Week 2 – Robotic Workcell Design

Advanced Robotic Systems – MANU2453

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Lectures

Wk	Date	Lecture (NOTE: video recording)	Maths Difficulty	Hands-on Activity	Related Assessment
1	24/7	• Introduction to the Course • Spatial Descriptions & Transformations			
2	31/7	• Spatial Descriptions & Transformations • Robot Cell Design			Robot Cell Design Assignment
3	7/8	• Forward Kinematics • Inverse Kinematics			
4	14/8	• ABB Robot Programming via Teaching Pendant • ABB RobotStudio Offline Programming		ABB RobotStudio Offline Programming	Offline Programming Assignment
5	21/8	• Jacobians: Velocities and Static Forces			
6	28/8	• Manipulator Dynamics			
7	11/9	• Manipulator Dynamics		MATLAB Simulink Simulation	
8	18/9	• Robotic Vision		MATLAB Simulation	Robotic Vision Assignment
9	25/9	• Robotic Vision		MATLAB Simulation	
10	2/10	• Trajectory Generation			
11	9/10	• Linear & Nonlinear Control		MATLAB Simulink Simulation	
12	16/10	• Introduction to I4.0 • Revision			Final Exam

Content

- What is a Robotic Workcell
- Part Storage
- Part Feeding and Transfer
- Part Recognition
- Robot
- End-of-Arm Tooling
- External Axis
- Safety
- New Generation Collaborative Robots

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Intro Video: How Cars are Made

- https://www.youtube.com/watch?v=hw9JrjsPhT8

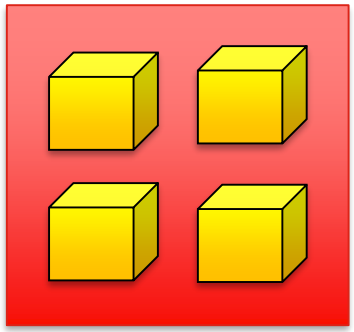
Robotic Workcell

- A grouping of robot and other peripheral equipment.
- Carry out task with little or no human intervention.

http://d2n4wb9orp1vta.cloudfront.net/resources/images/cdn/cms/1013CT_Emerging_PreformCenter.jpg

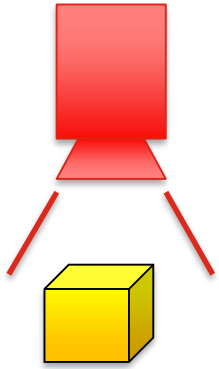
Robotic Workcell

- Overview



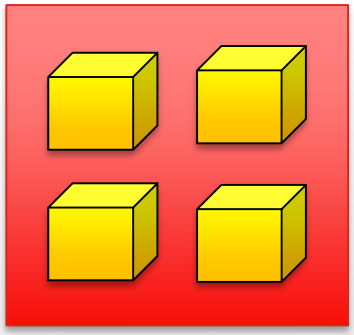
Raw Part Storage

Part Transfer



Part Recognition

Robot + End Effector



Finished Part Storage

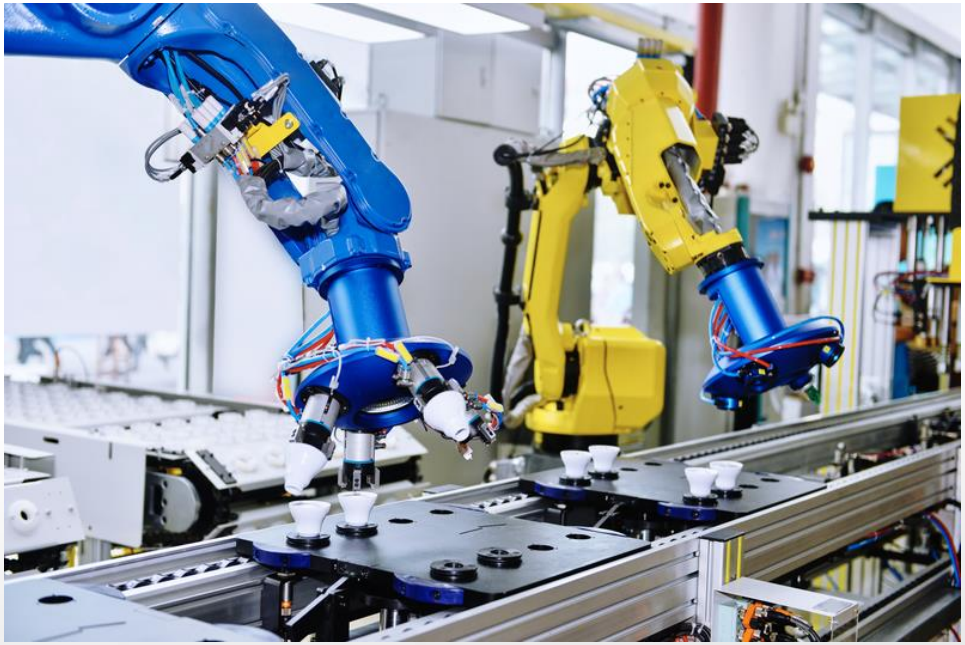
Layouts

- Robot-centered, in-line or mobile.
- Robot-centered:
  - Robot in the centre of work-cell.
  - One robot for several machines.

http://d2n4wb9orp1vta.cloudfront.net/resources/images/cdn/cms/1013CT_Emerging_PreformCenter.jpg

Layouts

- In-line robot workcell:
  - One or more robots along the in-line conveyer
  - Each robot performs one task.



https://recruitingdaily.com/robotics-automation-will-provide-talent-feed-shift/

Layouts

- Mobile robot workcell:
  - Robot fitted on a mobile-base or gantry.
  - Robot goes to different locations to do its required tasks.

https://www.azom.com/article.aspx?ArticleID=15531

https://www.youtube.com/watch?v=9C4lJaS5oVA

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Part Storage

- One of the commonly-used systems for storing parts is called Automated Storage and Retrieval System (ASRS).
- Parts are stored before and after production.
- Retrieval system brings parts to-and-from the robot.

https://www.youtube.com/watch?v=zJOAVOWIuro

Part Storage

- Shelfing is another alternative.
- Suitable if amount of goods are not as much as in the case for ASRS.
- Items will be picked up by forklifts.

http://www.clp.global/warehouse-shelf-tags-labels

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Part Feeding and Transfer

- After parts are retrieved from the ASRS, or placed at some suitable locations in a factory, they need to be transferred to the robot.
- Several systems are available:
  - Automated Guided Vehicle (AGV) or Automated Forklift

https://advantechfiles.blob.core.windows.net/cms/4595a46e-3a81-4dc7-8c49-7dd098523983/Content/contnt-img-49655573.png

https://www.youtube.com/watch?v=jCcFFbqFddQ

  - Guidance systems included magnetic track on floor, indoor GPS, visual markers.
  - Safety (collision avoidance) is crucial!

Part Feeding and Transfer

- Conveyor belts are commonly used.

Flat surface

https://www.indiamart.com/proddetail/conveyer-12213153012.html

With gaps

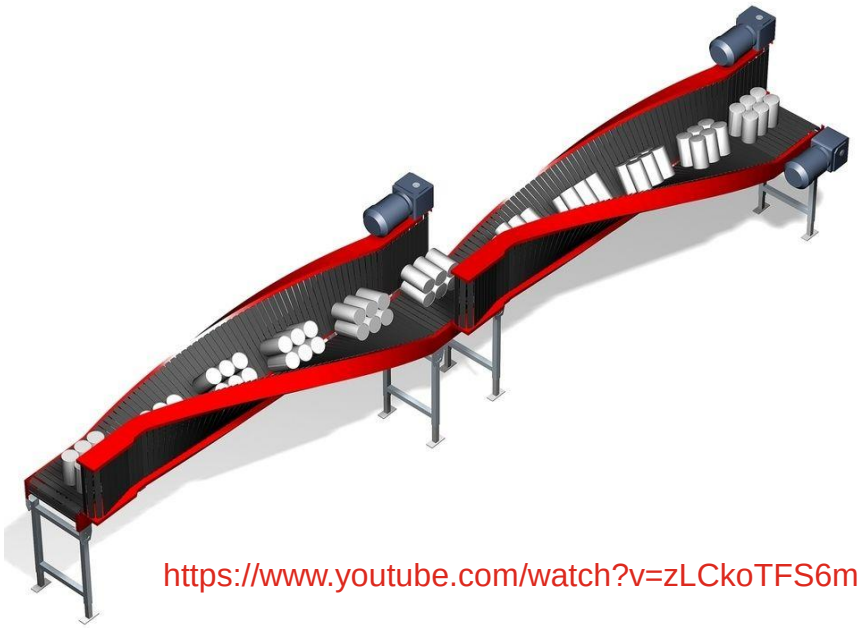
https://www.diytrade.com/china/pd/3998507/roller_conveyer.html

Angled (no motor needed)

https://www.alibaba.com/product-detail/belt-conveyer_639423264.html

Part Feeding and Transfer

- Twisted conveyer
  - To rotate parts



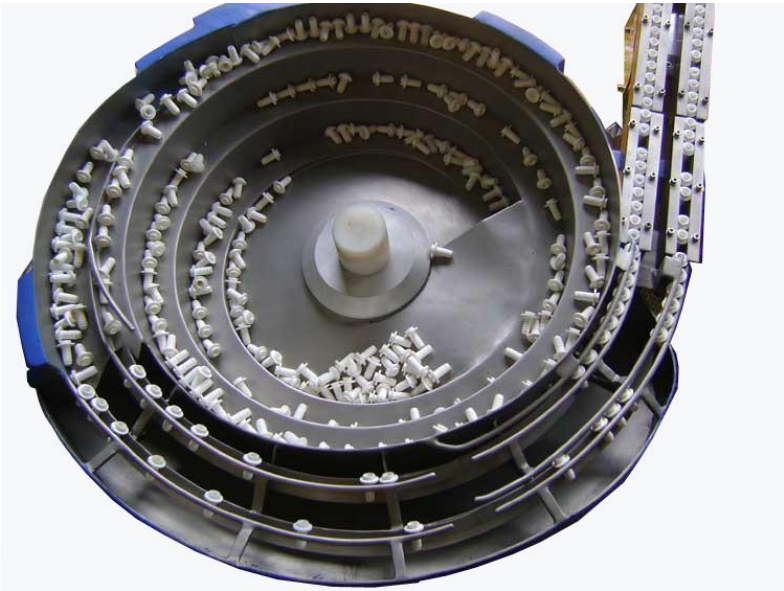
https://www.youtube.com/watch?v=zLCkoTFS6mE

Twisted conveyer to rotate or flip objects

http://www.directindustry.com/prod/apollo-vts-bv/product-9322-808241.html

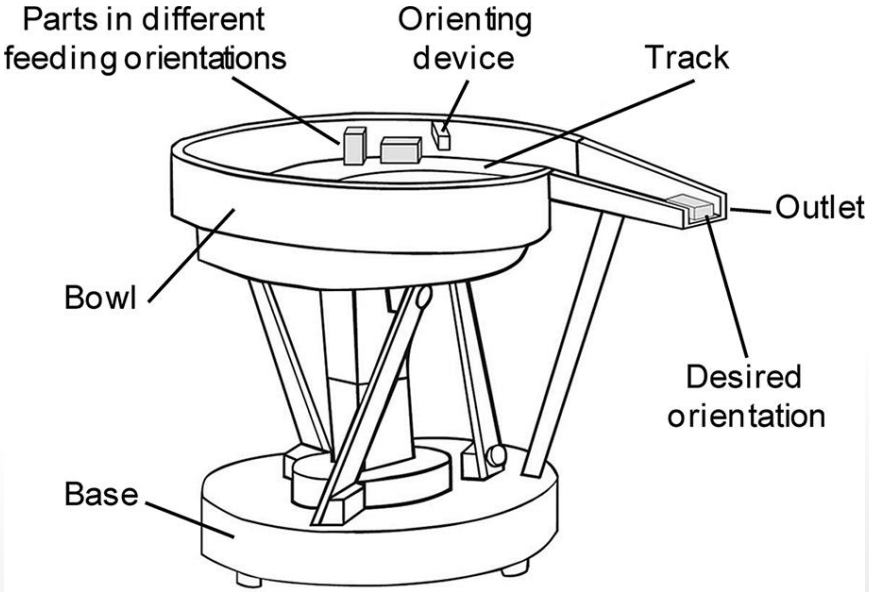
Part Feeding and Transfer

- Vibratory bowl feeders can feed and re-orient parts.



http://www.vibrofeedtech.com/photo/DSC06581.jpg

https://www.youtube.com/watch?v=QsJzSFVAnhk



http://manufacturingscience.asmedigitalcollection.asme.org/data/journals/jmsefk/927586/manu_135_05_051017_f001.png

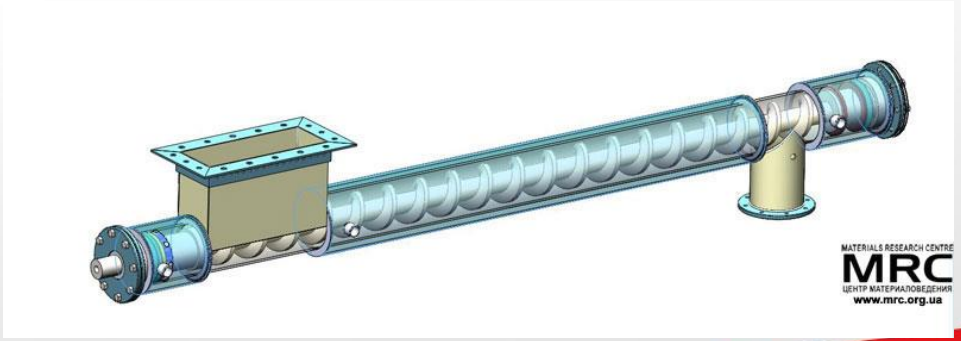
Part Feeding and Transfer

- Vibratory conveyor produces vibrating movement (e.g. 50Hz) and permits parts to be conveyed in a smooth manner.

http://www.heatandcontrol.com/productenlargements/vibe.jpg

https://www.youtube.com/watch?v=vKiZ8_ftSDA

- Another technology is the Screw feeder:



http://mrc.org.ua/images/screw-feeder/design/screw-feeder-water-cooled-shell.jpg

Intermittent or Continuous Transfer

- Intermittent:
  - Start-stop motion of conveyer.
  - Stop triggered by sensor.
  - Advantage: Fixed location and orientation; simpler robot program.

Use proximity sensors to detect object

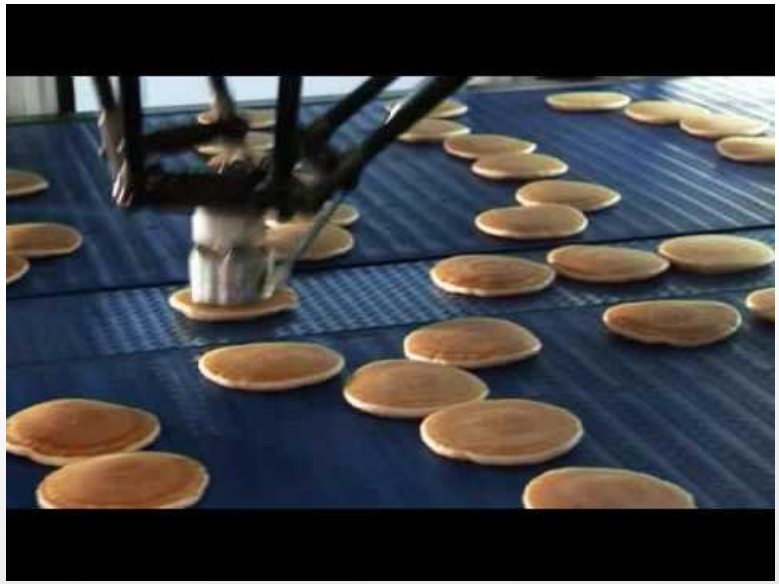
https://www.communiqueasia.com/2018/01/18/global-conveyer-belts-market-2017-fenner-bridgestone-habasit-ammeraal-beltech/

Use stopper to stop object

https://www.titanconveyors.com/products/chain-driven-live-roller/pop-up-transfer-stops-pallet-centering-pallet-lifts-and-pallet-crowder

Intermittent or Continuous Transfer

- Continuous Transfer
  - Object moves continuously.
  - Robot has to perform the task as the objects move.
  - Needs tracking – Robot needs to maintain position and orientation with respect to object.



https://www.youtube.com/watch?v=v9oeOYMRvuQ

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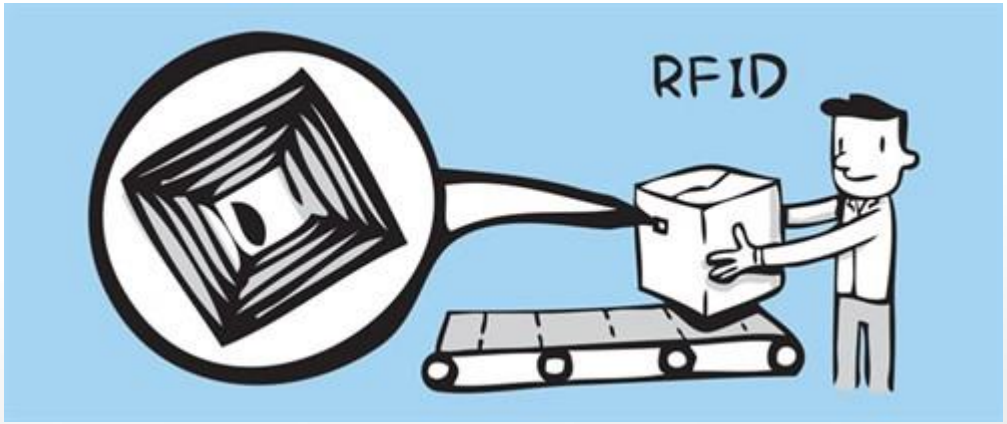
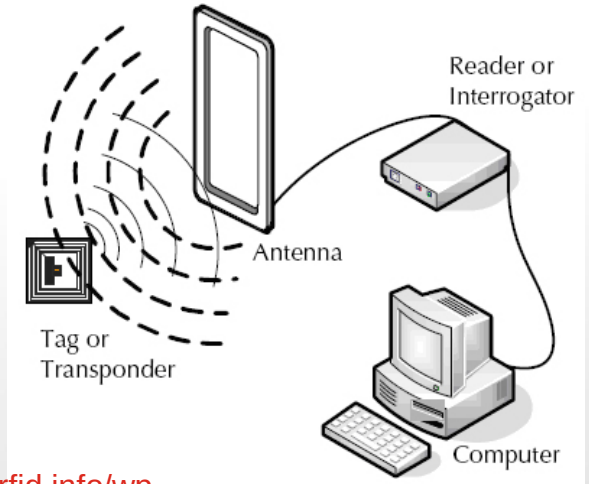
Part Recognition

- Now that the parts have arrived at the proximity of the robot, there may be a need to identify / recognize the part.
- RFID (Radio Frequency Identification) technology can be used to make sure that the part is correct.
  - In fact, RFID can be utilized to monitor the flow of the part throughout the whole manufacturing process (e.g. where is it in the ASRS, when should it be processed, how should it be processed etc.)



http://rfidarena.com/media/56891/rfid_illustration_499x209.jpg

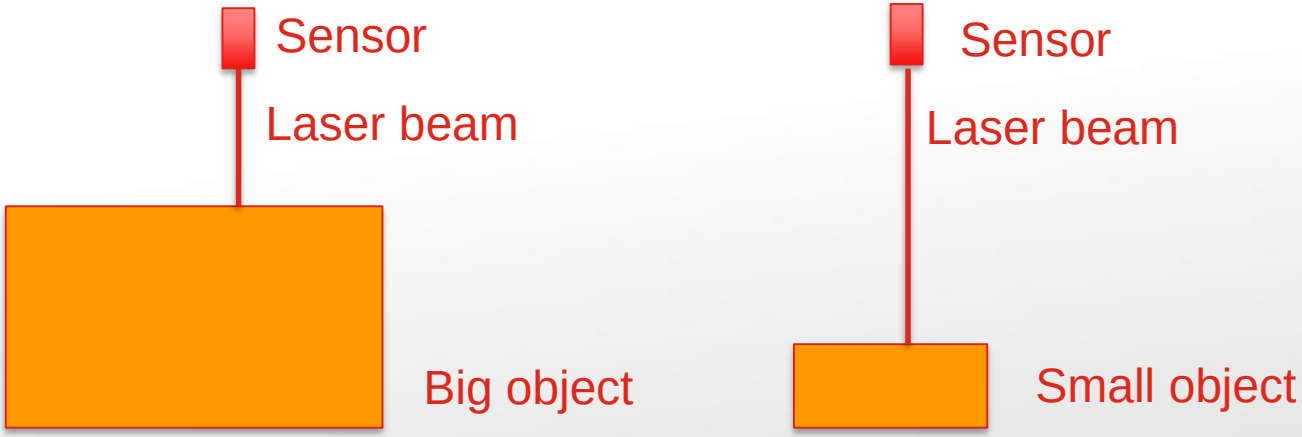


http://www.epc-rfid.info/wp-content/themes/gintinfo/images/how%20rfid%20works.png

Part Recognition

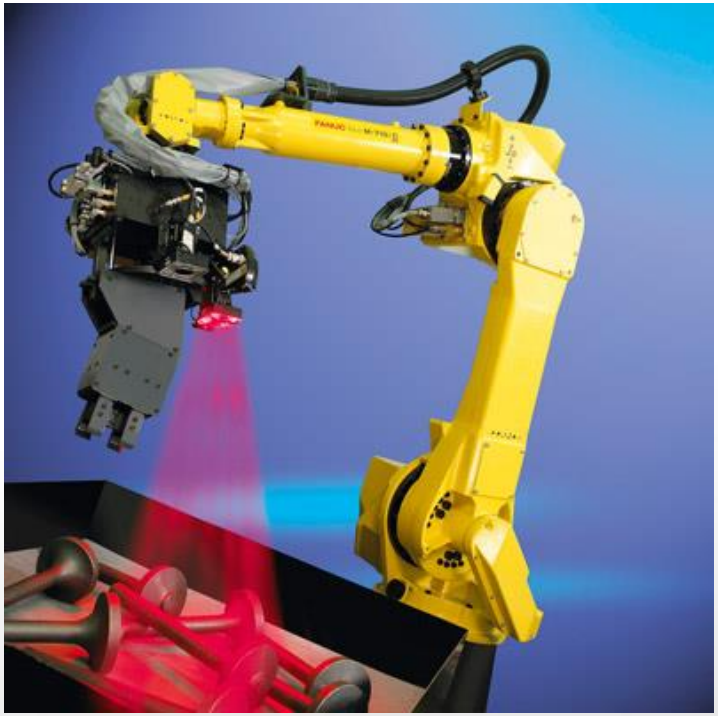
- Bar Code can also be used in place of RFID.

- If objects can be differentiated based on size / dimensions / weights, simple sensors can also be used for part recognition.

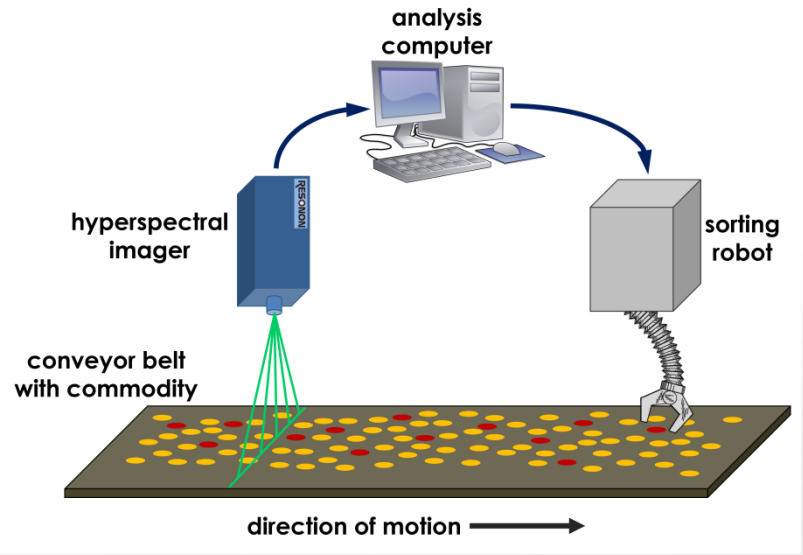


Part Recognition

- Robotics Vision is another popular method.
- It can be programmed to identify shapes, position (on conveyor belt), and also the orientation of parts.



https://media.robots.com/articles/1460305006_1.jpg



http://www.resonon.com/images/Machine%20Vision/machine%20vision%20schematic.png

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Robot

- At the centre of the robotic workcell is the robot.
- There are different kinds of robots.
- Serial robots:
  - Good workspace
  - But low stiffness

http://harmonicdrive.de/fileadmin/harmonicdrive/layout-images/robotik-und-automation/anwendung_kuka_1.jpg

Robot

- Parallel robots:
  - Stiffer
  - Can perform fast action
  - Workspace smaller

http://img.directindustry.com/images_di/photo-g/30265-7087535.jpg

https://www.youtube.com/watch?v=v9oeOYMRvuQ

Robot

- SCARA robots
  - 2R / 3R
  - 1T

http://i1-linux.softpedia-static.com/screenshots/SCARA-robot_1.jpg

- Orbital SCARA
  - Very fast

https://www.youtube.com/watch?v=sWrLojkCgVw

- Gantry robots
  - 3T

http://www.toshiba-machine.com/Upload/Product/03c599bcaa.jpg

Robots

- Sometimes, you can have more than 1 robot working together:

http://www.hanyu-auto.com/diy/pics/20140618/1403097462.jpg

Robots

- Question: which robot to choose in real application?
- Criteria:
  - Number of degrees of freedom
  - Workspace
  - Load capacity / Payload
  - Speed
  - Repeatability and accuracy
  - Kinematic configuration
    - Cartesian
    - Articulated
    - Scara
    - Gantry robot
  - Availability of external axis

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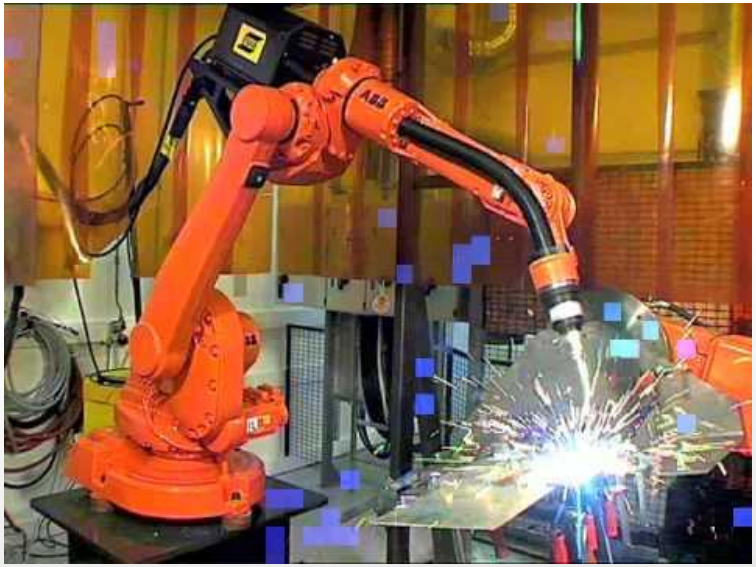
End-of-Arm Tooling

- Various equipment can be attached at the end of the robot to perform different tasks.
- Welding torch
  - Welding is one of the most popular robotic applications

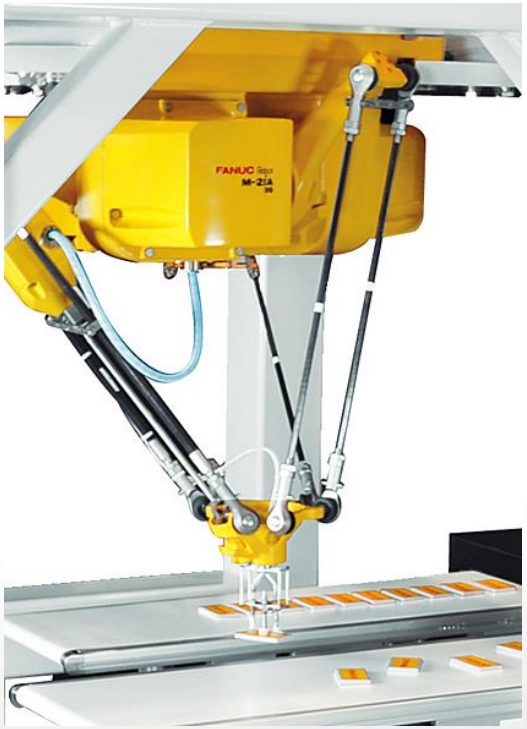


https://i.ytimg.com/vi/HUU3HdxOqZs/hqdefault.jpg

End-of-Arm Tooling

- Grippers
  - Used for pick-and-place

https://i.ytimg.com/vi/YaVlJA9d9tc/maxresdefault.jpg



http://www.foodbev.com/wp-content/uploads/2013/11/07/fanuc800.jpg

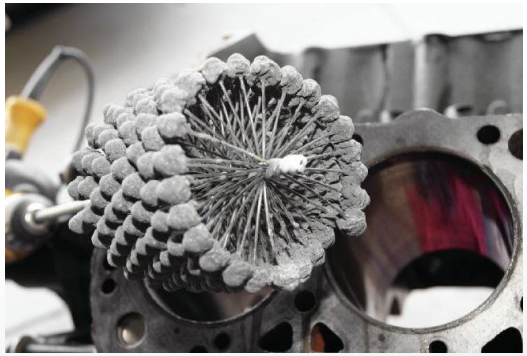
End-of-Arm Tooling

- Polishing / Deburring tools
  - To improve surface quality
  - May be used in conjunction with force control end-effectors.

http://www.csfrobotics.com.au/wp-content/gallery/polishing-linishing/dscn1574.jpg

Flap wheel

https://cdn.mscdirect.com/global/images/ProductImages/0038069-23.jpg

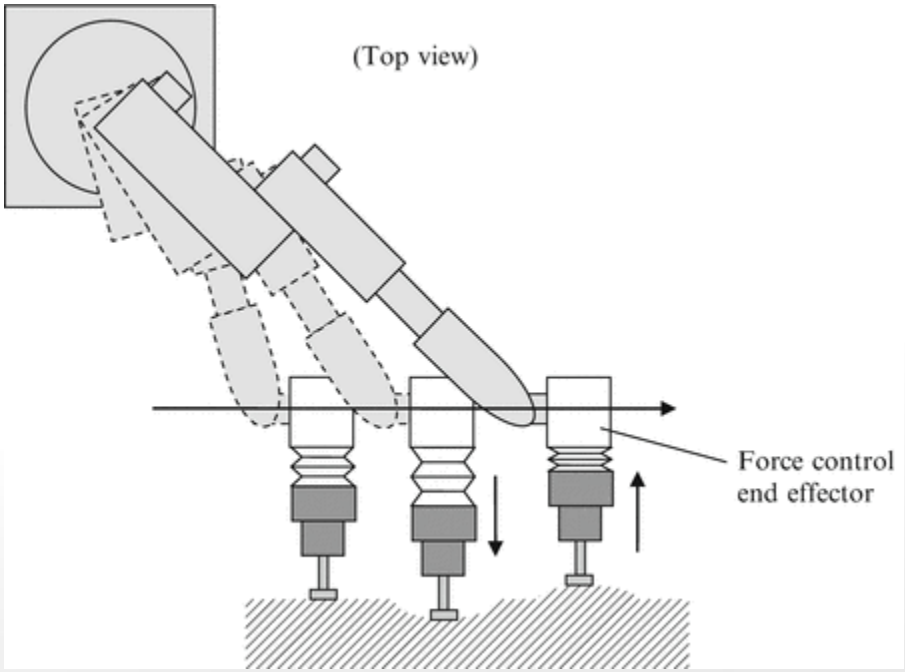


Flexhone

http://2.bp.blogspot.com/-L7Bzqct23Tg/Ui81lOCb0pI/AAAAAAAAAw0/j-wn6OWff7k/s1600/Flexhone_Diesel.JPG

End-of-Arm Tooling

- Force Control End-Effectors
  - Ensures the correct amount of force is pressed into object during polishing / deburring.



https://link.springer.com/referenceworkentry/10.1007%2F978-1-4471-4670-4_107

End-of-Arm Tooling

- Tool exchanger
  - This is not the tool itself, but is used to quickly exchange tools so that the robot can perform different operations.

http://www.ati-ia.com/Company/images/Robot_ATI_Tool_Changers.jpg

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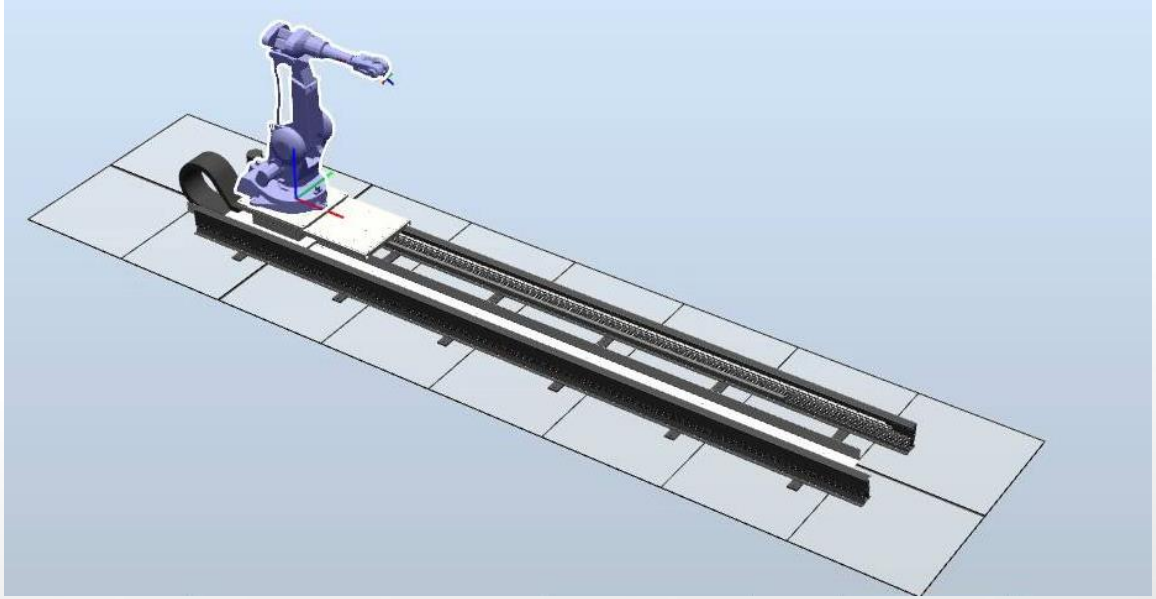
External Axis

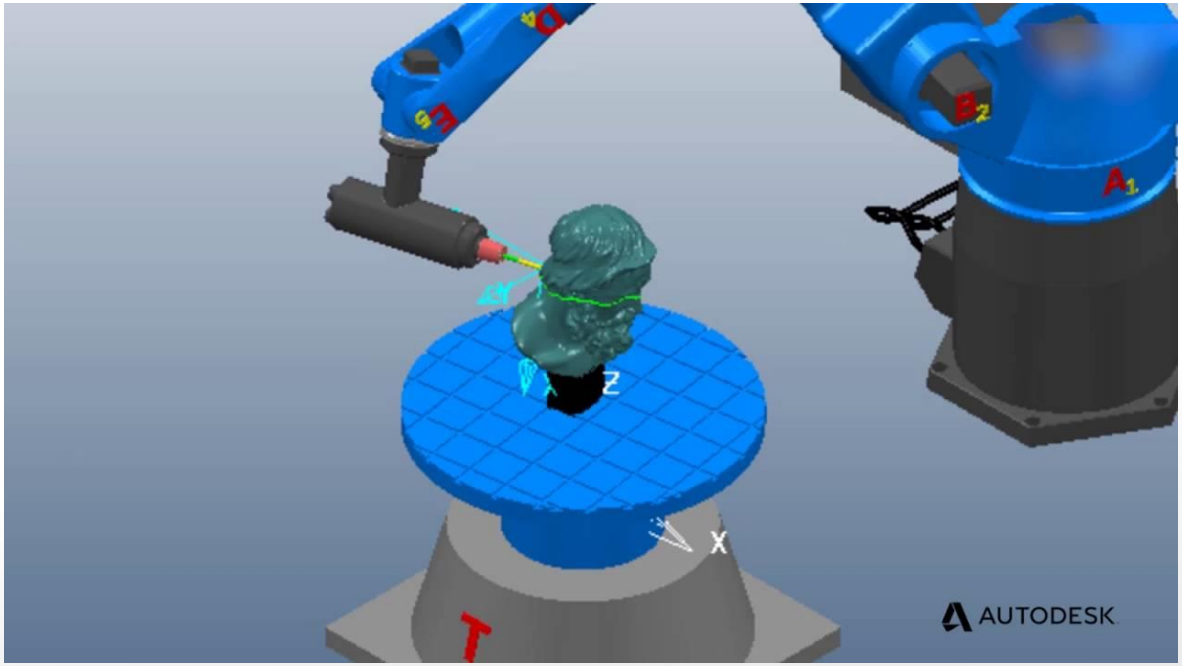
- Sometimes, you may want to increase the workspace of the robot.
- For example, when there is an oversized product.
- External axis can help to achieve this.
- Linear axis:



https://i.ytimg.com/vi/f_ZBBnIm7Tc/maxresdefault.jpg

External Axis

- Turntable:
  - Makes it easy to process all surfaces of an object



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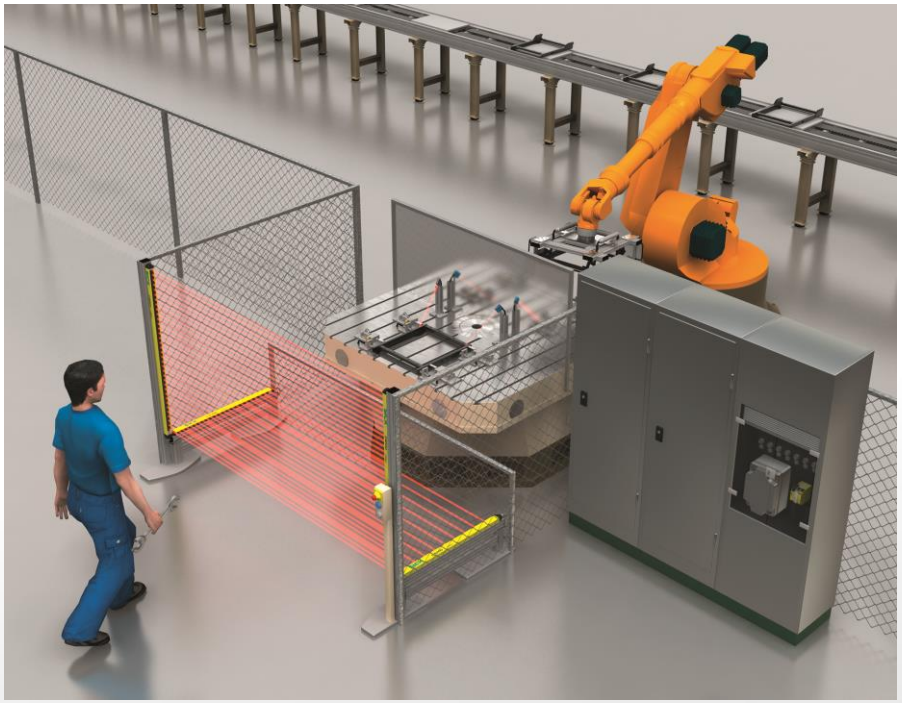
Safety

- Safety is of paramount importance when using a robot.
- Human should not stand near a robot when it is in operation.
- They should be isolated for better protection, e.g. using a cage or dedicated room:
  - A switch should be installed to trigger “off” if the cage door is opened.

http://motioncontrolsrobotics.com/wp-content/uploads/2015/04/fenced-in-robot.png

Safety

- Another method is using safety light curtain.
  - Robot is stopped if the light is interrupted.



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New Generation Collaborative Robot

- The workcell layout so far was based on conventional robotic systems.
- The robots are usually isolated from human due to safety reasons.
- One of the greatest advancements in robotics area in the past 5 years is the introduction of “collaborative robots”.
- They can be used in proximity of human because they are inherently safe.
  - Joints are not very stiff
  - Low speed
  - Made of lightweight material
  - Has torque sensors to detect collision with human
- With these robots, humans can now work alongside the robots, and the robots are called “robot co-workers”.

Examples of Collaborative Robots

- Baxter / Sawyer robot

http://www.plasticsnews.com/apps/pbcsi.dll/storyimage/PN/20130220/NEWS/130229992/AR/0/Baxter-robot-Rodon.jpg

Examples of Collaborative Robots

- Universal Robot

http://innovatetec.com/site/wp-content/uploads/2015/04/universal-robots-collaborative-robots.jpg

Examples of Collaborative Robots

- ABB YuMi

http://www04.abb.com/global/seitp/seitp202.nsf/0/db325d1c8b4be727c125801200587d32/$file/Yumi+robot.jpg

Examples of Collaborative Robots

- KUKA Lightweight Arm

https://media.robots.com/robots/1468219190_1.jpg

Thank you!

Have a good evening.

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