KEYENCE

VOL.1

Beginner's Guide to Vision Systems

Users that are new to vision systems may have the idea that they are complicated and take a lot of time and effort to install and setup. There are indeed a wide variety of models available that include many lighting and control options and it can seem overwhelming. However, having a good understanding of the key points to selecting and installing a vision system, any user can successfully employ a vision system to improve quality control and production yield rates. This series of guides explains the procedures and key points for selecting, installing and operating a machine vision system.

Volume 1: Selecting the devices required for inspection: Camera

The key steps to successfully installing a vision system

1 Selecting the devices required for inspection

Choose the correct devices that meet the inspection requirements.

- Camera
- Controller
- Lighting
- Lens
- Monitor

2 Sensing and judgment

Perform testing on the actual target with the vision system.

- Reference parts for OK and NG products
- Inspection cycle time
- Variety of inspection items

3 Selecting the installation location and procedure

Review the specific installation locations.

- Target in motion / stationary
- Environmental conditions, including ambient light and vibration

4 Controls for automation

Review the I/O controls for the vision system.

- Image capture timing
- Judgment output
- PLC control
- Data output

5 On-site testing

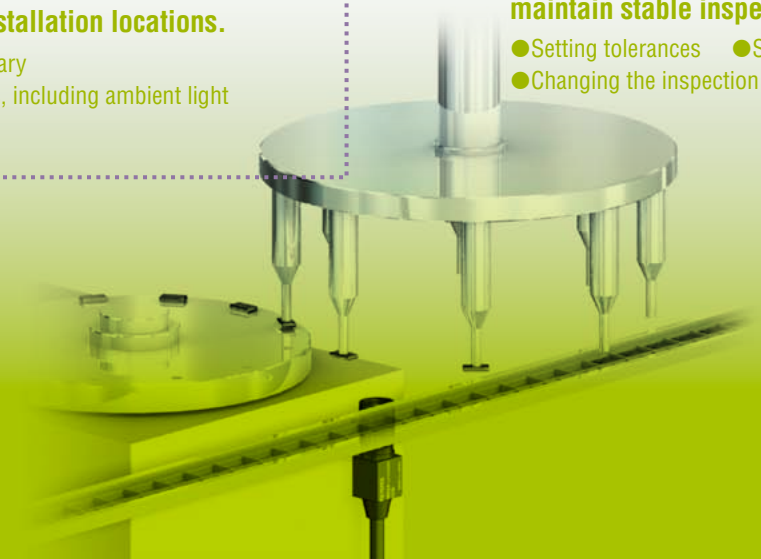
Test the vision system on the actual production line.

- Fine setup adjustment
- Statistics
- I/O control check

6 Understanding basic operations

Basic setup procedures to maintain stable inspection.

- Setting tolerances
- Sensitivity adjustment
- Changing the inspection settings
- Item registration



Device selection 1: Choosing the proper camera

The types of cameras used in vision systems can be broadly grouped into the categories below. From these categories, select the type of camera that provides the optimal images for the intended application and purpose.

1. High-resolution type
2. High-speed type
3. Standard type
4. Compact type

Each type has color and monochrome version available.

Selecting the camera 1 Selecting based on resolution (high or standard resolution).

The image sensor (CCD or CMOS) used in a vision camera is an aggregate of small pixels arranged in a grid. Standard type image sensors commonly have 310000 pixels (640 × 480) while high-resolution types can have anywhere from 2 to 21 megapixels. The application requirements will dictate the type of camera that is suitable.

As a general rule, select a camera based on the size of the field of view and the pixel resolution.
The size of the field of view is the area captured on an inspection target, which can be changed by the lens used.
The pixel resolution means how many millimeters each pixel is equal to, and the relationship is expressed by the following equation.

Pixel resolution = Size of field of view in the Y direction (mm) ÷ sensor pixel count in the Y direction

For an example of pixel resolution, 30 mm 1.18" field of view in the Y direction will be used.
The image sensor types that will be used in this example are the 310000-pixel standard model (Y = 480 pixels) and the general-purpose 2-megapixel high-resolution model (Y = 1200 pixels).

[Pixel resolution of a 310000-pixel camera] = 30 mm 1.18" / 480 pixels = 0.063 mm 0.002"/pixel
[Pixel resolution of a 2-megapixel camera] = 30 mm 1.18" / 1200 pixels = 0.025 mm 0.001"/pixel

If the desired pixel resolution is known for the application, the same equation can be used to calculate the approximate field of view the camera will provide.
Appearance inspection and dimension inspection are typical applications for vision systems. When performing pass/fail judgment, detection capability is considered for appearance inspections, and dimensional tolerance is considered for dimensional inspections.

The following general principles can be applied as reference for calculation:

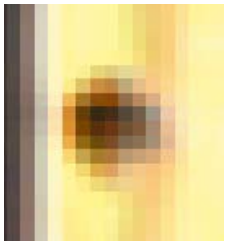
Detection capability = 4 pixel area
Dimensional tolerance = ±5 pixels

Using the pixel resolution calculated above, the detection capability for appearance inspection can be obtained.

[Detection capability of a 310000-pixel camera] = 0.063 mm 0.002"/pixel × 4 pixel area = 0.25 mm 0.01" area
[Detection capability of a 2-megapixel camera] = 0.025 mm 0.001"/pixel × 4 pixel area = 0.1 mm 0.004" area

Based off these calculations, if the inspection requires detection of foreign particles that are as small as 0.1 mm 0.004" with a field of view of 30 mm 1.18", a camera with a resolution of 2MP or more is needed.

Reference: Enlarged view of 0.5 mm 0.02" foreign particle in a 30 mm 1.18" field of view



310000 pixels

2 megapixels

* 2 megapixel cameras can capture images that show fine changes in higher contrast.

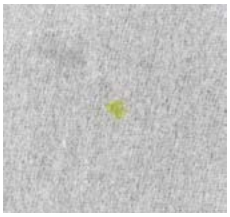
Selecting the camera point 1

You can select a camera with the optimal number of pixels by considering pixel resolution as the criteria for pass/fail judgment.

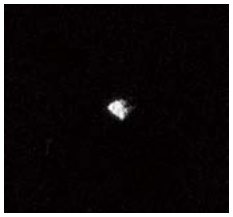
Selecting the camera 2 Selecting based on color or monochrome type image sensor

One common question when selecting a camera type is whether to use a color or monochrome type.
Generally speaking, if the differences at the sensing points are detected based on hue, the color cameras may have an advantage.
The following shows an example of using color processing to detect a yellow stain on a white base, which is not easily detectable by a monochrome camera.

(1) Image captured by a color camera



(2) Color-processed image



(3) Stain inspection contrast image

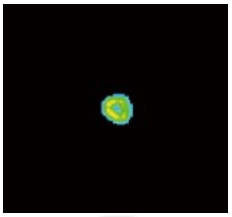
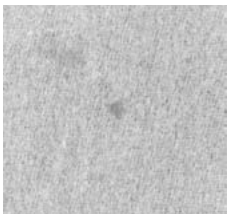


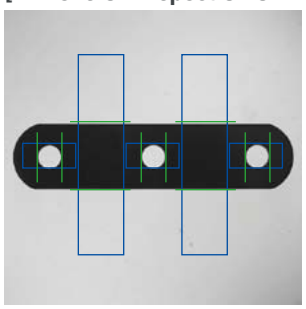
Image captured by a monochrome camera



In cases like this, when there is little difference in brightness, the contrast difference with the background is so slight that a monochrome camera is less likely to provide correct detection. Picture (2) shows that internally, the contrast between yellow and white is clearly detected with the color camera. Picture (3) shows a contrast image obtained by using the stain inspection tool. This shows that stable detection is available for actual inspections using color processing.

However, monochrome cameras do have some advantages over color. For dimension measurement using a backlight, as shown below, monochrome cameras are ideal as there is a large contrast change.
Furthermore, since color cameras use a Bayer filter (where each pixel is dependent on the neighboring pixels to get the full color information), they are generally less accurate than monochrome cameras for dimensional type measurements using edges.

[Dimension inspection of metal workpieces using backlight]



Selecting the camera point 2

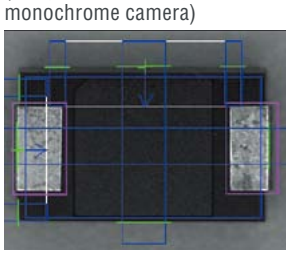
Determine whether the sensing points have a hue variation or a brightness variation when selecting the image sensor!

Selecting the camera 3 Selecting based on image transfer speed (high-speed or standard models)

Cameras used in vision systems can have different image transfer speeds even when the pixel counts are the same.
Using a 310000-pixel type as an example, standard models offer a transmission time of 16.0 ms while high-speed models can achieve a transmission time of 1.7 ms. Even higher speeds can be achieved via a partial capture function.
High-speed cameras are not only effective for fast production lines, but they are advantageous for normal speed applications as there is more processing time available for image filtering and tools that can stabilize the inspection.

[Applications using high-speed cameras]

Appearance inspection of chips (7× speed + 310000 pixel monochrome camera)



Inspections
- Stain inspection of the molded parts
- Dimension inspection
- Position correction (XYθ)

Trigger interval 3 ms
Inspection capability 19980 items per minute

Appearance inspection of caps (7× speed + 310000 pixel full color camera)

Inspections
- Print quality inspection
- Position correction (XY)
- Angle correction (360 degrees)

Trigger interval 12 ms
Inspection capability 4999 items per minute

Selecting the camera point 3

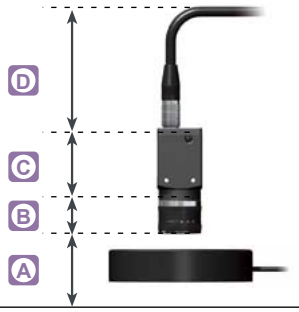
Benefits of selecting a high-speed camera include stable processing in addition to faster inspection cycle time!

Selecting the camera 4 Selecting based on camera size (compact or standard models)

Compact cameras are reduced in size, but are equipped with the same specifications as larger-sized cameras. Standard and high-resolution (2MP) compact types are available in color or monochrome. Compact types are primarily selected to efficiently use limited installation space. Particularly in cases where a vision system is to be installed in the available space of an existing facility, it is beneficial to use compact cameras to fit in a limited area without changing the machinery.

[Calculation of required installation space]

As shown below, the installation space needed for a camera is the sum of
A (WD: working distance, which is the distance between the tip of the lens and the workpiece), B (lens size), C (camera size), and
D (cable space, including bends).



Example: Using a standard camera with lens with a focal distance of 6 mm 0.24" and a field of view of 30 mm 1.18"

A: 40 mm 1.57"
B: 40 mm 1.57"
C: 50 mm 1.97"
D: 85 mm 3.35"
A + B + C + D = 215 mm 8.46"

A space of 215 mm 8.46" in the upward direction is required for this installation.

A significant space-saving can be achieved by using a combination of a compact camera and a side view attachment in cases where a space of 215 mm 8.46" cannot be provided.

A: 30 mm 1.18", B: 15 mm 0.59"
Installation space is only 45 mm 1.77" (A + B).

Selecting the camera point 4

Selecting compact cameras based on the known required installation space can prevent unnecessary changes to the production machine.

Vol. 1 Selecting the devices required for inspection: Camera (Summary)

The camera type is a key element to be selected for image processing to ensure stable inspection.
The below quick reference chart provides a summary of the different camera types that are available.

Pixel count		310000 pixels		470000 pixels		2 million pixels			5 million pixels		21 million pixels
		640 × 480		512 × 480	784 × 596	1600 × 1200			2432 × 2050		5104 × 4092
Transmission time	Monochrome	4.7 ms	16.0 ms	1.7 ms	2.9 ms	11.6 ms	29.2 ms	58.5 ms	27.6 ms	61.2 ms	109.9 ms
	Color								29.0 ms		
Camera size		Standard	Standard/ Compact *	Standard		Standard	Standard	Standard/ Compact *	Standard		Standard
CCD type	Monochrome	CV-H035M	CV-035M *	CA-HX048M		CA-HX200M	CV-H200M	CV-200M *	CA-HX500M	CV-H500M	CA-H2100M
	Color	CV-H035C	CV-035C *	CA-HX048C		CA-HX200C	CV-H200C	CV-200C *	CA-HX500C	CV-H500C	CA-H2100C

* Compact cameras in the KEYENCE lineup are the 310000 pixel models CV-S035M and CV-S035C, and the 2 megapixel models CV-S200M and CV-S200C.

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SAFETY INFORMATION
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