

Introduction to Robotics

CSE461

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BRAC University

Class routine Spring-2021

	9:30	11:00	12:30	14:00	15:30
SAT	CSE461 Sec-1		CSE461 Sec-2		CSE461 Sec-3
SUN					
MON			CSE360 Sec-1		
TUE					
WED			CSE360 Sec-1		
THU	CSE461 Sec-1		CSE461 Sec-2		CSE461 Sec-3

Catch me in

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are restricted for students to communicate
with me

Course outline

Topics	Materials
Introduction to robotics	Laws , types fo robots , application of robotics , Robot Subsystem Components, ROS, Recent trends
Mechanical Design of Robots	Review on Linear algebra and mechanics, kinematics and dynamics of robot manipulators, jacobian analysis, Gear, Screw, Differential
Control	PID control, Trajectory/Motion Planning, Localization, Manipulator Control, Motor, UAV Navigation
Vision and Perception	Image Processing, Vision Sensors and modules
Intelligent Robotics	CNN, Reinforcement Learning, Robot Path Planning
Communication	Robot Communication (IOT,Wireless, Bluetooth, RF, 5G, GSM)
CASE STUDY	Duburi and ChandraBot
CASE STUDY 2	Asimo
CASE STUDY 3	Perseverance and Mongol-tori

Course outline

- | | |
|--|--|
| <p>1 Introduction to Robotics: (Week-1, 2)</p> <ul style="list-style-type: none">1.1 Introduction1.2 Laws1.3 Types of robots1.4 Application of robotics1.5 Robot Subsystem Components1.6 Recent trends1.7 ROS <p>2 Mechanical Design of Robots: (Week-3, 4)</p> <ul style="list-style-type: none">2.1 Review on Linear algebra and2.2 Mechanics, kinematics and dynamics2.3 Robot Arm Kinematics2.4 Mobile Robot Vehicles2.5 Gear, Screw, Differential <p>3 Control System of Robots: (Week-5, 6)</p> <ul style="list-style-type: none">3.1 PID control3.2 Trajectory/Motion Planning3.3 Localization3.4 Manipulator Control3.5 Different types of Motor Control3.6 Navigation | <p>4 Robot Vision and Perception: (Week-7, 8)</p> <ul style="list-style-type: none">4.1 Image Processing4.2 Vision Sensors and modules4.3 LIDAR <p>5 AI in Robotics: (Week-8, 9)</p> <ul style="list-style-type: none">5.1 Introduction to CNN5.2 Reinforcement Learning5.3 Robot Path Planning <p>6 Robot Communication: (Week-10, 11)</p> <ul style="list-style-type: none">6.1 Wireless, Bluetooth, RF6.2 GSM, GPRS6.3 5G6.4 IOT <p>7 Robot Case Study: (Week-12, 13)</p> <ul style="list-style-type: none">7.1 AUV and UGV: Duburi and ChandraBot7.2 Humanoid Robot: Asimo and Sophia7.3 Interplanetary Robot: Perseverance and Mongol-tori |
|--|--|

Reference Books

- Robotics, Vision and Control: Fundamental Algorithms in MATLAB
 - by Peter Corke
- Modern Robotics: Mechanics, Planning, and Control
 - by Frank C. Park and Kevin M. Lynch

Project

- Design and Implement a Robot
 - Processing should be done on Raspberry PI or Jetson Nano or Laptop or Desktop preferably using ROS
 - Micro-controller and Arduino can be used as an interfacing
 - At least 3 Sensors including a camera and 3 Motor Action should be included in your Robot.
- Upload CAD design, Control algorithm and code to Github
- Upload Video Demonstration on Youtube
- Report writing in technical paper format

Marks Distribution

- Quiz: 15%
- Assignments: 10%
- Lab performance: 10%
- Project: 15%
- Midterm: 20 %
- Final: 30%
- Total: 100

Objective of Robotics

- Industry Automation
- Smart, IoT and Embedded Systems
- Efficient task specific Robot

Objective of Robotics

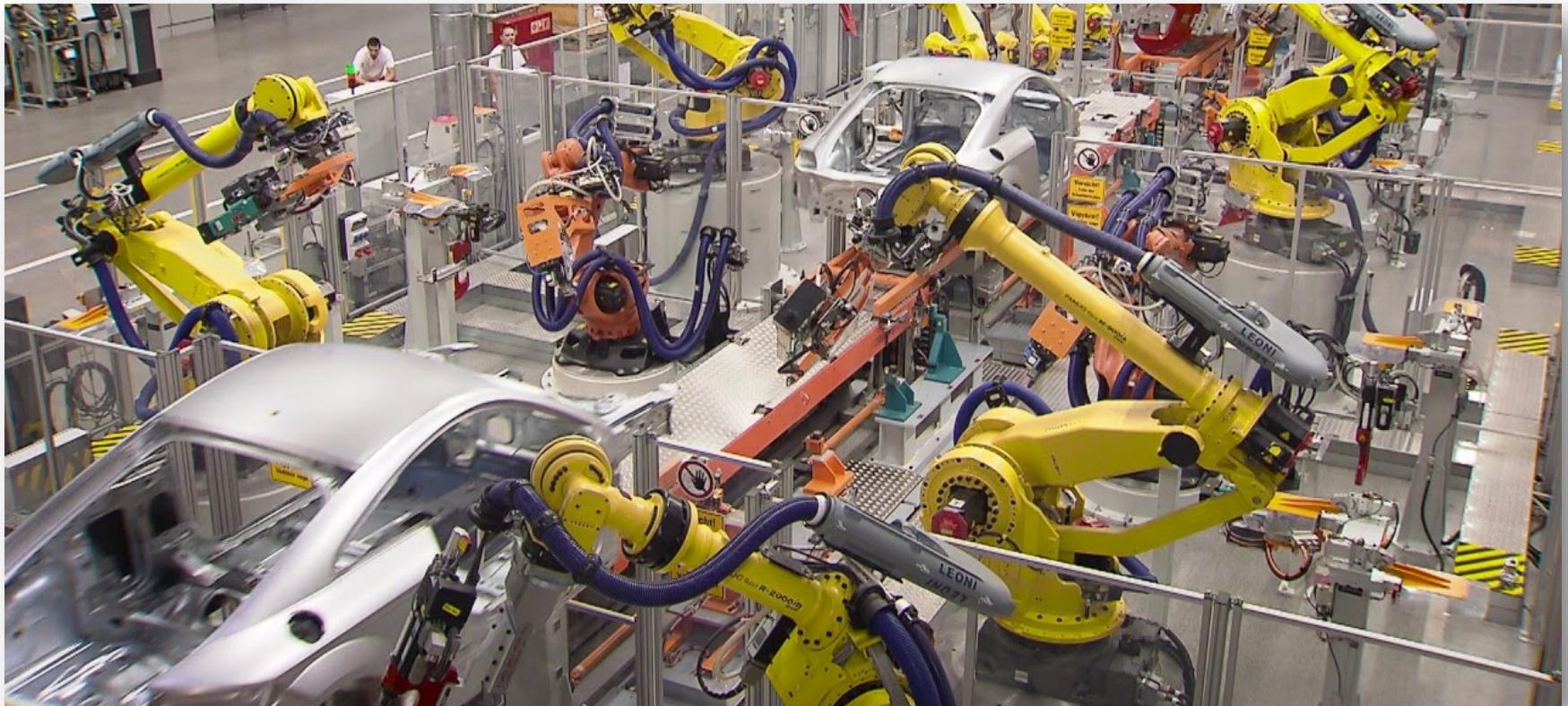
- Industry Automation
- Smart, IoT and Embedded Systems
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Objective of Robotics

- Industry Automation
- Smart, IoT and Embedded Systems
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4th Industrial Revolution

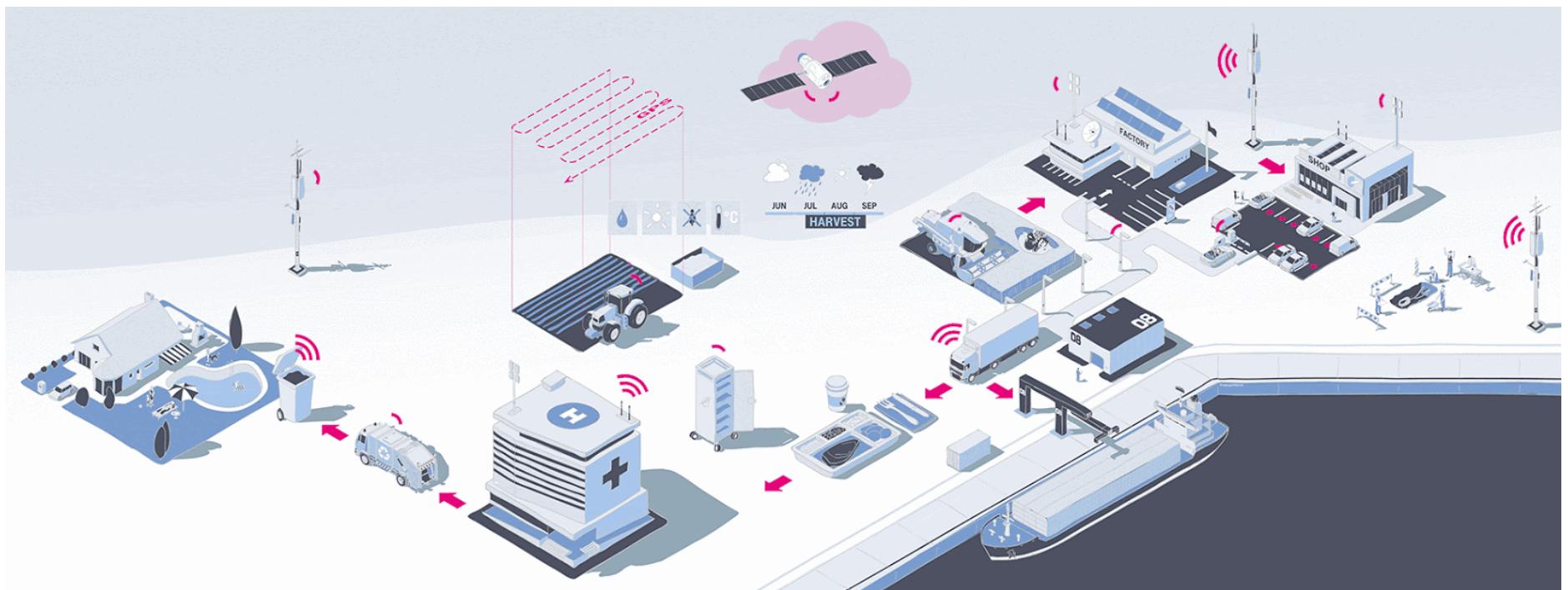
Industry Automation



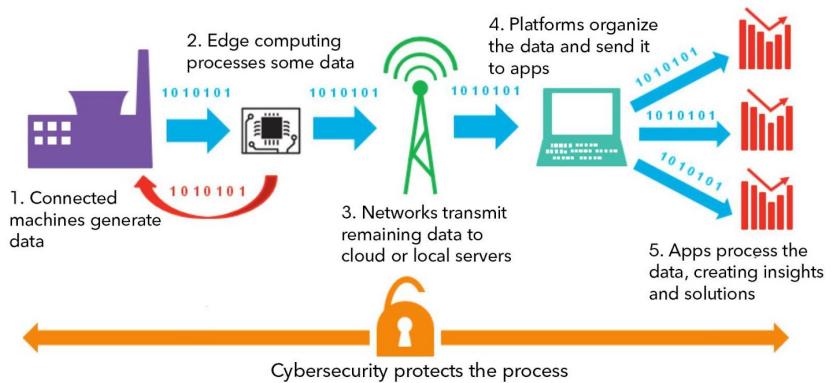


<https://www.youtube.com/watch?v=HX6M4QunVmA>

Connects Everything that has the ability to communicate automatically and Smart way



IoT+Cloud+Blockchain



Before 2005



Closed and centralized
IoT networks

Today



Open access IoT networks,
centralized cloud

2025 and beyond



Open access IoT networks,
distributed cloud

By Fusion of technologies...



Application specific Robot

Application specific Robot

Application specific Robot



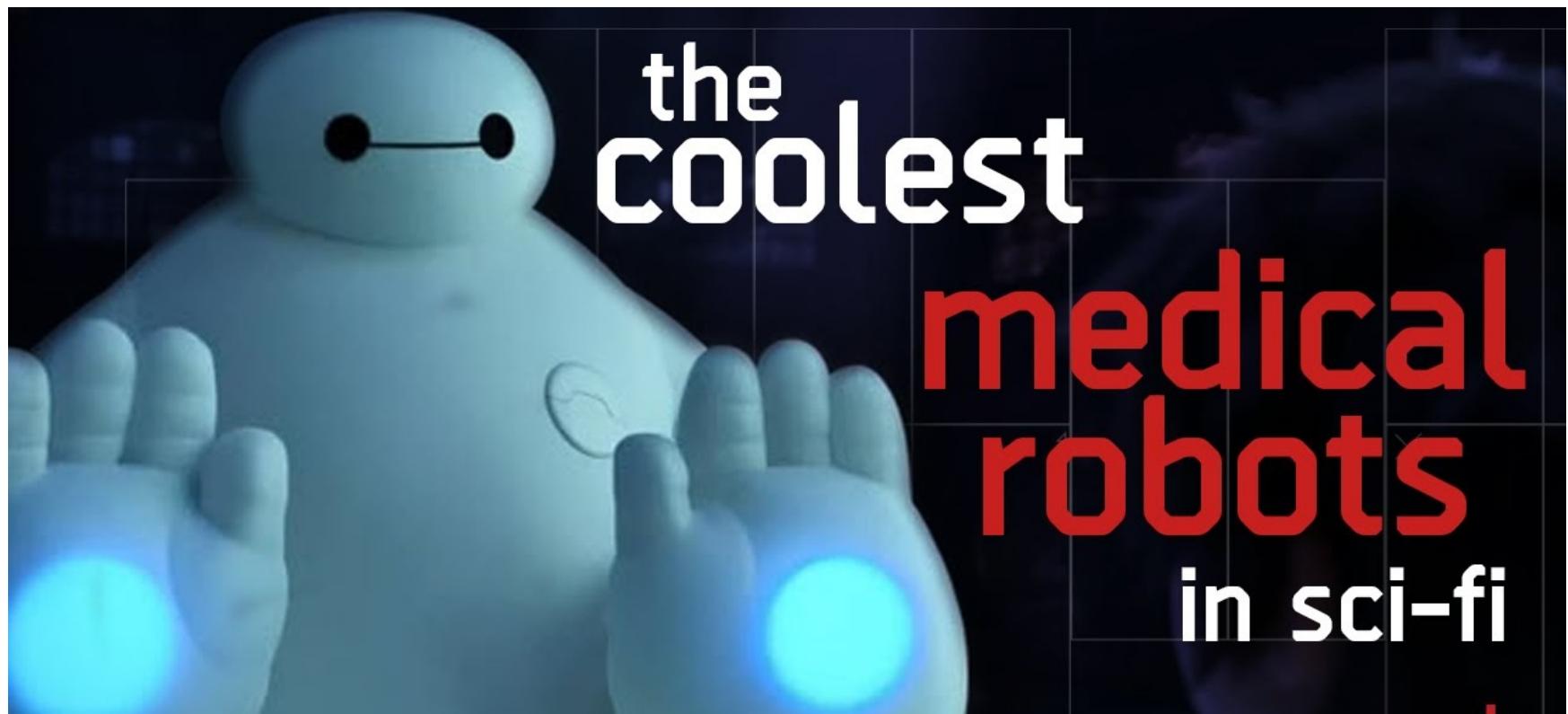
Application specific Robot



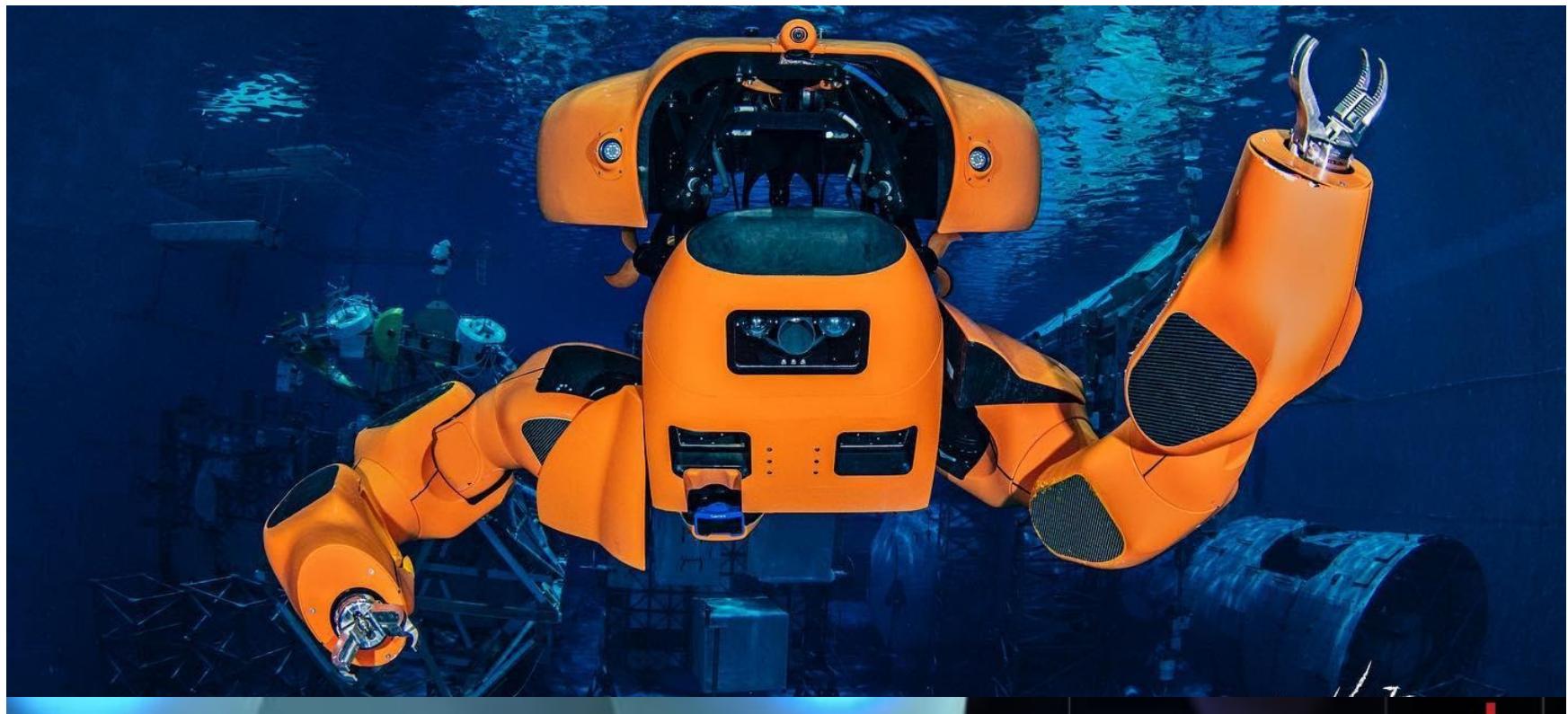
Application specific Robot



Application specific Robot



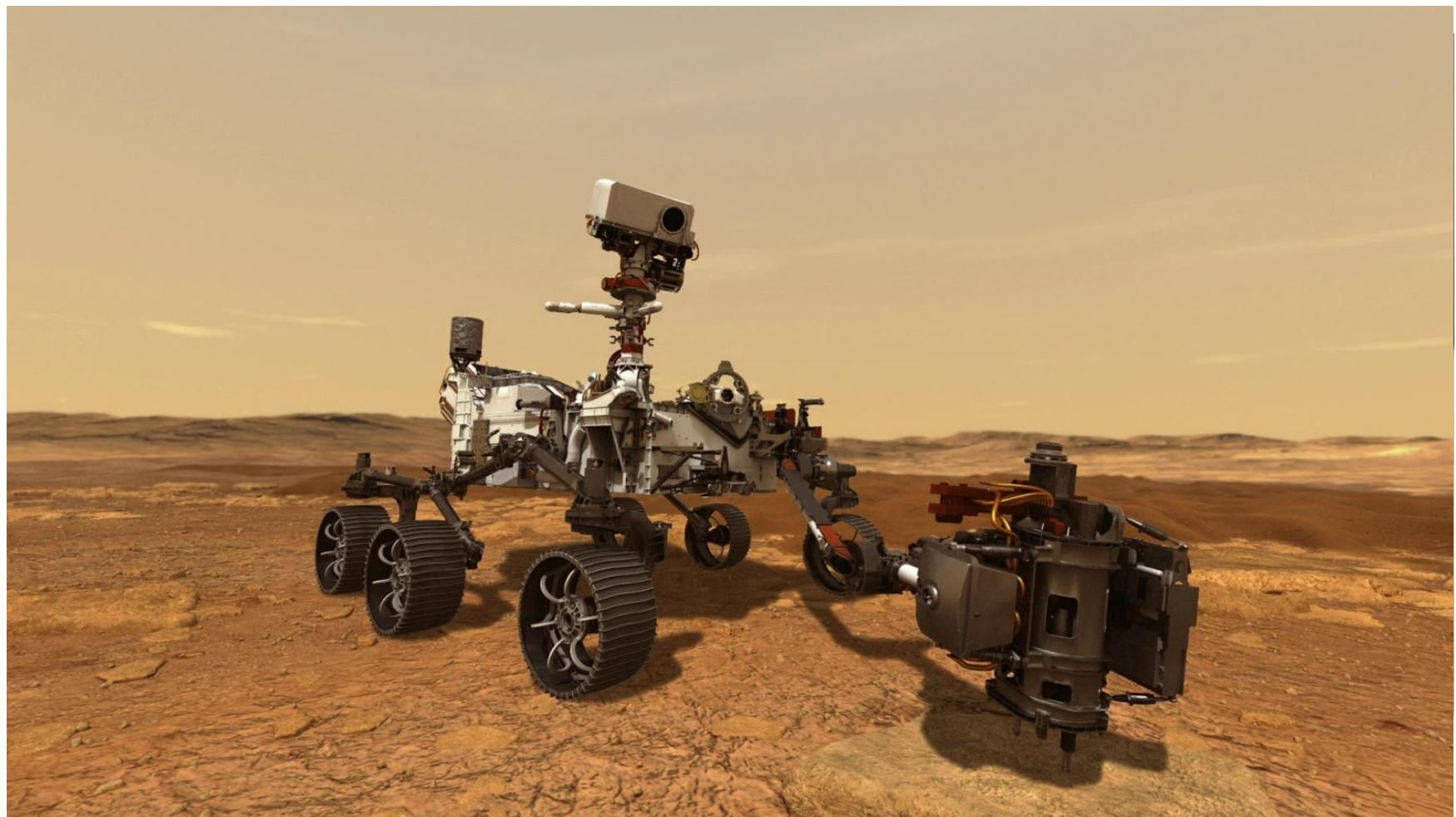
Application specific Robot



Application specific Robot



Application specific Robot



What is our ultimate goal?

- Robotics
- Embedded System
- Super Human (Ironman)
- Intelligent Machine



Why Intelligent Machines?

- Energy Saving
- Accuracy
- Convenience
- Efficiency
- Adaptability in Dynamic Environment
- Perform Dull, Dirty, difficult and Dangerous Job



Do Things that Living Things Can't



- **Fukushima**
- **World Trade center**
- **RANA Complex**
- **Tajrin fashion**



Dull, Dirty, difficult and Dangerous



Dull, Dirty, difficult and Dangerous



Dull, Dirty, difficult and Dangerous



Dull, Dirty, difficult and Dangerous



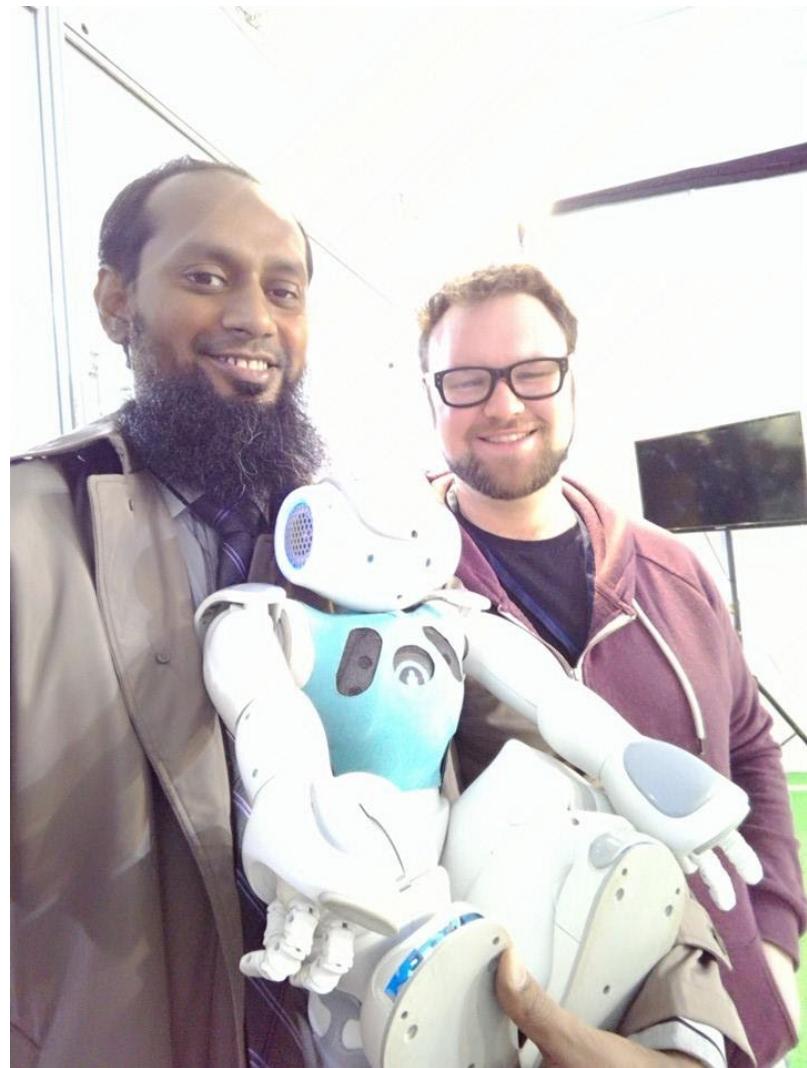
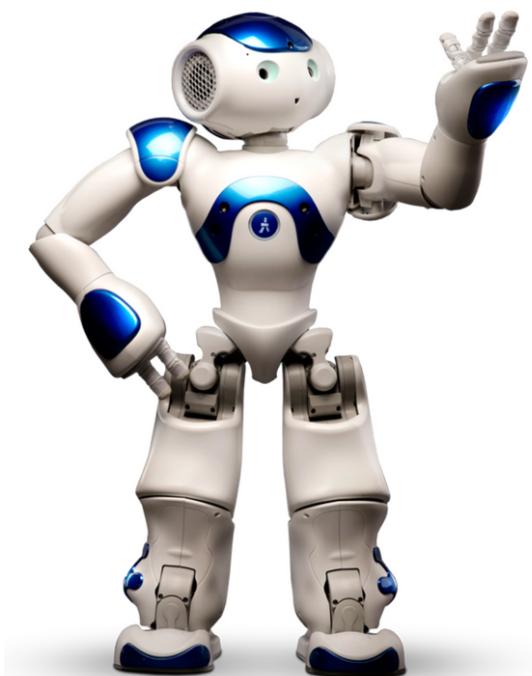
Dull, Dirty, difficult and Dangerous



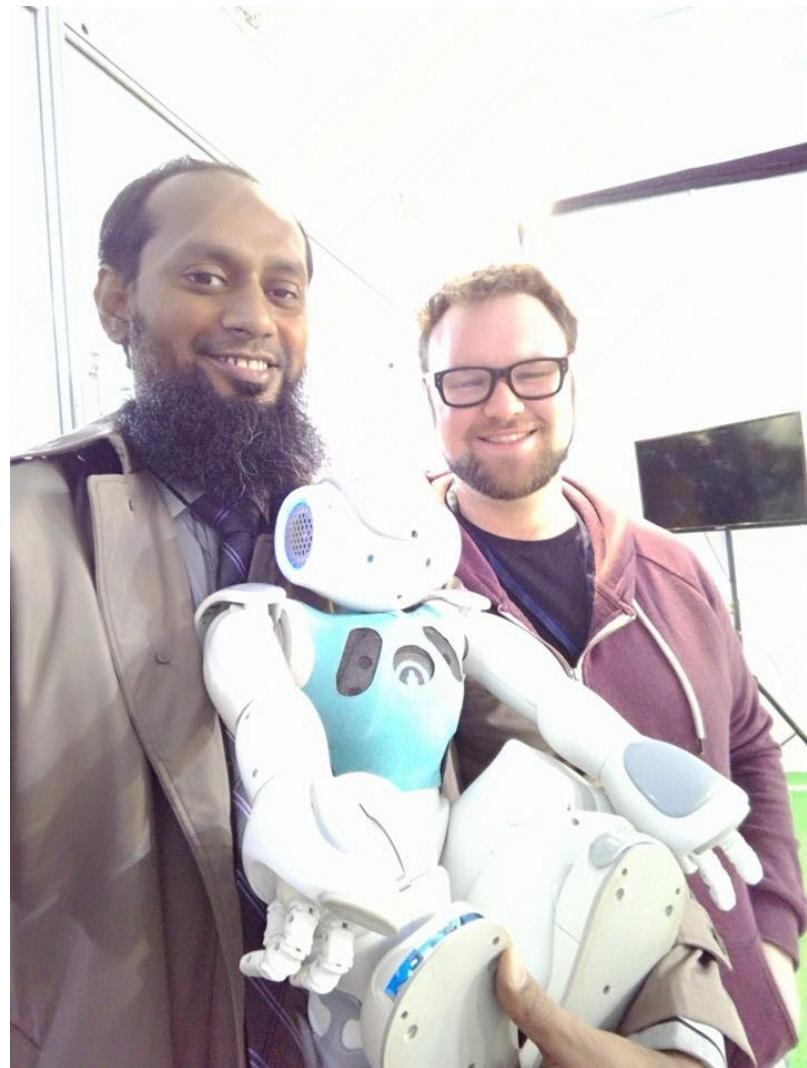
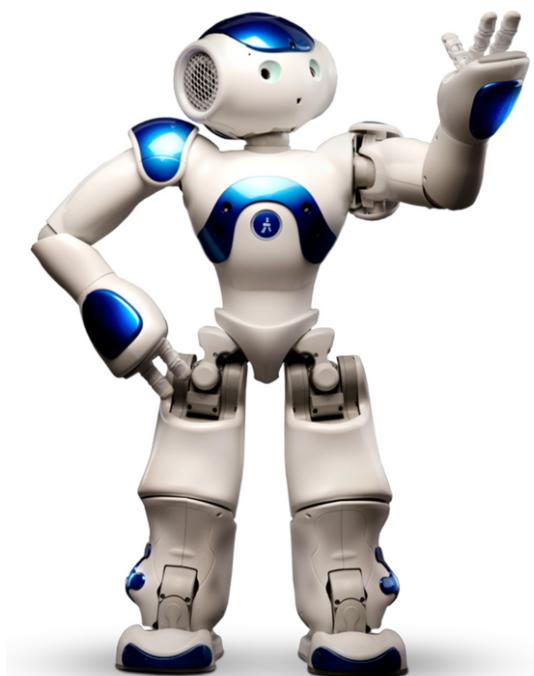
Why Superhuman?

- Limitation of:
 - Perfect Sensing
 - Numerical Processing
 - Muscle Power
 - Communication
 - Path planning
 - Localization
- Overcome by:
 - Sensor fusion
 - Computer
 - Motor, Actuator, Engine and Engineering
 - Communication Technologies and NLP
 - Algorithms
 - GPS

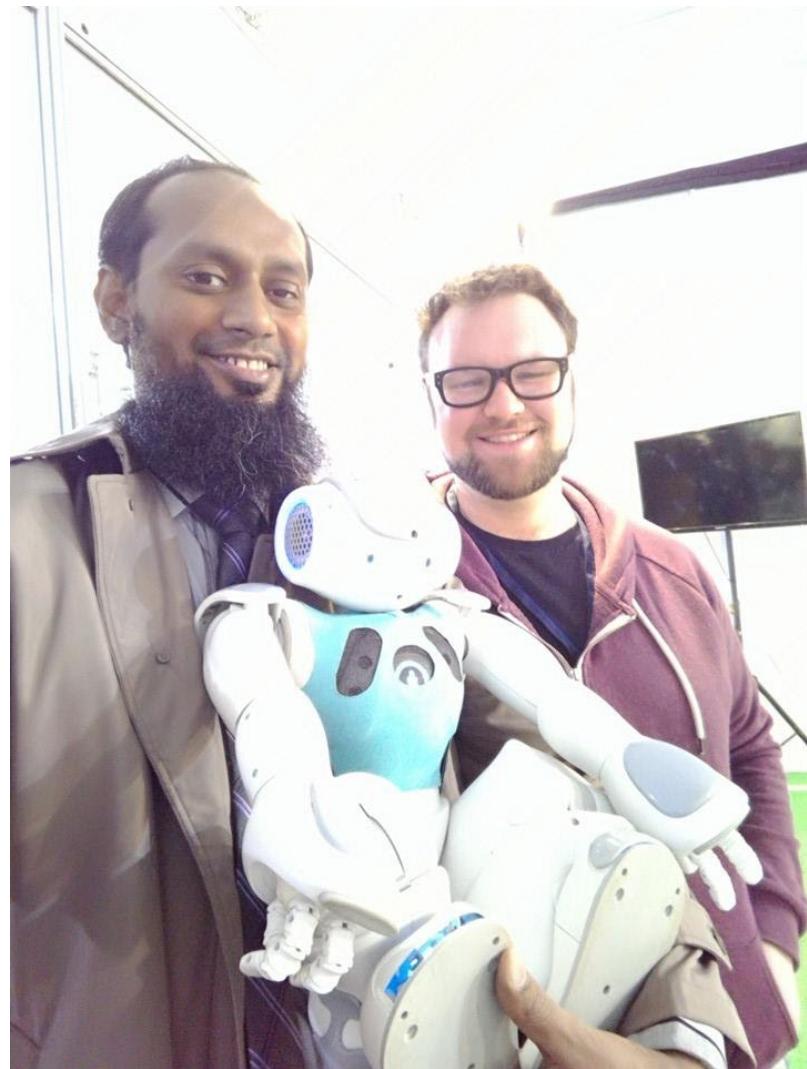
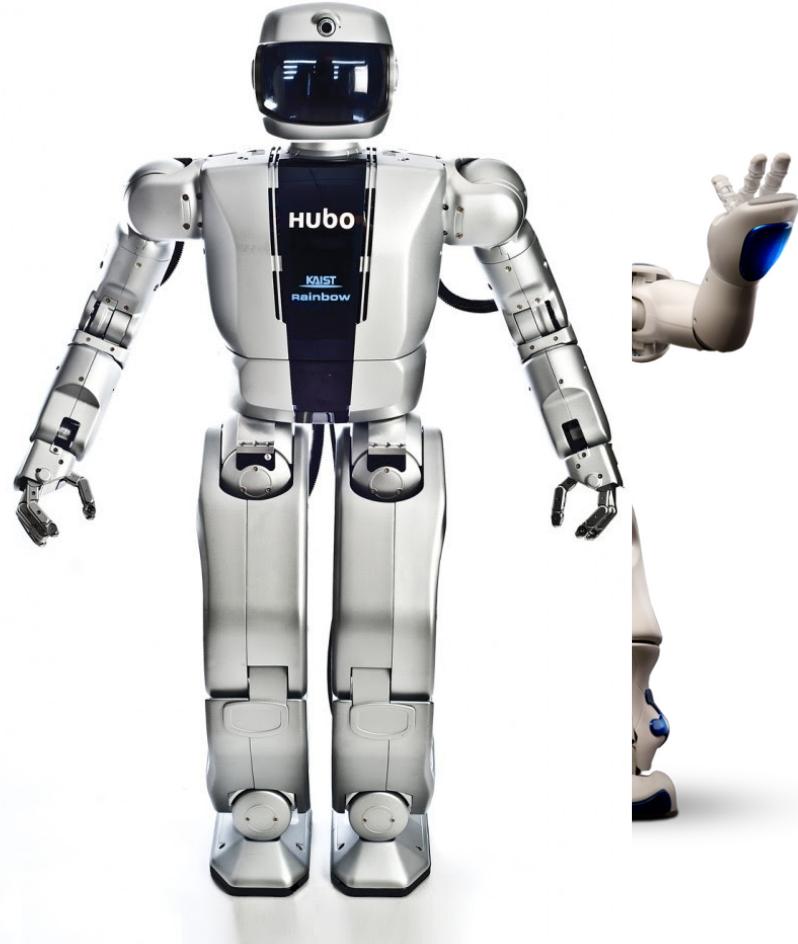
Popular Humanoid Robot



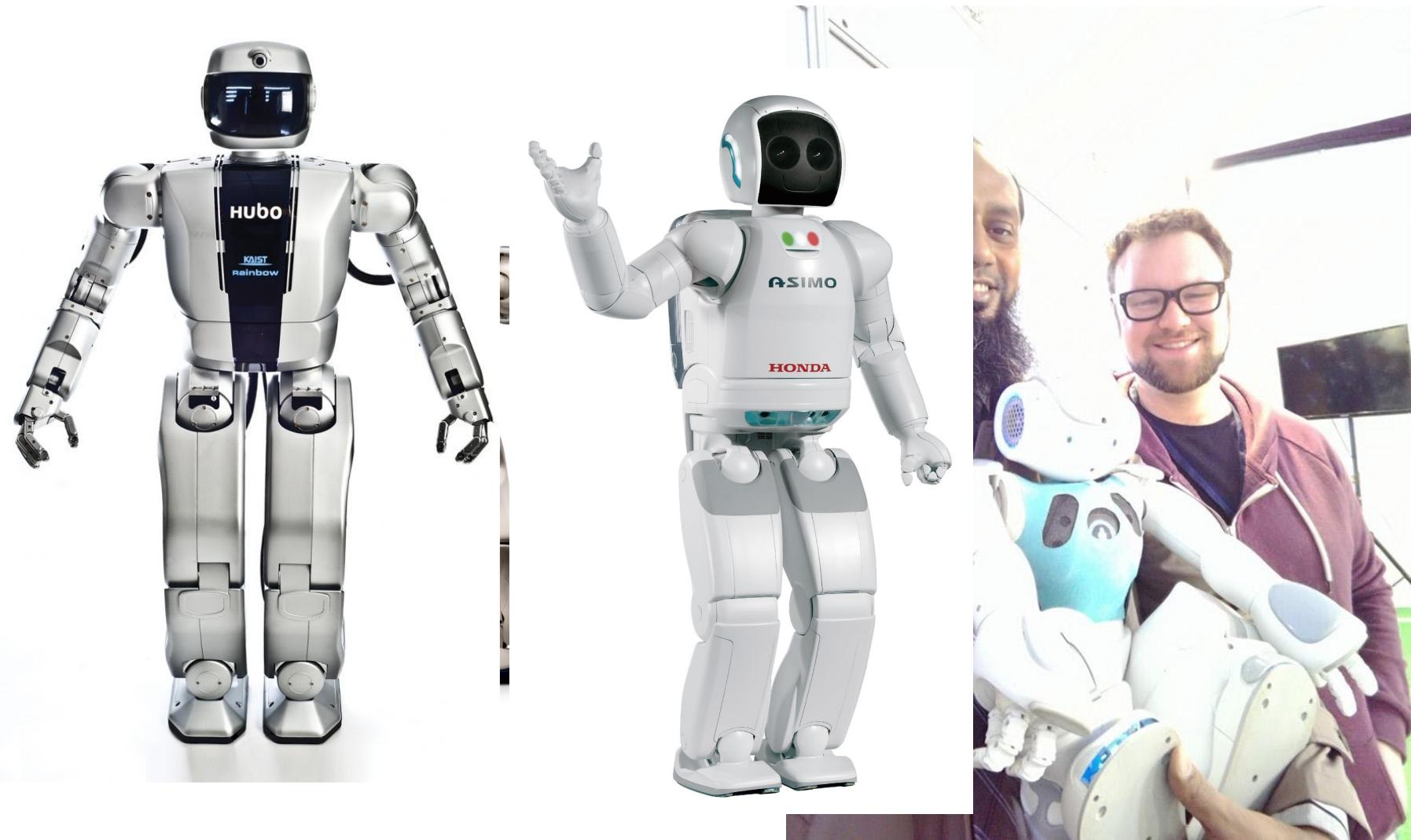
Popular Humanoid Robot



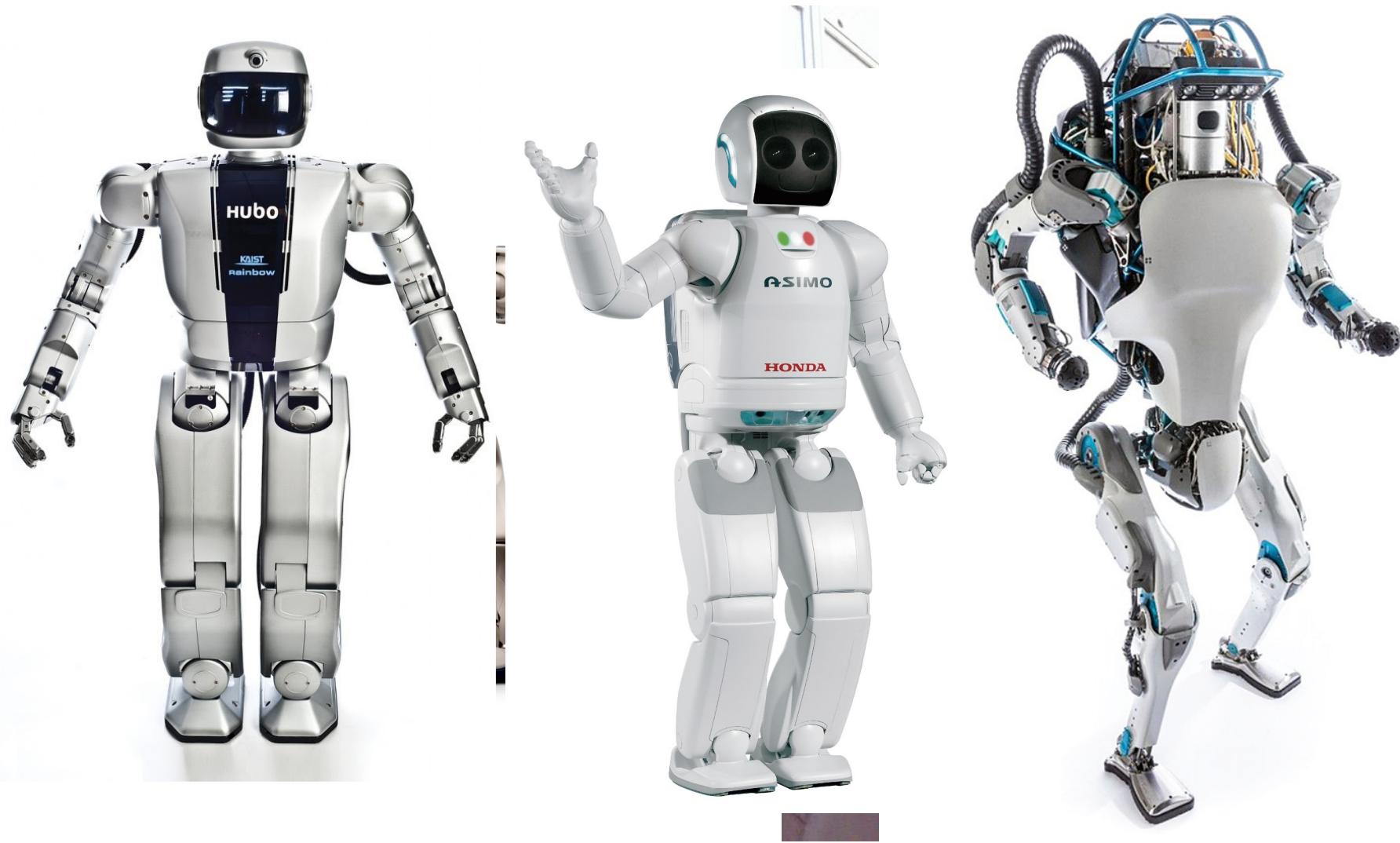
Popular Humanoid Robot



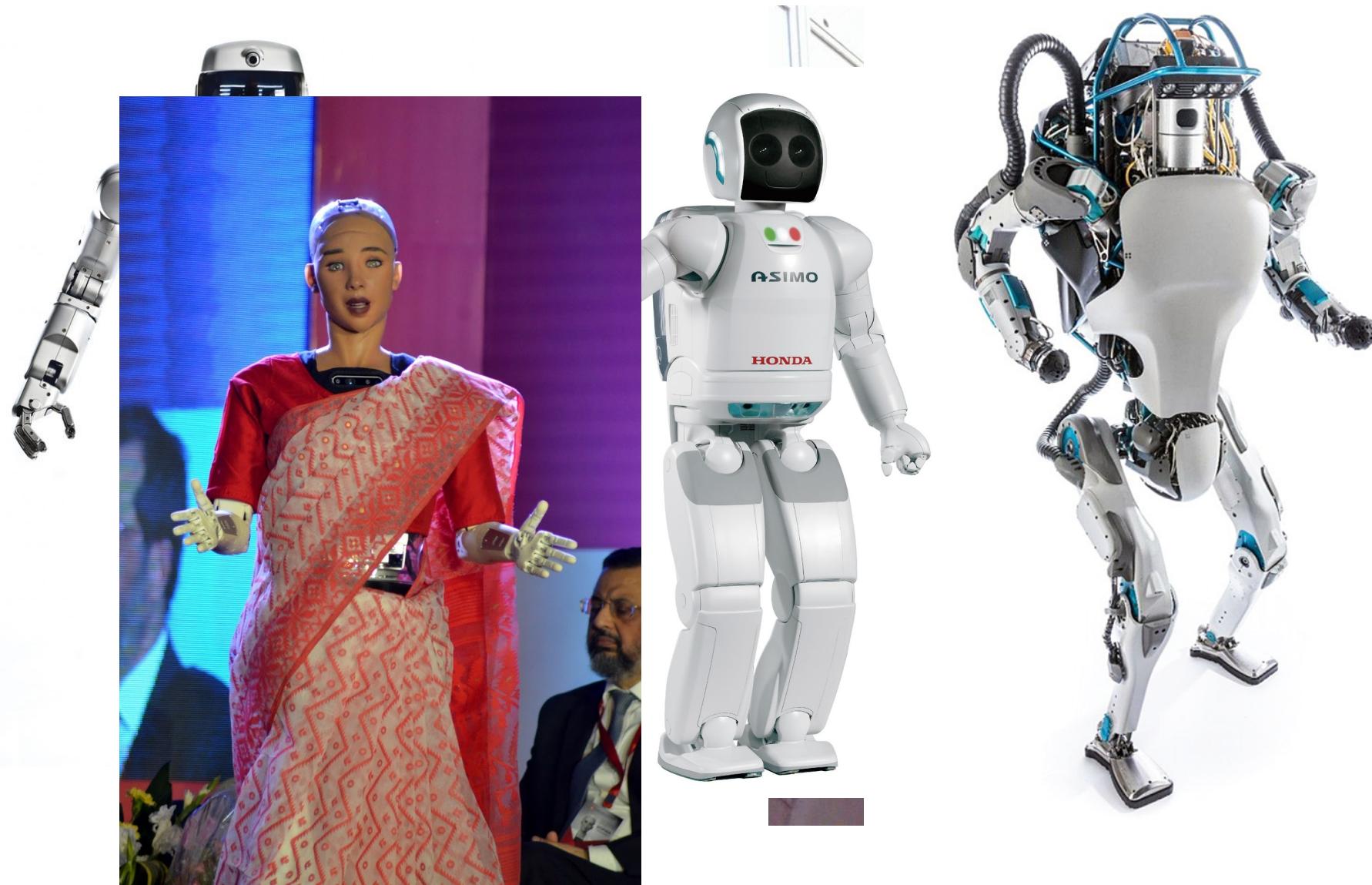
Popular Humanoid Robot



Popular Humanoid Robot



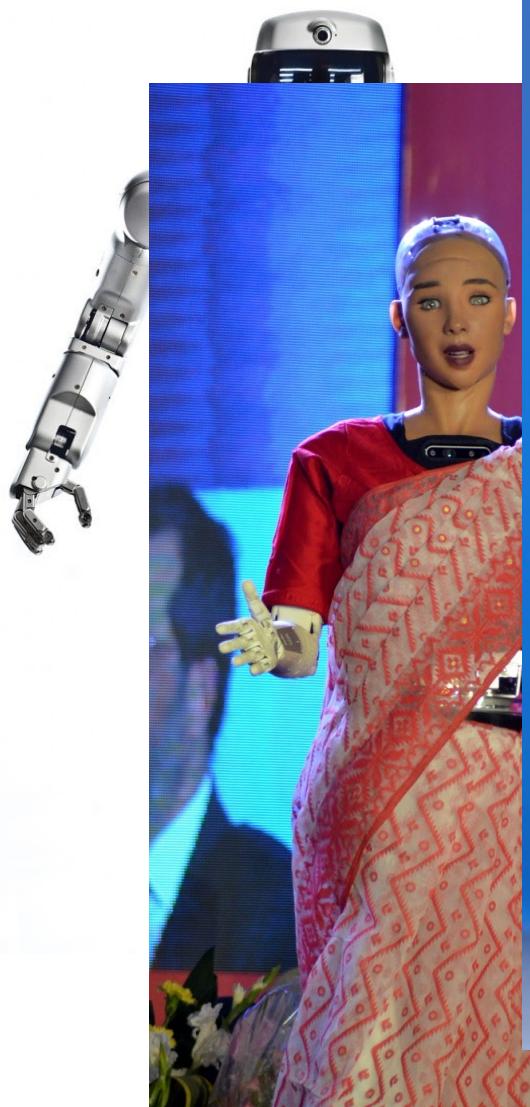
Popular Humanoid Robot



Popular Humanoid Robot



Pop Robot



Law of AI Robot

1. A robot must not harm human being, nor through in action allow one to come to harm.
2. A robot must always obey human beings, unless that is in conflict with the first law.
3. A robot must protect from harm, unless that is in conflict with the first two laws.
4. A robot always should have a kill switch.

Thumb Rules on the decision of a Robot Uses

- The first rule to consider, what is known as the Four D of Robotics, i.e. is the task dirty, dull, dangerous, or difficult? If so, a human will probably not be able to do the job efficiently. Therefore, the job is appropriate for automation or for robotic labor.
- The second rule is that a robot may not leave a human jobless. Robotics and automation must serve to make our lives more enjoyable, not miserable.
- A third rule involves asking whether you can find people who are willing to do the job. If not, the job is a candidate for automation and Robotics.
- A four rule of thumb is that the use of robots or automation must make short-term and long-term economic sense.

Uncrewed Vehicle

- Remote control vehicle (RC)
- Unmanned ground vehicle (UGV)
- Unmanned aerial vehicle (UAV)
 - Unmanned combat aerial vehicle (UCAV)
 - Miniature UAV (MUAV)
 - Delivery drone
 - Micro air vehicle (MAV)
 - Target drone
- Autonomous spaceport drone ship
- Unmanned surface vehicle (USV)
- Unmanned underwater vehicle (UUV)
 - Remotely operated underwater vehicle (ROUV)
 - Autonomous underwater vehicle (AUV)
- Uncrewed spacecraft: robotic spacecraft or space probe



Remote control vehicle (RC)



Unmanned ground vehicle (UGV)



Unmanned aerial vehicle (UAV)



Unmanned combat aerial vehicle (UCAV)
Miniature UAV (MUAV)
Delivery drone
Micro air vehicle (MAV)
Target drone



Unmanned aerial vehicle (UAV)



Unmanned combat aerial vehicle (UCAV)
Miniature UAV (MUAV)
Delivery drone
Micro air vehicle (MAV)
Target drone



Unmanned aerial vehicle (UAV)



Unmanned combat aerial vehicle (UCAV)
Miniature UAV (MUAV)
Delivery drone
Micro air vehicle (MAV)
Target drone

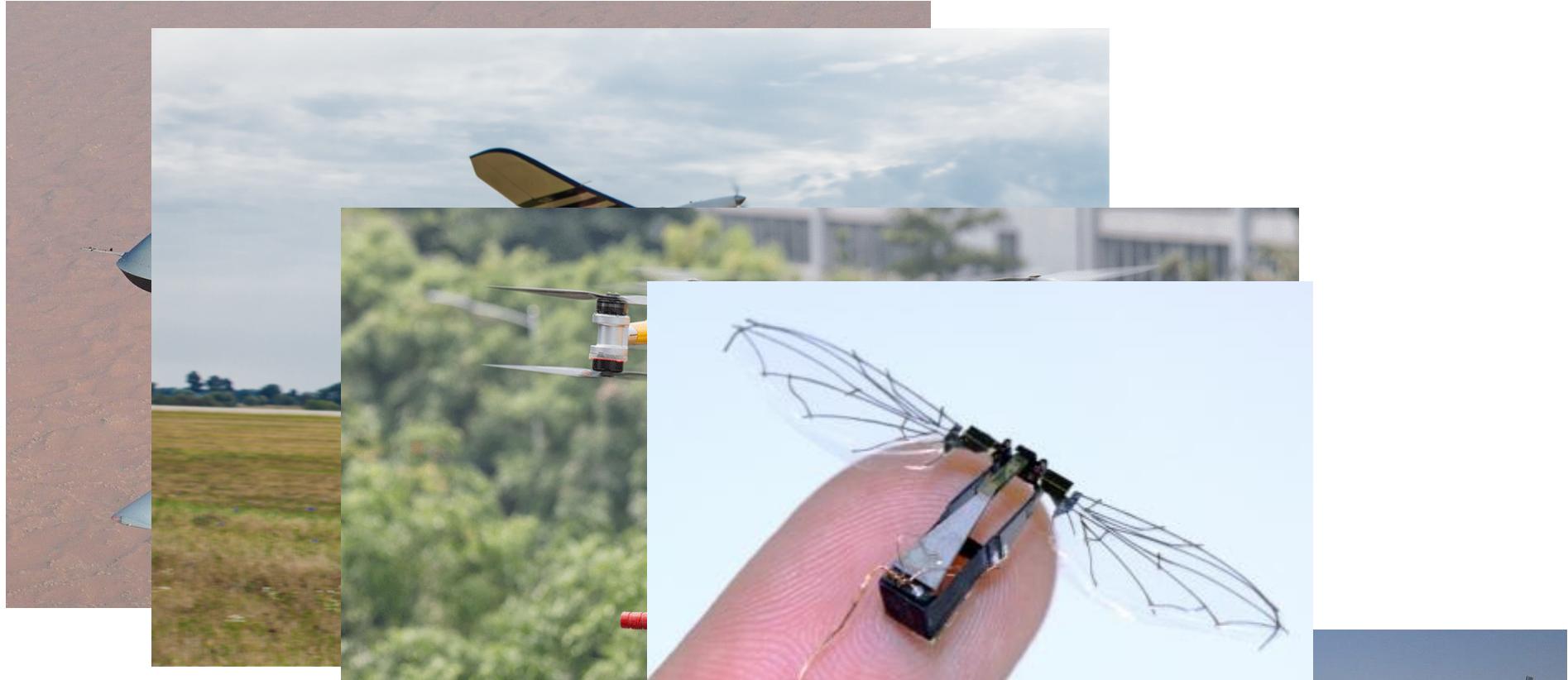


Unmanned aerial vehicle (UAV)



Unmanned combat aerial vehicle (UCAV)
Miniature UAV (MUAV)
Delivery drone
Micro air vehicle (MAV)
Target drone

Unmanned aerial vehicle (UAV)



Unmanned combat aerial vehicle (UCAV)
Miniature UAV (MUAV)
Delivery drone
Micro air vehicle (MAV)
Target drone



Unmanned aerial vehicle (UAV)



Unmanned combat aerial vehicle (UCAV)
Miniature UAV (MUAV)
Delivery drone
Micro air vehicle (MAV)
Target drone



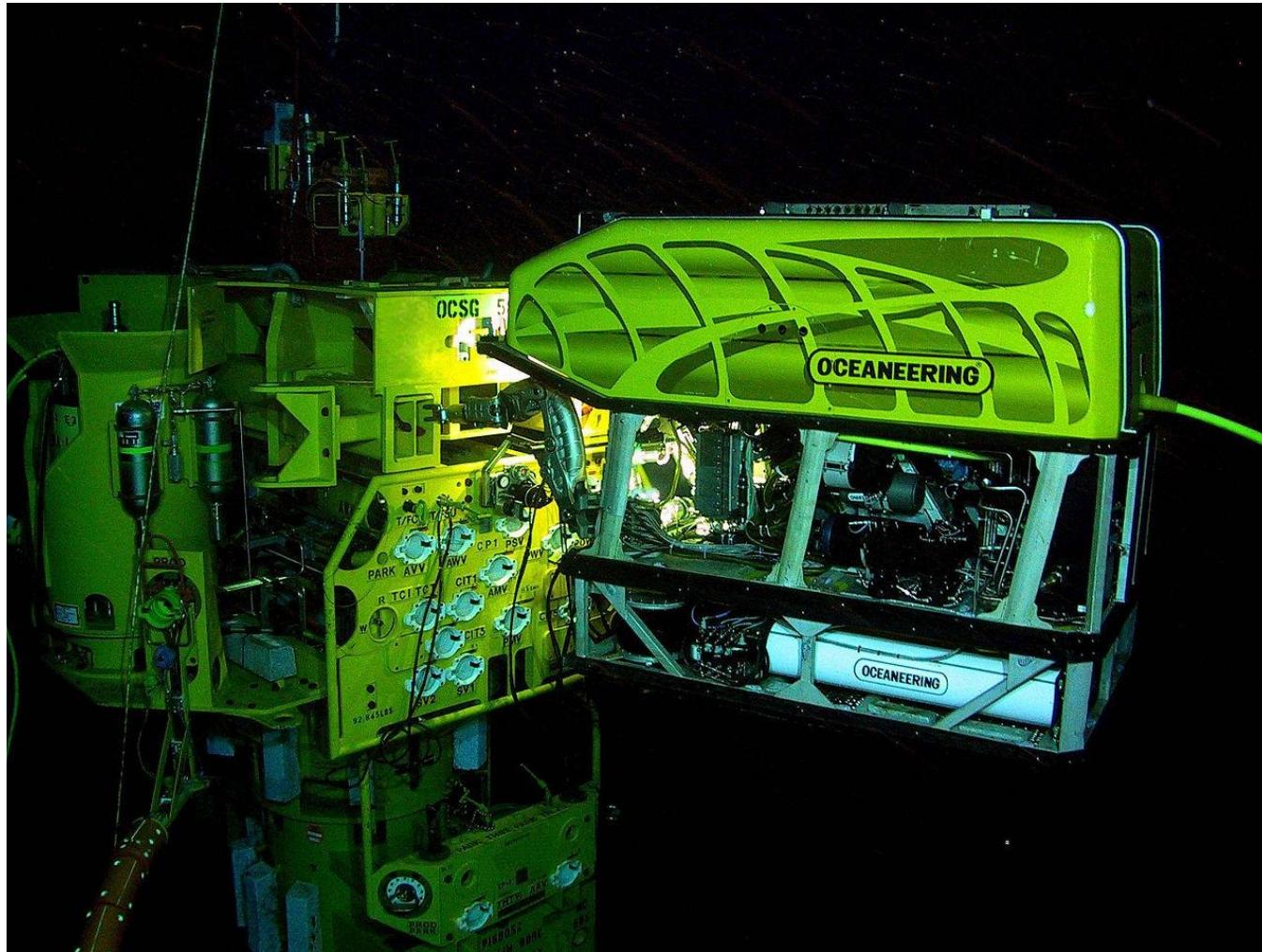
Autonomous spaceport drone ship



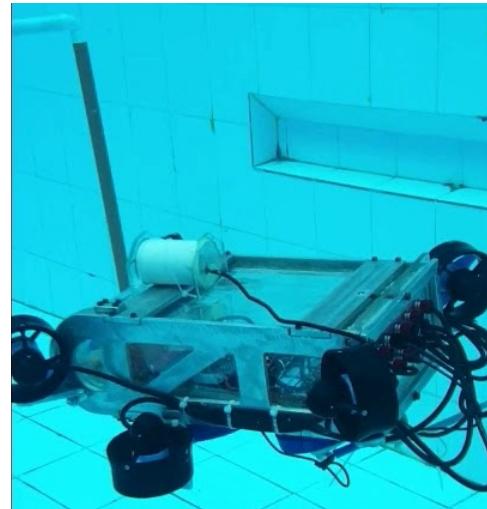
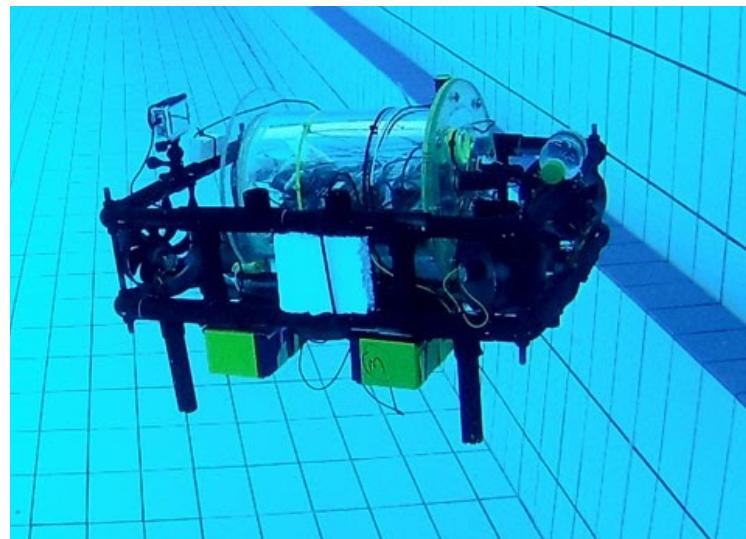
Unmanned surface vehicle (USV)



Remotely operated underwater vehicle (ROUV)

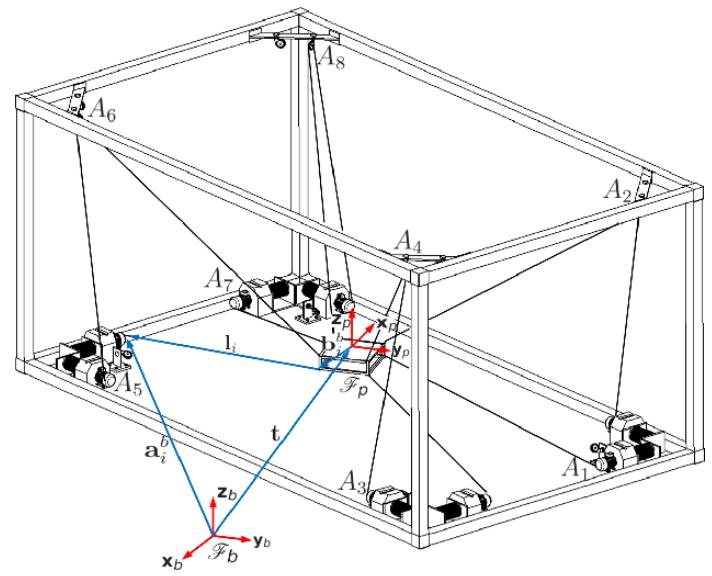
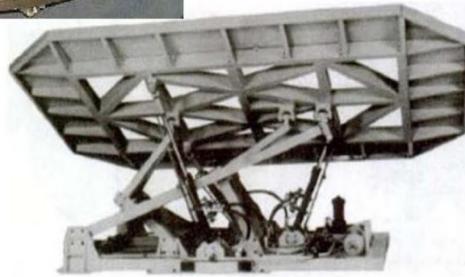


Autonomous underwater vehicle (AUV)



Parallel Robot

- Flight Simulator
- Milling Machine
- Cable Driven Parallel Robot



3D Printer



3D Printer



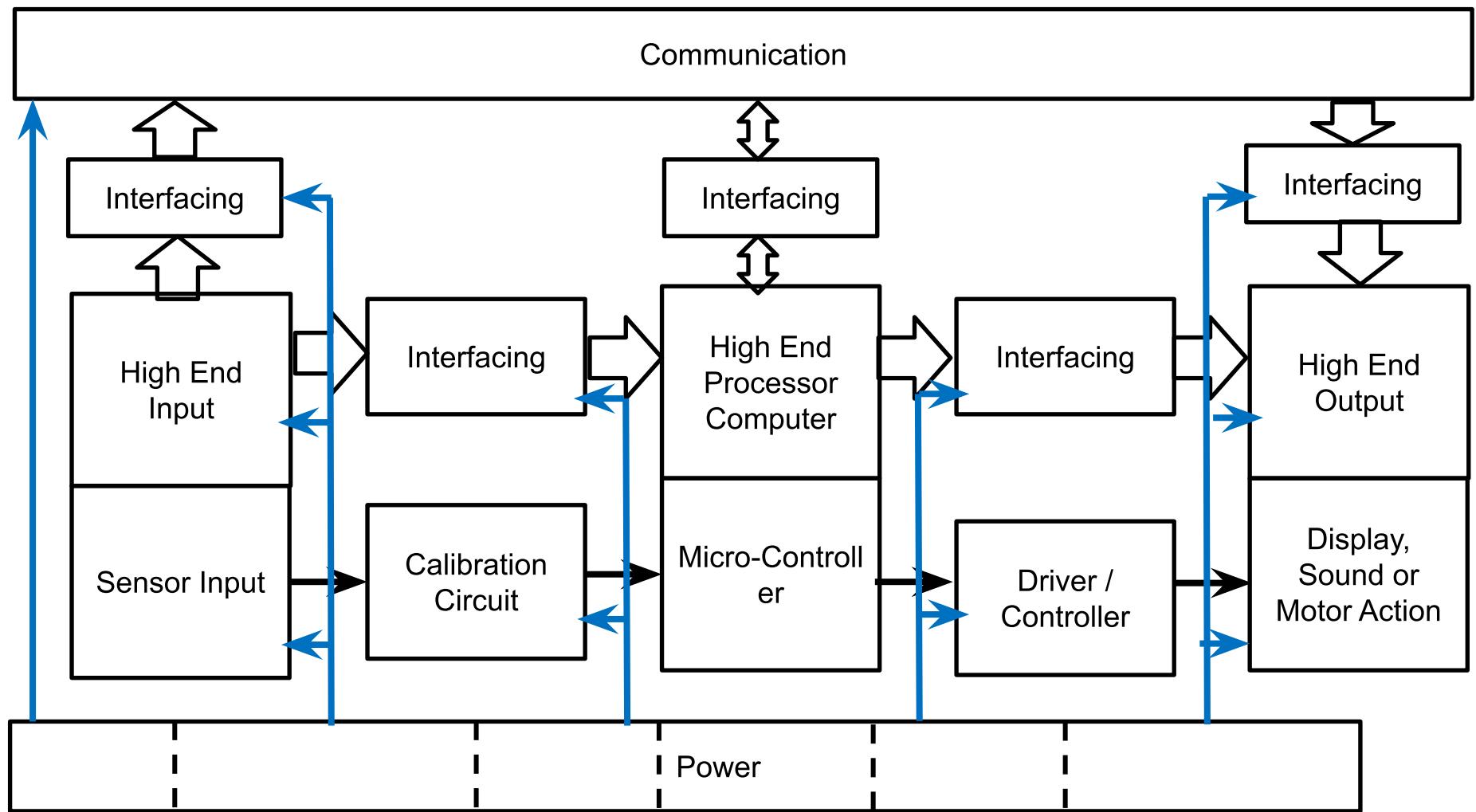
3D Printer



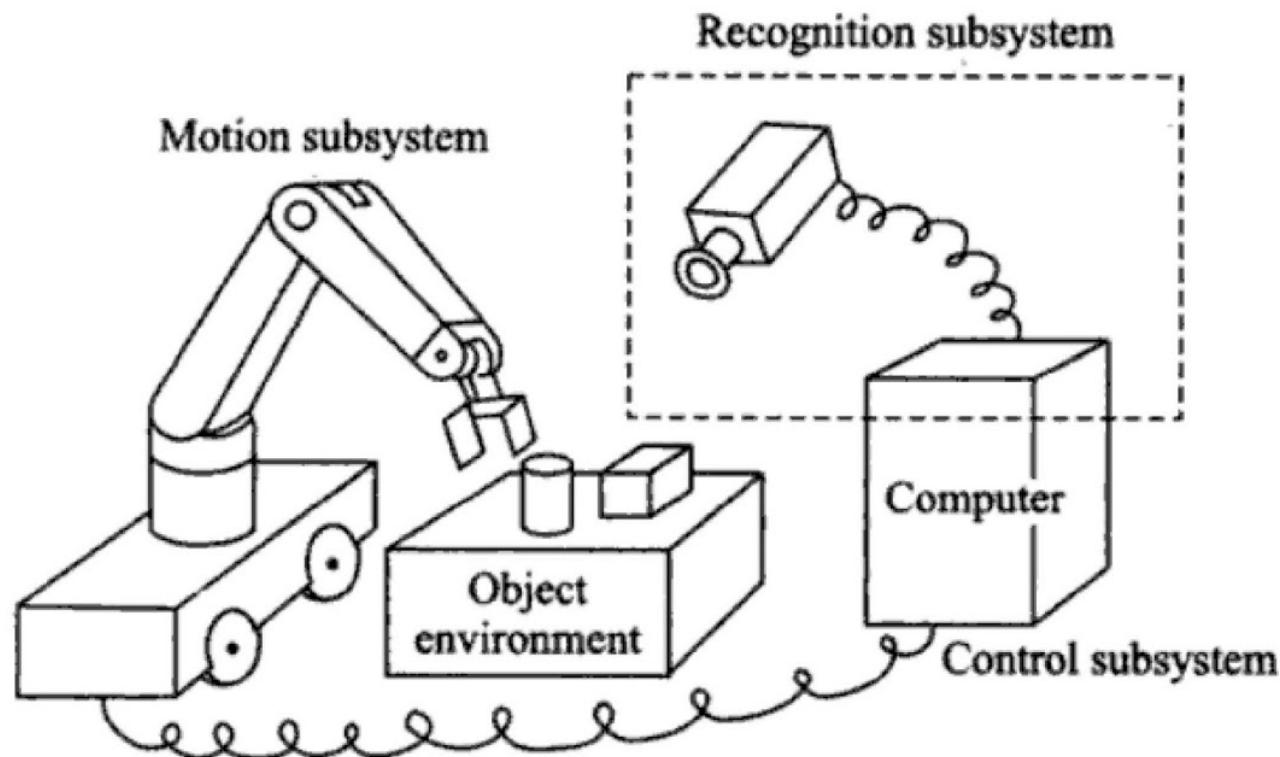
Sub-Systems

- Sense/Perception
- Plan/Control
- Act/Motor Action
- Power
- Communication

Hardware Architecture

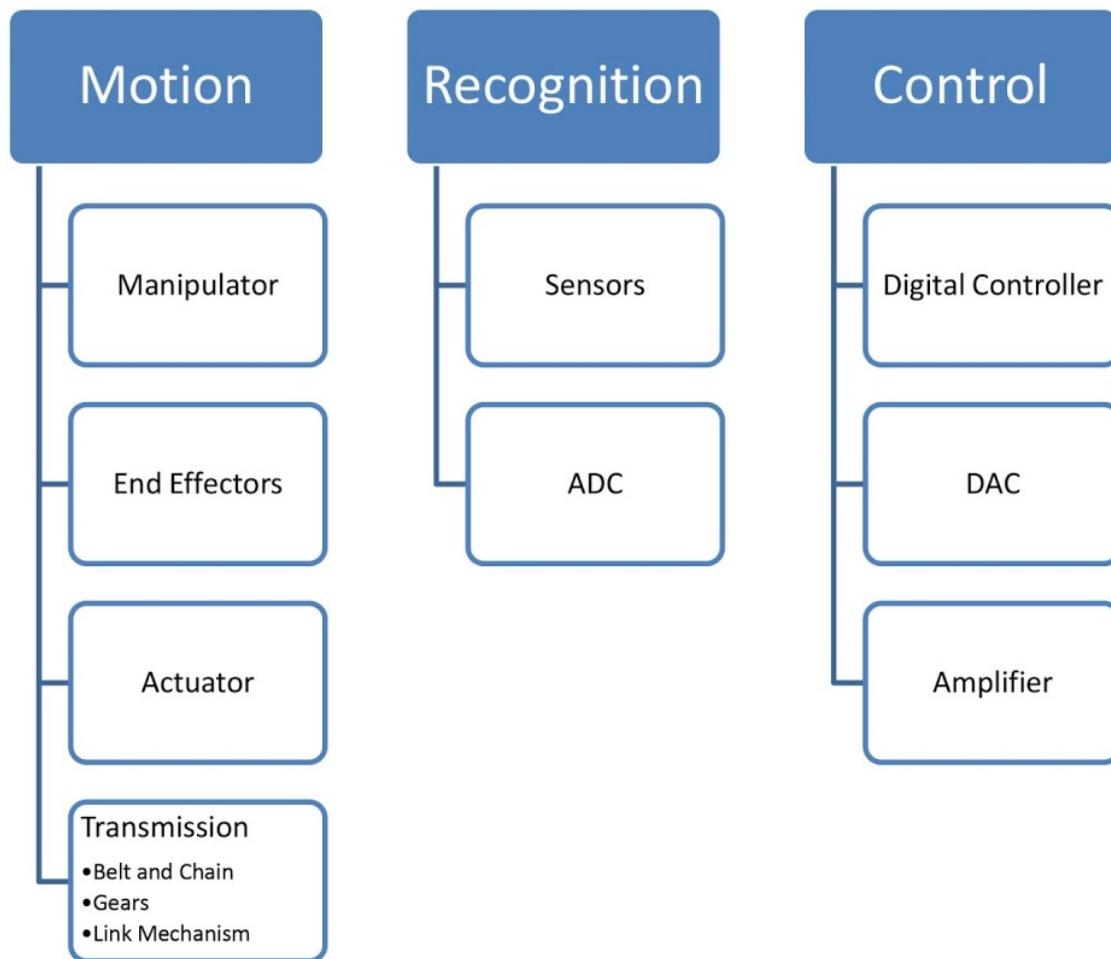


Robot Sub-systems

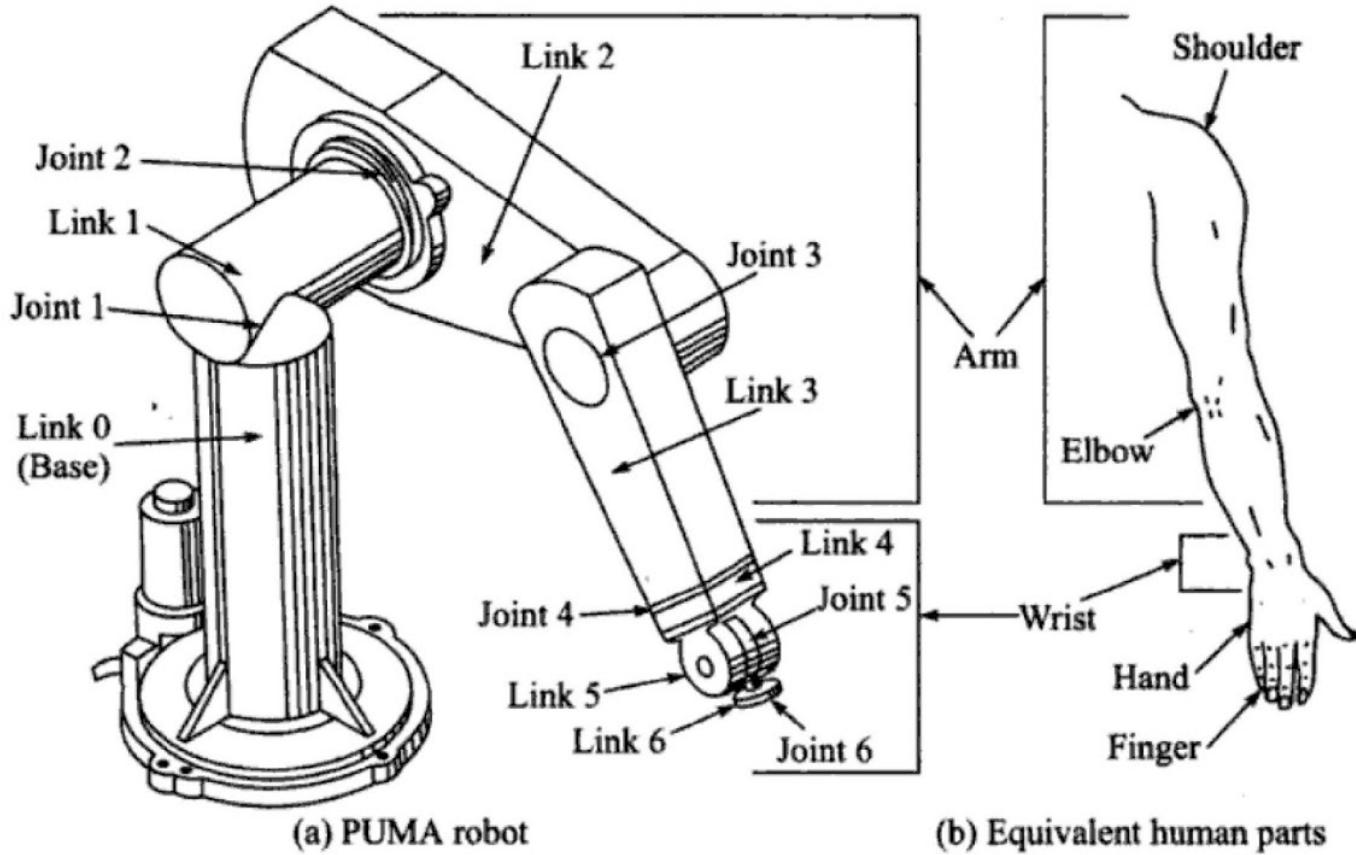


- Sense
- Plan
- Act

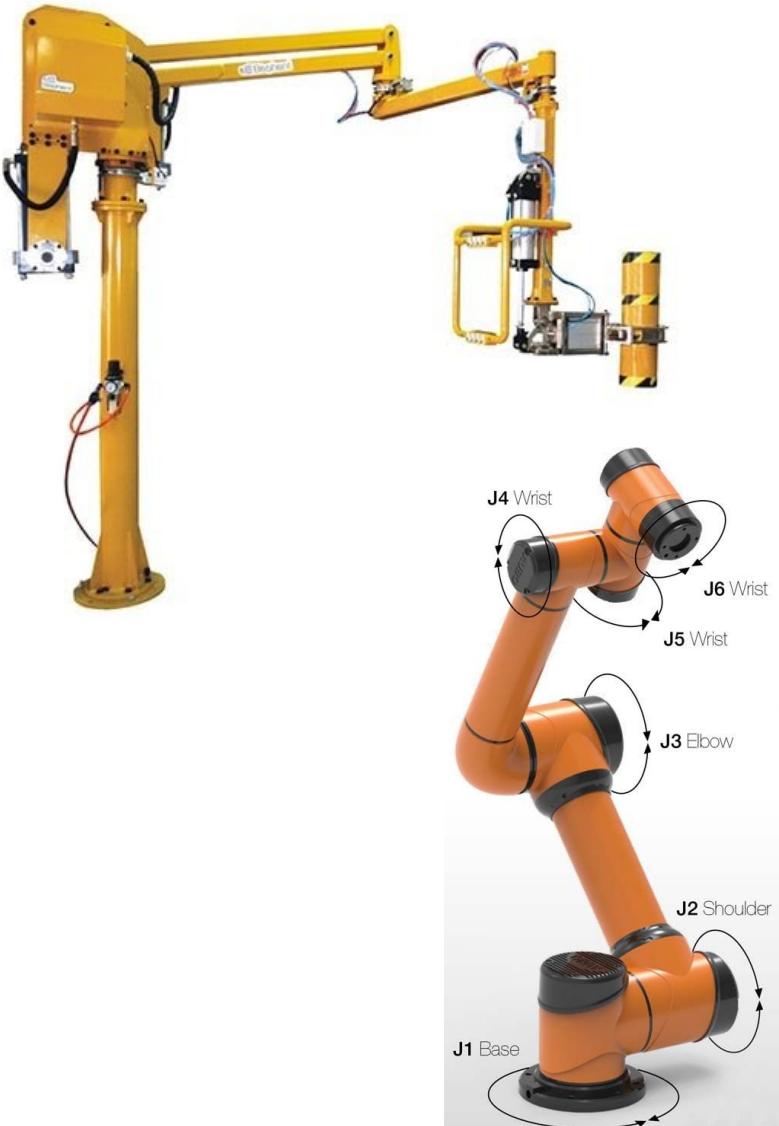
Subsystems



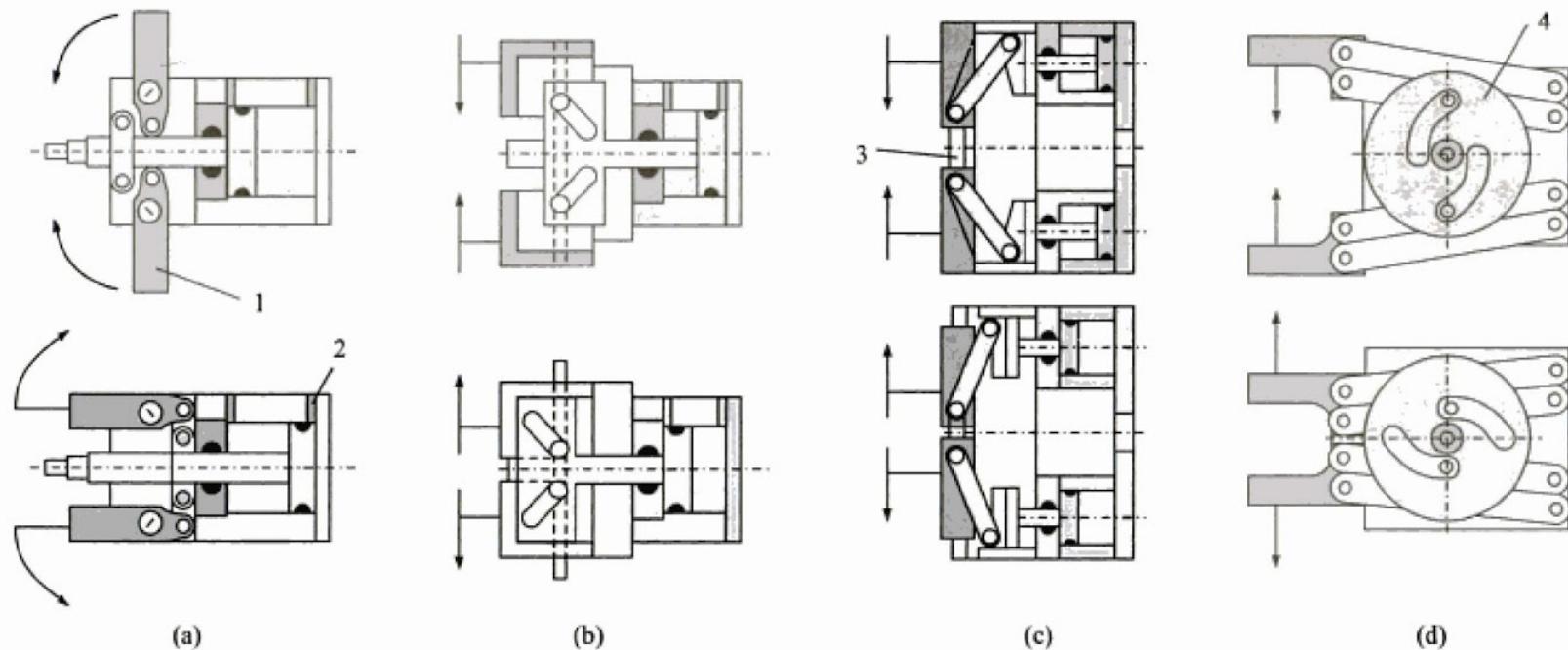
Manipulator



Manipulator

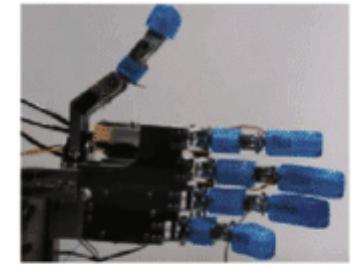
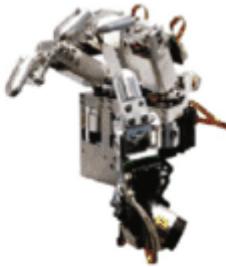
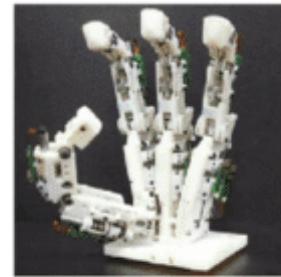


End-effector



1: Big jaw or finger; 2: Pneumatic cylinder; 3: Straight guideway; 4: Cam disk

End Effector

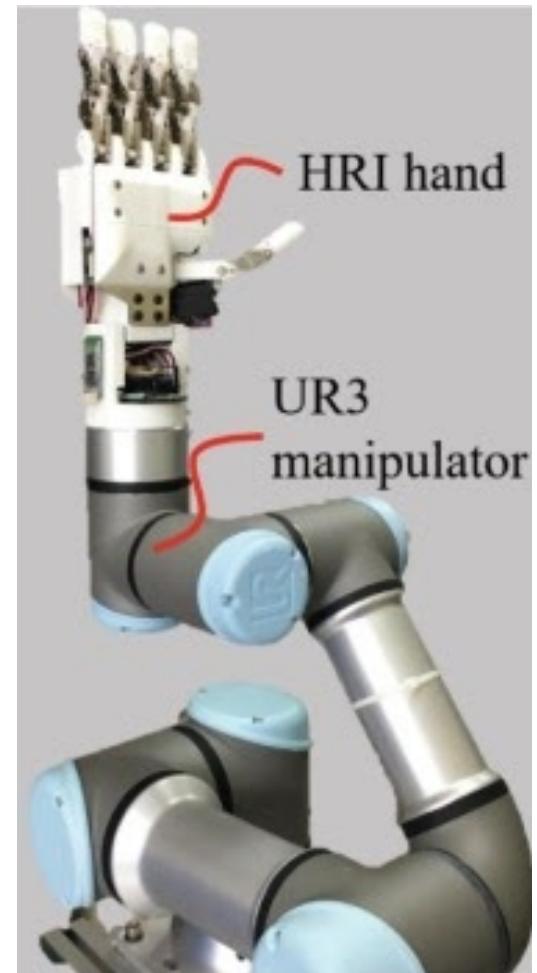
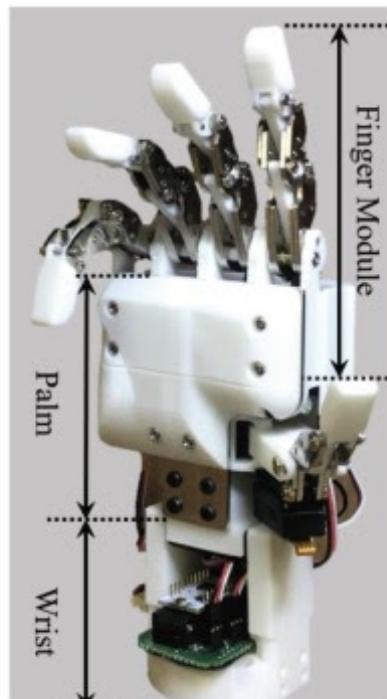
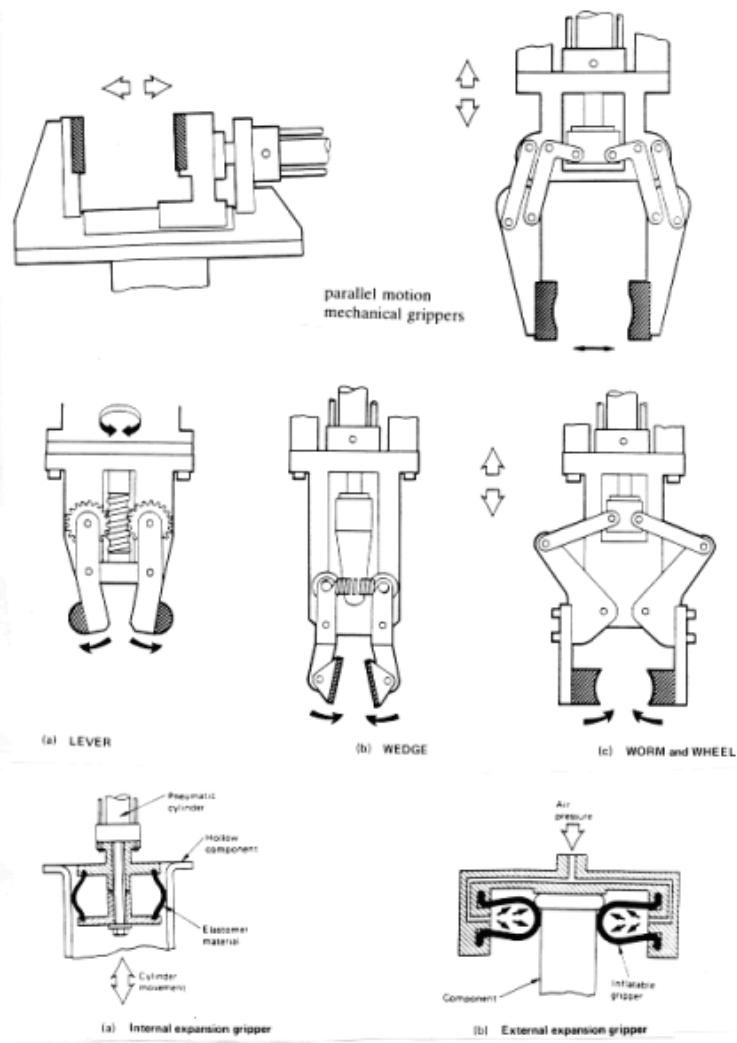


(a)

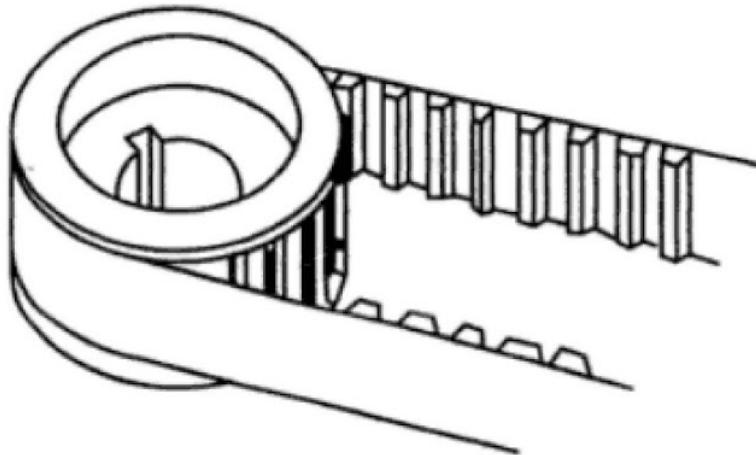
(b)

Two types of fingered end-effectors: (a) gripper type, (b) anthropomorphic type

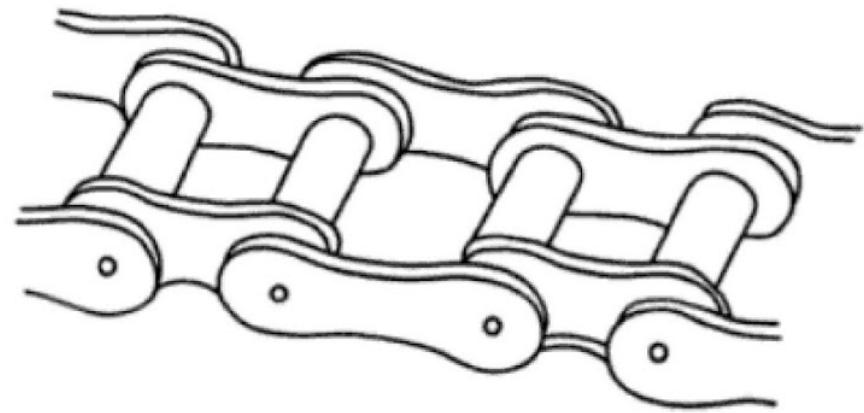
End Effector



Transmission (Belt and chain)

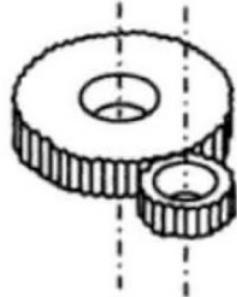


(a) Synchronous belt



(b) Roller chain

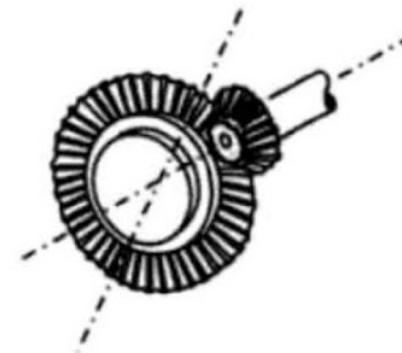
Transmission (Gears)



Spur gears



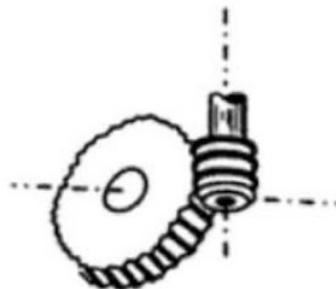
Helical gears



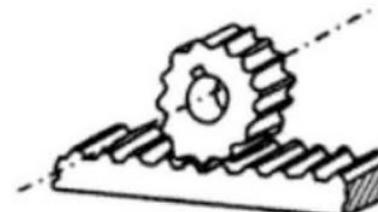
Straight bevel



Spiral bevel

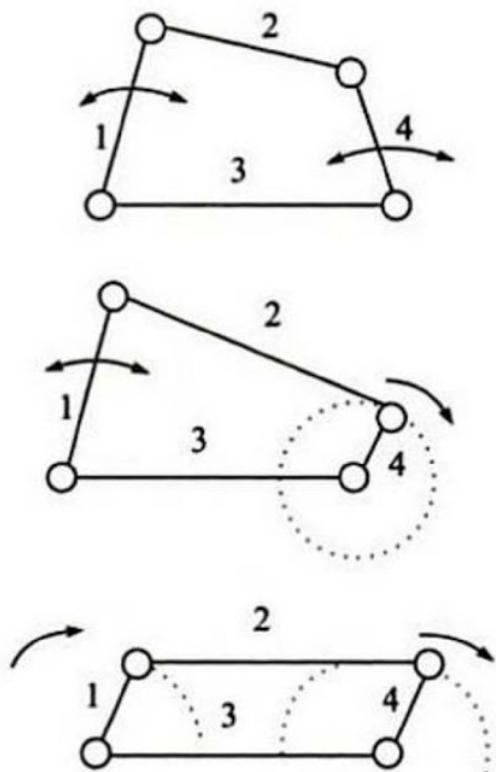


Worm

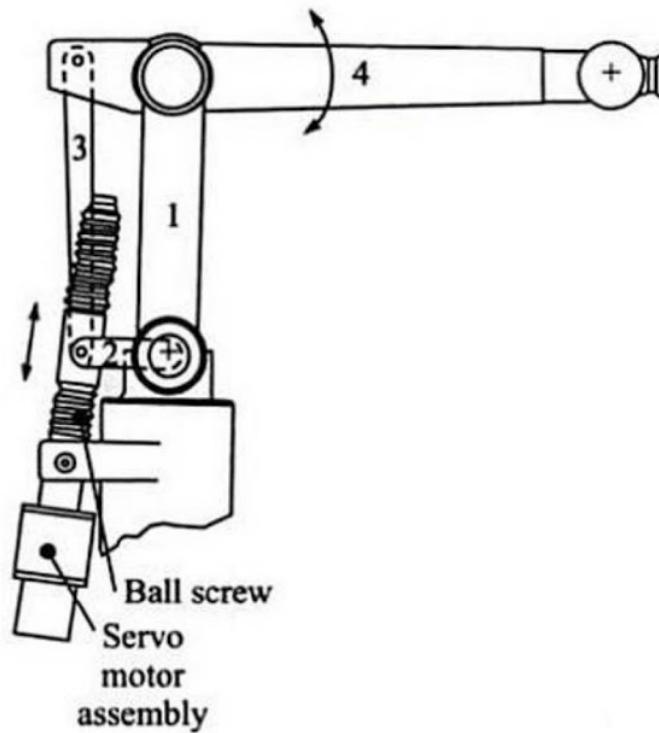


Rack and pinion

Transmission (Link Mechanism)



(a) Four-bar mechanisms



(b) Use of mechanisms in robot manipulator

Fig. 2.7 Mechanisms and their use in robot manipulator

DC, Stepper, Servo, Induction Motor

Motion

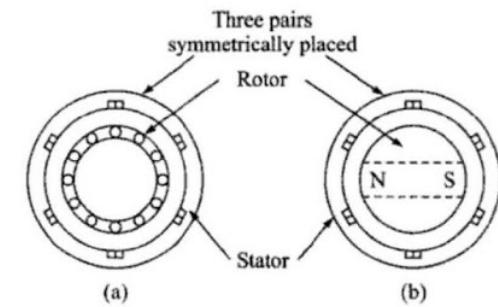
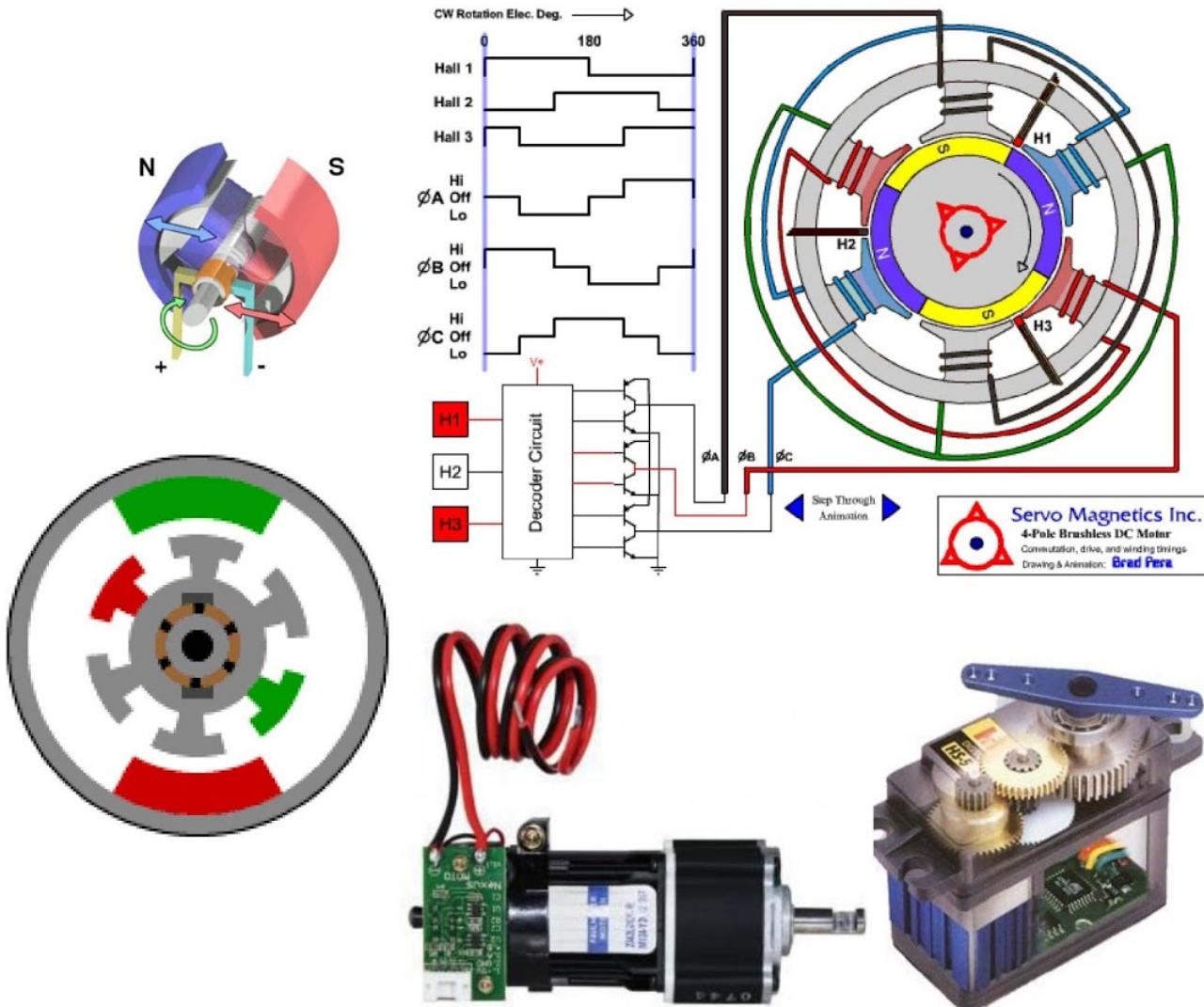


Fig. 3.13 AC three-phase motor

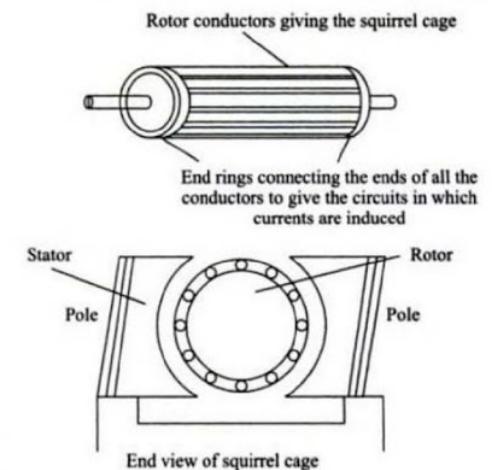


Fig. 3.12 Single-phase induction motor

Actuators



Pneumatic Actuator

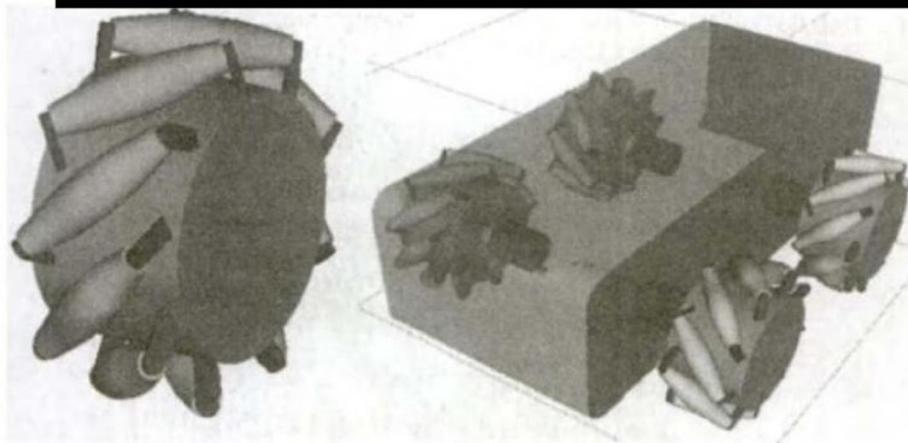
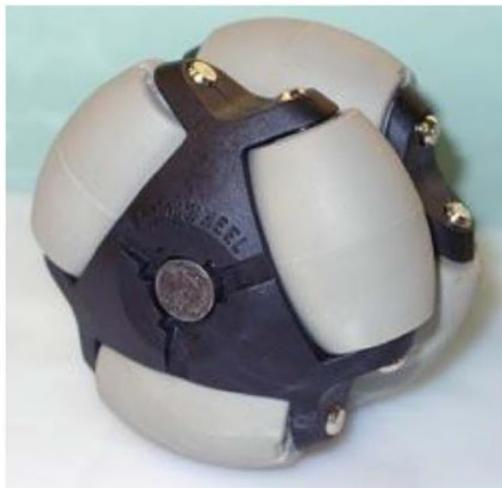


Hydraulic Actuator



Electric Actuator

AGV with Multi Directional Wheel

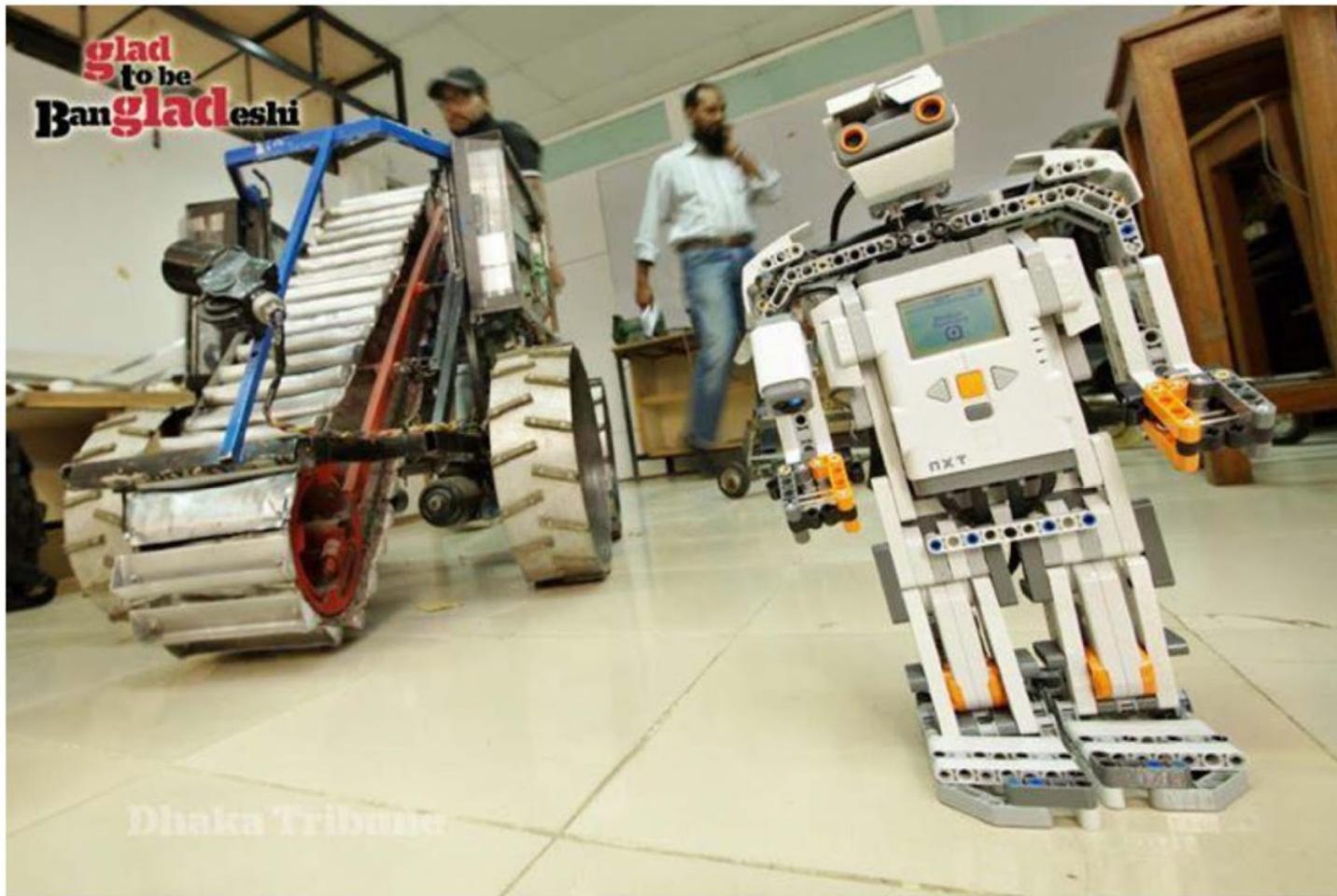


(a) A Mekanum wheel

(b) An AGV

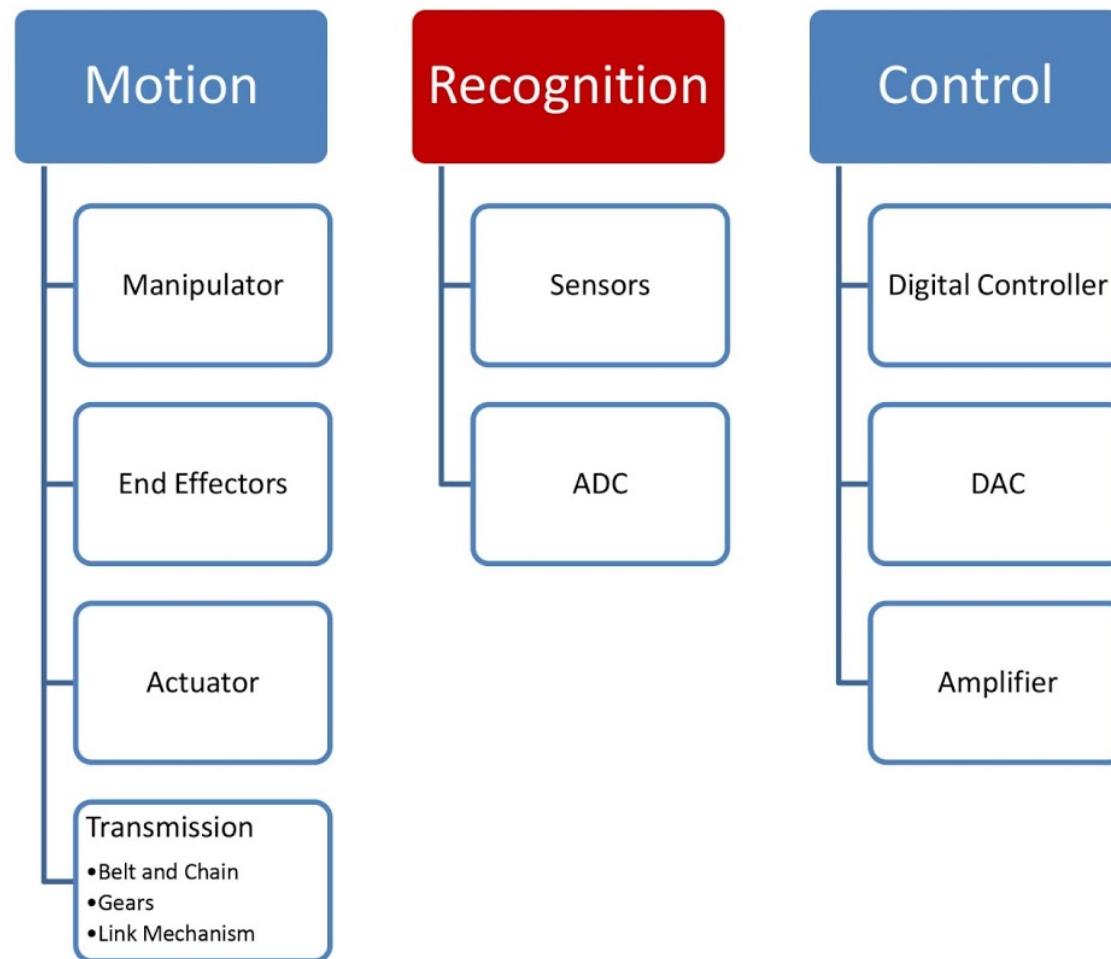
Fig. 1.5 An Automatic Guided Vehicle (AGV) with Mekanum wheels
[Courtesy: Angeles (2003)]

LEGO: MINDSTROM



Dhaka Tribune

Subsystems



Recognition

Sensors



Sensor Examples

Recognition

Physical Property

contact
distance
light level
sound level
rotation
acceleration

Sensor

switch
ultrasound, radar, infrared
photocells, cameras
microphone
encoders and potentiometers
accelerometers gyroscopes

More Sensor Examples

Recognition

Physical Property

magnetism

smell

temperature

inclination

pressure

altitude

strain

Sensor

compass

chemical

thermal, infra red

inclinometers, gyroscopes

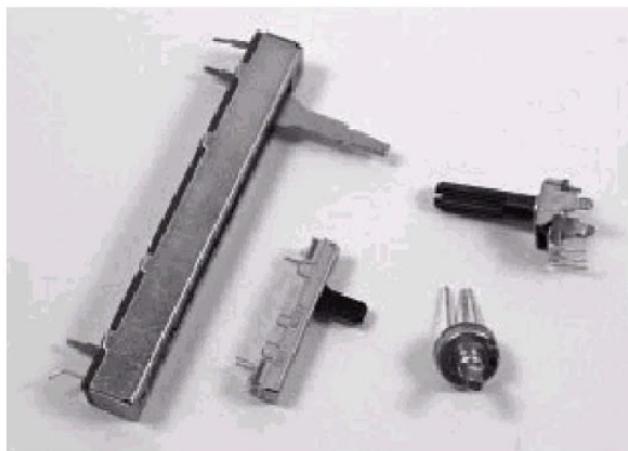
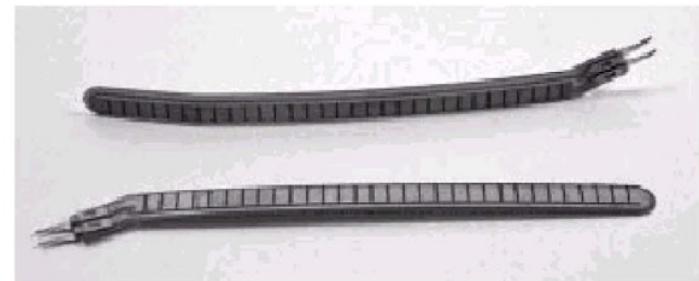
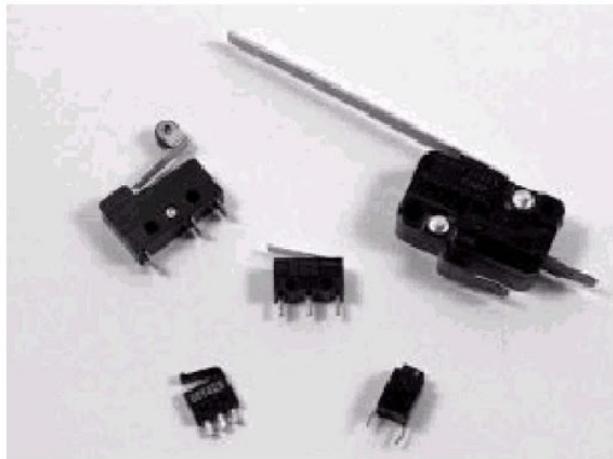
pressure gauges

altimeters

strain gauges

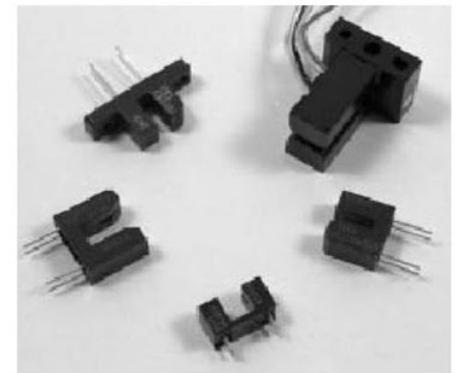
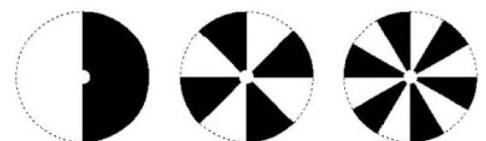
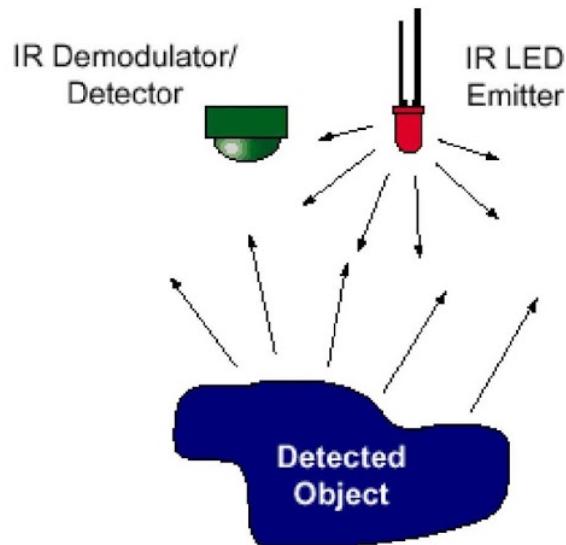
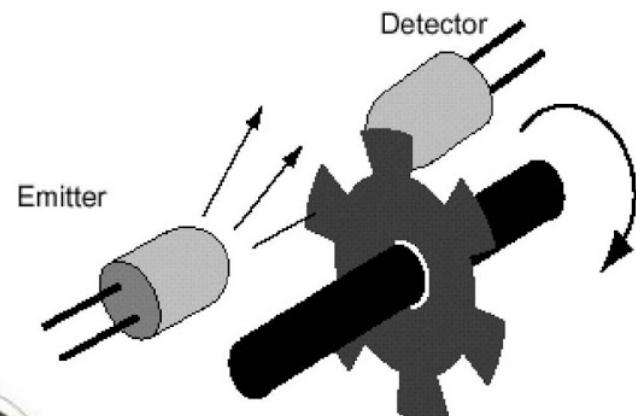
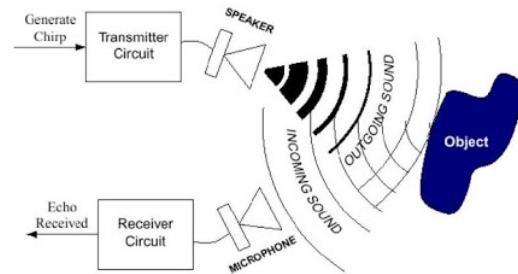
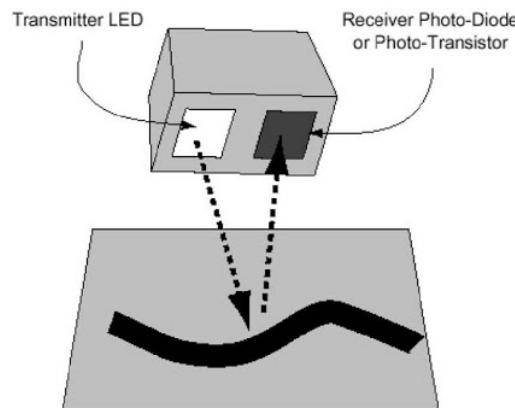
Recognition

Passive Sensor



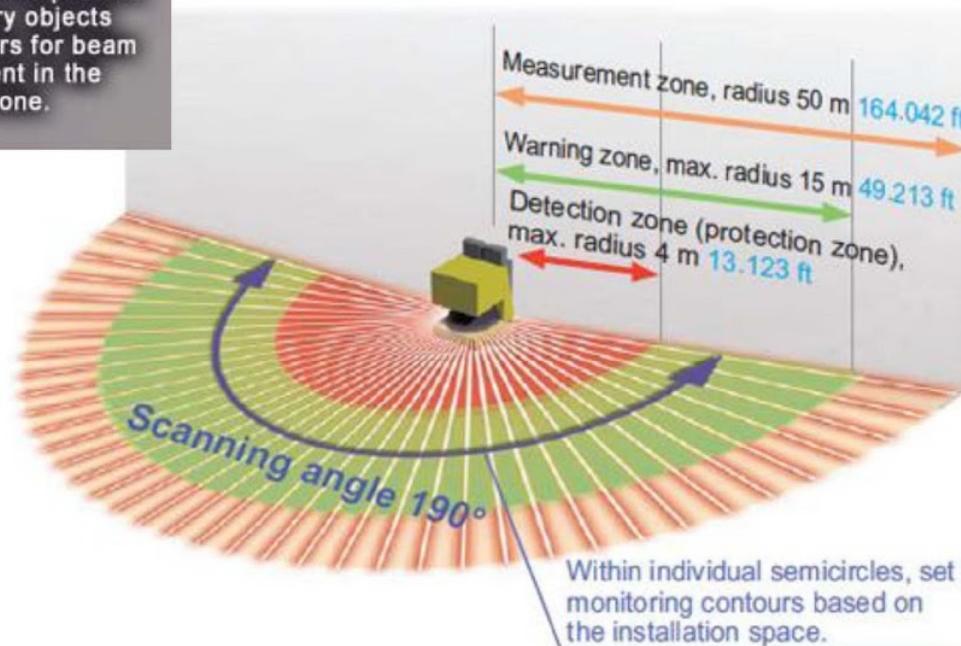
Recognition

Active Sensors



Recognition

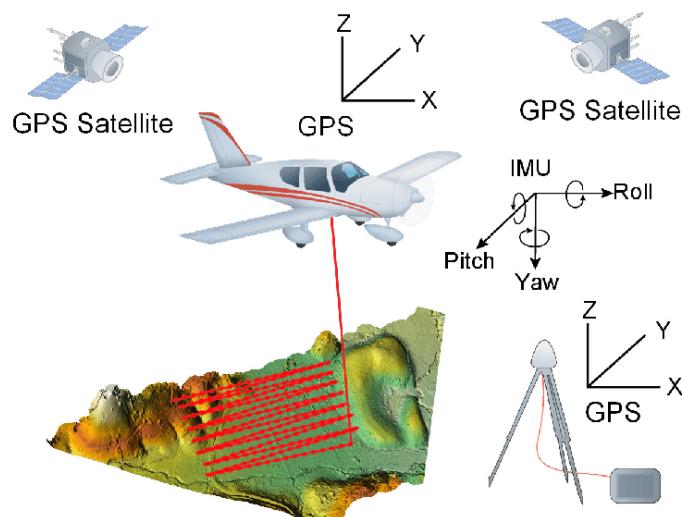
Laser Scanner



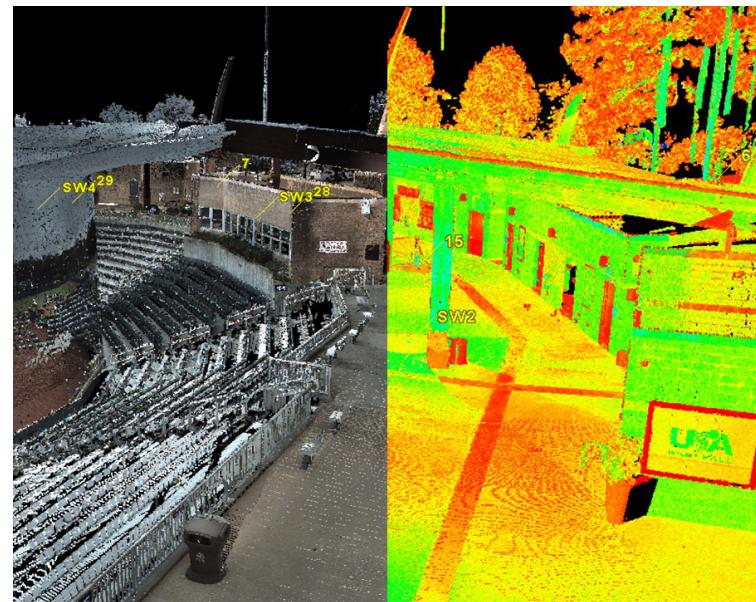
Detection zone: Instantly stops the machine upon intrusion (control output)
Warning zone: Releases warning upon intrusion (warning output)

LIDAR

Airborne LiDAR



Terrestrial LiDAR



Emotiv Electroencephalography (EEG) Headset

emotiv
you think, therefore, you can



LEAP Motion Sensor

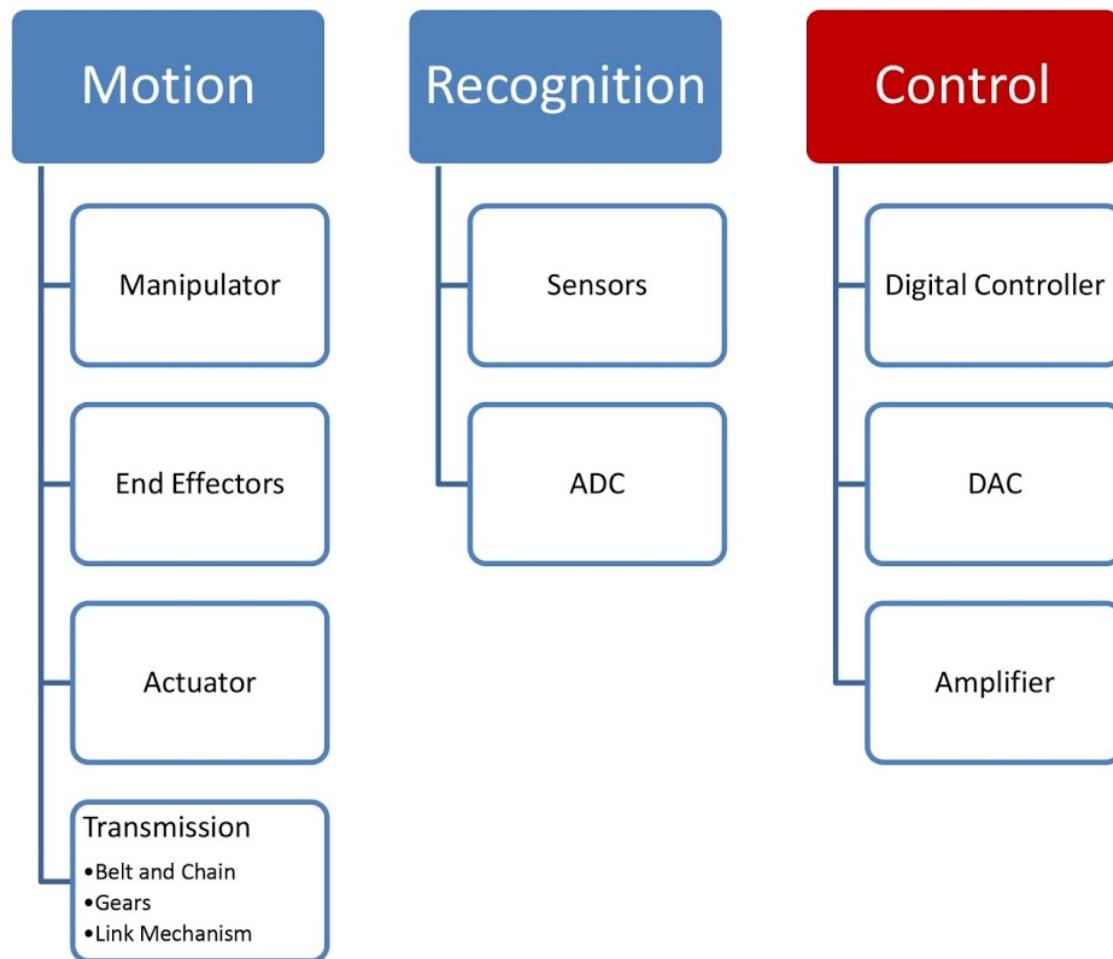


MYO

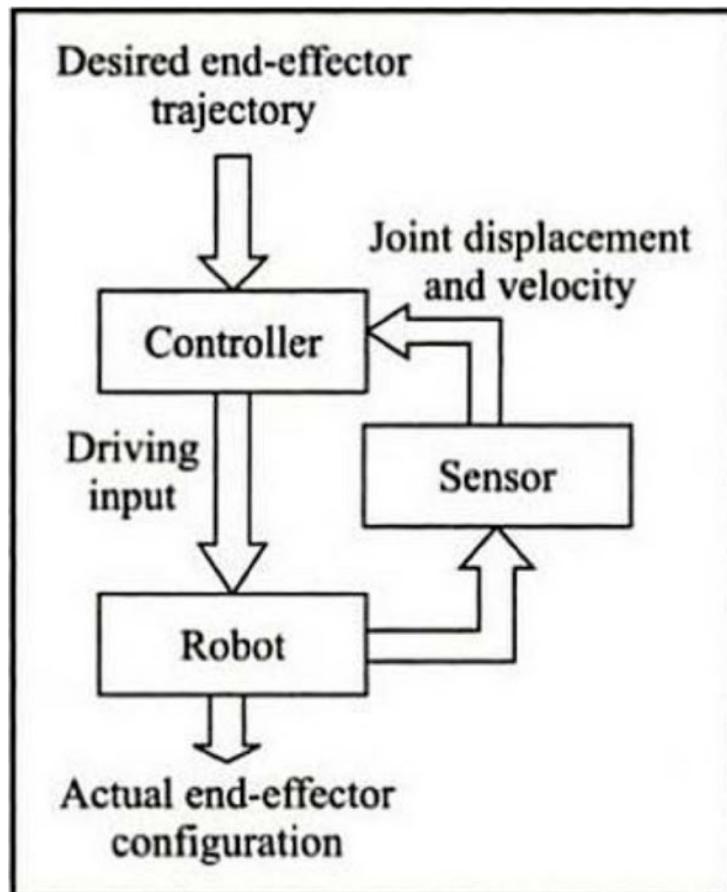


Image hosted by WittySparks.com

Subsystems



Control Software



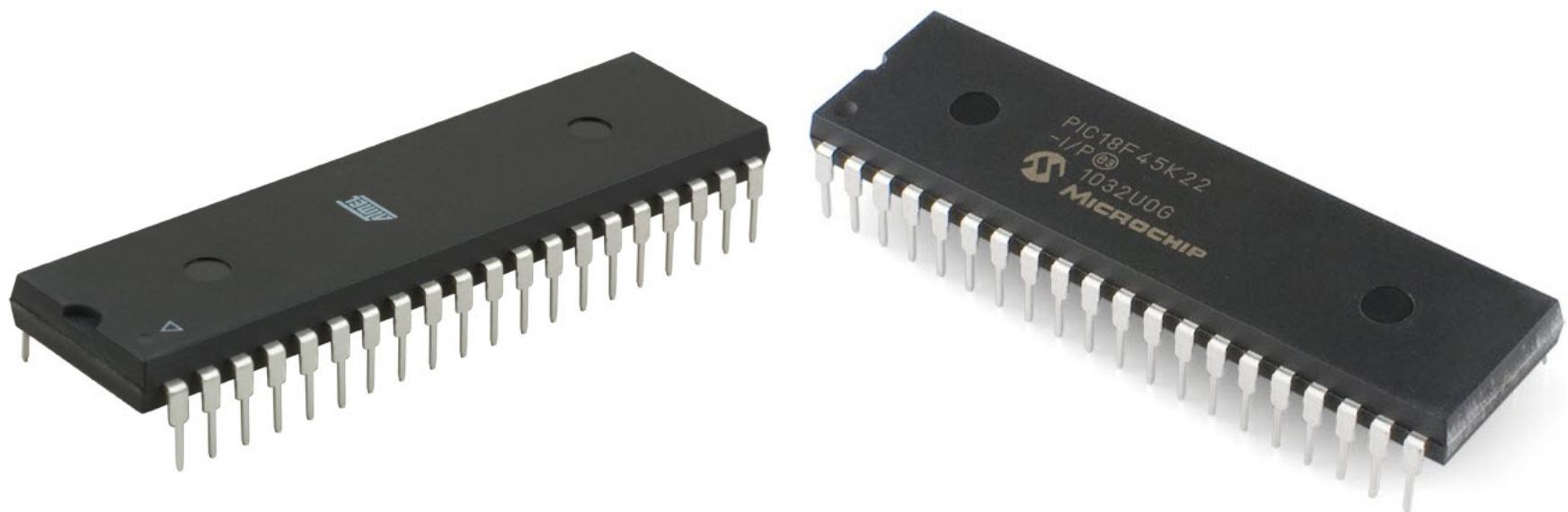
(a) Control scheme of a robot

- Robot Vision
- PID control
- Trajectory/Motion Planning
- Localization
- Manipulator Control
- UAV Navigation
- Sensors calibration and sensor fusion
- Kinematics and dynamics
- Interfacing
- Communication

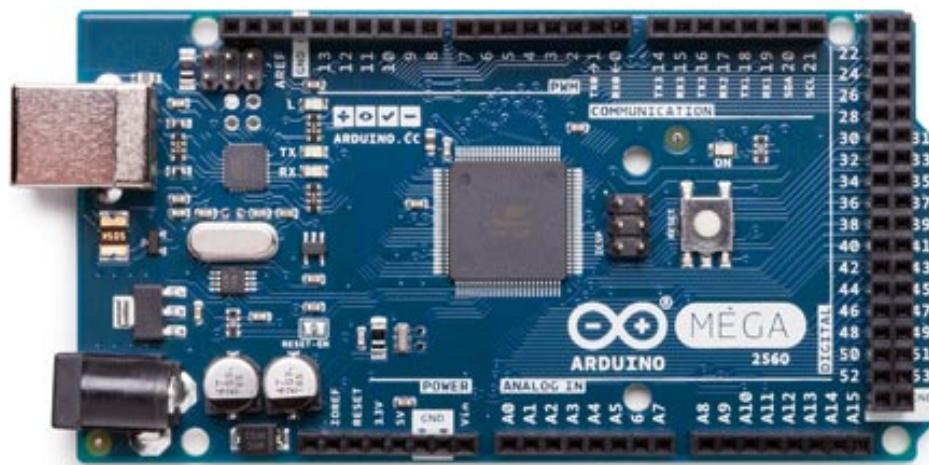
Control Hardware

- Microcontrollers
- Arduino
- PLC
- FPGA
- Single Board Computer
- Portable PCs
- Cloud Computing System

Microcontrollers



Arduino



Arduino



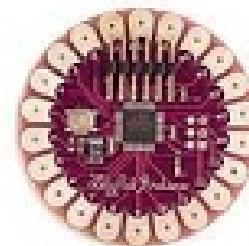
Arduino Uno



Arduino Leonardo



Arduino Mega 2560



Arduino LilyPad



Arduino Mega ADK



Arduino Fio



Arduino Ethernet



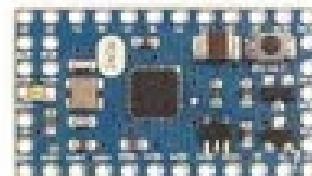
Arduino Pro



Arduino BT



Arduino Nano

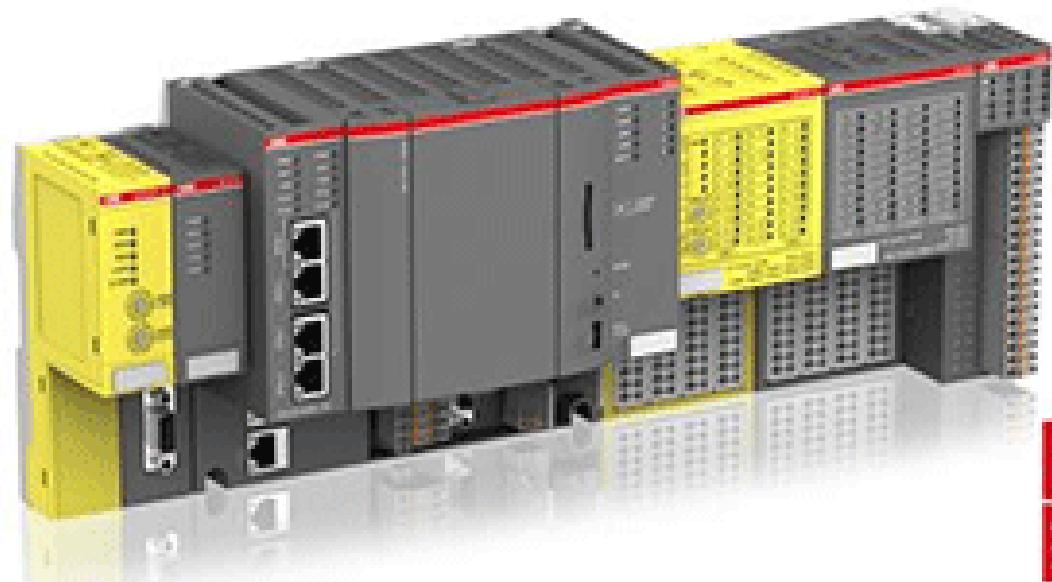


Arduino Mini

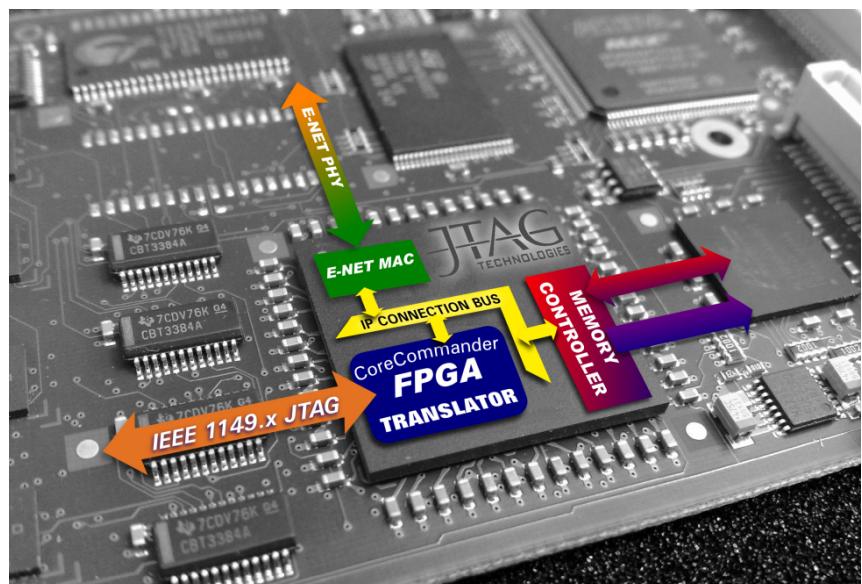


Arduino Pro Mini

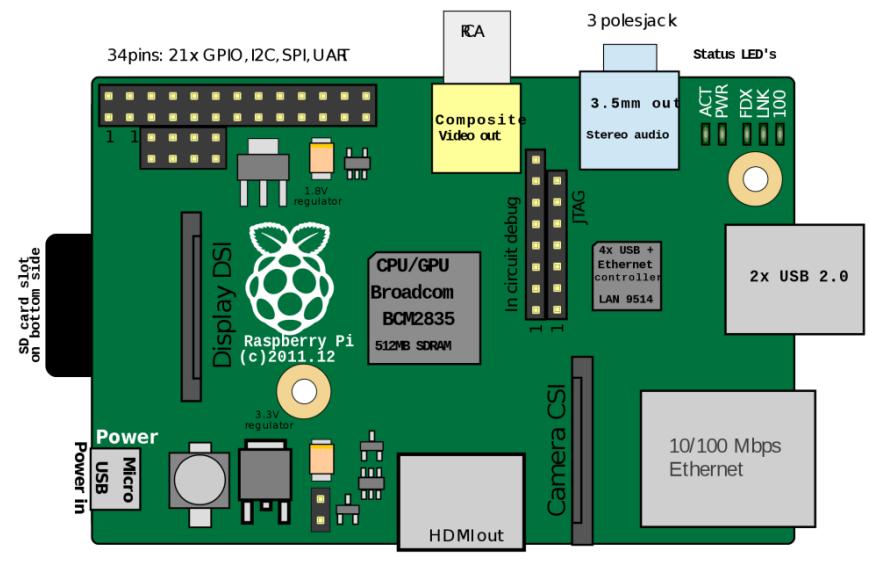
Programmable Logic Controller (PLC)



Field-Programmable Gate Array (FPGA)



Single board Computer



Raspberry Pi 4, Tinkerboard



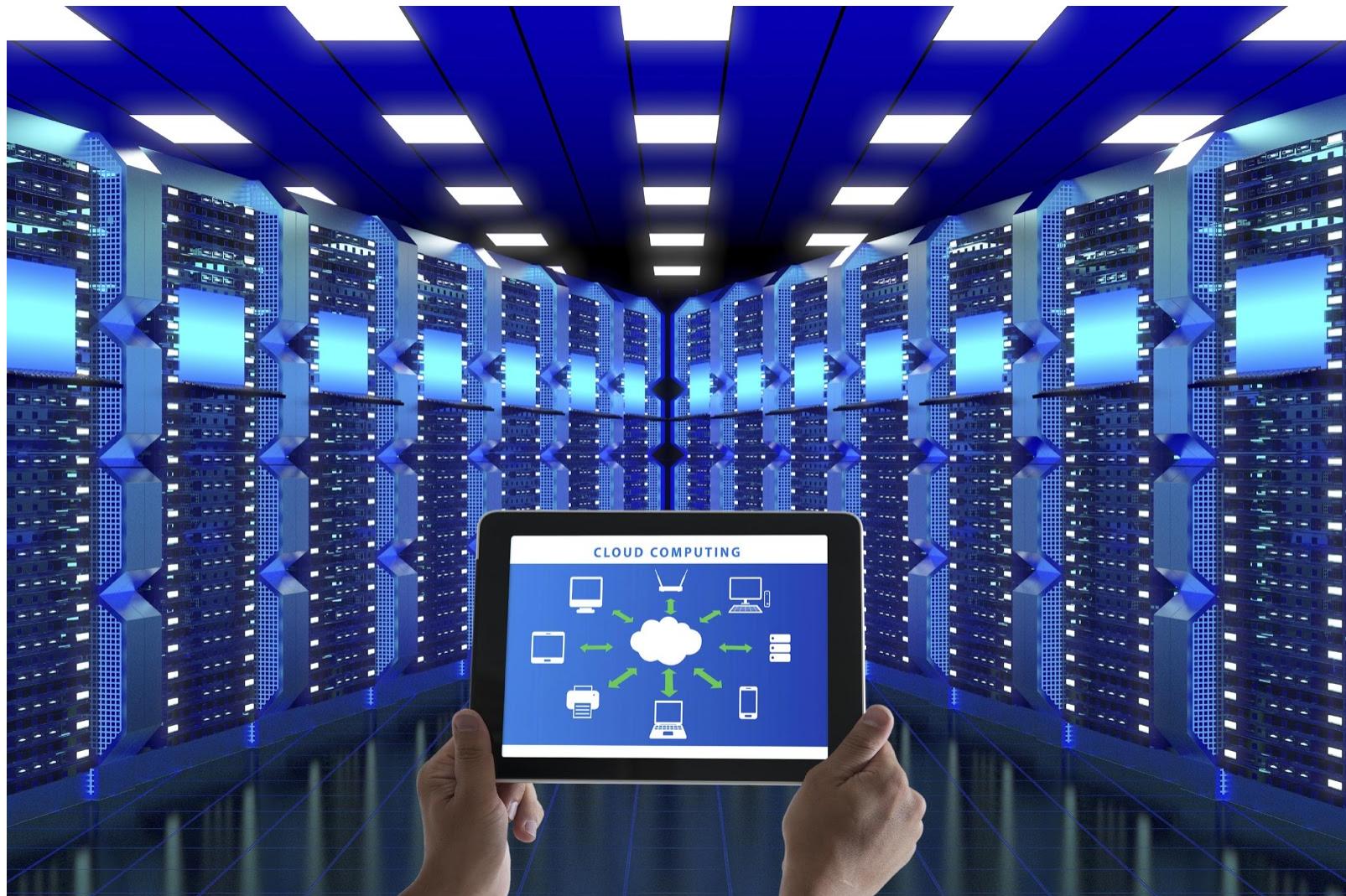
Little Panda and Jetson nano



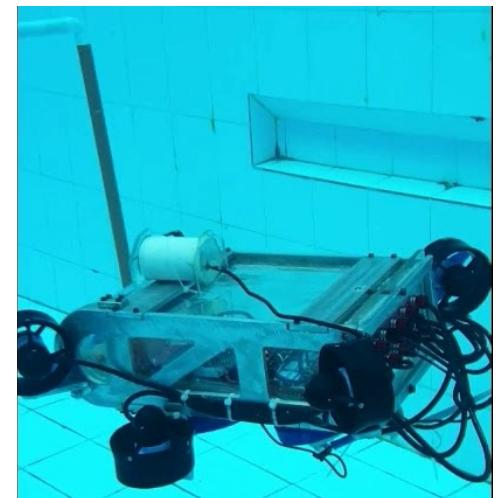
Intel Nuc and BRIX



Cloud Computing Infrastructure



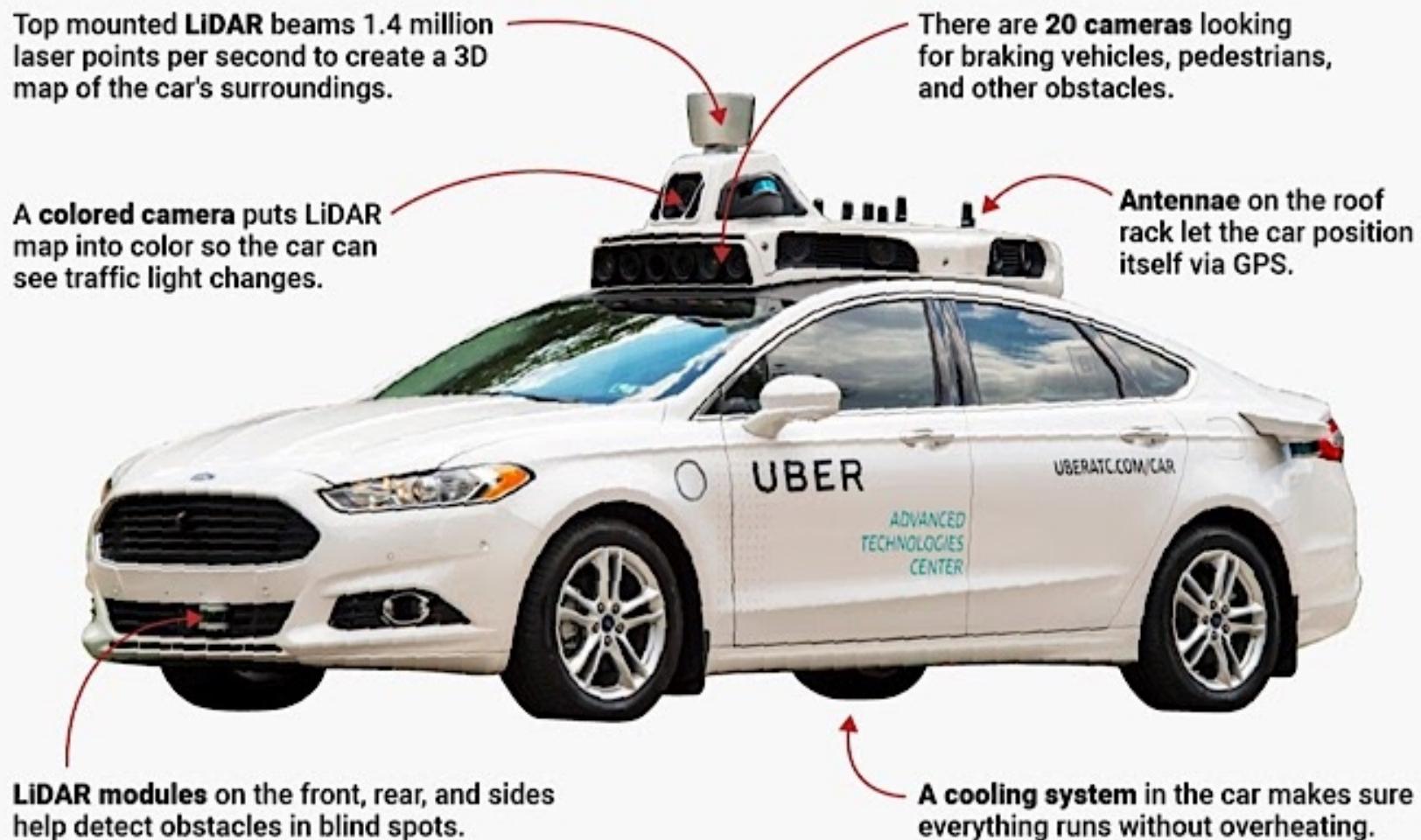
Projects we can proud of



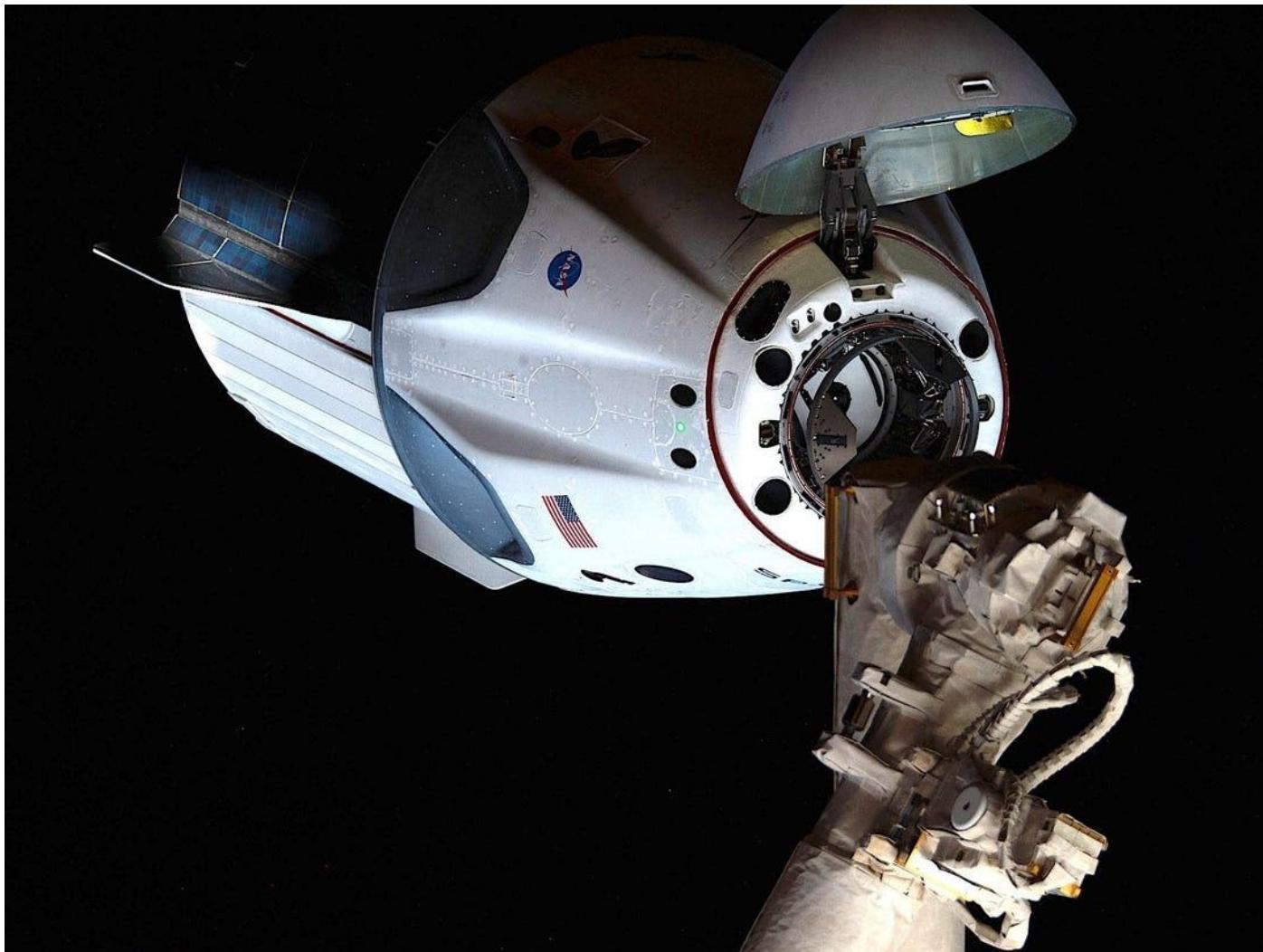
BRAC ONNESHA



Self-Driving Car



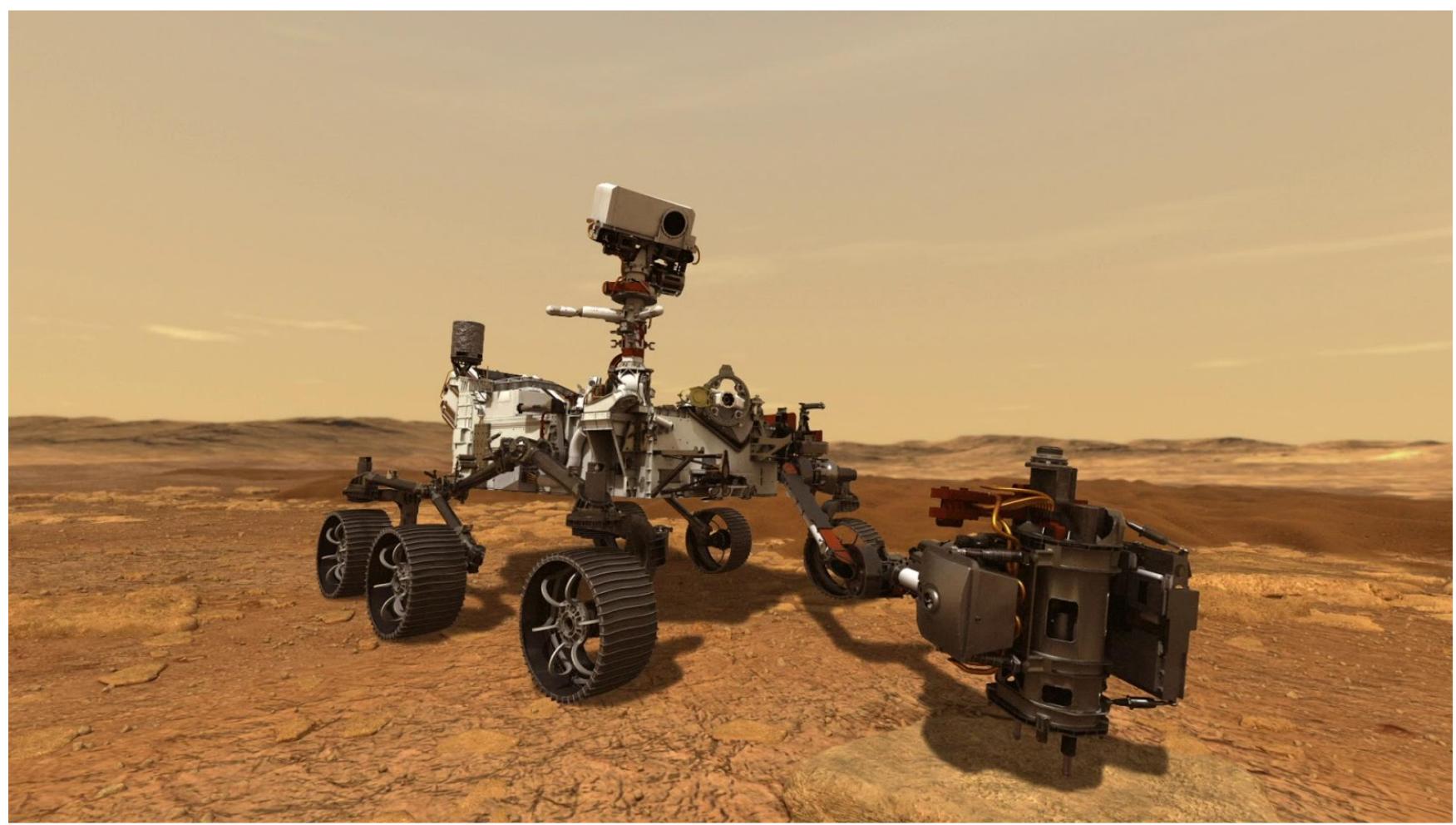
Autonomous Docking



Perseverance Mars Rover

Perseverance Mars Rover

Perseverance Mars Rover



Roomba



Boston Dynamics

Platforms



SpotMini



Spot



Atlas



Handle

The da Vinci Robotic Surgical System

