

# Frame grabbers get the picture when video cameras fall short

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Even when digital video cameras do away with frame grabbers ADCs, capture boards remain vital in real-time industrial imaging.

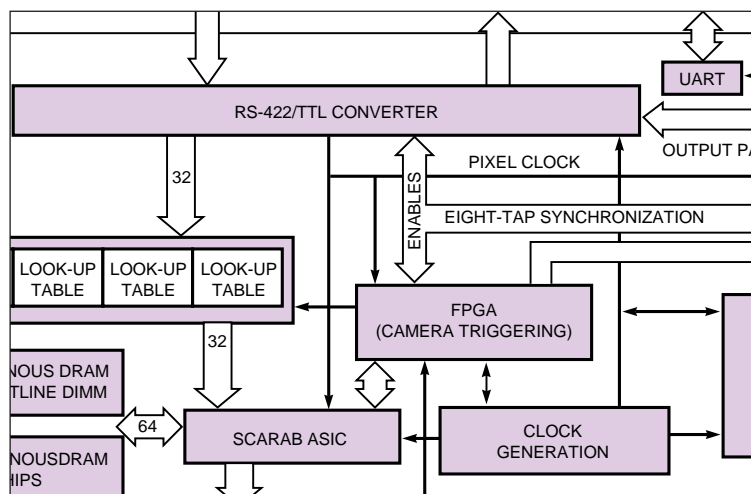
Video cameras that produce digital rather than analog outputs are here, but their arrival won't put an end to frame-grabber boards at least not for some time. Technology may yet overtake these camera-interface boards, which also go by the names of image-acquisition or image-capture boards. But years will probably go by before cameras incorporate all of the interface functions that industrial imaging requires. And the emergence of cameras that meet industrial needs without additional hardware is by no means certain.

Mass-market camera manufacturers may be unable to justify producing cameras that do away with frame grabbers. Some in the industry speculate that a new type of unit, which you will connect between a mass-market camera and a PC, may take over today's frame-grabber functions and perform additional ones. Frame-grabber boards from the current crop trigger acquisitions, select regions of interest within images, and modify images' gray scales to make elements stand out.

Industrial-imaging-system architects could make good use of a cost-effective, intelligent interface located close to the camera and outside the PC. In many applications, a smart interface could

reduce both the amount of data that travels to the host computer and the CPU's computing load. Indeed, such interfaces are already available as custom-designed items embedded systems, really. Some units even include the image sensor, justifying the name camera. Examples of such units are Imagenation Corp's Machine-Vision Cells.

Without host participation, a smart interface on a production line might, for example, reject over-filled and underfilled bottles. To perform this task,



This analog-input board, Matrox's Corona (\$1495 to \$2495), is also a 64-bit graphics controller. The board incorporates a PCI-bus master/slave interface, which can transfer images to the host PC's memory faster than 100 Mbytes/sec. The board can simultaneously display the acquired images with 24-bit color depth.

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the unit would compare images of newly filled bottles with an image of a correctly filled one. The decision to accept or reject a bottle is more complex than you might think, especially if the bottles contain not a liquid, but expensive solid objects, such as pharmaceutical tablets. A simple guard band around the portion of the bottle image where the tablets stop and the cotton plug begins might provide inadequate accuracy. Although interfaces of this type might inherit the name frame grabber, smart image-capture unit seems more descriptive.

The future is out of focus

Regardless of the form that next-generation products take, until they arrive, PCI- and even ISA-bus frame-grabber boards will remain a mainstay of industrial imaging. New boards that work with digital cameras are emerging from R&D labs, but analog cameras aren't playing dead just yet.

Despite desktop digital cameras' low cost, digital cameras whose resolution and frame rate suit them to industrial uses cost more than similarly performing analog cameras. Moreover, such high-end digital units are experiencing the kinds of teething problems that are common with most new technologies. The lack of I/O-signal and connector-pinout standardization is typical of difficulties of this sort. Therefore, frame-grabber manufacturers continue to enhance and cost-reduce lines of boards that work with analog cameras.

Digital-output cameras move the ADC out of the frame grabber and into the camera sometimes right onto the camera's image-sensor chip (Reference 1). The ADC is an expensive component, and you might think that moving it into the camera would improve frame grabbers and lower their cost. Many digital-input boards indeed offer advantages over their analog-input siblings. But despite the low cost of desktop digital cameras, digital technology is still more expensive than analog technology for most industrial imaging applications.

A noteworthy feature of digital-input boards is lower noise and, hence, wider dynamic range, even when long cables separate the camera from the frame grabber. Long cables between analog cameras and frame grabbers are sus-

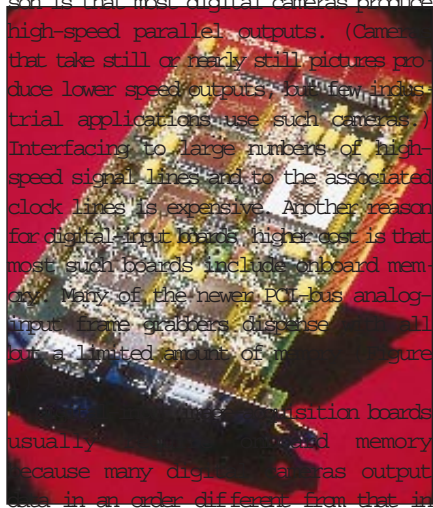
## @ a glance

- Most industrial imaging involves high-speed video capture, the requirements for which differ considerably from those of desktop video.
- Despite the low prices of digital-output desktop-video cameras, digital-output cameras for industrial applications usually cost more than analog-output cameras with similar performance.
- For industrial imaging, image-capture boards remain indispensable, although, in time, specialized cameras may assume the boards' functions.
- Even though digital-input image-capture boards lack ADCs (the ADCs are in the digital cameras), the boards usually cost more than analog-input boards. The reason is that PCI-bus analog-input image-capture boards can get by with little or no onboard memory, whereas digital-input boards cannot.
- Because analog cameras and boards cost less than their digital counterparts and the digital technology is still experiencing teething problems, analog units remain important, despite the digital units' superior performance.

ceptible to performance-degrading noise pickup. So far, however, the digital boards cost more than analog ones. Couple the higher board cost with higher camera cost, and you have a recipe for continued interest in the older analog technology.

Pricier than you might expect

Part of the explanation for the higher board cost lies in lower production volumes. But even when volumes increase, the savings that some users anticipate probably won't fully materialize. One reason is that most digital cameras produce high-speed parallel outputs. (Cameras that take still or nearly still pictures produce lower speed outputs, but few industrial applications use such cameras.) Interfacing to large numbers of high-speed signal lines and to the associated clock lines is expensive. Another reason for digital-input boards' higher cost is that most such boards include onboard memory. Many of the newer PCI-bus analog-input frame grabbers dispense with all but a limited amount of memory because many digital cameras output data in an order different from that in



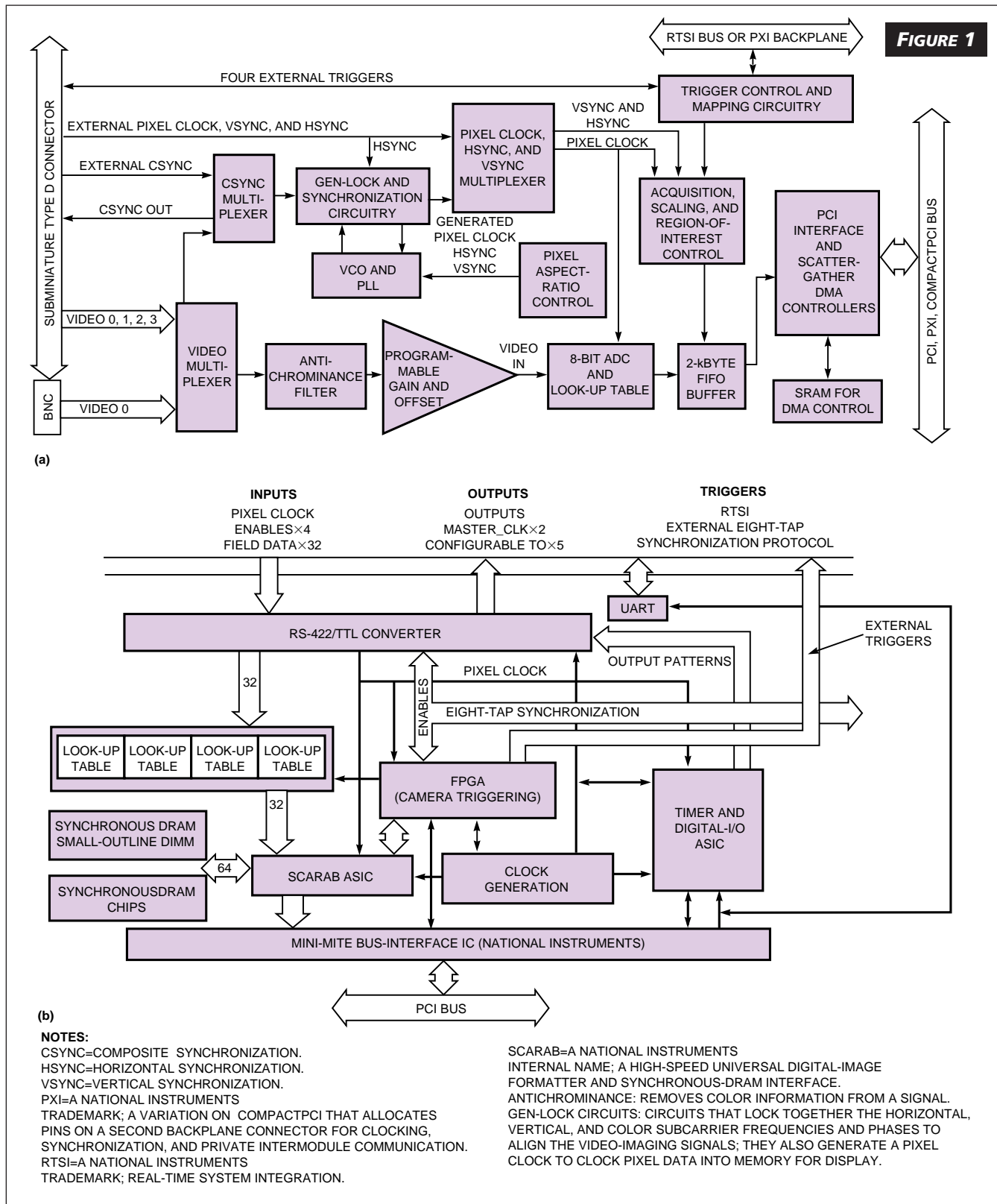
Digitization to 16 bits, combined with 3-D display at resolutions to 1600X1024 pixels, distinguish Coreco's PCI-based Bandit board.

which the pixels appear in the image. The acquisition board must accept the data in the order in which the camera transmits it. The board buffers the data and sends it to the PC in the order in which the pixels appear in the image usually left to right and top to bottom.

Cameras that provide no parallel digital interface, but instead interface to the IEEE-1394 (Firewire) serial bus, have started to appear. Firewire proponents characterize the bus as an ideal digital-camera interface, and it may be ideal for desktop video. But Firewire can have drawbacks for industrial imaging. The serial bus speed currently peaks at 400 Mops, although manufacturers of 800-Mops Fire-wire ICs are already sampling their wares to OEMs. But a camera that generates 1000X1000-pixel, 24-bit/pixel images at 60 frames/sec produces data at a rate 1.8 times as high as 800-Mops Firewire can handle.

Although few industrial applications involve such high resolution or such great color depth (many use monochrome images), most industrial applications use multiple cameras (often, four or five). Interleaving the bit streams from the several cameras can still overload the Firewire bus.

Moreover, synchronization of image acquisition with external events is a common industrial requirement. Nowadays, nearly all video cameras use CCD image



These PCI-bus analog-input (a) and parallel-digital-input (b) image-capture boards share many functions but also differ in important ways. The only signal memory on the analog board is a 2-kbyte FIFO buffer. The digital-input board accommodates high-capacity synchronous-DRAM (SDRAM) chips and an SDRAM small-outline DIMM (courtesy National Instruments).

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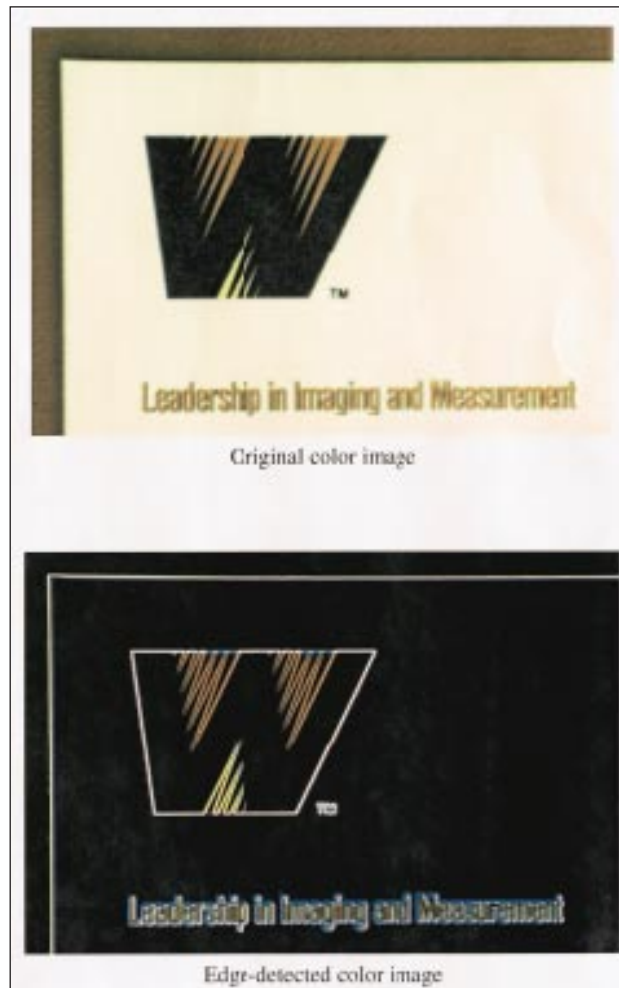
sensors. According to frame-grabber-board designers, CCDs are very forgiving, and it is no problem to reset them, say, to start acquiring a new image midway through the acquisition of another image. But if you want to reset the CCD, the camera that contains it must accept a reset signal. That capability requires a camera with a bidirectional interface. Although Firewire is bidirectional, the initial Firewire-interfaced cameras lack bidirectional interfaces; they simply pump data onto the bus.

Comparing the block diagrams of analog-input and parallel digital-input image-capture boards reveals many similarities and some differences (Figure 1). Both of the diagrams are for National Instruments PCI-bus boards. The digital-input board is not simply a copy of the analog-input board with the parallel digital interface replacing the analog interface and ADC. Although the boards use a few of the same devices, the designers partitioned many of the functions differently, which complicates the comparison.

As is common with such boards, both boards multiplex their inputs among several cameras. Thus, applications that use as many as four cameras need only one image-acquisition board.

As is typical of most image-capture boards, both boards include only limited image-processing capabilities. The idea is to have the host CPU or a separate DSP coprocessor perform the more complex image-processing functions. However, the boards not only control image acquisition, but also perform some image processing. The limited processing (defining a region of interest, using a look-up table to modify the gray scale) is more than a value-added nicety. Such functions enable PC-based industrial-imaging systems to control manufacturing processes in real time. This real-time capability makes image-capture boards indispensable.

The cost of the two boards is considerably different. The digital-input PCI-1424



Algorithms that detect the edges of objects within color images can simplify identifying those objects, even if the image is subsequently converted to monochrome (courtesy Wintress Engineering).

costs \$2195 with 8 Mbytes of RAM, and you can purchase the board with as much as 72 Mbytes. The analog-input PCI-1408 costs \$1195; a CompactPCI version, the EXI-1408, costs \$1395. All prices include the vendor's NHMAQ software.

#### Wide price range

Prices of frame grabbers vary widely, depending on features and performance. Reference 2, a white paper, presents one vendor's view of the factors you should consider when you select a frame grabber. Most of the points apply to analog-input boards, but some also apply to digital-input units.

Two major suppliers, Data Translation and Matrox, offer analog-input boards priced at less than \$600 and \$700, respectively. Despite their low prices,

some of these boards handle full color. Prices for other models reach \$2000 and more. The companies also offer digital-input models. Data Translation supplies a digital-input board for less than \$1500. You can also purchase boards incorporating DSPs that perform complex image processing. A vendor whose product mix emphasizes such capabilities is Imaging Technology. The price of an analog-input board with a DSP can exceed \$3000.

Different image-capture-board manufacturers divide industrial imaging applications into different categories. Here is one such list:

- counting objects,
- determining the location or position of objects,
- measuring dimensions, gauging,
- recognizing or identifying objects,
- reading analog or digital meters,
- inspecting objects,
- identifying flaws in manufactured parts, and
- determining whether parts meet quality standards.

Manufacturing companies use vision systems for many reasons.

The most obvious is to save labor costs by replacing human operators with automated systems.

Several other situations suggest

using a vision system, however. Among the environments in which vision systems are useful are:

- those that are extremely hot or cold or that are subject to radiation levels that can harm humans,
- those with light levels that are too low for human operators,
- those that are extremely clean, in which the presence of humans would introduce unacceptable contamination, and
- those in which events occur so slowly that human attention would wander or so quickly that humans can't keep up.

Imaging systems have received a warm reception from electronics manufacturing in the manufacture of ICs as well as subassemblies. According to the Automated Imaging Association ([www.automatedimaging.com](http://www.automatedimaging.com))

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ated-imaging.org), electronics accounted for almost 40% of 1994 s North American industrial-imaging-system revenues. The food industry, which accounted for about 10% of revenues, was next.

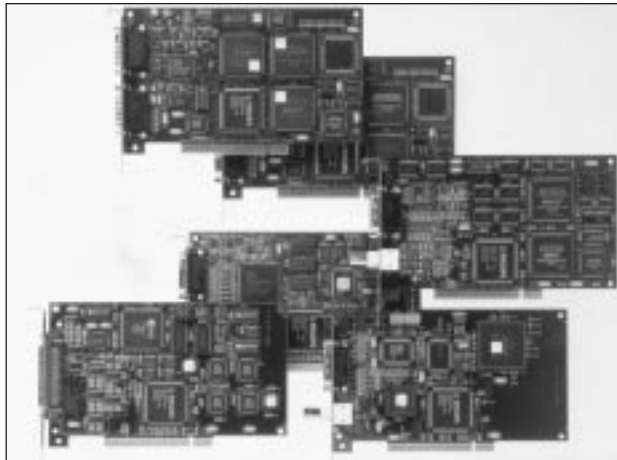
## Tip of the iceberg

In one sense, frame-grabber boards and cameras are just the tip of the industrial-imaging iceberg. Even when you add the cost of the PCs to which these items connect, you account for not quite half of the approximately \$1.5 billion spent worldwide each year on industrial imaging. The remainder goes into software and system integration.

Many companies that want to apply imaging to their manufacturing operations do not feel that they have the necessary talent to successfully develop imaging systems in-house. Development of imaging applications represents a sizable business, populated mostly by small and medium-sized resellers and system integrators. These companies integrate components from one or more manufacturers into their systems. Some of these system houses also act as distributors, selling system components to companies that do in-house industrial-imaging-system development.

Developers who work for system houses are likely to write applications in languages such as C and to obtain drivers from a company that specializes in imaging-system-component drivers. Some system houses devote considerable energy to writing drivers. They not only use the drivers in the systems they sell, but also separately market the drivers to people who buy hardware components directly from hardware manufacturers. In addition, several driver suppliers furnish drivers to hardware manufacturers who ship the drivers with their boards and cameras.

Several board suppliers also provide application-development packages that aim at helping relative neophytes to industrial imaging develop machine-vision applications. For example, National Instruments offers imaging-software modules that adapt the company s more general application-development packages, LabView and LabWindows/CVI, to imaging-system development.



This line of economical frame grabbers, Data Translation s Mach series, includes the DT3157 (lower left). The \$1495 PCI board accepts two 8-bit inputs (or one 16-bit input) at 40 Mbytes/sec.



The Hi\*Def Accura PCI board from Imagraph not only digitizes analog signals at 140M samples/sec with -500-psec timing accuracy, but also captures high-resolution, noninterlaced images to 1280X1024 pixels at 75 frames/sec.

## References

1. Wright, Maury Digital-camera interfaces lead to ubiquitous deployment, EDN, Jan 15, 1998, pg 63.
2. Imagenation Corp, Choosing a frame grabber for performance and profitability, [www.imagenation.com](http://www.imagenation.com).



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