Classification of Robots

RA 501 - Fundamental of Robotics

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Centre for Intelligent Cyber Physical Systems

Presenter - **Atul Bhagat** (224156004)
10th August 2022

Classification of Robots - 1

Fundamental Classification

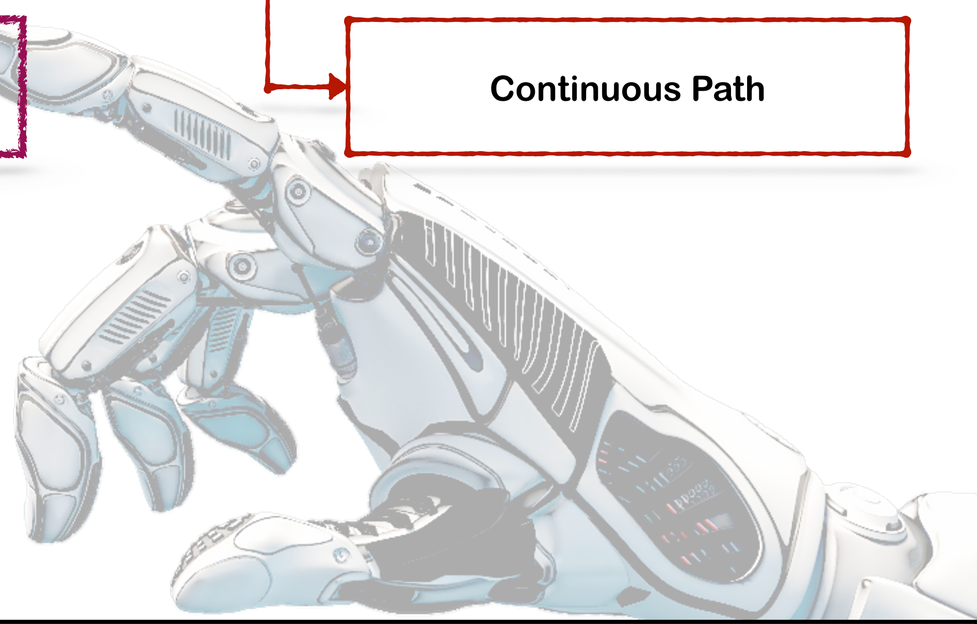
- Cartesian
- Cylinderical
- Spherical
- Revolute or Articulated

Based on **Type of Controller**

- Non-Servo-Controlled
- Servo Controlled

Based on **Type of Task Performed**

- Point-to-Point
- Continuous Path



References

1. *Fundamentals of Robotics*, D.K. Pratihar, *ISBN* 978-81-8487-577-5
2. *Introduction to Robotics Analysis*, Control, Applications, Saeed B. Niku, *ISBN* 978-81-265-3312-1
3. *Introduction to Robotics*, S K Saha, *ISBN-13*: 978-93-329-0280-0

Classification of Robots - 2

Based on **Mobility Level**

- With Fixed Base (Manipuators)
- Mobile Robots

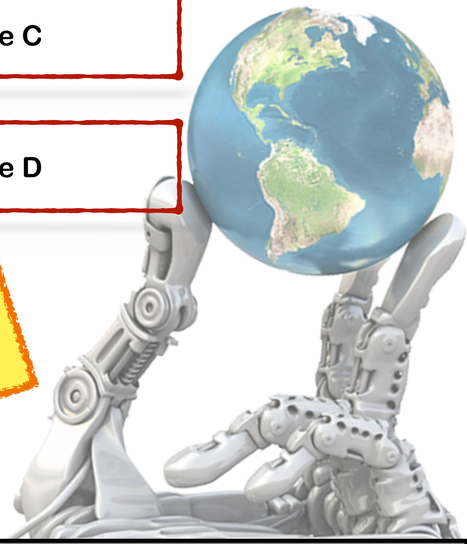
Japanese Industrial Robot Association (JIRA)

- Class - 1
- Class - 2
- Class - 3
- Class - 4
- Class - 5
- Class - 6

Association Francaise de Robotique (AFR)

- Type A
- Type B
- Type C
- Type D

Robotics Institute of America (RIA)



References

1. *Fundamentals of Robotics*, D.K. Pratihar, *ISBN* 978-81-8487-577-5
2. *Introduction to Robotics Analysis*, Control, Applications, Saeed B. Niku, *ISBN* 978-81-265-3312-1
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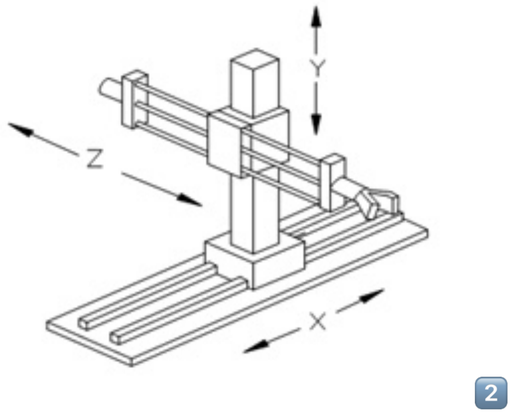
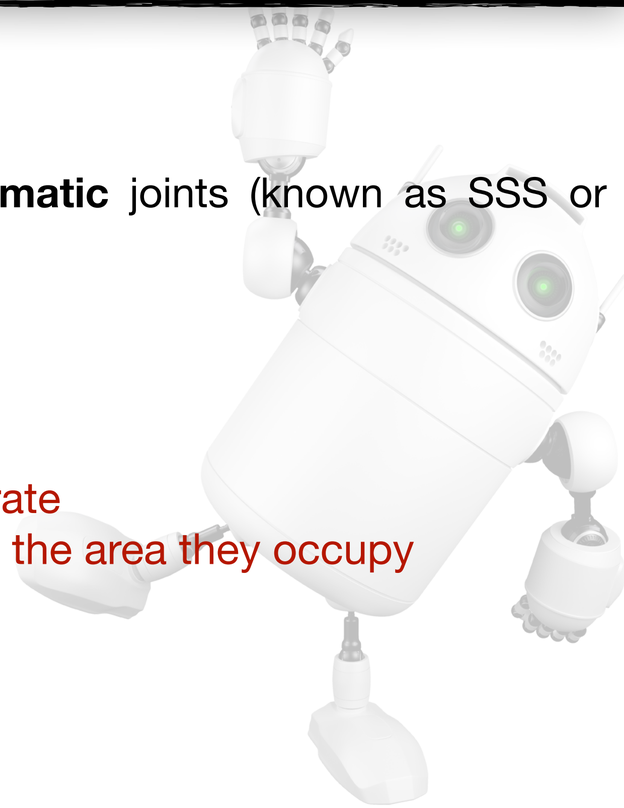
Cartesian Coordinate Robots



1) IBM's **RS-1** Robot, 2) Generic Coordinate System Robot, 3) Plotter and 4) Gantry Robot

Features

1. Linear movements
   - Uses either **Siding or Prismatic** joints (known as SSS or PPP, respectively)
2. Generally, rigid and accurate
3. Easy to visualise
4. Good for precise operations
5. Relatively easy to control
6. Require large Volume to operate
7. Smaller operating range than the area they occupy
8. Requires High Maintenance



Suitable for

1. Pick and Place
2. Laser Cutting

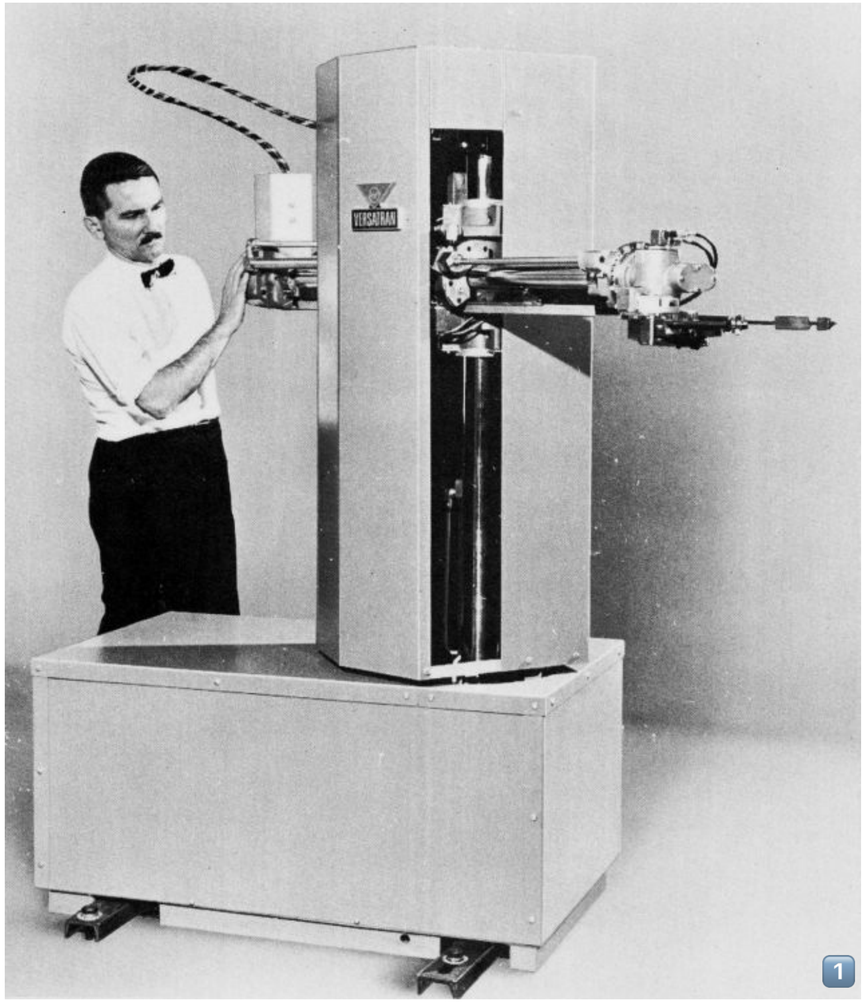
Note: P - Prismatic (1-DOF)
S - Sliding (1-DOF)

References

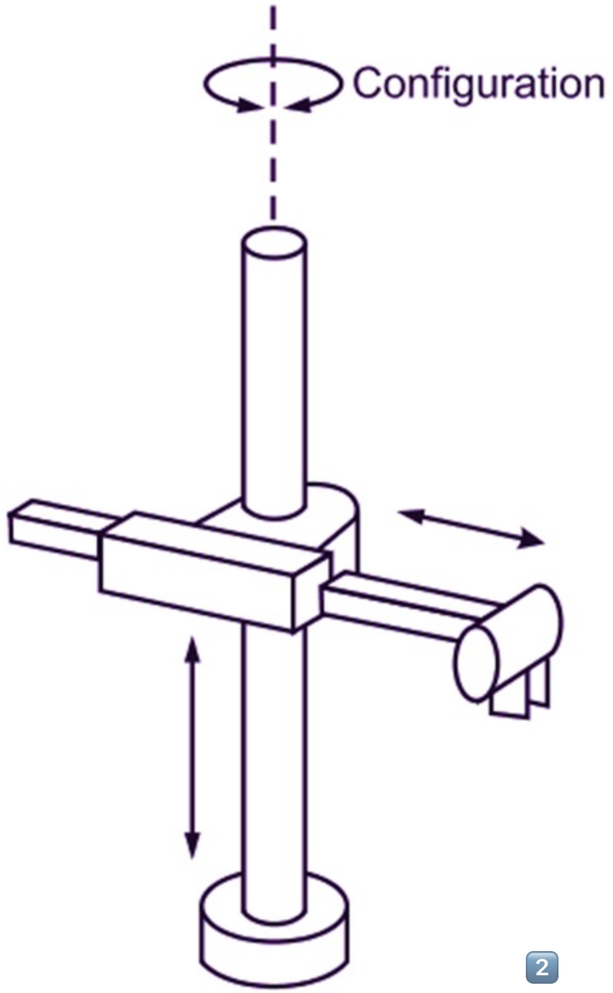
1. https://www.ibm.com/ibm/history/exhibits/robotics/robotics_5.html
2. www.tecnowey.com
3. https://commons.wikimedia.org/wiki/File:Hp_9862a.jpg
4. https://electricalworkbook.com/cartesian-robot/

Cylindrical Coordinate Robots

Video Link



1. **VERSATRAN** Robot, developed by American Machine and Foundry (AMF) in 1962



2. Cylinderical Robot Schematic

Features

1. Two linear and one rotary movements (TPP or TSS)
2. Could be installed in small/ compact spaces
3. *Unable to pick objects from ground*

Suitable for

1. Spot Welding Automation or Welding pipes
2. Basic Pick and Drop in manufacturing systems
3. Coating applications
4. Task requires reaching into small openings

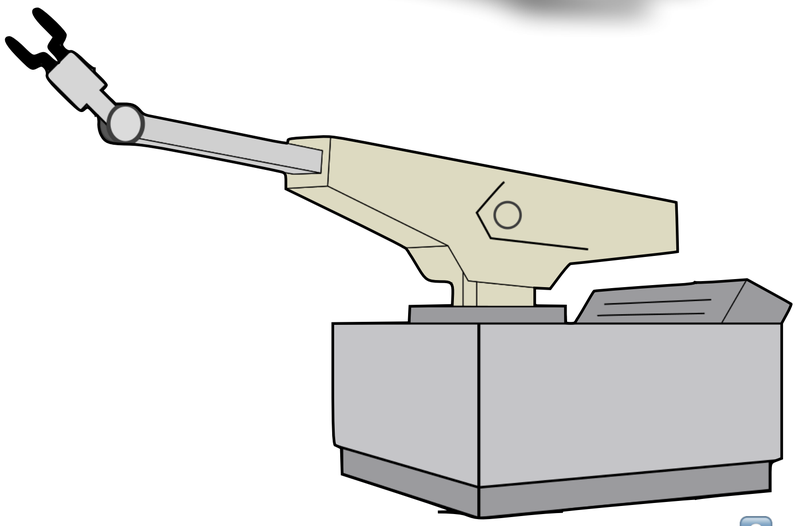
Note: P - Prismatic (1-DOF)
S - Sliding (1-DOF)
T - Twisting (1-DOF)

References -

1. http://cyberneticzoo.com/early-industrial-robots/1958-62-versatran-industrial-robot-harry-johnson-veljko-milenkovic/
2. https://electricalworkbook.com/cylindrical-robot/

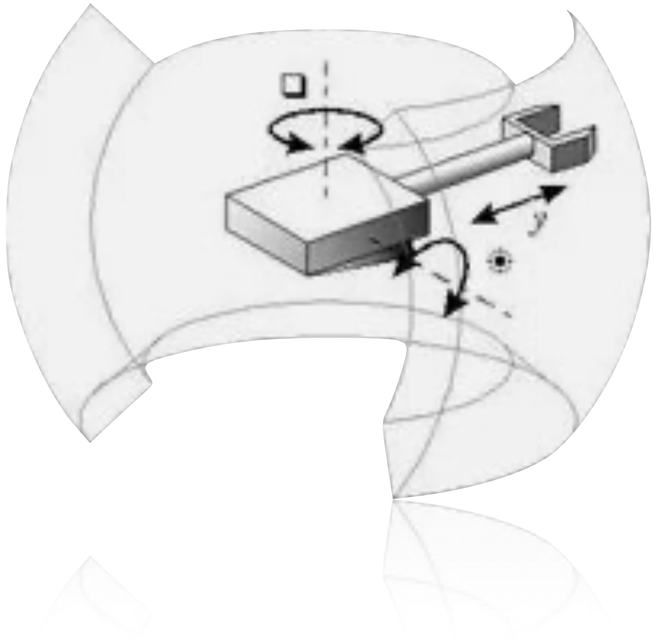
Spherical Coordinate Robots

1



2

1,2 - **Unimate 2000B**



Video Link

Features

1. One linear and Two rotary movements (TRP or TRS)
2. Large work volume
3. Used for relatively complex areas like contour painting
4. Short Vertical Reach
5. Unable to handle heavy loads as compared to the other robots

Suitable for

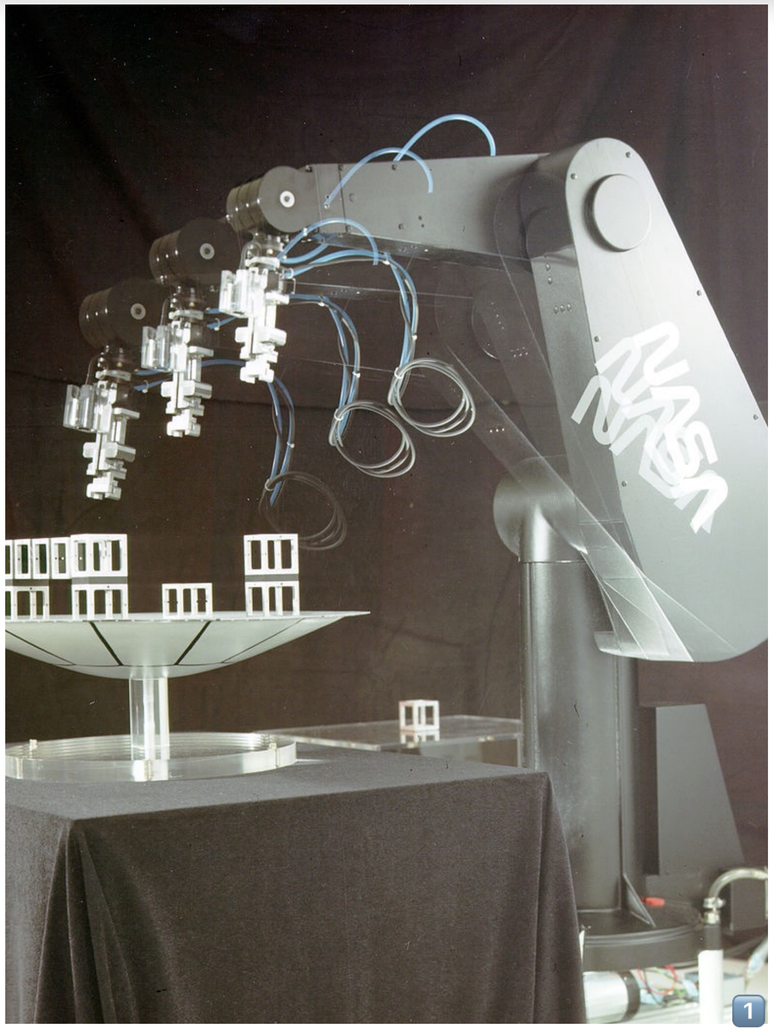
1. Performing welding on auto-bodies
2. Handling Parts/ objects in a manufacturing system

Note: P - Prismatic (1-DOF)
S - Sliding (1-DOF)
T - Twisting (1-DOF)
R - Revolute (1-DOF)

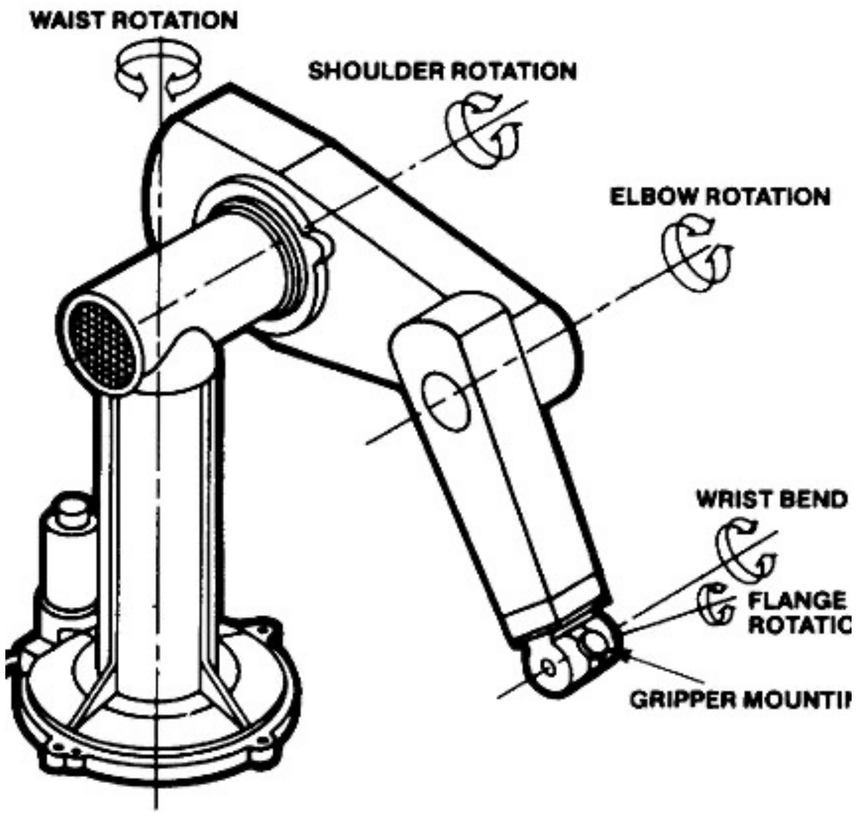
References

1. https://www.brighthubengineering.com/robotics/29493-spherical-base-robot-construction-and-workspace/
2. https://www.automate.org/a3-content/joseph-engelberger-unimate
3. https://collection.sciencemuseumgroup.org.uk/objects/co50678/unimation-2000b-industrial-robot-c-1979-industrial-robot

Articulated Coordinate Robot



1) Programmable Universal Machine for assembly (**PUMA**) Robot,



2) PUMA schematic

Features

1. **Largest Work Volume** for least floor space
2. Also know as ***TRRs***
3. Can reach above or below obstacles
4. Allows wraparound around an object
5. Workable area (workspace) is larger than they consume space
6. Two or more ways to reach a point
7. Most Complex out of all

Suitable for

1. First robotic stereotactic brain biopsy in 1985
2. Assembly line, paint, and welding work

Note: T - Tw/isting (1-DOF)
R - Rotary (1-DOF)

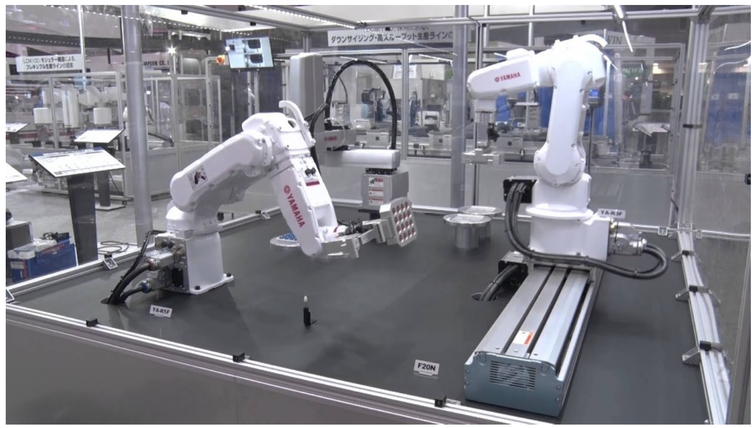
References -

1. https://www.nasa.gov/multimedia/imagegallery/image_feature_433.html
2. Kwoh YS, Hou J, Jonckheere EA, Hayati S. A robot with improved absolute positioning accuracy for CT guided stereotactic brain surgery. *IEEE Trans Biomed Eng.* 1988;35:153–160. doi: 10.1109/10.1354.

Vertical & Horizontal Articulated Coordinate Robot

Vertically Articulated Robots

- Also know as Simply Articulated Robots
- Arm Structure resembles human arm, therefore suitable for human substitutes



Horizontally Articulated Robots

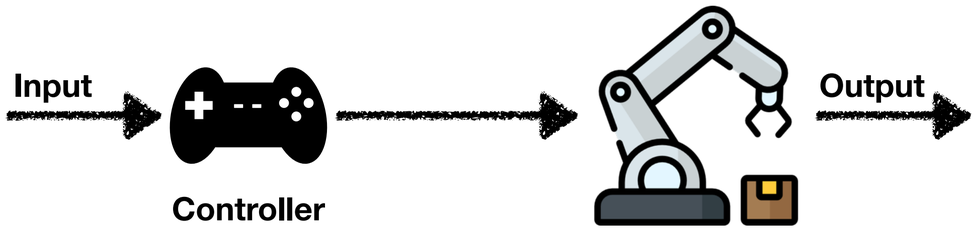
- Also know as Scalar Robots
- Used for assembly operations such as insertion of parts or tightening of screws
- High Rigidity in vertical direction

References -

1. https://www.mitsubishielectric.com/en/index.html
2. https://s3-ap-southeast-1.amazonaws.com/manufacturer-bucket/company-products/product-company-2390-product-company-2365-product-company-2310-DENSO_SCARA1.jpg
3. https://i.ytimg.com/vi/wNY01XEi_nI/maxresdefault.jpg

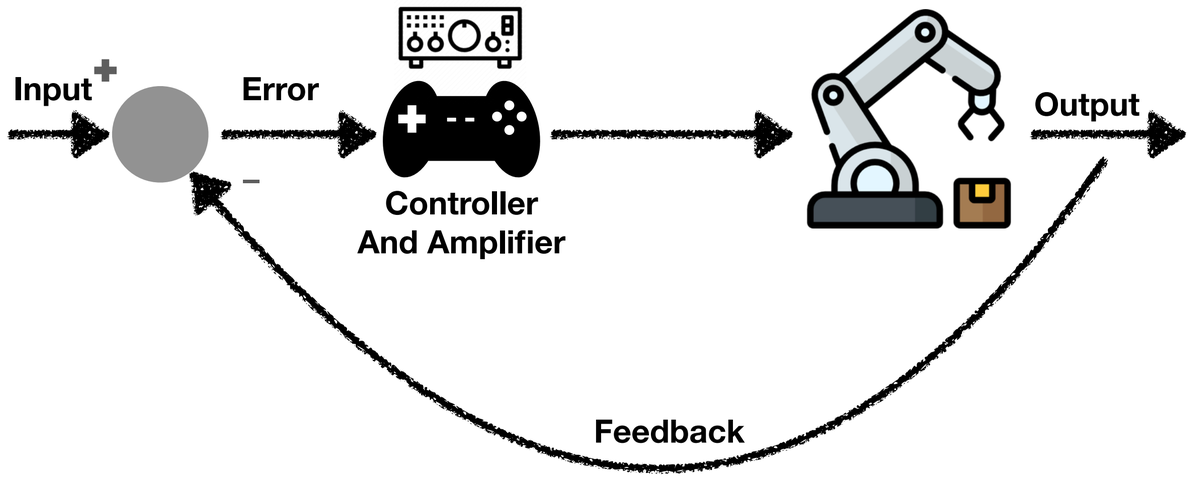
Based on Type of Controllers

Non-Servo Controlled



- Output **isn't** measured **(Open Loop)**
- **No** Feedback loop, thus no error compensation
- Less Expensive and Less Accurate
- *Examples* - Seiko PN-100

Servo Controlled



- Output **is** measured **(Closed Loop)**
- Feedback loop **present** which feeds error back to the controller, tries to minimise error
- More Expensive and More Accurate
- *Examples* - PUMA, CRS etc.

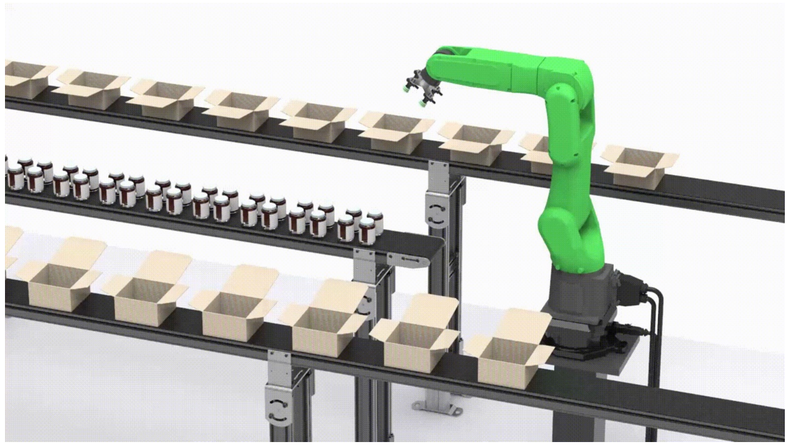
References -

1. https://cdn4.iconfinder.com/data/icons/multimedia-outline-2/64/Amplifier-player-receiver-512.png
2. https://cdn-icons-png.flaticon.com/512/1377/1377884.png
3. *Fundamentals of Robotics*, D.K. Pratihar, *ISBN* 978-81-8487-577-5

Based on Task Performed

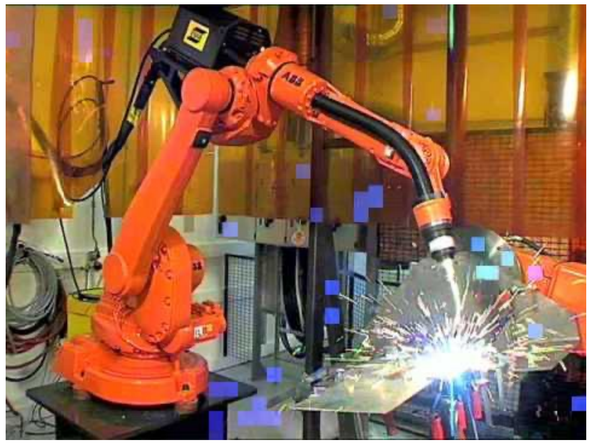
Point-to-Point Robots

- Tool **isn't in contact** with the job, continuously
- Examples - Pick and Place Robots, Drilling etc.
- *Robots - UNIMATE - 2000, T^3*



Continuous Path Robots

- Tool **is in contact** with the job, continuously
- Examples - Spray Paint Jobs, Welding, Polishing etc.
- *Robots - PUMA, CRS*



References -

1. https://i.ytimg.com/vi/HUU3HdxOqZs/hqdefault.jpg
2. https://www.howtorobot.com/sites/default/files/2021-11/painting-robot.jpg
3. https://www.sorgule.com/pick-and-place-robotics-resources
4. https://forums.macrumors.com/attachments/826678/
5. *Fundamentals of Robotics*, D.K. Pratihar, *ISBN* 978-81-8487-577-5

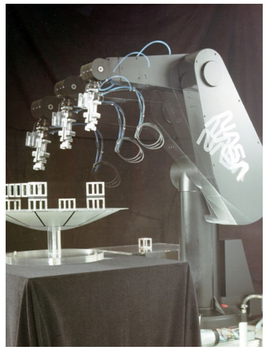
Based on Mobility

Fixed Base Robots (Manipulators)

Serial Manipulator

Links Connected in **Series**

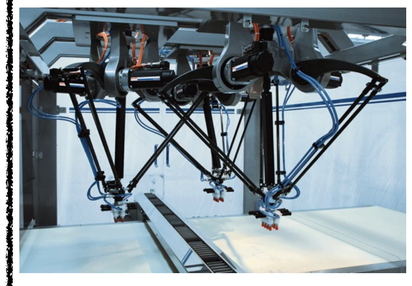
Examples - PUMA, CRS etc.

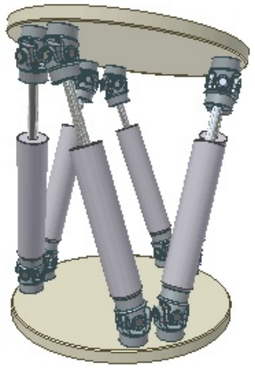


Parallel Manipulator

Links Connected in **Parallel**

Examples - Stewart Platform (a.k.a 6-DOF Parallel mainpulator)





Mobile Robots

Wheeled Robot

Tracked Vehicles

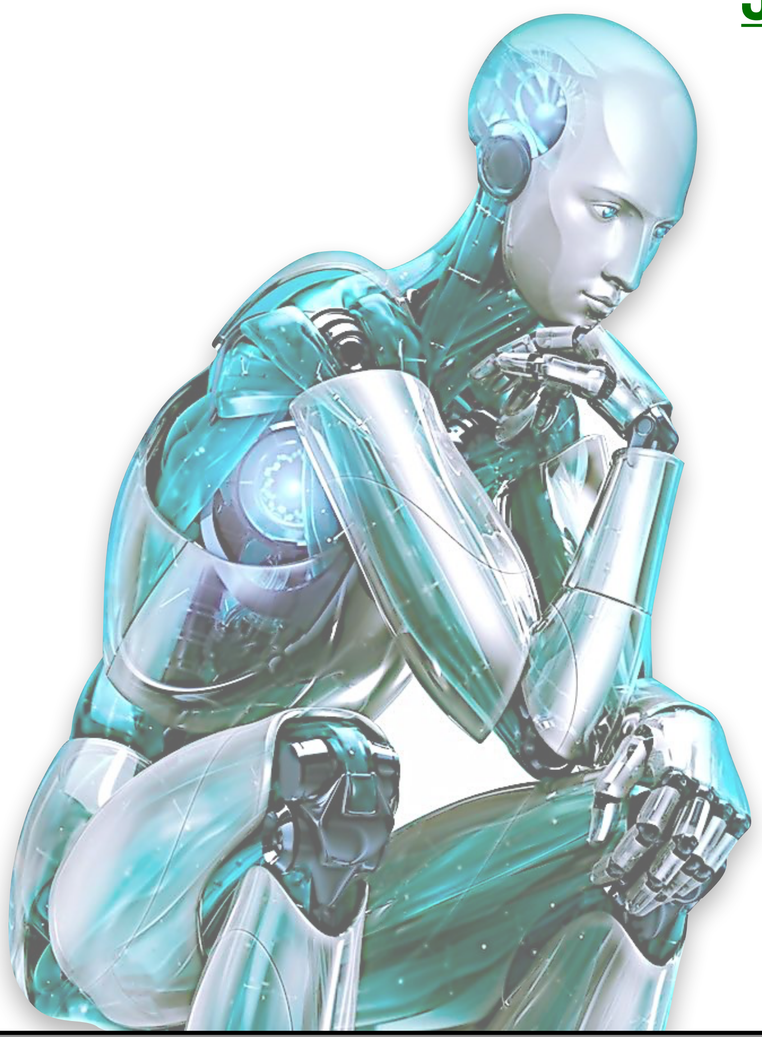
Multi-Legged Robots

Smooth Terrain → **Extremely Rough Terrain**

References

1. https://upload.wikimedia.org/wikipedia/commons/thumb/0/0c/ActivMedia_Pioneer_3-AT_robot.jpg/220px-ActivMedia_Pioneer_3-AT_robot.jpg
2. https://en.wikipedia.org/wiki/Stewart_platform
3. https://cdn.shopify.com/s/files/1/0168/2197/7152/products/product-image-712195319.jpg?v=1578151425
4. https://www.bostondynamics.com/legacy
5. https://img.packworld.com/files/base/pmmi/all/image/2011/09/pw_1955_camacntrlscomponents.png?auto=format%2Ccompress&q=70

Classification - According to JIRA



JIRA - Japanese Industrial Robot Association

Class - I : Manual handling Device - *has multiple DOFs, but an operator directly controls it.*

Class - II : Fixed Sequence Robot - *performs a single, pre-programmed task or set of tasks, making exactly the same movements each time*

Class - III : Variable Sequence Robot - *very similar to class-2, but can be reprogrammed easily to adapt to new tasks*

Class - IV : Playback Robot - *first operator teaches the robot and then robot performs independently*

Class - V : Numerical Control Robot - *can follow sequence of commands, which operator inputs*

Class - VI : Intelligent Robot - *it **senses, thinks** & **acts***

The **R**obotics **I**nstitute of **A**merica ***(RIA)*** only considers **class 3-6** of the above as robots!!

References -
1. https://www.nicepng.com/png/detail/17-175680_robot-high-quality-png-future-robot-png.png

More Robotics Associations

IEEE Robotics & Automation Society

WRO® WORLD ROBOT OLYMPIAD™

aira All India Robotics Association

IFR International Federation of Robotics

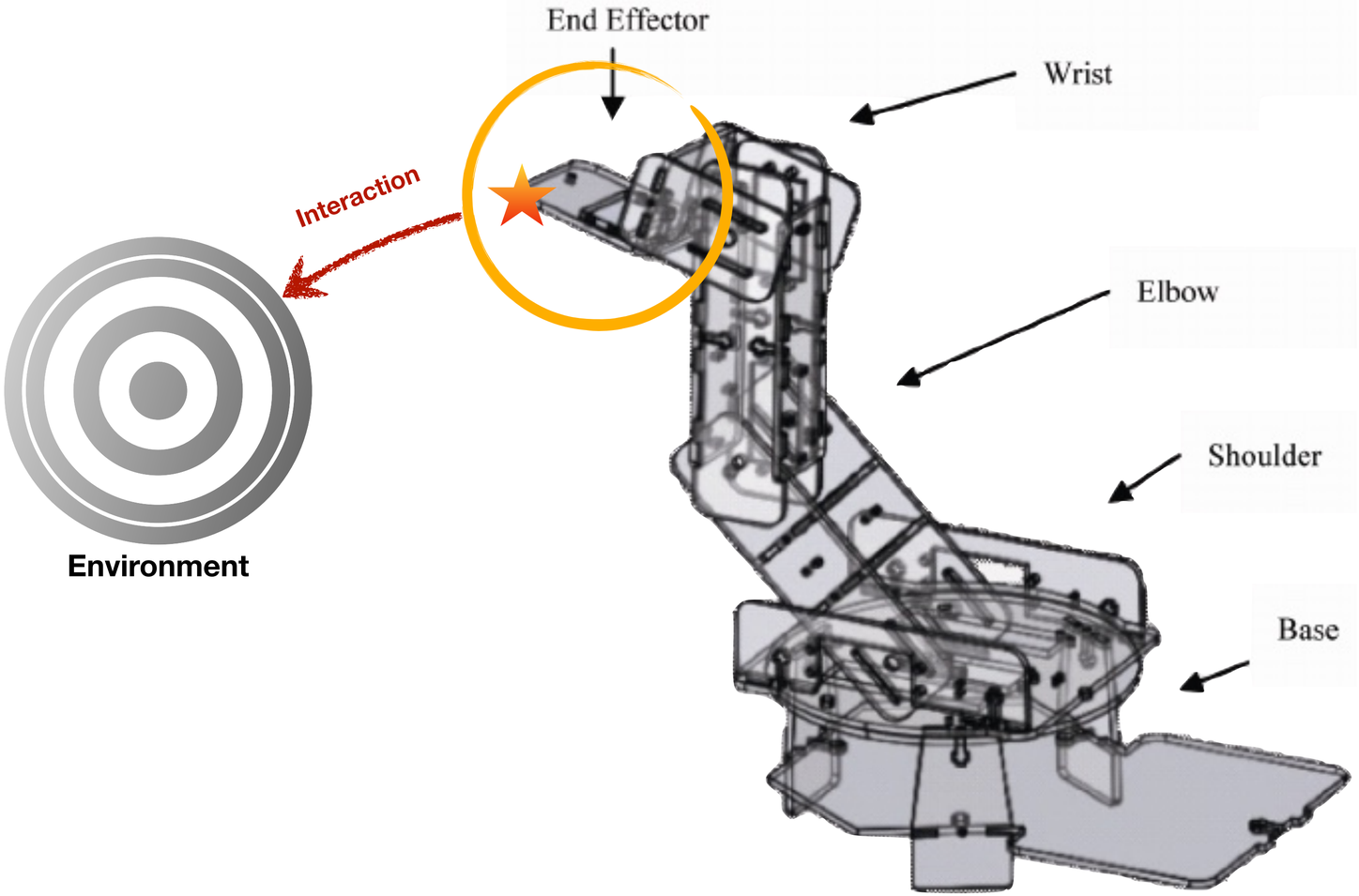
ria ROBOTIC INDUSTRIES ASSOCIATION

CRIA China Robot Industry Alliance — China Robot Industry Alliance

EUnited Robotics · European Engineering Industries Association

Types of End Effectors

End effector is *attached to the wrist* of the manipulator which could be used for either Grasping (known as **Gripper**) and holding parts or a **tool** that performs a specific task

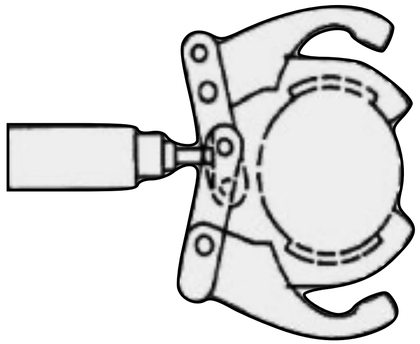


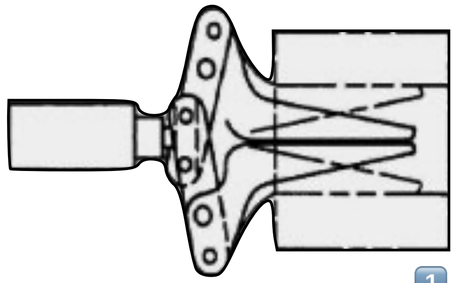
References

1. *Fundamentals of Robotics*, D.K. Pratihar, *ISBN* 978-81-8487-577-5
2. https://www.researchgate.net/figure/Robot-arm-complete-assembly_fig2_268437501
3. http://www.tthk.ee/inlearcs/wp-content/uploads/2020/11/Picture-72.png

Classification of Grippers

- Internal and External [1]
- Single and Double [2]
- Hard and Soft [3]
- Active and Passive





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3

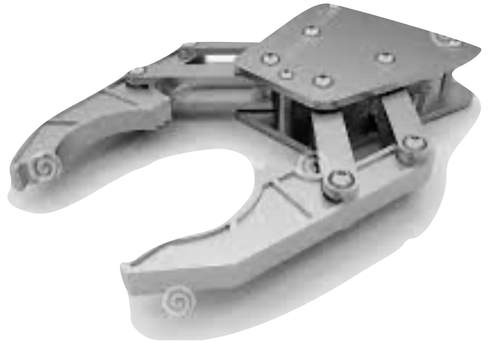
2

References

1. *Fundamentals of Robotics*, D.K. Pratihar, *ISBN* 978-81-8487-577-5
2. https://img.brainkart.com/imagebk6/LOAtNpM.jpg
3. https://www.allied-automation.com/partners/onrobot/dual-gripper/

A Few Robotic Grippers

- Mechanical Grippers [1]
- Vacuum Gripper [2]
- Magnetic Gripper [3]
- Adhesive Gripper [4]



[1]

[3]

[2]

[4]

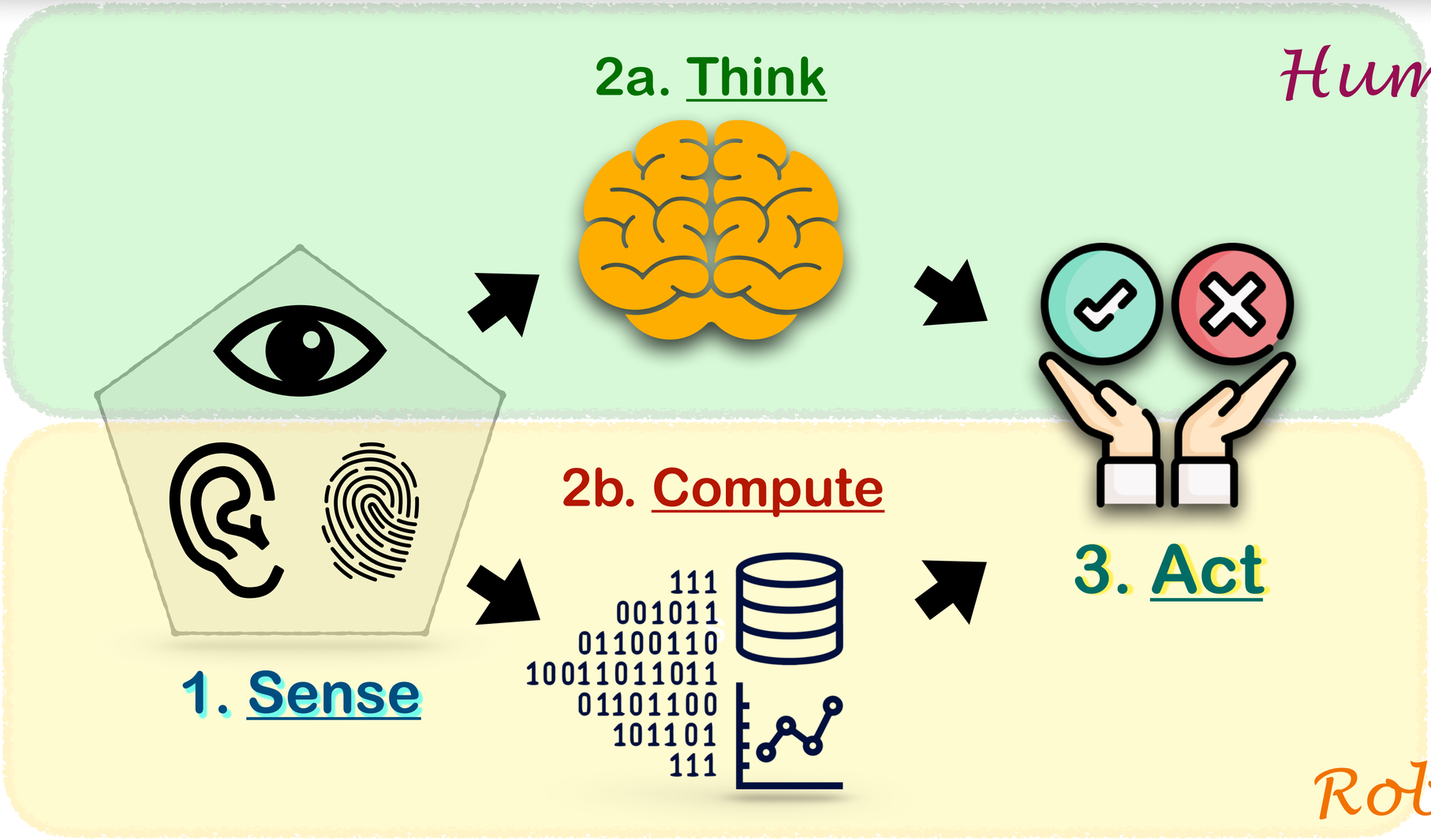
Mechanical grippers utilises mechanical fingers that are actuated by some mechanisms. Few examples are

- **Gripper with linkage actuation**
- **Gripper using Swing-Block Mechanism**
- **Gripper with Rotary Actuation**
- **Gripper with CAM Actuation**

References

1. *Fundamentals of Robotics*, D.K. Pratihar, *ISBN* 978-81-8487-577-5
2. https://grabcad.com/library/vacuum-gripper-robot
3. https://www.directindustry.com/prod/pascal-corporation/product-31630-2351590.html
4. https://onrobot.com/en/products/gecko-single-pad-gripper

Basic Idea


Humans
2a. Think
1. Sense
2b. Compute
111
001011
01100110
10011011011
01101100
101101
111
3. Act
Robots

Thank You