Introduction to Machine Vision

Joe Wesoloski | October 3, 2019

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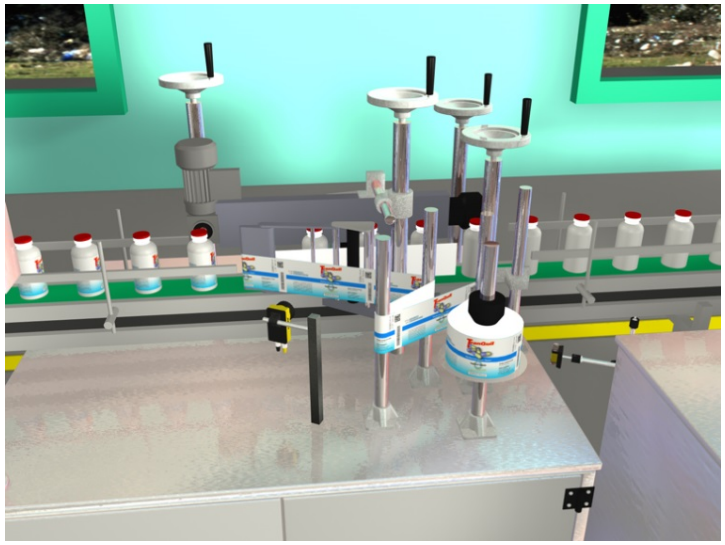
Agenda

- What is machine vision?
- Why use machine vision?
- Machine vision applications
- Types of machine vision systems
- Vision system components
- Machine vision terms
- Improving vision system performance
- Summary
- Q&A

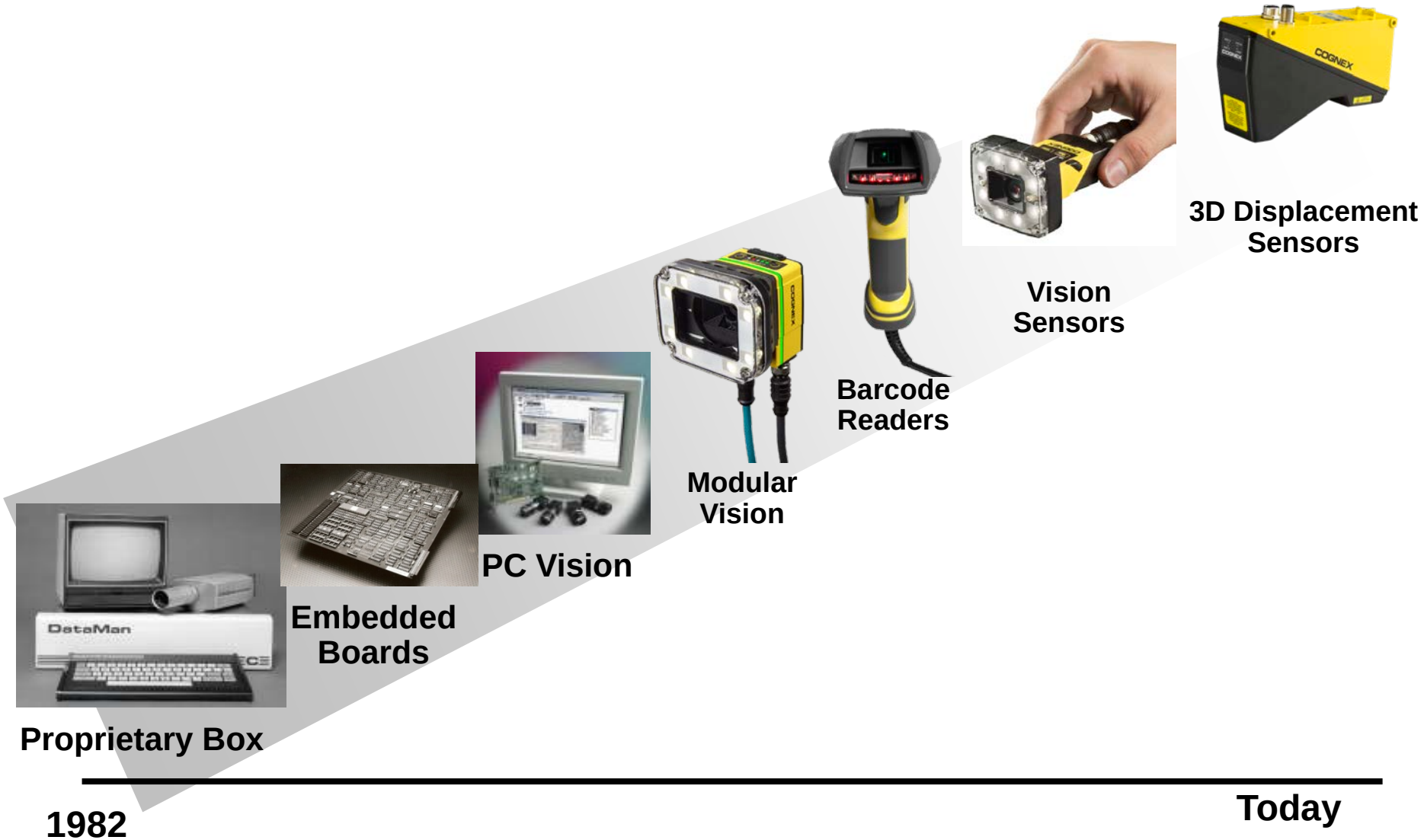


What Is Machine Vision?

The camera lens and sensor capture images…

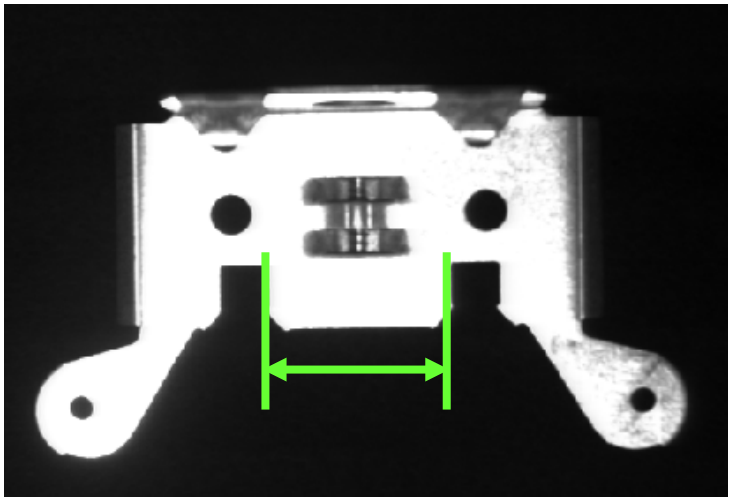
Cognex advanced vision software interprets what's being seen

Evolution of Machine Vision



Simple Examples

- Machine vision systems analyze images
  - Then makes decisions and/or returns numeric results about each image it gets



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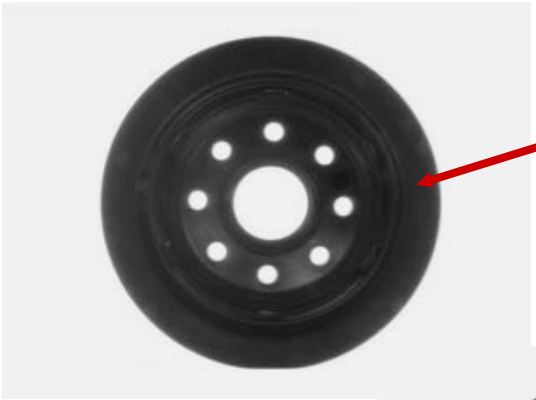
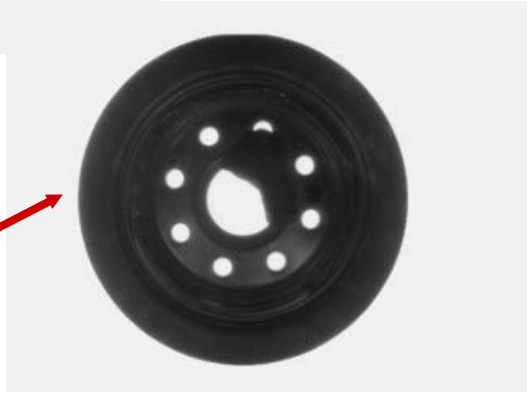


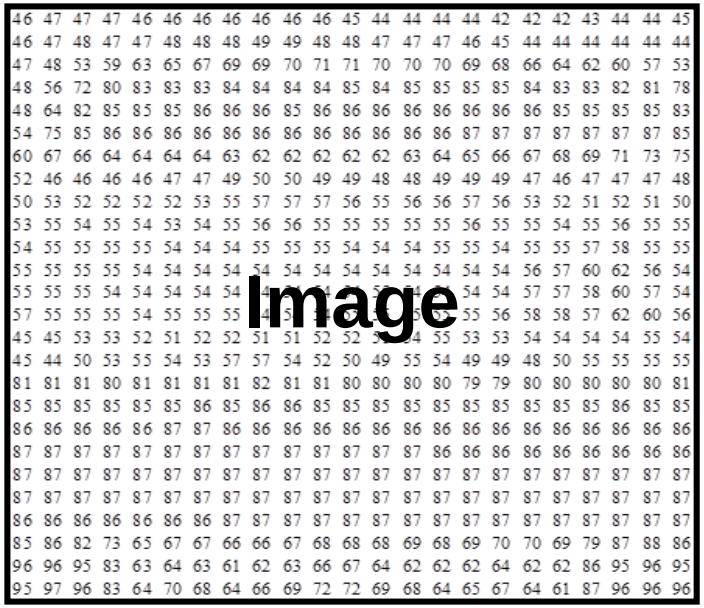
Good Oil Filter – all holes are open

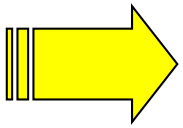


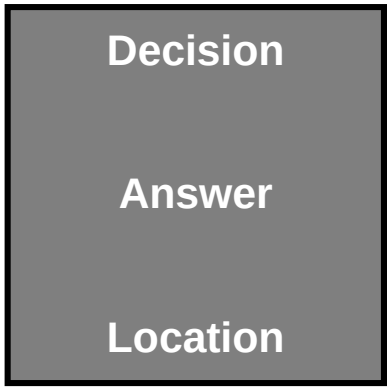
Reject oil filter – some holes are blocked

Image Analysis

The primary purpose of machine vision is *image analysis*







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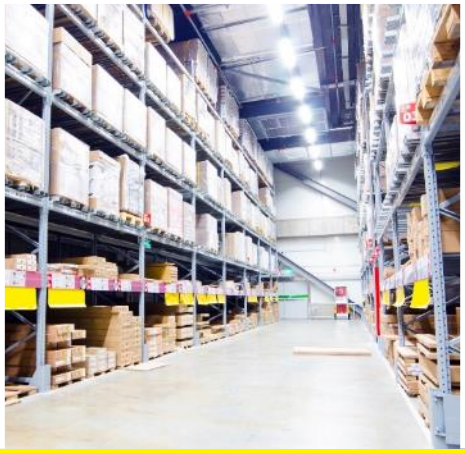
PRODUCTS ACROSS

ALL

INDUSTRIES



ARE MADE BETTER AND
AT LOWER COST WITH

COGNEX VISION

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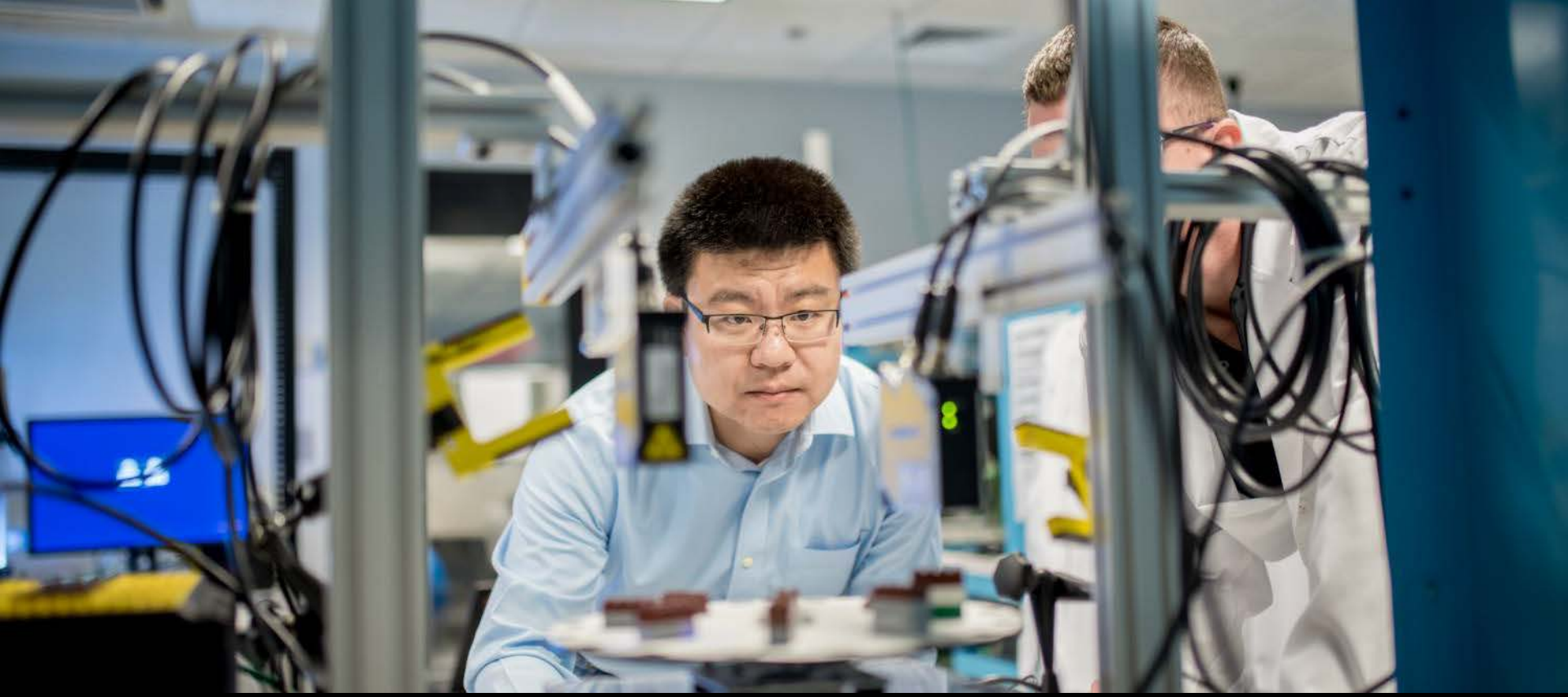

Why Use Machine Vision?

Critical for Achieving Strategic Goals

- High speed production lines
- Clean room environments
- Hazardous environments
- Microscopic inspection
- Closed-loop process control
- Robot guidance
- Precise non-contact measurement

Benefits of Machine Vision

Strategic Goal	Machine Vision Applications
Higher Quality	Inspection, measurement, gauging, and assembly verification
Increased Productivity	Repetitive tasks formerly done manually are now done by MVS
Production Flexibility	Measurement and gauging / Robot guidance / Prior operation verification
Less Machine Downtime and Reduced Setup Time	Changeovers programmed in advance
More Complete Information and Tighter Process Control	Manual tasks can now provide computer data feedback

Benefits of Machine Vision

Strategic Goal	Machine Vision Applications
Lower Capital Equipment Costs	Adding vision to a machine improves its performance, avoids obsolescence
Lower Production Costs	One vision system vs. many people / Detection of flaws early in the process
Scrap Rate Reduction	Inspection, measurement, and gauging
Inventory Control	OCR and Identification
Reduced Floorspace	Vision System vs. Operator

Machine Vision Applications

Think: GIGI

Guidance

Inspection

Gauging

Identification

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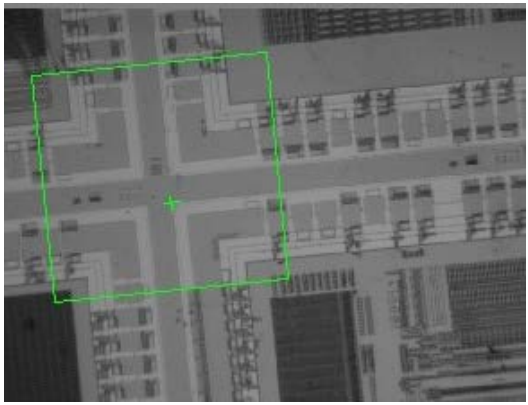
Guidance

Determines part position (x, y, and angle)

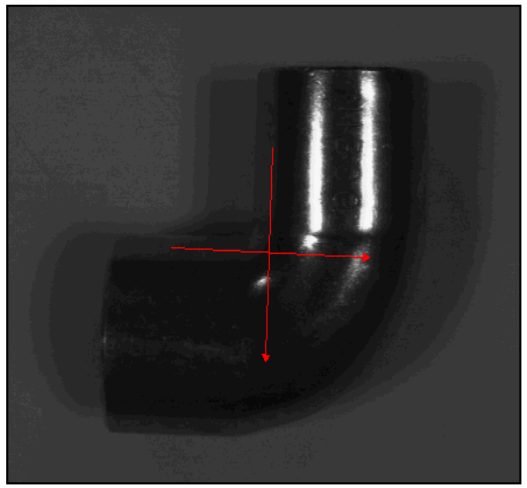
Automates handling of parts for machines:

- Alignment & Placement
- 2D & 3D Picking
- Eliminates need for fixturing & improves robot flexibility

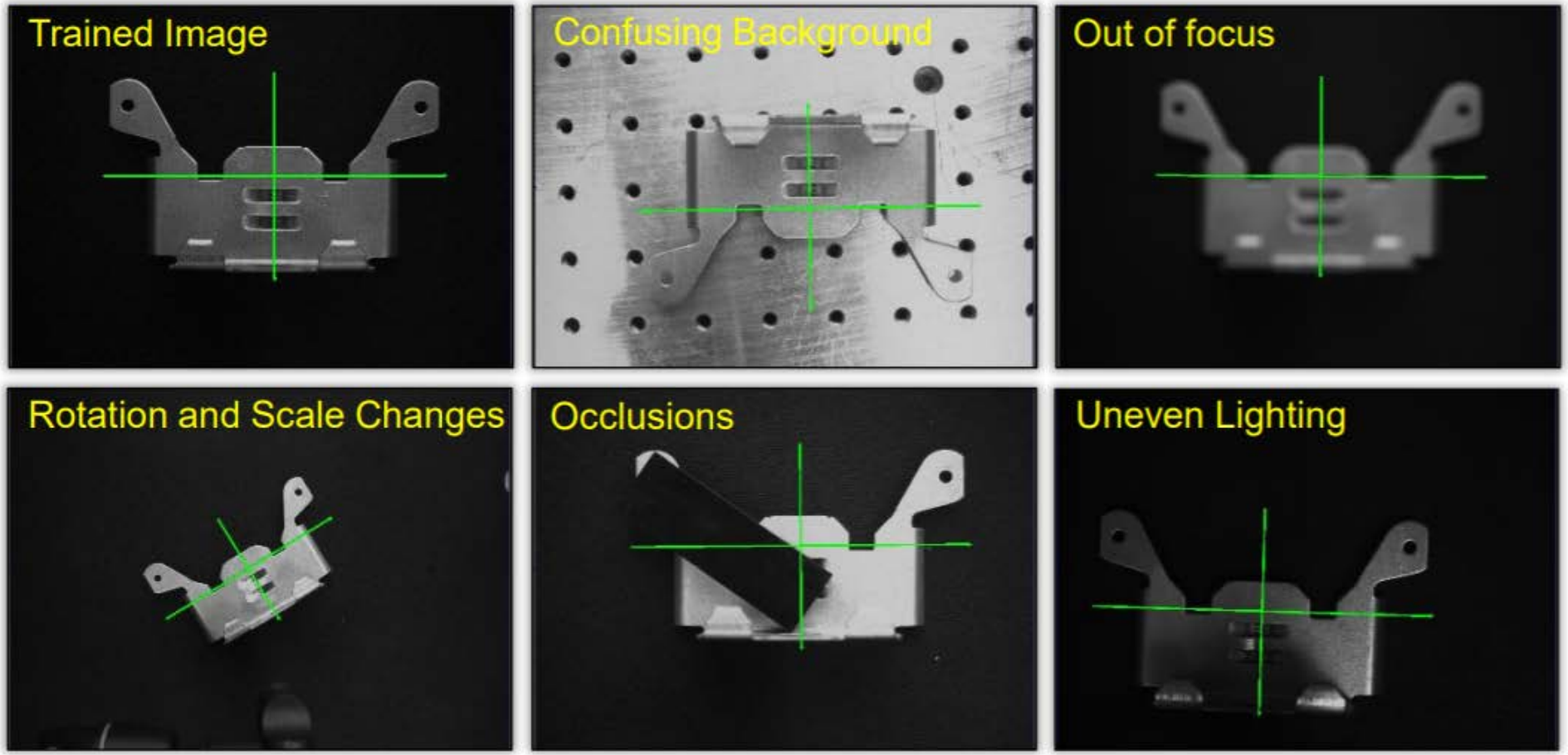


Vision tool alignment, fixturing

- Locate at least one feature on a part for the purpose of calculating the (x, y) position and rotation of the part to position other vision tools precisely

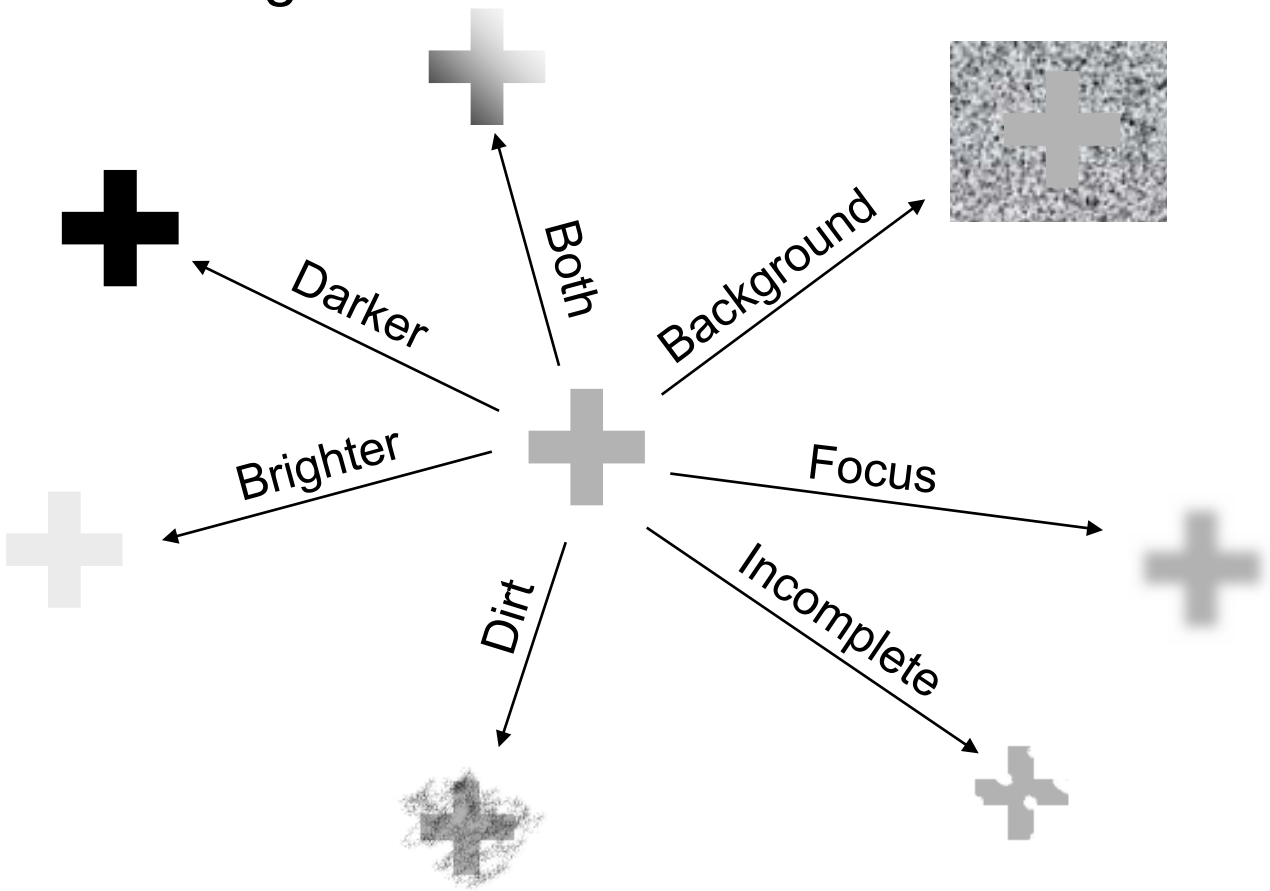


Geometric Pattern Matching



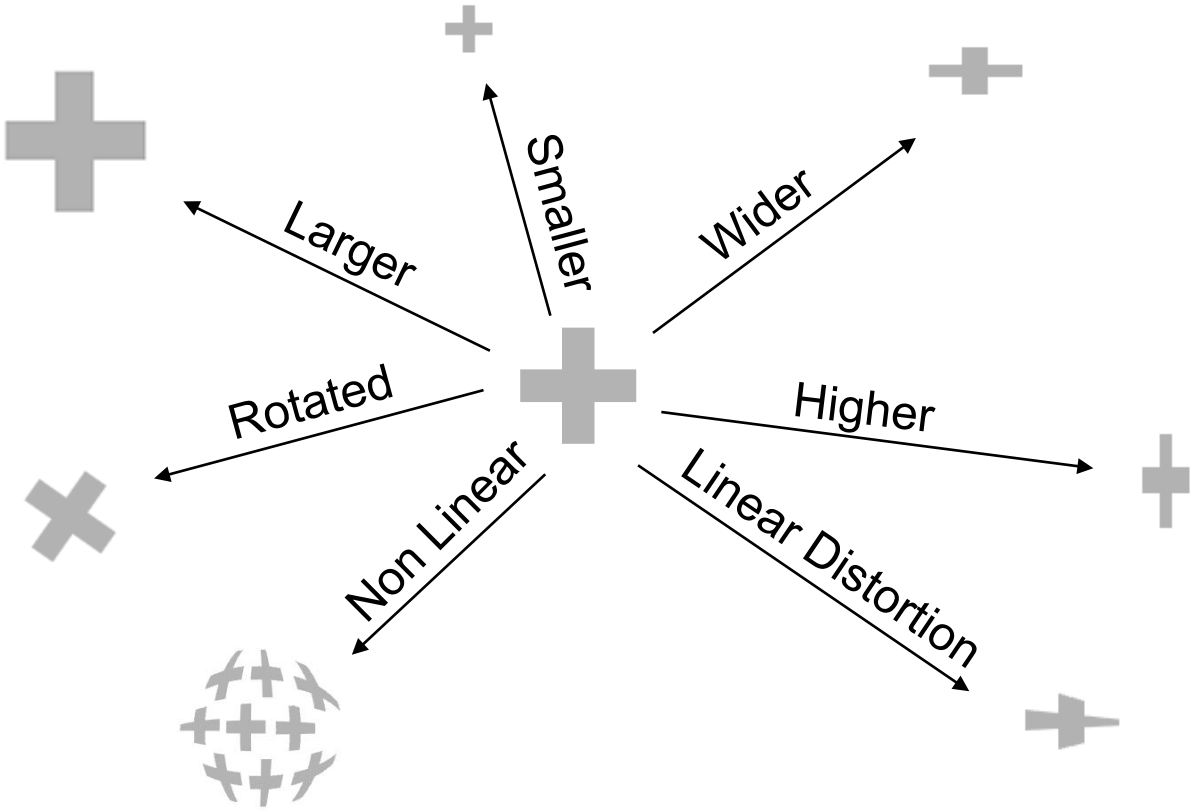
Part Location Challenges

Appearance changes



Part Location Challenges

Variation in part appearance



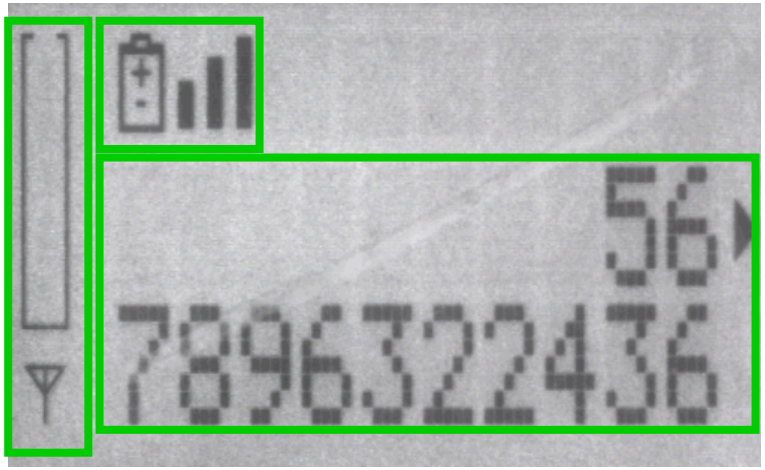
Inspection

Broad category of vision applications:

Correct location
- Orientation
- Skew

Quality
- Defect Detection
- Surface Inspection
- Contaminants

Completeness
- Fill Level
- Feature Presence
- Counting
- Assembly Verification



Gauging

Precise dimensioning

- Automated metrology and data recording

Ensure tolerances

- Diameters
- Gaps
- Bushings
- Threads, etc.

Identification

Read codes

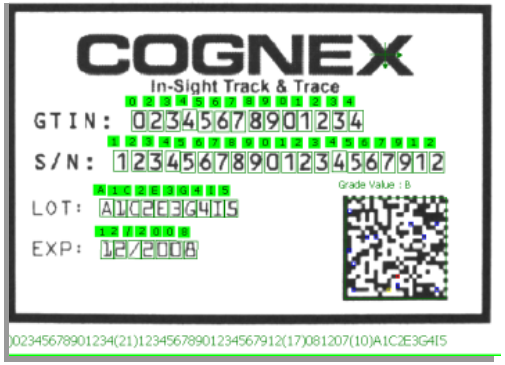
- Bar codes & 2-D Matrix
- Labels & direct part mark

Read characters

- OCR / OCV

Recognize objects

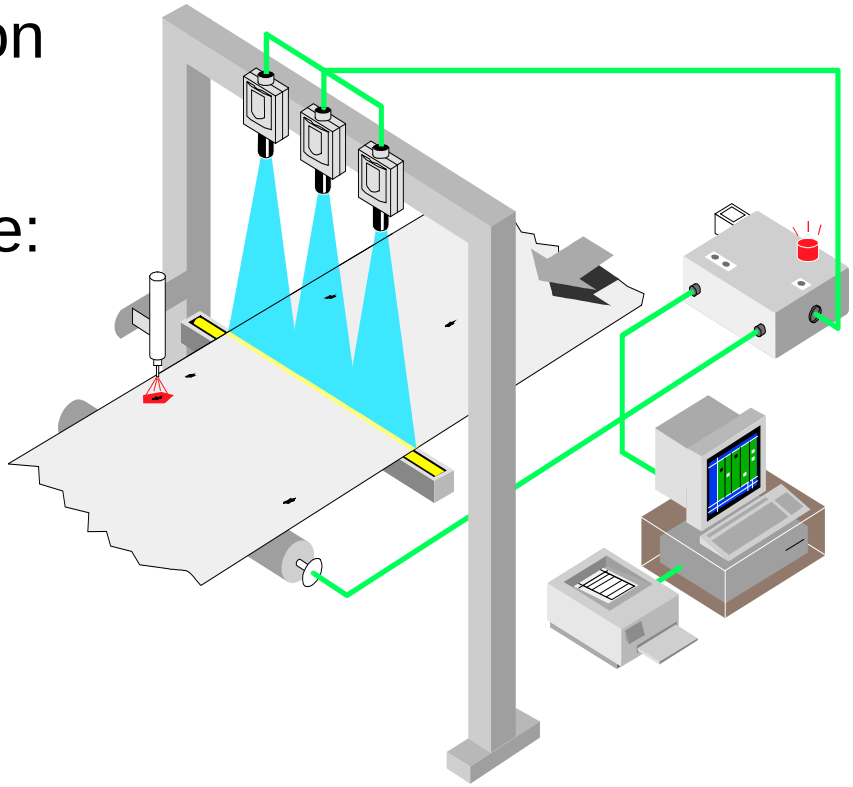
- Based on color, shape, or size



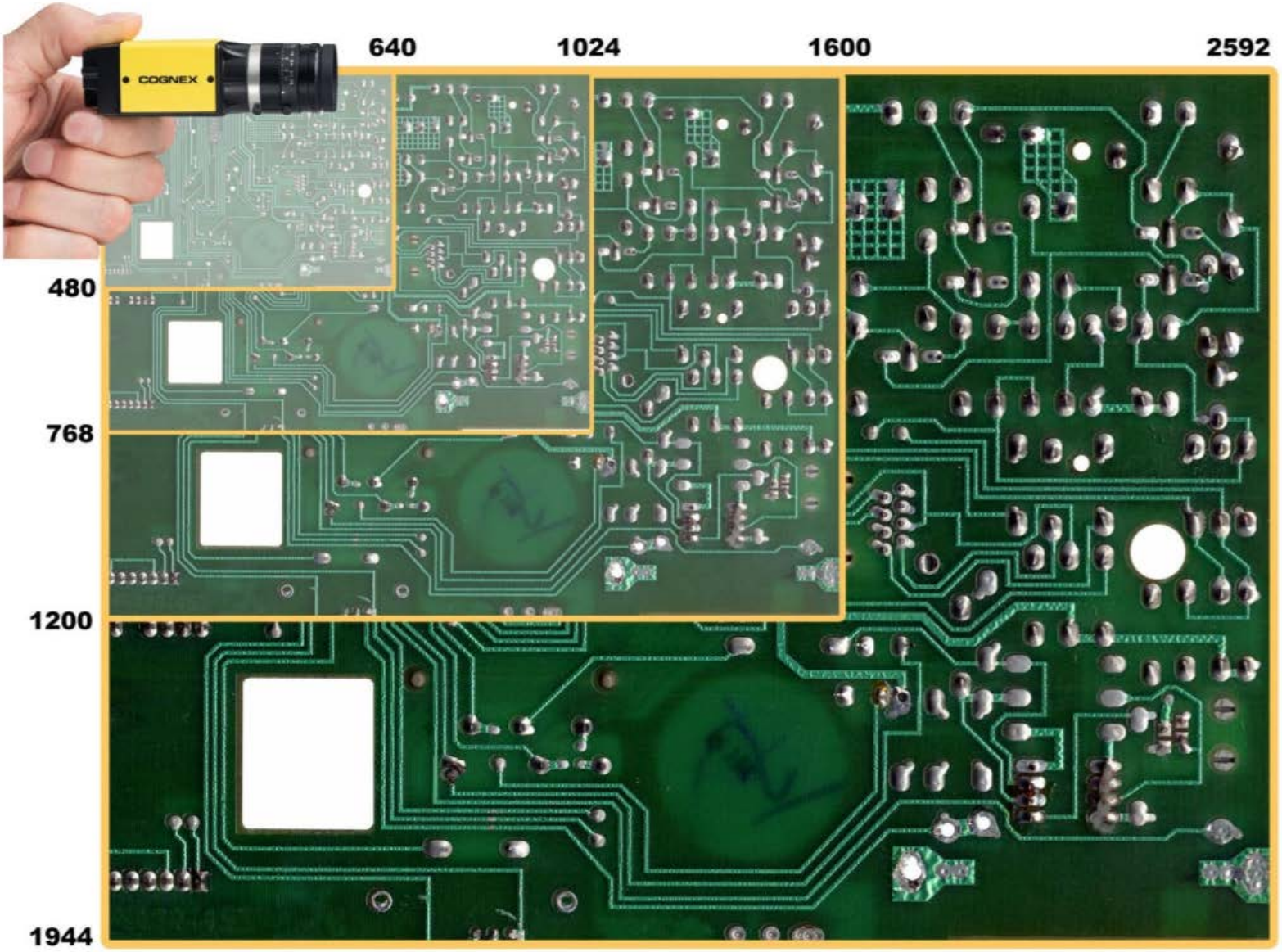
Types of Machine Vision Systems

1D Machine Vision

- 100% continuous web inspection and classification
- Uses line-scan cameras
- Materials inspected include:
  - Metals
  - Non-wovens
  - Plastics
  - Paper

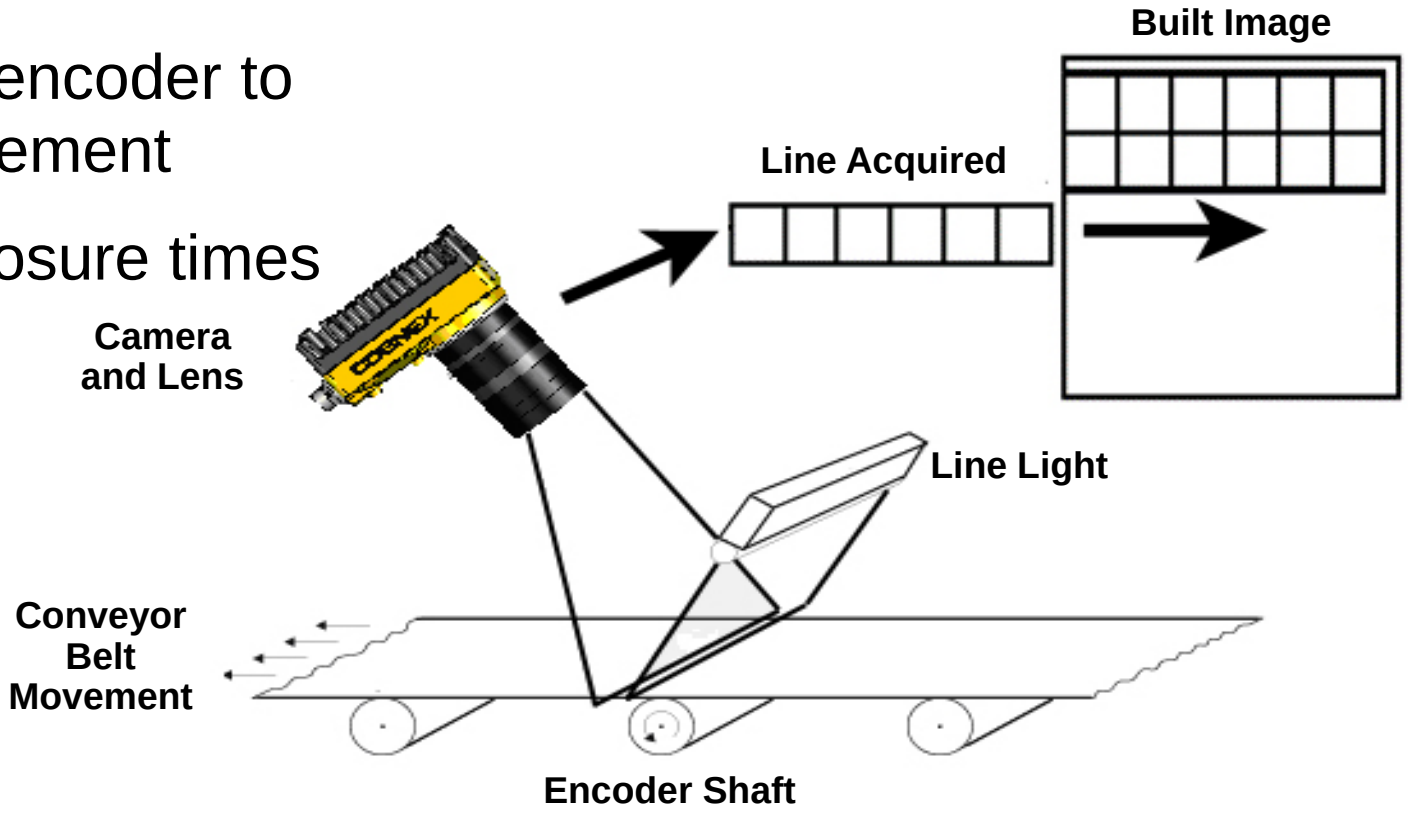


2D Machine Vision – Area Scan



2D Machine Vision – Line Scan

- Image is built line by line
- Movement is needed
- Requires encoder to track movement
- Short exposure times



Four Reasons To Use Line Scan

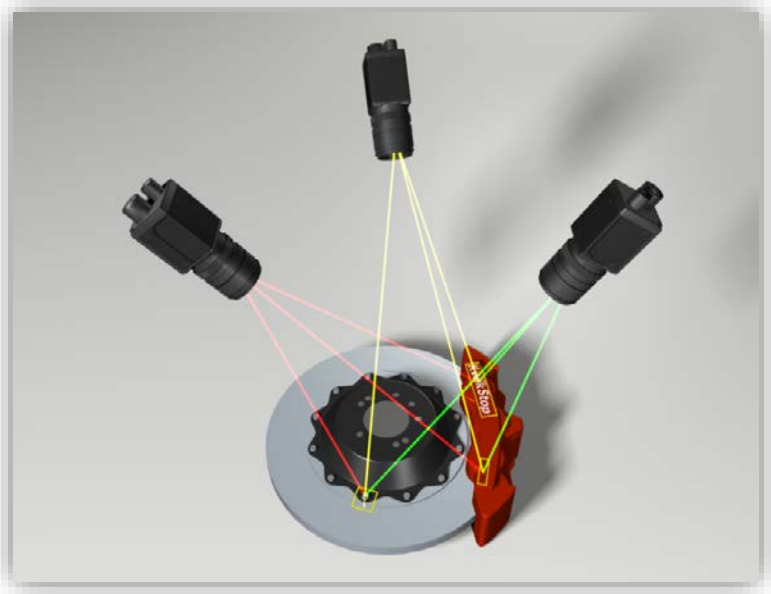
1. Unwrap cylindrical objects for inspection

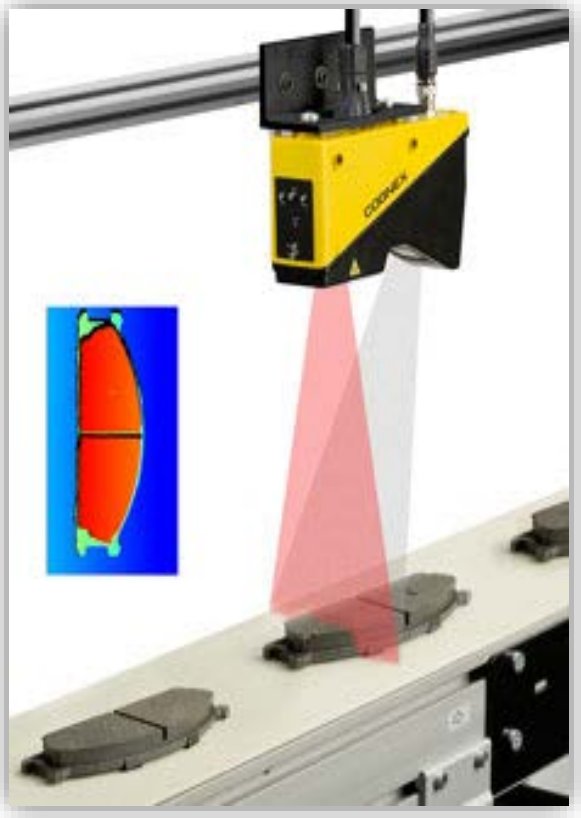
2. Add vision to space-constrained environments

3. Meet high-resolution inspection requirements

4. Inspect objects in continuous motion

3D Machine Vision



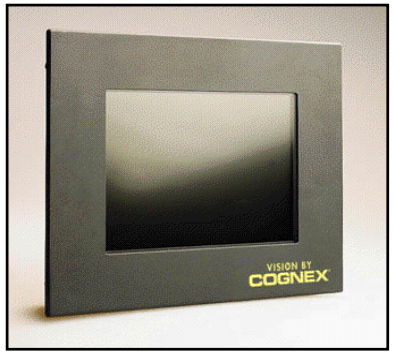


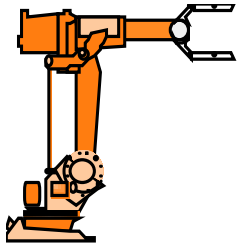
Machine Vision System Components

Key Parts of a Vision System

Light Source

Communication





I/O Comm.

Lens | **Camera** | **Vision Software**

Vision System

Inputs/Outputs: switches, PLCs, robots, lights

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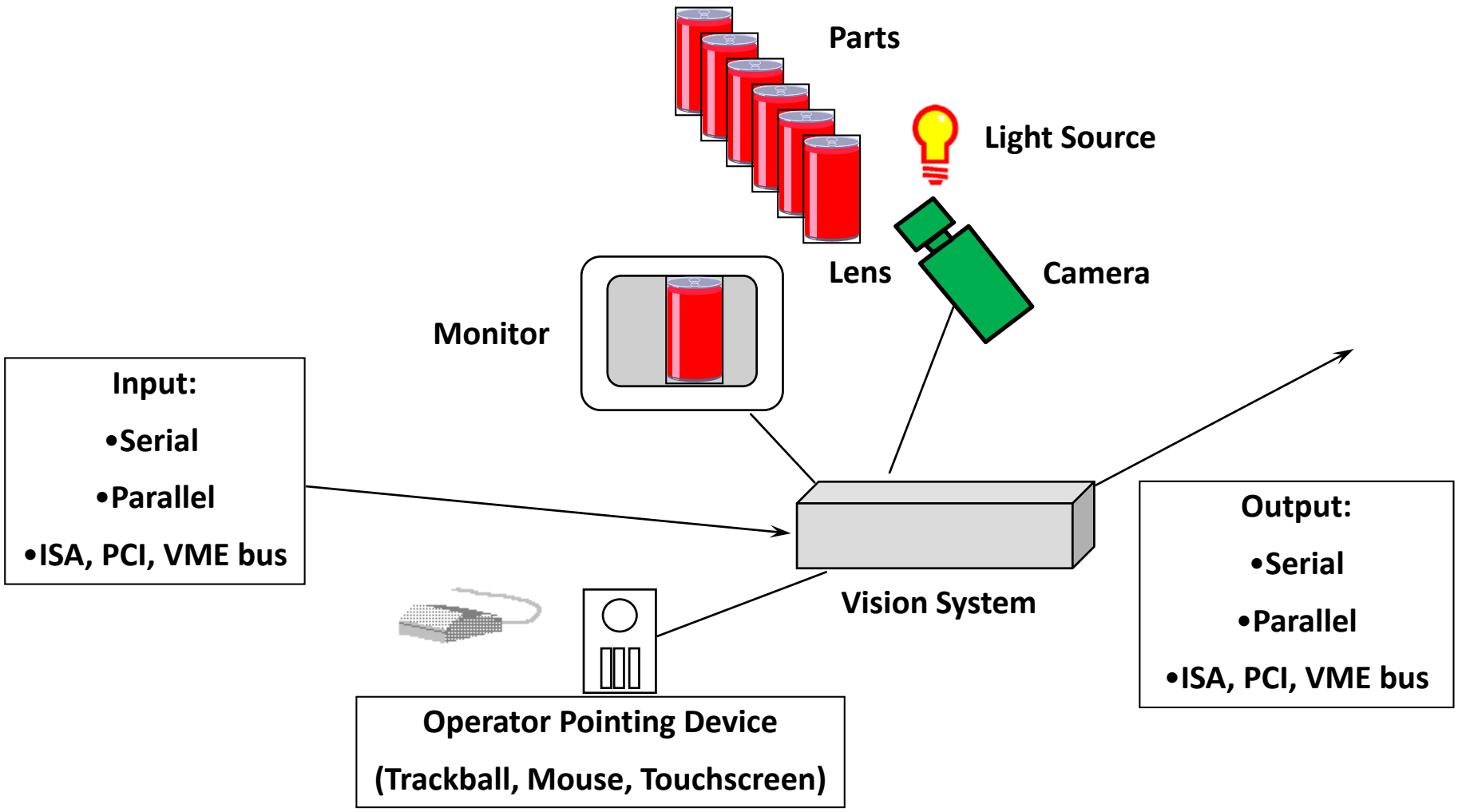
Putting It All Together



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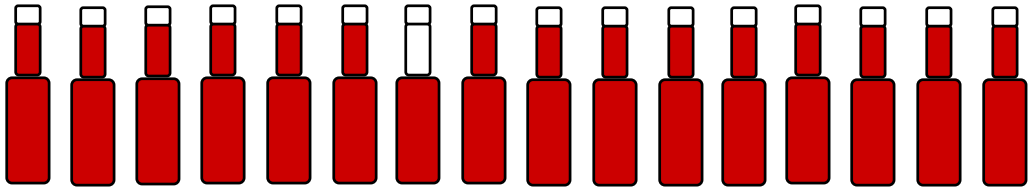
How the System Works

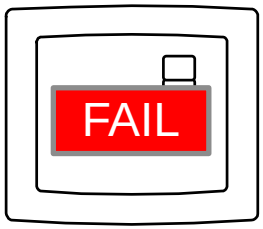
1. Part arrives at inspection station

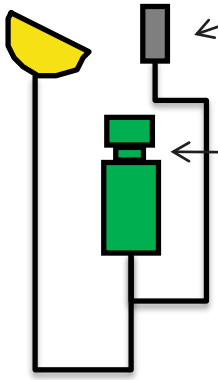


2. Sensor detects part and sends a trigger to the vision system

3. Strobe is flashed to illuminate part

4. Vision System acquires the image from the sensor.





5. Software algorithms running on vision system performs image processing and/or image analysis on acquired image

6. Vision system sends signal along a discrete output line which activates a diverter if the part is bad

7. Operator can view rejected parts and ongoing statistics on display, and can take system off-line if necessary

Machine Vision Algorithms

Algorithms used by Vision Tools transform raw numbers into useful higher level features

- Raw numbers turned into edges, colors, characters, and other characteristics

… then makes decisions

- Returns answers such as position, similarity, distance, presence, quality

All within just one to tens of milliseconds!

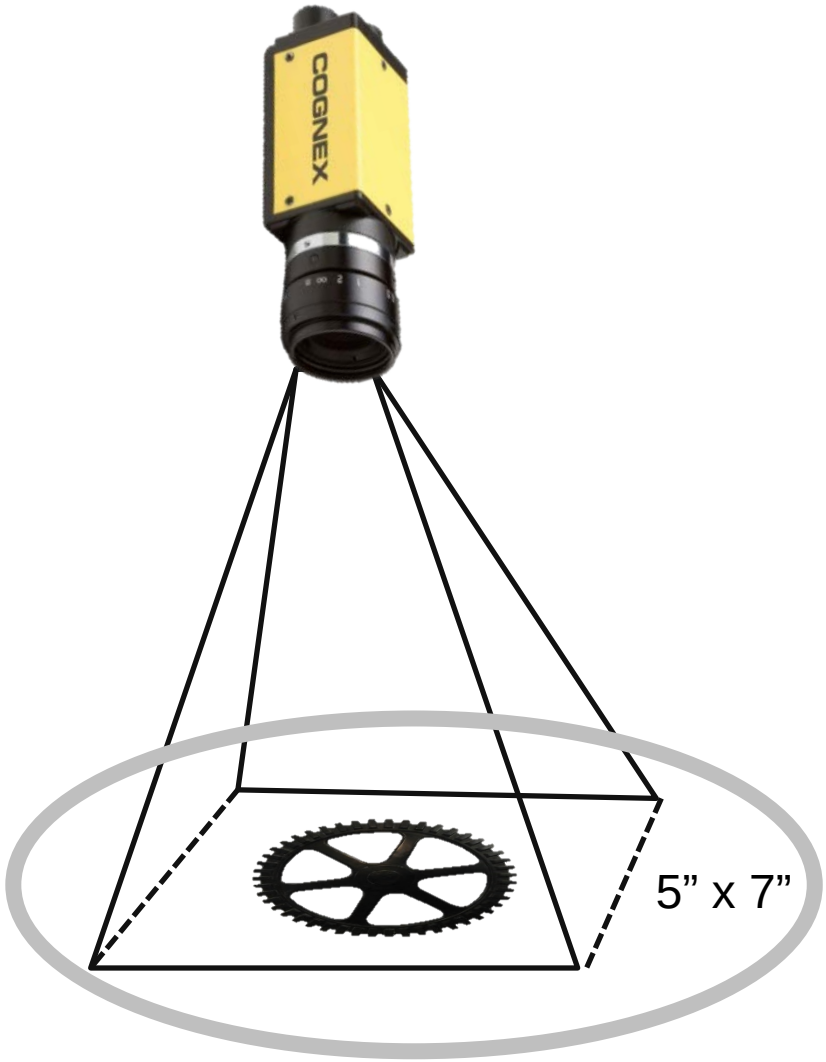
Machine Vision Terms

Vision Definitions

Field of View (FOV)

- The part which can be seen by the machine vision system at one moment.

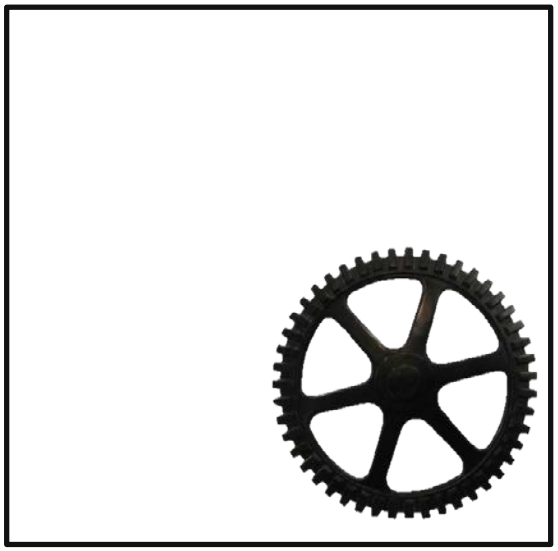
- The field of view depends on the lens of the system and the working distance between object and camera.



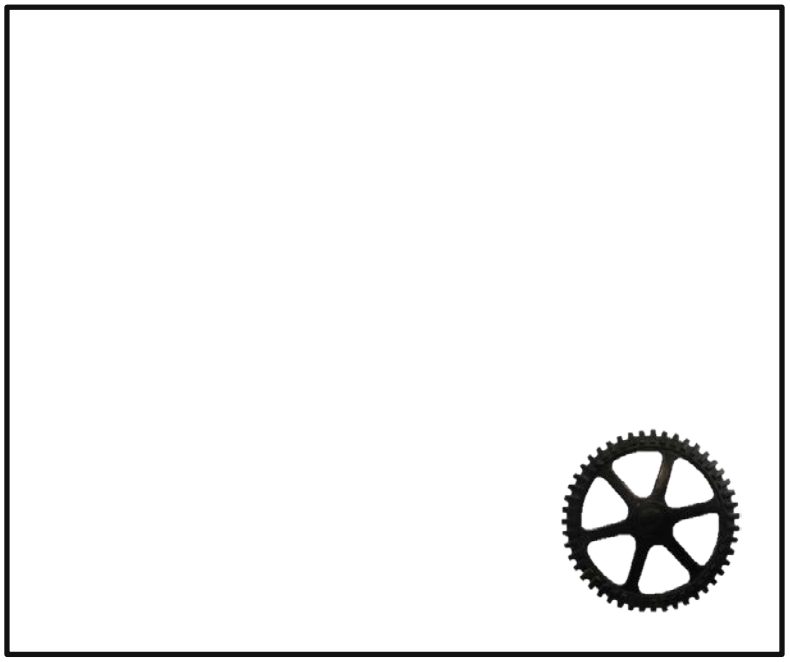
Field of View

What is my field of view?

4”



8”



15”

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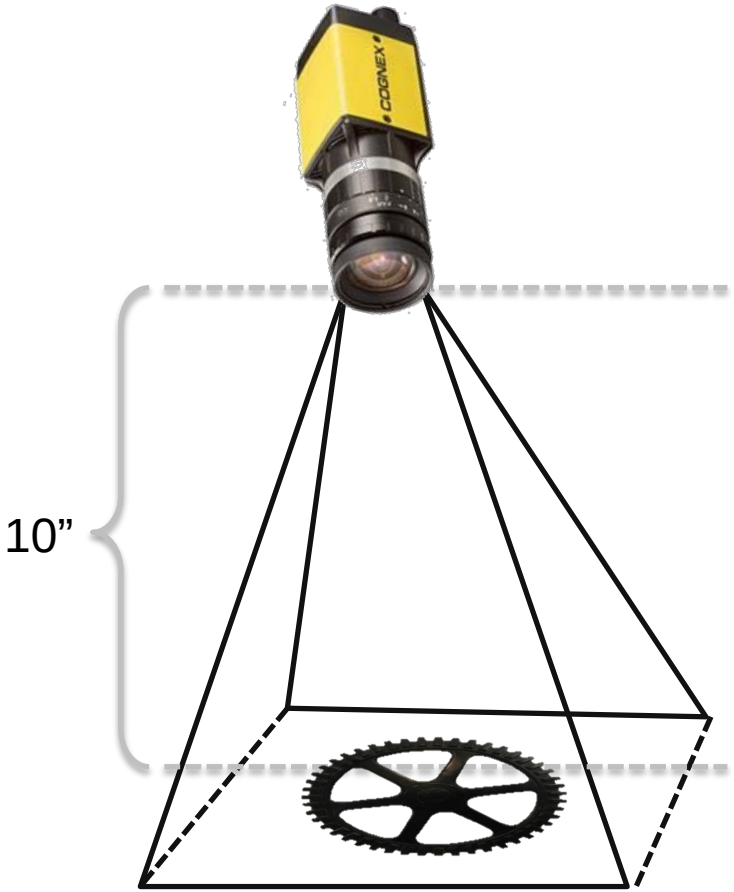
Working Distance and Resolution

Working Distance (WD)

- Distance between the FRONT of the lens and the target

Resolution

- The minimum feature size of the object under inspection.



Working Distance and FOV are Interrelated

Working Distance and Field of View

The distance from the vision systems' lens to the part that needs to be inspected is the working distance; field of view is what the vision system can see at that distance. As the working distance increases, so does the size of the field of view.

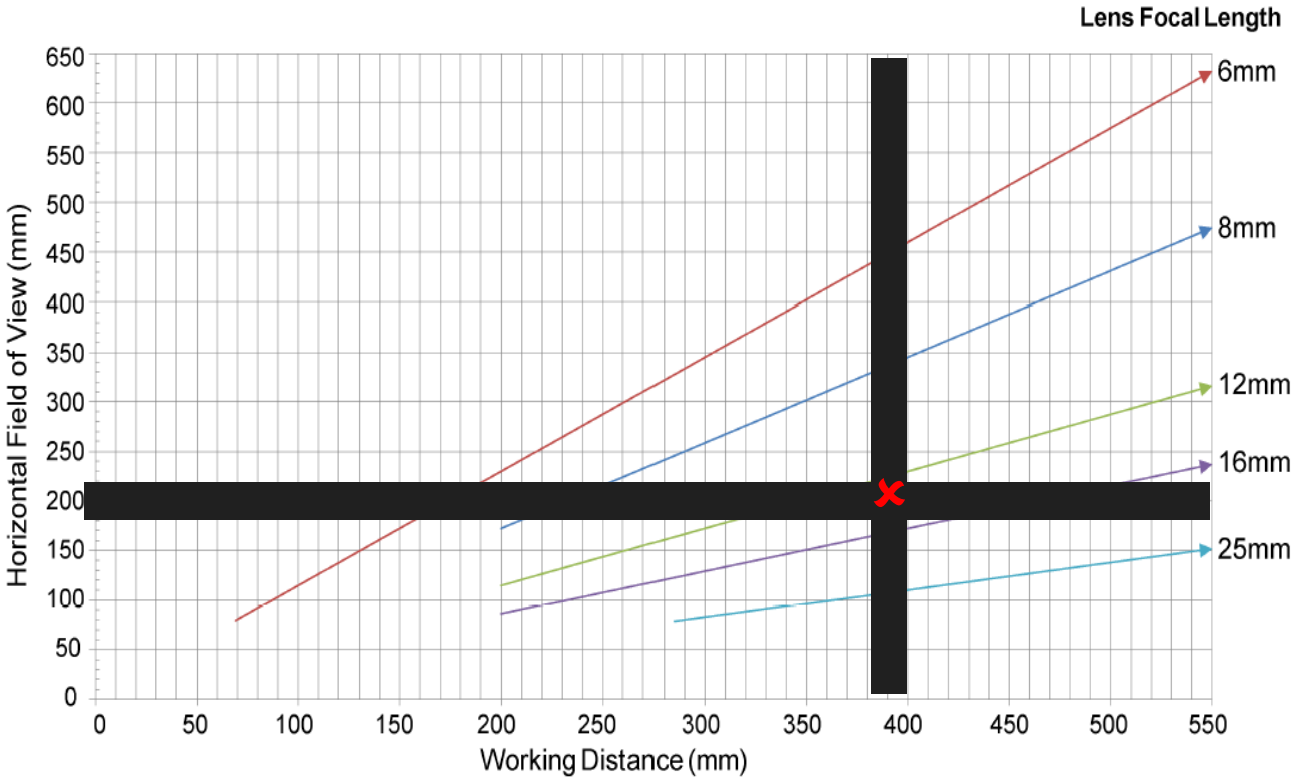
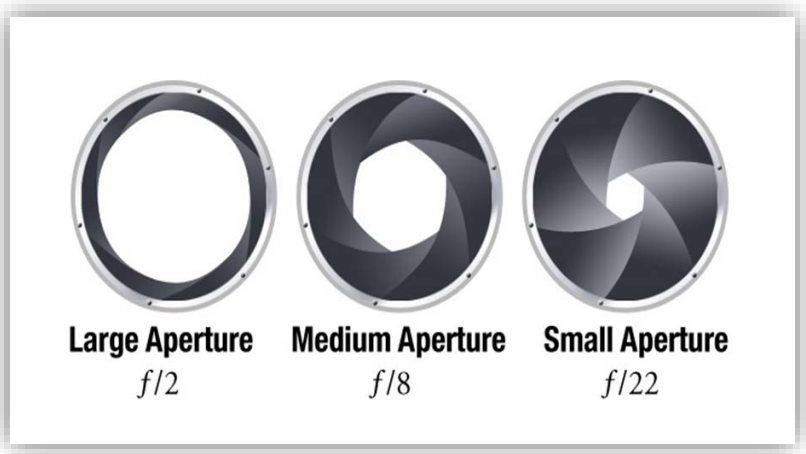


Figure 2-3: Vision System with 1280 x 1024 Resolution (mm)

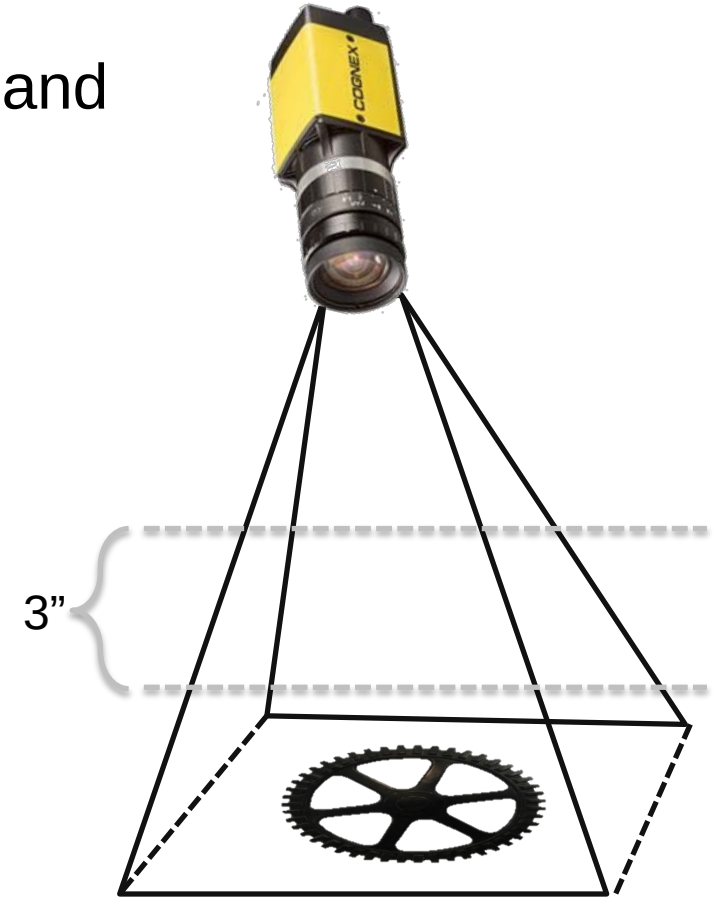
Depth of Field

Depth of Field (DOF)

- The distance in front of and behind the object which appears to be in focus

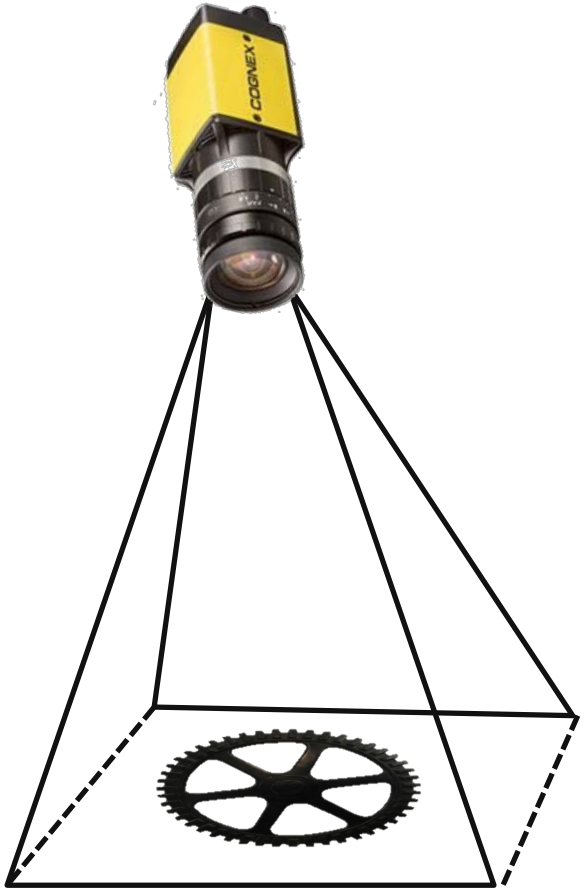


More DOF with a small aperture (high f/number) than with a large aperture (low f/number)

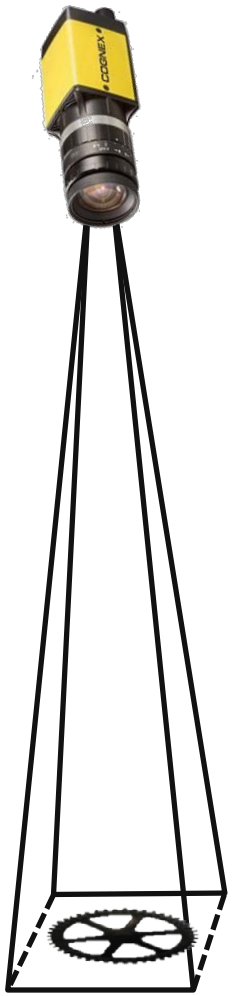


Improving Vision System Performance

Different Lens ... Same Image?

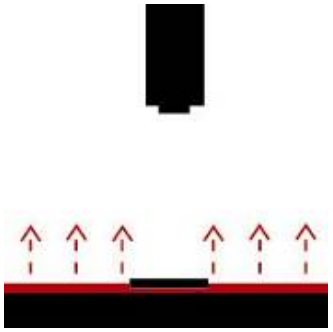


- Lighting
- Depth of field
- Working distance
- Line speed
- Exposure time
- Aperture
- Budget

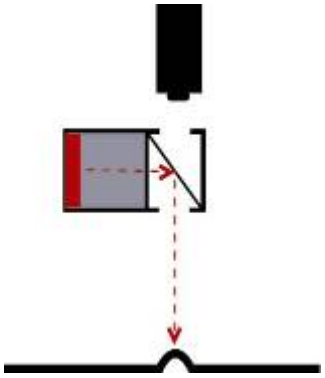


Lighting Techniques

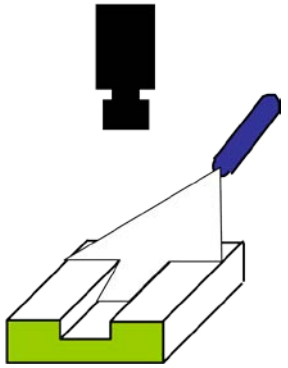
Light can be structured in different ways. Angle and direction of the light determine how the mark and space is seen by the camera.



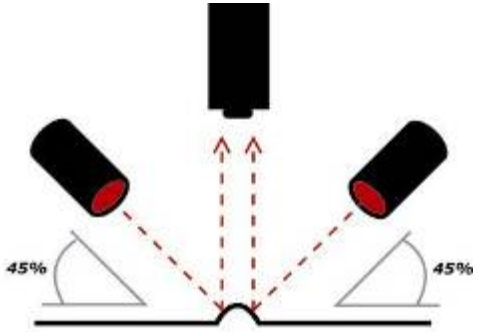
Back Lighting



Axial Diffuse

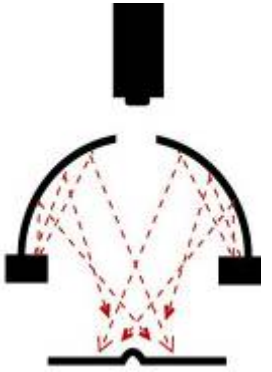


Structured



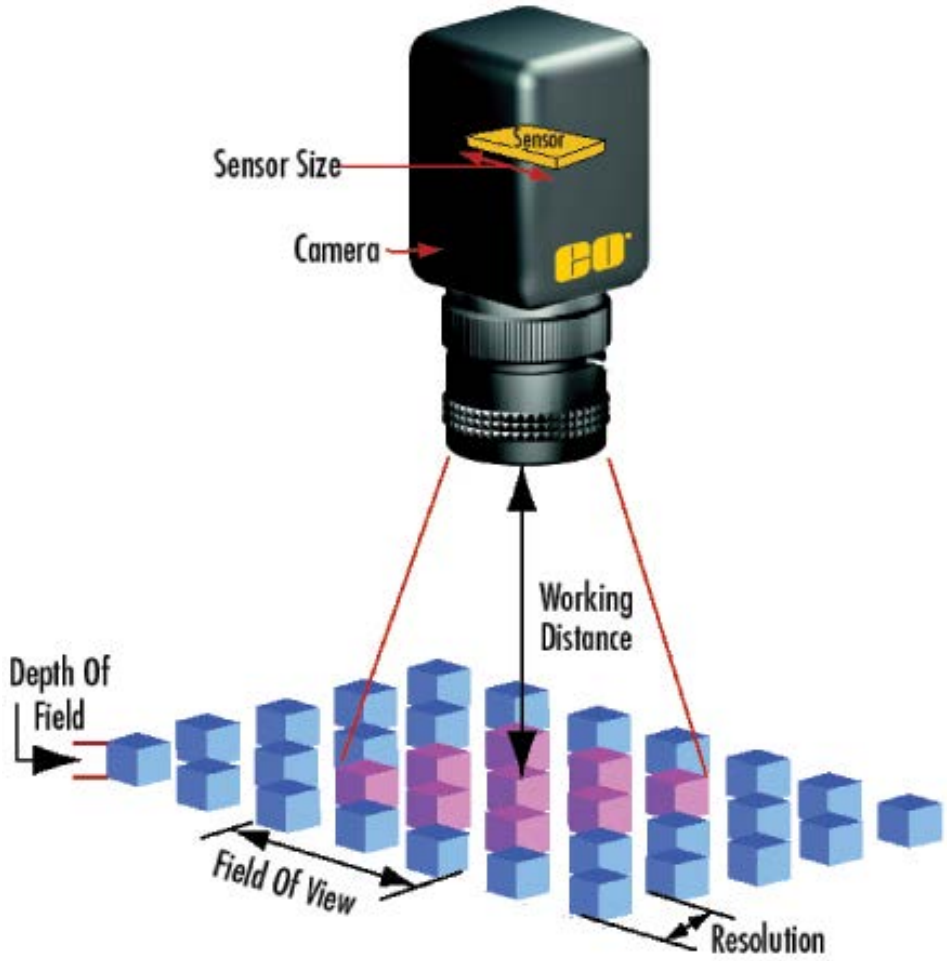
Dark Field

Bright Field



Diffuse Dome

Optics



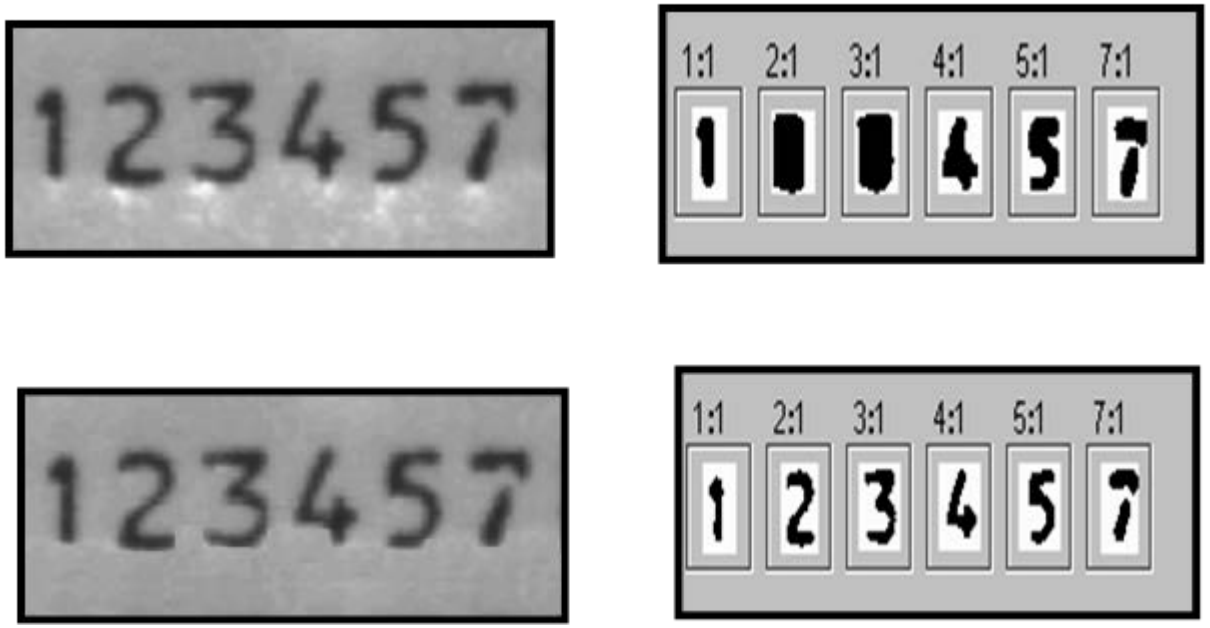
To learn more about choosing the right optics go to Cognex.com > Resources > On-Demand Webinars

Filtering Techniques

- Control quality and quantity of light
- Block all unwanted ambient lighting
- Pass only the output of lighting used for inspection
- Increase contrast and resolution

For more on optical filters, go to Cognex.com > Resources > On-Demand Webinars

Image Pre-Processing Tools



To learn more about image pre-processing, go to Cognex.com > Resources > On-Demand Webinars

Summary

- Make products better, faster, and less expensively
- Gauging, Inspection, Guidance, and Identification are the key applications
- Key components are the lens, camera, lighting, vision software and communications
- Learn more about optics, lighting, filters and image pre-processing to improve system performance
- Don’t go it alone…get help from experts!

Questions?

