First 10 Steps in Setting up a Successful Vision Application

By

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First Step

- “ Is my machine vision requirement a killer app.?” Is it the right candidate for a vision application?

Or

- Is machine vision my only solution?

Second Step

- A problem identified is half the problem solved.

The issue could be:

- Error proofing
- Increase in production process / cycle time
- Savings in cost
- Customer satisfaction

Second Step contd……

- **Reduce waste:** Vision Technology allows you to reduce scrap and waste by identifying process errors
- **Improve labor utilisation:** Vision technology allows you to trade manual inspection for fast, reliable automated inspection allowing you to redirect labor force for better utilisation
- **Gain productivity:** Vision technology enables production improvements by identifying bottlenecks, allowing you to improve processes for higher productivity.

Third Step

My application is defined as:

- Gauging
- Guiding
- Identification
- Inspection

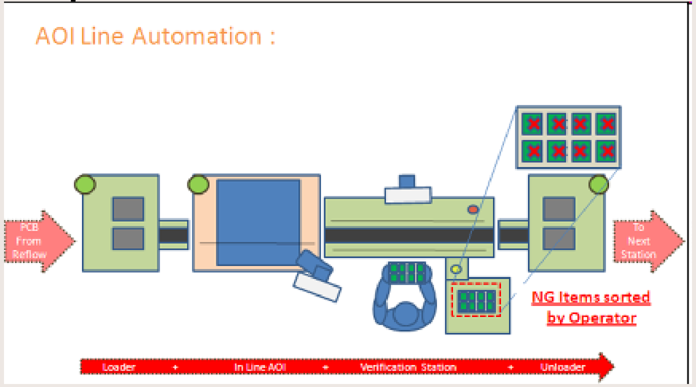
Where to begin?

- A Manual or Beta station to asses the complexities involved.
- To gain hands on experience with vision basics
- Or if the process is well defined with minimum variations for a full fledged automatic line.

Where to begin contd ...

For example, an automated application would involve:

- Manual loading of parts in conveyor or fixture.
- Part presence by sensor / trigger
- Image acquisition & processing.
- Signal to actuator for sorting.
- Signal at collection bin on receipt of material
- Bin level indication for transfer / line stop
- Machine Components Failure / Safety / Emergency stop.
- Ease of control & maintenance aspects.



Fifth Step

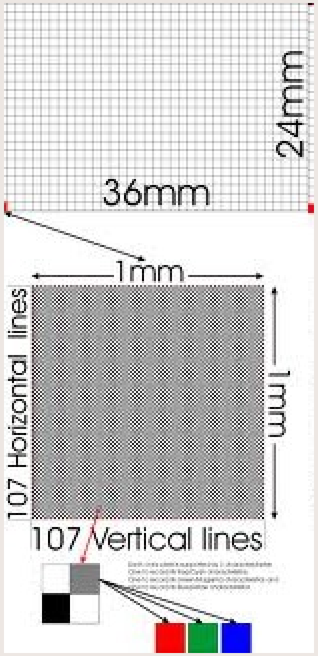
Fundamentals of imaging

• The 'pixel' is the building block of a camera imager. The image of a scene is focused on a rectangular array of pixels in the camera.

• Circuitry inside the camera converts the light falling on the pixels into signals for processing.

•In analog cameras, the output is a time varying video signal. The video signals are prone to noise; analog cameras like analog TVs are practically obsolete.

•In digital cameras, the signals are converted into a data stream and output in a variety of formats such as CameraLink and GigE.

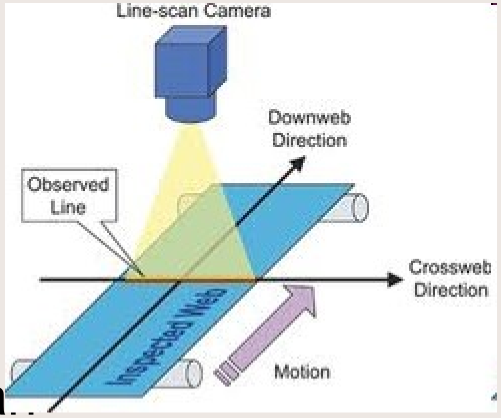


Fifth step contd…

In a CCD camera, each pixel consists of a photo sensor that generates and stores an electric charge when it is illuminated. This charge is converted into a digital signal by connecting each pixel,in turn,to analog-digital converter circuits inside the camera.

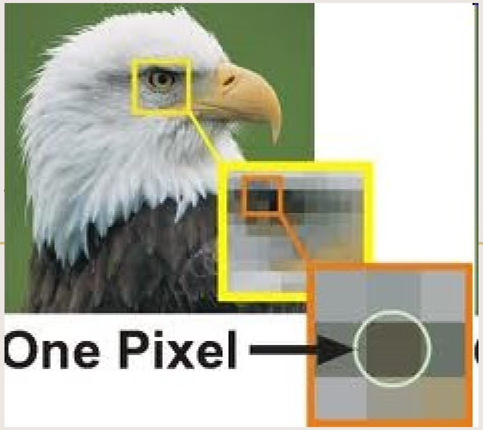
- In a CMOS camera, each pixel is an active semiconductor element and contains its own circuit to convert light energy into a voltage. These voltages are then converted into digital signals.

- CMOS cameras have benefitted tremendously from advances made in the semiconductor industry, and now offer higher speeds and lower cost with quality comparable to traditional CCD cameras.



In an Area Scan camera, the imager is a rectangular array. While capturing the image of a… object in motion, one needs to set the appropriate exposure time in order to obtain blur free images.

Fifth Step contd.



- There are two kinds of resolution to consider when setting up your imaging system: pixel resolution and image resolution.
- Pixel resolution refers to the minimum number of pixels you need to represent the object under inspection.
- Image Resolution indicates the amount of object detail that the imaging system can reproduce. Images with low resolution lack detail and often appear blurry. Three factors contribute to the resolution of your imaging system :
- field of view, the camera sensor size, and number of pixels in the sensor.
- When you know these three factors, you can determine the focal length of your camera lens.

Fifth Step contd…

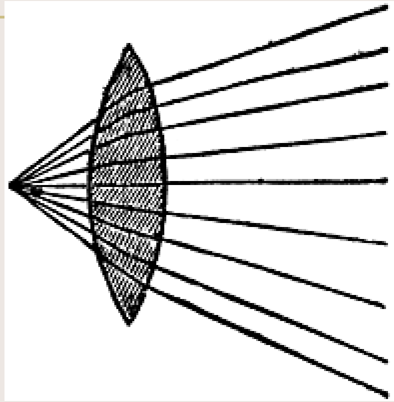
Field of View:

- The field of view is the area of the object under inspection that the camera can acquire.

Sensor Size and Number of Pixels in the Sensor:

- The camera sensor size is important in determining your field of view, which is a key element in determining your minimum resolution requirement.
- 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. Choose a camera with a sensor that satisfies your minimum resolution requirement.
- For example, a 640 X 480 resolution camera covering a field of 64mm X 48mm would give an accuracy of 0.1mm per pixel.

Fifth Step contd…



Lens Focal Length:

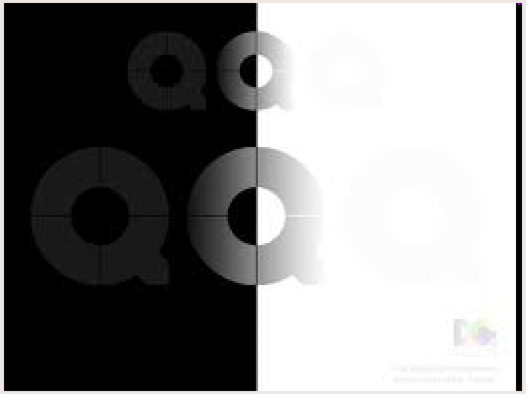
- When you determine the field of view and appropriate sensor size, you can decide which type of camera lens meets your imaging needs. A lens is defined primarily by its focal length and its distortion characteristics. Higher quality lenses will have lower distortion at the outer edges of the lens.
- Lens calculators are available as free down loads.

Fifth Step contd…

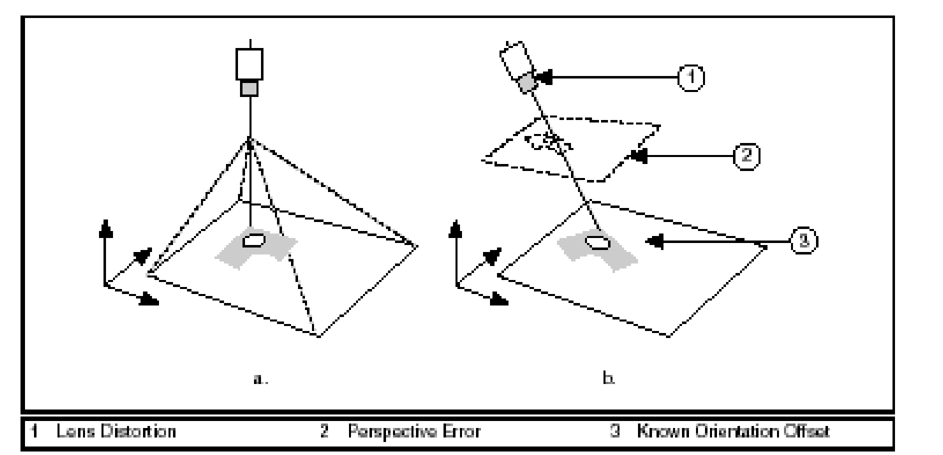
GI GO: Good Image = Good Output

Contrast

- Resolution and Contrast are closely related factors contributing to image quality.
- Contrast defines the differences in intensity values between the object under inspection and the background.
- Your imaging system should have enough contrast to distinguish objects from the background. Proper lighting techniques can enhance the contrast of your system.



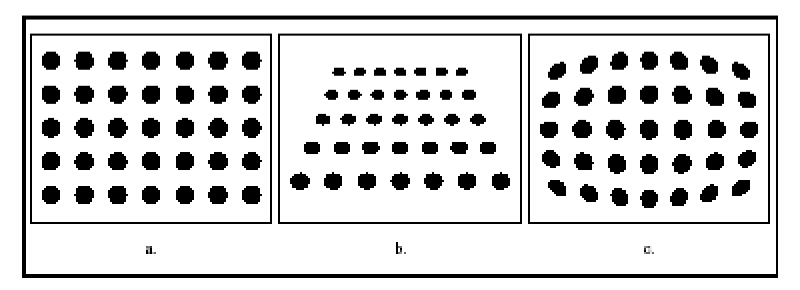
Fifth Step contd…



Perspective errors:

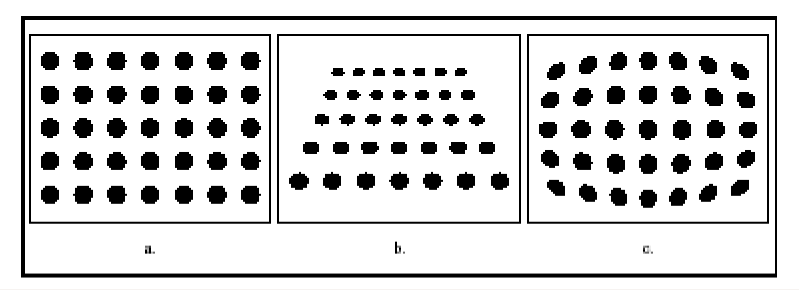
- Perspective errors often occur when the camera axis is not perpendicular to the object you are inspecting. The Figure (a) above shows an ideal camera position, while figure (b) shows the possible errors arising from a non-ideal position.

Fifth Step contd…



- The figure (a) above shows the image of a grid of dots from an ideally positioned camera, while (b) shows typical perspective errors caused by non-ideal positioning.
- Try to position your camera perpendicular to the object you are trying to inspect, to reduce perspective errors. If you need to take precise measurements from your image, correct perspective error by applying calibration techniques to your image.

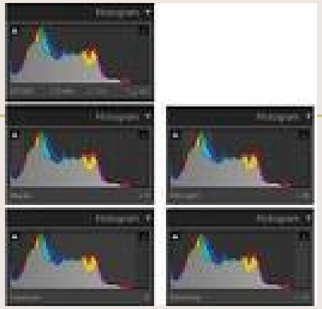
Fifth Step contd…



Distortion

- Nonlinear distortion is a geometric aberration caused by optical errors in the camera lens. A typical camera lens introduces radial distortion. This causes points that are away from the lens's optical center to appear further away from the center than they really are.
- Figure (c) above illustrates the effect of distortion on a grid of dots. When distortion occurs, information in the image is misplaced relative to the center of the field of view, but the information is not necessarily lost. Therefore, you can undistort your image through spatial calibration.

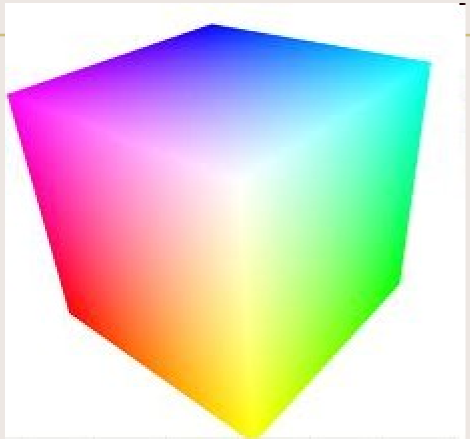
Fifth Step contd…

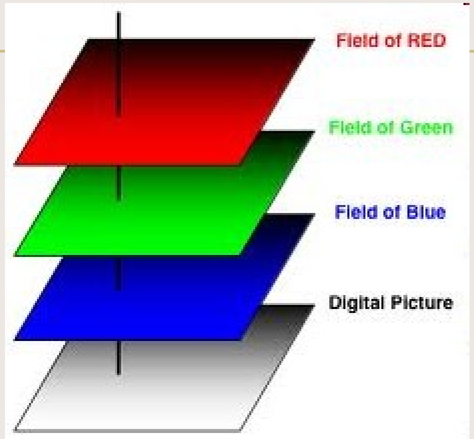


A histogram

- counts and graphs the total number of pixels at each grayscale level. From the graph, you can tell whether the image contains distinct regions of a certain gray-level value.
- A histogram provides a general description of the appearance of an image and helps identify various components such as the background, objects, and noise.

Fifth Step contd…

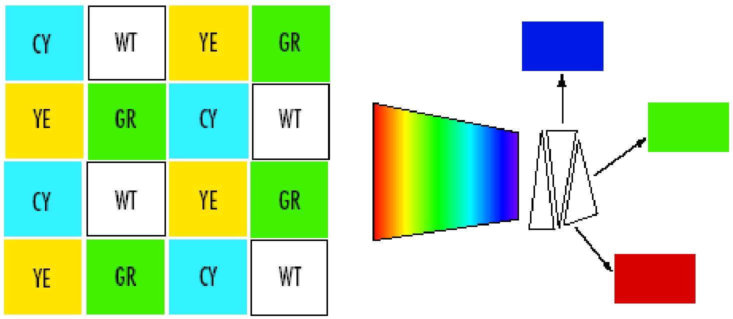




Color Cameras:

The CCD or CMOS imager is based on a photoelectric effect and, as a result, cannot distinguish between colors. There are two types of color cameras, single chip and three-chip. The single chip offers a common, low-cost imaging solution and uses a mosaic filter to separate incoming light into a series of colors. Each color is directed to a different set of pixels.

Fifth Step contd…



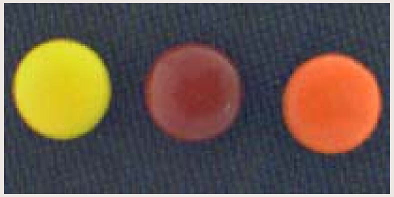
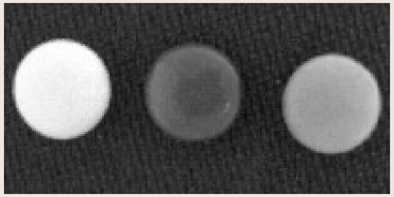
a) Single Chip Color CCD Camera: This is an example of how a mosaic filter allots different colors to neighboring pixels.

b) Three-Chip Color CCD Camera: A prism is used to break up the incoming image into its red, green, and blue components.

(see Figure a).

- The precise layout of the mosaic pattern can vary, but the most commonly used is a Bayer pattern : 2 green, 1 red, 1 blue pixel, which closely matches the sensitivity of the human eye.
- Since more pixels are required to recognize color, the single chip color cameras have a color resolution that is inherently lower (typically 1/4th) than the monochrome resolution.
- The three-chip camera was designed to solve this resolution problem by using a prism to direct each section of the spectrum to a different chip (see Figure b). Three-chip cameras can offer extremely high resolutions but have lower light sensitivities, apart from being delicate and expensive.

Fifth Step contd…

- Color is the manifestation of light from the visible part of the electromagnetic spectrum. It is perceived by an observer and is therefore subjective – two people may discern a different color from the same object in the same scene.
- Each object in a scene absorbs and reflects (i.e., filters) this spectrum differently and the camera system responds to (i.e., accepts and rejects) the reflected spectrum in its own way. The challenge for color machine vision is to deliver consistent analysis throughout a system’s operation – and between systems performing the same task–while also imitating a human’s ability to discern and interpret colors.
- Color images contain a greater amount of data to process (i.e., typically three times more) than grayscale images and require more intricate handling. Efficient and optimized algorithms are needed to analyze these images in a reasonable amount of time.

Sixth Step

Vision Evaluation:

- The machine vision evaluation is usually done under lab conditions with simulations on actual field conditions. This evaluation actually defines the application feasibility at the basic level. The applicator has to actually produce / simulate the process criteria to the extent possible.
- At this stage the consistency of results has to be established beyond doubt.

Sixth Step contd…

The applicator zeros down on:

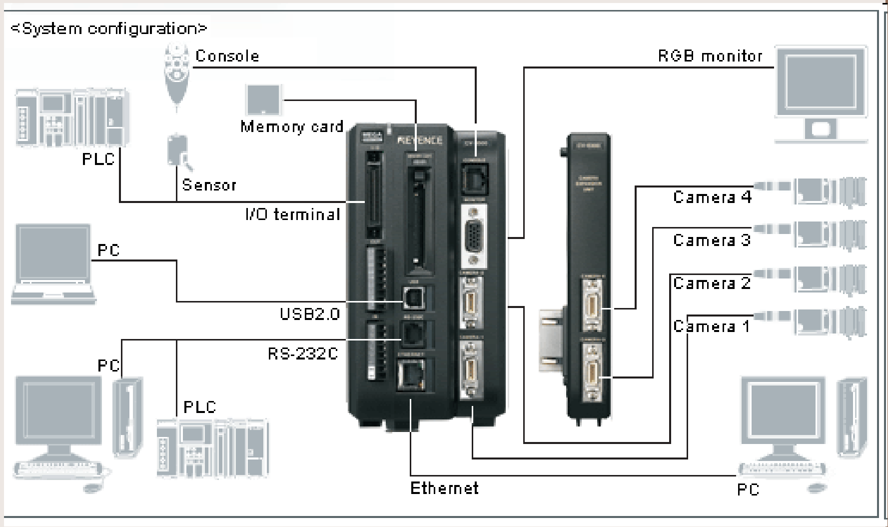
- Basic feasibility & complexities involved
- Selection of type of image sensor or camera
- Lighting
- Communication requirements
- Control requirements
- Data Collection and Operational Metrics requirements

Seventh Step

Selection of Hardware & Scalability:

The selection of hardware involves the definition of all the control elements involved in the vision application like

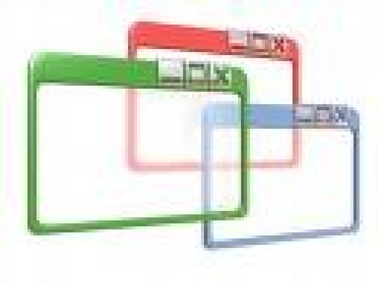
- The camera
- Lens
- Lighting
- Communication / Interfaces
- I/O
- Display / Annunciator
- Data logging & analysis
- The applicator should keep in mind the future needs and up-gradation of hardware to cater for advancements in technology.



Comparison : Smart Camera v/s PC Based System

Smart Camera	PC Based Vision System
Limited choice of Sensors and Resolutions	Wide choice of sensors and resolutions - also UV, Infrared, other special options
Limited processing power and memory capacity	High processing power and memory, independent of imaging requirements
Ready to apply vision tools for standard applications	Advanced vision programming and special algorithms for complex applications
Proportional increase in cost with number of cameras per application	Low incremental cost of adding more cameras to a basic system
Industrial protocol and I/O interface support is vendor dependent	Any industrial protocol and I/O interfaces can be integrated, independent of imaging requirements
High cost of harsh environment (IP65/67) compliance, as CPU is subjected to same environment	Harsh environment compliance cost can be lowered, as CPU not in same environment as camera
Additional hardware needed to view images, change process parameters	Images can be viewed and process parameters changed from the PC
Simplified cabling, generally no cable length restrictions	Cabling simplicity comparable to smart cameras, using the latest generation GigE
Support for data collection and operational metrics is vendor dependent	Unlimited flexibility in data collection and operational metrics implementation

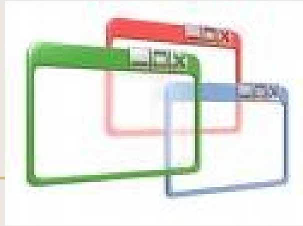
Eighth Step



Selection of software:

- The main criteria in software selection, apart from meeting the performance criteria, should be the ability to handle all the variations that can occur on the production line.
- The vagaries in imaging caused by variations in lighting, positioning and production processes are actually handled by the software and tools provided by the vision vendor.
- It is most important that the software tools can accurately and correctly detect or measure object features down to the sub-pixel consistently.
- The filtering tools sharpen the edges, remove noise or extract frequency information.
- The image calibration tools remove non linear and prospective errors caused by lens distortion and camera placement. The calibration tools also enable measuring in real world units like microns & millimetres instead of pixels.

Eighth Step contd…



- Ability to locate features is important, as the vision uses fixtures in terms of X,Y and Theta for job location & orientation.
- Look for features that enable OCR / OCV, Bar Code or 2D Data as these enable data capture and part tracing as these are very much vision attributes and help improve process.
- Algorithm performance is another important criteria - as the application gets more complex and more tools being applied, it slows down the speed of the image processing.

Eighth Step contd…

- One would realize that the vision system is often part of a much larger control system consisting of PLC system, robot controller, data acquisition, remote monitoring and control. Check that the vision system can support the protocols you plan to use for these range of devices.
- Check for software bundles so as to optimize the requirement to your specific application.
- Check you vision supplier's ability and track record in customizing the standard software bundles to your specific requirements.

- **Vision Sensors:** Easiest and most affordable way to solve simple, single function vision tasks

- **Vision Systems:** Mostly smart cameras, rugged industrial vision systems that can virtually solve any vision task, comes in variety of options.

- **Vision software:** Highest performance and most advanced vision tools for most demanding of vision applications

- **ID readers:** Image based 1D barcode readers, Direct Part Marked 2D Codes, OCR and OCV applications to specific industry standards.

Ninth Step

Product vendor, Integrator, support and training:

•Machine Vision, though sold as a product, is more of a technology. Basic training is a must. Check for local support and the integrator's expertise to ensure a successful implementation and optimum system utilization.

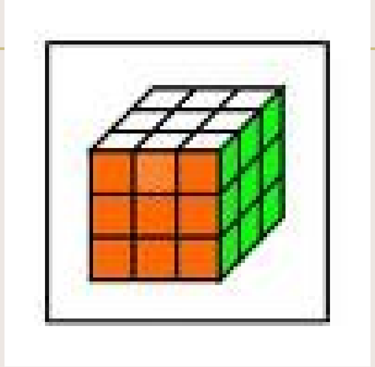
•This being a technology driven field, check for product life cycles and upgrades.

Tenth step

Neatly document the whole experience as a project file on your vision application system configuration and send out RFQs.

•It is advisable to opt for on-site training on machine vision deployment with an authorised training center or vision lab.

Now, on completing the tenth step, you are off to a sure start for implementing a successful vision application!



Thanks! Any questions?

Please contact us !