



Case Studies in 3D Bin Picking

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TOPICS

- Bin picking application overview
- Details of enabling technologies involving both robot and vision components and capabilities
- Real-world examples of advanced industrial applications in 3D VGR for robotic bin picking
 - Challenges present in the various applications, and techniques used to overcome these challenges in order to deliver successful applications



Case Studies in 3D Bin Picking

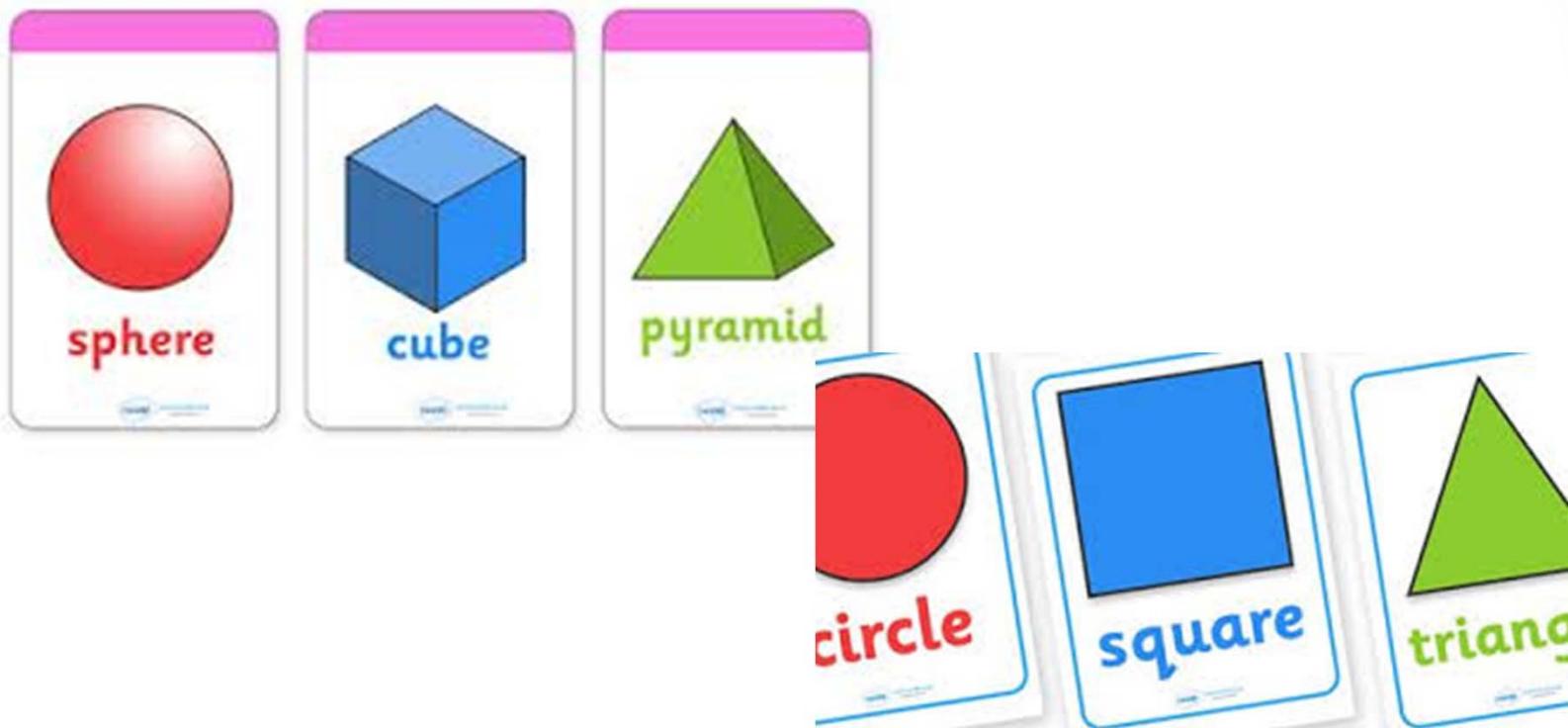
Introduction and Overview

**Machine vision for bin picking apps
Robot and vision – enabling technologies**

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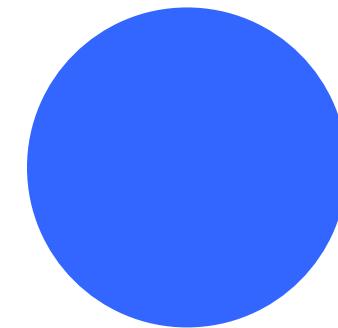
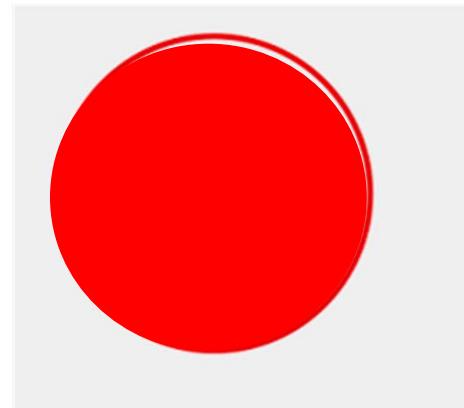
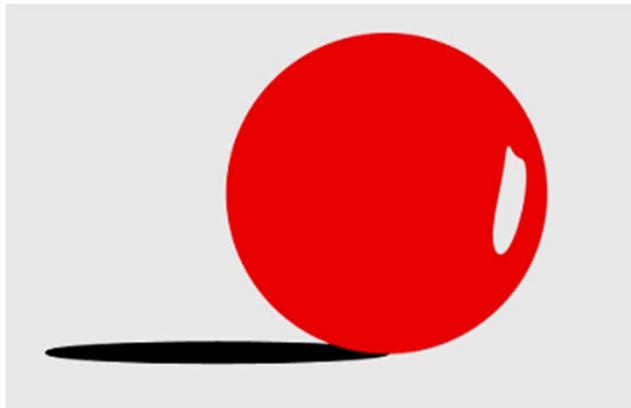
Machine Vision for Bin Picking Applications

Perception in a 3D world



Machine Vision for Bin Picking Applications

Machine vision - a flat view of 3D scenes



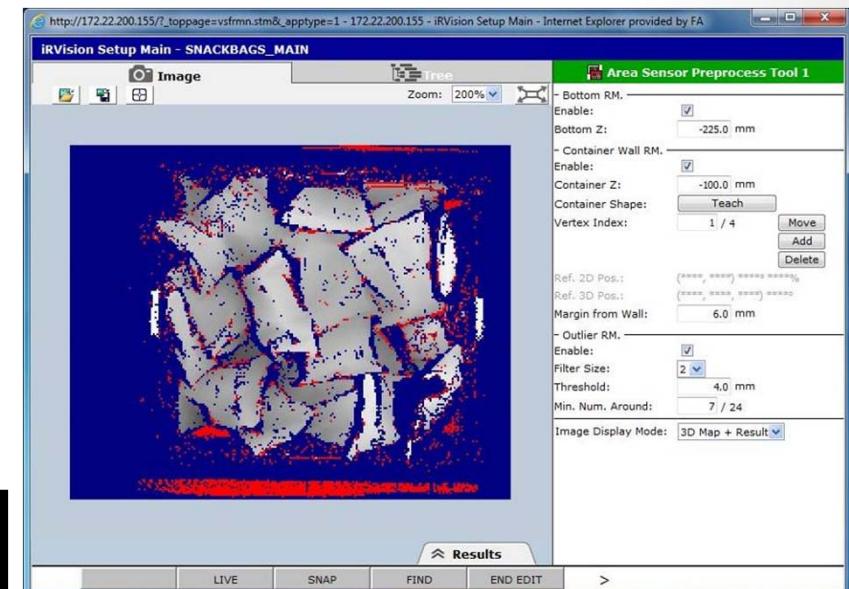
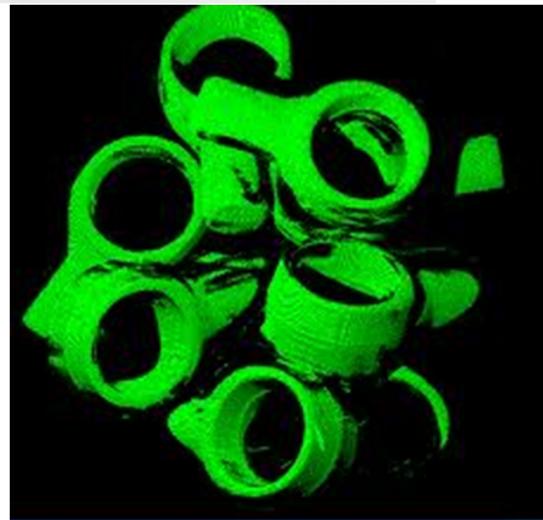
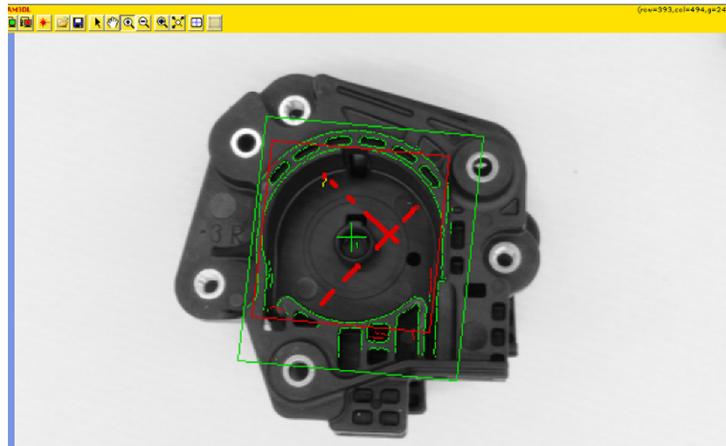
Machine Vision for Bin Picking Applications

Visual perception is intuitive



Machine Vision for Bin Picking Applications

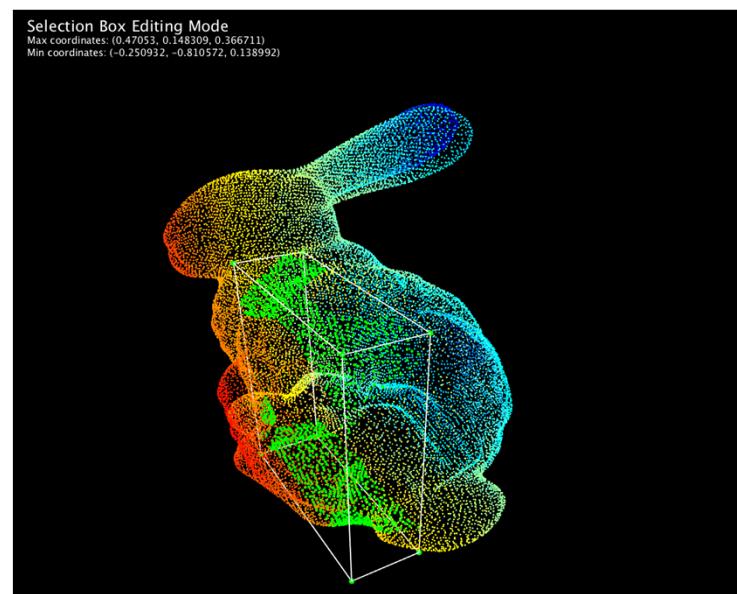
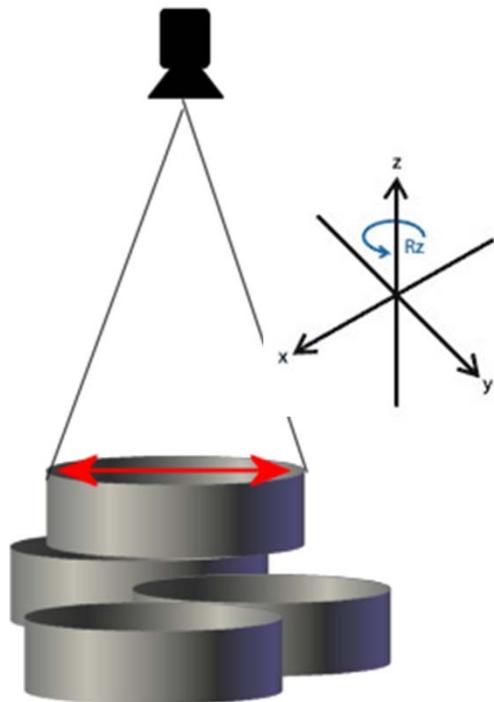
- Representing 3D for machine vision



Overview Of 3D Imaging For Machine Vision

3D image feature representation for machine vision

- Single points
- Clouds of points
 - Granularity as “resolution”



Machine Vision for Bin Picking Applications

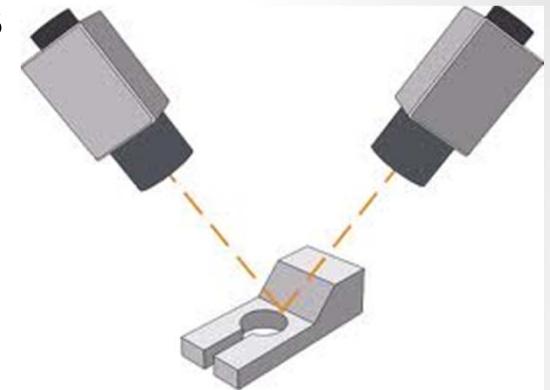
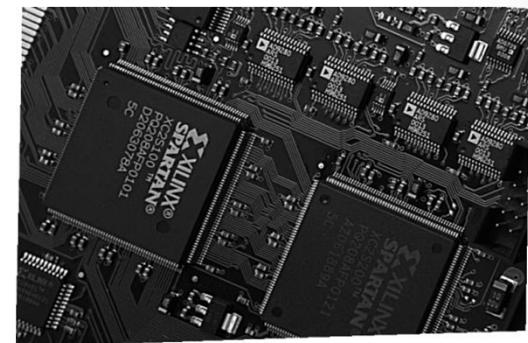
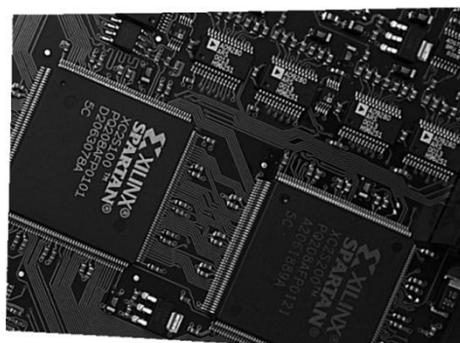
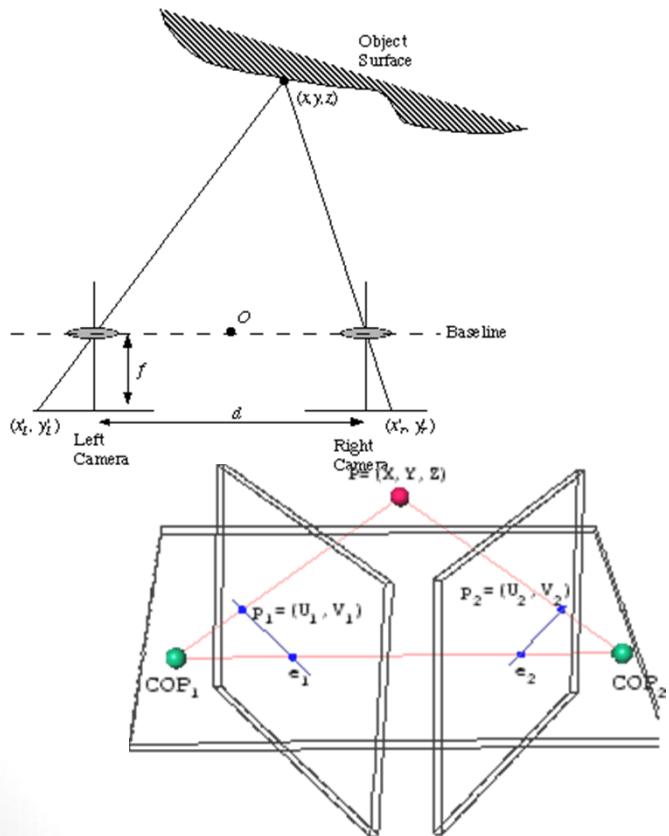
Methods for acquiring 3D information from flat images

- Stereo or multiple cameras
- Structured illumination
 - Light pattern projection
 - Multiple images with variation in illumination shape, color, or direction
- Time of flight
- Height from focus, shape, shading, or sensing
- Phase shifting
- Interferometry

Machine Vision for Bin Picking Applications

Stereo (binocular) camera pair or multiple cameras

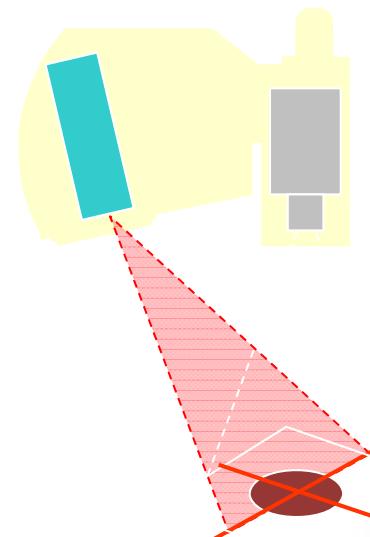
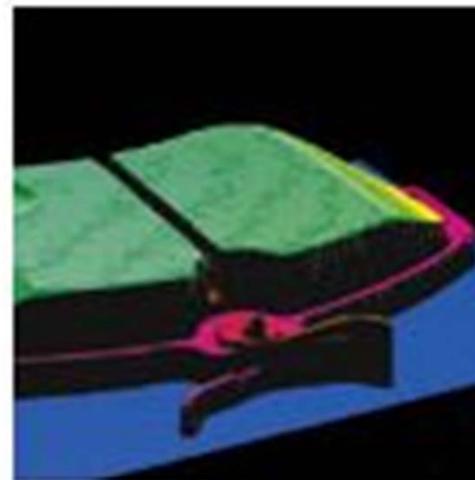
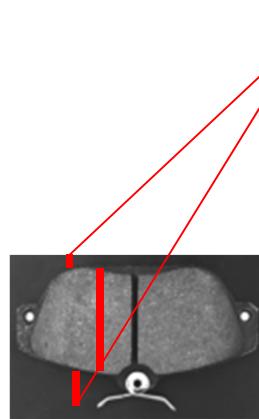
- Typical returned data
 - Discrete points
 - Point cloud (in some cases)



Machine Vision for Bin Picking Applications

Structured illumination – sheet of light

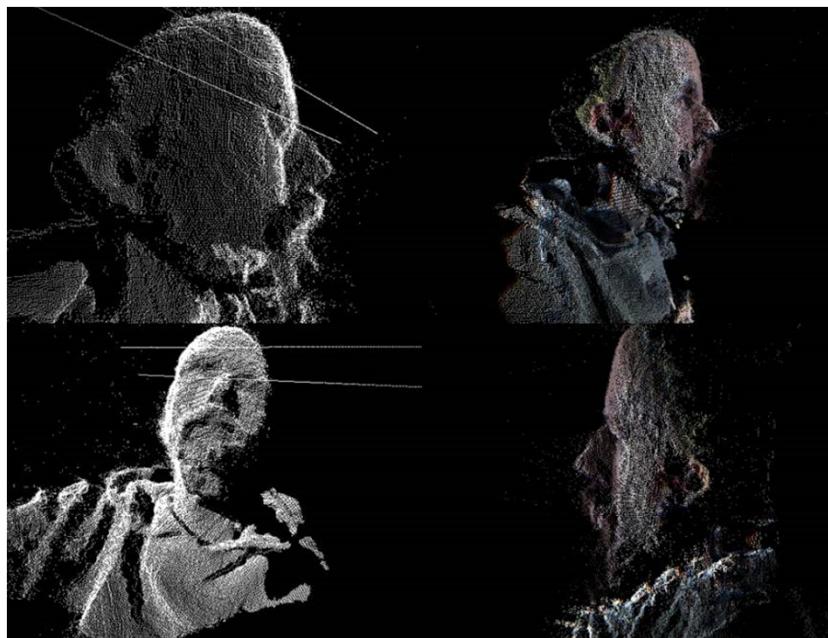
- Typical returned data
 - Point cloud (requires scanning)
 - Discrete object points with planar orientation



Machine Vision for Bin Picking Applications

Structured illumination - light pattern projection

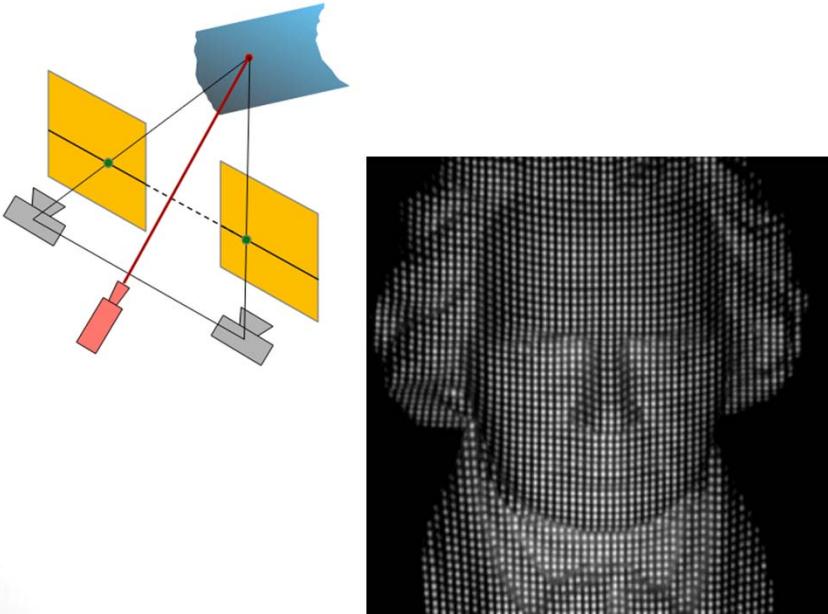
- Typical returned data
 - Point cloud
 - No scanning, may require multiple images
 - Granularity issues
 - Kinect



Machine Vision for Bin Picking Applications

Structured illumination – shape or color variation

- Typical returned data
 - Point cloud
 - No scanning, may require multiple images
 - Improved granularity
 - Combine with stereo cameras
 - Reduce the correspondence problem to improve accuracy and feature extraction



Machine Vision for Bin Picking Applications

Time of Flight

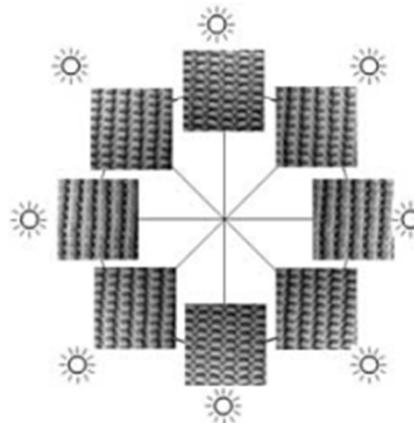
- Typical returned data
 - Point cloud
 - No scanning, may require multiple images
 - Limited height resolution
- Phase modulation vs. pulsed



Machine Vision for Bin Picking Applications

Height from focus, shape, shading, or sensing

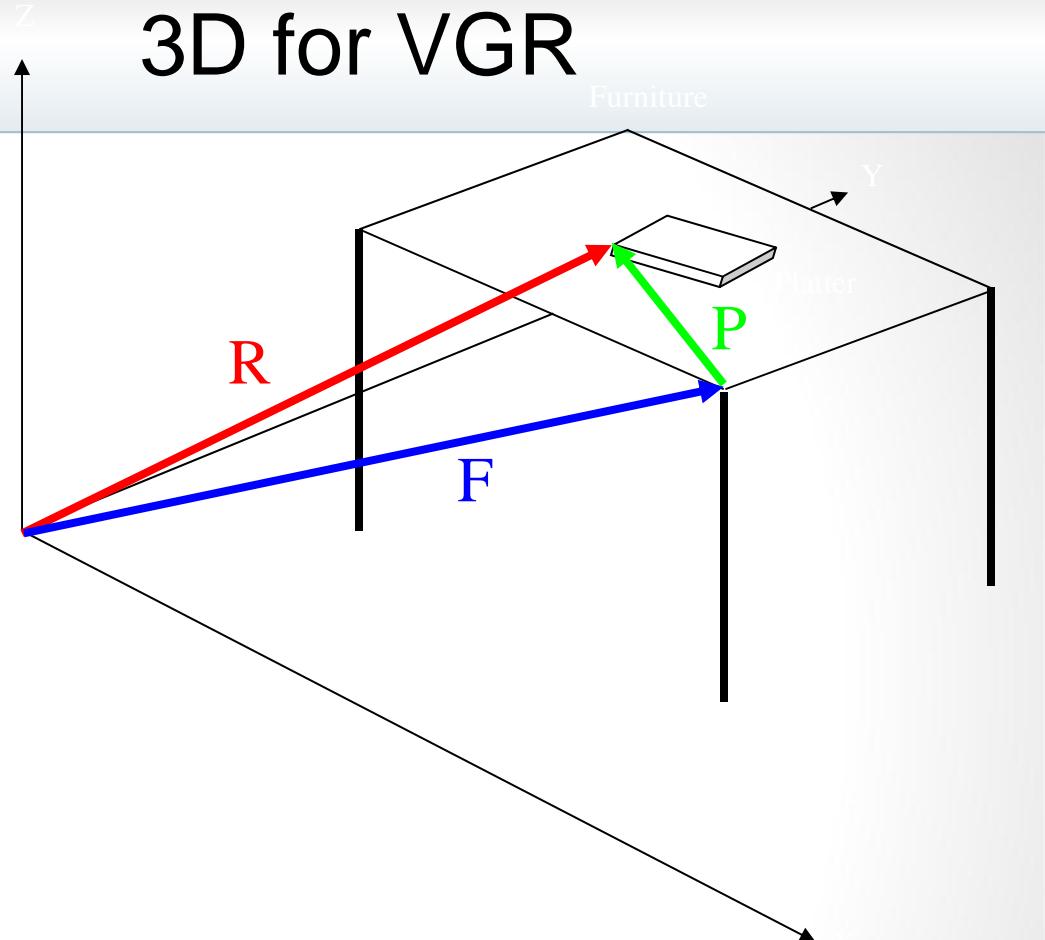
- Typical returned data
 - Point cloud
 - Requires multiple images



3D for VGR

Integration Considerations

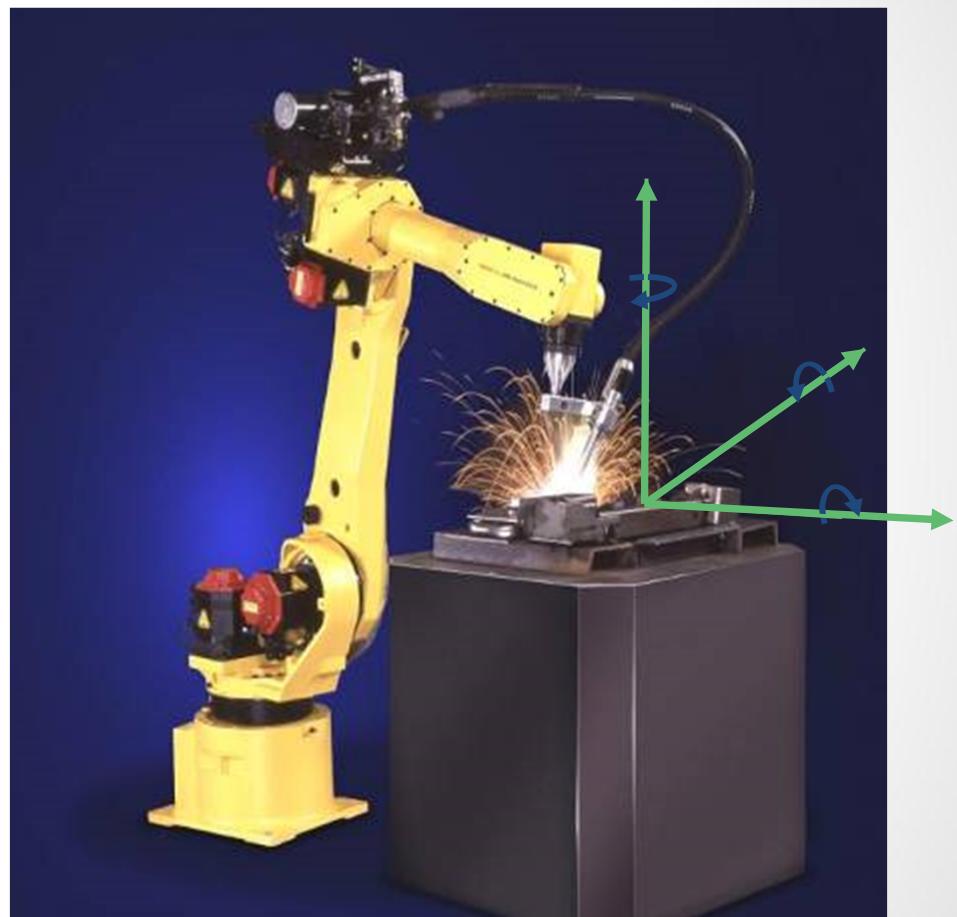
- Understanding robot space
- Start with a Cartesian coordinate system for rendering position (X,Y,Z).
- **R** is the position of the platter relative to the room.
- **F** is the position of the furniture in the World coordinate system.
- **P** is the position of the platter in the furniture frame or furniture coordinate system.



Robot and Vision – Enabling Technologies

Integration Considerations

- Consider the Robot's Face Plate Position with respect to a part (X,Y and Z).
- Now consider a plane pivoting around this point. Rotating around X,Y and Z.
- This is part positioning with 6 degrees of freedom.
- Our ultimate goal:
How can vision be used to guide the robot to the position of a part?



Robot and Vision – Enabling Technologies

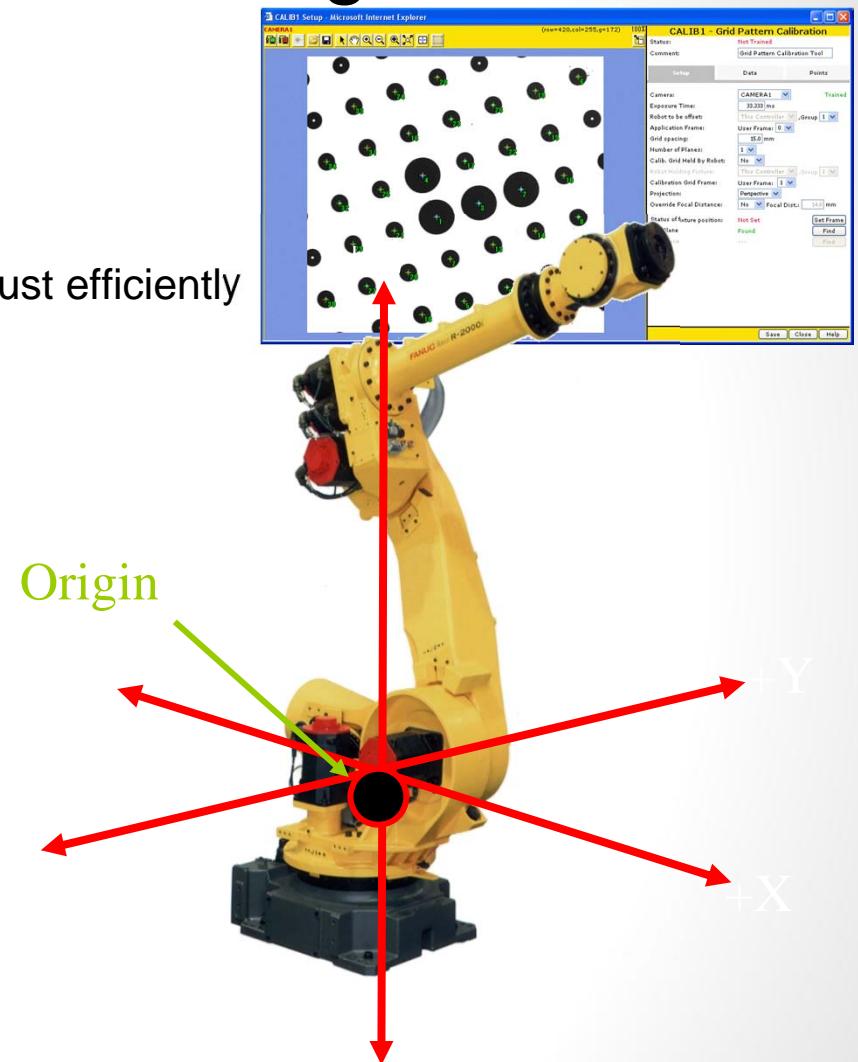
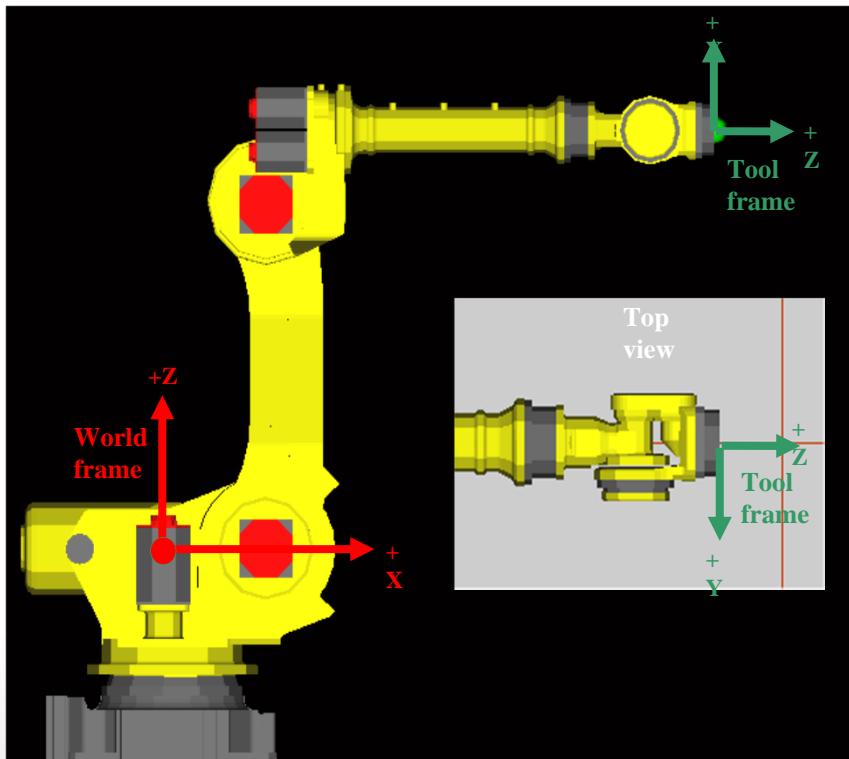
Integration Considerations

- Camera(s) may be fixed or robot mounted
- Impact on integration

Robot and Vision – Enabling Technologies

Integration considerations

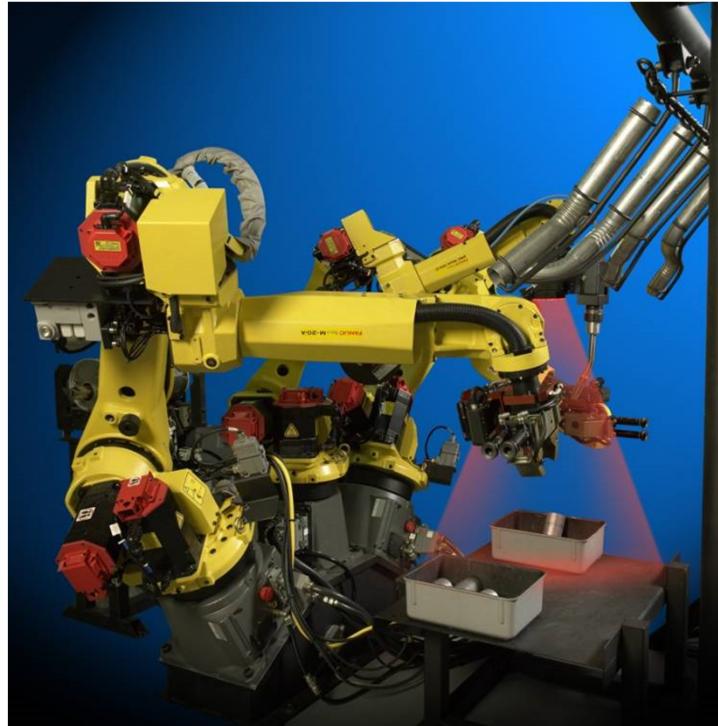
- Communications
 - The robot and vision components must efficiently share data



Robot and Vision – Enabling Technologies

Integration Considerations

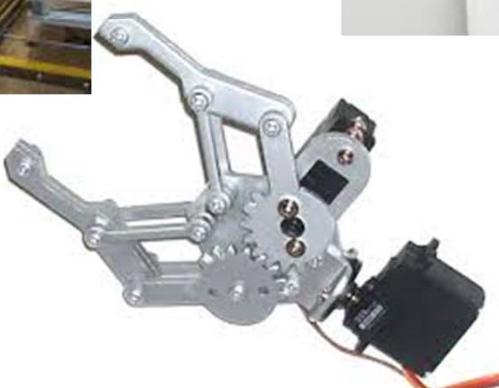
- Illumination and ambient light



Robot and Vision – Enabling Technologies

Integration Considerations

- Gripping
 - Often most challenging aspect





Case Studies in 3D Bin Picking

Application Examples

Techniques, Components, Challenges

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Application Examples

Structured lighting – single camera point and plane

- Semi-random/layered part orientation
- Technical issues
- Challenges and solutions

Structured Lighting – sheet of light

- Random part orientation
- Technical issues
- Challenges and solutions

Point cloud from patterned illumination

- Random part orientation
- Technical Issues
- Challenges and solutions

Point cloud from patterned illumination - 2

- Random part orientation
- Technical Issues
- Challenges and solutions

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