By Kristin Lewotsky

Choosing an Interface

The digital interface choice depends on application variables such as speed, distance and resolution.

- Interface standards
- Camera Link
- GigE Vision
- Hardware and many standards

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No matter how sophisticated its technology, a company is only as good as its communication. Similarly, no matter how advanced the components of a digital imaging system, performance is only as good as the interface. How do you make the right choice, whether you're a camera manufacturer, a system integrator or an end user? As with many things, it comes down to understanding your choices and applications.

Although analog cameras still represent the majority of imagers sold, the proportion of digital cameras sold is steadily rising. There are four major interface formats currently vying for position in the digital imaging market: USB, FireWire (IEEE 1394), Camera Link, and GigE Vision. Although USB offers the familiar plug-and-play performance we're used to from consumer computer applications, it was never designed for imaging. It may be appealing for certain medical applications that require plug-and-play performance, but it lacks the speed and control options of the alternatives, so we won't focus on it here.

FireWire is a cabling interface intended for a wide range of applications, not just machine vision. It offers power within the cable, but it's not fast enough for high-resolution imaging, not compatible with networking, and it is not as broadly supported by computer manufacturers.

THE CAMERA LINK CONNECTION

Prior to the development of these standards, the basic interface was parallel LVDS, which left far too much unspecified. "Every camera manufacturer used a different connector and pinout, every frame grabber also had a different pinout and connector as well," said Steve Kinney, product manager at JAI-Pulnix (San Jose, Calif.) and Camera Link standards committee chair for the Automated Imaging Association (Ann Arbor, Mich.). The chaos motivated the effort to develop digital interface standards specifically for machine vision.

Camera Link was the first AIA standard released. Requiring a frame grabber, it offers speeds of nearly 700 MB/sec over cables as long as 10m, and real-time camera control from the frame grabber to the camera. The industry verdict so far? It works. "For a high-speed application where minimal or zero latency of the image delivery is required and we want a strong set of controls over camera hardware," said David Dechow, president and owner of system integrator Aptura (Lansing, Mich.). "I think there's nothing at this moment that can do more than Camera Link."

An imminent upgrade will specify miniaturized cabling and by year end, an additional upgrade will feature a powered cable.

The standard has some challenges,

however. It's not as simple as just buying a Camera Link camera and frame grabber and plugging in the cable. From an end user standpoint, it's essential to ensure that the specific Camera Link components chosen will be able to work together. "Camera Link just defines the data highway between the camera and the frame grabber," said Kinney. "If the frame grabber can only accept a 40 MHz max pixel clock before, then the frame grabber still only accept a 40 MHz max pixel clock (with Camera Link), even if the Camera Link data highway provides 85 MHz worth of bandwidth." It's also essential to ensure that the components touted as Camera Link components actually are such—you can confirm the latter fact by checking the list of approved suppliers on the AIA website.

More significant issues stem from performance. If your application requires interfacing over more than 10m, Camera Link isn't for you. A potentially bigger concern is that the standard is point-to-point— one camera, one computer port. For some applications, this is sufficient. For applications requiring multiple cameras for a single inspection or a network integrating multiple inspection stations, though, the standard is limited.

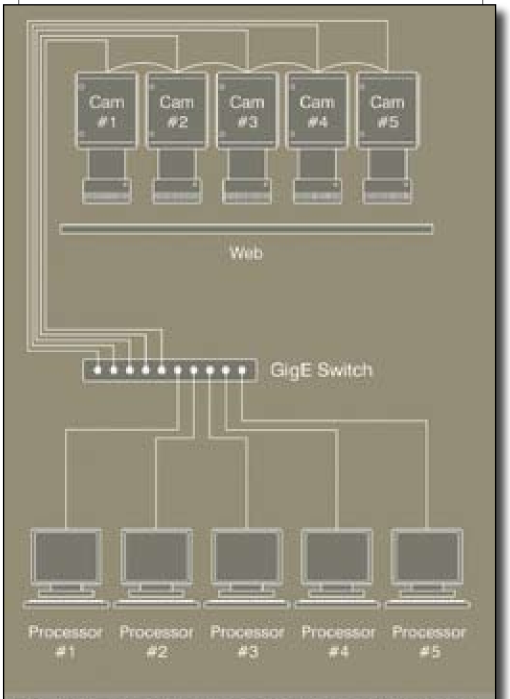
Not that there aren't ways to get around it, Kinney said. "Because there's such high bandwidth, some manufacturers are able to connect two or four slower cameras, multiplex them to appear like one camera, then use Camera Link connect back to one port on the PC." The frame grabber then separates the images.

GIGE VISION GETS GOING

Gigabit Ethernet was designed from the beginning for computer networking. Approved in May 2005, GigE Vision is designed to leverage the Gigabit Ethernet standard to create a packet-based interface standard tailored to machine vision and imaging applications. The approach offers big payoffs. Currently operating at 1 Gb/s, GigE Vision is set to migrate to 10 Gigabit Ethernet and faster. GigE Vision will also scale. "The standard doesn't discuss that transport layer," said Jeff Fryman, director of standards development for the AIA. "We interface on the one side to it and interface on the other side from it, so as it increases speed, GigE Vision will come along with it."

GigE Vision also operates over distances as long as 100m, and with relatively low cost cable compared to other technologies.

But engineering is always a process of dealing with tradeoffs. As with Camera Link, manufacturers may tout GigE Vision products that are not compatible with the standard. The AIA plans to go one better than just listing approved suppliers, though; they're in the final throes of approving a software tool that customers can use to test a GigE Vision component to ensure compatibility.



GigE networks enable multiple point broadcast and parallel processing.

Courtesy Dalsa.

The basic standard does not involve a frame grabber—data goes directly to the PC, where it is integrated into an image. That takes PC processing power, perhaps 3 percent for a VGA-resolution camera, but that goes up by a factor of 10—20 percent to 30 percent—with the shift to 10 Gigabit Ethernet. "Yes, there is a scalable path to 10 Gigabit Ethernet, but people need to keep in mind that since you don't have a frame grabber for image reconstruction, going to 10 Gigabit Ethernet is going to increase the workload of the CPU by the same amount," said Eric Carey, manager of the smart product group at DALSA (Waterloo, Ontario, Can.) and committee chair for the AIA GigE Vision standard. One solution is to use a transmission offload engine to release the CPU from having to deal with the packets, a technique that GigE Vision may eventually incorporate in the future, Carey noted.

A bigger issue stems from the inherent packet-based nature of GigE Vision. For an ultra-high-speed application that involves, triggering, for instance, the standard may introduce unacceptable latencies. Then again, points out Carey, most PC operating systems do as well, particularly Windows, the most commonly used interface. Real-time operating systems like QNX can eliminate the latter latency, but they're unusual and require specialized staff or integrators.

Which brings up what, in Carey's experience, may be the most common problem of GigE Vision system integration —the double-edged sword of networking. Networking can be a powerful tool, but it requires skills more commonly found in IT departments than engineering.

Among the four standards, it falls to the end user to determine which balance of capabilities best fits the application at hand. If plug-and-play performance is paramount and your application can tolerate short distances and low speed, then perhaps USB will suffice. If you need high speed and direct camera control, but can tolerate 10-m distances and point-to-point configurations, then go with Camera Link. If cost and cabling length are more important than speed, then FireWire may be your option. If you can tolerate some latency but you need to network a system over an entire production floor and want speed scalability, then GigE Vision is your best choice.

To satisfy this range of needs, manufacturers should ideally support more than one standard. Again, this philosophy raises challenges—if you're focusing on the two AIA standards, for example, you need to offer two separate pieces of compatible hardware, whether you make cameras, frame grabbers, or cabling. The best approach is a modular design, though you'll still need engineering and support staff with capabilities in both standards.

Trying to be everything to everybody is no more successful in business communications than it is in digital interfaces. Ultimately, it comes down to first principles in engineering success: Know your application requirements, know your limitations.

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