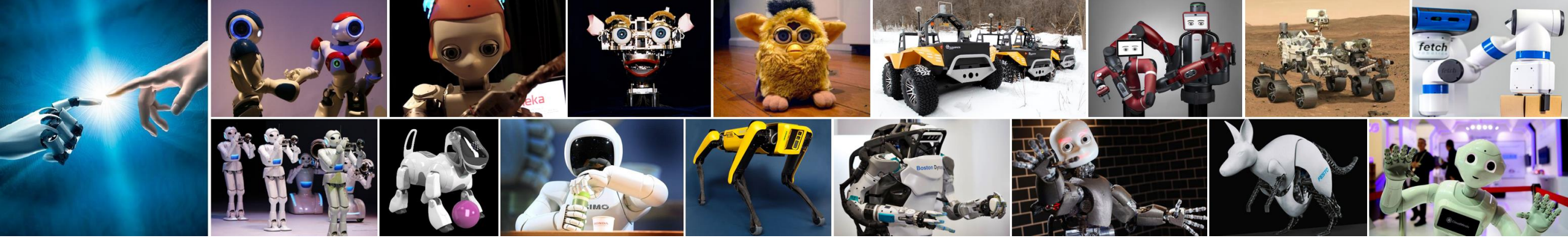
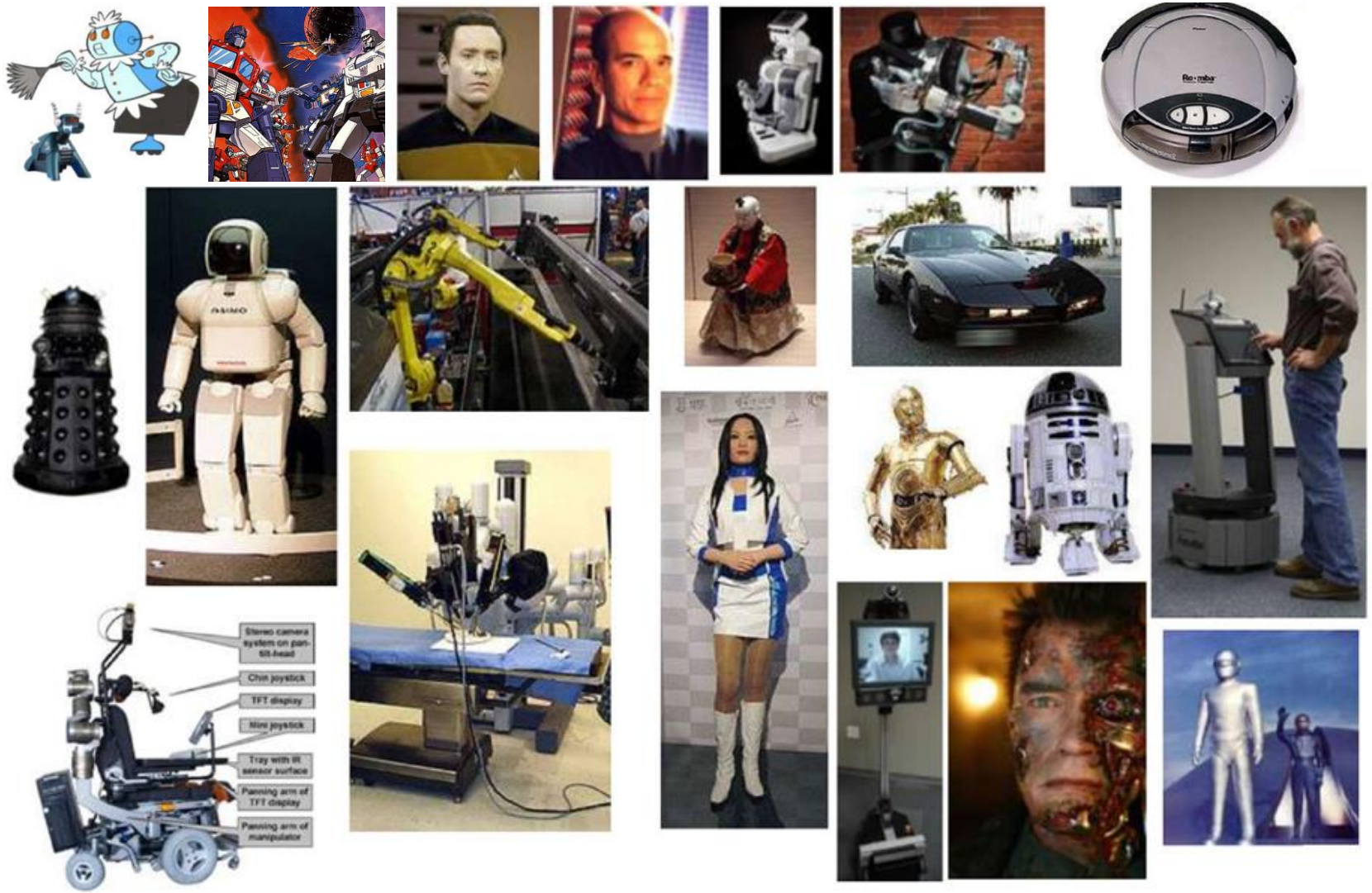


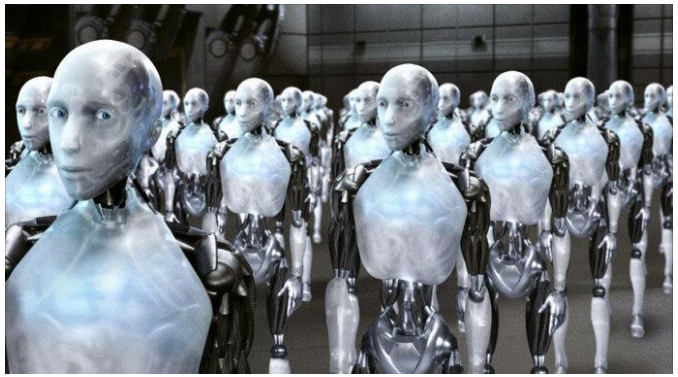
COMPSCI-603: Robotics

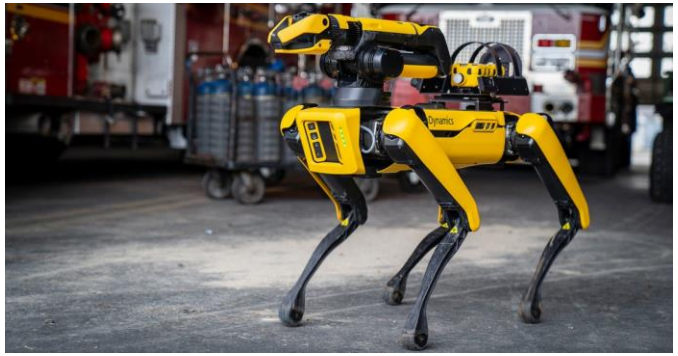
Introduction to Robotics

What image comes to your mind when you think of a **robot**?

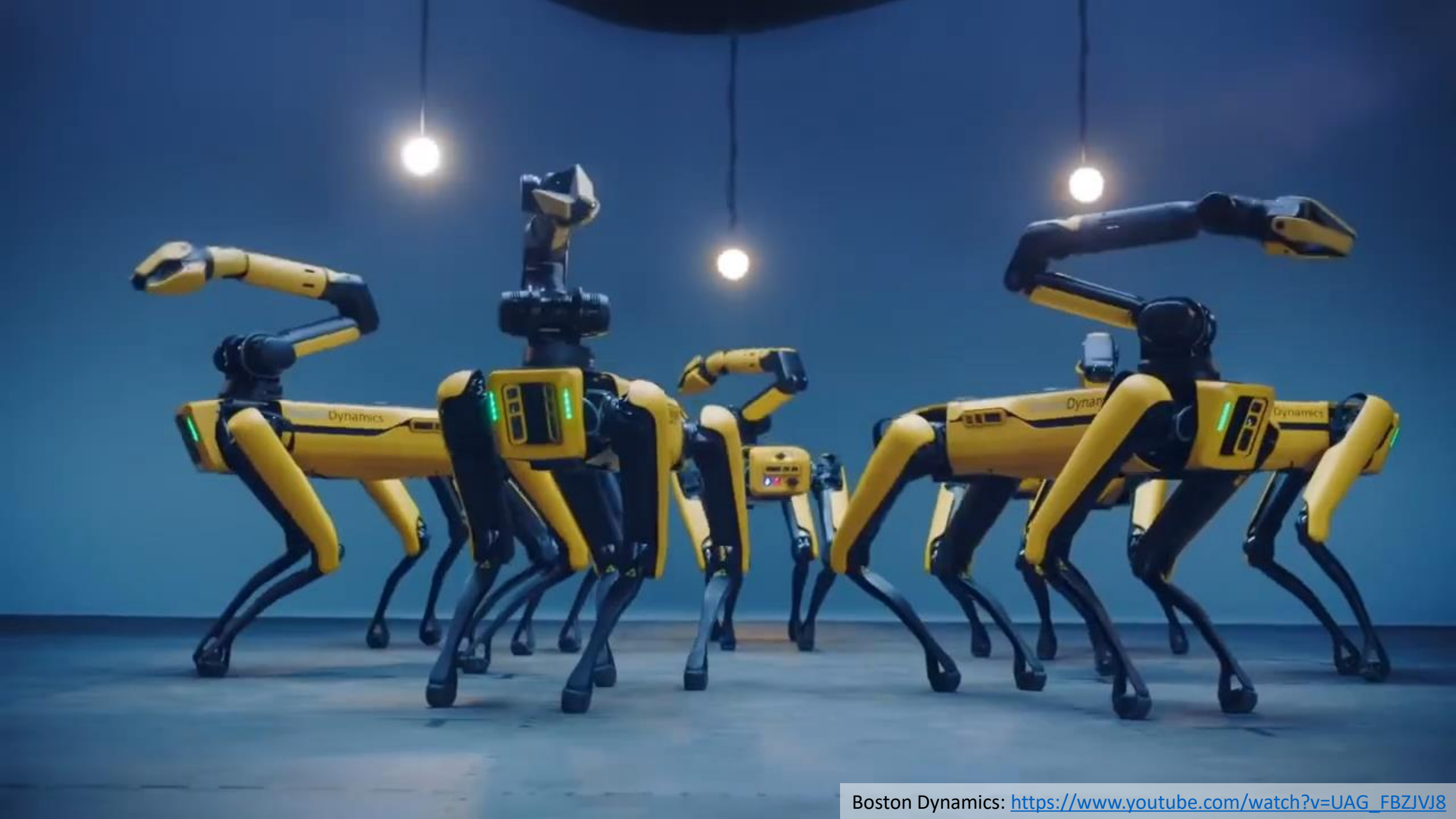
Some Images of Robots







Sky Element Drown Shows 2023: https://www.youtube.com/watch?v=BHL8IaV6xV4



Boston Dynamics: https://www.youtube.com/watch?v=UAG_FBZJVJ8

Amazon Robotics: https://www.youtube.com/watch?v=H11MaLGUAoQ

Waymo Self-driving: https://www.youtube.com/watch?v=hA_-MkU0Nfw

Google’s everyday robots: https://www.youtube.com/watch?v=DNtTUHPh-qo

Newworldai.com: Top 22 best robotics and AI movies of all the time

What is a “Robot”?

What of these are required characteristics of a robot?

1. Ability to move – legs, wheels, fly, burrow, swim, orbit
2. Ability to sense – eyes, ears, other inputs
3. Ability to manipulate – arms, hands, fingers
4. Ability to mimic – appearance, human tasks
5. Ability to interact – expressions, sounds, voice, digital, analog
6. Ability to think – mechanical brain, computer, self-awareness
7. Ability to operate – remotely, semi-autonomously
8. Ability to react and respond to different situations
9. Ability to do something useful

https://www.youtube.com/watch?v=E2evC2xTNWg

What is a “Robot”?

- Can a software program be considered a robot?
  - Is Siri a robot?

  - Is ChatGPT a robot?

  - How about a mobile sensor?

What is a “Robot”?

What of these are required characteristics of a robot?

Yes (opt) 1. Ability to move – legs, wheels, fly, burrow, swim, orbit

Yes 2. Ability to sense – eyes, ears, other inputs

Yes (opt) 3. Ability to manipulate – arms, hands, fingers

~~4. Ability to mimic – appearance, human tasks~~

~~5. Ability to interact – expressions, sounds, voice, digital, analog~~

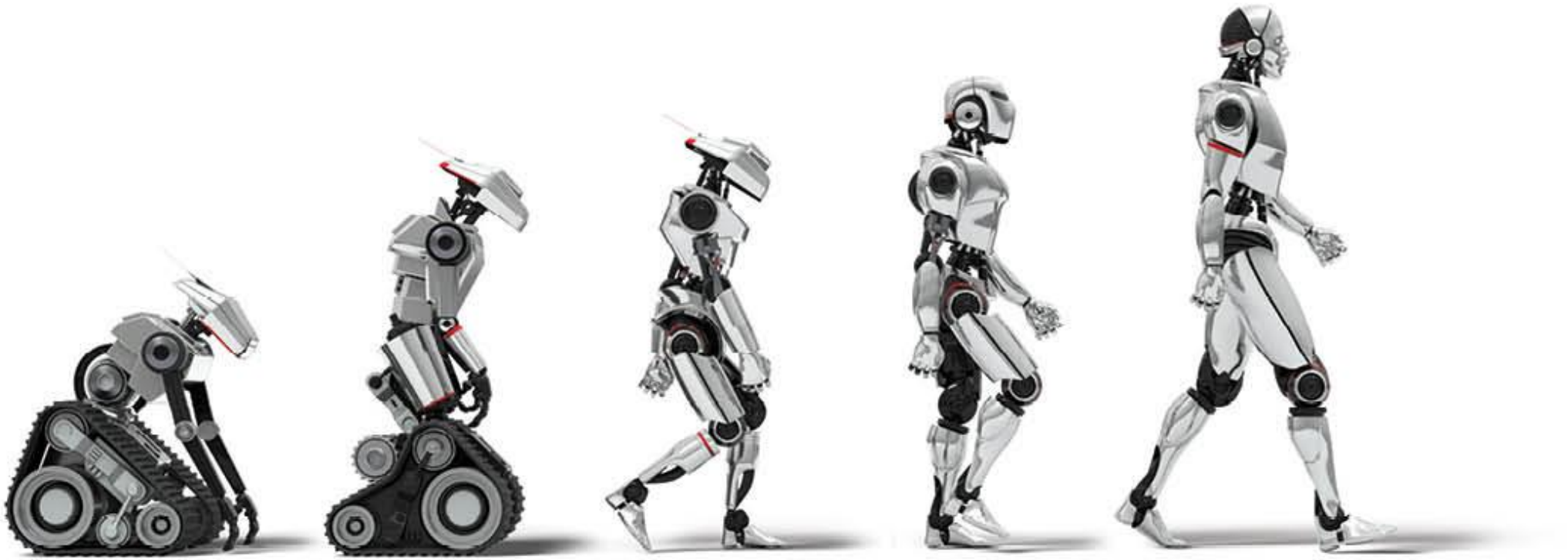
Yes 6. Ability to think – mechanical brain, computer, self-awareness

~~7. Ability to operate – remotely, semi-autonomously~~

Usually 8. Ability to react and respond to different situations

Usually 9. Ability to do something useful

There is no all- accepted definition of “robot”.



And… Robots are evolving!

Evolution of Robots

https://www.youtube.com/watch?v=Uzf-K7UtD78

The rise of Robotics and AI

Fueled by advances in computing power and connectivity, the fields of robotics and artificial intelligence have grown rapidly

1921
The term **robot** is first used by Czech writer Karel Capek

1939
Elektro, a humanoid robot, debuts at the World's Fair, smoking cigarettes and blowing up balloons

1941
Isaac Asimov formulates the **Three Laws of Robotics:**

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

1948
William Grey Walter creates **the first autonomous robot with complex behavior**

1950
Alan Turing publishes paper about the possibility of machines that think, develops idea known as the **Turing's Test.**

It tests a machine's ability to "think" by answering a series of questions. **In essence, the tester must think the machine's answers are coming from a human**

1951
Marvin Minsky builds the first neurocomputer, **SNARC**

1954
George Devol invents the first digitally operated and programmable robot

1956
Field of AI research founded at a conference at Dartmouth

1960
Frank Rosenblatt constructs **Mark I Perceptron**, a computer that learned new skills by trial and error

1961
GM installs Unimate robot to lift and stack hot pieces of metal

1968
Mobile robot "Shakey" is introduced. It's controlled by a computer the size of a room

1972
Stanford researcher develops PARRY, designed to simulate a paranoid schizophrenic.

1974
Intel produces its second-generation 8080 general-purpose chips

1979
SCARA, an articulated robot arm, is developed for assembly lines

1984
The RB5X, developed by General Robotics Corp., includes software enabling it to learn from its environment

1984
Doug Lenat and his team start **Cyc,** to codify millions of pieces knowledge that compose human common sense

1985
Jaron Lanier's VPL Research, Inc., sells first VR glasses and gloves; Lanier coins the phrase **virtual reality**

1986
Honda creates the E0, the first of a series of humanoid robots that walk on two feet

1988
Researchers launch Jabberwacky, an AI chatbot designed to learn through conversation

Nope, I'm human.

1988
The first HelpMate service robot begins work at Danbury Hospital

How are you feeling today?

I have had enough of this.

1956 IBM 305, the first hard disk drive **5MB**

1970 IBM 1330 **100MB** per pack

1985 IBM 0665, a 5.25" disk with **20-40MB**

Minimize and maximize
Shrinking disk sizes and exponentially growing capacity help fuel robotics and AI

Source: PWC

Robotics and AI
charging forward

With technologies advancing at breakneck speeds, robotics and artificial intelligence are finding new applications in factories, businesses, and homes

1990 Tom Caudell coins the phrase **augmented reality**

1990 iRobot® Corporation is founded, producing domestic and military robots

1997 Deep Blue defeats Garry Kasparov in a game of chess

1997 NASA's Pathfinder lands on Mars

1998 Dr. Cynthia Breazeal creates Kismet, a robot that interacts emotionally with humans

2000 The UN estimates there are 742,500 industrial robots in use worldwide

2005 Stanford robot Stanley drives autonomously for 131 miles

2006 IBM introduces Watson, a question-answering computer system that later defeated a Jeopardy! champion

2007 Fanuc develops an industrial robot arm that can grab 120 items per minute

2010 Google launches a 3D version of its Street View

2011 Siri is introduced

2012 Google introduces its Siri response: **Google Now**, which already has been rendered obsolete by Google Assistant

2012 An estimated 8.7 billion devices are connected to the internet

2012 Baxter, created by Rodney Brooks, can do light repetitive tasks

2013 Google launches **Google Glass**, augmented reality glasses

2015 Amazon launches **Alexa**, a "virtual assistant" that helps communicate with connected devices in the home

2016 Amazon makes first drone delivery in UK

2020 By 2020, the drone industry could be worth **$127 billion**

The FAA expects 7 million drones to ship in the US, including 2.7 million commercial drones

2016 Sony PlayStation launches **PlayStation VR**

2016 Uber begins testing driverless cars in California and Arizona

2016 Companies utilize an estimated 1.8 million industrial robots

Growing capacities
As disk size has shrunk, capacity has grown exponentially since 2000

Industrial robots: looking forward
A common fixture in the factory, the industrial robot has reshaped the manufacturing landscape through the years by performing duties unsuitable for humans

Robotics and other computerization could replace 47 percent of U.S. jobs, according to a 2013 University of Oxford study

2034

Source: PWC

What is a “Robot”?

- Common modern notion of robot:
  - Mechanically capable → Physical components
  - Programmable → Software components
  - Flexible → Intelligence components

- Our working definition of robot:
  - Physical agent that generates “intelligent” connection between perception and action.
  - That is – an autonomous system which exists in the **physical world**, can **sense** its environment, **reason**, and **act** on it to achieve some goals.

Human-Centered or Collaborative Robotics

- Robots that can coexist with humans.

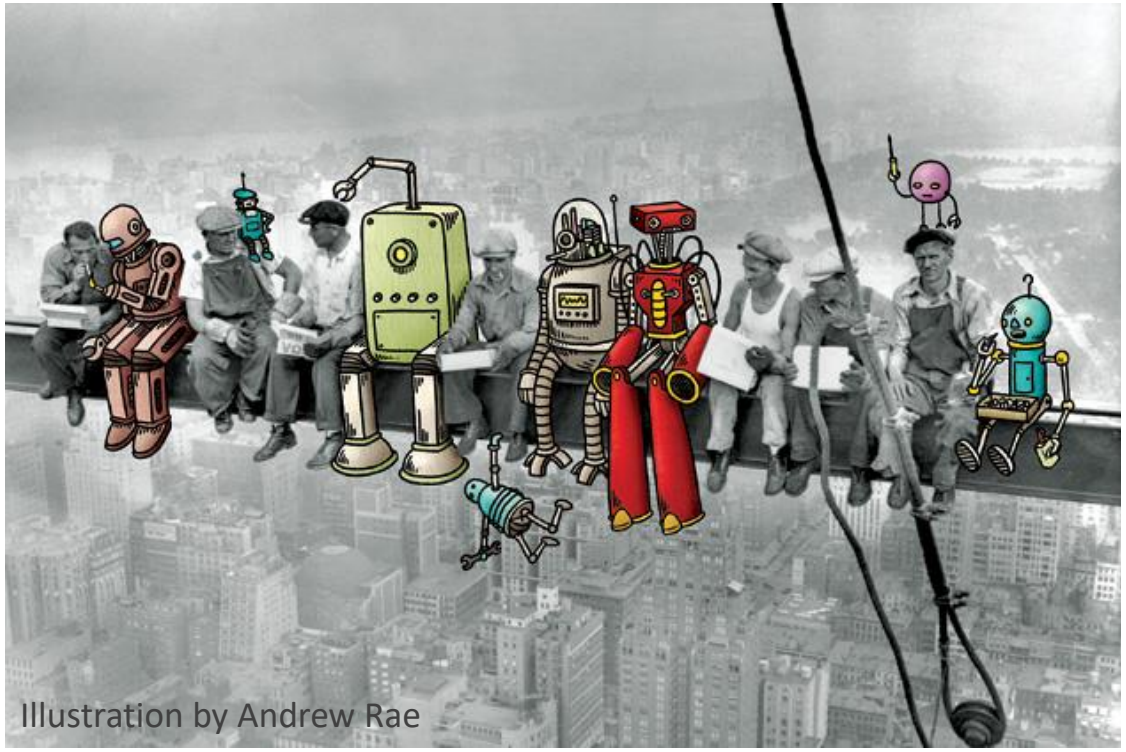


Illustration by Andrew Rae

Human-Centered or Collaborative Robotics

- Discussion from the previous NSF's National Robotics Initiative:
  - The co-robot theme of the NRI recognizes the emerging analytical, computational, mechanical, electrical, and cognitive technologies that will make the next generation of robotic systems able to safely co-exist in close proximity to humans in the pursuit of mundane, dangerous, precise or expensive tasks.
  - Co-robots will need to establish a symbiotic relationship with their human partners, each leveraging their relative strengths in the planning and performance of tasks.
  - Co-robots will be distinguished from robots of the past by their new levels of environmental modeling, situational understanding, and resourcefulness due, in part, to the use of real-world data in real time.
  - As research advances, co-robots will operate with ever-increasing levels of intelligence, safety, productivity, and autonomy in unstructured, human-dominated environments. This will ultimately manifest in levels of robot intelligence and adaptability seen only in animals and humans.
  - Despite the vastly improved capabilities for broad diffusion, access, and use (and hence, to achieve societal impacts), co-robots must be relatively cheap, easy to use, and available everywhere.

Human-Centered or Collaborative Robotics

Coexisting with humans introduces more challenges to robotics:

Yes (opt) 1. Ability to move – legs, wheels, fly, burrow, swim, orbit

Yes 2. Ability to sense – eyes, ears, other inputs

Yes (opt) 3. Ability to manipulate – arms, hands, fingers

~~4. Ability to mimic – appearance, human tasks~~

Usually 5. Ability to interact – expressions, sounds, voice, digital, analog

Yes 6. Ability to think – mechanical brain, computer, self-awareness

~~7. Ability to operate – remotely, semi-autonomously~~

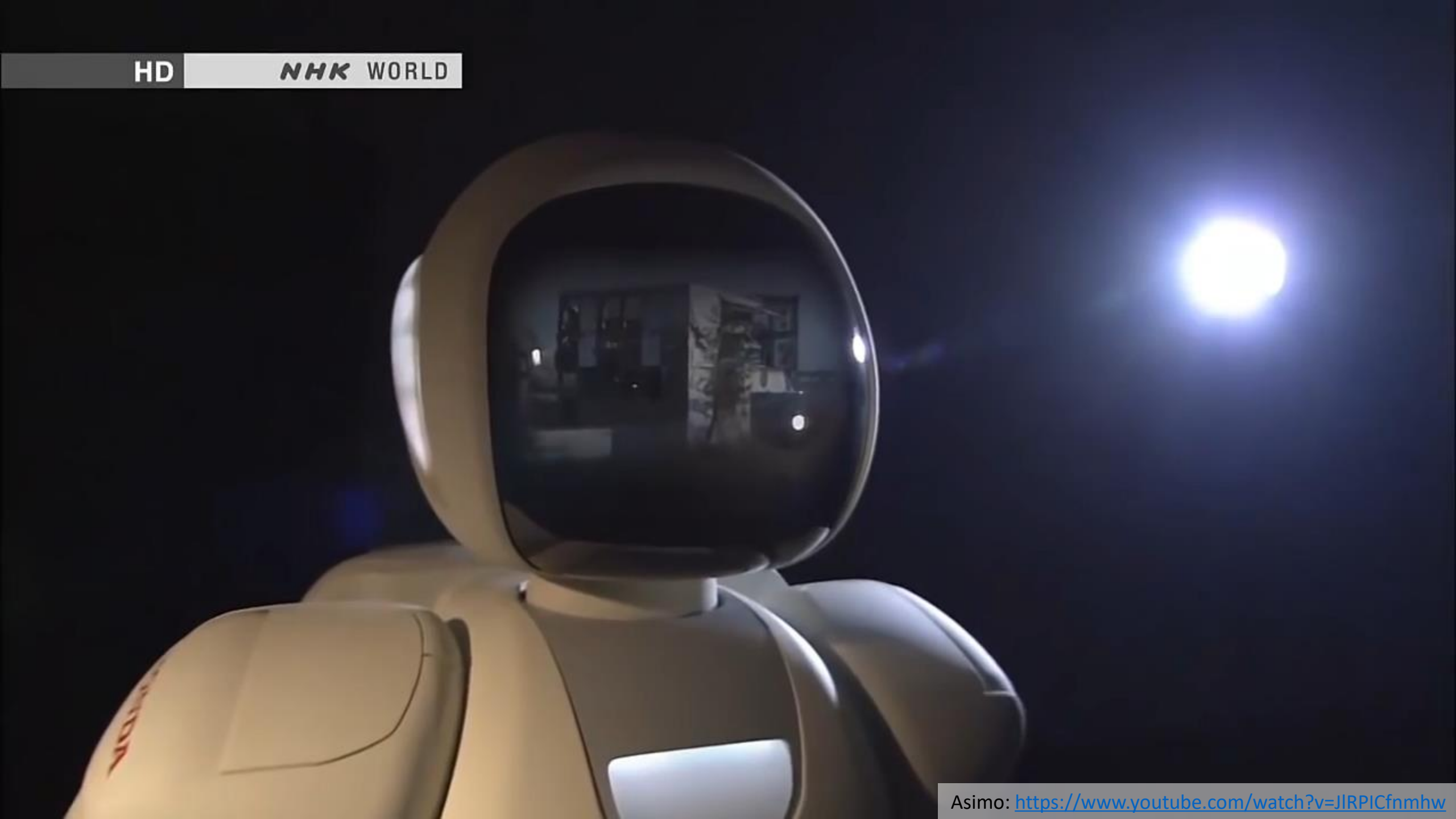
Yes 8. Ability to react and respond to different situations (humans & env.)

Yes 9. Ability to do something useful (to be assistive)

\+ Human factors (safety, ethics, trust, etc.)

As a means to alleviate the operator from repetitive tasks and increase product throughput, a collaborative application incorporating the LBR iiwa has been developed.

Human-Robot Collaboration for BMW/MINI: https://www.youtube.com/watch?v=keh99z1M5LI



Asimo: https://www.youtube.com/watch?v=JIRPICfnmhw

Challenges of Robotics

None of the following is easy for a robot:

Yes (opt) 1. Ability to move – legs, wheels, fly, burrow, swim, orbit

Yes 2. Ability to sense – eyes, ears, other inputs

Yes (opt) 3. Ability to manipulate – arms, hands, fingers

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Challenges of Robotics

- Same person?
- How to locate the person on a New York street?
- How can a robot navigate in this environment?
- How can a robot follow the person in this environment?

Course Overview

- This course is intended to serve as an advanced overview of robotics from the perspective of computer science and artificial intelligence.
- The course discusses the complete autonomy loop, including perception, cognition, and action.
- This course covers the theories, algorithms, and computational implementations related to these topics.
- Students will gain hands-on experience in implementing and extending such algorithms using simulations and real robots.
- The course offers project-based learning, with focus on open discussions for how to do robotics research to go beyond the state of the art.

Course Objectives

- Get students motivated!
- Introduce students the state-of-the-art robotics research and robotic systems.
- Teach student fundamental theories and algorithms to build intelligent robots.
- Provide students experience of constructing a working intelligent robotic system.
- Improve students' other skills, including technical writing, presentation, and teamwork.

Course Focus

- This course is about
  - Designing algorithms of embodied artificial intelligence for robotics.
    - Perception: representation, localization, and mapping
    - Cognition & Action: learning and planning for navigation
  - Programming robots with state-of-the-art open-source tools
    - Robot learning for wall following and obstacle avoidance
    - Bayesian methods for robot localization
- This course is NOT about
  - Mechanical engineering
  - Electrical engineering
  - Low-level programming
- Side note: although all students are very welcome, course difficulty is largely tuned towards CS PhD students.

Related 600-level Courses

- COMPSCI 670 – Computer Vision
- COMPSCI 674 – Intelligent Visual Computing
- COMPSCI 682 – Neural Networks: Modern Intro
- COMPSCI 683 – Artificial Intelligence
- COMPSCI 685 – Advanced Natural Language Processing
- COMPSCI 687 – Reinforcement Learning
- COMPSCI 689 – Machine Learning

- MIE 642 – Design of Advanced Feedback Systems
- MIE 643 – Mechatronic Systems