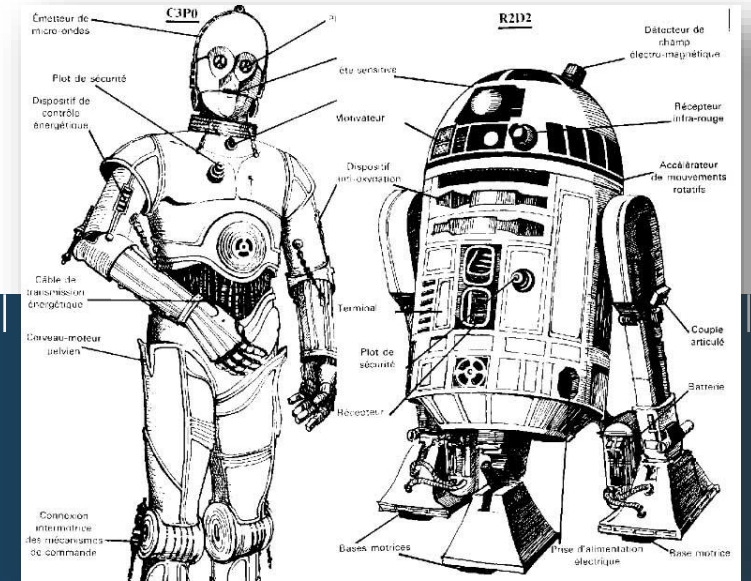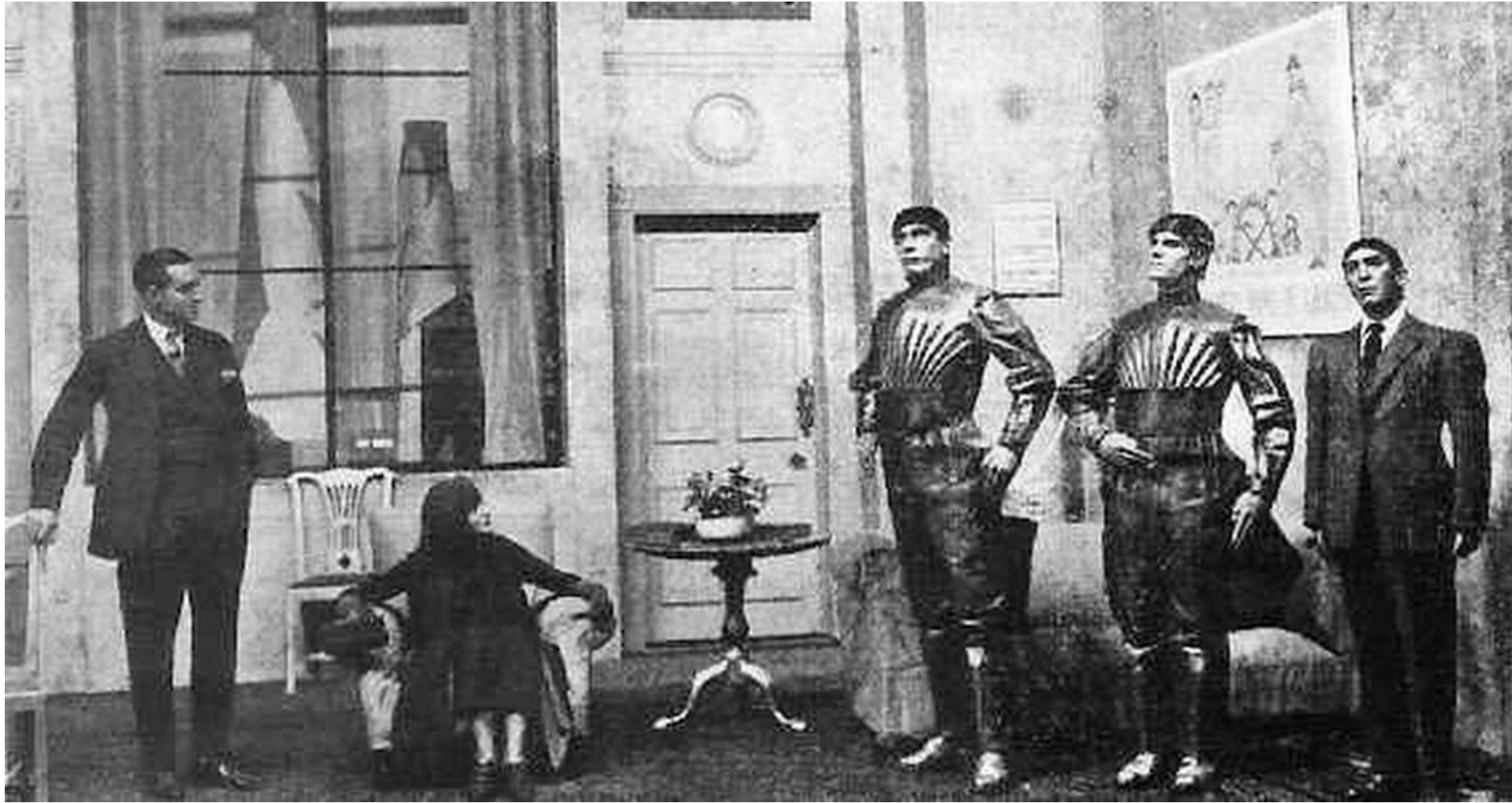# Robotics

Introduction

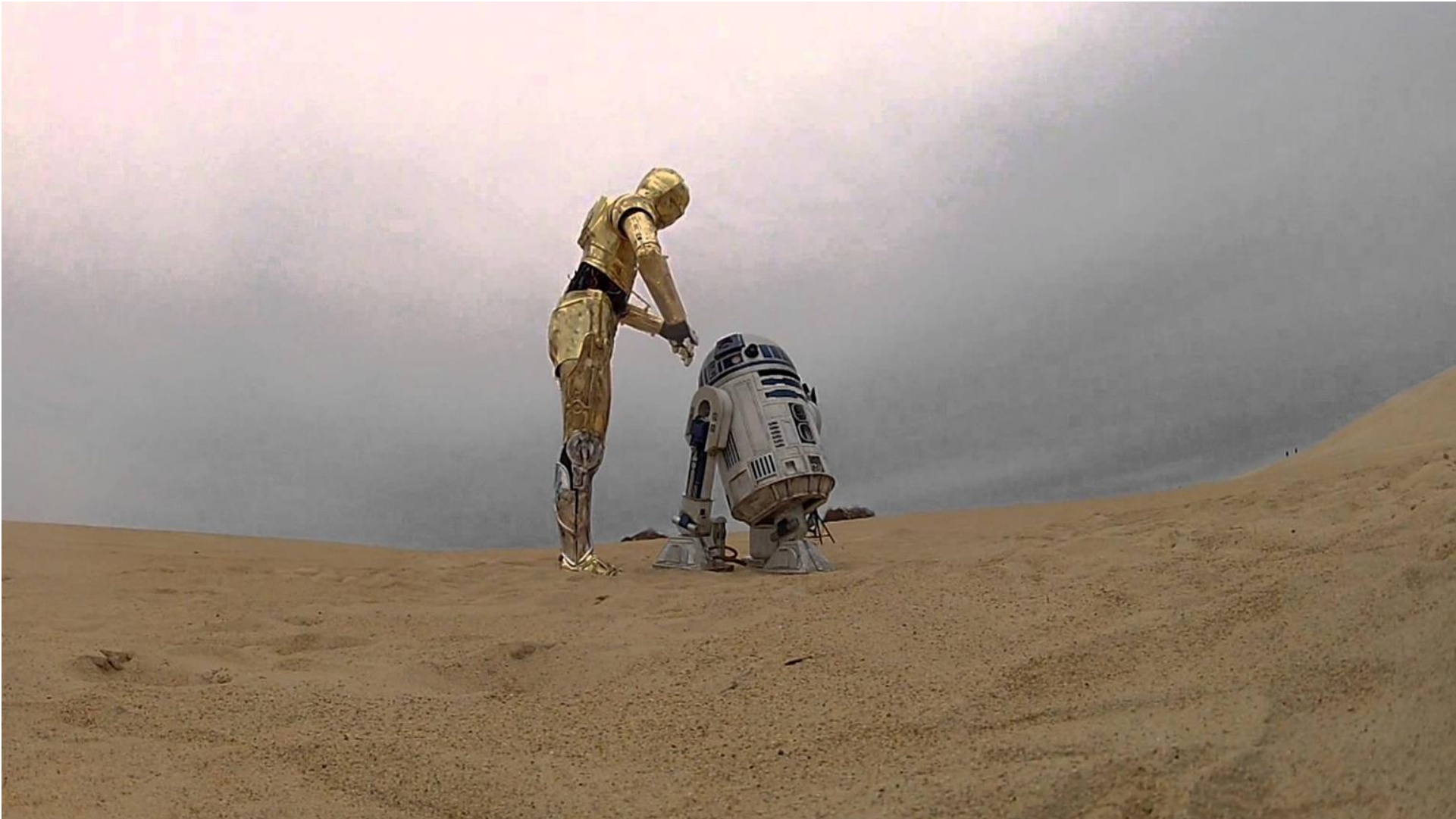Matteo Matteucci
matteo.matteucci@polimi.it

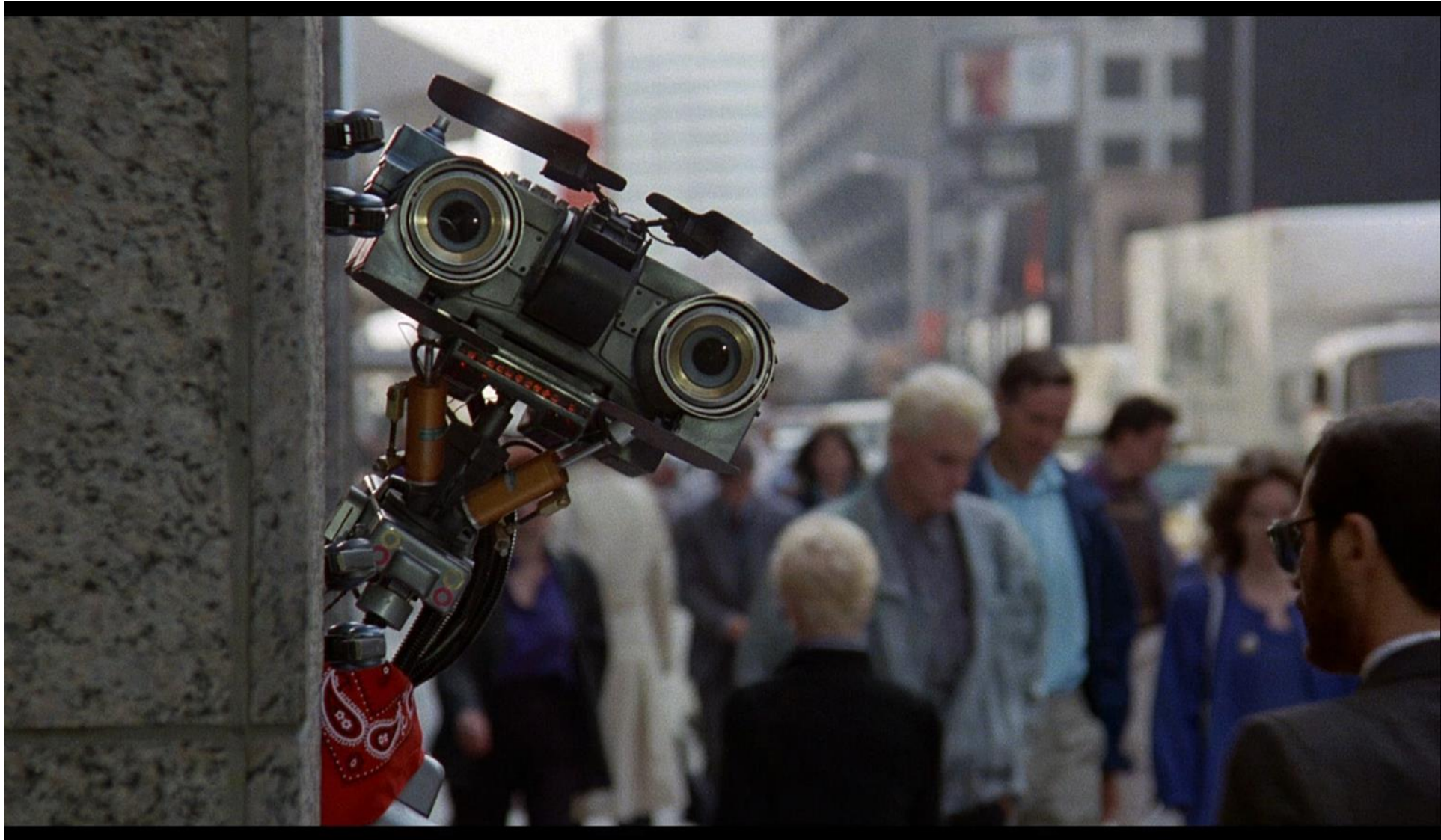*Artificial Intelligence and Robotics Lab - Politecnico di Milano*

Rossum Universal Robots (1920)

Star Wars (1977)

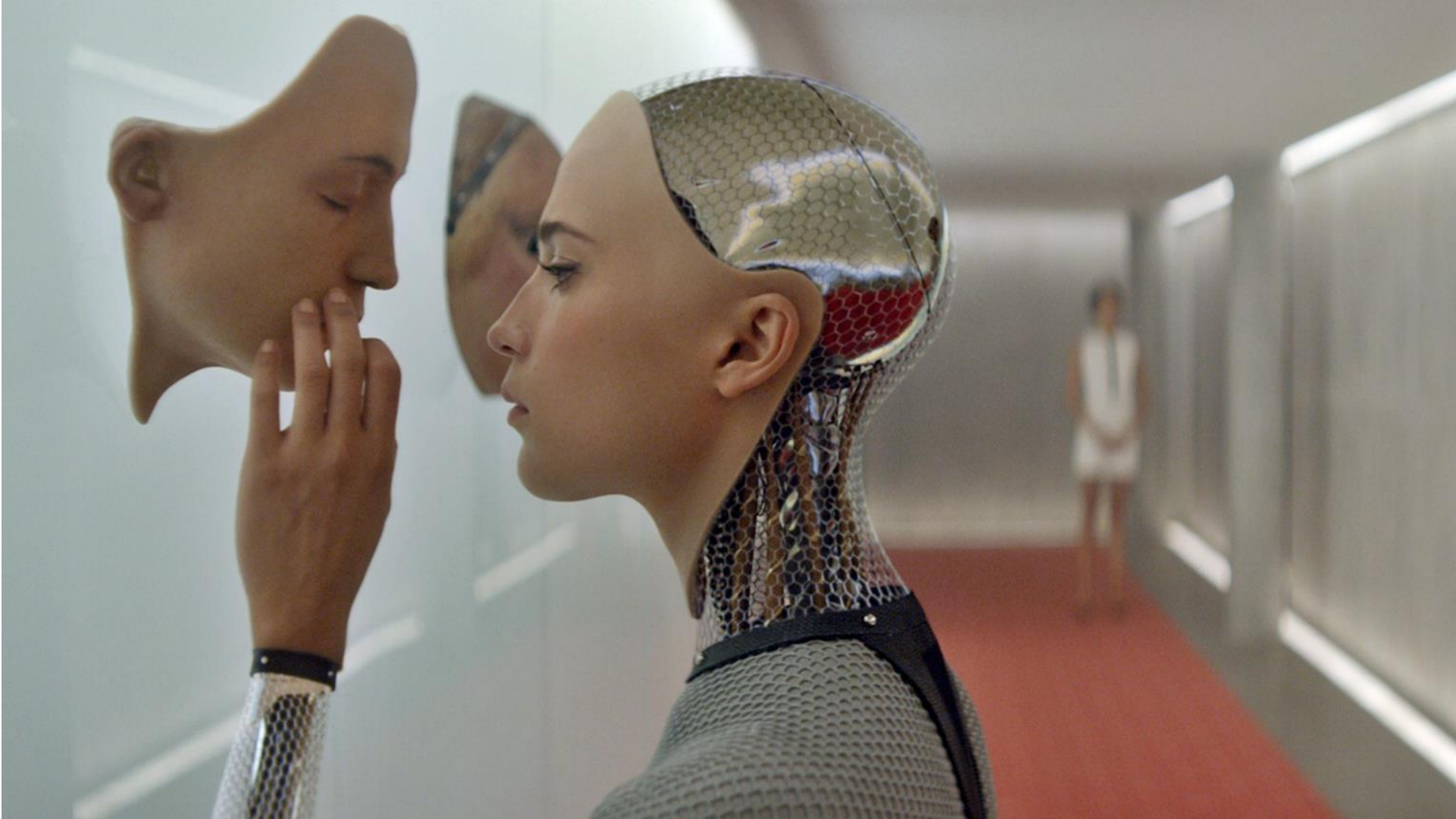# Short Circuit (1986)

I Robot (2001)
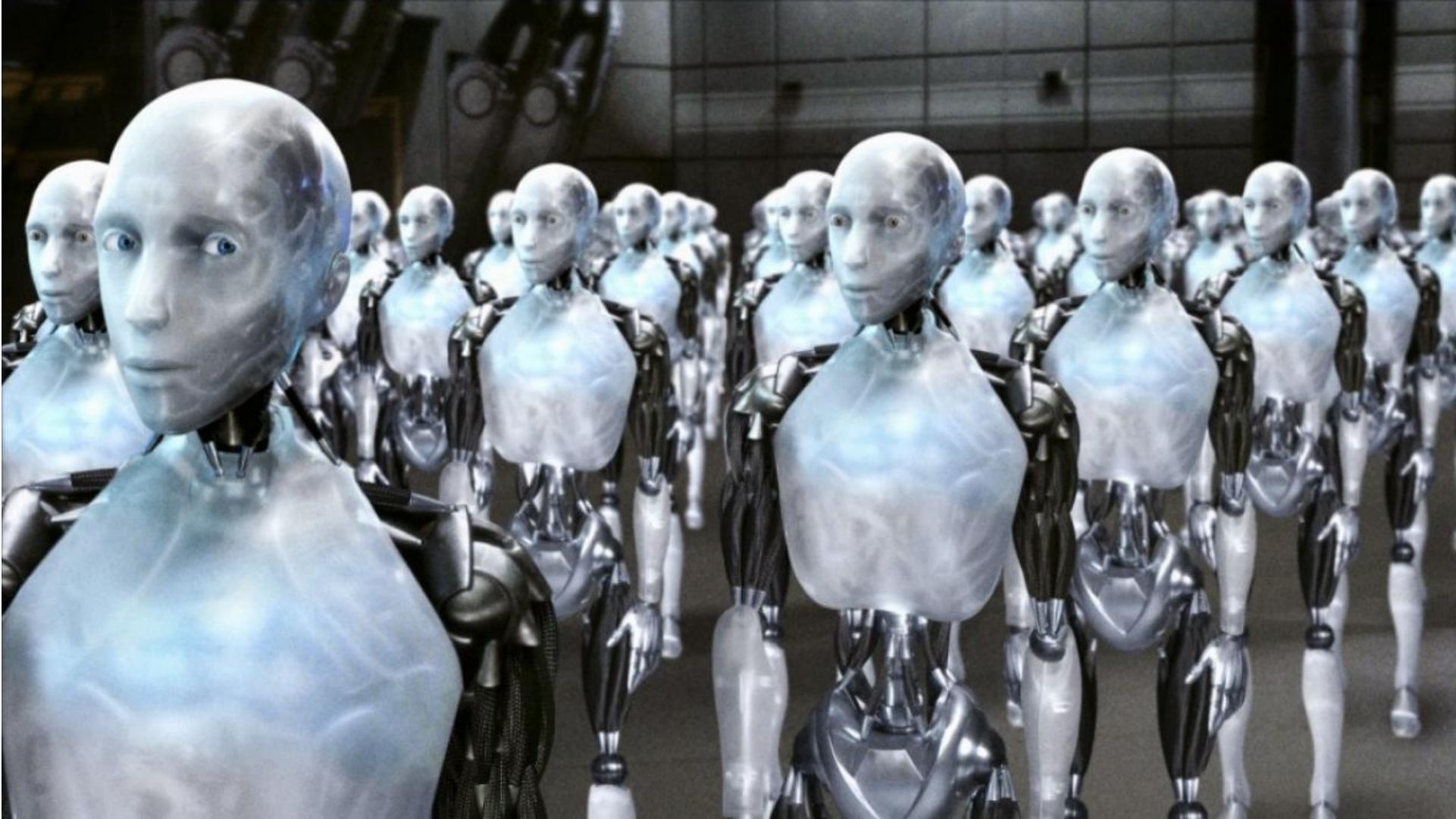
Ex Machina (2015)

Sometimes reality is different...

... and the winner is ...
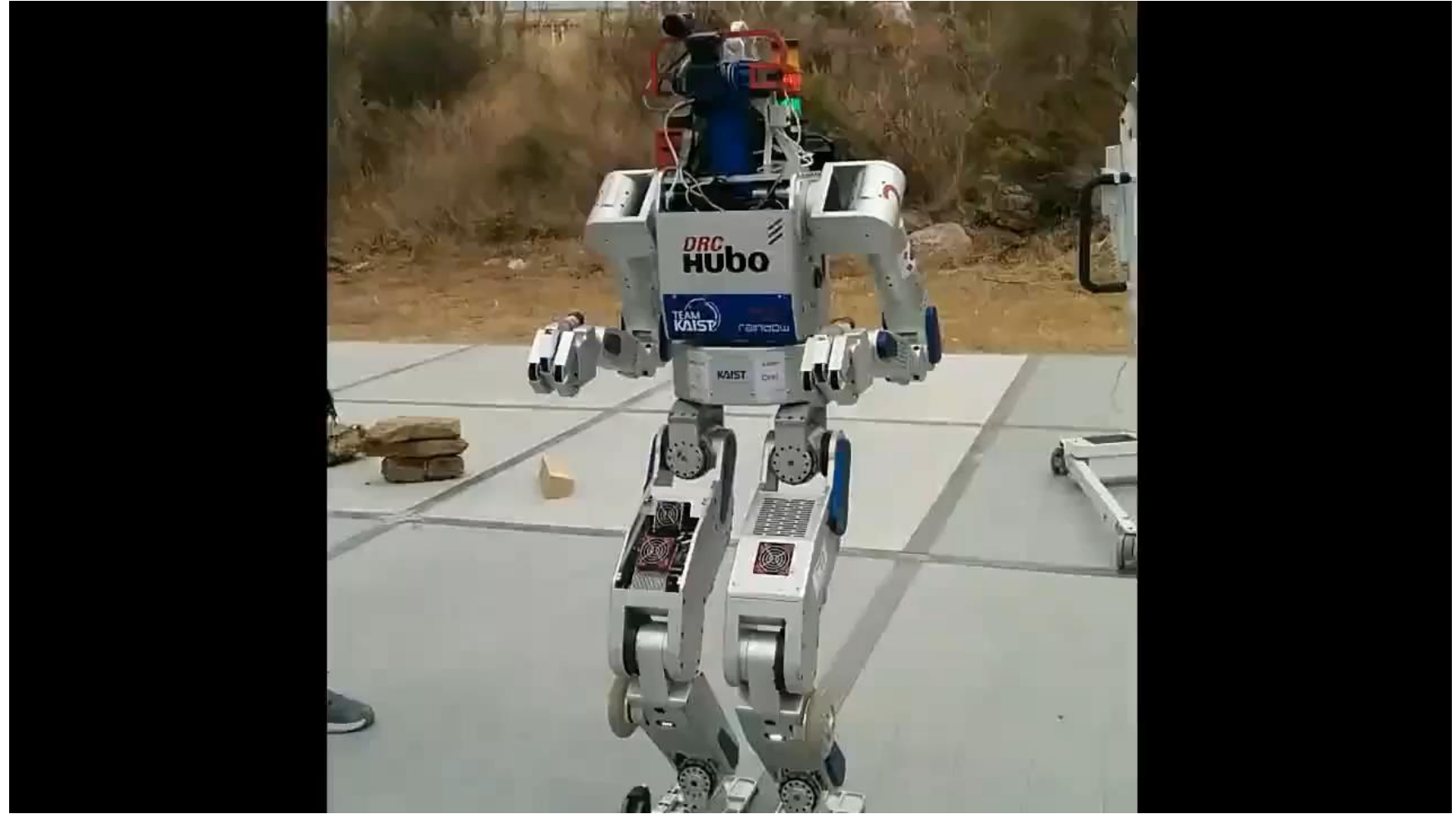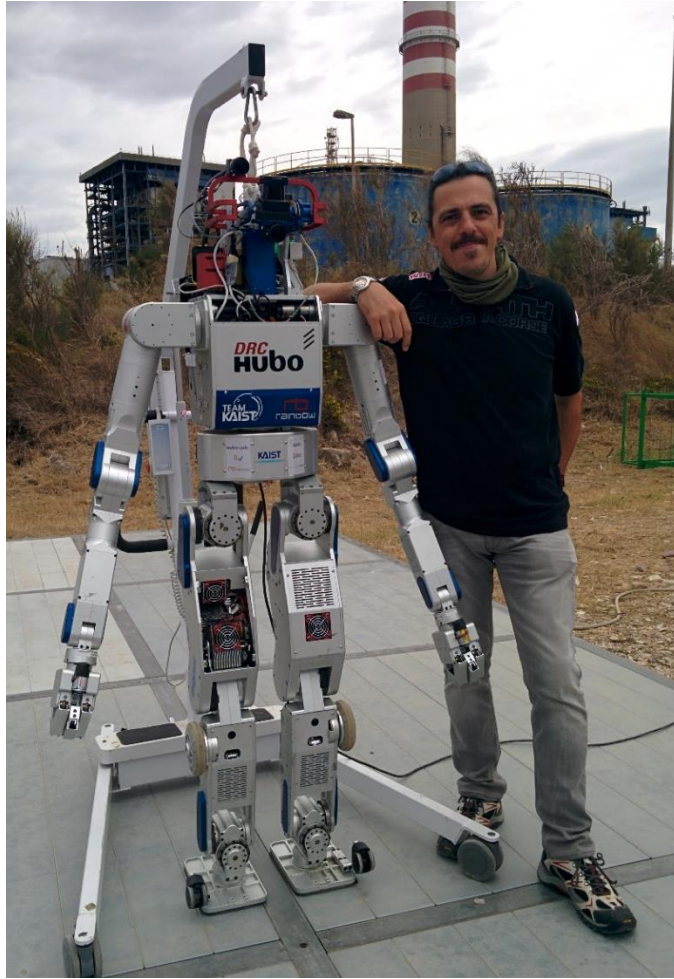
... and check! Sometimes dreams come true (ATLAS 2016) ...

... and every year it gets better ☺

Boston Dynamics

Boston Dynamics

... and better ☺
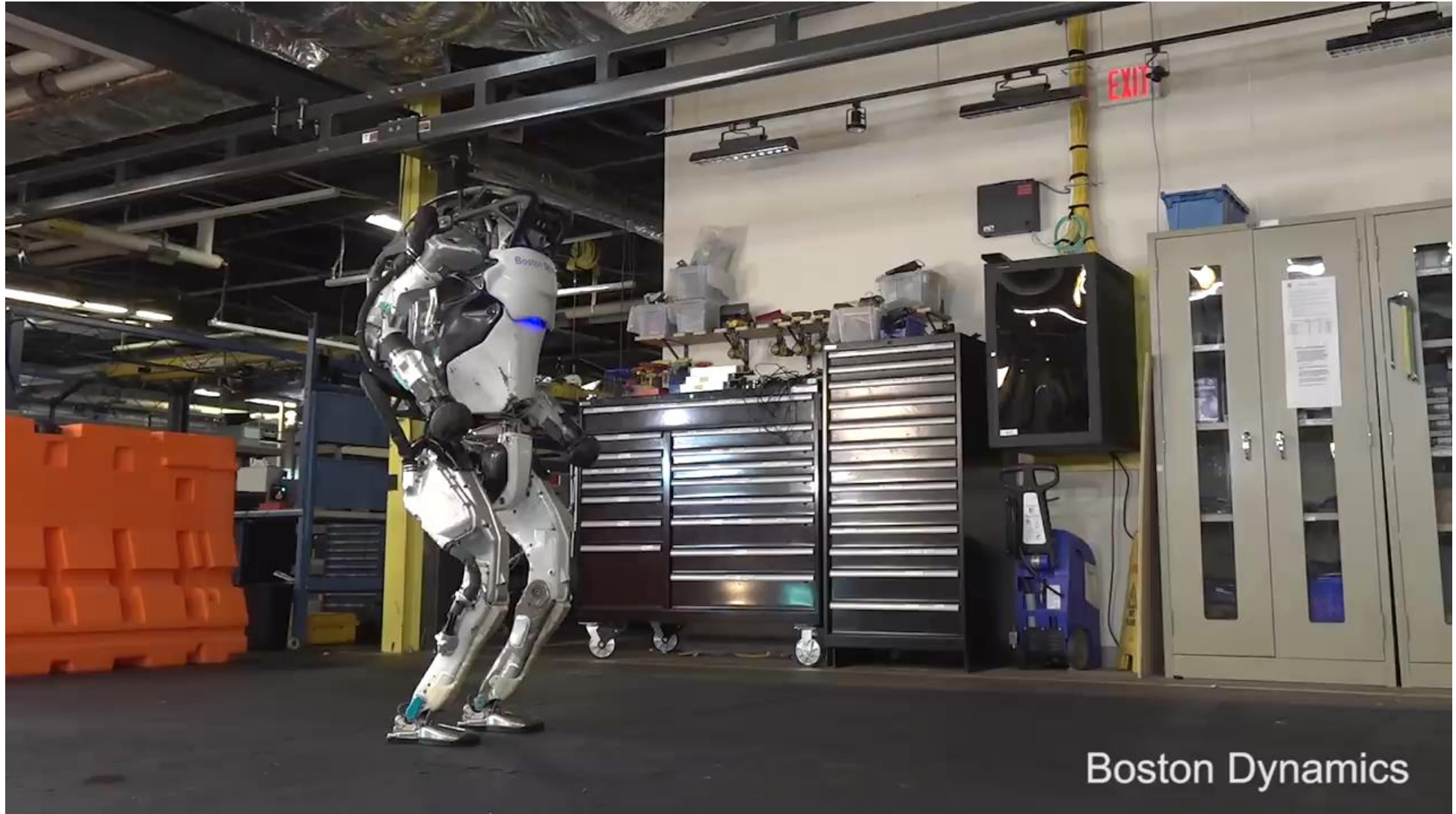
Boston Dynamics

Steps in robot history

Mechanical era (1700):
- automata
- karakuri-ningyo

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Automata: the robot ancestors

Karakuri-ningyo
Edo Period
(1603 – 1868)

The Writer
Pierre Jaquet-Droz
(1721-1790)
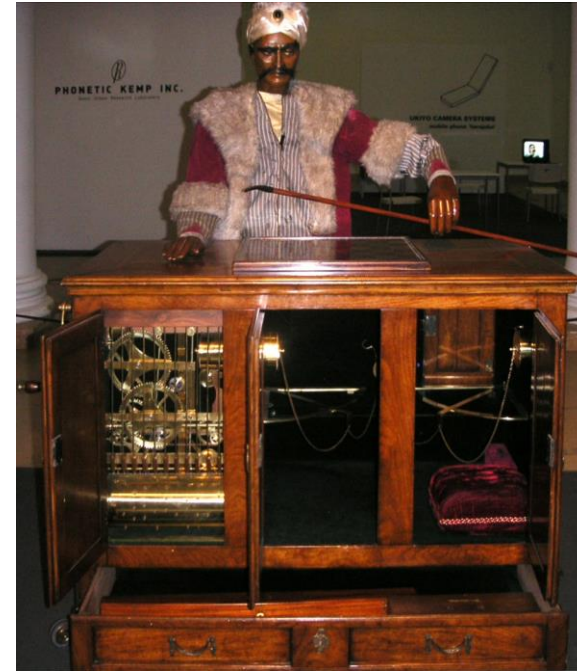
The Turk
Wolfgang von Kempelen
(1734 – 1804)

Steps in robot history

Mechanical era (1700):
- automata
- karakuri-ningyo

Fiction era ('20s):
- *Rossum Universal Robot*

Cybernetics era ('40s):
- Turtle and telerobot

Early «robot» experiments

Grey Walter's tortoises ('50s): mechanical plausibility of animal tropism. (Tropism/taxis: animal movement directed by stimuli).

Steps in robot history

Mechanical era (1700):
- automata
- karakuri-ningyo

Fiction era ('20s):
- *Rossum Universal Robot*
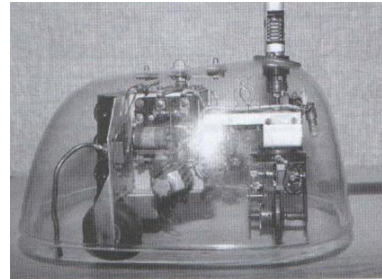
Cybernetics era ('40s):
- Turtle and telerobot

Automation era (from the '60s):
- Industrial robots
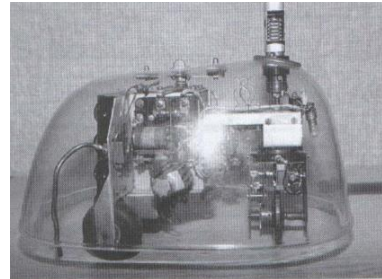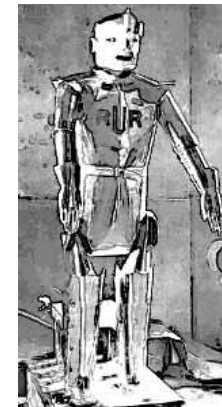
First robots

1961 - UNIMATE, the first industrial robot, began work at General Motors. Obeying step-by-step commands stored on a magnetic drum, the 4,000-pound arm sequenced and stacked hot pieces of die-cast metal.
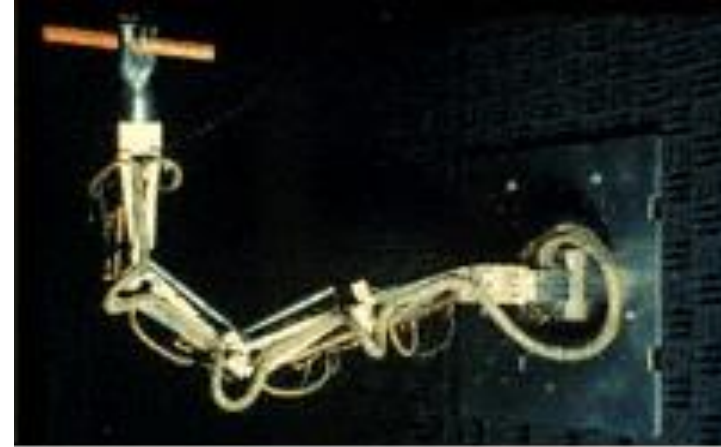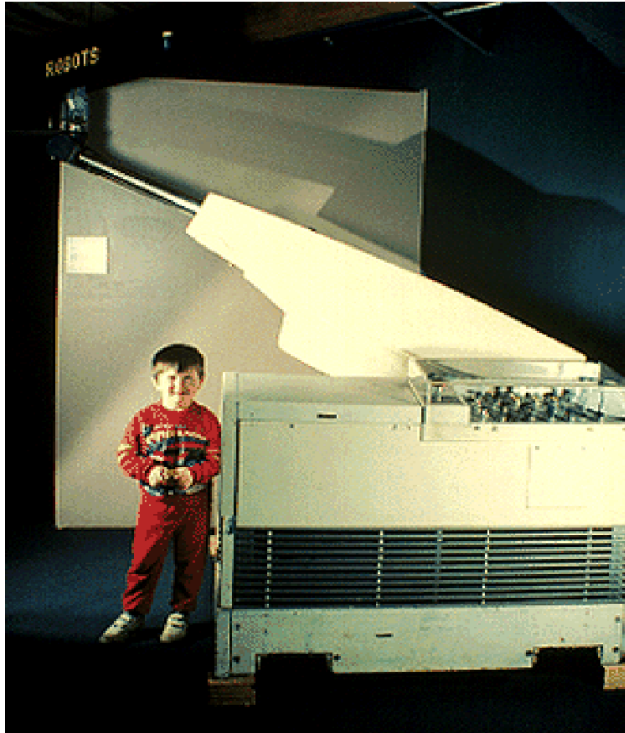
1968 - Marvin Minsky developed the Tentacle Arm, which moved like an octopus. It had twelve joints designed to reach around obstacles. A PDP-6 computer controlled the arm, powered by hydraulic fluids. Mounted on a wall, it could lift the weight of a person.

What is a Robot?

A reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks.

(Robot Institute of America, 1980)

An what about these???

We need a different defintion of robot!

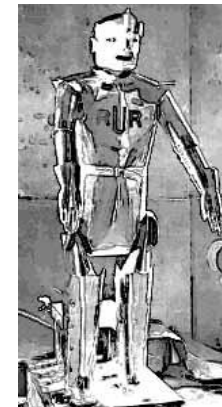3D Robotics

jibo

STARSHIP

Steps in robot history

Mechanical era (1700):
- automata
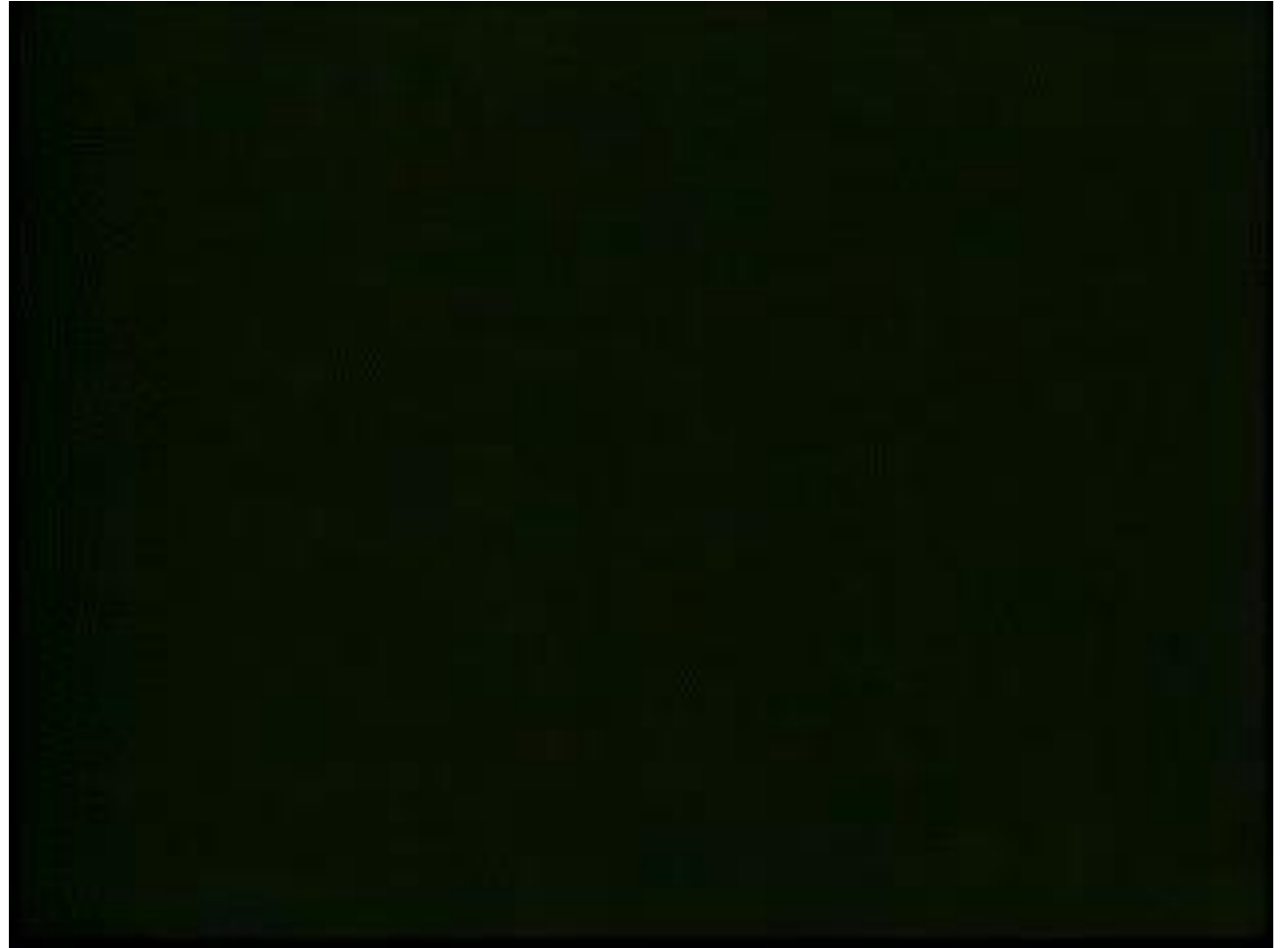- karakuri-ningyo

Fiction era ('20s):
- *Rossum Universal Robot*

Cybernetics era ('40s):
- Turtle and telerobot

Automation era (from the '60s):
- Industrial robots

Information era (from the '90s):
- Intelligence
- Autonomy
- Cooperation
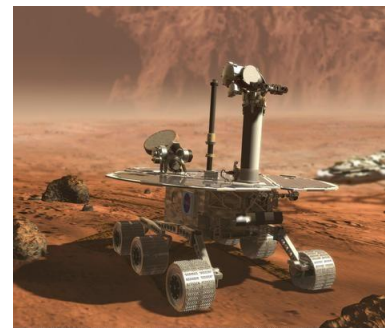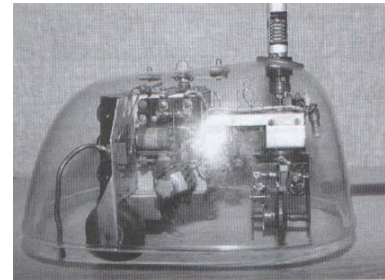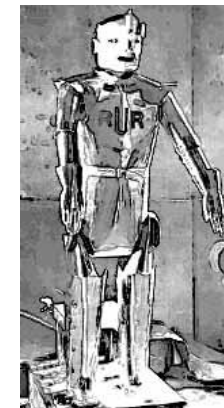
Shakey (1972) and the Stanford Cart (1970)
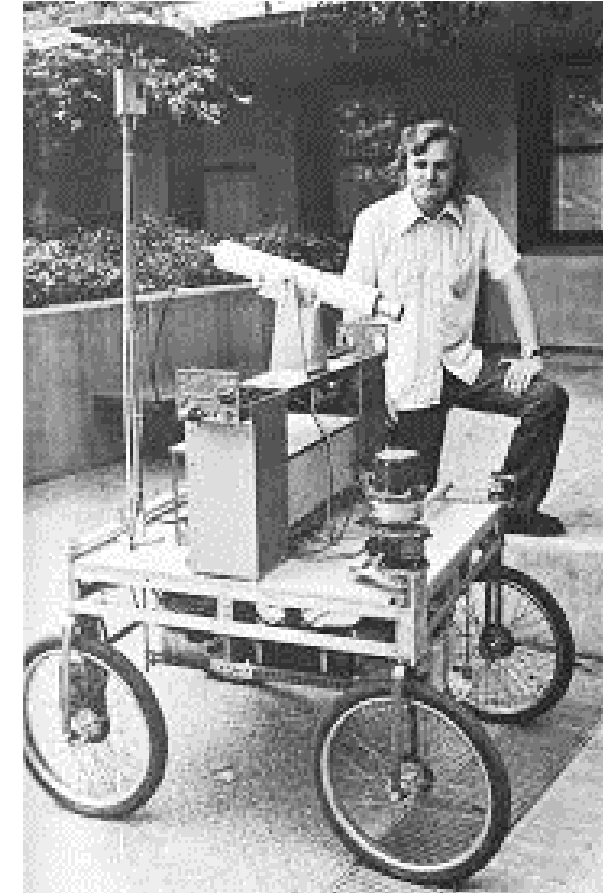
✓A robot is an actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks. Autonomy in this context means the ability to perform intended tasks based on current state and sensing, without human intervention.

✓A service robot is a robot that performs useful tasks for humans or equipment excluding industrial automation application.

Industrial vs Service Robotics
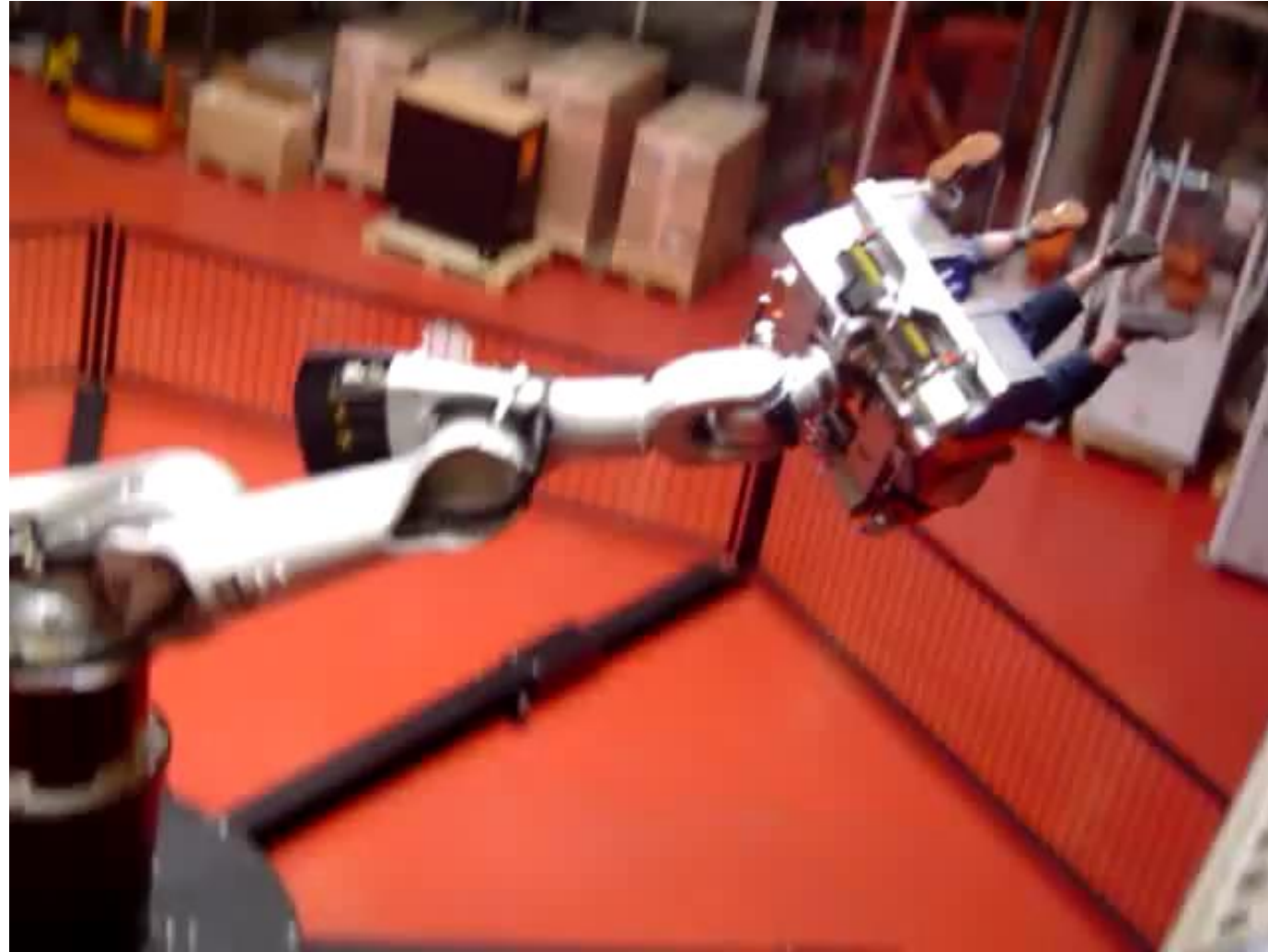
ISO 8373:2012 - Robots and robotic devices

- ✓ A robot is an actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks. Autonomy in this context means the ability to perform intended tasks based on current state and sensing, without human intervention.

- ✓ A service robot is a robot that performs useful tasks for humans or equipment excluding industrial automation application.

- ✓ A personal service robot or a service robot for personal use is a service robot used for a non-commercial task, usually by lay persons. E.g., domestic servant robot, automated wheelchair, personal mobility assist robot, and pet exercising robot.

Autonomous service robot

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✓ A robot is an actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks. Autonomy in this context means the ability to perform intended tasks based on current state and sensing, without human intervention.
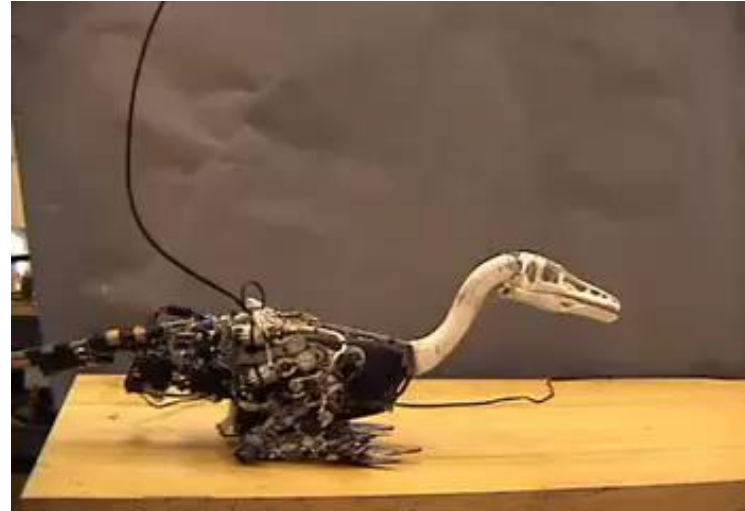
✓ A service robot is a robot that performs useful tasks for humans or equipment excluding industrial automation application.

✓ A personal service robot or a service robot for personal use is a service robot used for a non-commercial task, usually by lay persons. E.g., domestic servant robot, automated wheelchair, personal mobility assist robot, and pet exercising robot.

✓ A professional service robot or a service robot for professional use is a service robot used for a commercial task, usually operated by a properly trained operator. E.g., cleaning robot for public places, delivery robot in offices or hospitals, fire-fighting robot, rehabilitation robot and surgery robot in hospitals. In this context an operator is a person designated to start, monitor and stop the intended operation of a robot or a robot system.

The Bill Gates "Prophecy" …

http://www.koreaherald.com/

Industrial and Service Robots Market (https://ifr.org/free-downloads)
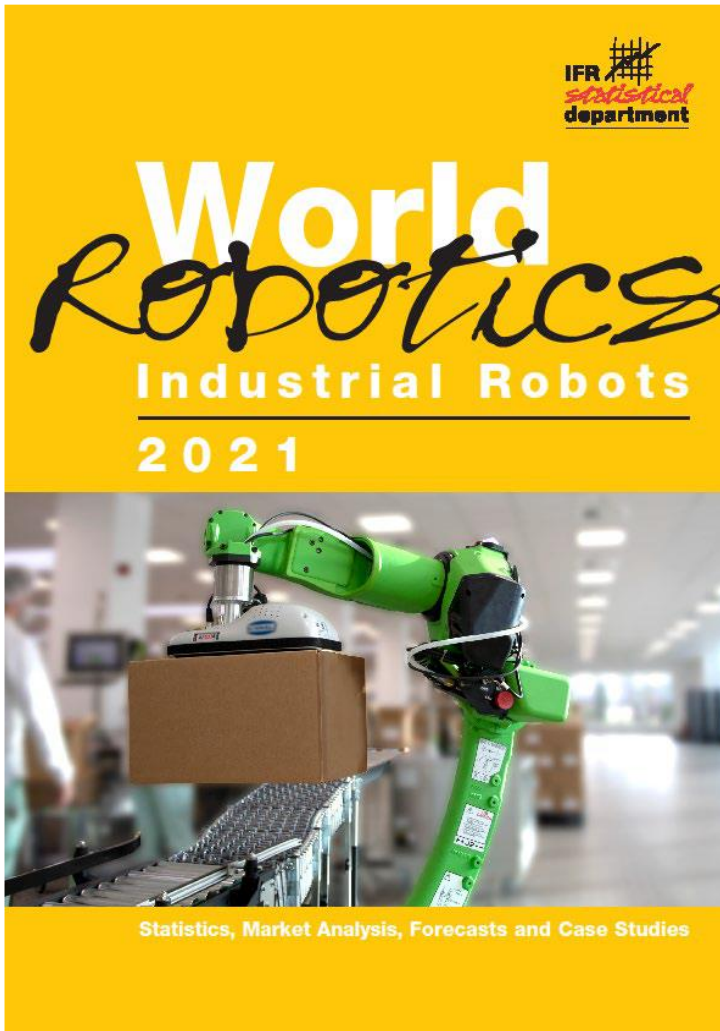
Some notes about the ISO definitions

- ✓ A robot system is a system comprising robot(s), end-effector(s) and any machinery, equipment, or sensors supporting the robot performing its task.

- ✓ According to the definition, "a degree of autonomy" is required for service robots ranging from partial autonomy (including human robot interaction) to full autonomy (without active human robot intervention). In this context human robot-interaction means information and action exchanges between human and robot to perform a task by means of a user interface.

Medical robots

- ✓ A robot system is a system comprising robot(s), end-effector(s) and any machinery, equipment, or sensors supporting the robot performing its task.
- ✓ According to the definition, "a degree of autonomy" is required for service robots ranging from partial autonomy (including human robot interaction) to full autonomy (without active human robot intervention). In this context human robot-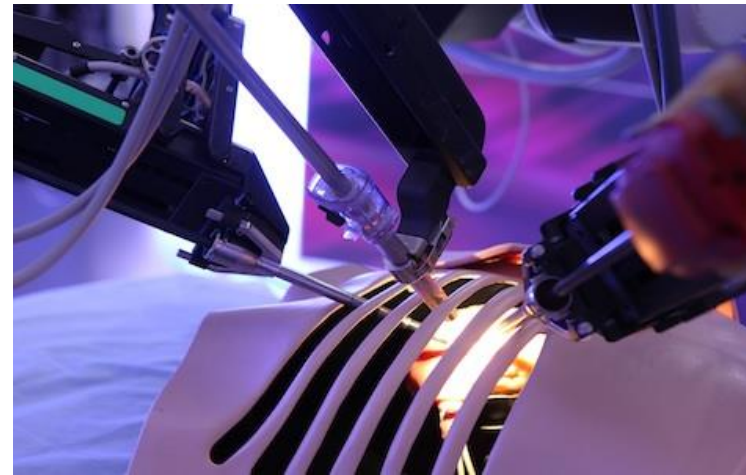interaction means information and action exchanges between human and robot to perform a task by means of a user interface.
- ✓ Manipulating industrial robots (which can be either fixed in place or mobile) could also be regarded as service robots, provided they are installed in non-manufacturing operations. Service robots may or may not be equipped with an arm structure as is case with some industrial robots. Often, but not always, service robots are mobile.

Space robots

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Autonomous vehicles

Grand Challenge 2005 — The Race
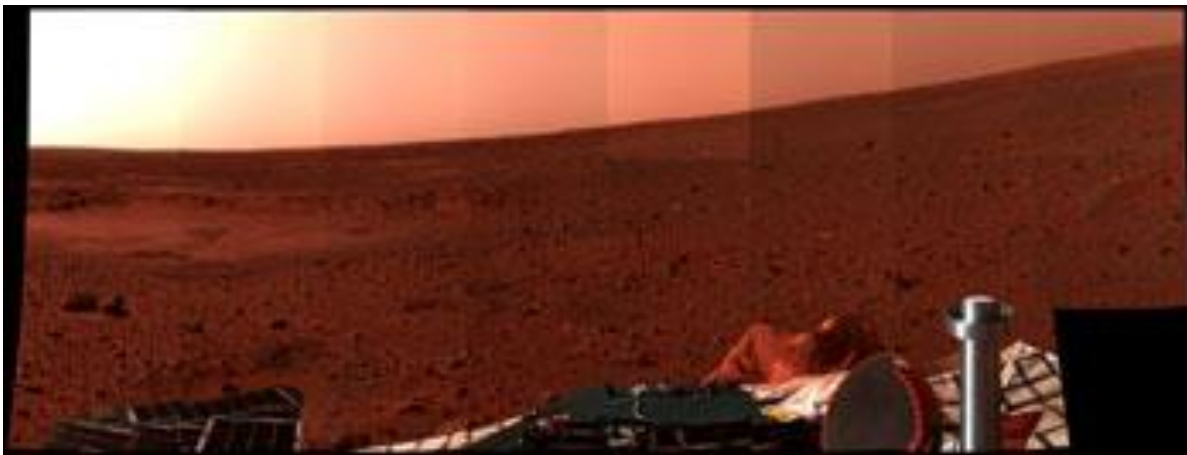
Traffic Ahead

Many carmakers are developing prototype vehicles that are capable of driving autonomously in certain situations. The technology is likely to hit the road around 2020.

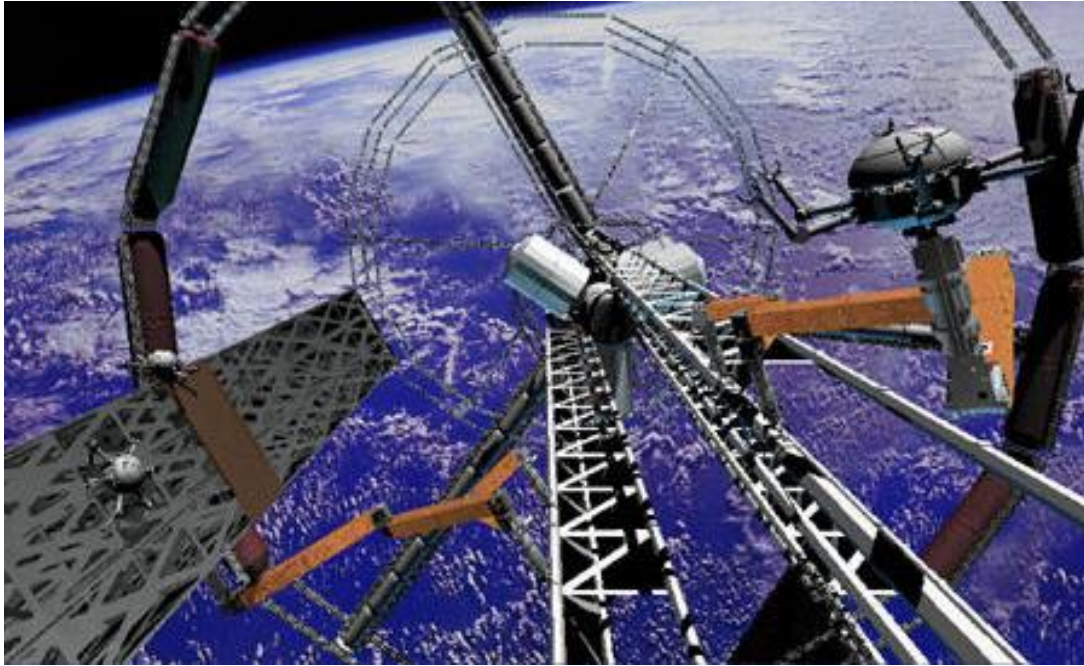|	BMW	Mercedes-Benz	Nissan	Google	General Motors
VEHICLE	5 Series (modified)	S 500 Intelligent Drive Research Vehicle	Leaf EV (modified)	Prius and Lexus (modified)	Cadillac SRX (modified)
KEY TECHNOLOGIES	• Video camera tracks lane markings and reads road signs • Radar sensors detect objects ahead • Side laser scanners • Ultrasonic sensors • Differential GPS • Very accurate map	• Stereo camera sees objects ahead in 3-D • Additional cameras read road signs and detect traffic lights • Short- and long-range radar • Infrared camera • Ultrasonic sensors	• Front and side radar • Camera • Front, rear, and side laser scanners • Four wide-angle cameras show the driver the car's surroundings	• LIDAR on the roof detects objects around the car in 3-D • Camera helps detect objects • Front and side radar • Inertial measuring unit tracks position • Wheel encoder tracks movement • Very accurate map	• Several laser sensors • Radar • Differential GPS • Cameras • Very accurate map

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✓ In some cases, service robots consist of a mobile platform on which one or several arms are attached and controlled in the same mode as the arms of industrial robot. Furthermore, contrary to their industrial counterparts, service robots do not have to be fully automatic or autonomous. In many cases these machines may even assist a human user or be tele-operated.

Teleoperated and telepresence robots

What makes an autonomous robot?

A machine gets information from a set of sensors and upon these accomplish its task autonomously by moving its body parts …

Plan

Sense

Act
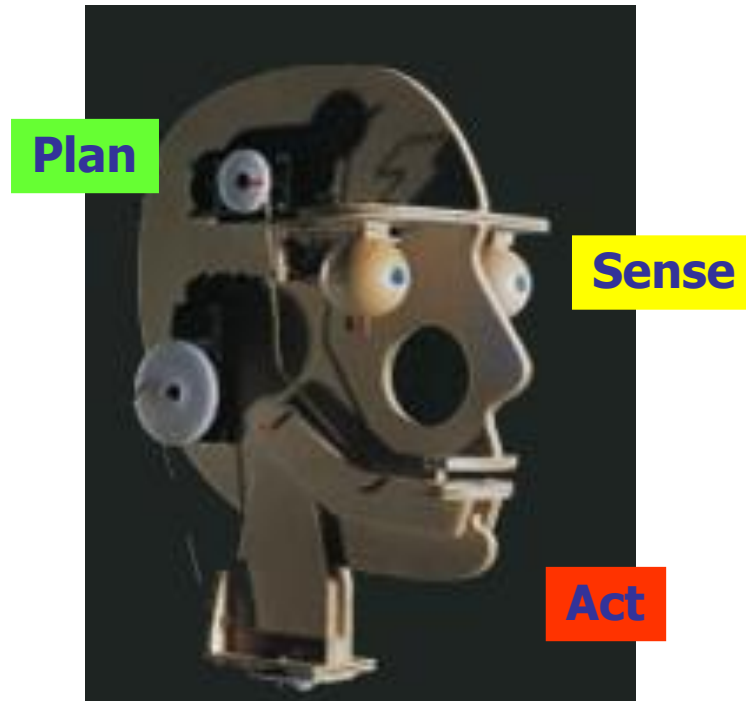
Note: The Sense-Plan-Act model is just one possible cognitive architecture for autonomous robots (Cognitive Robotics)

What does it make a mobile robot?

Algorithms

Sensors

Actuators

A Simplified Sense-Plan-Act Architecture

Map

What's around?

Mapping

Sensors

Lower Frequency

Trajectory Planning

Goal Position

Trajectory

High Frequency

Trajectory Following
(and Obstacle Avoidance)

Motion Commands

Current Position

Where am I?

Localization

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