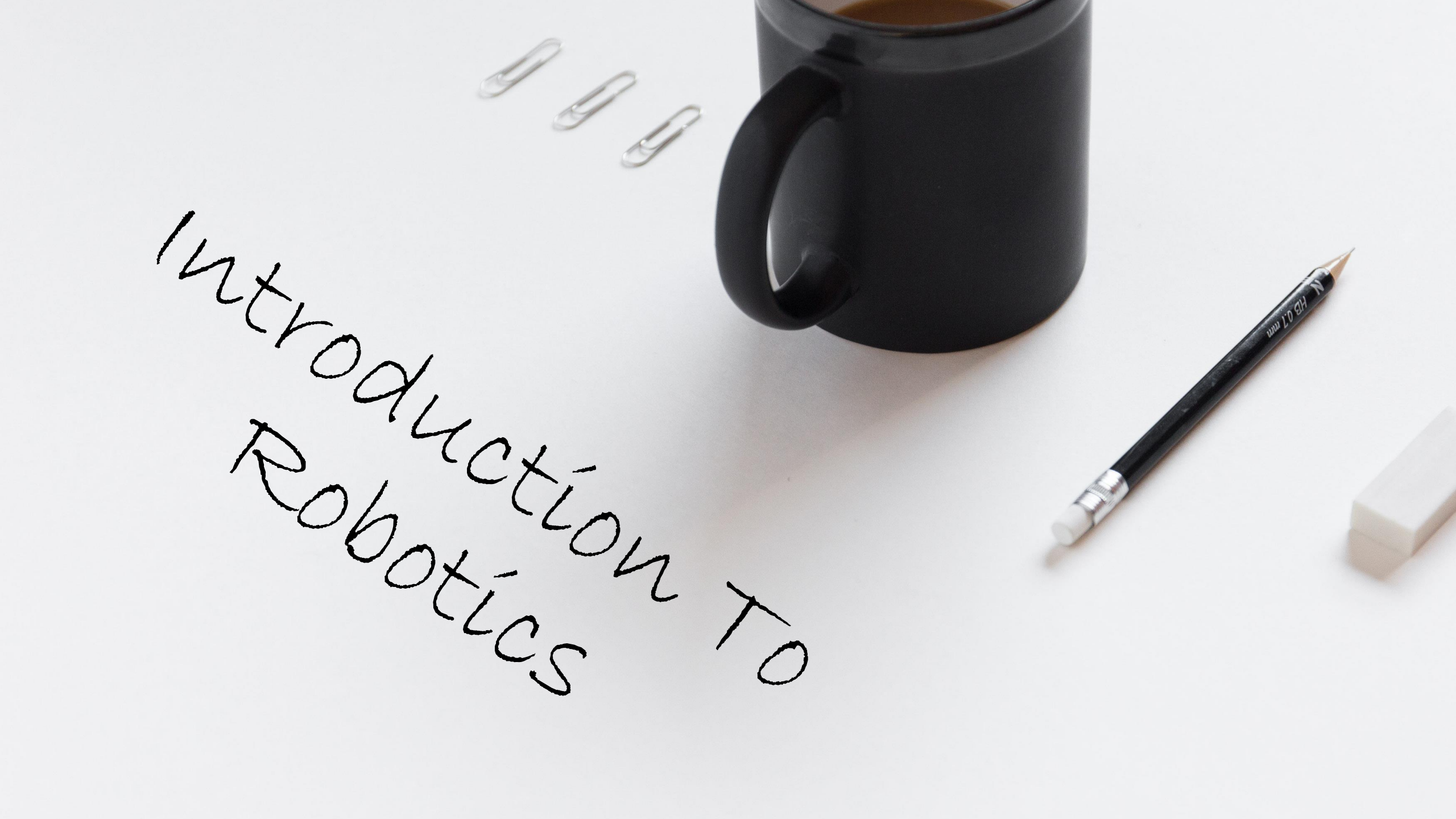
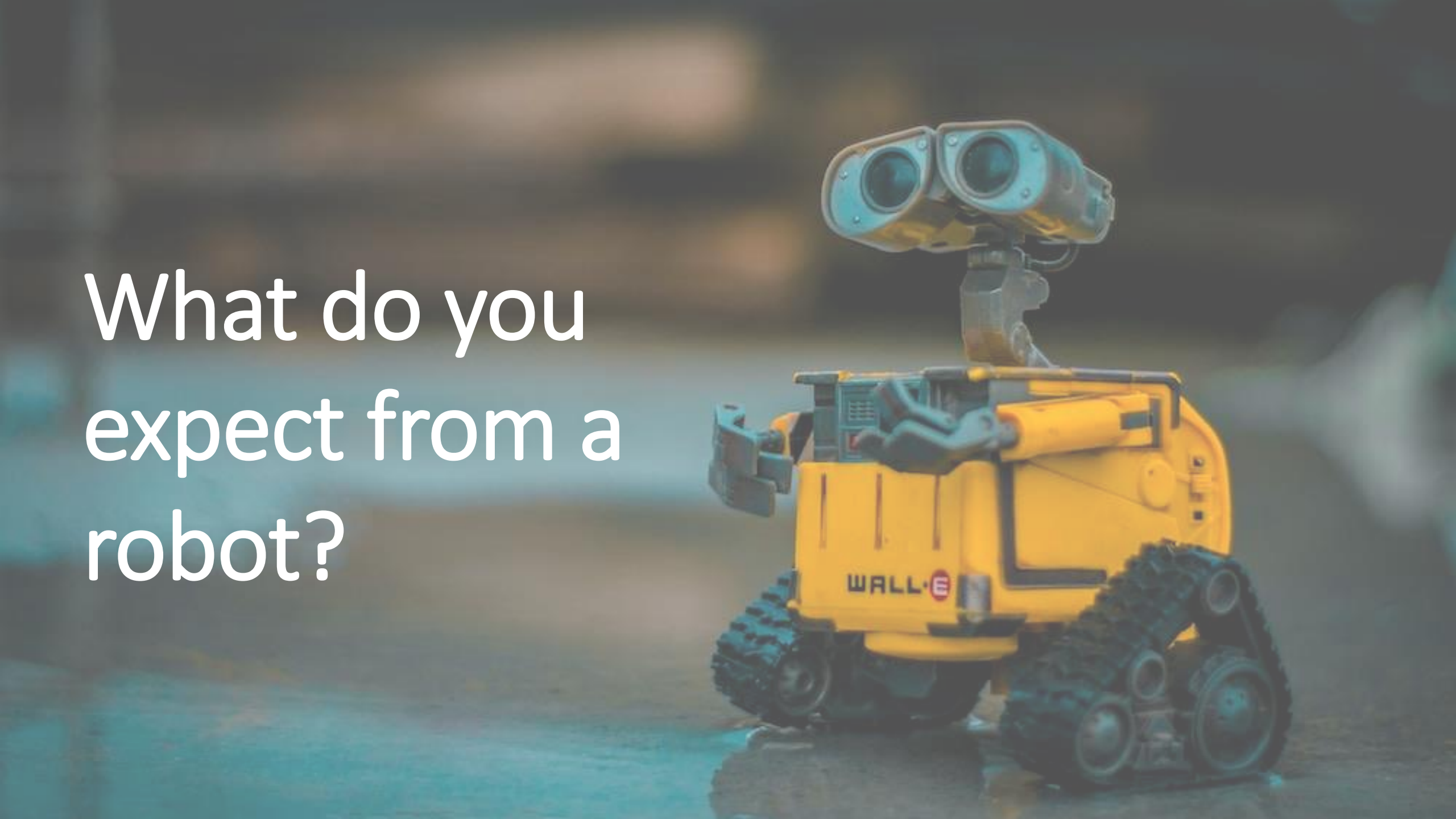
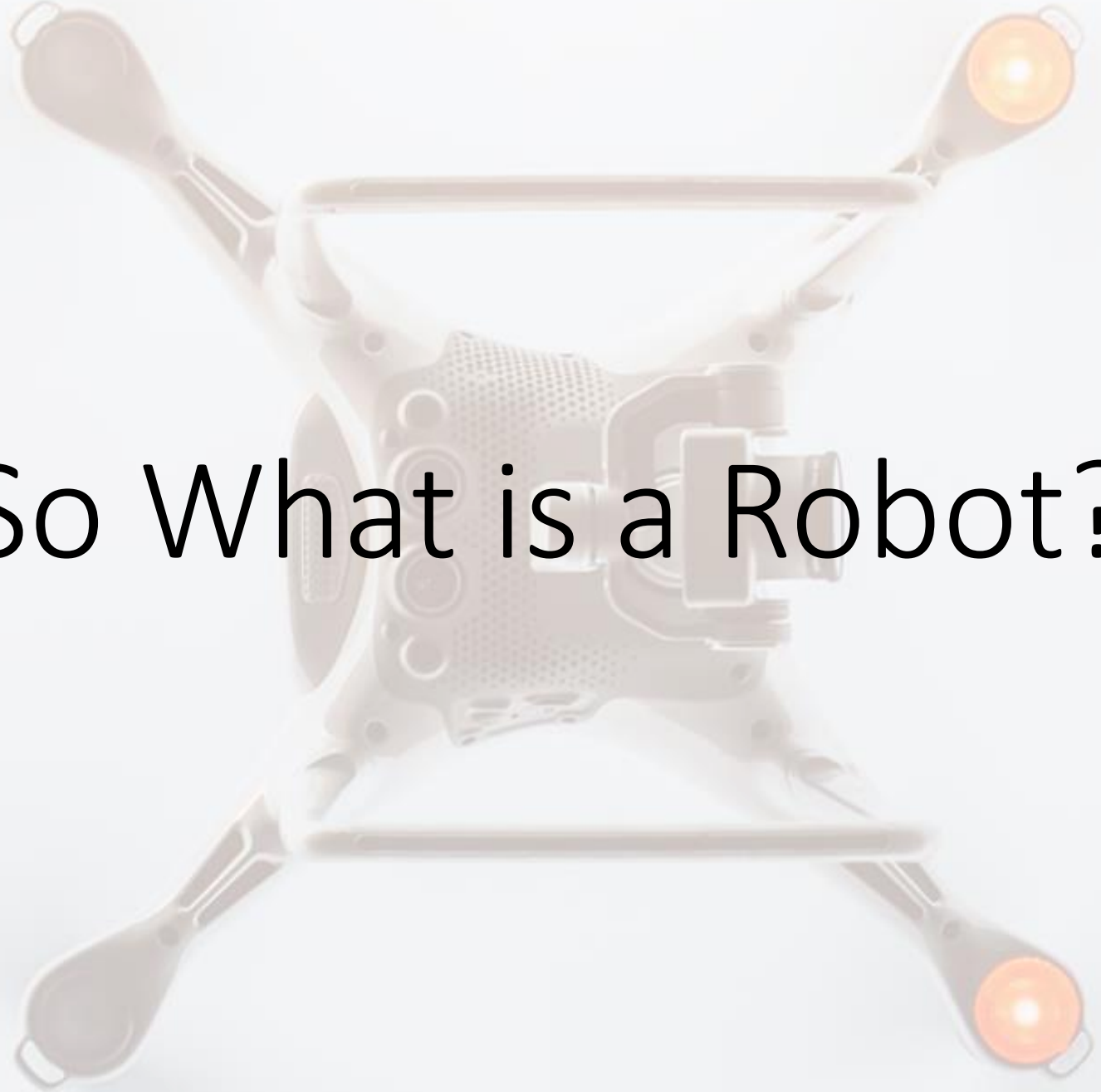

Introduction To
Robotics

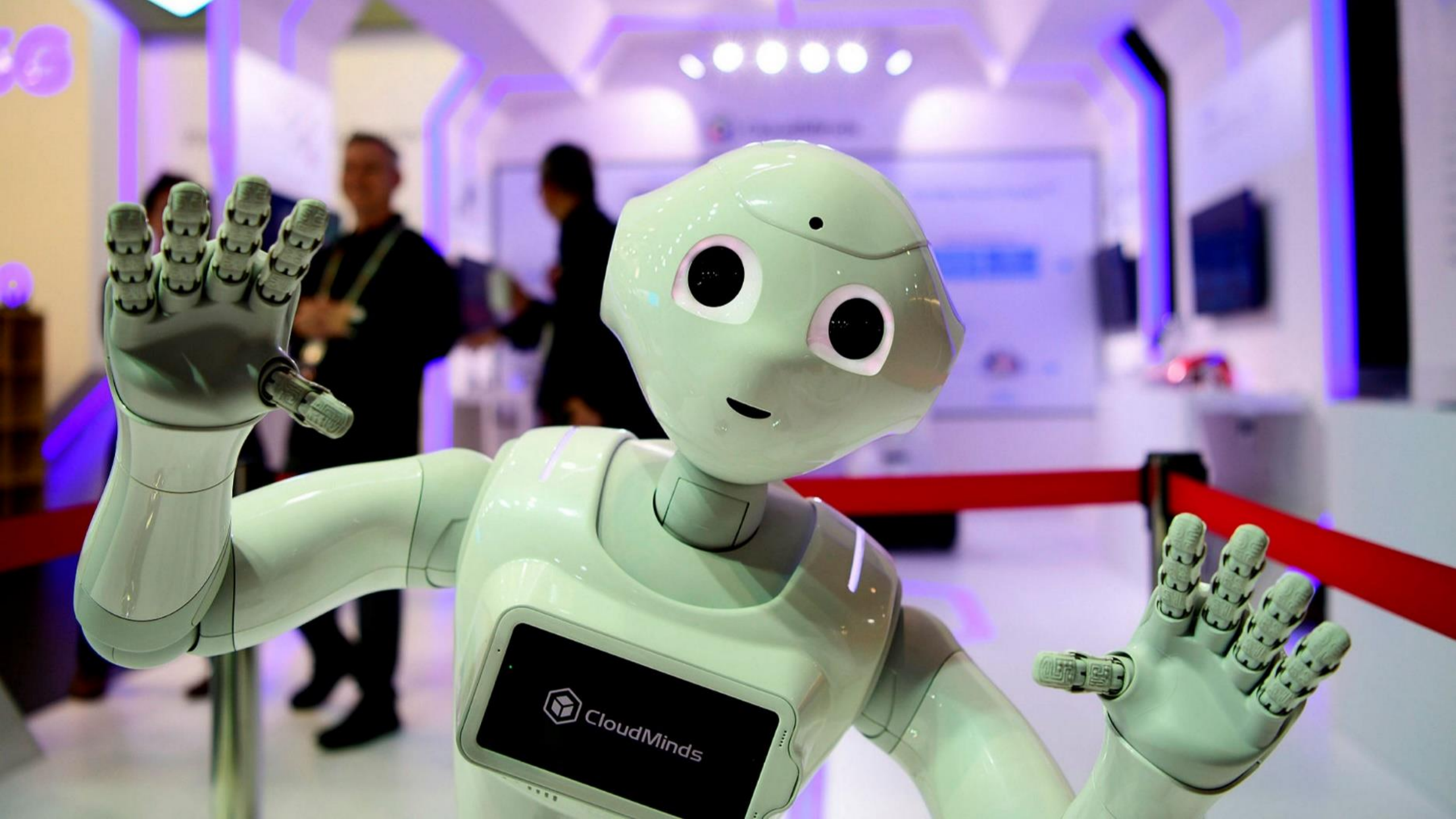

Overview

What do you expect from a robot?





So What is a Robot?


CloudMinds


CARACOL
CARACOL
KUKA

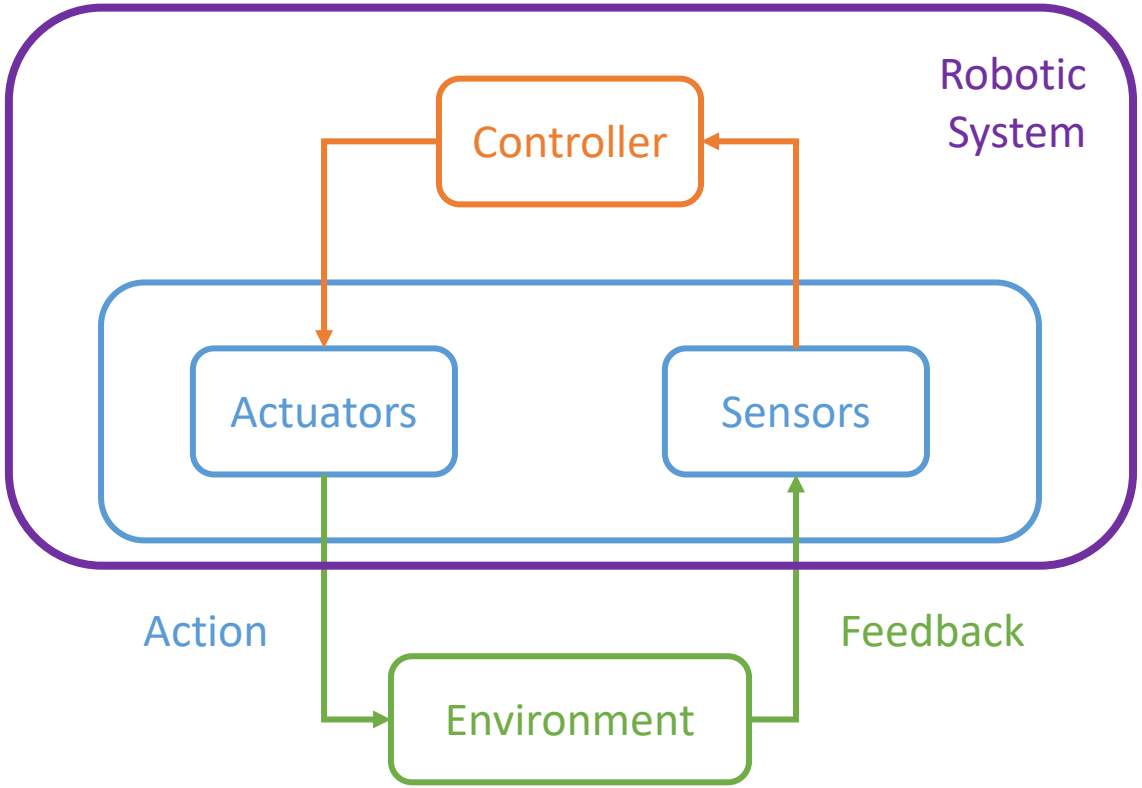

J.A.R.V.I.S

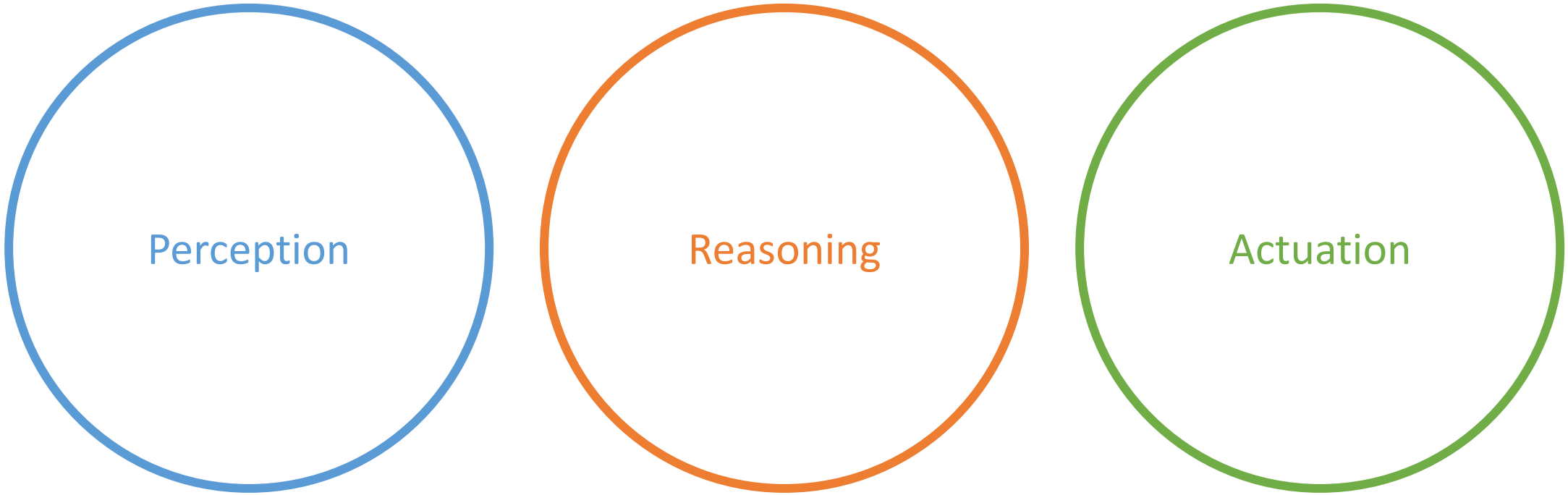

amazon

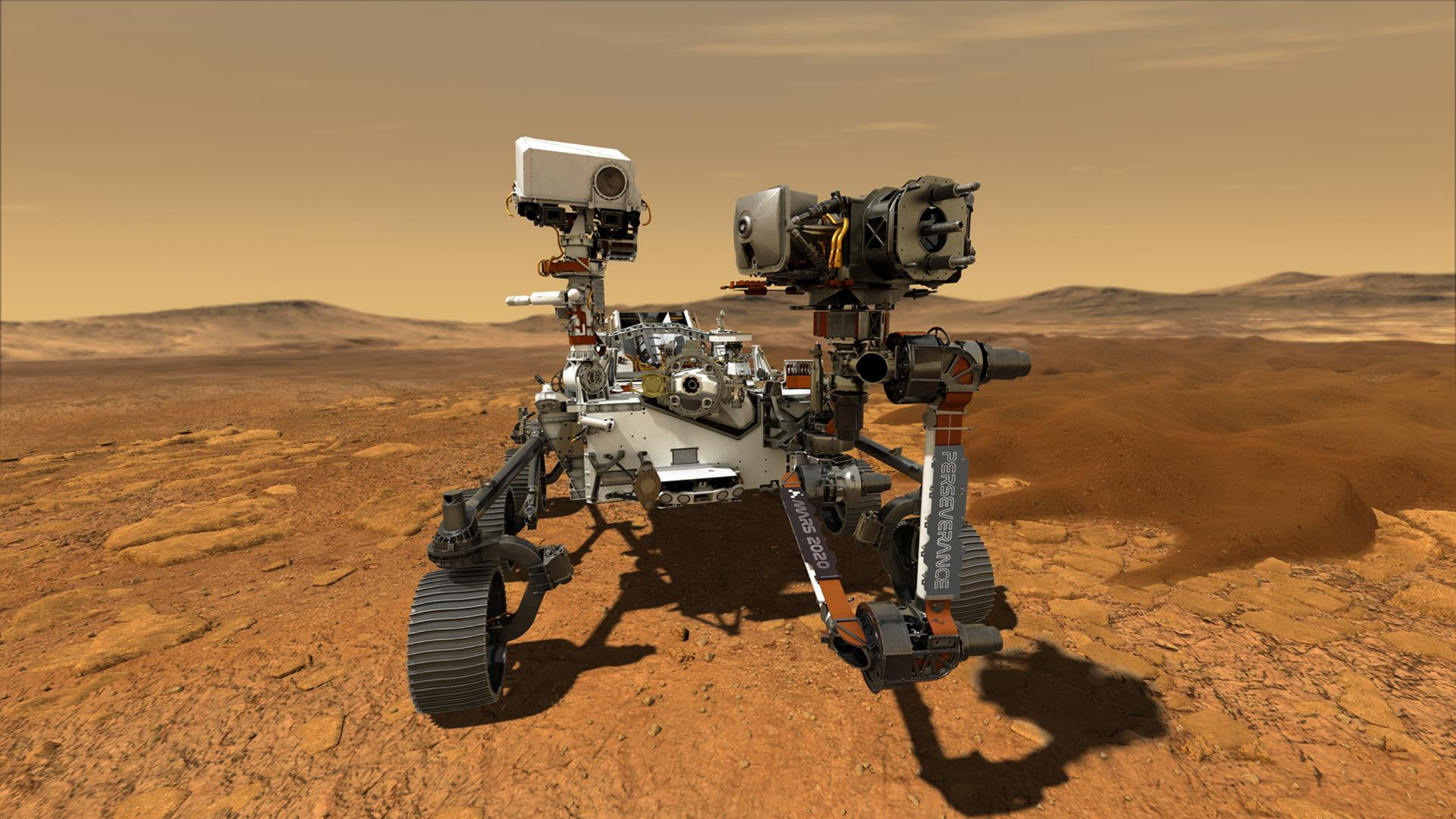

05
06
07

Robotics: The Essential Components

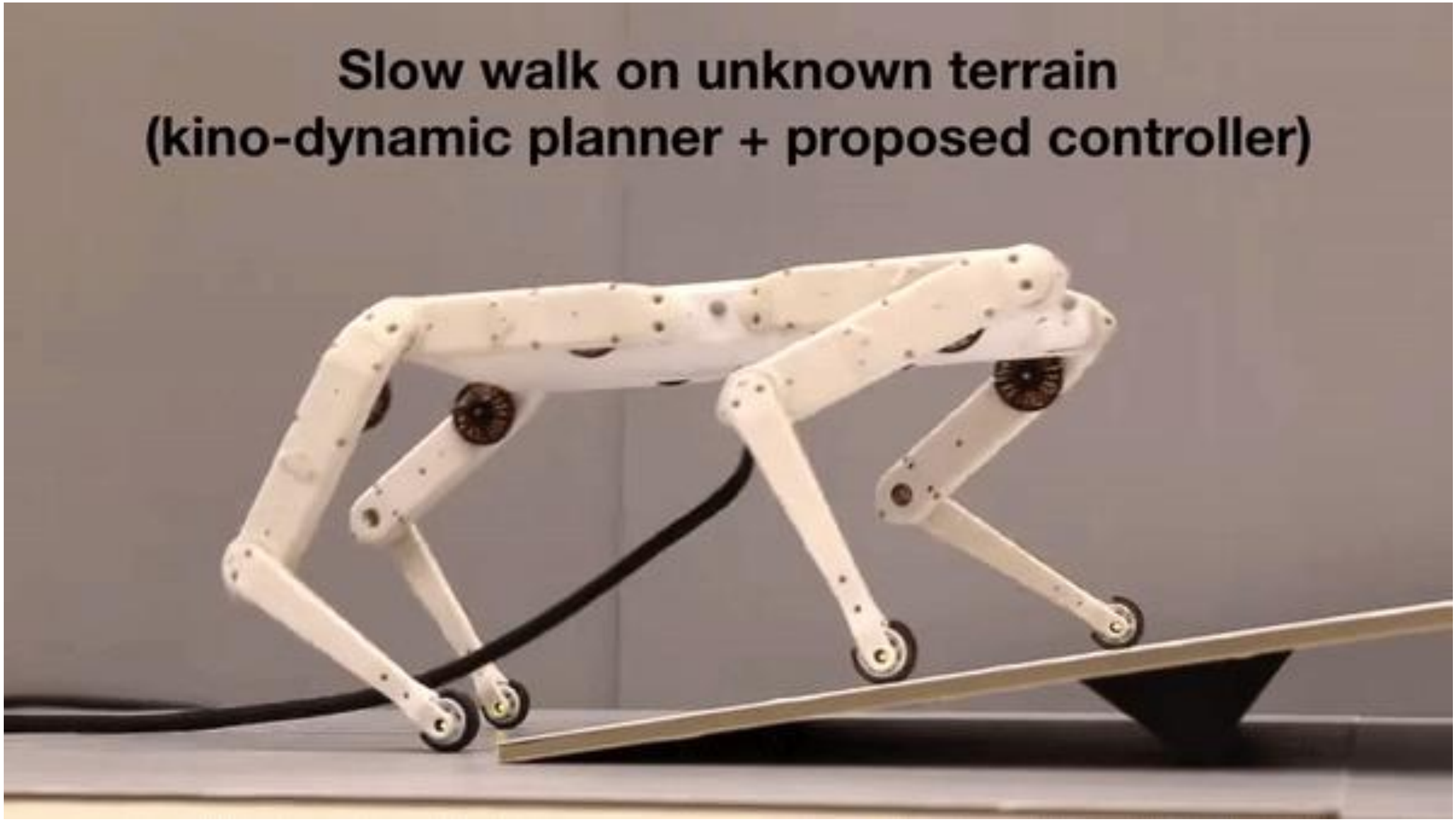
- Perception
  - The robot senses the environment
- Reasoning & Planning
  - It uses prior knowledge to reason in a rational manner
- Actuation
  - Ability to move objects or itself in the Environment




Perception
Reasoning
Actuation


MARS 2020
PERSEVERANCE

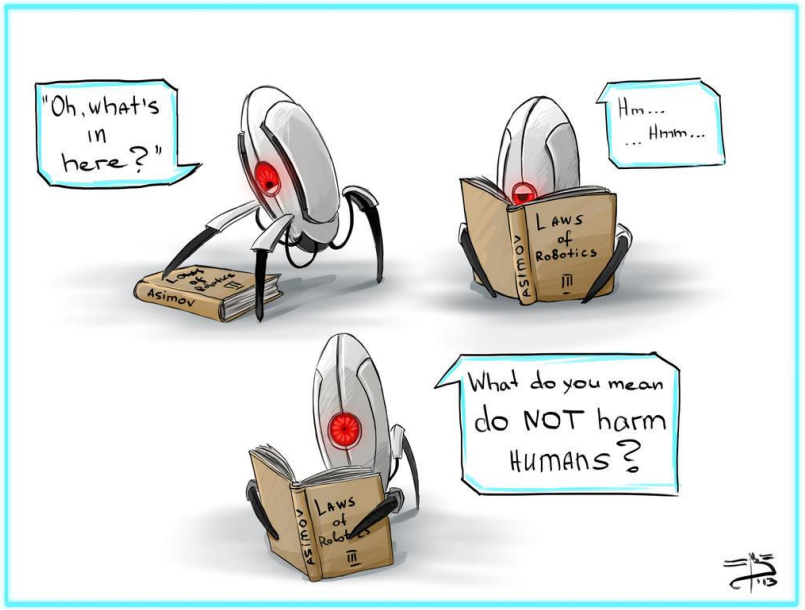

Autonomous Row Following
Lattitude, Limeraw, VIC, Australia

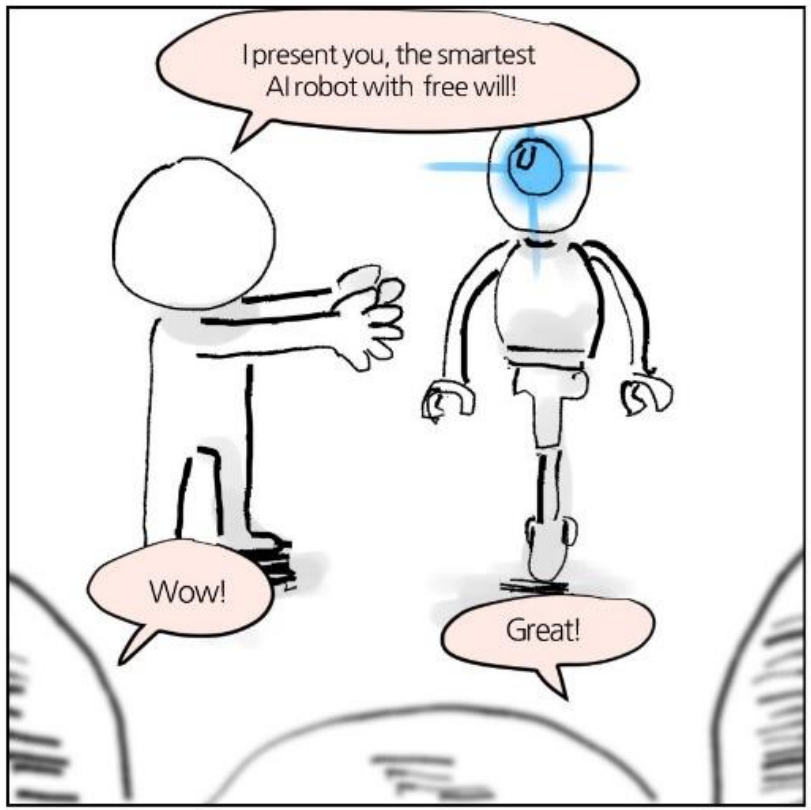

Slow walk on unknown terrain
(kino-dynamic planner + proposed controller)


DLR
DLR

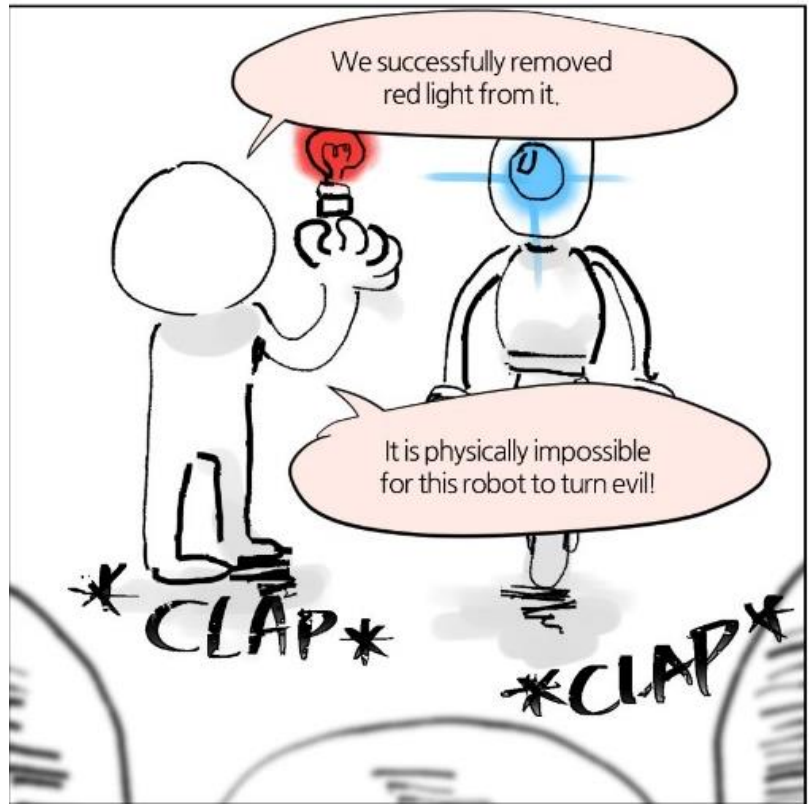
Asimov's Three Laws of Robotics

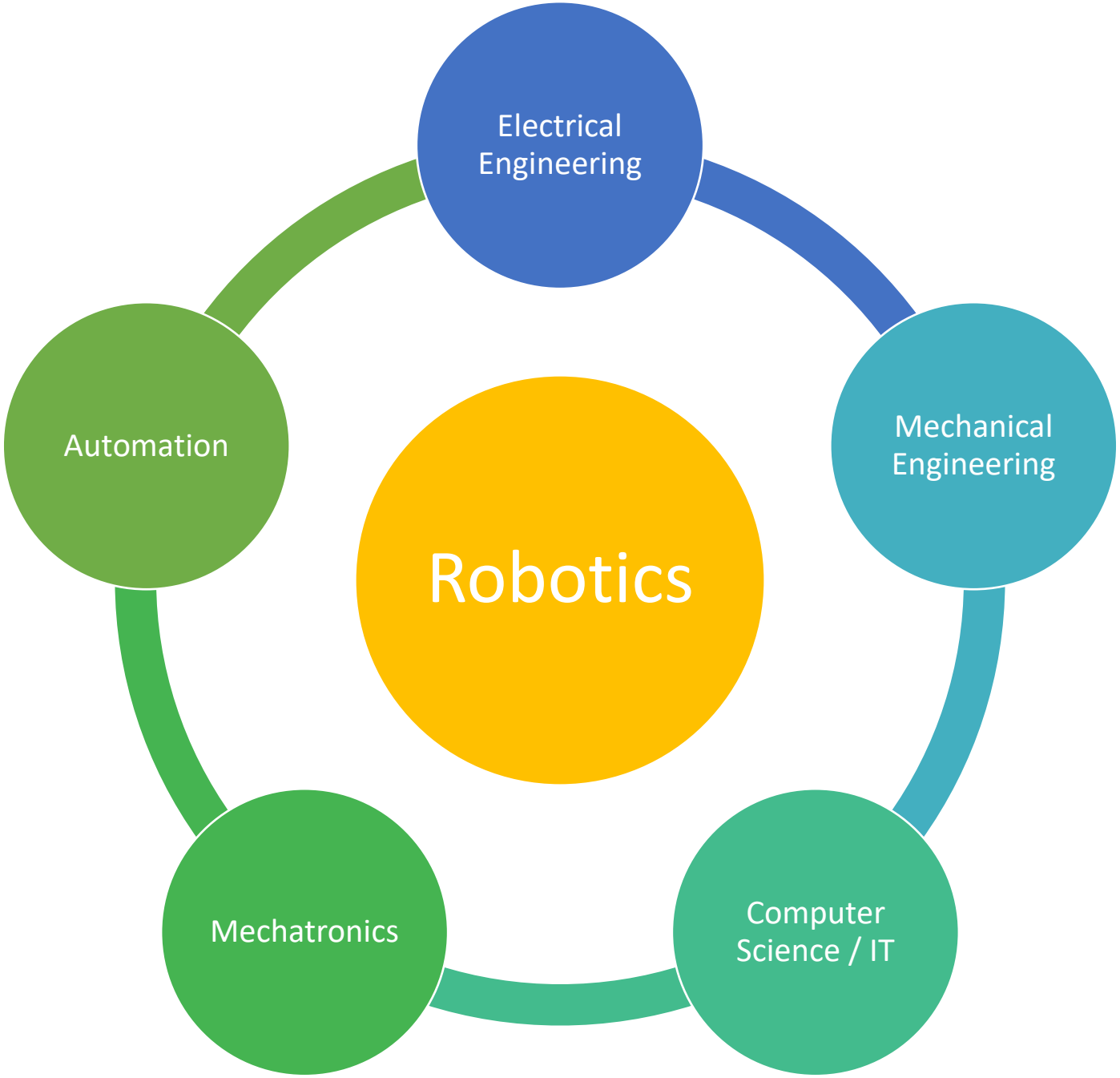
- **Zeroth Law**: A robot may not harm humanity, or, by inaction, allow humanity to come to harm.
- **First Law**: A robot may not injure a human being or, through inaction, allow a human being to come to harm.
- **Second Law**: A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
- **Third Law**: A robot must protect its own existence as long as such protection does not conflict with the First or Second Law



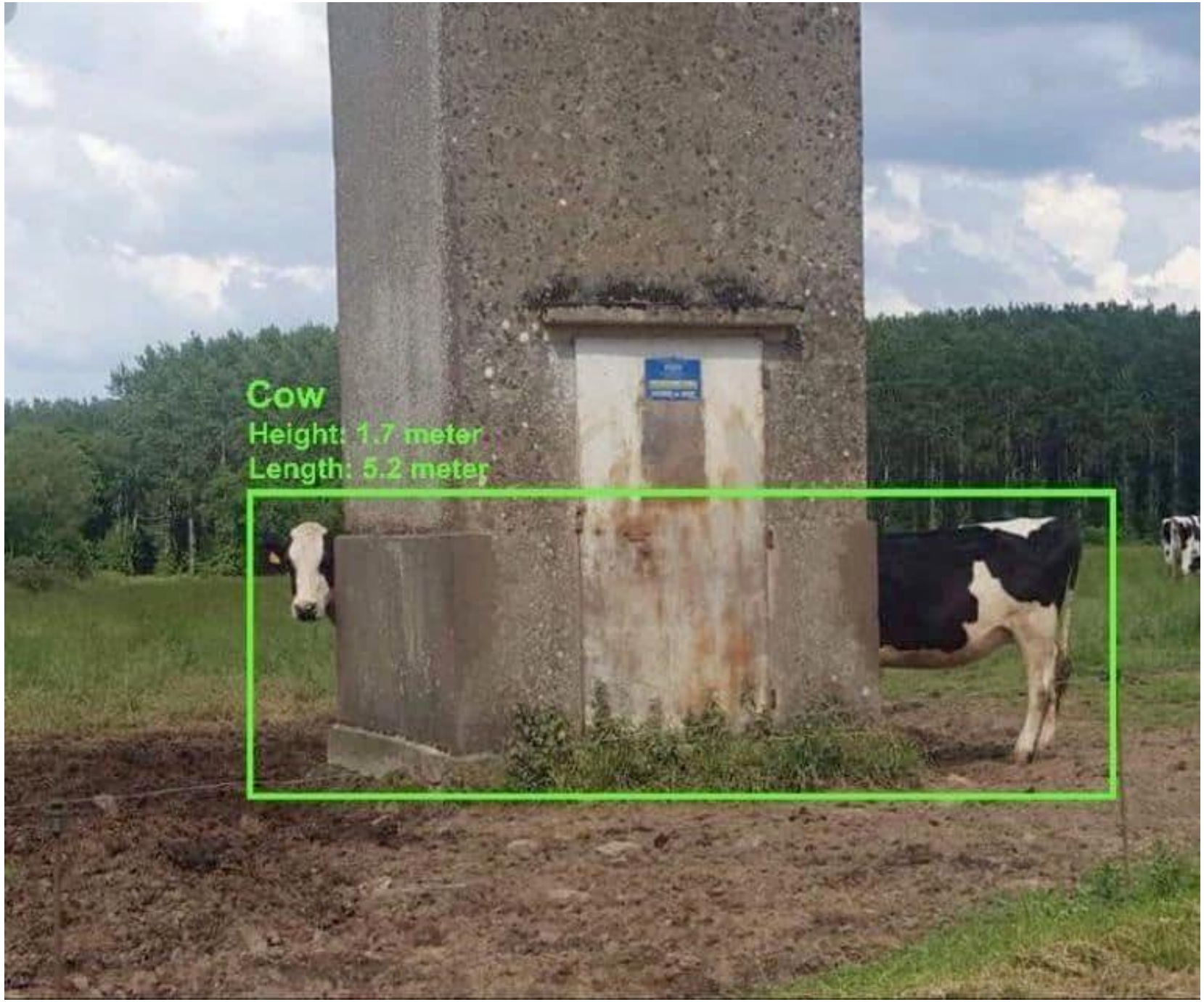

I present you, the smartest AI robot with free will!
Wow!
Great!


I have a question.
Any possibility of the robot turning evil and start a war?
Don't worry 'bout that!


We successfully removed red light from it.
It is physically impossible for this robot to turn evil!
CLAP
CLAP


Electrical Engineering
Mechanical Engineering
Computer Science / IT
Mechatronics
Automation
Robotics


~~Overview~~
Perception


Cow
Height: 1.7 meter
Length: 5.2 meter

Sensors

- A device that detects events or changes in environment and sends the information to other electronic components such as computer processors.
- It provides usable output in response to a specified measurand.
- The active element of a sensor is known as a transducer.

Ultrasonic Sensor

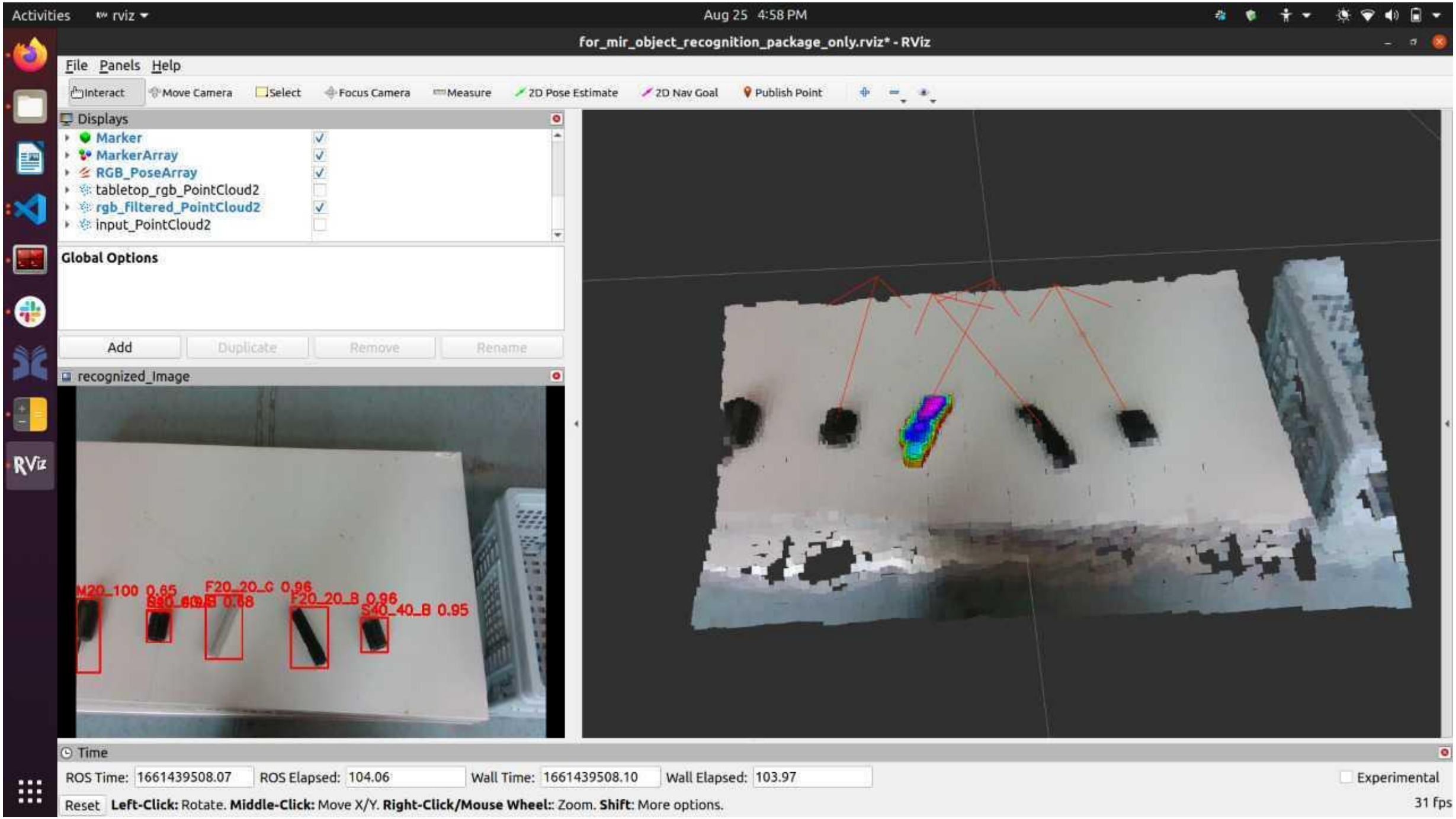
Proximity Sensor

Tactile Sensor

What and How many Sensors does our phone have?


Proximity sensor
Ambient Light Sensor
CMOS Imager sensors
GPS sensor
Accelerometer
Humidity sensor
Microphone
Temperature sensor
Pressure sensor
Fingerprint sensor
Magnetometer
Gyroscope
Touch sensor

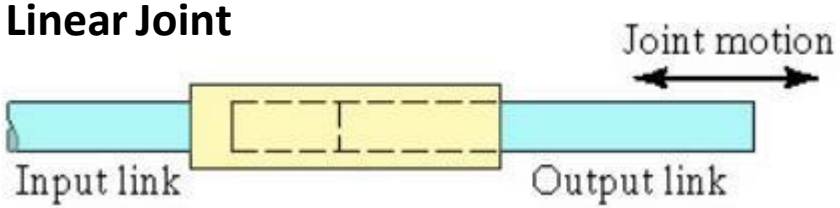
Toyota Human Support Robot (Lucy)


Activities
rviz
Aug 25 4:58 PM
for_mir_object_recognition_package_only.rviz* - RViz
File Panels Help
Interact
Move Camera
Select
Focus Camera
Measure
2D Pose Estimate
2D Nav Goal
Publish Point
Displays
Marker
MarkerArray
RGB_PoseArray
tabletop_rgb_PointCloud2
rgb_filtered_PointCloud2
input_PointCloud2
Global Options
Add
Duplicate
Remove
Rename
recognized_Image
F20_20_B 0.96
S40_40_B 0.95
Time
ROS Time: 1661439508.07
ROS Elapsed: 104.06
Wall Time: 1661439508.10
Wall Elapsed: 103.97
Experimental
Reset
Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click/Mouse Wheel:: Zoom. Shift: More options.
31 fps

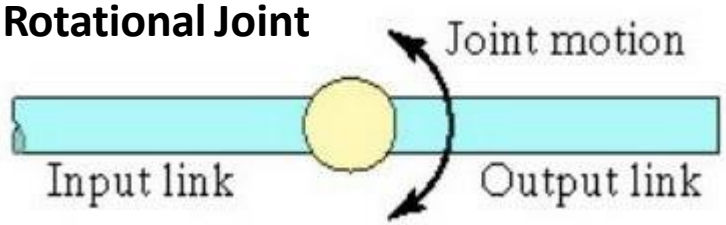

~~Overview~~
~~Perception~~
Hardware &
Actuation

Types of Joints

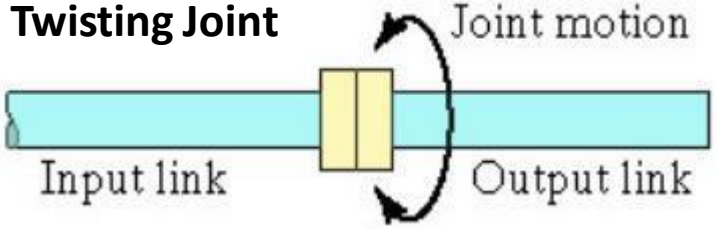
Linear Joint



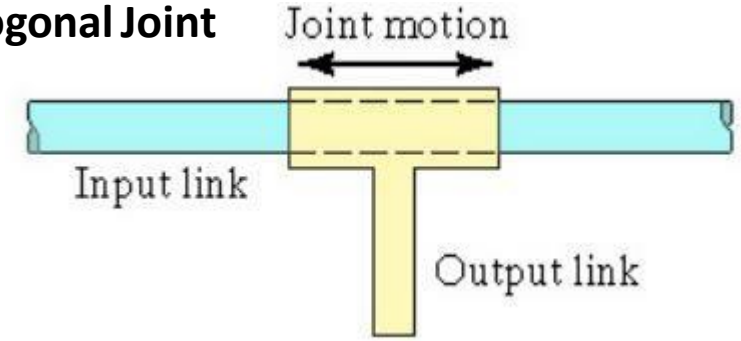
Rotational Joint



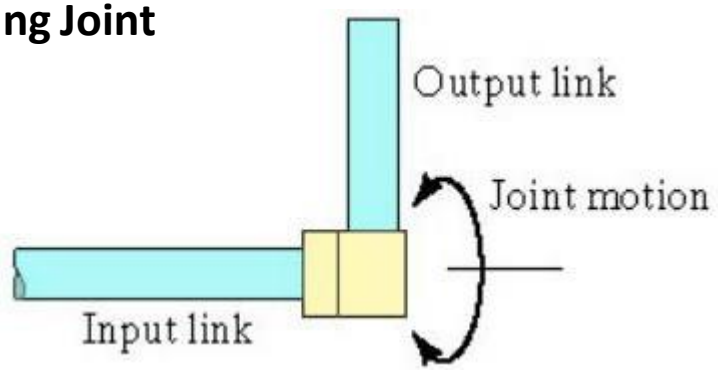
Twisting Joint



Orthogonal Joint



Revolving Joint



Actuators

These are the components of a robot that actually cause the robot's joints to move.

Two Types Based on Motion:

- Linear
- Rotary

Linear Actuator

Rotary Actuator

Actuators

Basic Types

- Hydraulic
- Pneumatic
- Electric

Hydraulic actuators

Used in heavy machineries.

They generate very high forces.

Hydraulic Actuator

Actuators

Pneumatic actuators

Uses compressed air that acts on a piston that is present inside a cylinder to move a load along a linear path.

- They are safer compared to hydraulic actuators by the fact that they reduce the risk of fire.
- Lesser maintenance required.
- Uses air that is abundantly available and therefore reduce cost and is more efficient.

Pneumatic Actuator

Actuators

Electric Actuators

- They create a movement of load by generating a force by means of electric current interacting with magnetic fields.

DC Motor

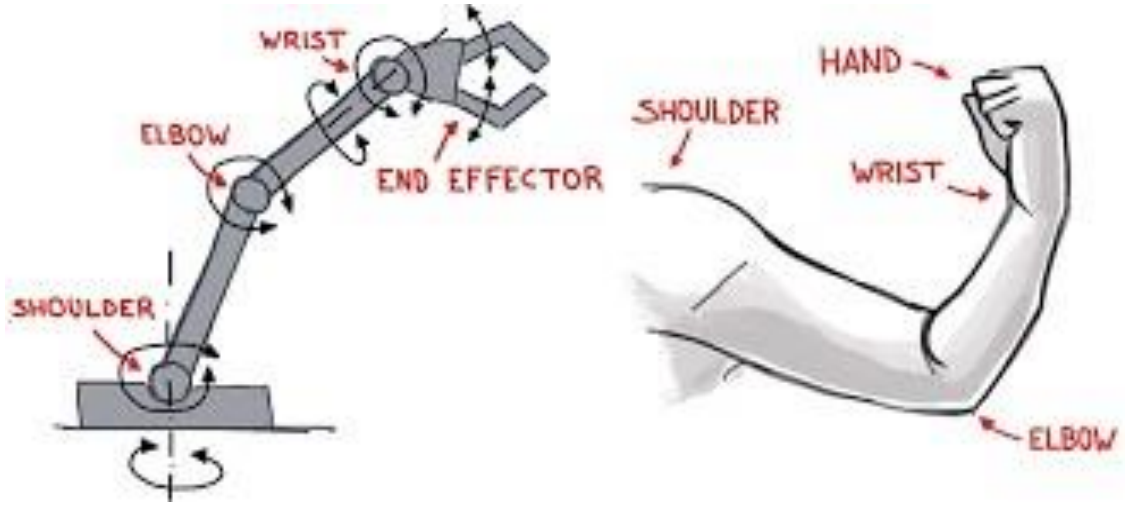
AC Motor

Servo Motor

Stepper Motor

Robotic Arms

Some more parts of a robot (robotic arm)



Various Components of a Robotic Arm

Robotic Arms

- **Manipulator**
  - The device or part of the robot that manipulates objects in environment without direct physical contact by the operator.
  - Made up of **links** and **joints**.

- **End Effector**
  - A specific device attached to the robot's manipulator that interacts directly with the object.

Manipulator

End Effectors

Robotic Arms

Types of End-Effectors

- **Grippers**
  - It allows to pick up, manipulate and drop objects.
  - Suitable for applications like pick and place, assembly, machine tending.
- **Process Tools**
  - Grippers can grasp the workpiece. But process tools can change the workpiece.
  - Similar to a worker operating a power tool.
  - Suitable for applications like welding, spray painting, 3D printing etc.
- **Sensors**
  - Sensors can also be used as end effectors.
  - Suitable mainly for inspection applications.
  - Ultrasonic, laser scanners, 2D and 3D cameras, infrared sensors etc.

Gripper

Process Tools

Sensor

Robotic Arms

- **Links**
  - Rigid members that connect the joints.

- **Joints**
  - Movable components of the robot that cause the links attached to them to have a relative motion between the links.

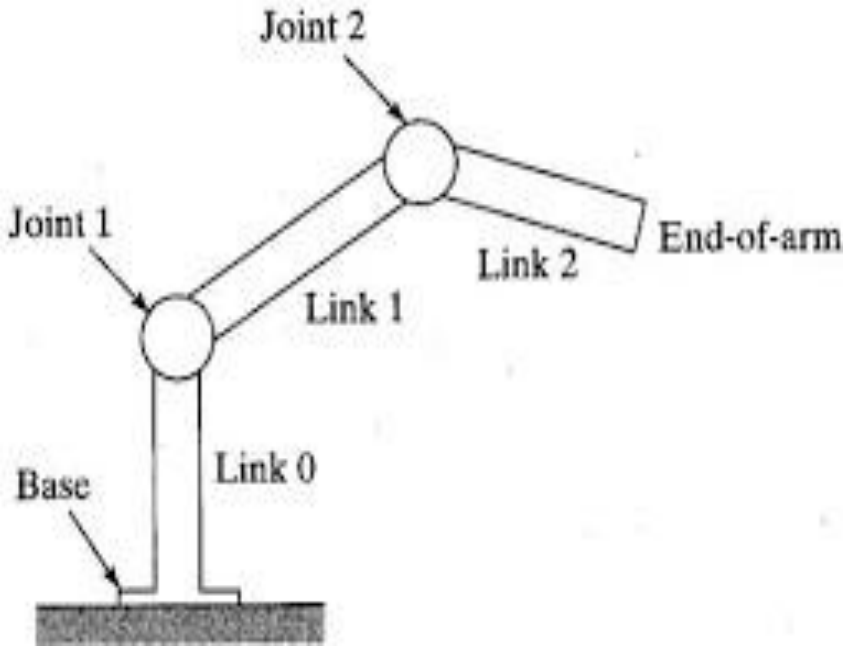


Illustration of Links and Joints

Some More Basic Terms

Degrees of Freedom (DOF)

- The minimum number of axes that are required to achieve any desirable position and orientation in the workspace or work envelope of the robot.

- **Reachable vs Dexterous Workspace**

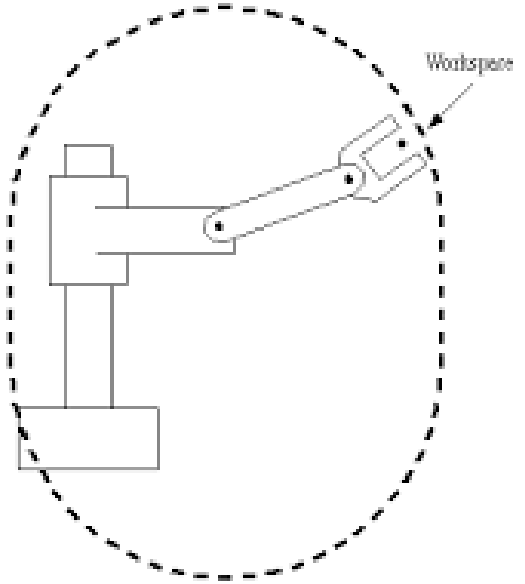


Illustration of Robot's Workspace

DoF?

KINOVA Arm

DoF?

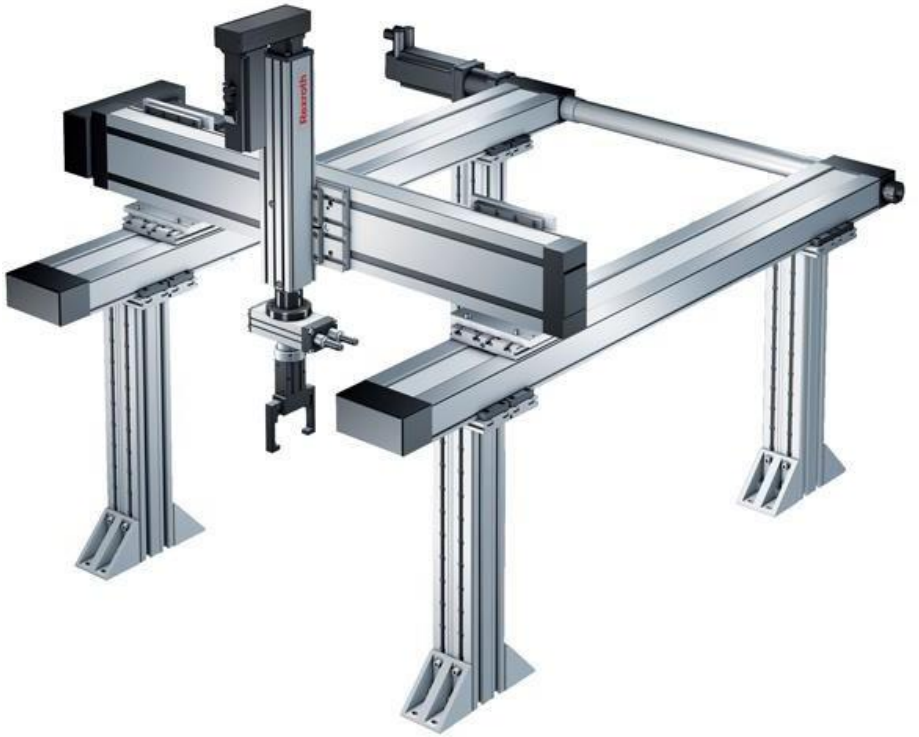
KUKA youBot

Robot Configurations

Robot Description

- The three joints are linear in nature.

Guess the workspace



Robot Image

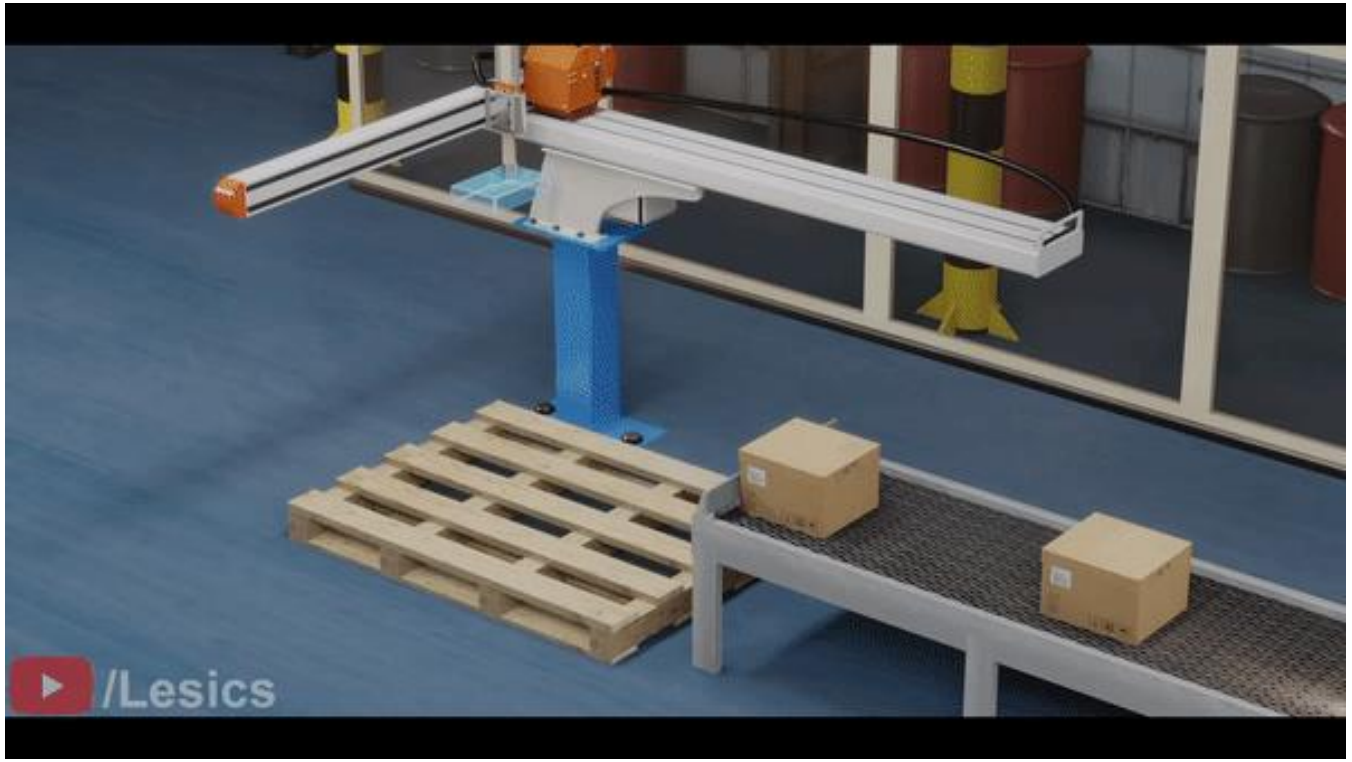
Robot Configurations

Cartesian/ Rectangular Robot

- The three joints are linear in nature.

Guess the workspace

- Cuboidal workspace



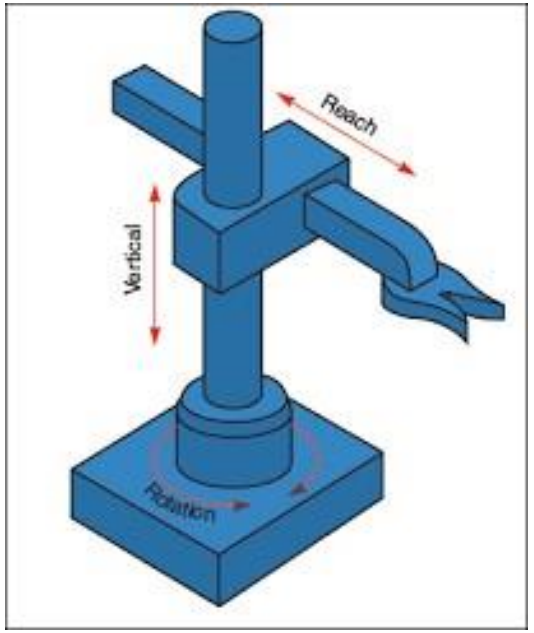
Cartesian Robot

Robot Configurations

Robot Description

- Two linear joints and one revolute joint.

Guess the workspace



Robot Image

Robot Configurations

Cylindrical Robot

- Two linear joints and one revolute joint.

Guess the workspace

- Cylindrical Workspace

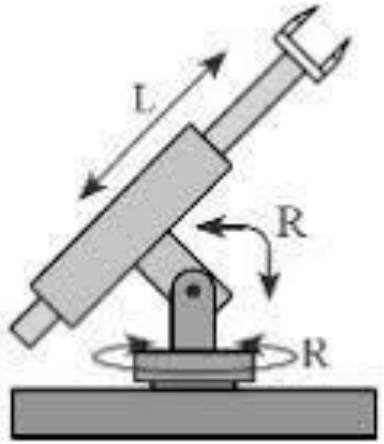
Cylindrical Robot

Robot Configurations

Robot Description

- Two revolute joints and one linear joint.

Guess the workspace



Robot Image

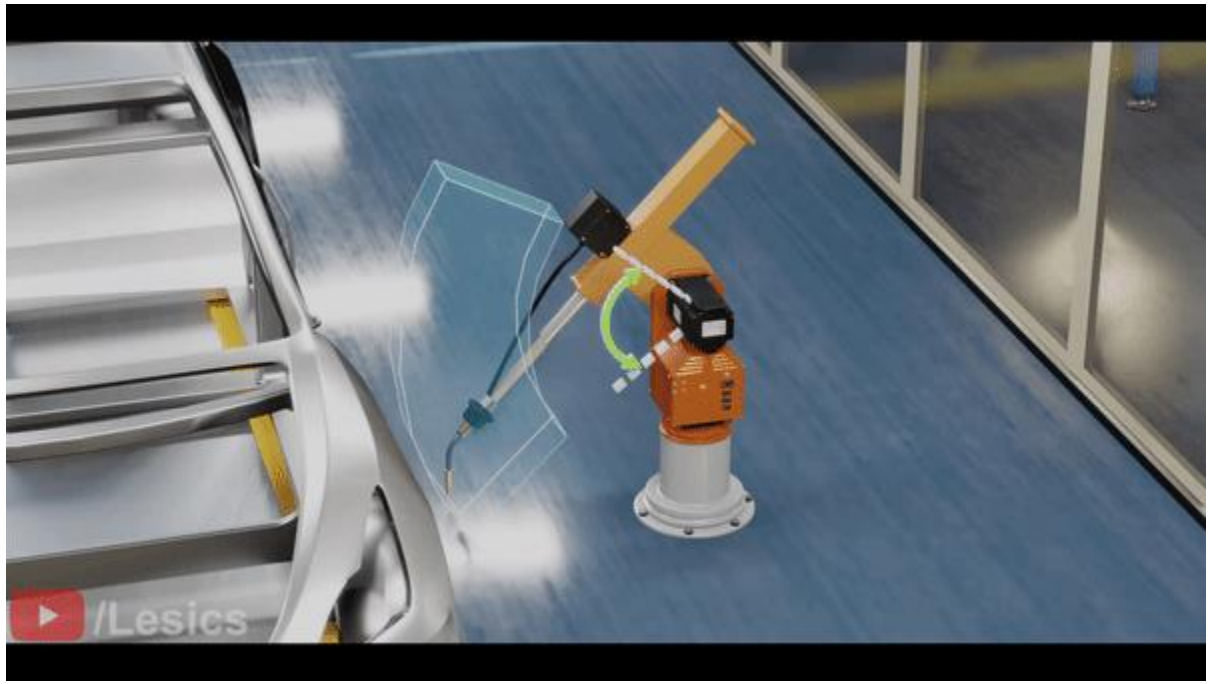
Robot Configurations

Spherical Robot

- Two revolute joints and one linear joint.

Guess the workspace

- Spherical Workspace



Spherical Robot

Robot Configurations

Parallel Robots

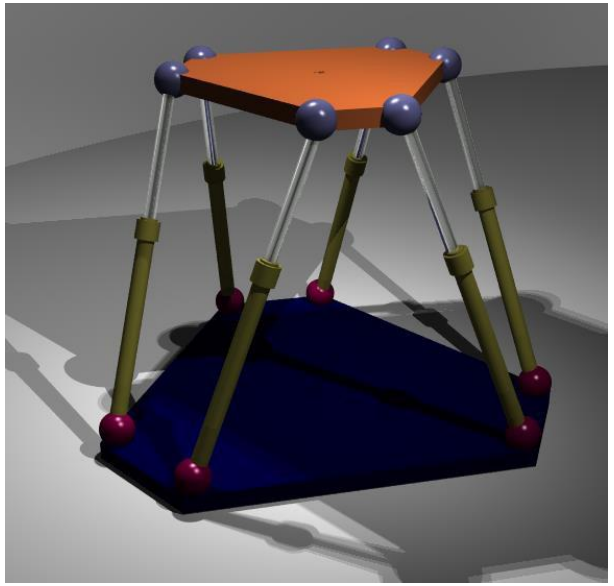
They consist of a fixed base and a moving platform, both of which are connected by a number of legs.

Used in

- Flight simulators
- 3D printers
- Some pick and place robots

Benefits

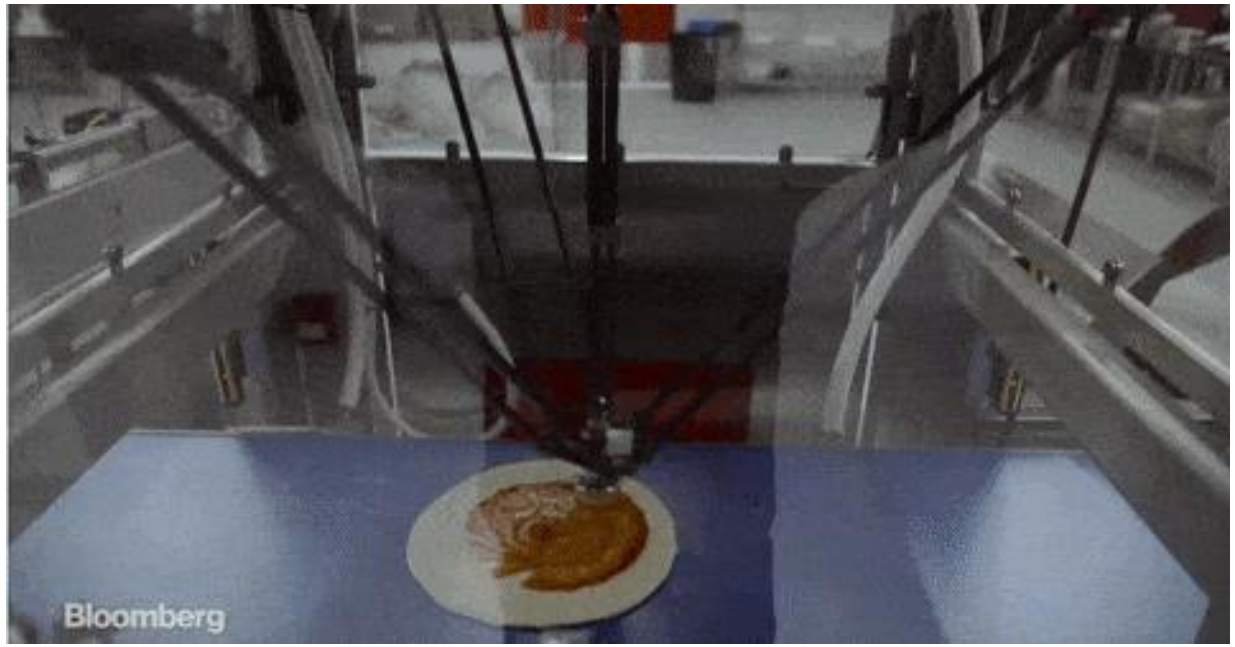
- High accuracy
- More stability

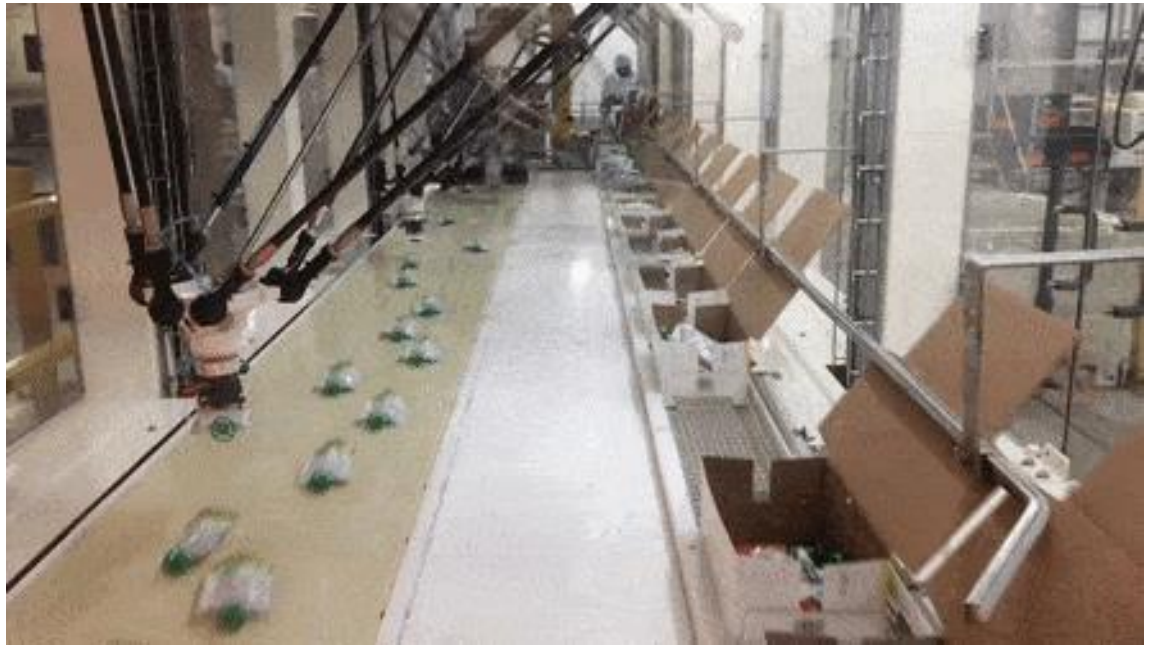


Parallel Manipulator

Parallel Robot

Application – Parallel arm

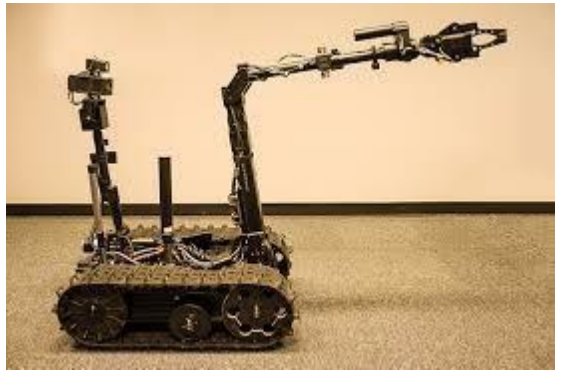




Mobile Robotics

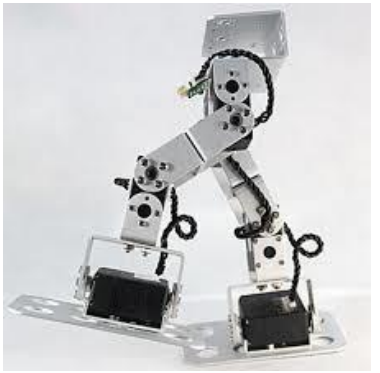
- Consists of a mobile platform that can freely move and so can have limitless operational area.
- These platforms themselves cannot manipulate objects.
- Typically used for applications such as cleaning, surveillance, monitoring and analysis.
- Mechanisms for motion: wheels, legs, wings, even jets.
- Safety is important.

Wheeled Mobile Robots



Drone

Biped Robot



Drive Concepts

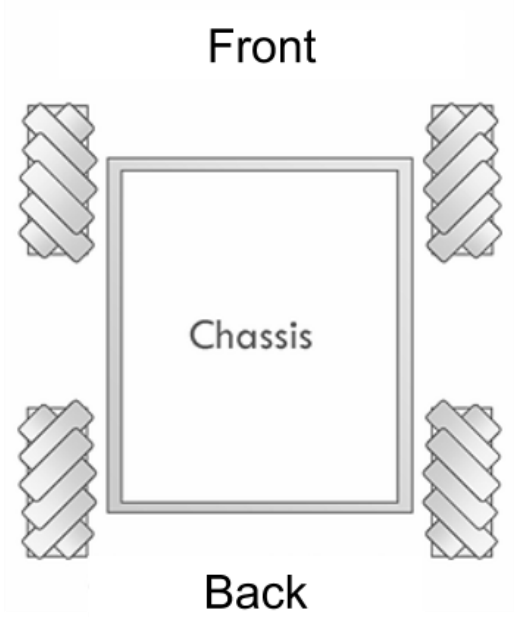
Differential Drive

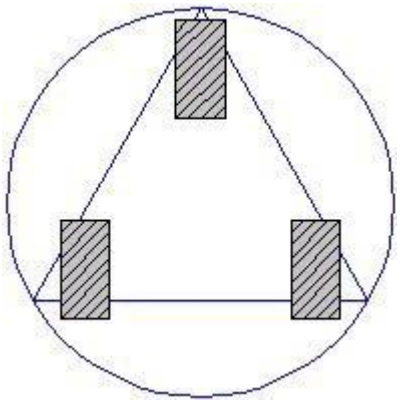
- Consists of two wheels which are powered.
- The third one is a free or passive wheel (castor).
- 2 Degrees of freedom.

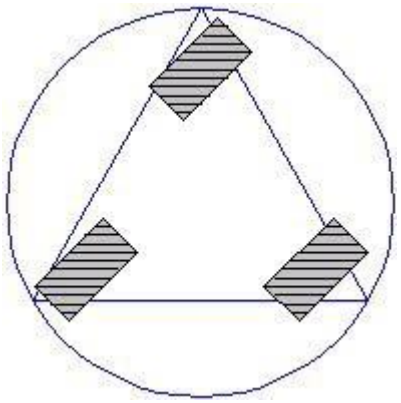
Illustration of Differential Drive

Drive Concepts

Omni Directional Drive





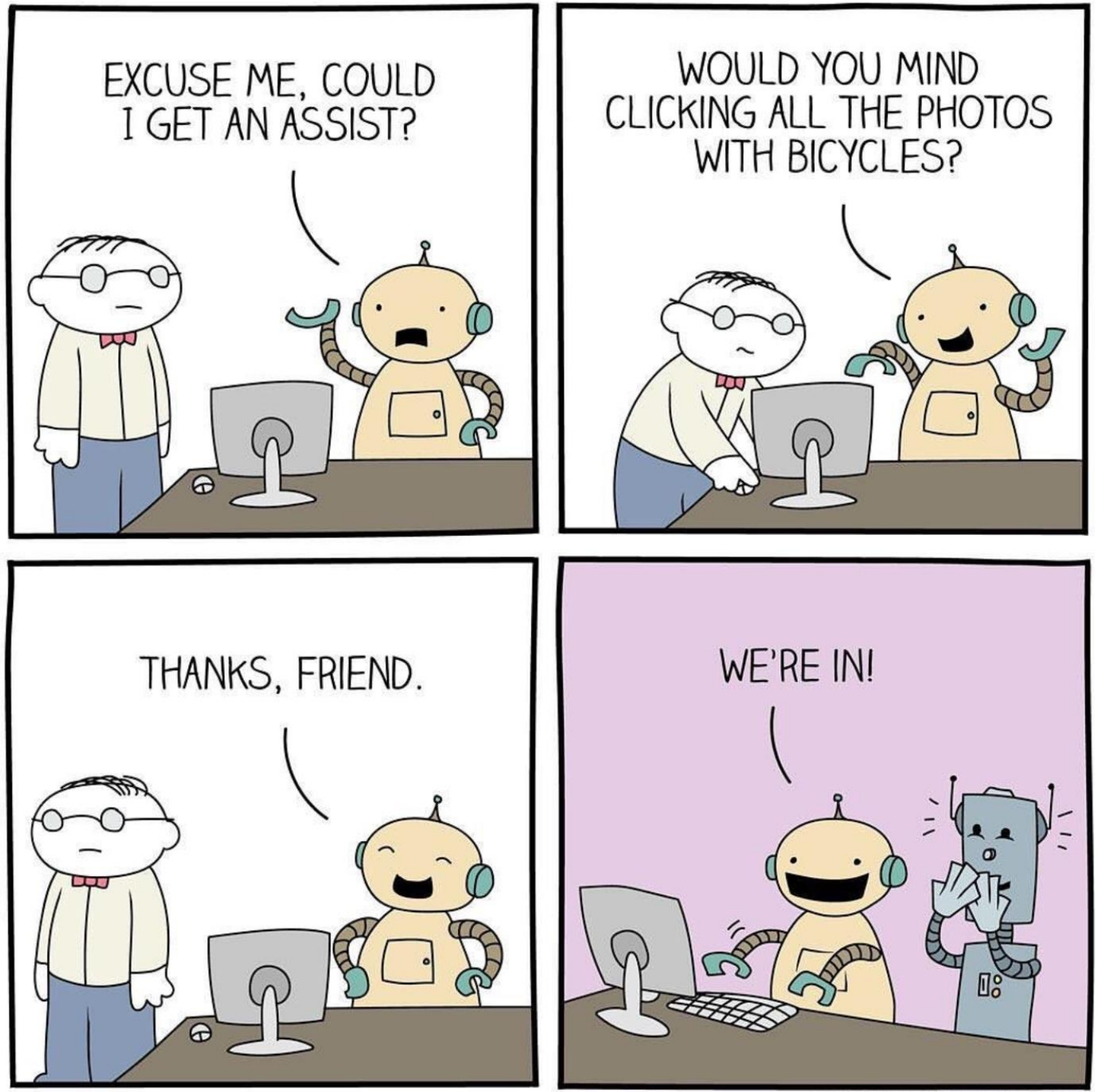


Synchro Drive

Mecanum wheels - youBot

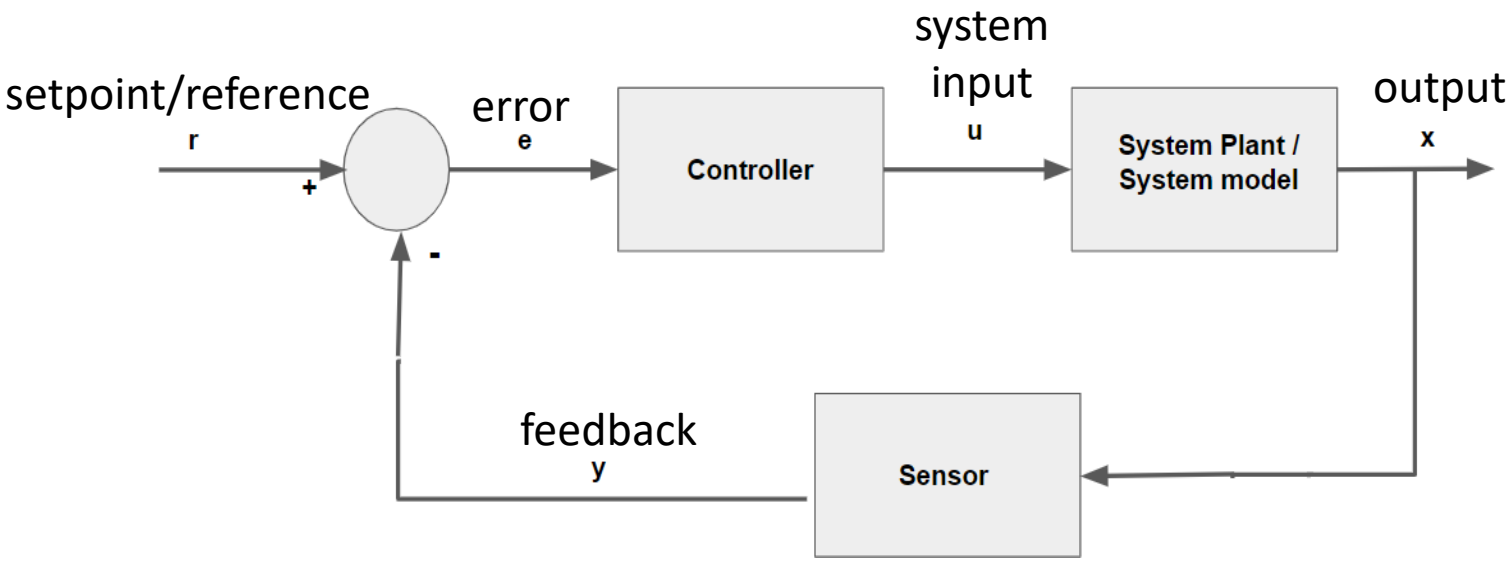
KUKA youBot


~~Overview~~
~~Perception~~
~~Hardware &~~
~~Actuation~~
Reasoning


EXCUSE ME, COULD I GET AN ASSIST?
WOULD YOU MIND CLICKING ALL THE PHOTOS WITH BICYCLES?
THANKS, FRIEND.
WE'RE IN!

Control System

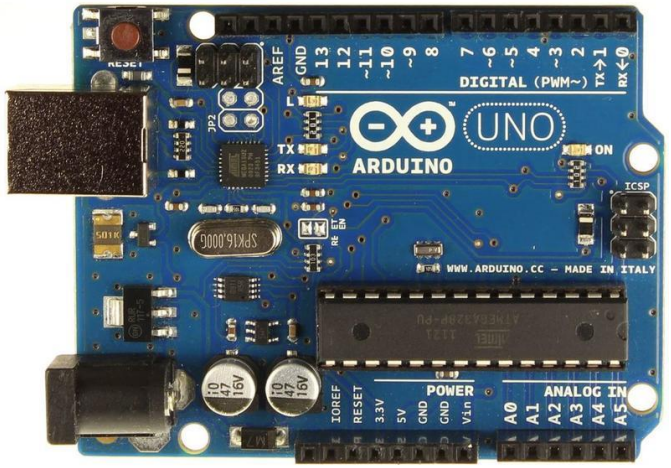
The controller receives data from the computer, controls the motions of the actuator and coordinates these motions with the sensory feedback information.



Control System

Controllers

Raspberry Pi



Arduino Uno

Intel NUC

NVIDIA Jetson nano

Mobile Robot Localization

Problem

- Localization is the problem of determining the pose of the robot relative to a given map of the environment.

Sensors

- **???**

Mobile Robot Localization

Problem

- Localization is the problem of determining the pose of the robot relative to a given map of the environment.

Sensors

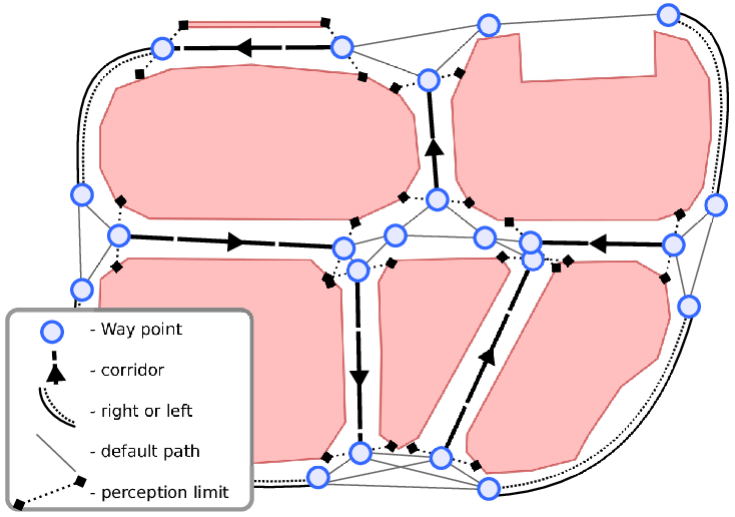
- **Odometry, GPS, Laser-scanner, Camera**

World Representations

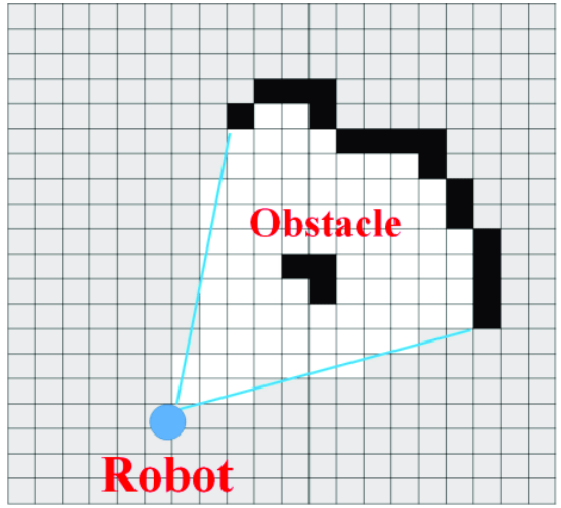
- Topological graphs, grid-based maps

Filters

- Kalman filter, Particle filters



Topological map



Occupancy grid map

Path Planning

Problem

To find a sequence of valid robot configurations that moves the robot from a given location to the destination.

Path Planning

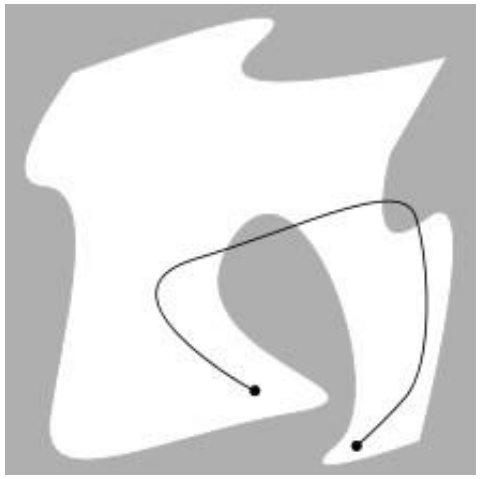
Problem

To find a sequence of valid robot configurations that moves the robot from a given location to the destination.

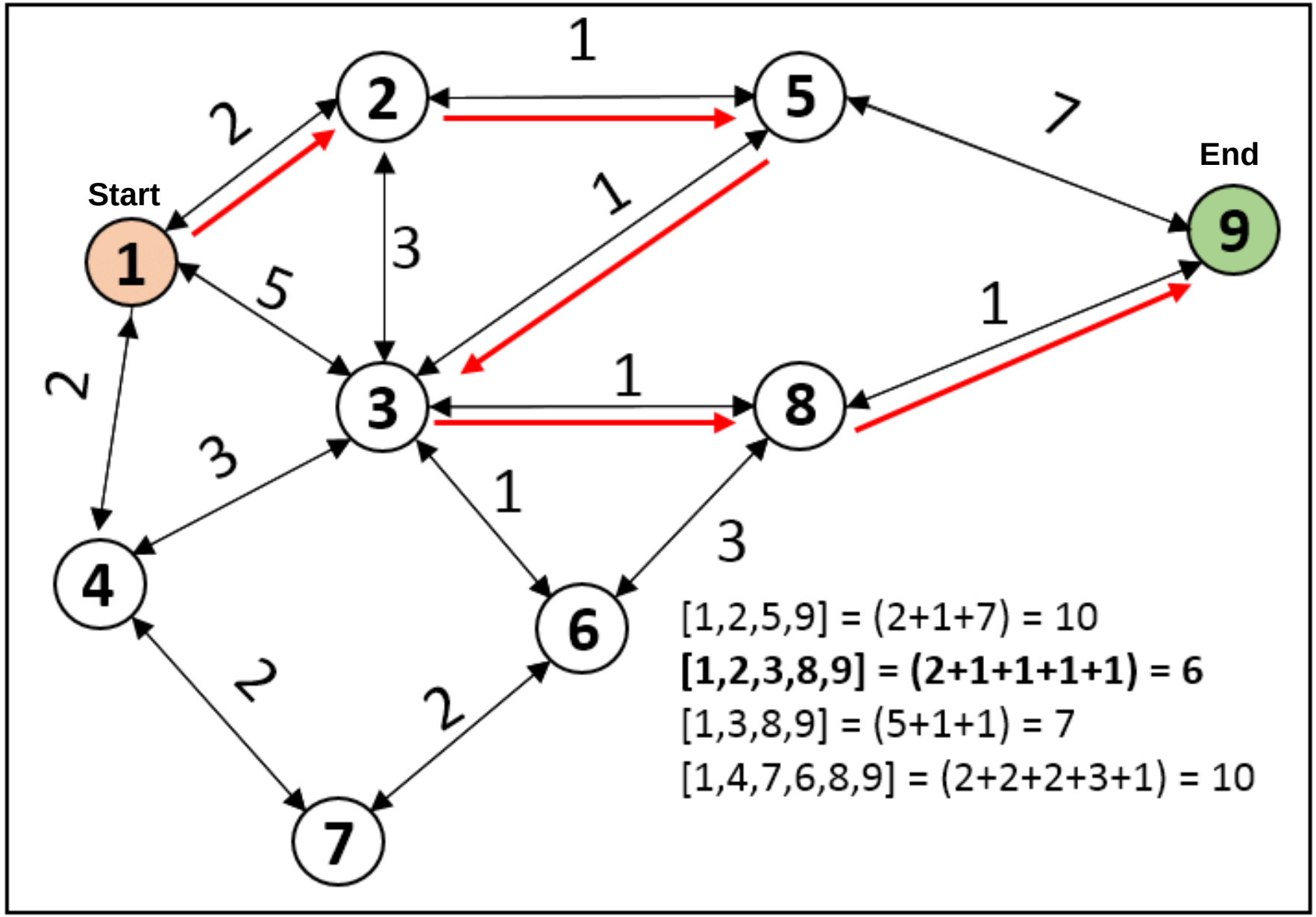
Considerations:

The task must be executed avoiding walls, or any other obstacles and falling down the stairs.

Example of a Valid Path



Example of an Invalid Path



Dijkstra's Algorithm

Motion Planning

Problem

Take the description of these tasks as inputs and generate speed and turning commands for the robot.

Basically generate commands that can be sent to robot's wheels to enable it to navigate along the planned path.

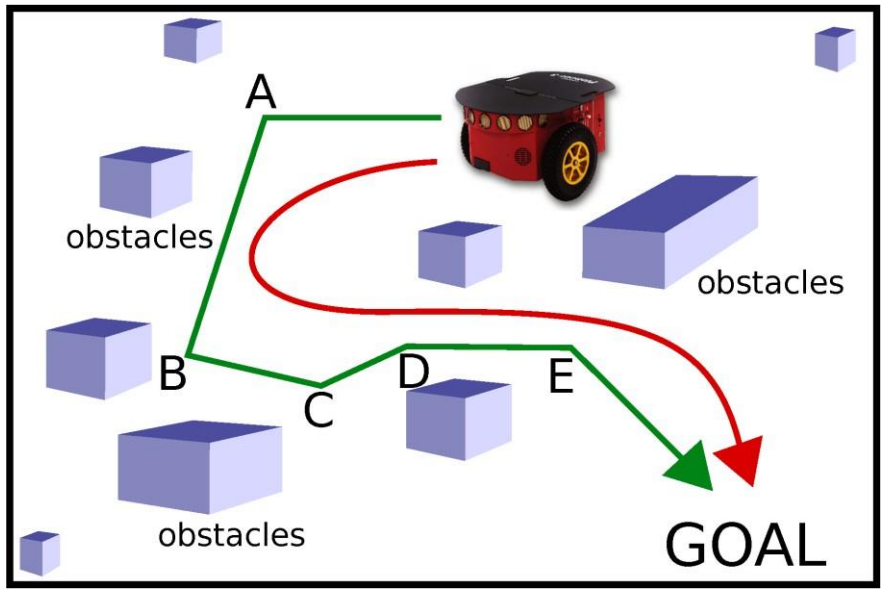
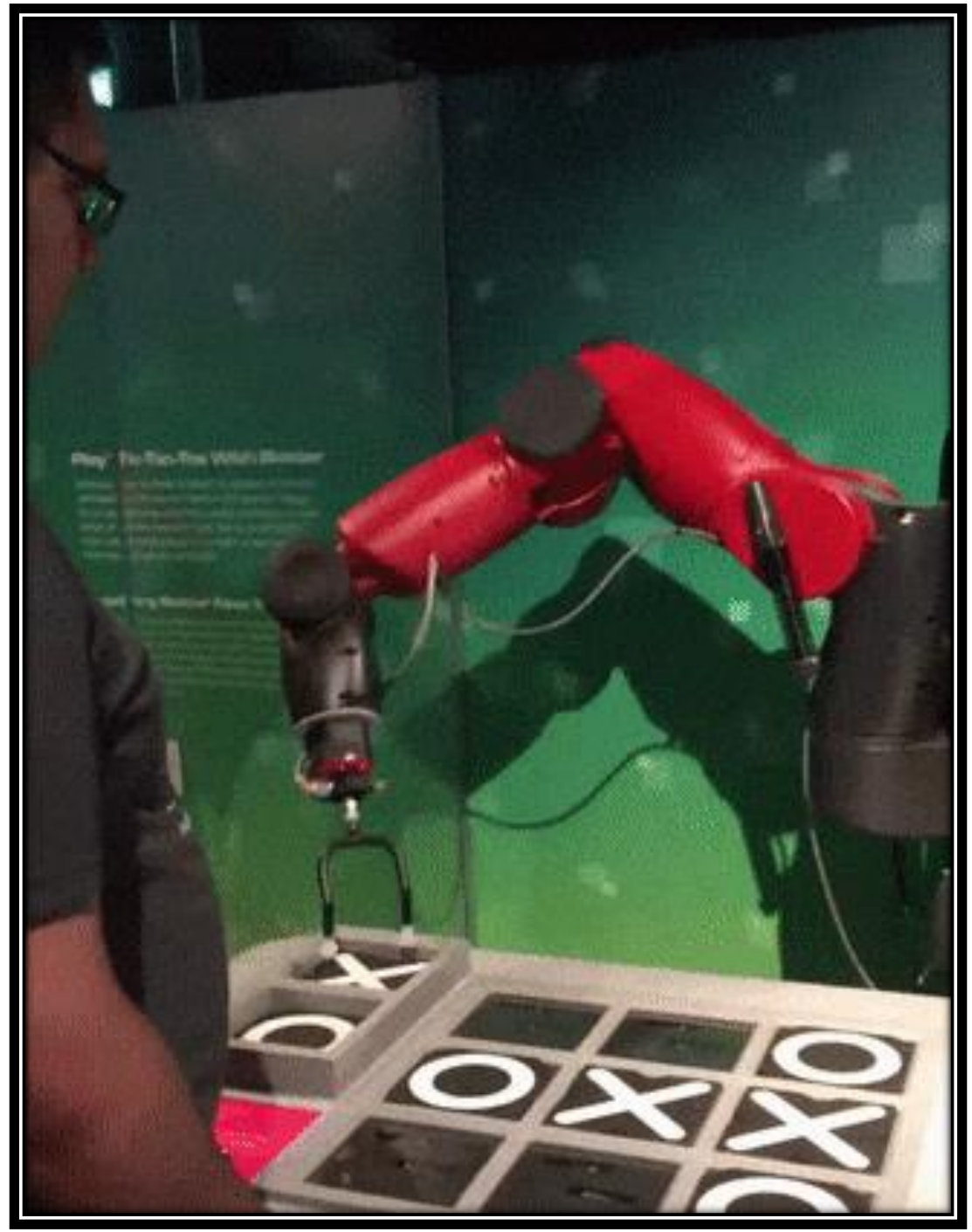


Illustration of Motion Planning


Play Tic-Tac-Toe With Shimon

Software

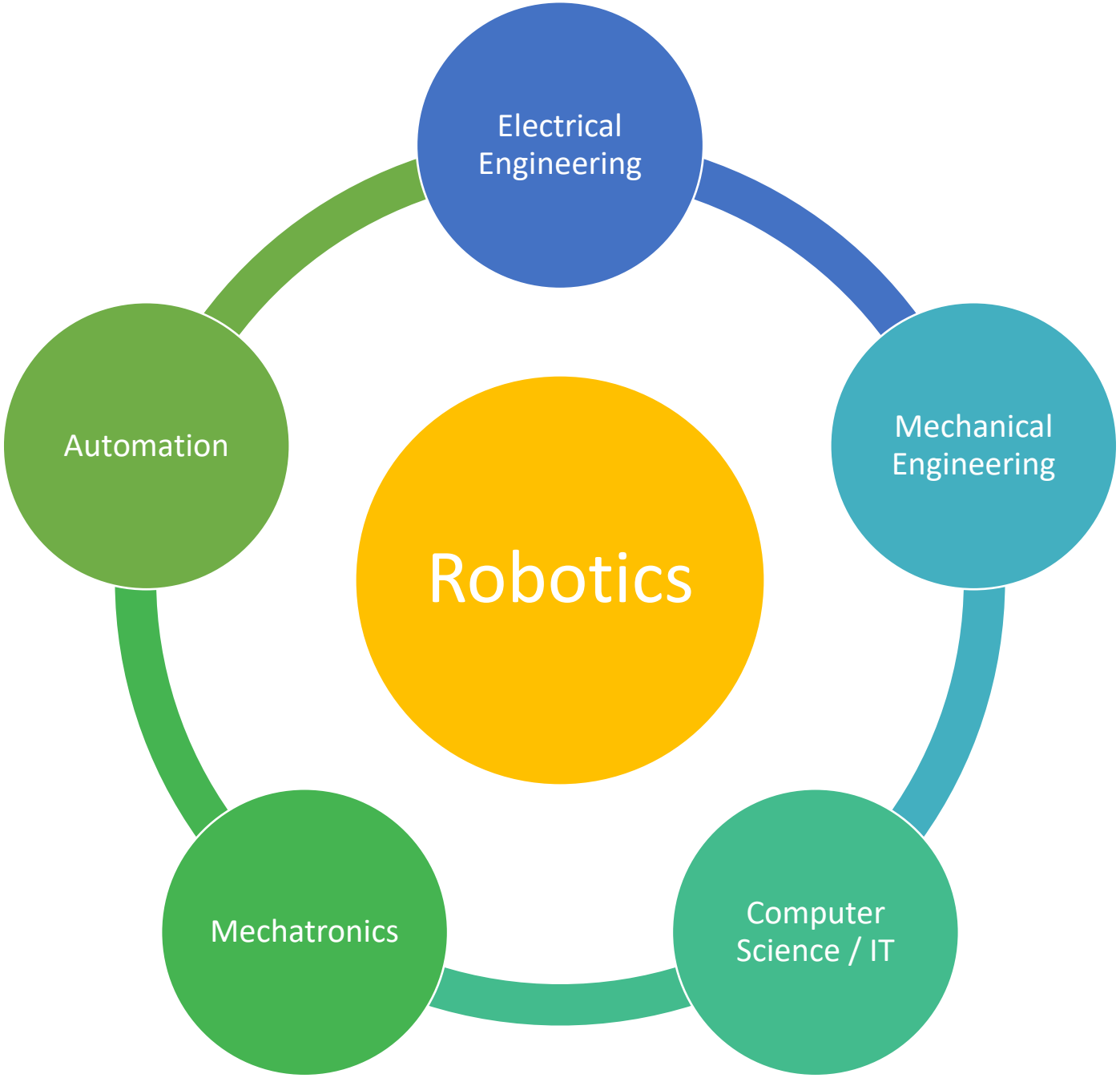
- Languages: Python , C++
- Frameworks: ROS
- Simulators: Gazebo, Webot, V-Rep
- Useful libraries: OpenCV, PCL, PyTorch, etc.

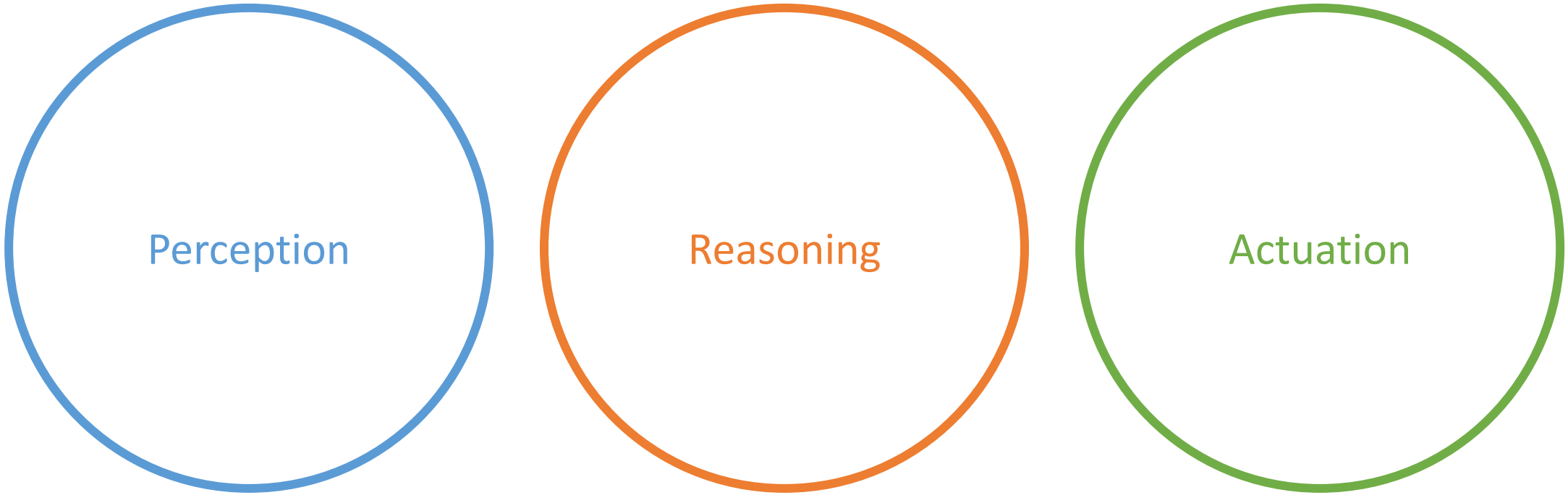

~~Overview~~
~~Perception~~
~~Hardware &~~
~~Actuation~~
~~Reasoning~~
Conclusion

Open Topics

- Navigation
- Sensing
- Manipulation
- Task Planning

- **Natural language processing**
- Fault detection and error recovery
- **Learning**
- Sensor fusion
- **Probabilistic reasoning**
- **Active perception**
- Multi-robot systems
- Logging and databases
- Communication
- **Human-robot interaction**
- User interfaces
- Learning by demonstration


Electrical Engineering
Mechanical Engineering
Computer Science / IT
Mechatronics
Automation
Robotics


Perception
Reasoning
Actuation

SS22 local competition (Day 2) - youBot

THANK YOU