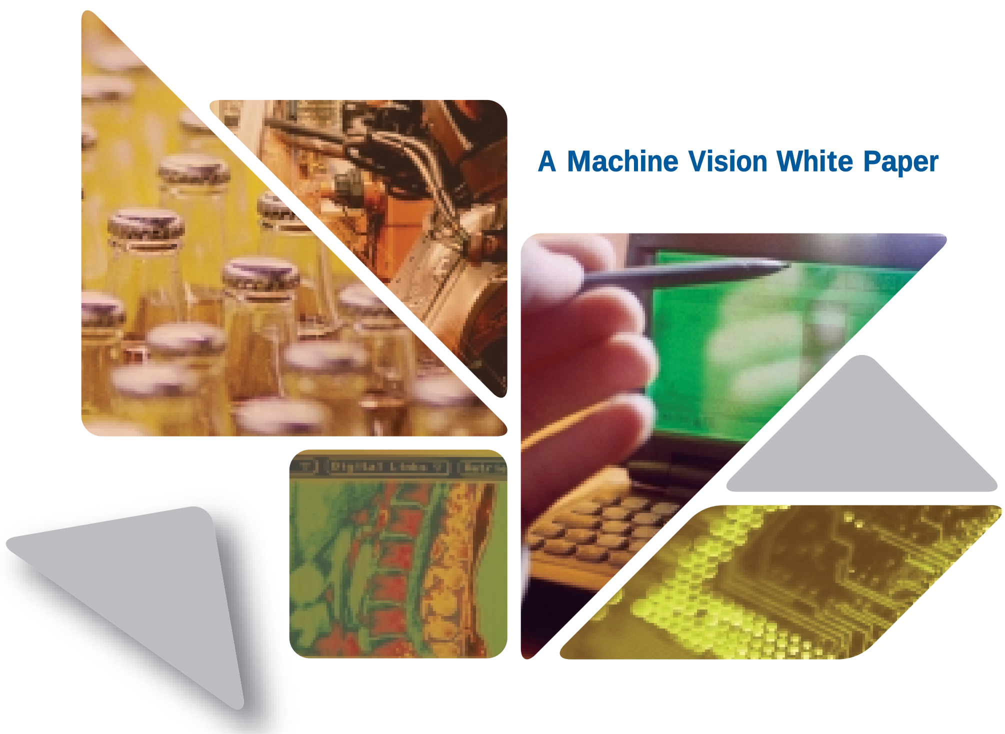
Choosing the Right

Image Acquisition Technology



A Machine Vision White Paper

CORECO iMAGING

EXCELLENCE IN MACHINE VISION

Today, machine vision is used to ensure the quality of everything from tiny computer chips to massive space vehicles. Machine vision has evolved to become a vital and effective automation tool that enables computers to replace human vision in many high-speed and high-precision manufacturing applications.

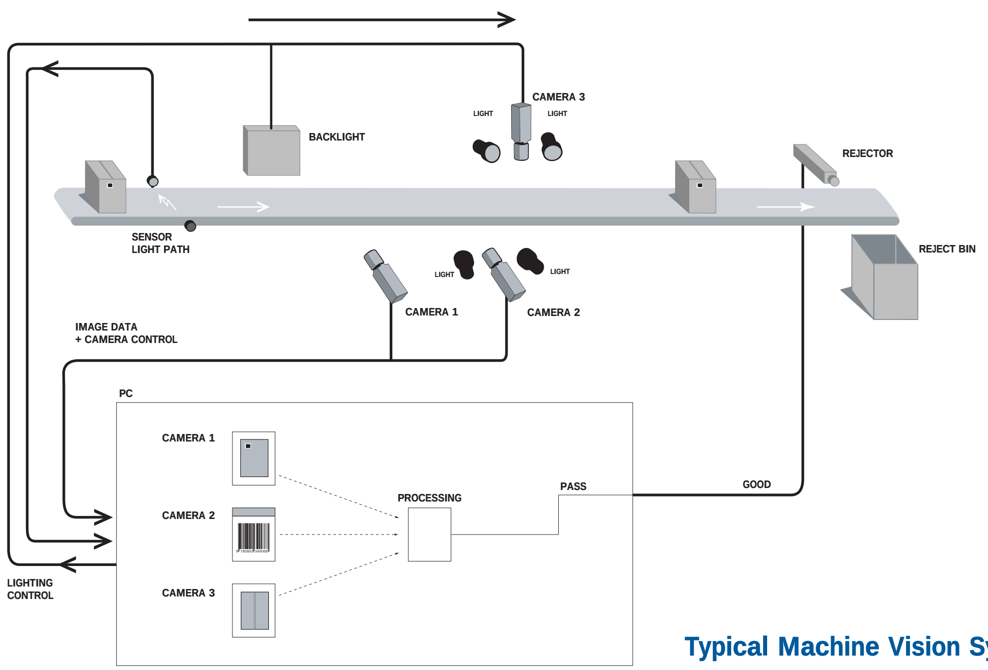
While improvements in the performance of this technology have encouraged more and more companies to adopt machine vision, significant challenges remain in designing and building highly reliable vision systems for truly demanding applications. Not the least of these is the challenge of integrating a number of discrete components that must work together efficiently in any system.

This white paper will focus on one of the key processes within the vision system—the image acquisition process—and more specifically, on the image acquisition board (frame grabber) and its related software. It will outline the critical functions these components play and discuss some of the recent engineering innovations being deployed to significantly increase the reliability of this process.

FUNCTIONS DISCUSSED INCLUDE:

- **Programmable Delays**
- **Managing False Triggers**
- **Time Stamping**
- **Circular Buffers**
- **Validating Data Integrity**

Frame grabbers play an essential role in ensuring that a machine vision system acquires an image of the correct target, and that the stored image data correlates to the correct target and that the data is then transferred reliably to the system's memory for processing. Achieving this level of dependability requires integrating various image acquisition control functions—including trigger inputs, strobe outputs, camera control signals and external I/O—into on-board hardware, and using software functions for command and control.



Typical Machine Vision System

ACQUIRING THE RIGHT TARGET

Integrating camera control functions such as trigger and strobe control into a vision system's on-board hardware sounds simple enough: a trigger input generates a strobe output for lighting control and camera exposure. Some circumstances, however, demand a delay between the two events, such as when the camera and lighting units are not in the same position on the conveyor as the trigger sensor. Coordinating the events through software is certainly not reliable—especially given the inherent variations in the Windows operating system.

To compensate, some frame grabbers permit programmable delays between the signals, so that developers can establish a precise delay between the trigger input and the firing of the lighting and camera exposure. Unfortunately, any programmed delay reflects only the theoretical speed of a production line. If the actual speed differs or is not constant, the camera will not acquire the target properly.

In contrast, a frame grabber that includes an integrated trigger and strobe mechanism always matches the production line's actual speed by establishing each delay according to shaft-encoder ticks. This feature allows proper control of the camera to capture the image of the target being inspected. Although these hardware features remain under software control, once initialized they act independently to produce consistent and predictable results.

TRIGGERS, TRIGGERS, AND MORE TRIGGERS

After a camera sensor acquires a target image, the inspection system must read the data from the sensor and transfer it to the host computer for processing. It's nearly impossible to anticipate all the conditions that could lead to unreliable image acquisition. The sensor may never detect the object in the first place, so it won't generate a trigger signal to the system. To combat this possibility, some frame grabber manufacturers are working with camera vendors to take advantage of the new camera models' fast-scan and partial-scan modes that allow the frame grabber to act as the triggered device.

Too many triggers (as in false triggers) can also occur. Or triggers can follow so close together that the system cannot read the sensor memory completely before the next exposure occurs. In this case, the system can notify the host application software of missed triggers through event callbacks. The analysis software becomes aware of the double trigger and automatically rejects the target into the "not inspected" bin, flags the error for a human operator to review or takes other appropriate action.

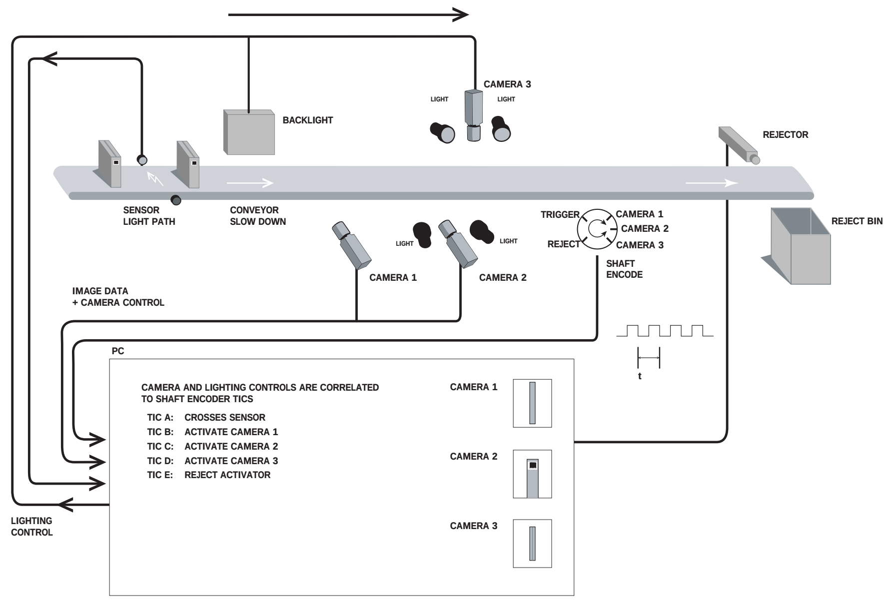
TIME STAMPS

Detecting targets, firing lighting strobes and cameras when the targets are in place and reading the correct data from the sensor are only the beginning of a reliable image acquisition process. The system also has to coordinate the image data and correlate the images with the corresponding physical objects.

Consider a parts-handling unit processing up to 3600 parts/minute. The system must inspect all four surfaces of each part. Because of positioning, it cannot acquire all four images at the same location, but must acquire them individually as the target moves through the system. The imaging system must therefore acquire 14,400 images/minute and correlate four different acquisition locations with the image data stream. As each object emerges from material handling, the inspection system must decide whether to accept, reject or re-inspect it.

To correlate all this data, a frame grabber can add an important piece of information to the mix: a time stamp. A time stamp inserts a unique time code into the image data structure, derived either from an on-board hardware clock or from the shaft-encoder ticks. This provides a direct correlation between the movement of the target through the system and the acquired data.

Shaft encoder or time stamp provides a direct correlation between target and data.



Because there is a time lag between image capture and analysis, the time stamp ensures that the system always acts on the correct target. The time stamp can also help with long or high-speed image sequences, where analyzing the time interval between images can determine if an image was missed during the capture sequence.

MONITORING THE ACQUISITION PROCESS IN HOST MEMORY

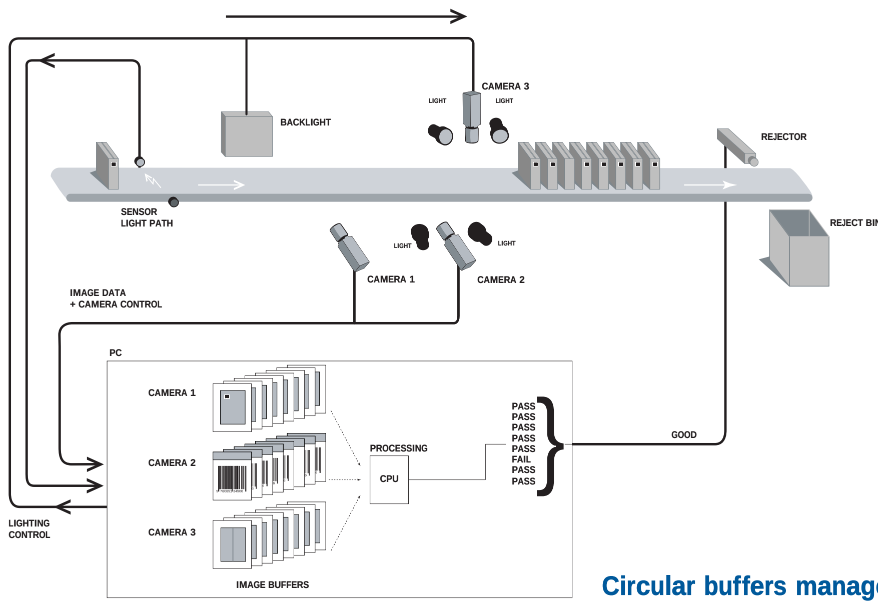
When transferring image data into system memory, software can ensure that the frame grabber captures all the necessary images accurately. Tracking the events (Table 1) allows the inspection system to accurately monitor the capture and transfer sequence.

Table 1. Capture and transfer sequence

EVENT	ACTION
Trigger	Notifies the host application that a trigger event has occurred
Double trigger	Notifies the host that a trigger event occurred that did not produce image data
Start of frame/field	Notifies the host that an image is being acquired
End of frame/field	Notifies the host that an image has been acquired
Start of transfer	Notifies the host that an image is being transferred to system memory
End of transfer	Notifies the host that an image has been transferred to system memory

Through these events, the host can monitor the target acquisition process from the time the object arrives at the inspection point to the time that the image resides in host memory. To assist the monitoring process, each event can be placed on a specific channel that relates to only one camera. Within each channel, an index counter can increment on each event. An incorrect index value would immediately indicate that an error has occurred.

Proper system design demands a certain amount of over-capacity to handle peak loads, such as when a system must acquire, process and analyze the 14,400 images/minute of the earlier example. To reliably process thousands of images, a machine-vision system can take advantage of circular buffers. By depositing image data into the next available location within a circular buffer, the system can maintain multiple images within a single channel.



Circular buffers manage data flow

If the system acquires images faster than it can process them, filling up the buffer space, the frame grabber can deposit the extra image data in a special frame buffer called the "trash buffer." The system can then initiate a hardware event, indicating that there is image data in the trash buffer that must be monitored. As a partial recovery, the application software can read the image's time stamp, track that object through the system and assign it to the "not inspected" bin.

MAXIMIZING DATA QUALITY

Even if a frame grabber reliably captures data, there's no guarantee that the data is usable. What happens if a noise or power glitch merges two pixels or lines together, compromising the data from the camera? Is all the subsequent acquired data incorrect? Must you restart the system?

To be truly reliable, a frame grabber must ensure that the data is not corrupt. It should compare the number of pixels and lines being captured to the camera file.

If an error has obliterated some camera data, the system can recover on the next incoming image. At the same time, the system can set a status flag indicating the suspect quality of the acquired image.

Frame grabbers that can detect problems and act on them greatly simplify system development. With such a frame grabber, an OEM doesn't have to invest time and effort to understand why a system failed. In addition, the frame grabber can reduce maintenance and support once the inspection equipment is installed in the field, lowering total system costs.

CHOOSING THE RIGHT IMAGE ACQUISITION TECHNOLOGY

By gaining more control over the image acquisition process, engineers can expect significant improvements in the overall performance of their machine vision system, increasing yield and ultimately ROI.

This demand for improved reliability is why Coreco Imaging has implemented an engineering framework called "Trigger-to-Image Reliability." Trigger-to-Image Reliability leverages Coreco Imaging's hardware and software innovations to control, monitor and correct the image acquisition process from the time that an external trigger event occurs to the moment the data is sent to the PCI bus. Trigger-to-Image Reliability enables more efficient and reliable machine vision inspections by securing the image acquisition process, providing traceability when errors do occur and permitting graceful recovery from those errors.

HOW TO LEARN MORE

Coreco Imaging is dedicated to helping customers understand and simplify the complexities of machine vision systems. To that end, Coreco Imaging offers a comprehensive knowledge base of tutorials, application notes and white papers prepared by our own engineers and by third-party machine vision specialists. This knowledge draws from more than 25 years' experience solving machine vision problems in many domains. We invite you to learn more by exploring this knowledge base at www.imaging.com.

CORECO iMAGING

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HEADQUARTERS 7075 Place Robert-Joncas, Suite 142, Saint-Laurent, Quebec, Canada H4M 2Z2

T: 514.333.1301 F: 514.333.1388

visit us online @ **www.imaging.com**