraLink addresses the bandwidth issue by offering more than 200 Mbytes/second but requires a relatively expensive 24-pin cable and specialized interface. The cable is also limited to a 5 m run. On the other hand, CameraLink parallel structure provides a more robust and deterministic data transfer than the packet-based Ethernet, providing reliable real-time performance for activities such as triggering.

Finally, developers should consider the amount of in-house expertise they have available to apply to camera selection issues as well as software development for the image processing. With in-house limited resources developers should consider enlisting the help of camera vendors or distributors to help in the selection process. In either case, the answers to the key system questions will help guide the camera selection process through the maze of possibilities.

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