Integration of Miniature Smart Cameras into Robotic Applications

Steven J. King
Product Manager - Machine Vision and Lighting
Microscan Systems

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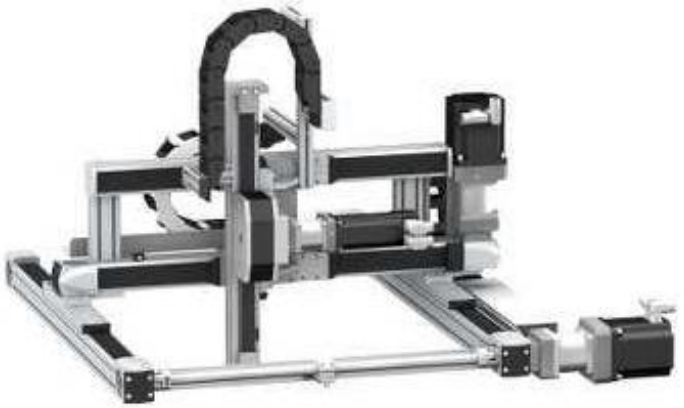
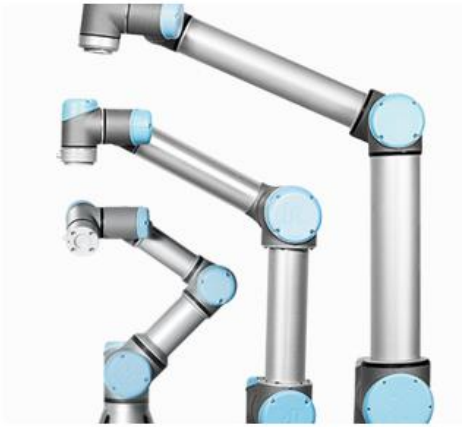
Many Definitions of a Robot

- Multi-Axis Motion Systems
- Traditional Industrial Robots
- Collaborative Robots
- Mobile Robots
- Warehouse Robots
- Self Driving Cars



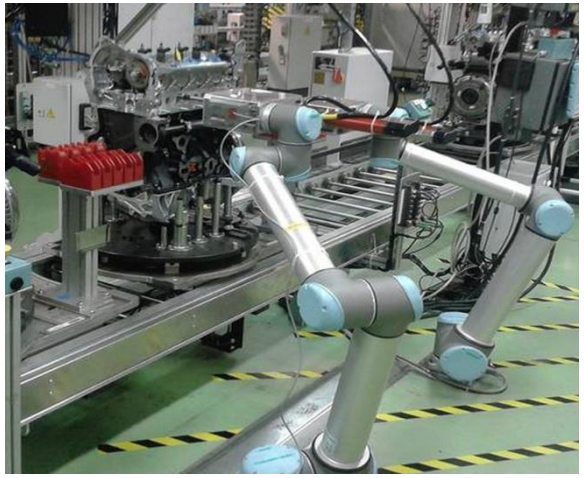


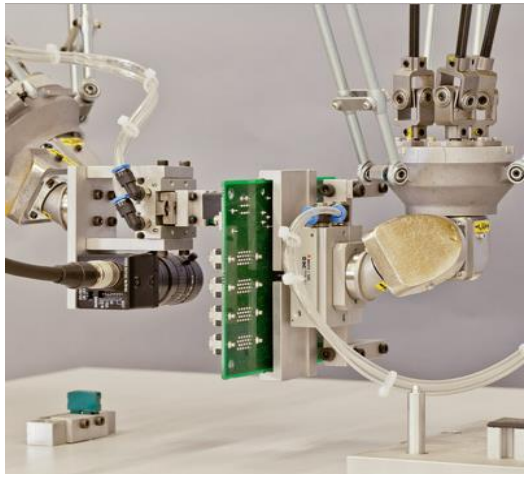
Universal Robots: UR3, UR5, UR10

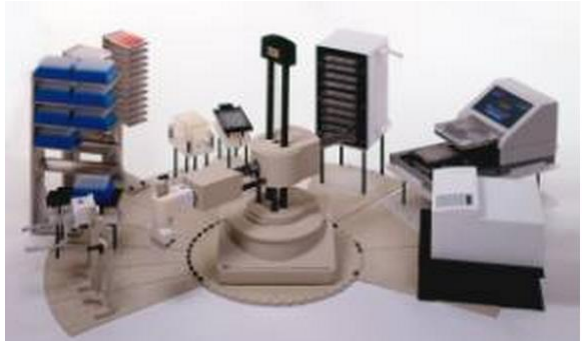
Source: Schneider Elec, Unimation, UR, TRC, Tech Xplore (Fetch), Google

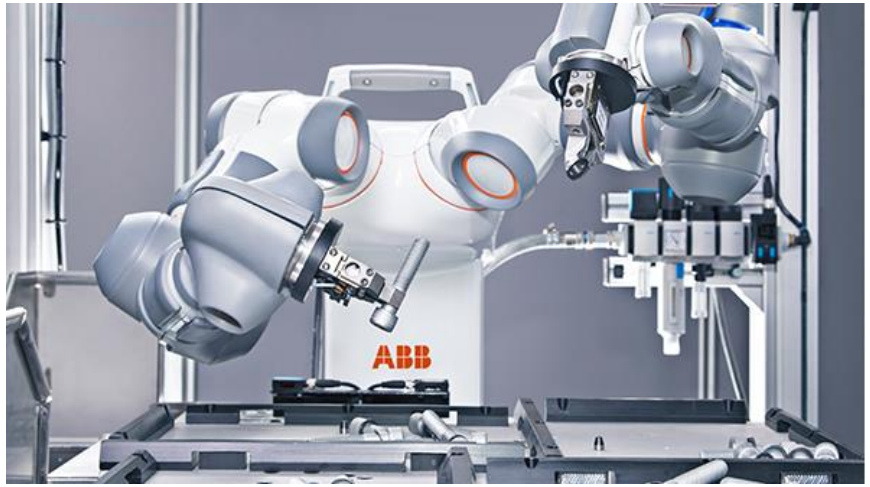
Robot Markets

- Automotive
- Electronics
- Clinical
- Food and Beverage
- Packaging
- Warehousing
- General Manufacturing









Source: UR Robots, Fanuc, Montclaire.edu, Motoman, ABB (Electronic Design)

Robot Applications

- Pick and Place
- Assembly
- Quality Inspection
- Packaging and Palletizing
- Lab Analysis and Testing
- Screw Driving
- Labeling
- Gluing, Dispensing and Welding
- Polishing
- Injection Molding

Robot Applications – (Vision and AutoID Apps)

- Pick and Place – (Locate, Read, Guide)
- Assembly – (Locate, Read, Guide, Check)
- Quality Inspection - (Check, Measure, Read)
- Packaging and Palletizing - (Locate, Read, Guide, Check)
- Lab Analysis and Testing - (Locate, Measure, Read, Guide, Check)
- Screw Driving - (Locate, Guide, Check)
- Labeling - (Locate, Read/Verify)
- Gluing, Dispensing and Welding - (Guide, Check)
- Polishing - (Check)
- Injection Molding - (Check, Measure)

AutoID - Reading 1D and 2D codes are integral to many applications

Challenges Integrating Vision with Robots

- Robot Applications need AutoID and Machine Vision to Achieve:
  - Fuller autonomy
  - Greater speeds
  - Greater accuracy
  - Ability to perform high value operations

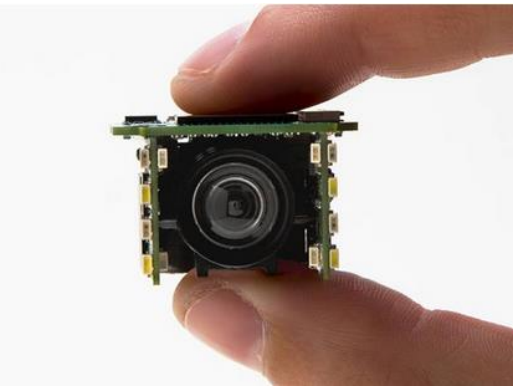
- Robot Applications Face Challenges in Many Areas:
  - Physical Installation – Mounting, Size, Optics, Lighting
  - Cabling – High Flex cables capable of millions of cycles
  - Programming – Simplicity, Flexibility, UI integration with Robot Controller
  - Calibration – 2D and 3D, Multiple coordinate systems
  - Integration of Results – Data formatting, Protocol support, Image display

Miniature Smart Cameras

- Miniature Smart Cameras Use Cases
  - General Use
    - Fully Integrated Camera – Lighting to communications
    - Powerful toolset, simple programming and deployment software
    - Highly configurable to achieve best price
  - Light weight on the end of a robot arm
    - Low mass
    - Integral to robot gripper
  - Dense pack many cameras together over a single part
    - Multiple cameras needed for high resolution inspection
    - Avoids parallax issue with single camera looking at all features
  - Embedded – One/multiple cameras in very small spaces
    - SMT Pick and Place machines as one example
    - Desk top clinical analyzer as another

Source: UR, Microscan

Miniaturization – Camera Examples



MV-Engine

Ethernet,
Serial,
Digital IO

MV-20

Ethernet
over USB

MV-30

Serial,
Digital IO

MV-40

Ethernet, Serial,
Digital IO

- Lighting
- Optics
- AutoFocus
- Processing
- Comm

Source: Microscan

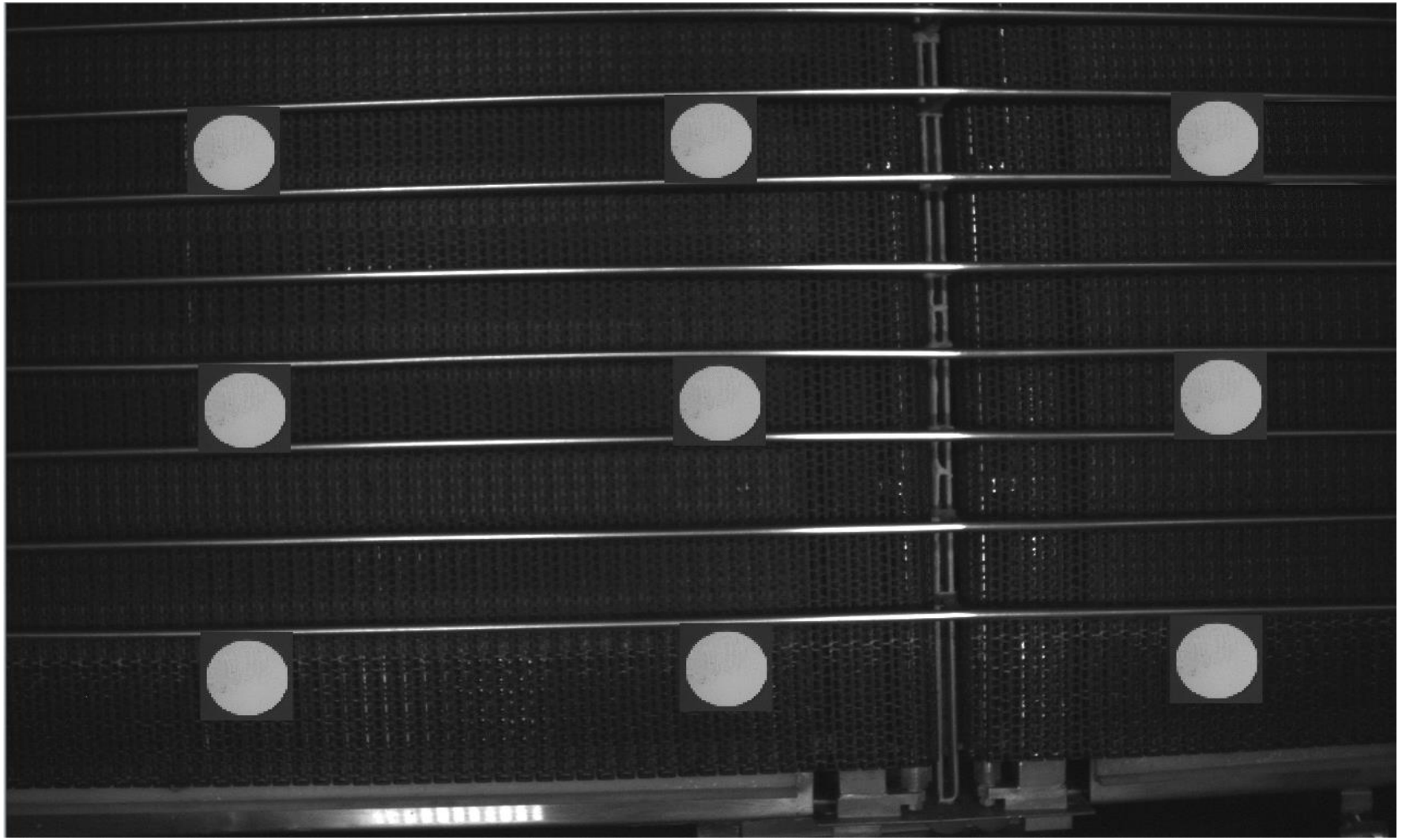
General Use Example – Food and Beverage

- Mounting – Over the Work Space
- Lighting – General Large Area Lighting
- Optics – Wide Angle
- Calibration – Vision to Robot Pick Area
- Tools
  - Morphology/Blob
  - Custom Scripts for Pick Ordering
- Output
  - Serial, TCP/IP Socket
  - Pick Order, X, Y, Size, Defects

Source: Motoman

General Use Example – Calibration

- Calibration is performed using robot placed target/targets
- Vision gets calibrated to robot pick space

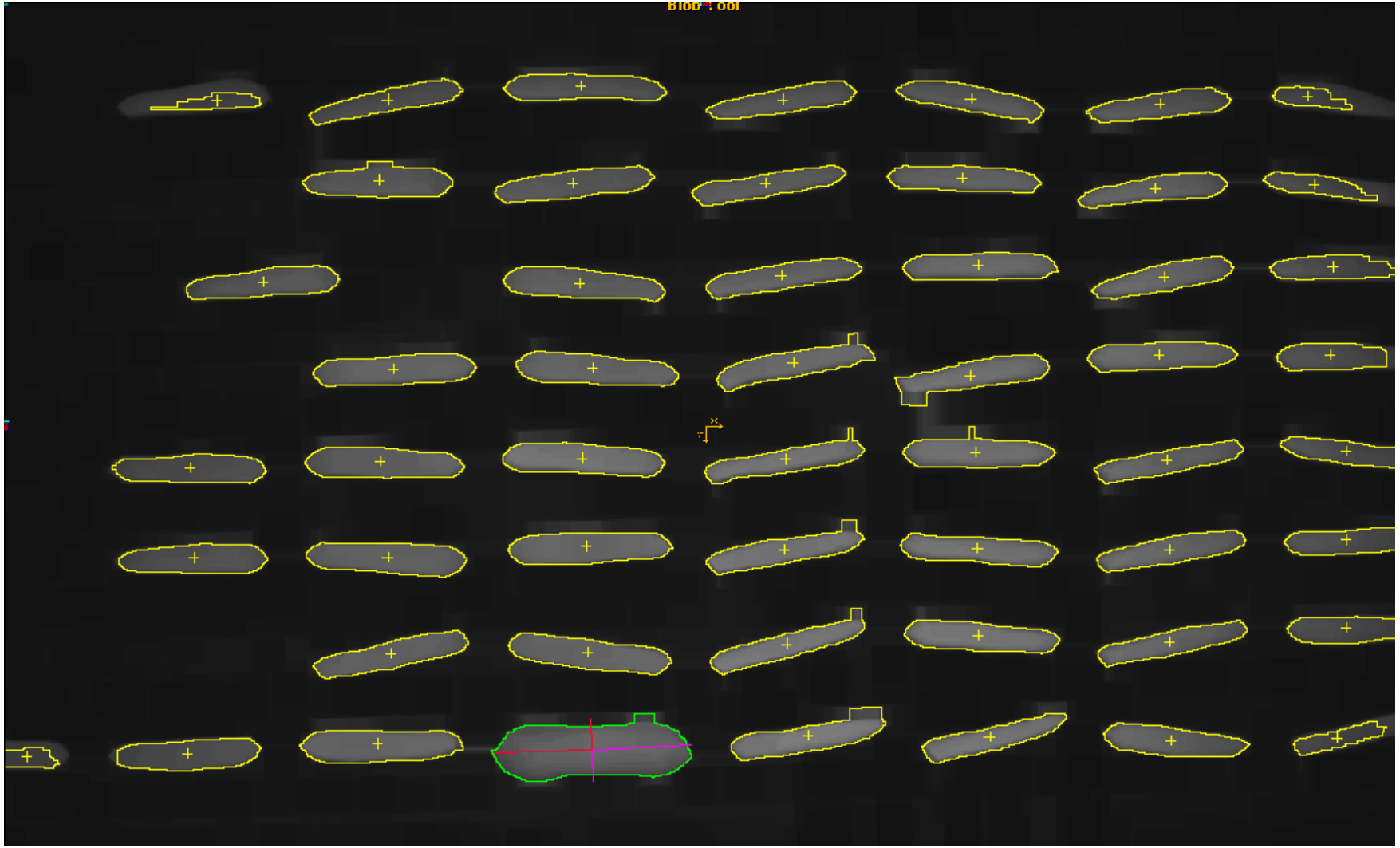


General Use Example – The Task

- Product fills lanes
- Vision Computes Count, X, Y, Size, Pick Order
- Reports data to robot
- Robot picks up product

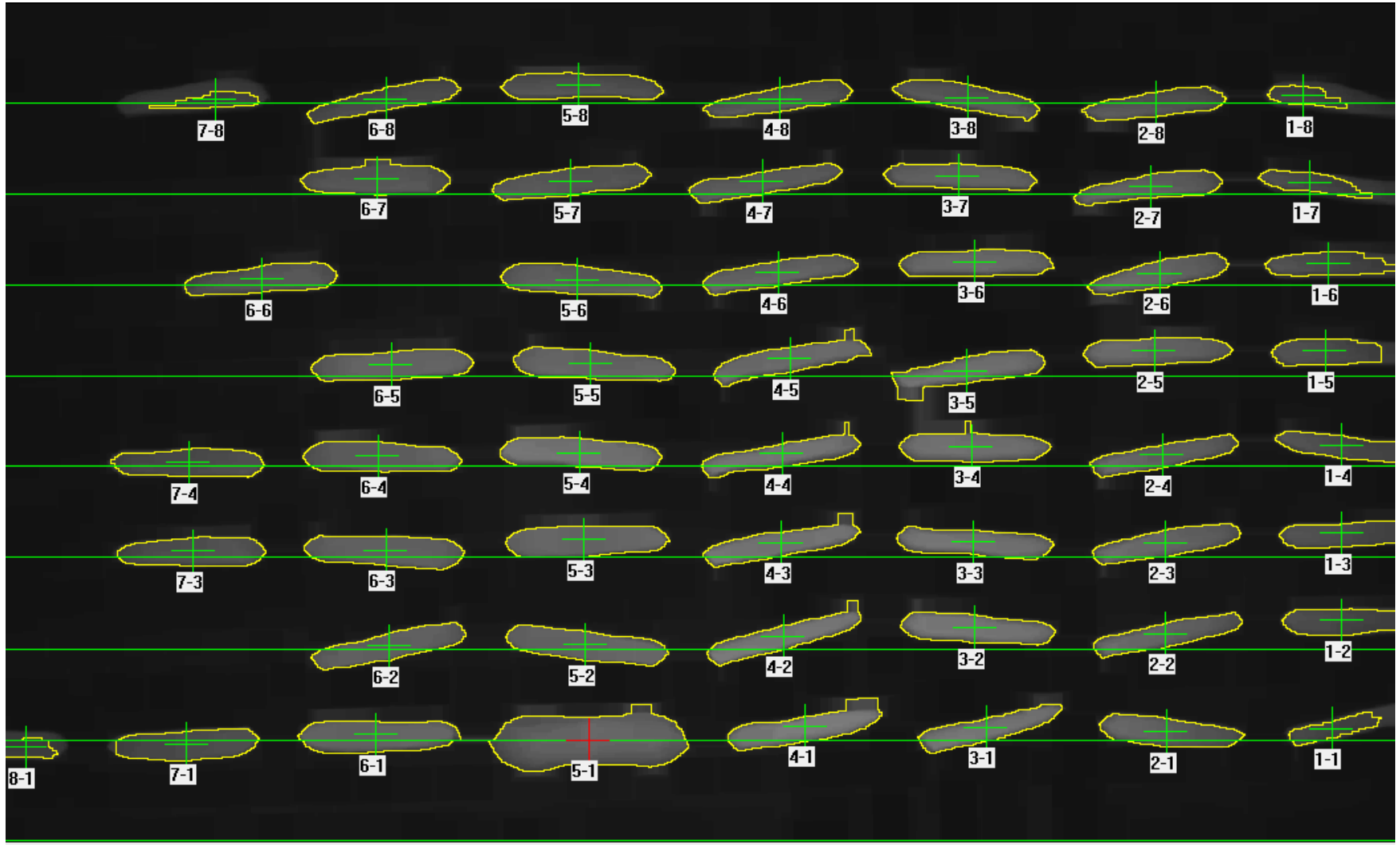
General Use Example – Tools

- Morphology
  - Separate and Segment
- Blob
  - Centroid
  - Angle
  - Size
- Custom Scripting tool sorts results and sends “pick” order to robot



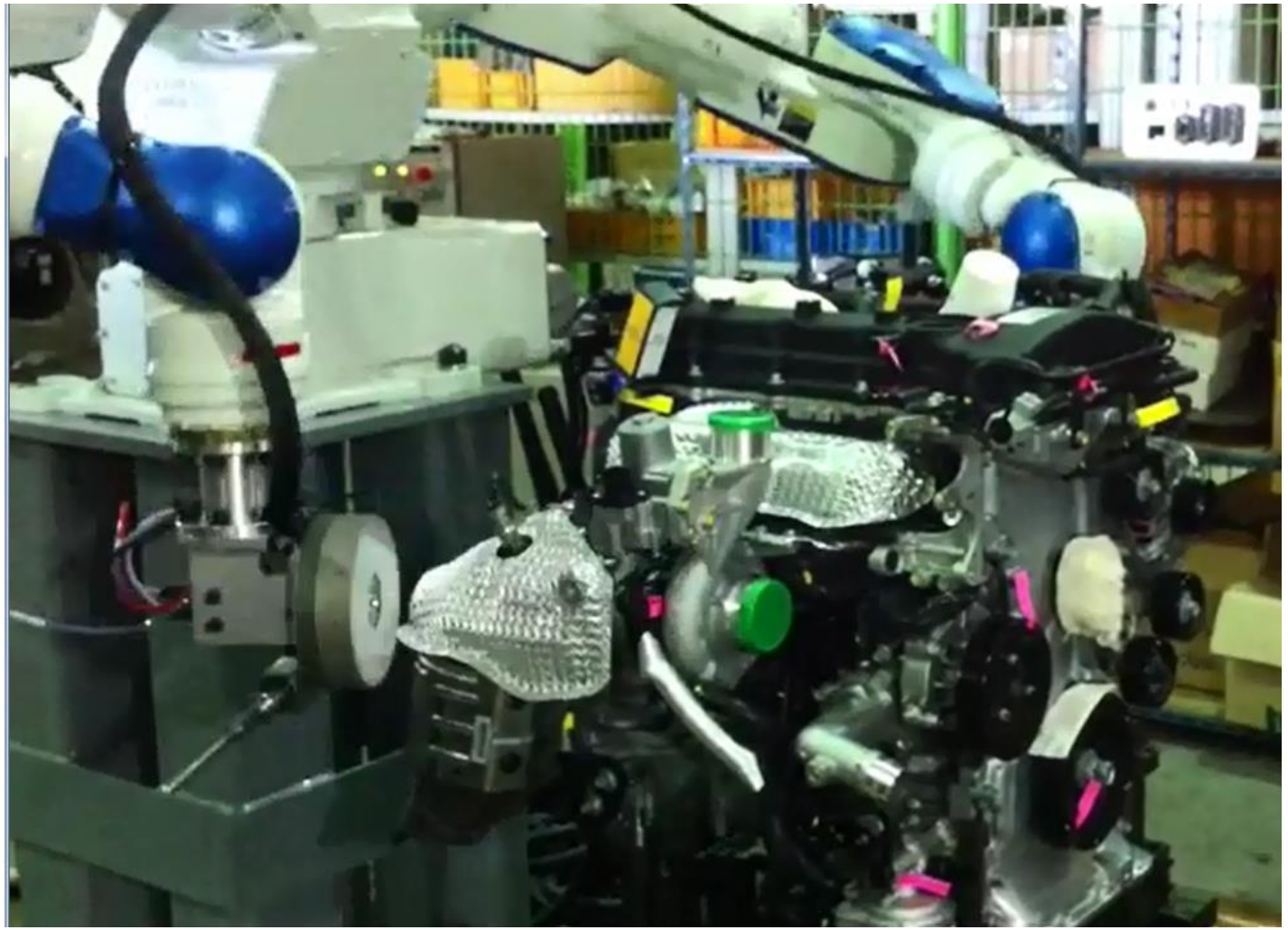
General Use Example – Outputs

- Sends all data to Robot via:
  - RS-232
  - Socket
  - PLC Links
- Display image on HMI



End of Arm Example – Automotive, Engine Check

- Mounting – End of Arm
- Lighting - Integrated
- Optics - Auto Focus
- Calibration - Simple
- Programming
  - Multiple Inspections
  - Asynch Triggering
- Tools
  - Presence/Absence
  - Reading
  - Measure …
- Output
  - P/F or Data per Inspection

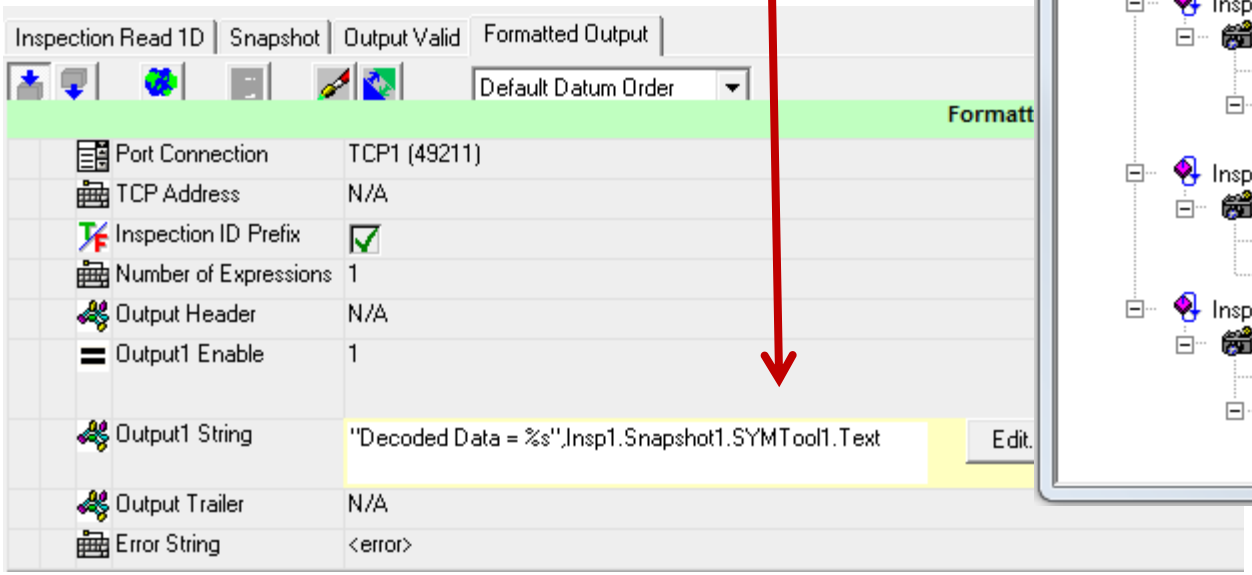


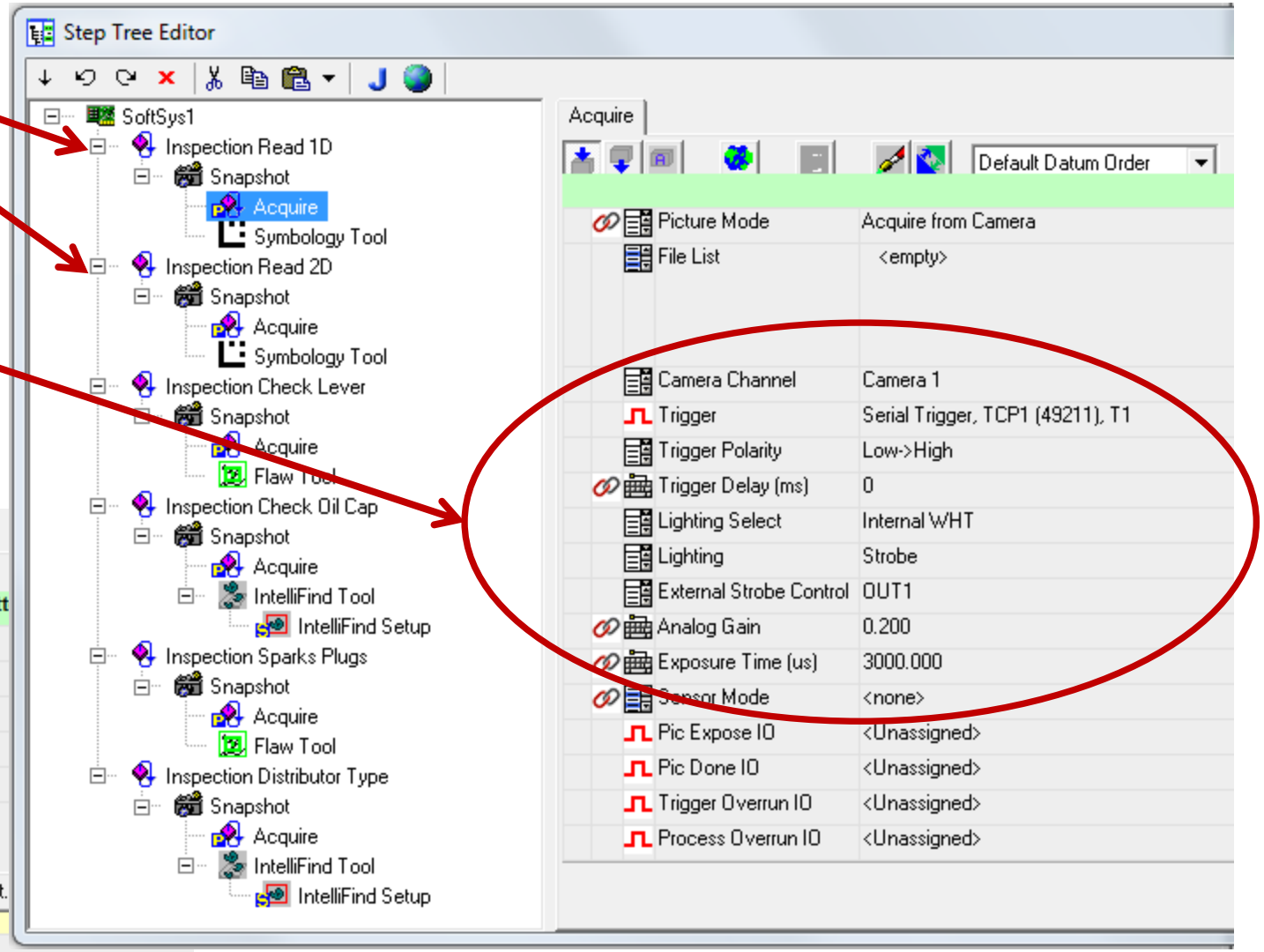
End of Arm Example - Challenges

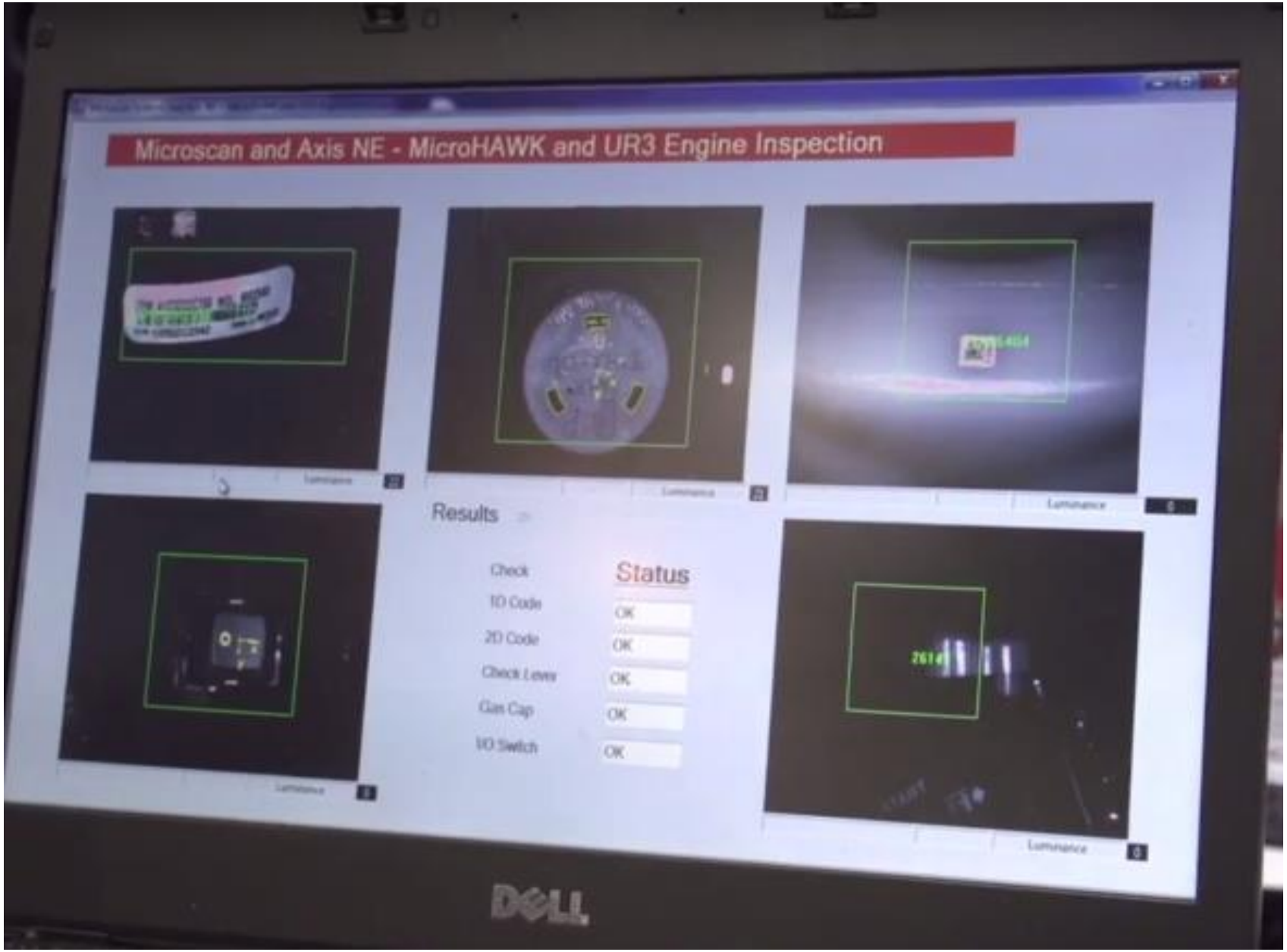
- High Speed Robot Motion
  - Requires Low Camera Mass
- Very High Cycle Counts
  - Requires high flex Power and EtherNet cables
- Multiple Inspections
  - Requires multiple inspections within a single job
    - Unique Triggers
    - Unique Sets of Tools
    - Unique Vision Results
  - Requires fast AutoFocus lens to inspect at different distances
  - Requires active control over gain, exposure and lighting for optimum images
- Processes in Parallel With Robot Motion to Next Inspection Point

End of Arm Example - Programming

- Multiple Inspections
  - Unique Triggers
  - Focus Distance
  - Exposure/Gain
  - Lighting
  - Custom Output Result



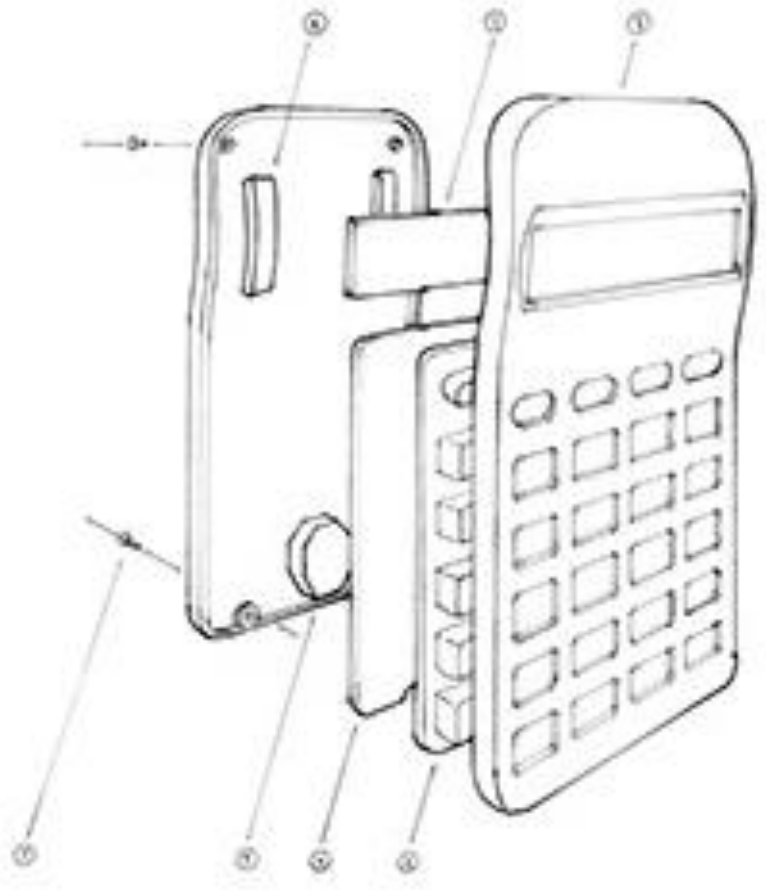



Microscan and Axis NE - MicroHAWK and UR3 Engine Inspection
Results
Check
Status
ID Code
OK
2D Code
OK
Check Lens
OK
Gas Cap
OK
I/O Switch
OK
DELL


SEE OWNER'S MANUAL
SAE 5W-30
OPEN

Dense Pack Example – Consumer Electronics

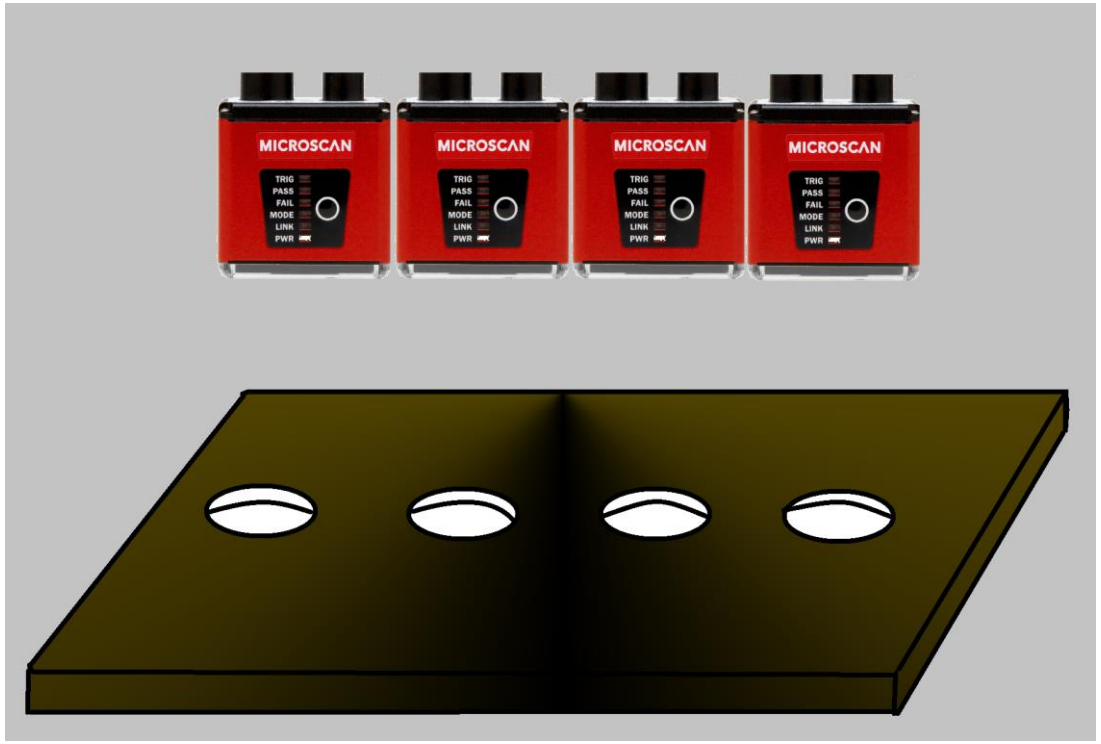
- Assembly of Consumer Electronics
- Locate Critical Features on Each Part
- Computer Overall Location of Each Part
- Compute Offset of One Part to Other
- Robot Assembles Parts Together

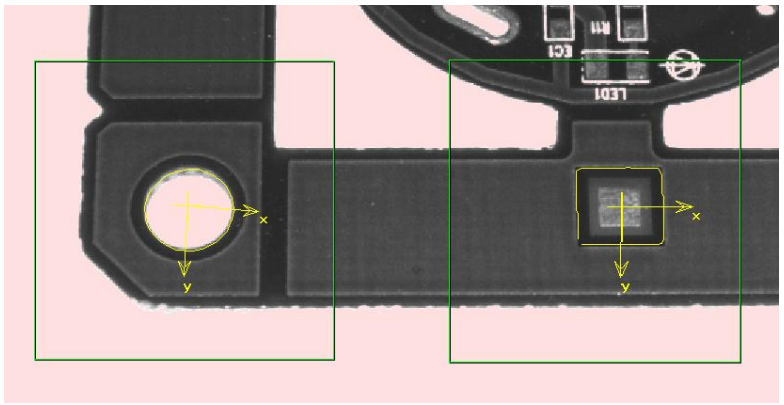


Source: Joe Hu, AD 146 Rasche

Dense Pack Example – Challenges

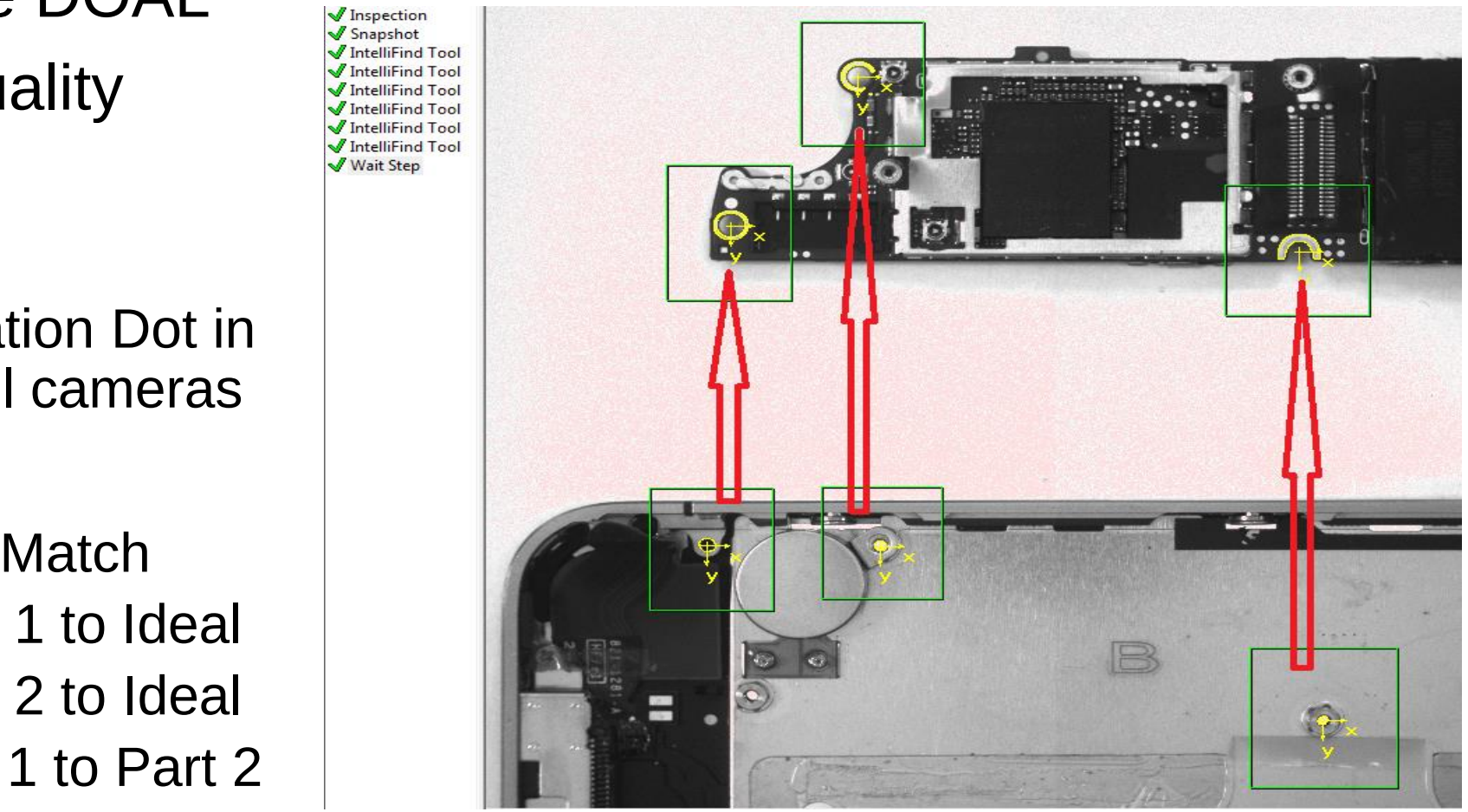
- Very High Accuracy Required
- One to Two Features Per Camera
- Features Very Close Together
- Cameras Close Together
- All Cameras Look Through One Light
- Combine all Camera Results
- Calibrate Vision to Robot





Dense Pack Example – Assembly

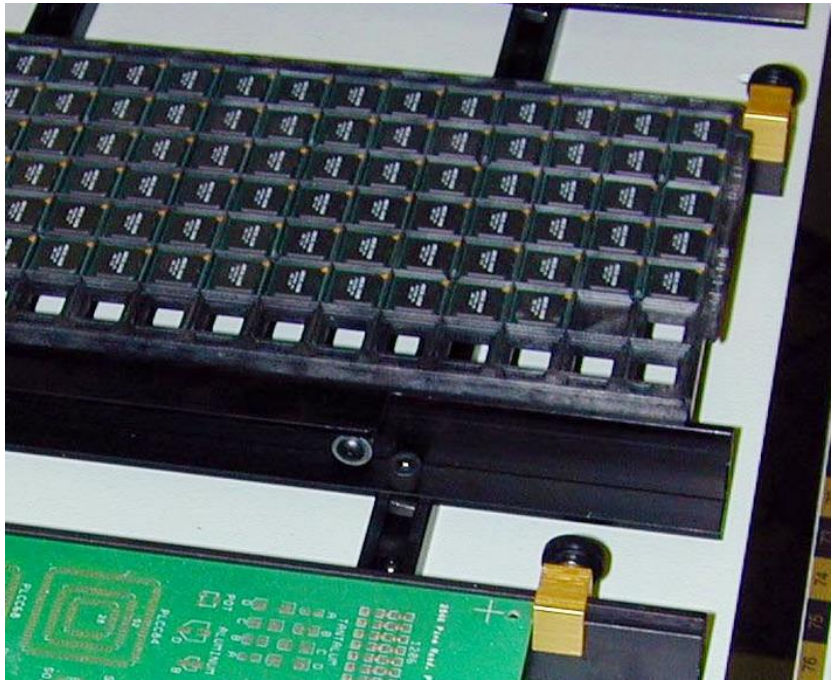
- Lighting – Very Large DOAL
- Optics – Gauging Quality
- Calibration
  - Vision to Robot
  - Robot Moves Calibration Dot in Grid Pattern under all cameras
- Tools
  - Edge Based Pattern Match
  - Rigid Body Fit - Part 1 to Ideal
  - Rigid Body Fit - Part 2 to Ideal
  - Compute Offset Part 1 to Part 2
- Output
  - Offset for aligning Part1 to Part 2

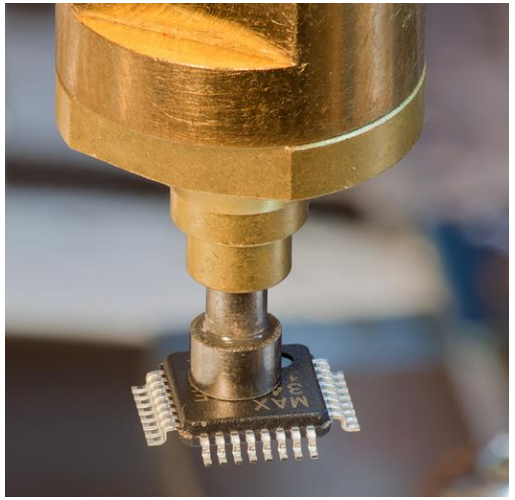


Embedded Example – Electronics

- Robot Picks Multiple Part Types from Trays
- Pick Head Flies Part over Camera
- Vision Computes X, Y, Theta of Part
- Robot Places Part on Board

Single or Multiple Cameras. Very small envelope for cameras and lighting.



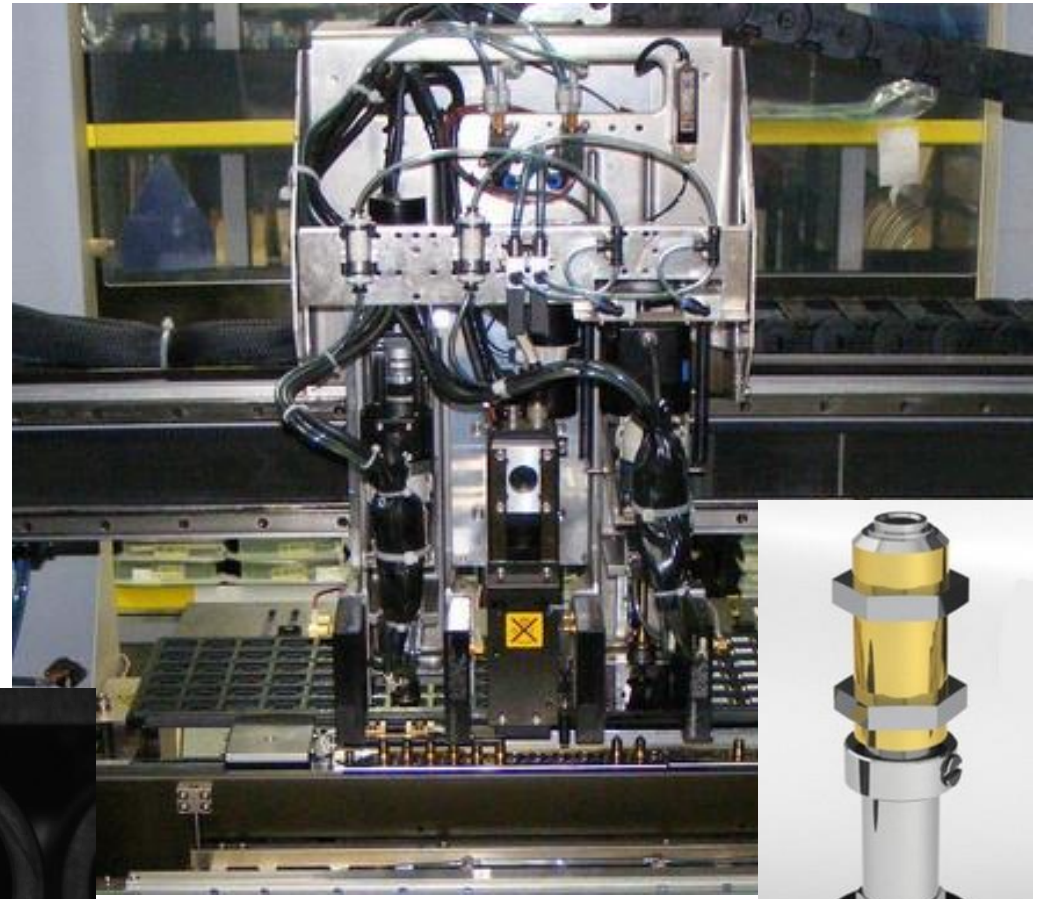


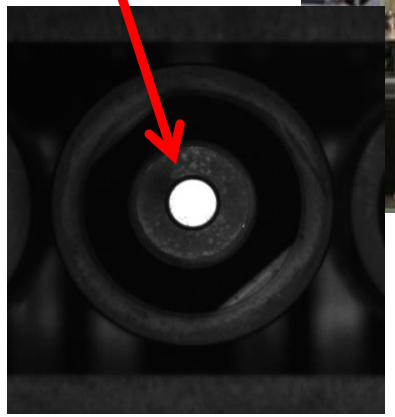
Embedded Example - Challenges

- One or Multiple Cameras Buried in Very Small Spaces
- Very High Resolution Required - Micron Tolerances
- Very High Accuracy Achieved by Calibrating Vision to Pick Head
- Pick Head Needs Previously Calibrated to the PC Board (Fiducials)
- Handle Multiple Part Types – BGA, QFN, TSOP, etc.
  - Requires unique inspection and trigger per part type
  - Requires unique lighting, exposure and gain per part type
  - Employ Strobe lighting to freeze motion as robot “flies” part over camera
  - Requires automatic part training to locate features
    - Match features to cad model of part
    - Used to compute Rigid Body Fit of Part to ideal location on PCB

Embedded Example – Pick and Place Vision

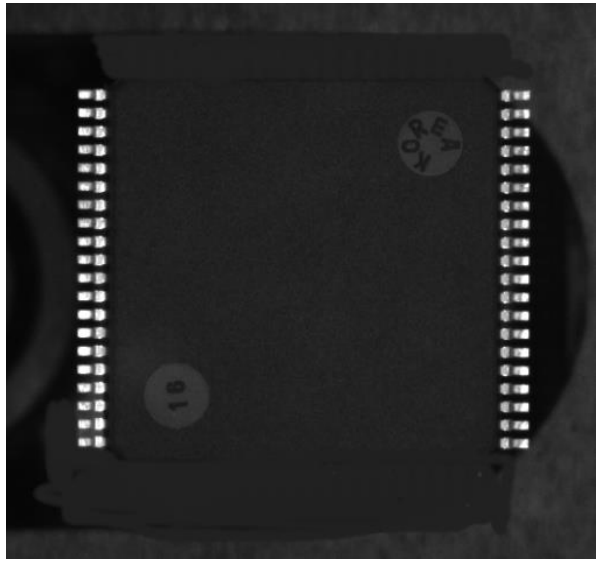
- Lighting – Part Specific.
  - Low Angle Ring, Diffuse On Axis.
- Optics – Gauging Quality
- Calibration – Vision to Robot Gripper
  - Gripper is moved in a grid pattern
  - Vision locates gripper at all positions
  - Calibrate to robot coordinates
- Tools
  - Various for lead/pin/ball locate
  - Rigid Body Fit to Model Part
- Output
  - X, Y and Theta of Part

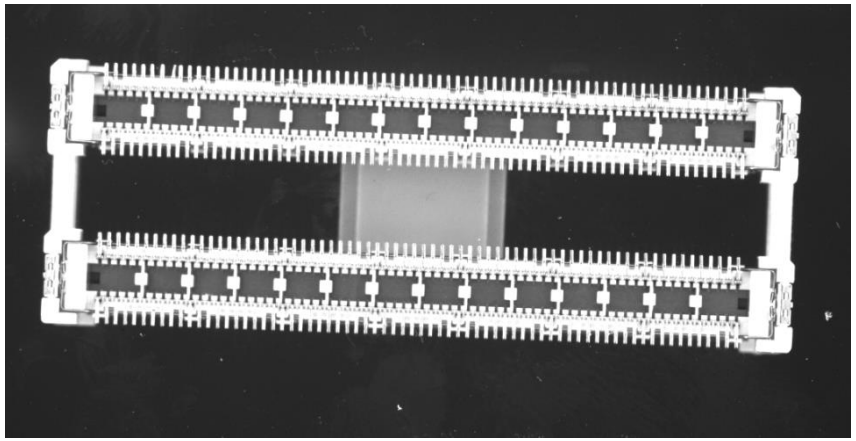


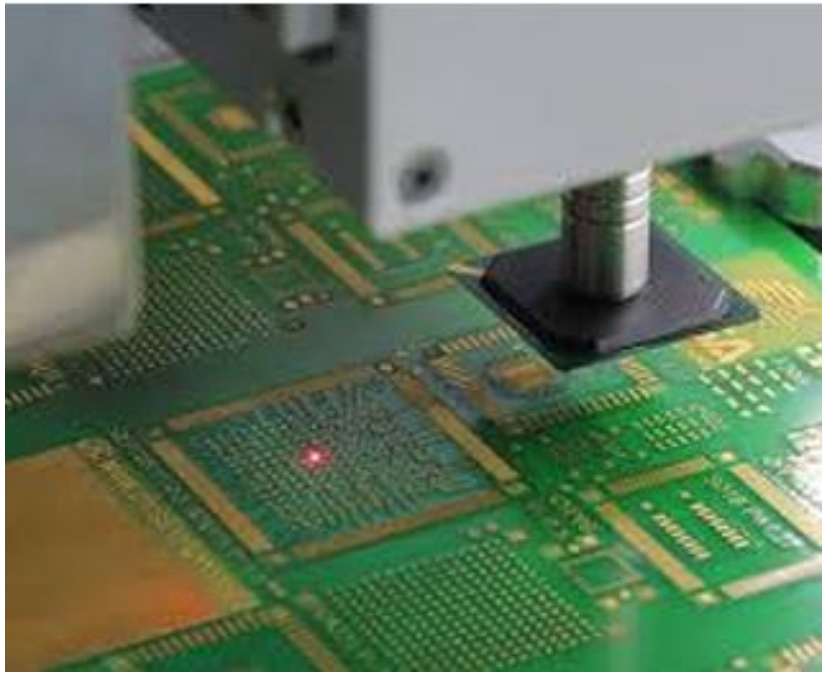


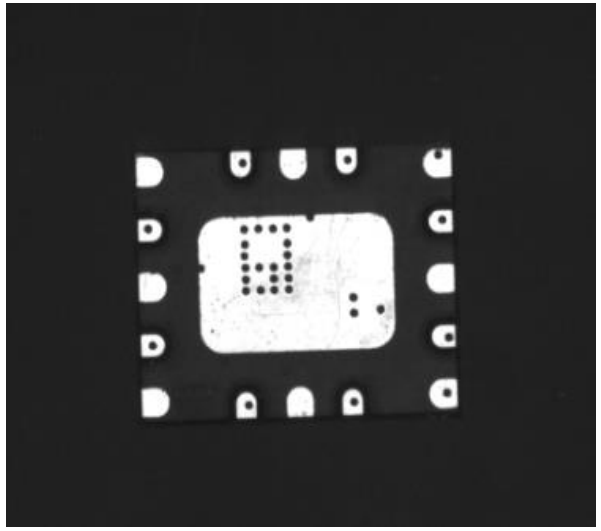
Source: Juki Automation Systems

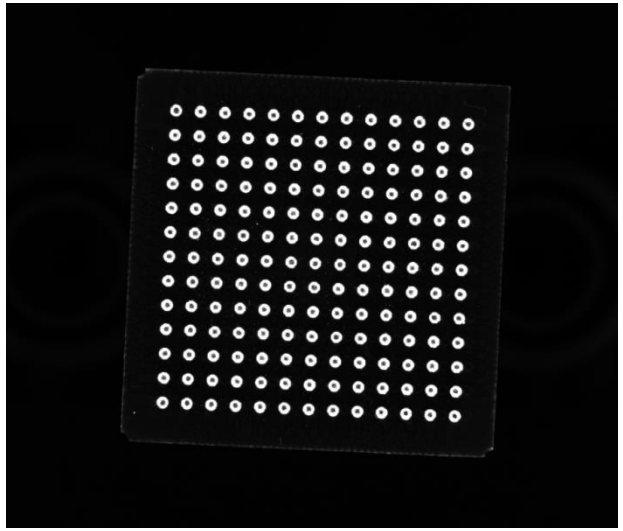
Embedded Example – Part Types

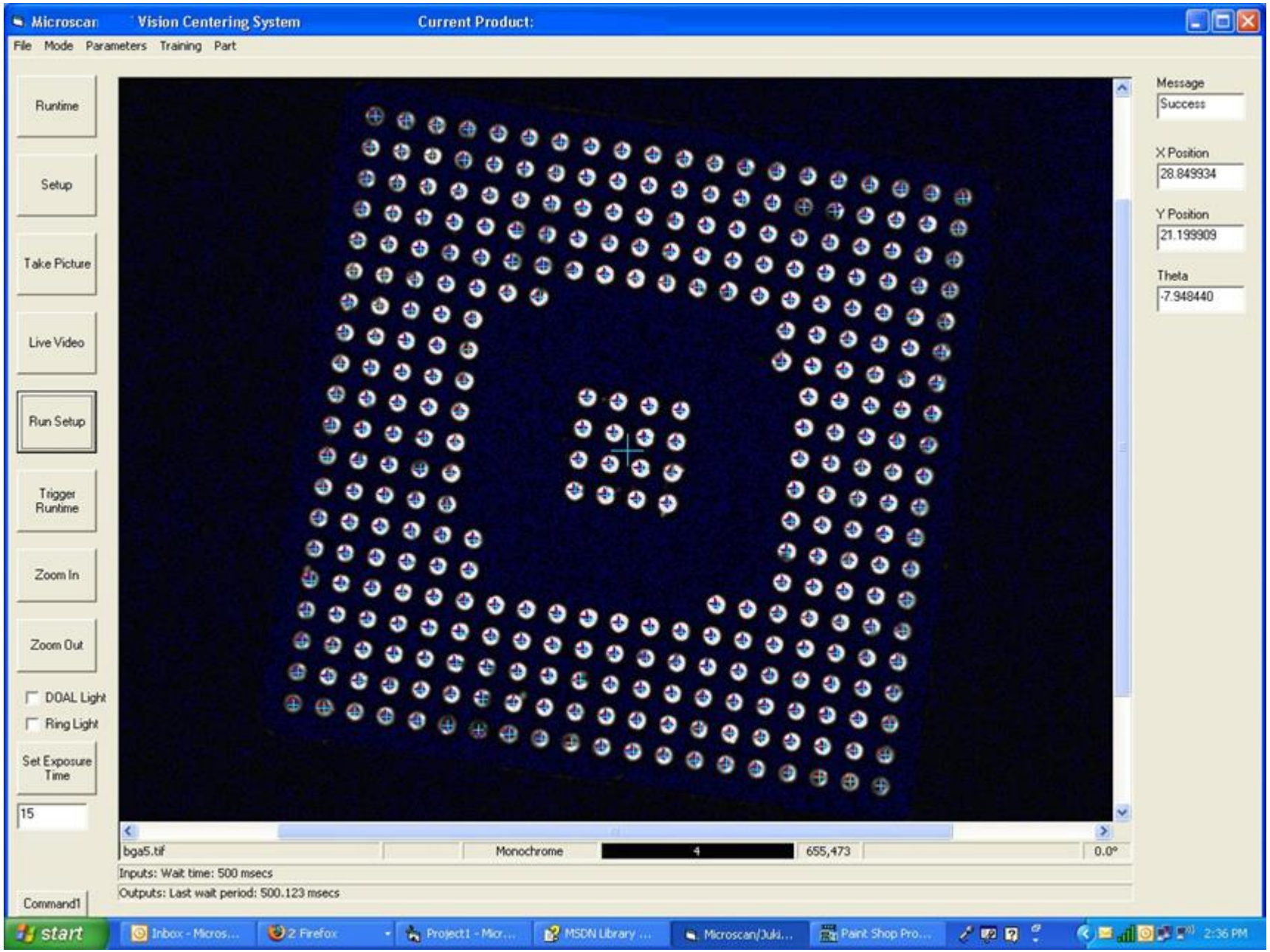






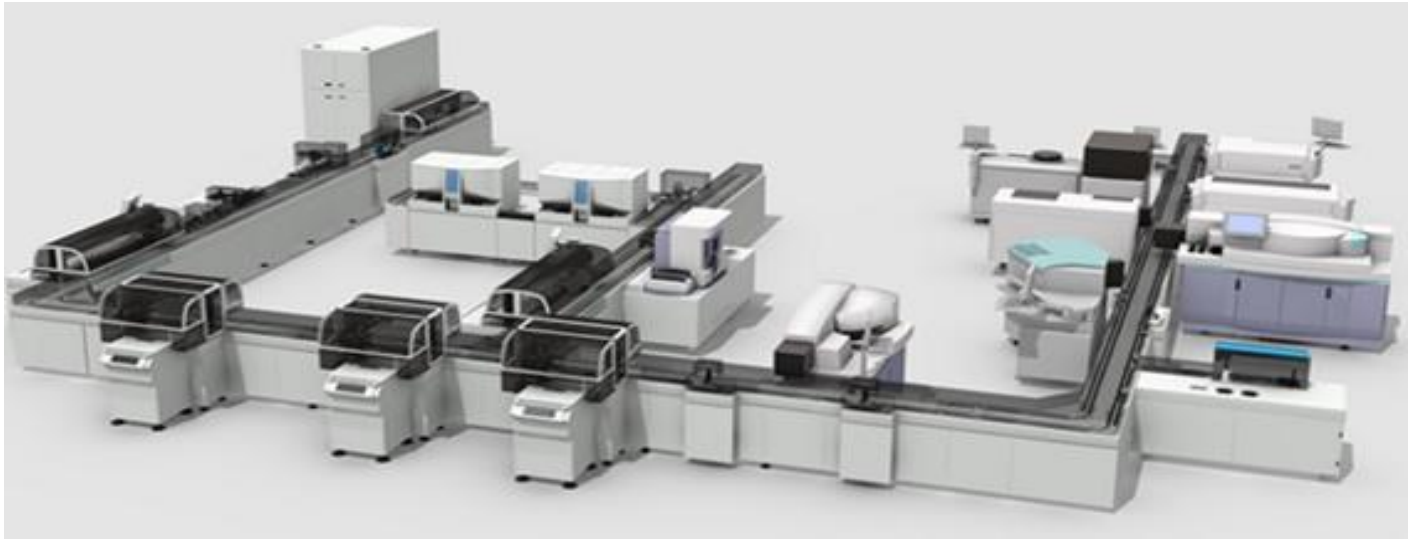





Microscan
Vision Centering System
Current Product:
File
Mode
Parameters
Training
Part
Runtime
Setup
Take Picture
Live Video
Run Setup
Trigger Runtime
Zoom In
Zoom Out
DOAL Light
Ring Light
Set Exposure Time
15
Command1
Message
Success
X Position
28.849934
Y Position
21.199909
Theta
-7.948440
bga5.tif
Monochrome
4
655,473
0.0°
Inputs: Wait time: 500 msecs
Outputs: Last wait period: 500.123 msecs
start
Inbox - Micros...
2 Firefox
Project1 - Micr...
MSDN Library ...
Microscan/Juki...
Paint Shop Pro...
2:36 PM

Embedded Example – Automation in Life Sciences

- Clinical Diagnostics Instrumentation
- Point-of-Care Instrumentation
- Pathology Instrumentation
- Laboratory Automation



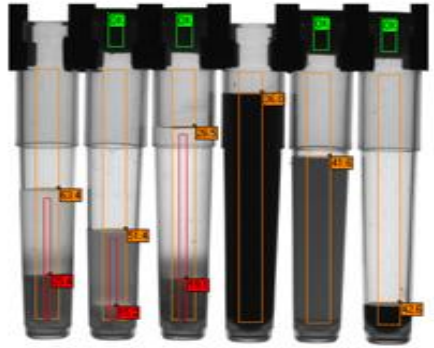
Embedded Example – Automation in Life Sciences

- Identification
- Inspection
- Measurement
- Guidance









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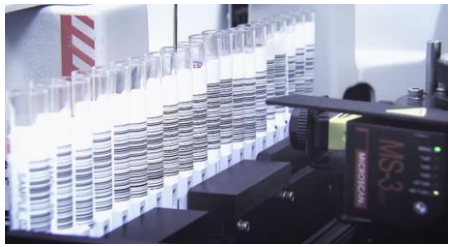
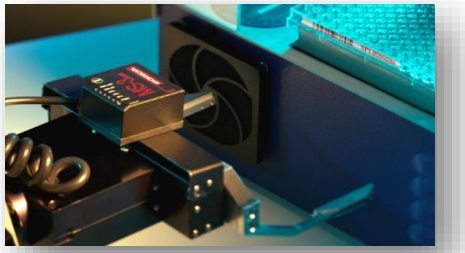
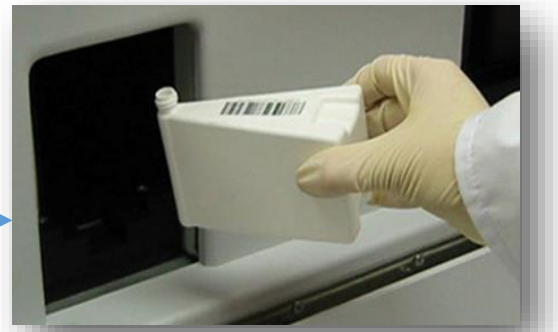
Embedded Example – Automation in Life Sciences

- Identification of
  - Specimen Tubes
  - Reagents
  - Tube carriers
  - Specimen slides/cassettes
  - Microwell plates
  - Pre-coded vials





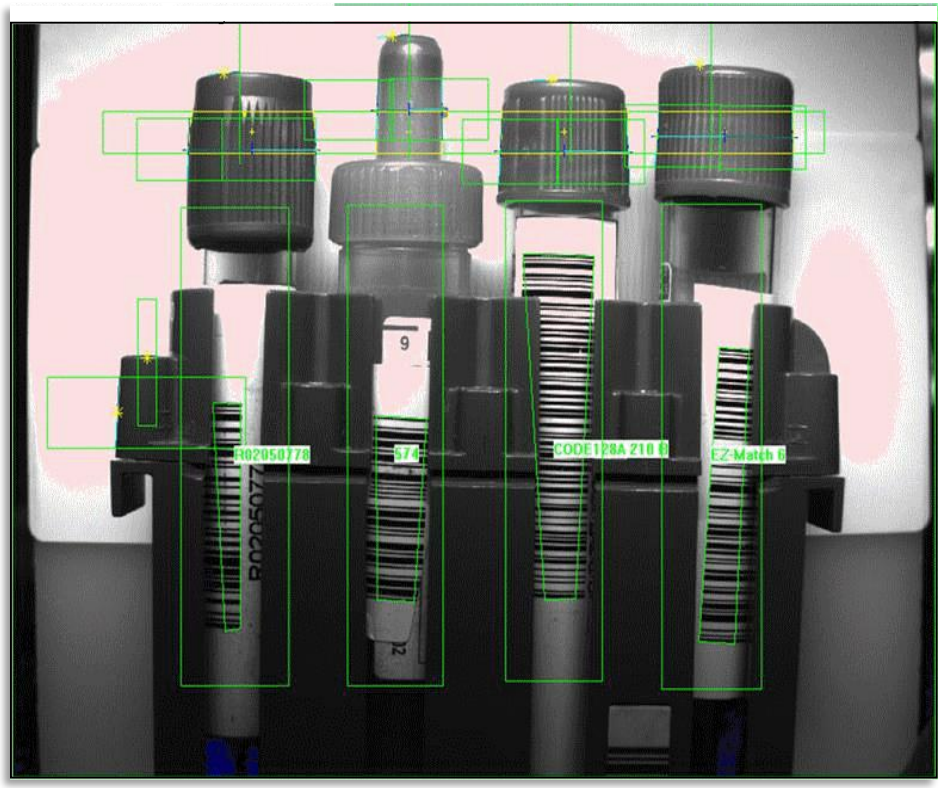


Embedded Example – Automation in Life Sciences

- Test Tube Check for
  - Tube presence
  - Cap presence
  - Tube height
  - Tube diameter
  - Cap type
  - Cap color
  - Label presence
  - Label location
  - Fluid level detection

Embedded Example - Challenges

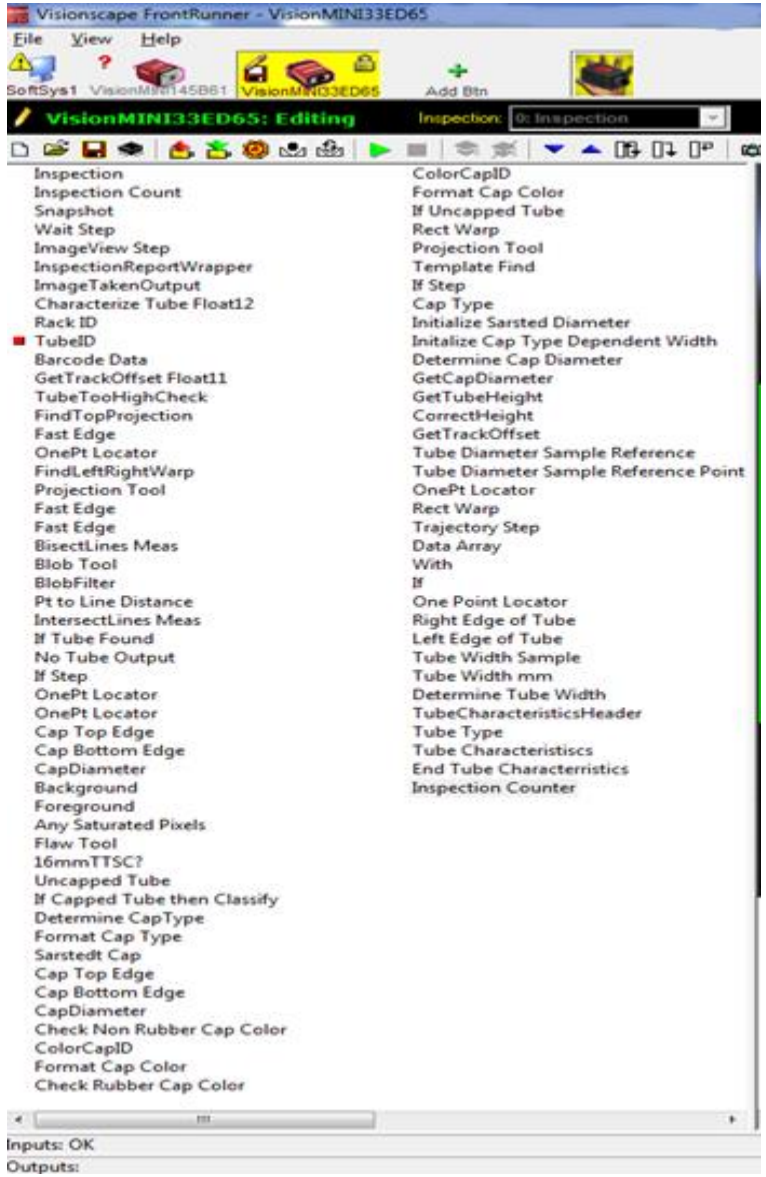
- Small Footprint Machines
- One or Multiple Cameras On Miniature Robots
- Very Low Cost
- Large Number and Variety of Inspections
- Very Short Working Distances
- Very Wide Fields of View
- Difficult Lighting Situations
- Calibrated and Un-calibrated Inspections
- Proof Testing on 10,000+ Samples



Embedded Example – Life Sciences

- Lighting
  - Embedded on Camera
  - Single LEDs at Critical Locations in Workspace
  - Retroflective surfaces for Backlight
- Optics – 2.8 mm to 6 mm, 60-80 degree fields of view
- Calibration – Done on Model Tubes
- Inspections – 10 to 30. Up to 300 tools per job.
- Tools
  - Read
  - Inspect
  - Locate, Measure
  - Custom

Embedded Example – Life Sciences



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Summary

- Robot Applications Face Challenges in Many Areas:
  - Physical Installation – Mounting, Size, Optics, Lighting
  - Cabling – High Flex, capable of millions of cycles
  - Programming – Simple yet Flexible, UI integration with robot controller
  - Calibration – 2D and 3D, marrying multiple coordinate systems
  - Integration of Results – Data formatting/output, Protocol support, Image display
- Miniature Smart Cameras Solve Many of These Challenges
  - General Use - Fully Integrated, Simple Programming, Configurable to Achieve Best Price
  - End of the robot arm - Low mass, Built into robot gripper, High number of inspections
  - Dense packed - Many cameras fit together over a single part for high accuracy results
  - Embedded applications - Fit multiple cameras into small spaces

Contact

Steven J. King
Vision and Lighting Product Manager

Microscan Systems
486 Amherst Street
Nashua, NH
USA

Telephone: (603)-320-5085
Email: sking@microscan.com

www.microscan.com