Promoting robotic design and entrepreneurship experiences among students and teachers

Lesson 17: Grippers and End-effectors
CONTENTS

• Robot configurations
• Grippers and end-effectors
• Robot arm work envelope
• They consist of three prismatic/linear/sliding joints

• The motion of the joints is linear

• Two of the joint axes are orthogonal to each other, i.e., the motion of two links will be perpendicular
Part assembly system

Transferring parts from a conveyer belt to a holding location
POLAR/SPHERICAL COORDINATE ROBOT

- It consists of a linear joint (L), a twisting joint (T) and a rotary joint (R)

- Linear movement allows arm to extend and retract at the linear joint

- The arm is placed on top of a twisting joint for vertical movement perpendicular to base

- Vertical movement about the pivot point because of a rotary joint
POLAR COORDINATE ROBOT EXAMPLES

Unimate robot

Video: Polar/Spherical coordinate robot
It consists of a vertical column, relative to which an arm is moved up or down making a vertical linear joint (L).

The arm can be moved in or out relative to the column with a second linear joint (L).

The arm can rotate along the vertical axis with a rotary joint (R).
Video: Cylindrical robot
• **SCARA** (Selective Compliance Assembly Robot Arm) is a type of industrial robot

• This type of robots are used for various material handling tasks such as pick and place applications

• It consists of two rotary joints (R) and a prismatic/linear joint (L)
**GRIPPERS AND END-EFFECTORS**

- **End-effector** is attached at the end of robot arm or the wrist to interact with the environment.

- It increases the number of degrees of freedom in a robot arm with its ability to manipulate the environment.

Robot arm with a suction cup type end effector.
<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
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</table>
| Vacuum cup mechanism         | • Suitable for flat, clean and smooth surfaces  
                                 • Potentially can create large gripping forces  
                                 • Can also be used for manipulating small objects                                               | • Unsuitable for porous materials  
                                 • Requires continuous air pressure supply                                                      |
| Finger gripping mechanism    | • Produces sufficient force (variable and according to need)  
                                 • High versatility and adaptability                                                              | • Actuation can potentially be complex                                                             |
### TYPES OF GRIPPERS AND MECHANISMS

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumatic powered grippers</td>
<td>• Smaller units, quicker assembly</td>
<td>• Maintaining constant air pressure to provide constant force is difficult</td>
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<tr>
<td></td>
<td>• High cycle rate</td>
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<td></td>
<td>• Easy maintenance</td>
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<tr>
<td>Hydraulic powered grippers</td>
<td>• High strength and speed</td>
<td>• Large robots that take up space and are noisy</td>
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<td></td>
<td>• Mechanical simplicity</td>
<td>• Possibility of oil leakage</td>
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<td>• Heavy payloads can be withstood</td>
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<tr>
<td>Motor Actuation</td>
<td>• High accuracy, repetitive power</td>
<td>• Requires Electronic control system, may be complex</td>
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<tr>
<td></td>
<td>• Less floor space, low cost, easy maintenance</td>
<td>• Small load compared with hydraulic powered grippers</td>
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Innovative Technology Experiences for Students and Teachers (ITEST), Professional Development Program, NYU Tandon School of Engineering, July 2017-19
**Mechanism**

Magnetic mechanism (electromagnetic magnets)

**Advantages**
- Suitable for magnetic materials
- Single surface gripping is possible
- Invariant with respect to type of object - universal, and quick

**Disadvantages**
- Highly specific
- Chance of slipping during movement, or if lubrication is present

Roller mechanism

**Advantages**
- Allows for realignment of object during gripping

**Disadvantages**
- Slow action
- May not be suitable for irregular objects
**Mechanism**

- **Parallel / Linear / Translational mechanism**
  - Advantages: Accurate form of gripping
  - Disadvantages: Possible loss of stability during tangential force application

- **Angular / Contour mechanism**
  - Advantages: Very useful for irregular objects
  - Disadvantages: Difficult to implement, expensive and complex
ACTIVITY

• Can you list an industrial gripper except the VEX Clawbot? Which category should you put it into? Can you list an disadvantage and advantage of it?

• Observe the VEX Clawbot and tell the disadvantages and advantages of its manipulator
• The end-effector is attached to wrist assembly

• The function of wrist assembly is to orient end-effector to manipulate its environment

• It can have two or three degrees of freedom:
  o Roll - This is also called wrist swivel; this involves rotation of the wrist mechanism about the arm axis
  o Pitch - It involves up & down rotation of the wrist, also called as wrist bend
  o Yaw - It involves right or left rotation of the wrist
• **Work envelope** is a three-dimensional shape that defines the boundaries that the robot manipulator can reach

• It is determined by the maximum distance the arm with manipulator can reach when extended forward, backward, left and right, i.e., in all possible directions

• For example, a spherical coordinate robot has spherical envelope, a cartesian coordinate robot has a cuboid envelope and so on.
WORK ENVELOPE

Cartesian robot  Cylindrical robot  Spherical robot

Source
Can you draw the work envelope for these mechanisms on a paper?

(a) 

(b)
Thank You!

Questions and Feedback?