LabVIEW Machine Vision and Image Processing

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What You Need To Get Started

LabVIEW Machine Vision Online Exercises PDF

Pass the browser test at http://onlinecourses.ni.com/browsertest.htm to use the National Instruments remote computers for your exercises

<or>

Install LabVIEW 8 on your computer and download the exercise and solution VIs to complete the exercises on your own computer

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Lesson 1
Introduction to NI Vision

TOPICS

A. Image acquisition (IMAQ) products
B. Vision software products
C. Camera configuration using MAX

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NI Image Acquisition (IMAQ) Hardware

IMAQ devices feature:

- Connectivity with parallel digital, analog and Camera Link devices
- Advanced triggering and I/O capabilities
- Up to 80 MB of onboard memory
- Compatibility with motion control and data acquisition systems using the National Instruments RTSI bus
- Preprocessing, which allows pixel and line scaling and region-of-interest acquisition
- Real-time acquisition

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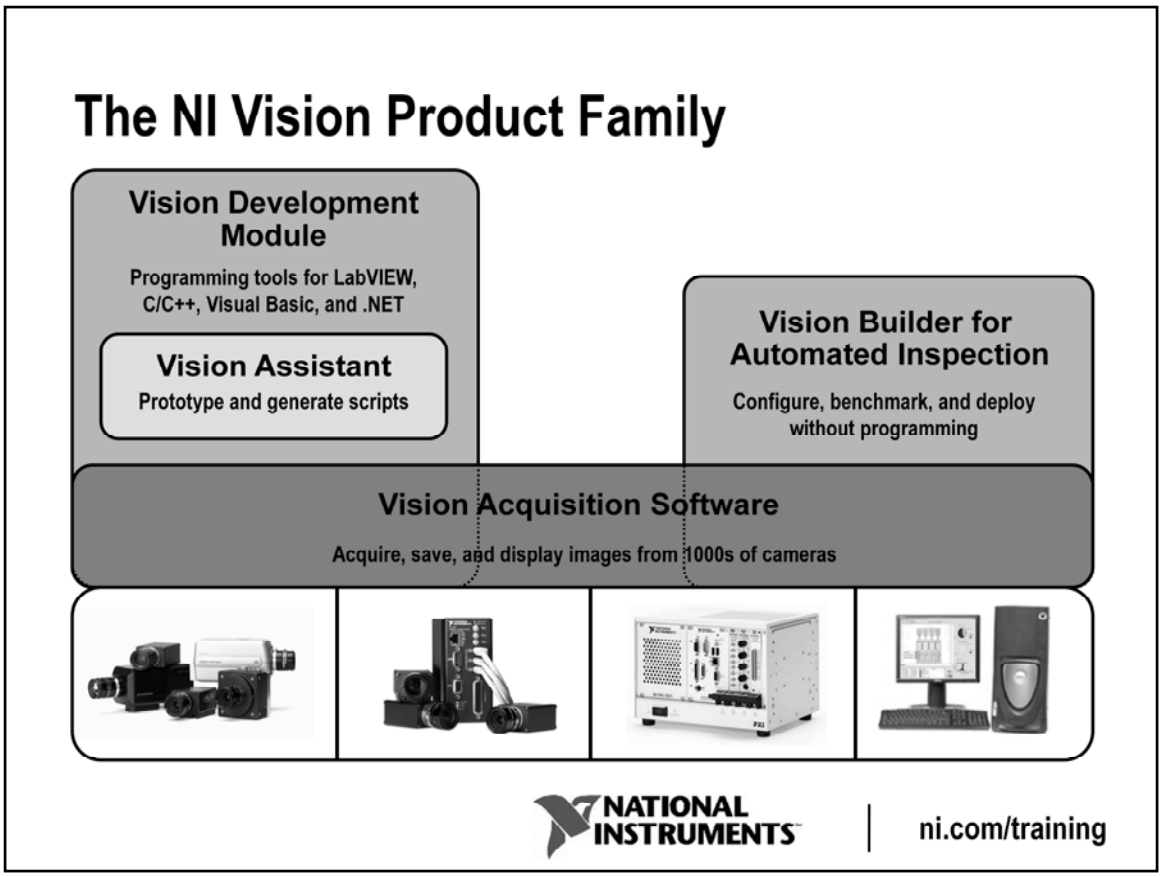
The National Instruments line of IMAQ devices features image acquisition boards that connect to parallel digital, analog, and Camera Link cameras. These devices include advanced triggering and digital I/O features that you can use to trigger an acquisition from an outside signal. These are also referred to as Frame grabbers.

IMAQ devices feature up to 80 MB of onboard memory, which allows you to acquire images at extremely high rates while sustaining high-speed throughput and greater overall system performance.

Most IMAQ devices work with motion control and data acquisition hardware using the National Instruments real-time system integration bus (RTSI). On National Instruments PCI boards, you can use a ribbon cable to connect RTSI connectors on adjacent boards to send triggering and timing information from one board to another.

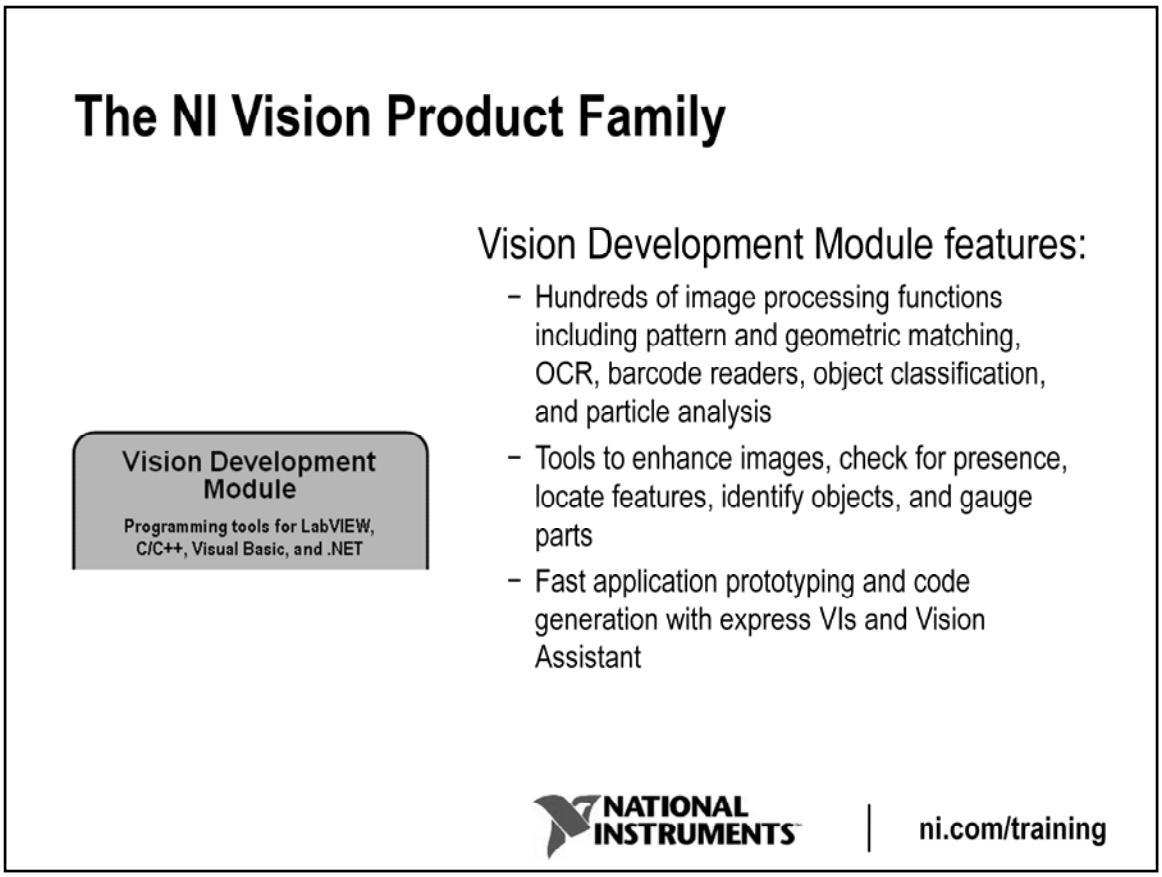
Real-Time Acquisition is available with LV RT on a PXI chassis or with LV RT and Vision Builder for Automated Inspection on a CVS (1450 Series).



NI Vision is the image processing toolkit, or library, that adds high-level machine vision and image processing to your programming environment. NI Vision includes routines for LabVIEW, LabWindows/CVI, Measurement Studio, and MS Visual Studio.

NI Vision Assistant is a tool for prototyping and testing image processing applications. Create custom algorithms with the Vision Assistant scripting feature, which records every step of your processing algorithm. It also can produce a working LabVIEW VI based on the script created or generate a builder file that contains the calls needed to execute the script in C or Visual Basic. Vision Assistant is included as part of Vision Development Module.

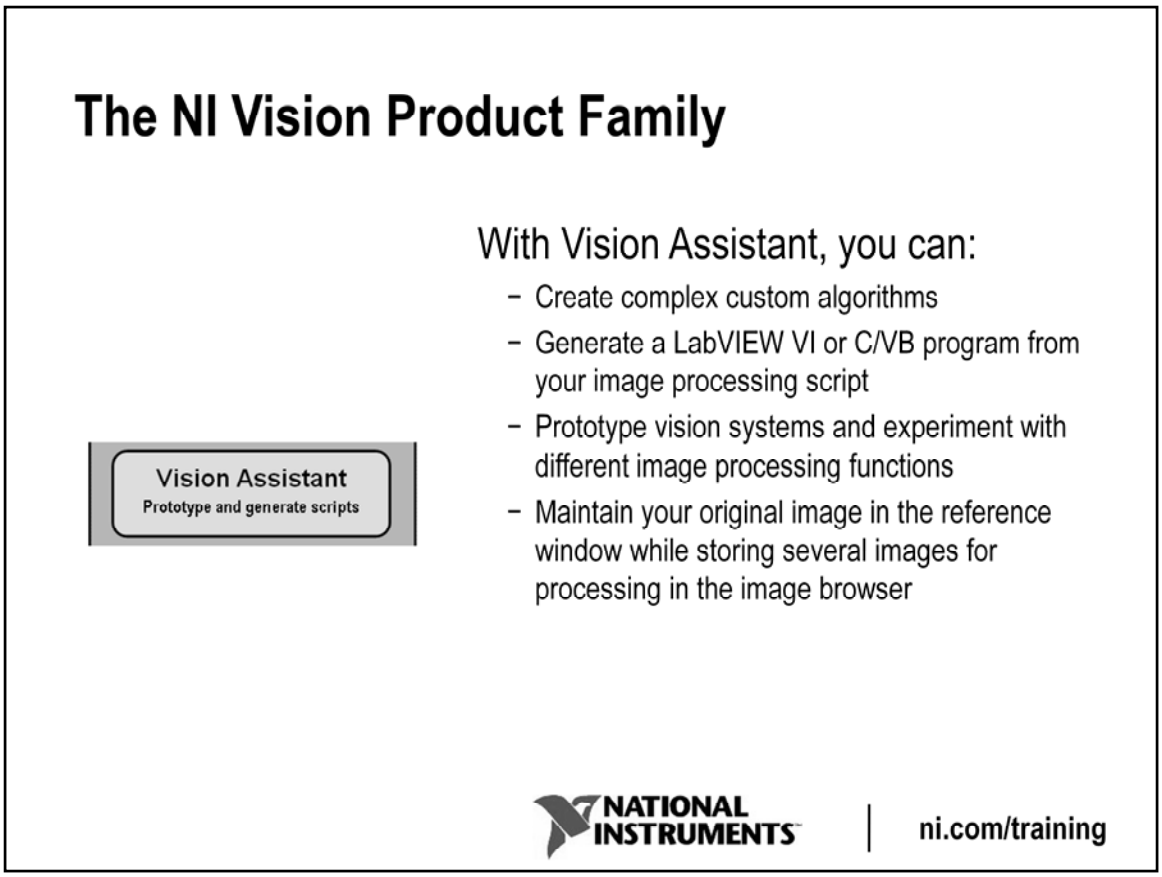
NI Vision Builder for Automated Inspection (**Vision Builder AI**) is a stand-alone prototyping and testing program, much like Vision Assistant. However, you can run your final inspection application from within Vision Builder AI. Vision Builder AI requires no programming experience, which enables you to develop projects in a shorter amount of time. The software includes functions for setting up complex pass/fail decisions, controlling digital I/O devices, and communicating with serial devices such as PLCs.



NI Vision Development Module includes an extensive set of MMX-optimized functions for the following machine vision tasks:

- Grayscale, color, and binary image display
- Image processing—including statistics, filtering, and geometric transforms
- Pattern matching and geometric matching
- Particle analysis
- Gauging
- Measurement
- Object Classification
- Optical character recognition

Use NI Vision Development Module to accelerate the development of industrial machine vision and scientific imaging applications.



Vision Assistant uses the Vision library but can be used independently of other development environments.

• Useful for prototyping .

• Useful for learning more about functions and see their results on your images.

Good for both because it has:

• Reference window that shows the original image

• Script window showing the processing steps

• Processing window that reflects changes as you apply new parameters.

The NI Vision Product Family

Vision Acquisition Software hardware drivers:

- Compatible with LabVIEW, C/C++, Visual Basic, and .NET
- Acquire, save, and display images from thousands of different cameras
- Included with all NI Vision frame grabbers and IEEE 1394
- Included with the Vision Development Module and Vision Builder AI
- Work with any NI frame grabber, IIDC-compliant FireWire camera, and GigE Vision Camera

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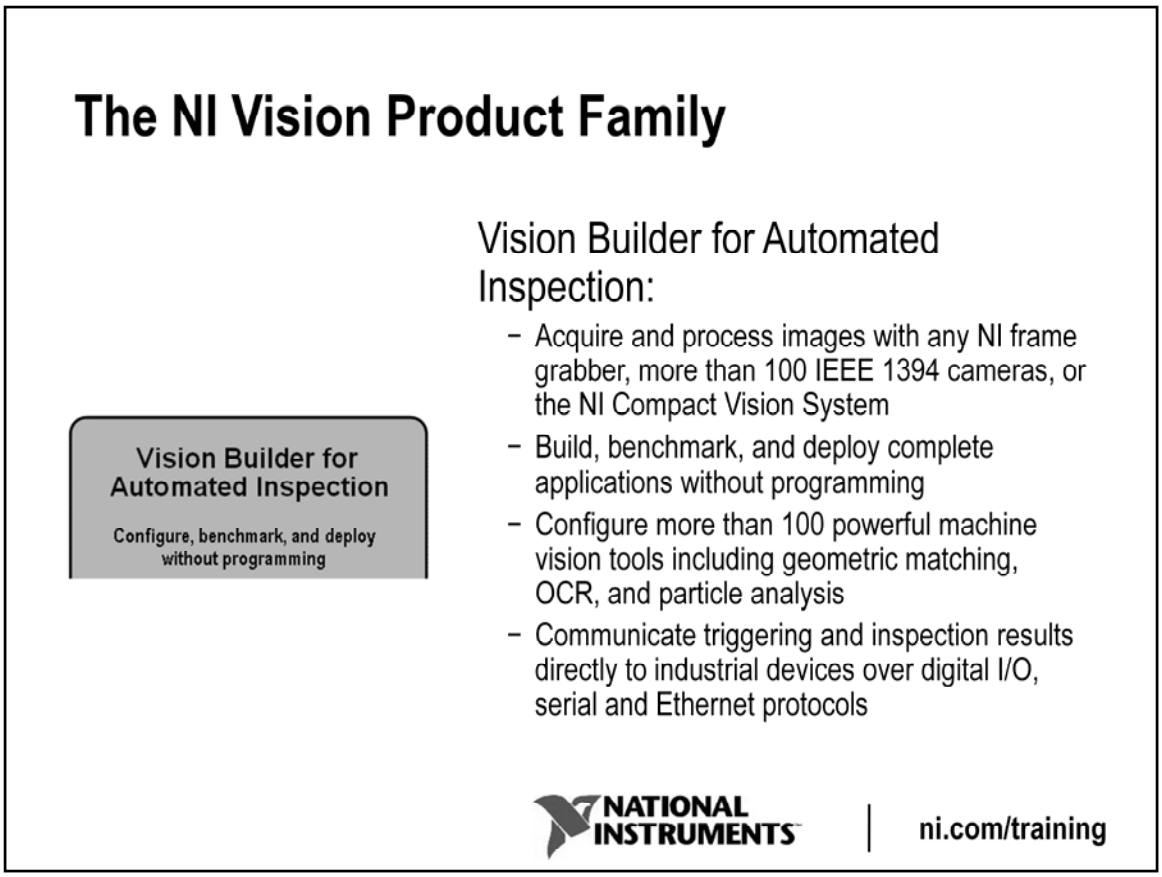
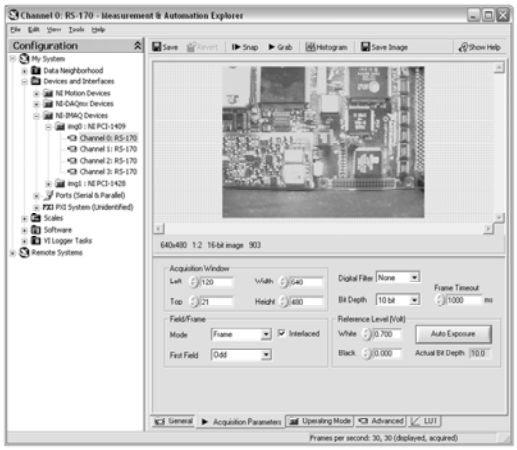


NI Vision Builder for Automated Inspection is configurable machine vision software that you can use to prototype, benchmark, and deploy applications. NI Vision Builder for Automated Inspection does not require programming, yet is scalable to powerful programming environments such as LabVIEW. A built-in deployment interface is included so you can quickly deploy your inspection, guidance, and identification applications. The software also includes abilities to set up complex pass/fail decisions, control digital I/O devices, and communicate with serial devices such as PLCs.

Vision Builder for AI will not be covered in this course.

Measurement and Automation Explorer



- One-stop configuration of all your NI hardware
- Set camera attributes
- Configure frame grabber features
- Test your acquisition
- Access remote devices on your network

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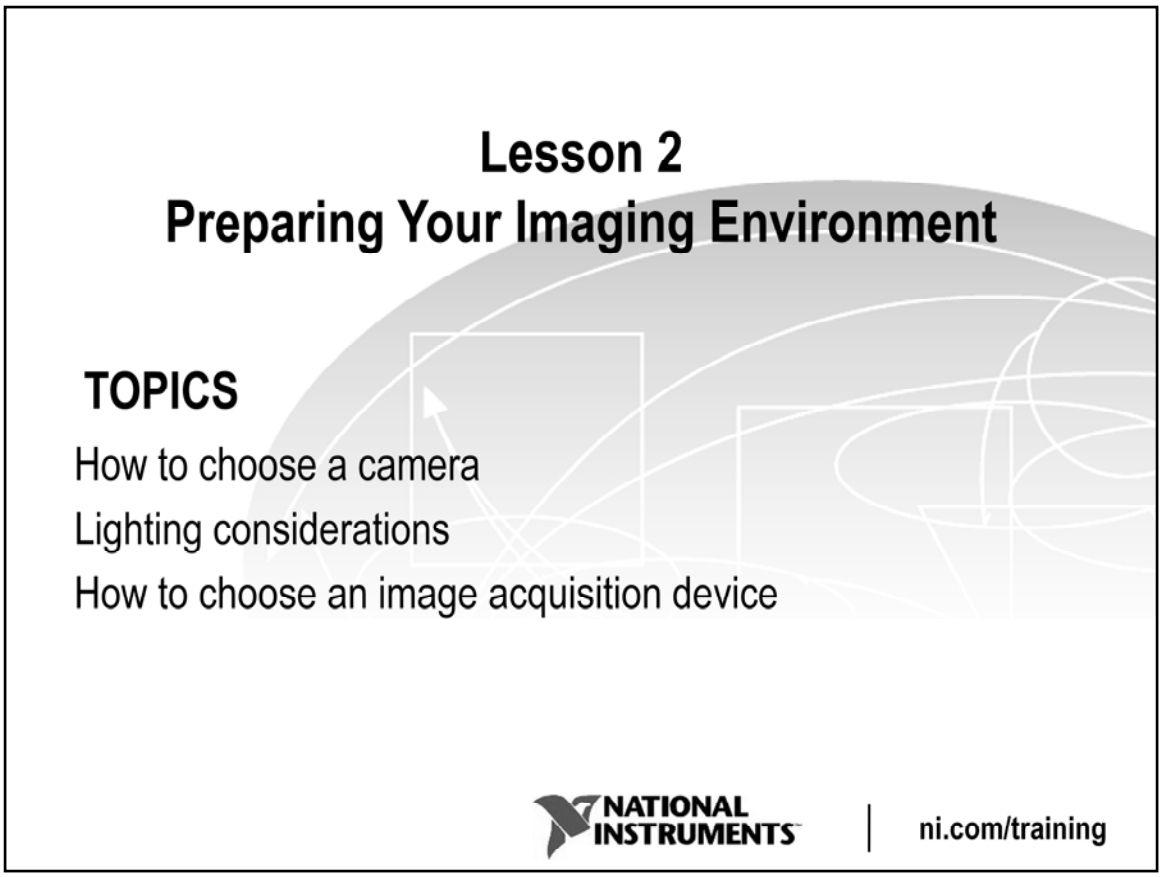

In order to properly prepare your imaging environment for your specific application, you must first examine your inspection task to determine your machine vision requirements. During system setup, you decide the type of lighting and lens you need and determine some of the basic specifications of your imaging tasks.

Setting up your imaging environment is a critical first step to any imaging application. If you set up the system properly, you can focus your development energy on the application rather than problems caused by the environment, and you can save precious time during execution.

How to Choose a Camera

Deciding factors in camera choice:

- Physical dimensions of your imaging system
  - Maximize detail of features and size of projected image
- Scan type
  - Line/Area
- Format and standard of data
  - Analog/Digital, standard or nonstandard, needed bandwidth
- Budget

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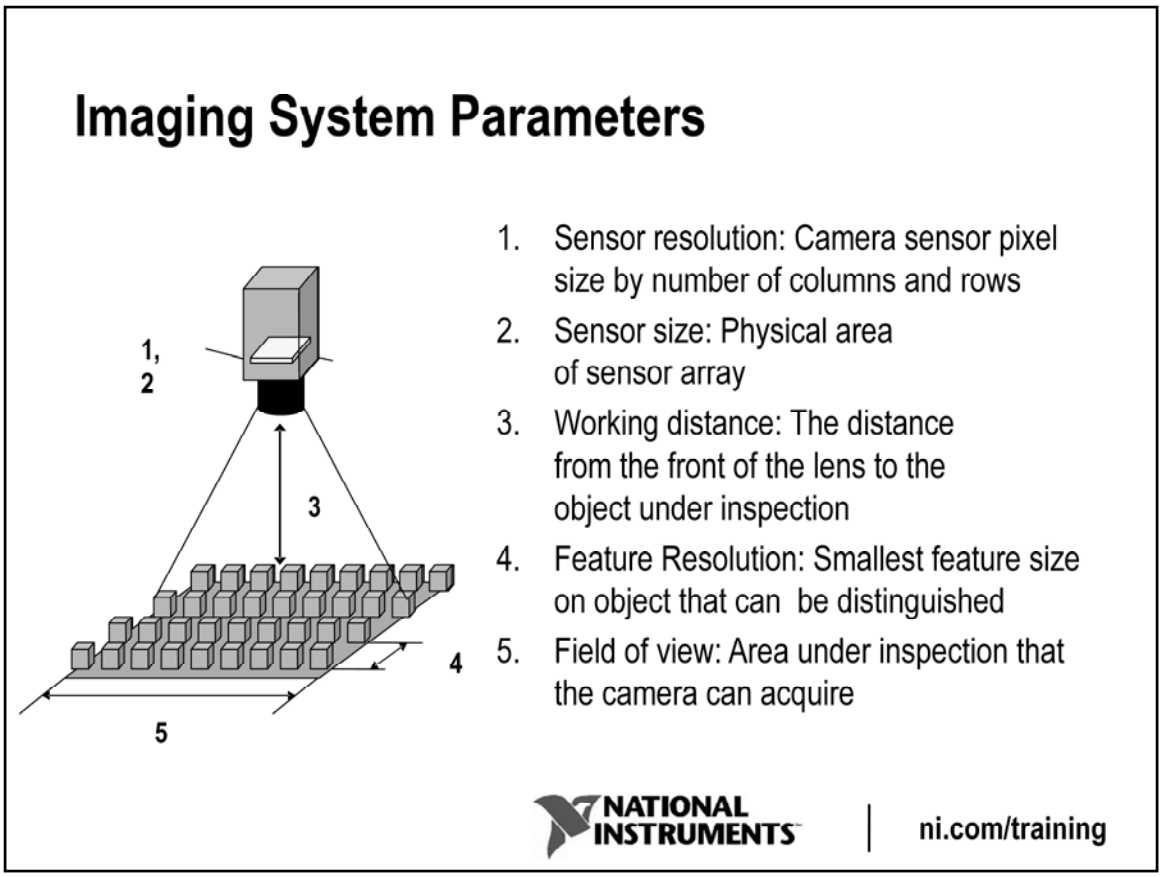
For the first half of this lesson, we will discuss the parameters needed to choose a camera and lens, talk about different types of cameras, and how to communicate with each.

The second half of the chapter will deal with NI's solutions and lighting setups.

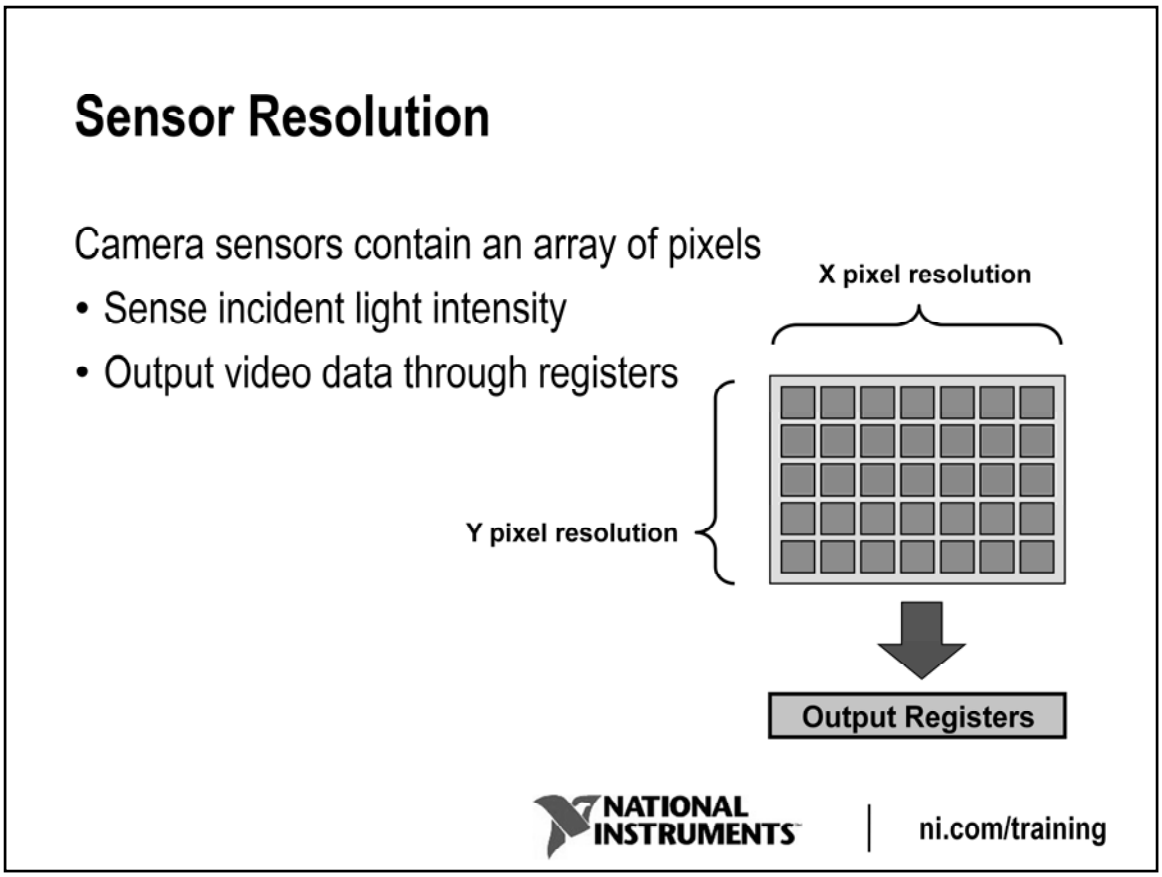


Sensor resolution is the number of columns and rows of CCD pixels in the camera sensor.

The **working distance** is the distance from the front of the lens to the object under inspection.

Feature Resolution indicates the amount of object detail that the imaging system can reproduce.

The **field of view** is the area under inspection that the camera can acquire. The horizontal and vertical dimensions of the inspection area determine the FOV

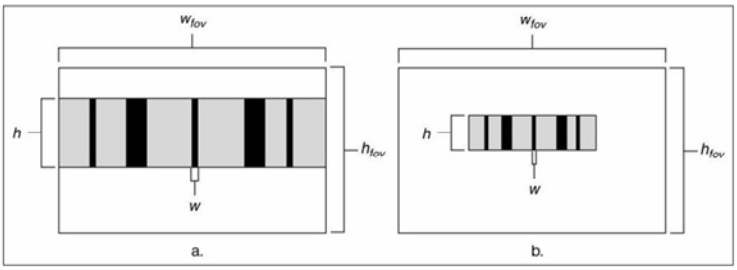


Acquiring images involves exposing a sensor to light and then measuring the amount of light intensity across a two dimensional field. You can transmit this measurement data serially or in parallel through output register to your NI-IMAQ software, where it is digitized.

The sensor itself will typically be either a CCD (charge-coupled device) or a CMOS. A CCD is a photodiode and circuitry used to store images. When light strikes the chip, it is held as a small electrical charge in each photo sensor. The charges are converted to voltage one pixel at a time as they are read from the chip. CMOS is essentially the same except each sensor does its own charge-to-voltage conversion and often each cell has its own digitization circuit.

Determining Necessary Sensor Resolution

To be properly recognized by inspection algorithms, the smallest feature in the image must be represented by at least two pixels



minimum sensor resolution = (FOV / feature resolution) x 2

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You can determine the required sensor resolution of your imaging system by measuring (in real-world units) the size of the smallest feature you need to detect in the image.

To compute sensor resolution, you must first find the *field of view*, which is defined by the horizontal and vertical dimensions of the inspection area.

Use the same units for *FOV* and *size of smallest feature*. Choose the largest FOV value (horizontal or vertical).

We multiply the ratio by 2 because we want the smallest feature to be represented by at least two pixels.

Common Sensors

Cameras are manufactured with a limited number of standard sensors

Number of CCD Pixels	FOV	Sensor Resolution
640 x 480	60 mm	0.185 mm
768 x 572	60 mm	0.156 mm
1281 x 1072	60 mm	0.093 mm
2048 x 2048	60 mm	0.058 mm
4000 x 2624	60 mm	0.030 mm

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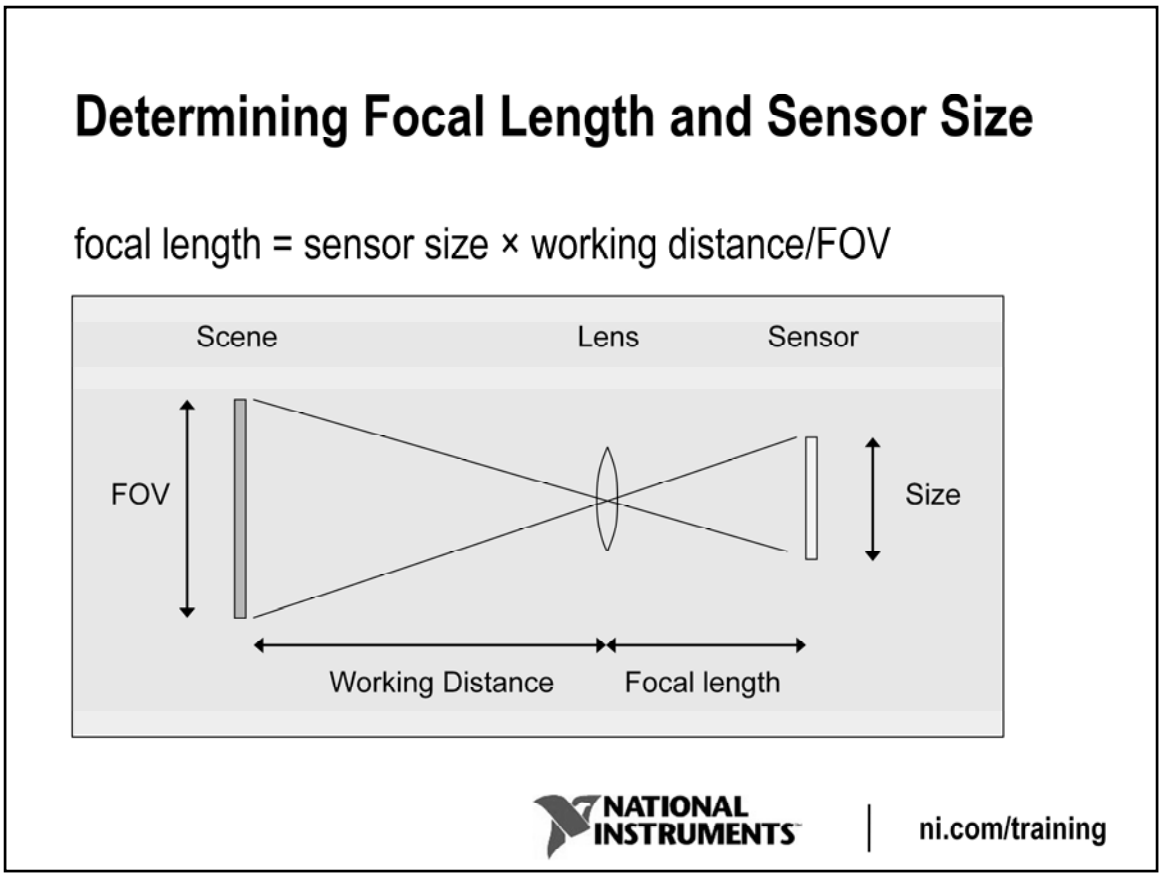
This chart displays sample sensor resolutions for given sensor sizes using a given FOV size.

If your required sensor resolution does not correspond to a standard sensor resolution, choose a camera whose sensor resolution is larger than that you require, or use multiple cameras. Be aware of increasing camera prices as sensor sizes increase.

By determining the sensor resolution you need, you narrow down the number of camera options that meet your application needs.



Another important factor that affects your camera choice is the physical size of the sensor, known as sensor size. The sensor's diagonal length specifies the size of the sensor's active area. The number of pixels in your sensor should be greater than or equal to the pixel resolution.

Lenses are manufactured with a limited number of standard focal lengths. Common lens focal lengths include 6 mm, 8 mm, 12.5 mm, 25 mm, and 50 mm. Once you choose a lens whose focal length is closest to the focal length required by your imaging system, you need to adjust the working distance to get the object under inspection in focus.

Lenses with short focal lengths (less than 12 mm) produce images with a significant amount of distortion. If your application is sensitive to image distortion, try to increase the working distance and use a lens with a higher focal length. If you cannot change the working distance, you are somewhat limited in choosing a lens.

As you set up your system, you will need to fine tune the various parameters of the focal length equation until you achieve the right combination of components that match your inspection needs and meet your cost requirements.

Exercise: Camera Attributes

GOAL

Determine the focal length and camera resolution for a barcode application.

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Scenario

You are developing a system to verify that the correct barcode is placed on each newly assembled product. The length of the bar code is 62 mm. The smallest bar has a width of 0.2 mm.

- Due to mechanical constraints in the system, the lens can be no closer than 124 mm from the barcode.
- The sensor size on your camera is 10 mm.

1. Determine the optimal size of the lens (in mm) you would purchase for this application.

   Focal Length = _____

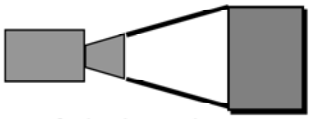
2. Your camera features a resolution of 640 x 480 pixels. Given that the smallest bar has a width of 0.2 mm, determine if the resolution of this camera is acceptable for reading this barcode.

   Resolution needed for barcode: _____

   Acceptable? _____

Scan Type

Area Scan



Scans an area of pixels and acquires the entire rectangular image at once.

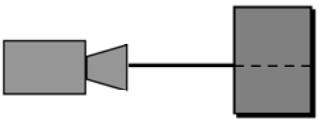
Advantages:

- Less processing needed
- Inexpensive

Disadvantage:

- Slower acquisition
- 2

Line Scan



Scans one line of pixels at a time, and image is pieced together afterward.

Advantages:

- Faster acquisition
- Accommodate moving objects

Disadvantages:

- Processing required to build image
- Expensive

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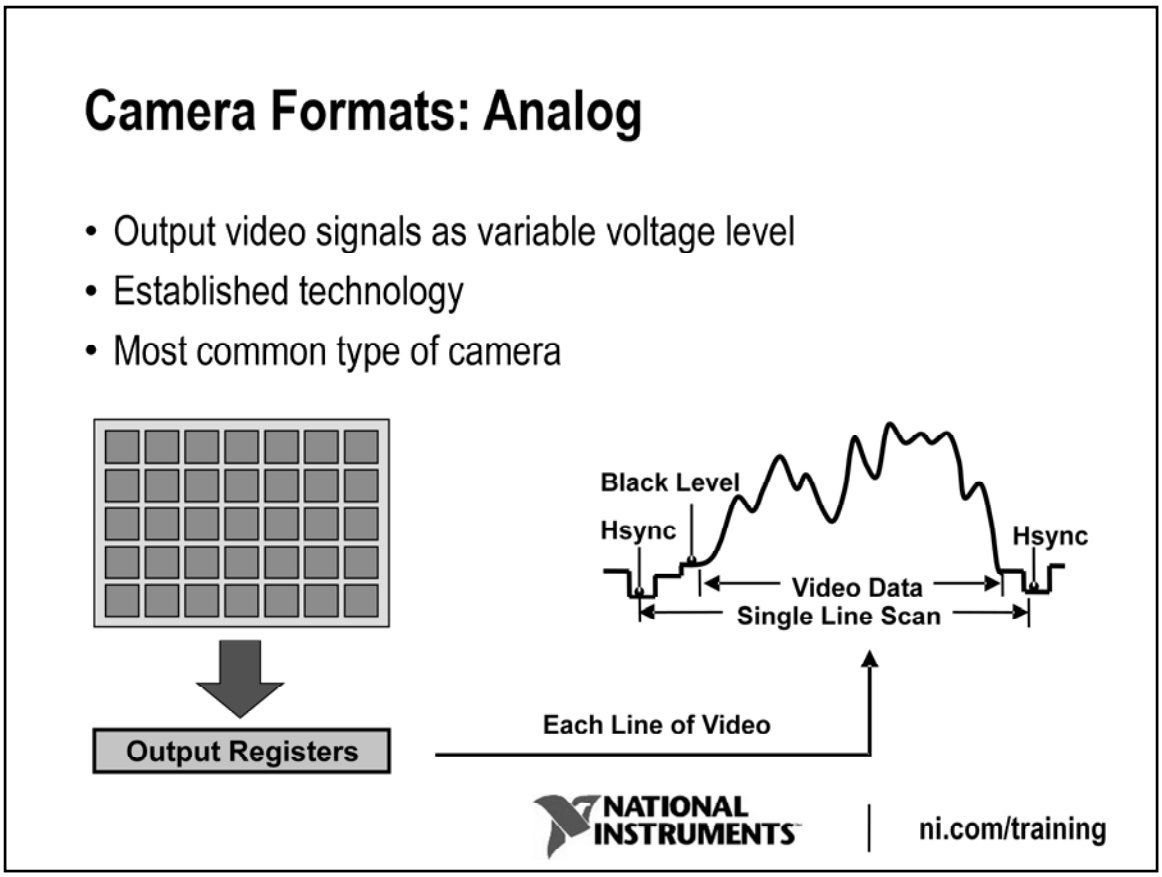


Analog cameras output video signals in an analog format. The horizontal sync (HSYNC) pulse identifies the beginning of a line; several lines make up a field. An additional pulse, the vertical sync (VSYNC) identifies the beginning of a field. The reason the pulse was low was so that data would not be output during reset of cathode.

In television broadcasting, the front porch is a brief period (about 1.5 microsecond) inserted between the end of each transmitted line of picture and the leading edge of the next line sync pulse. Its purpose was to allow voltage levels to stabilize in older televisions, preventing interference between picture lines.

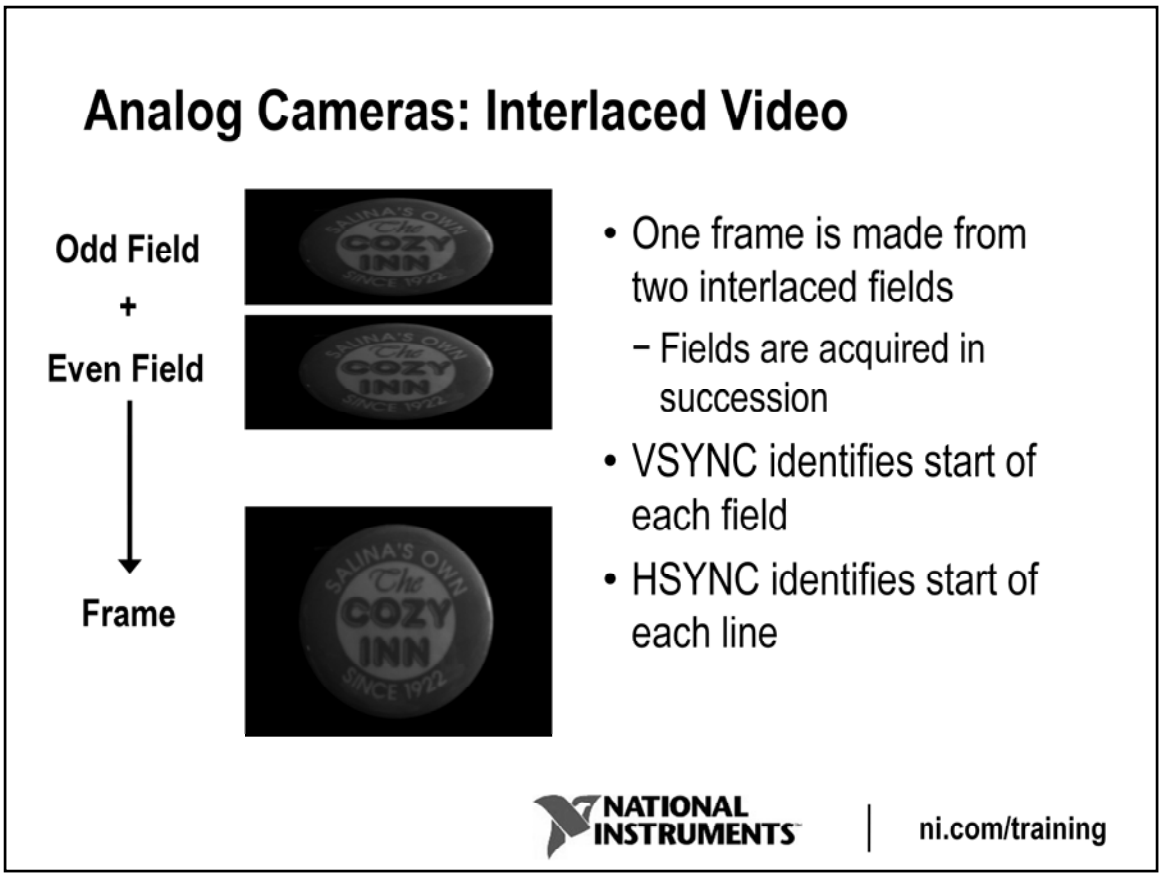
Back porch refers to the portion in each scan line of a video signal between the end (rising edge) of the horizontal sync pulse and the start of active video. It was originally allocated to allow the slow electronics in early televisions time to respond to the sync pulse and prepare for the active line period. With faster electronics making the delay unnecessary, the period has found other uses, including color burst and sometimes embedded audio info.

Black level - voltage below which everything is digitized to black.

White level - voltage above which everything is digitized to white.

Color burst is a signal used to keep the chrominance subcarrier synchronized in a color television signal. By synchronizing an oscillator with the color burst at the beginning of each scan line, a television receiver is able to restore the suppressed carrier of the chrominance signals, and in turn decode the color information.

Notice the black level identified in the figure. This is a reference voltage used for measuring pixel intensities. Low voltages typically indicate darker pixels, while higher voltages identify light pixels. Black-level clamping occurs here on the back porch to determine a reference point.



Flicker fusion threshold - light that is pulsating below this rate is perceived by humans as flickering; light that is pulsating above this rate is perceived by humans as being continuous. The exact rate varies depending upon the person, their level of fatigue, the brightness of the light source, and the area of the retina that is being used to observe the light source. 40 Hz is usually acceptable in dimly lit rooms, while up to 80 Hz may be necessary for bright displays that extend into peripheral vision.

When motion picture film was developed, movies were filmed at 16Hz, with 3-bladed shutters to interrupt the light three times on every film frame, resulting in 48 fps. Later, sound was added to film, and the standard went to 24 fps with two-bladed shutter. This same principle could not be applied upon the introduction of television – showing the same image multiple times required more bandwidth, or a frame buffer, which was not available until 1980s. The solution was interlacing, technology developed in 1936. All 4 major standards use interlacing.

For most low-end cameras, the odd and even fields are interlaced to increase the perceived image update rate. Two fields are combined to make up a frame.

Analog Cameras: Standard Formats

Standard	Location	Frames per second	Color	Image size
RS-170	USA, Japan	30	No	640 x 480
NTSC	USA, Japan	30	Yes	640 x 480
CCIR	Europe	25	No	768 x 576
PAL	Europe	25	Yes	768 x 576

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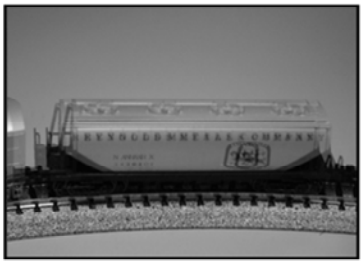
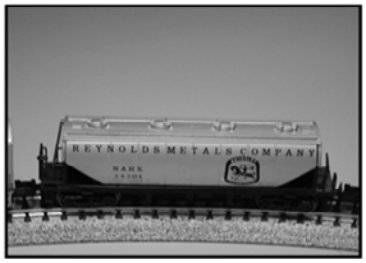
This table is included for your reference. If you use an analog camera, it will most likely adhere to one of these four standards.

Note: These are all interlaced.

Analog Cameras: Progressive Scan (Nonstandard)

- Non-interlaced, no separate fields
- All lines in a frame are exposed at same time
- Eliminates any “ghosting” resulting from object motion





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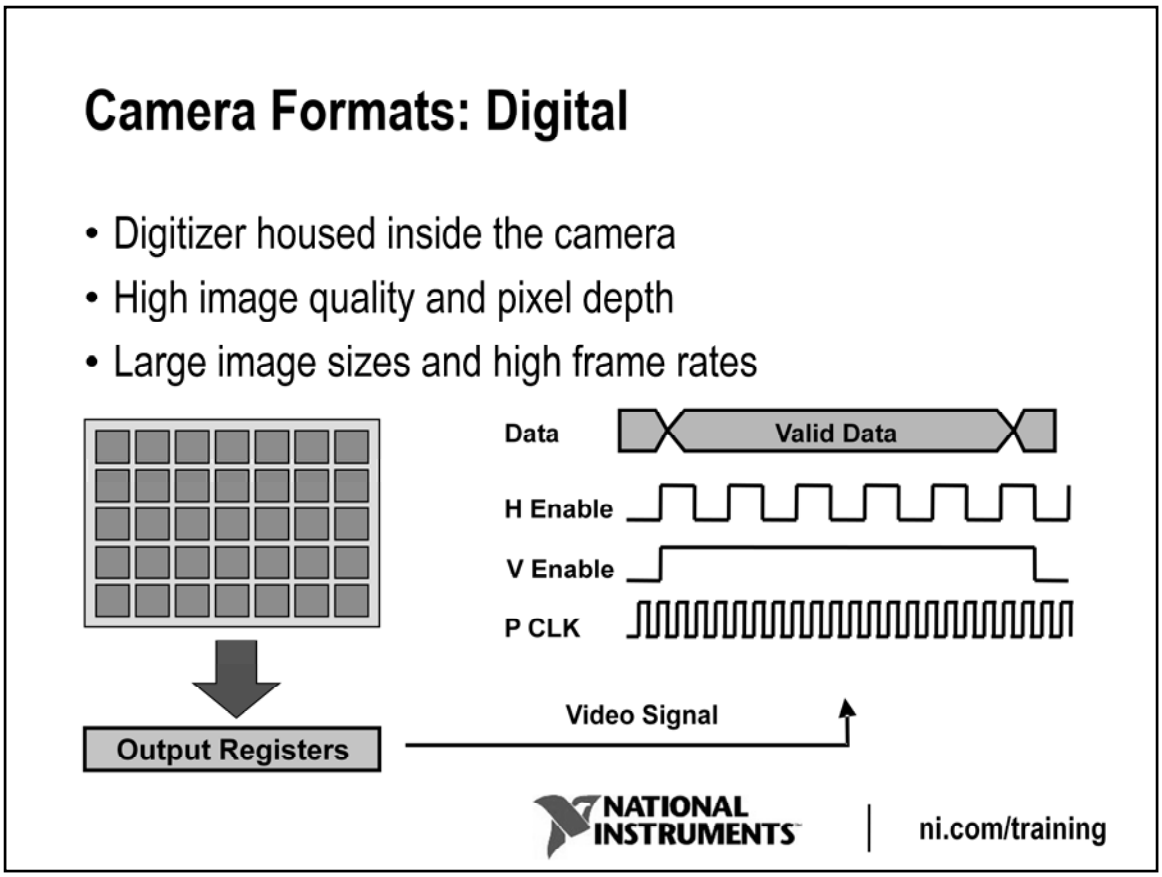
Progressive scan cameras are typically used in applications where the object or the background is in motion. Instead of acquiring the image one field at a time and then interlacing them for display, the CCD array in progressive scan cameras acquires the entire scene at once. If you use a standard analog camera in a motion application, there is a slight delay between the acquisition of each of the two fields in a frame. This slight delay causes blurring in the acquired image. Progressive scan cameras eliminate this problem by acquiring the entire frame at once, without interlacing. If you have motion in a scene and you only have a standard analog camera with interlaced video, you can use the National Instruments configuration software to scan only one field of each frame, which will eliminate blurring in the acquired image.



Digital cameras use three types of signals – data lines, a pixel clock, and enable lines.

- Data lines – Parallel wires that carry digital signals corresponding to pixel values
- Digital cameras typically represent pixels with 8, 10, 12, or 14 bits
- Color digital cameras can represent pixels with up to 24 bits
- Depending on your camera, you may have as many as 24 data lines representing each pixel
- Pixel clock – A high-frequency pulse train that determines when the data lines contain valid data.
- On the active edge of the pixel clock, digital lines have a constant value that is input to your IMAQ device
- The pixel clock frequency determines the rate that pixels are acquired
- Enable lines – Indicate when data lines contain valid data
- The HSYNC signal, also known as the Line Valid signal, is active while a row of pixels is acquired. The HSYNC goes inactive at the end of that row
- The VSYNC signal, or Frame Valid signal, is active during the acquisition of an entire frame.

Digital line scan cameras consist of a single row of CCD elements and only require a HYSNC timing signal. Digital area scan cameras need both HSYNC and VSYNC signals.

Digital Cameras: Standard and Nonstandard

Interface	Advantages	Disadvantages
Parallel	High speed Easy to configure	Complex cabling No interface standards
IEEE 1394 (FireWire)	Simple cabling Low cost	Slower data transfer rate
Camera Link	High speed Uniform cables Standard interface	10m cable length limit
GigE Vision	High speed Standard interface	Non-determinism Limited bandwidth

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The parallel interface standard is well-established that provides a wide range of acquisition speeds, image sizes, and pixel depths. Parallel cameras often require you to customize cables and connectors to suit your image acquisition device.

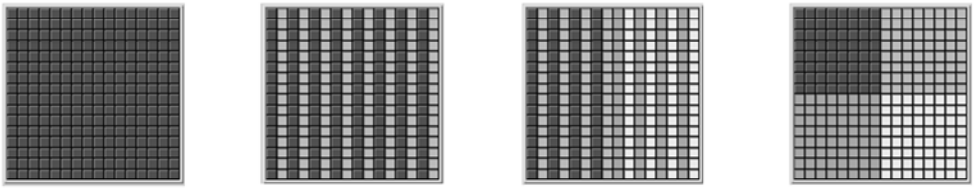
The IEEE 1394 standard offers simple daisy chain cabling with a uniform interface, but lacks some data throughput capabilities as well as trigger synchronization capabilities. You can trigger the camera, not the board.

The Camera Link standard was developed by a consortium of companies, including National Instruments, representing the framegrabber and camera industries. This standard is designed to offer speed and trigger functionality with the ease of standardized cables and interfaces.

Digital Cameras: Taps

A tap, or channel, is a group of data lines that carry one pixel

- Single-tap cameras latch only one pixel during the active edge of the pixel clock
- Multi-tap cameras can access multiple pixels during one active edge



1 tap | 2 taps interlaced vertically | 4 taps split and interlaced vertically | 4 taps in quadrants

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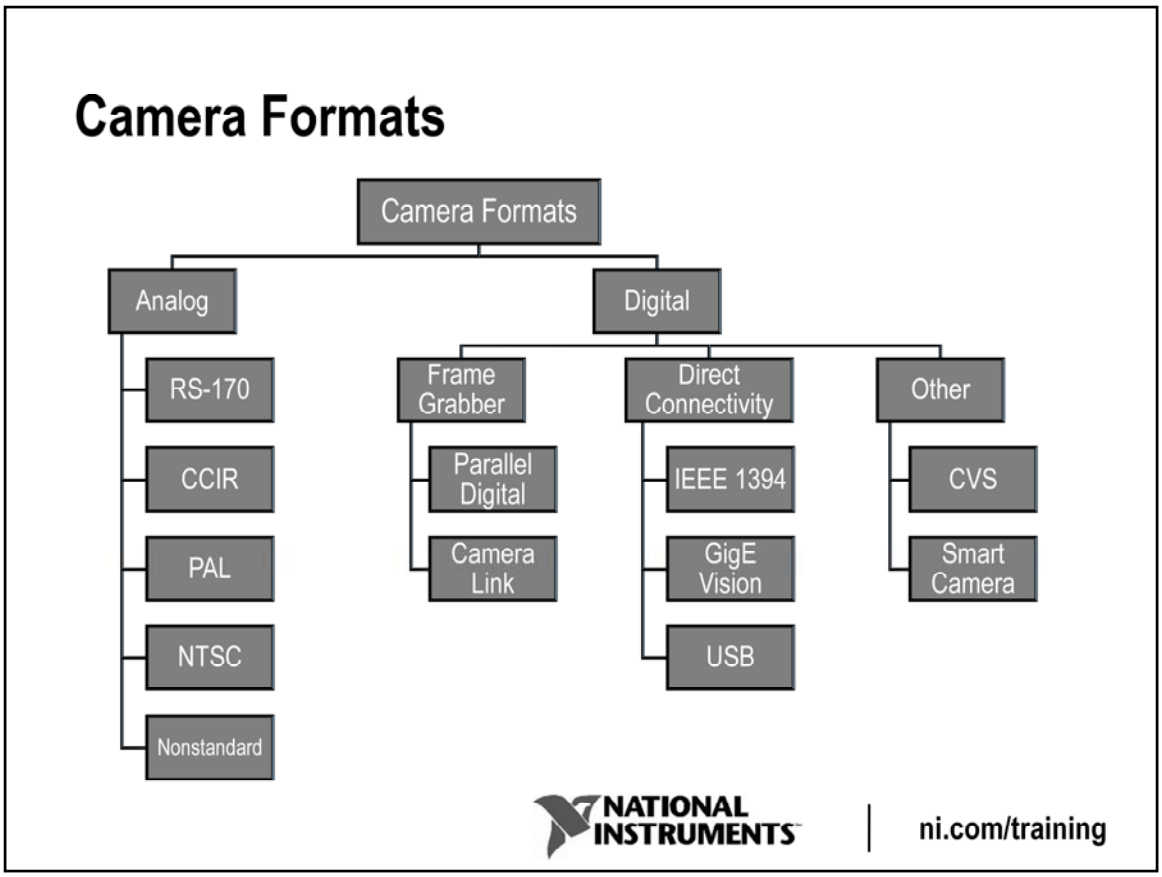
Increasing the speed of a digital camera's pixel clock or acquiring more than one pixel at a time greatly improves acquisition speed.

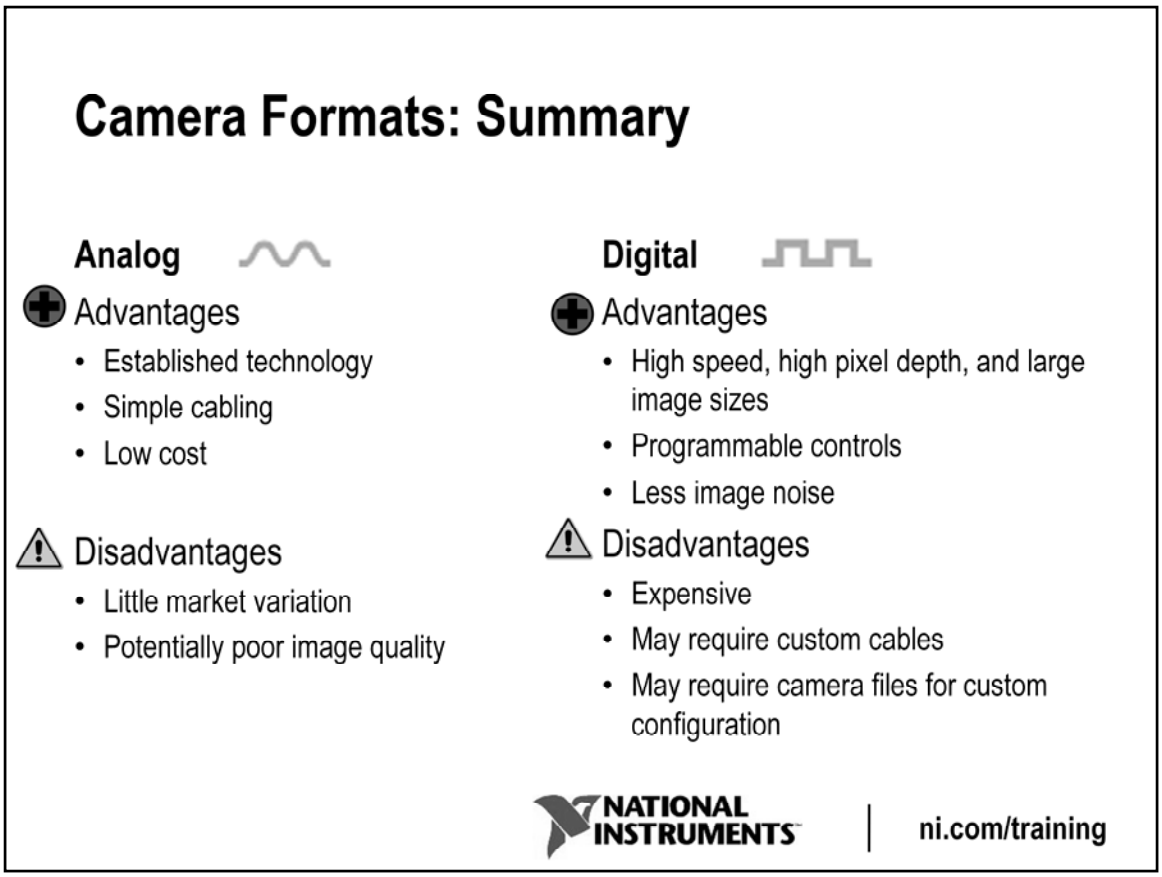
Note: Taps only apply to CL and Parallel cameras. The 1394 bus transfers data in packets, so the idea of taps does not apply to those cameras.



This table illustrates all of the supported camera formats. It also indicates how each should be connected – note that all analog cameras require a frame grabber to connect.

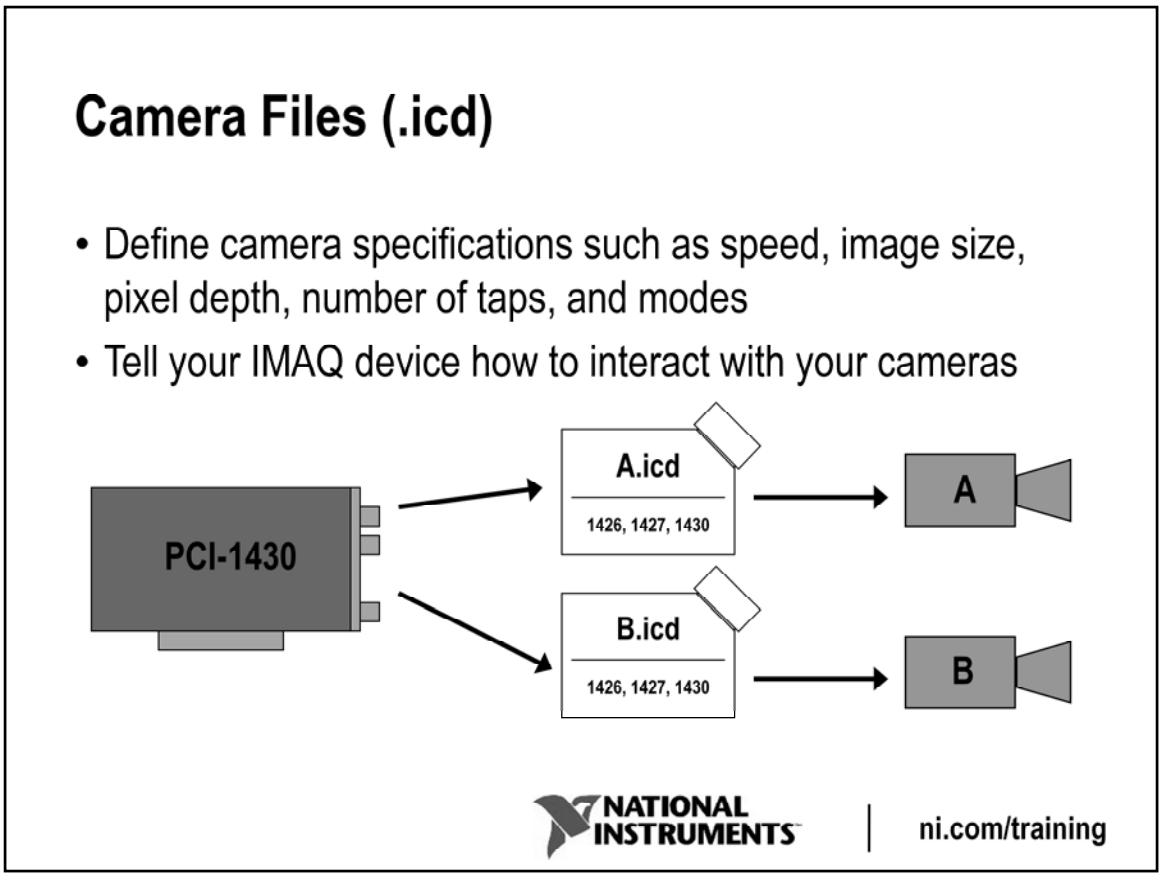
The CVS connects to IEEE 1394 cameras, but is categorized as “other” because it can operate as a stand-alone system.

NI-IMAQ for USB Cameras is a free software driver for acquiring images from any DirectShow imaging device into LabVIEW. These devices include USB cameras, webcams, microscopes, scanners, and many consumer-grade imaging products. Please note that while NI-IMAQ for USB Cameras comes with complete documentation, it is not officially supported by National Instruments and requires the Vision Development Module for functional operation. USB is included in this slide to give you a thorough idea of all acceptable camera types.



When choosing between digital and analog cameras, keep in mind that digital cameras tend to be more expensive than analog cameras, but they allow faster frame rates, higher bit and spatial resolution, and higher signal-to-noise ratios.

Analog cameras are based on older, proven technology and are therefore more common and less expensive. A low-cost, monochrome analog camera is an appropriate choice for most beginner vision applications.



Because digital cameras vary in specifications such as speed, image size, pixel depth, number of taps, and modes, NI-IMAQ requires a camera file specific to your camera to define all of these values in order to use that camera with your image acquisition device. Camera files are custom designed to provide efficient and effective interaction between your camera and your image acquisition device. You can find a list of camera files that have been tested and approved by National Instruments online at the Camera Advisor (ni.com/cameras).

Analog cameras use these, but there is less variety in analog, so the standards (NTSC, PAL, CCIR, and RS-170) serve as definitions for camera files.

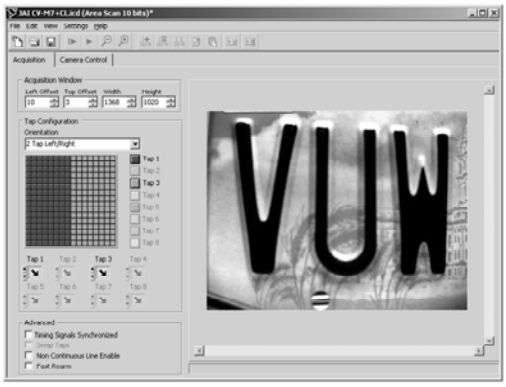
Camera files are also used with IEEE 1394 and GigE Vision cameras as a means of storing settings about the acquisition parameters. These are typically created when a camera is connected by the IMAQdx driver from settings that the camera exposes to the driver.

NI Camera File Generator

Free utility for creating your own digital camera files

Provides control over:

- Tap configuration
- Pulse generation
- Triggering
- Acquisition size and offset
- Serial Communication



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If you do not find a camera file for your camera at the Camera Advisor, you can create a custom camera file using the NI Camera File Generator. The NI Camera File Generator is a menu-driven, configuration environment for generating new camera files to equip cameras for which National Instruments does not have files, or for adding features to existing NI camera files. The NI Camera File Generator is a free software tool available from the Camera Advisor Web site.

Selecting a Camera

Selecting a camera is an important step in preparing your imaging environment. You should use the parameters of your application to decide whether you need an analog or digital imaging system.

National Instruments offers Camera Advisor, a one-stop Web resource for selecting an imaging camera featuring features and specifications for more than 100 cameras, at (www.ni.com/cameras).

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Camera Advisor is a one-stop Web resource that engineers and scientists can use when selecting an imaging camera. Using this virtual catalog of cameras, you can view features and specifications for more than 100 cameras. Camera Advisor also explains how various cameras work with National Instruments hardware and software.

By visiting this section of ni.com, you can compare different models and makes of cameras, such as line scan, area scan, progressive scan, and digital and analog cameras. You can also use Camera Advisor to compare the technical details and specifications of various cameras. You will also find a complete list of cameras that have been tested and are fully compatible with National Instruments products.

Lighting: A Critical Consideration

Lighting is one of the most important aspects in setting up your imaging environment.

- Separates the feature you want to inspect from the background of the image
- Makes your image processing easier and faster
- Reduces glare, shadows, and effects caused by changes in weather or time of day

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If objects in your image are covered by shadows or glare, it becomes much more difficult to examine the images effectively. Some objects reflect large amounts of light due to the nature of their external coating or their curvature. Poor lighting setups in the imaging environment can create shadows that fall across the image.

Whenever possible, position your lighting setup and your imaged object such that glare and shadows are reduced or eliminated. If this is not possible, you may need to use special lighting filters or lenses, which are available from a variety of vendors.

Ring Lighting

Light encircles the camera lens

Advantage: Even illumination without shadows along lens axis

Disadvantage: Can produce a circular glare

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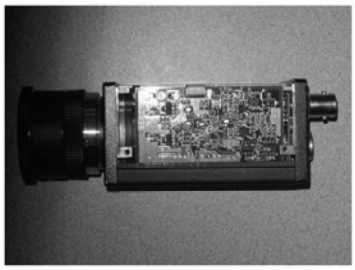
Strobe Lighting

Light pulses as frame is acquired

Advantage: Reduces motion blur

Disadvantages: May have to apply artificial gain to avoid dark images



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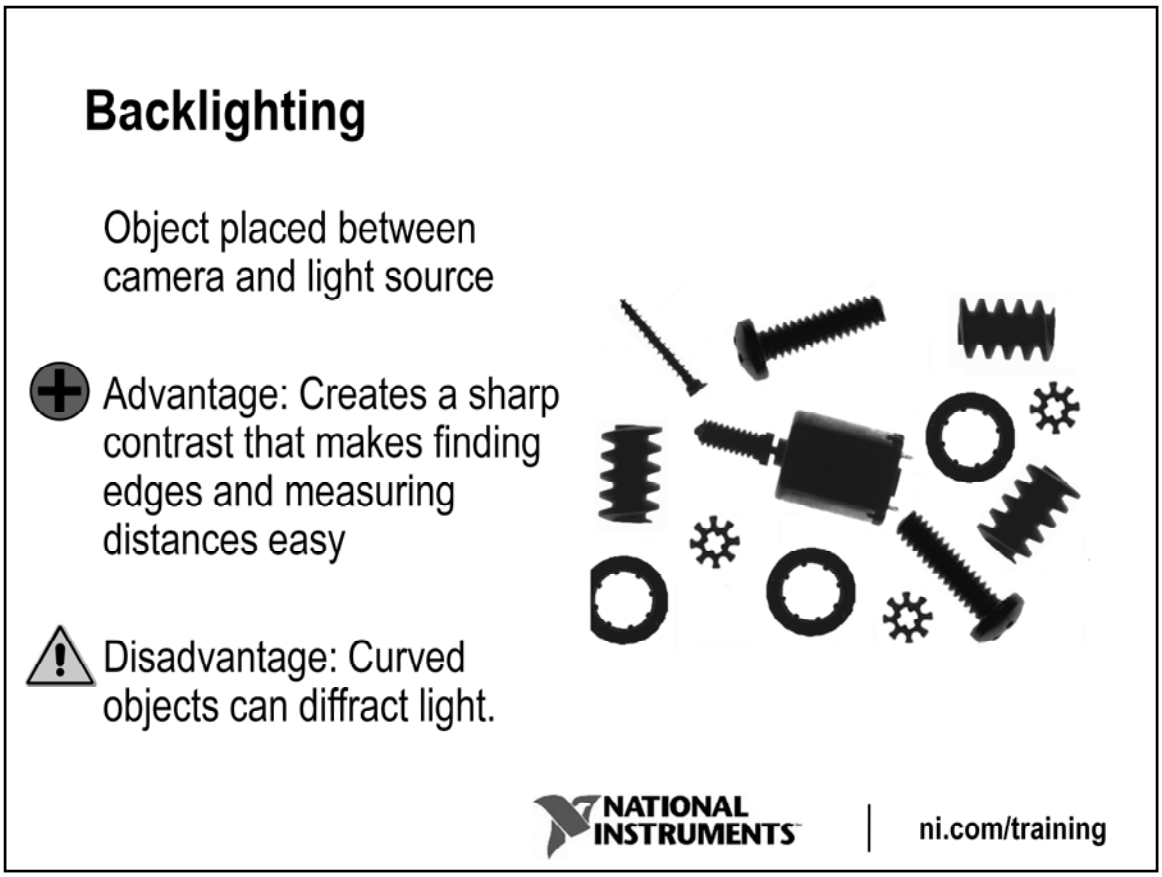
If a moving object is blurry, then the object was exposed for too long. There are two potential solutions: shorten integration time for sensor, or strobe the light source, using a short duration for strobe.



Use backlighting when you can solve your application by looking only at the shape of an object. This figure shows an image of a stamped metal part that was acquired using a backlight.

Many other factors, such as your camera choice, contribute to your decision about appropriate lighting for your application. You may want to choose lighting sources and filters whose wavelengths match the sensitivity of the CCD sensor in your camera and the color of the object under inspection.

Diffused Lighting

- Some objects reflect light due to their surface texture or curvature
- You can use diffused lighting to eliminate glare

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In this example, the first barcode image was acquired using highly directional light, which increased the sensitivity of specular highlights, or glints, causing a glare that makes the image difficult to analyze. The second barcode was acquired using diffused lighting to reduce glare.

Optics Resources

National Instruments recommends the following partner companies for your lighting and lens needs:

- Graftek Imaging www.graftek.com
- Edmund Industrial Optics www.edmundoptics.com
- Fostec www.fostec.com
- Stocker & Yale www.stkr.com

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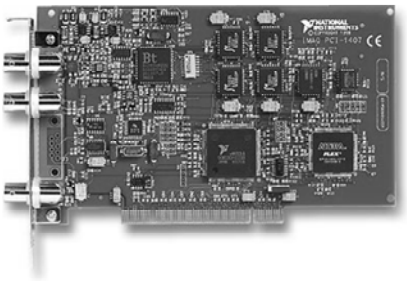
Visit ni.com for information on some of NI's partners who specialize in lighting equipment for the vision industry.

Analog IMAQ Hardware



- Support for color and monochrome cameras
  - Up to four monochrome channels
- Standard and nonstandard formats
  - All worldwide standards (RS-170, CCIR, NTSC, PAL)
  - S-video and progressive scan connections
- Plug into PCI and PXI form factors

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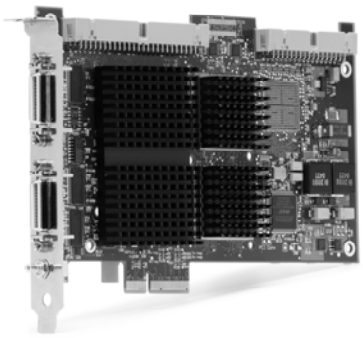
The IMAQ PCI-1410 image acquisition board offers easy-to-use driver and camera configuration software for up to four standard and nonstandard cameras. You can use the 1409 to acquire data from nonstandard cameras featuring variable pixel clocks from 2 MHz to 40 MHz. You can configure monochrome acquisition from RS-170, CCIR, NTSC, PAL, and RGB, and progressive scan cameras.

The 1407 Series boards offer low-cost, single-channel monochrome accuracy. You can configure the 1407 for standard RS-170 and CCIR analog monochrome cameras. Unlike other low-cost machine vision image acquisition boards, the 1407 Series offers advanced features such as partial image acquisition, onboard decimation, lookup table processing, programmable gain, and triggering.

You can configure your 1411 Series board for color image acquisition from standard NTSC, PAL, and S-Video cameras. You can also acquire from monochrome RS-170 and CCIR cameras. Unlike other color machine vision boards, the 1411 offers fast color conversion to hue, saturation, and luminance (HSL) image data. This is especially useful for high-speed color matching and inspection applications, even in varying illumination conditions.

Digital IMAQ Hardware



- Support for 32-bit color and 16-bit monochrome cameras
  - Multiple taps
  - Multiple cameras
  - Pixel clock up to 85 MHz
- Standard and nonstandard interfaces
  - IEEE-1394, CameraLink, parallel digital, Gigabit Ethernet
- Plug into PCI, PXI, PCIe form factors

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With a digital camera and a digital IMAQ board, you can acquire images at thousands of frames/s with greater grayscale resolution and more spatial resolution. National Instruments 1424 Series boards for PCI and PXI/CompactPCI are some of the fastest digital image acquisition boards available, with a 50 MHz pixel clock and 32-bit wide digital input (four 8-bit pixels). Using upto 128 MB of onboard memory, the 1424 can acquire data at a top rate of 200 MB/s. The 1422 Series boards feature a 16-bit input and a 40 MHz pixel clock for lower cost digital image acquisition applications.

National Instruments offers IMAQ hardware for the low-voltage differential signaling (LVDS) standard. LVDS extends the performance of the commonly-used digital camera RS-422 differential data bus, which limits frequency to the 20 MHz range. However, LVDS cameras can clock data out at 50 MHz using the IMAQ PCI-1424 LVDS board. You can also use the LVDS of the IMAQ board to transmit data as far as 100 ft. LVDS also reduces noise significantly.

Camera Link is an industrial, high speed serial data and cabling standard developed by NI and other companies for easy connectivity between the PC and camera. Camera Link currently supports speeds of up to 680Mb/s, and offers future data rate capabilities up to 2.3 gigabits per second.

Compact Vision System

- Embedded high-performance processor for increased inspection speed
- 3 FireWire camera inputs
- Integrate with other devices through Ethernet, serial, and digital I/O
- Configure with NI Vision Builder for Automated Inspection, or program with NI LabVIEW and Vision Development Module

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The National Instruments Compact Vision System extends the power of LabVIEW Real-Time to a rugged machine vision package that withstands the harsh environments common in robotics, automated test, and industrial inspection systems. It offers unprecedented I/O capabilities and network connectivity for distributed machine vision applications. It uses FireWire (IEEE 1394) technology, compatible with more than 40 cameras with a wide range of functionality, performance, and price. In addition, you can connect up to three cameras to one CVS to significantly lower the price of your deployed system. You can also integrate the CVS with the industrial measurement and control capabilities of NI Compact FieldPoint. To program the CVS, you have the choice of configuring your machine vision application quickly with Vision Builder for Automated Inspection, or programming your application with LabVIEW and the Vision Development Module.

NI Smart Camera

- Embedded high-performance processor 400/533 MHz
- Integrate with other devices through Ethernet, serial, and digital I/O
- Multiple sensors starting with monochrome VGA CCD, 60 fps

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National Instruments Smart Cameras are industrial, high-quality image sensors combined with powerful processors to create rugged, all-in-one solutions for machine vision applications. You can use these cameras for applications including quality control, packaging verification, robot guidance, optical character recognition, and 2D code reading. NI Smart Cameras integrate easily with Programmable Automation Controllers (PACs), PLCs, and industrial HMIs. NI Smart Cameras are shipped with the NI Vision Builder for Automated Inspection (AI), configurable machine vision software that requires no programming.

Lesson 3
Acquiring and Displaying Images

TOPICS

A. NI-IMAQ utility functions
B. Single and multiple buffer acquisitions
C. Displaying images
D. Triggering features of NI-IMAQ

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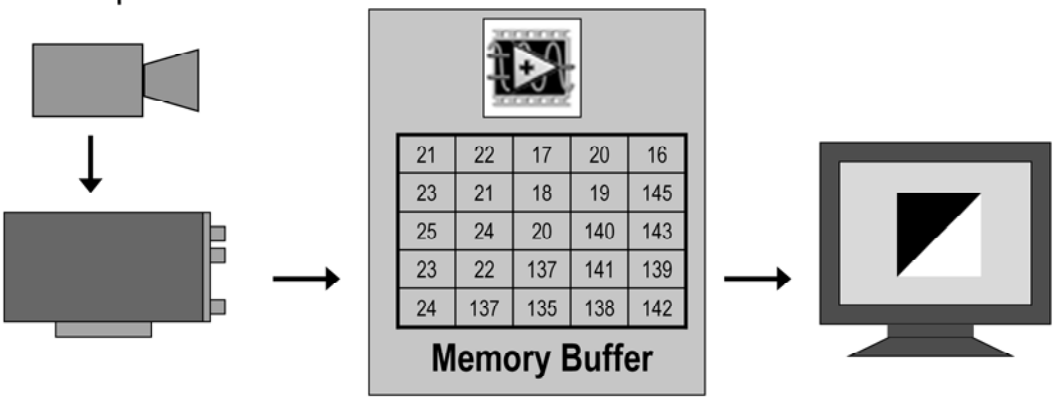
Images in Memory

- Images are not displayed directly when acquired.
- Stored in a memory buffer so they can be accessed and manipulated



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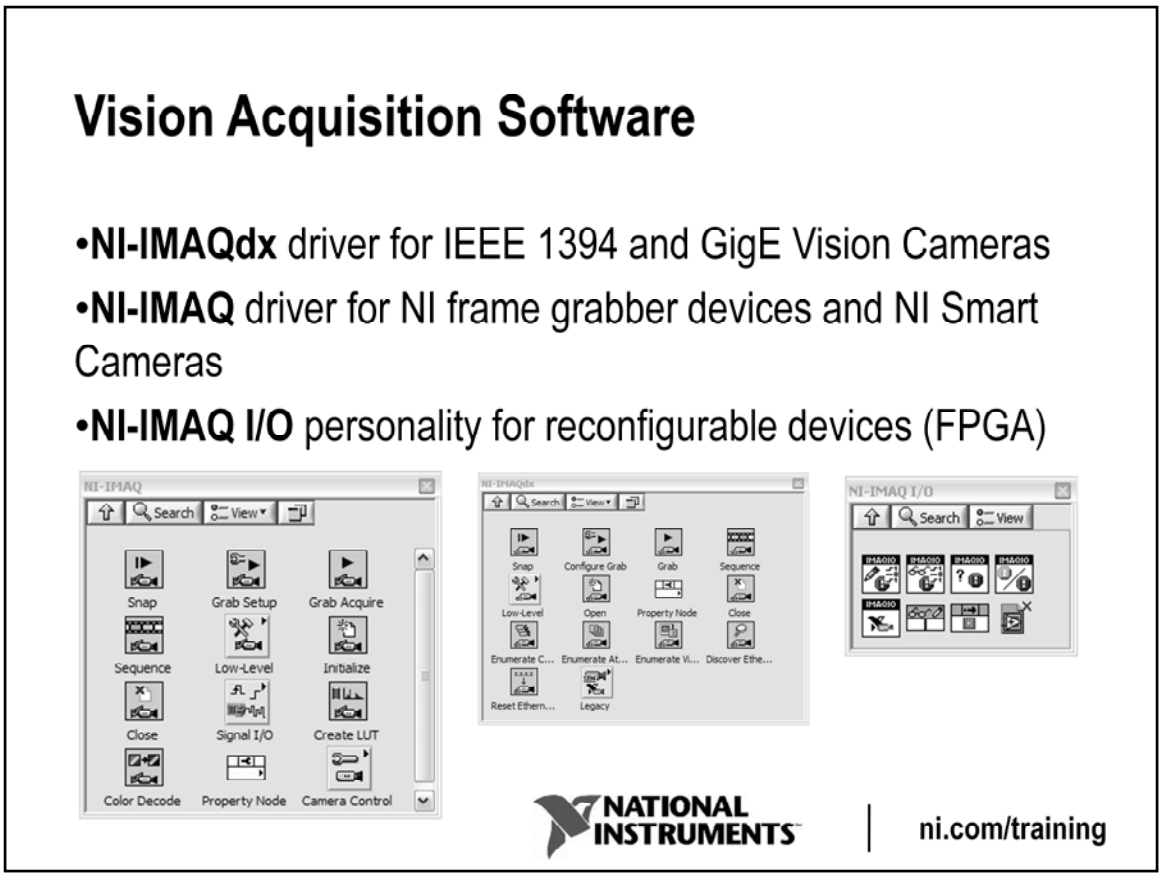

Vision Acquisition Software is a complete and robust API for image acquisition that works with LabVIEW, Measurement Studio, Visual Basic, or Visual C++. It features an extensive library of functions, including routines for video configuration, image acquisition (continuous and single-shot), memory buffer allocation, trigger control, and board configuration.

Vision Acquisition Software performs all of the computer- and board-specific tasks, allowing straightforward image acquisition without register-level programming. Note the similarities between the pallets of the different drivers. The same functions are available with the different drivers (Snaps, grabs, property nodes, etc.)

Vision Acquisition Software is included with hardware at no charge.

NI-IMAQdx replaces the NI-IMAQ for IEEE 1394 (Legacy) driver. NI also provides a free, unsupported driver for connecting to DirectShow-compliant USB cameras. For any camera that doesn't meet standards (GigE Vision for Ethernet cameras, Dcam for Firewire cameras, etc.) the camera can still be used if the camera has a .dll that can be called from LabVIEW or if it can be controlled through ActiveX.

Image Acquisition Functions

Acquisition management
- Configure sessions and memory allocation

Single buffer acquisition
- Acquire images to one memory buffer

Multiple buffer acquisition
- Acquire images to multiple memory buffers

Trigger
- Synchronize acquisition with real-world events

Display
- Customize image display and user interface

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Vision Acquisition Software drivers use five categories of functions to acquire and display images:

•Acquisition Management functions—Allocate and free memory used for storing images; begin and end image acquisition sessions

•Single buffer acquisition functions—Acquire images into a single buffer using the snap and grab functions

•Multiple buffer acquisition functions—Acquire continuous images into multiple buffers using the ring and sequence functions

•Display controls—Display images for processing

•Trigger functions—Link a vision function to an event external to the computer, such as receiving a pulse to indicate the position of an item on an assembly line

Acquisition Management Functions

Interface Management	Memory Management
IMAQdx Open Camera • Opens a session with the camera or device	IMAQ Create • Creates an image buffer in memory
IMAQdx Close Camera • Ends a session	IMAQ Dispose • Removes an image from memory

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IMAQdx Open Camera opens a IMAQdx camera, queries the camera for its capabilities, loads a camera configuration file, and creates a unique reference to the camera. Use IMAQdx Close Camera.vi when you are finished with the reference.

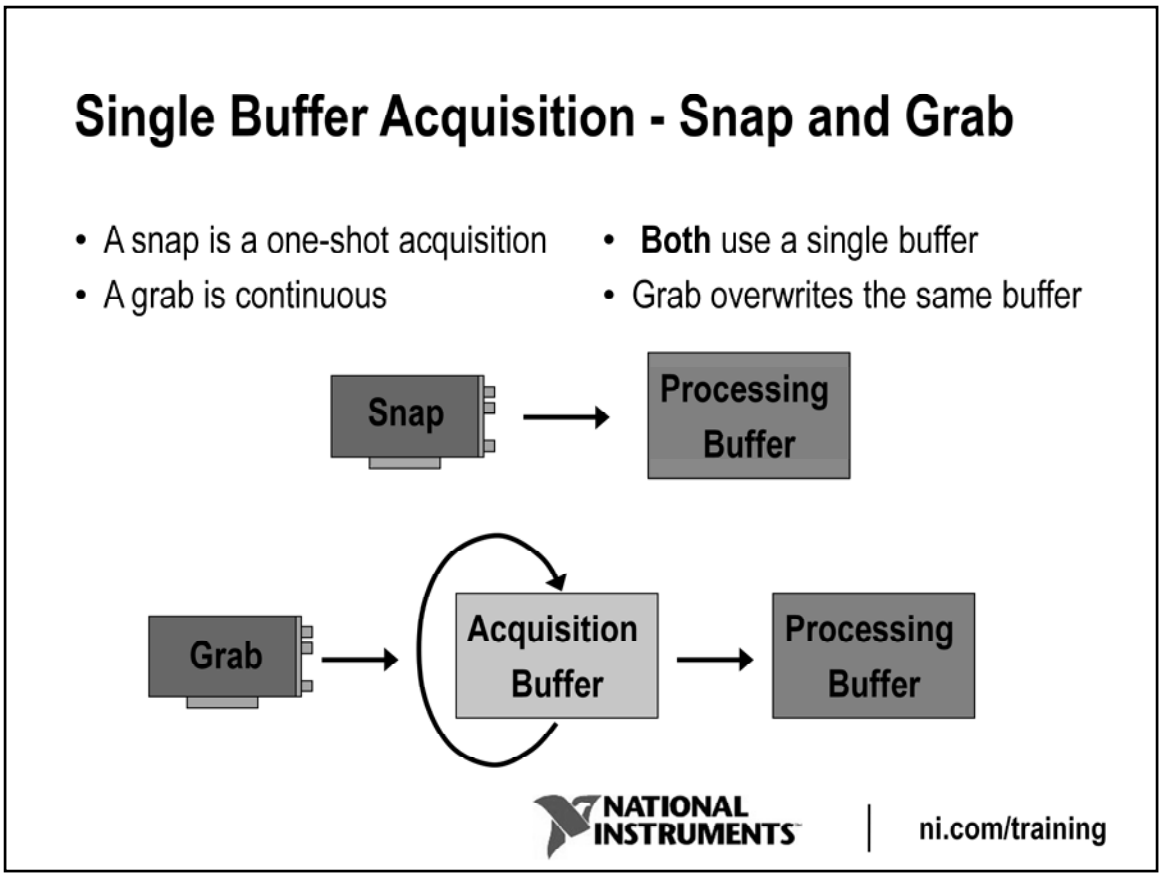
IMAQdx Close Camera stops an IMAQdx acquisition in progress, releases resources associated with the acquisition, and closes the specified session.

IMAQ Init loads camera configuration information and configures an IMAQ device. Interface Name (default img0) refers to the device name from MAX. IMAQ Init generates an IMAQ Session that will be used to reference any future NI-IMAQ driver calls.

IMAQ Close directs the IMAQ board to stop acquiring images, release any allocated resources back to the system, and close the specified IMAQ Session. Restarting LabVIEW produces the same results as IMAQ Close.

IMAQ Create creates an image buffer that you be input into any of the acquisition functions of your IMAQ device.

IMAQ Dispose disposes an image and frees the memory allocated for the image. Call IMAQ Dispose only when the image is no longer required for the remainder of the processing.



Snaps and Grabs are the most basic types of acquisitions. You used these functions in the MAX configuration exercise earlier in the course. A snap is simply a snapshot, in which you acquire a single image from the camera into a memory buffer. A grab is more like a video, in which you acquire every image that comes from the camera. The images in a grab are displayed successively, producing a full-motion video, consisting of around 25 to 30 frames per second. Grab acquisitions transfer images into a single buffer and overwrite the same buffer with new frames as long as the acquisition is in progress. The buffers are copied as necessary to a separate processing buffer where analysis or display may occur.

Single Buffer Acquisition Functions

Snap	Grab
IMAQdx Snap • Acquires an image from the device and writes it to a buffer	IMAQdx Configure Grab • Prepares device to continuously acquire images
	IMAQdx Grab • Retrieves an image from device and writes it to a buffer

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These are high-level functions that configure your IMAQ device for you. If you choose to control more of the low-level features of your board, take a look at the “LL Snap” and “LL Grab” examples in the Example Finder.

Vision Acquisition Express VI

- Configure your Snap or Grab
- Simulate acquisition without any hardware
- Test your camera and acquisition attributes

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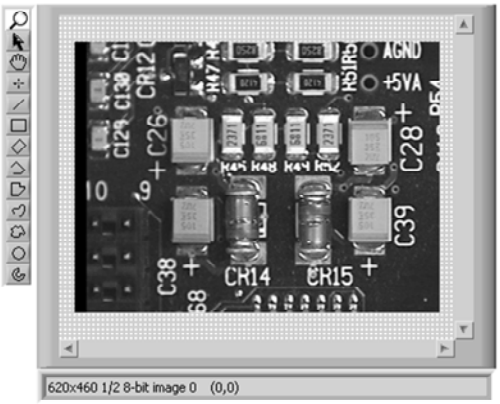
Image Display

- Most common method of viewing images
- Display is not necessary for acquiring images
- Displayed image is not necessarily the acquired image
  - Color palette may change or be limited
  - Viewed image may not represent all data acquired



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One of the first things you will want to do when you acquire an image is display it on your monitor. With LabVIEW 7.0 the **Image Display** control was introduced, allowing users to embed the image on the front panel. This is the easiest method and the one you will use during this course.

Remember that when you display images, the display may differ from the actual image stored in memory. For instance, if your monitor only displays 16 or 256 colors, but you want to display an 8-bit monochrome image, the image may appear distorted depending on how many colors are being used by other programs. In addition, if you acquire a 10-, 12-, 14-, or 16-bit image, you will only be able to display an 8-bit representation of that image. (This is limited by the operating system and video output hardware.)

The display of your images is not necessary for required for acquisition and processing. If your application does not require a human operator, you may want to eliminate all displays from the application's source code.

WindDraw VIs

- Alternate display method based on floating (dialog) windows
- Separate palette and functions
- Provide up to 16 different display windows that are not connected to main program window

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Images in LabVIEW

- The Image type is a pointer to a memory location (buffer) that holds image data.
- Does not follow usual dataflow
- Data can change without notice
- Functions read data from this location without consideration for what that data is

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File I/O

- Not necessary for acquiring images
- Supports common image file types
- Read and Write capability
- Also supports AVI file operations for writing multiple images to one file

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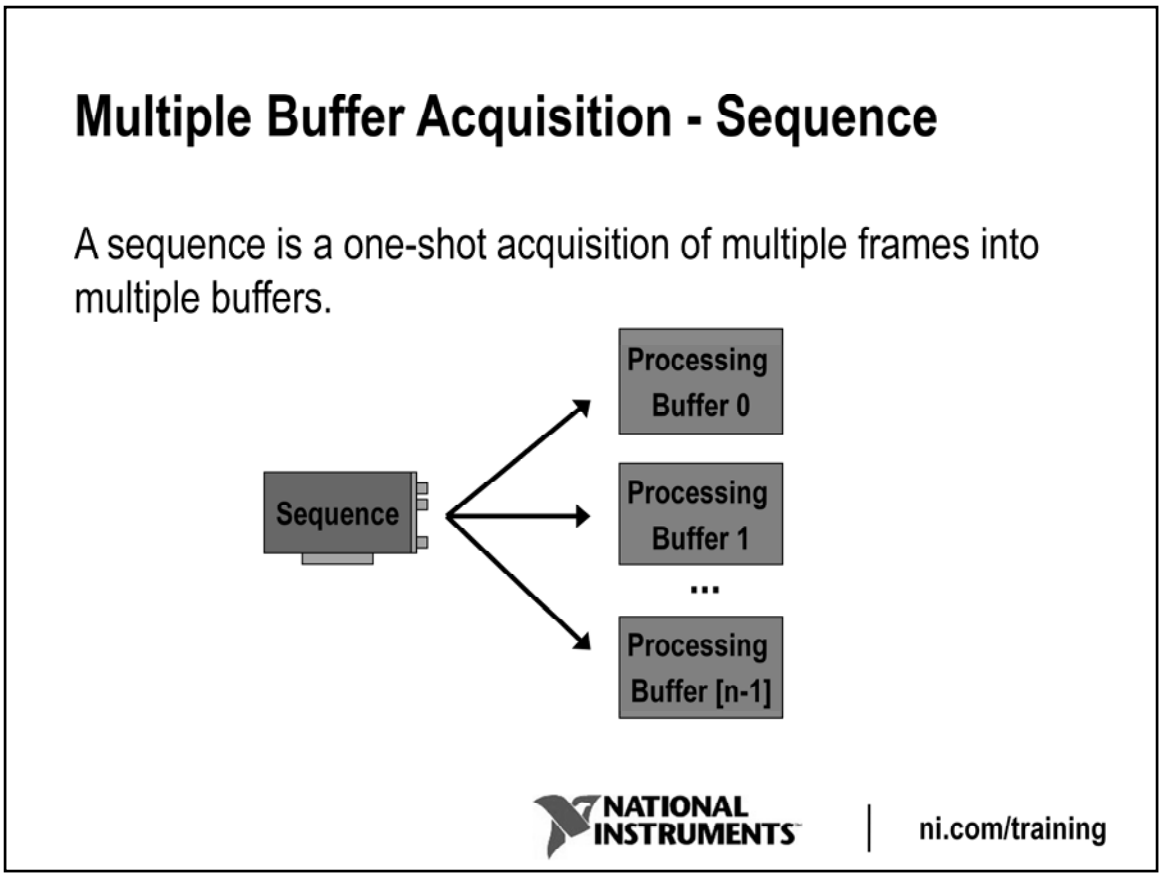
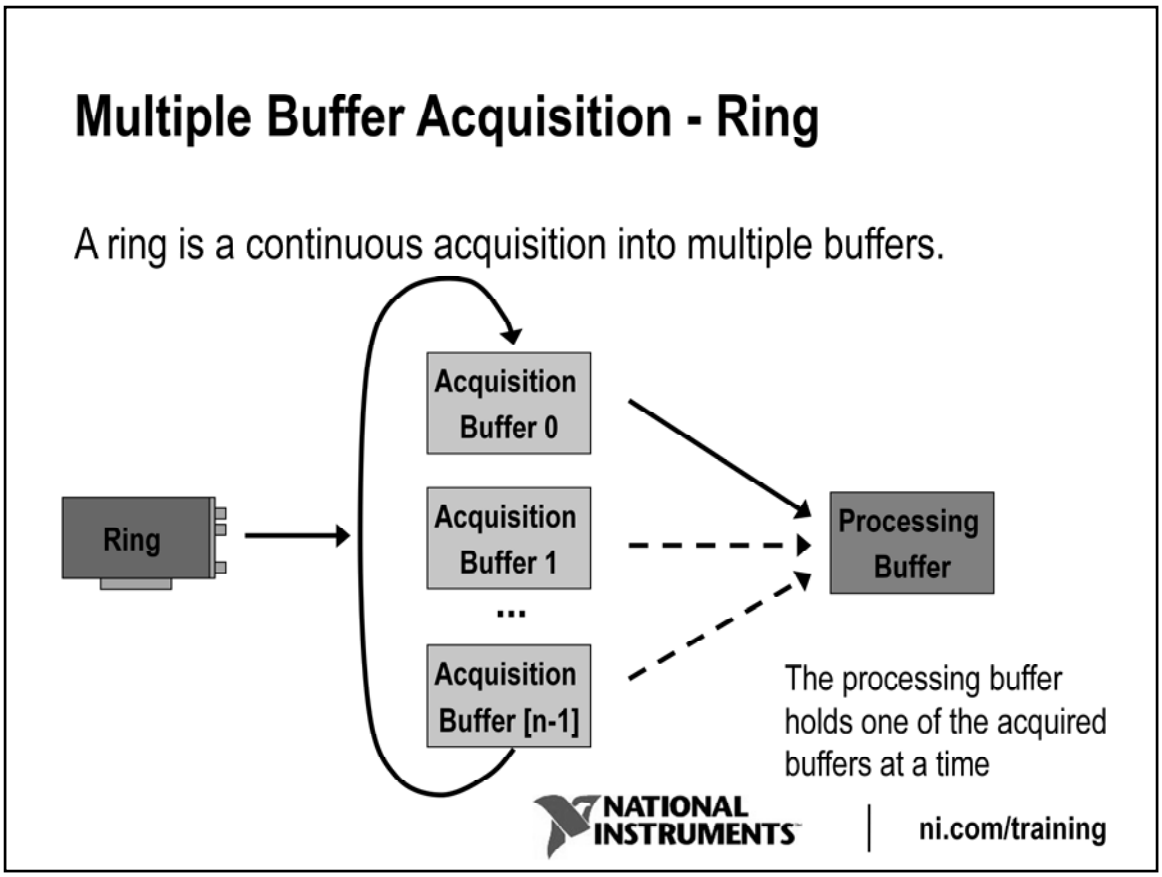
IMAQ ReadFile reads an image file. The file format can be a standard format (BMP, TIFF, JPEG, JPEG2000, PNG, and AIPD) or a nonstandard format known to the user. In all cases, the read pixels are converted automatically into the image type passed by Image.

IMAQ Write File 2 writes the image to a file in the selected format. The format can be BMP, JPG, JPG2000, PNG, PNG with Vision info, or TIFF.



Sequences and Rings are cousins to the other two types of acquisitions that you've studied, Snaps and Grabs.

A sequence of images is a one-shot acquisition that fills up multiple buffers with images a single time. You can use NI-IMAQ functionality to specify a certain number of frames to skip between each acquisition buffer. For example, if your camera acquires 30 frames per second, use a sequence to acquire 30 images with no frames skipped and an acquisition time of one second, or to acquire 30 images with one frame skipped after each buffer with acquisition time of two seconds.



A ring is similar to a sequence in that it uses multiple buffers, but a ring acquires images continuously. Each buffer is filled one at a time until all buffers contain an image. When all buffers are full, NI-IMAQ writes over the existing images one at a time, beginning with the first buffer. When you get ready to process or display an image from one of these buffers, you simply extract it from the ring, while the ring continues in the background.

Note: A ring is typically better than a grab for obtaining images for Vision analysis. A ring function will extract one buffer while another buffer is being updated.

Multiple Buffer Acquisition Functions

Sequence	Ring
IMAQdx Sequence • Acquires a number of images from the device and writes them to memory buffers	IMAQdx Configure Acquisition • Allocates a memory to a list of acquisition buffers
	IMAQdx Start Acquisition • Adds a buffer to the list
	IMAQ Extract Buffer • Extracts a buffer from the acquisition list into the processing buffer

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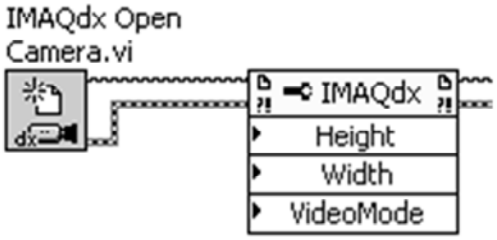
IMAQdx Property Node

- Sets and gets properties of acquisition attributes, camera attributes, camera information, and status information
- Properties are carried through the Session wires



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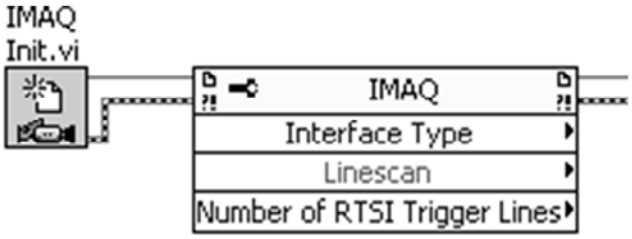
Use IMAQdx Property Node with IIDC-compliant 1394 cameras and GigE Vision cameras.

IMAQ Property Node

- Sets and gets properties of board information, acquisition parameters, image parameters, and status information
- Properties are carried through the Session wires



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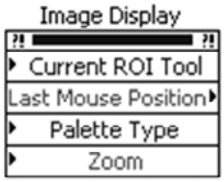
Use the IMAQ Property Node with NI Frame Grabbers and the NI Smart Camera.

Image Display Property Node

Sets and gets properties of Image Display control on front panel and currently displayed image

- Tools available to user
- Region currently selected
- Palette used for display
- Read or set Zoom level
- many, many more…



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Using Triggers

May need to coordinate an image acquisition with motion control, data acquisition, or real-world events

- Can drive or receive trigger signals
  - RTSI bus for NI device synchronization
  - External lines for real-world coordination

Examples:

- Start image acquisition with external trigger received as the unit under test passes in front of the camera
- Send trigger to DAQ card to acquire data as each frame is read from camera

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All triggers, whether they are driven or received, have programmable polarity. In the following sections, a trigger is said to have a value of logical ‘0’ if it is unasserted (if it is low for a high-true trigger signal and high for a low-true trigger signal), and a logical ‘1’ if the trigger is asserted.

Driving Trigger Lines – Frame Grabbers

Internal signals that can drive triggers:

- Acquisition Done
- Acquisition in Progress
- Pixel Clock (PCLK)
- Unasserted (logical "0")
- Asserted (logical "1")
- Horizontal Synchronization Signal (HSYNC)
- Vertical Synchronization Signal (VSYNC)
- Frame Start
- Frame Done
- Scaled Encoder

Trigger VI

IMAQ Trigger Drive

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Acquisition Done —This signal will pulse to a logical '1' once the last piece of data from an image acquisition is captured by the IMAQ board.

Acquisition in Progress—This signal will remain a logical '1' from the time a capture command is sent to the IMAQ board until the last byte of data is captured.

Pixel Clock —The clock signal used to latch incoming data from the A/D converter

Unasserted —Logical '0'

Asserted —Logical '1'

HSYNC —Horizontal synchronization signal that is produced at the beginning of each line by the camera

VSYNC—Vertical synchronization signal that is produced at the beginning of each line by the camera

Frame Start —High when a frame is being captured

Frame Done —Asserted at the end of each frame that is captured

Receiving Trigger Signals – Frame Grabbers

- Read trigger signals on any external or RTSI line
- Configure a triggered acquisition with any of the following actions:
  - Trigger start of acquisition
  - Trigger start of each buffer list
  - Trigger each buffer
  - Trigger each line (linescan)
  - Trigger end of acquisition

Trigger VIs

IMAQ Trigger Read

IMAQ Configure Trigger

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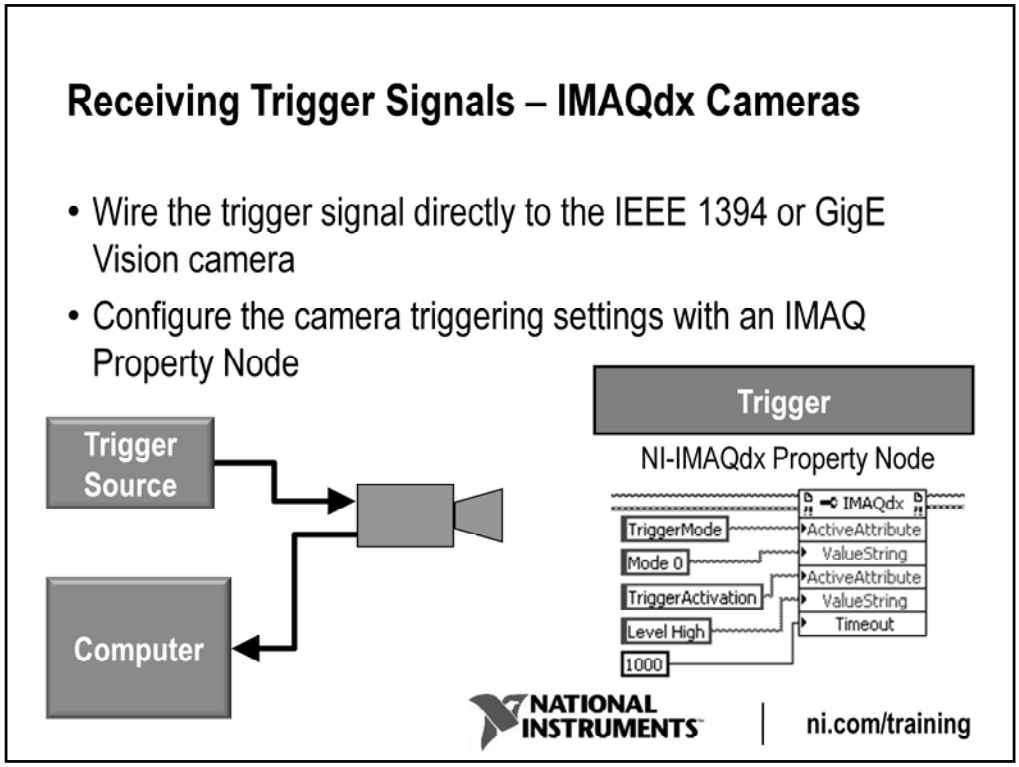
Assert External Trigger 0

Call IMAQ Init to get an interface number to the board. Call IMAQ Trigger Drive VI to drive External Trigger 2 Asserted. The **Get/Set** input must be set to TRUE to set the value of the trigger.

Check Value of External Trigger Line 0

Call IMAQ Init to get an interface number to the board. IMAQ Trigger Read VI is used to sense the current value of External Trigger 2. The value of the trigger is returned in **Trigger status**.



In this configuration wire the sensor output directly to the IEEE 1394 or GigE Vision camera. This method is straightforward as long as the signal from the sensor is compatible with the trigger circuitry of the camera. Many cameras have optically isolated trigger inputs which may require some additional circuitry from your sensor signal for proper functionality. When the camera is triggered it will send the image data to the computer where it can be acquired and processed as needed.

To run a VI where the camera is triggered, your software setup will be very similar to a normal Snap or Grab application. The important step in this configuration is that the camera is put into triggered mode. Using IMAQdx you can query the available trigger modes, then select from the available modes and set this mode on the camera. You can also use the Vision Acquisition express VI which queries the available trigger modes and lets you select the trigger settings. You can also see the available trigger modes for your camera in Measurement and Automation Explorer (MAX) in the Attributes tab.

End of Self-Study Section

Thank you for completing the self-paced portion of the LabVIEW Machine Vision Online Course.
You will learn more about Vision software in the live, online portion of the course.

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