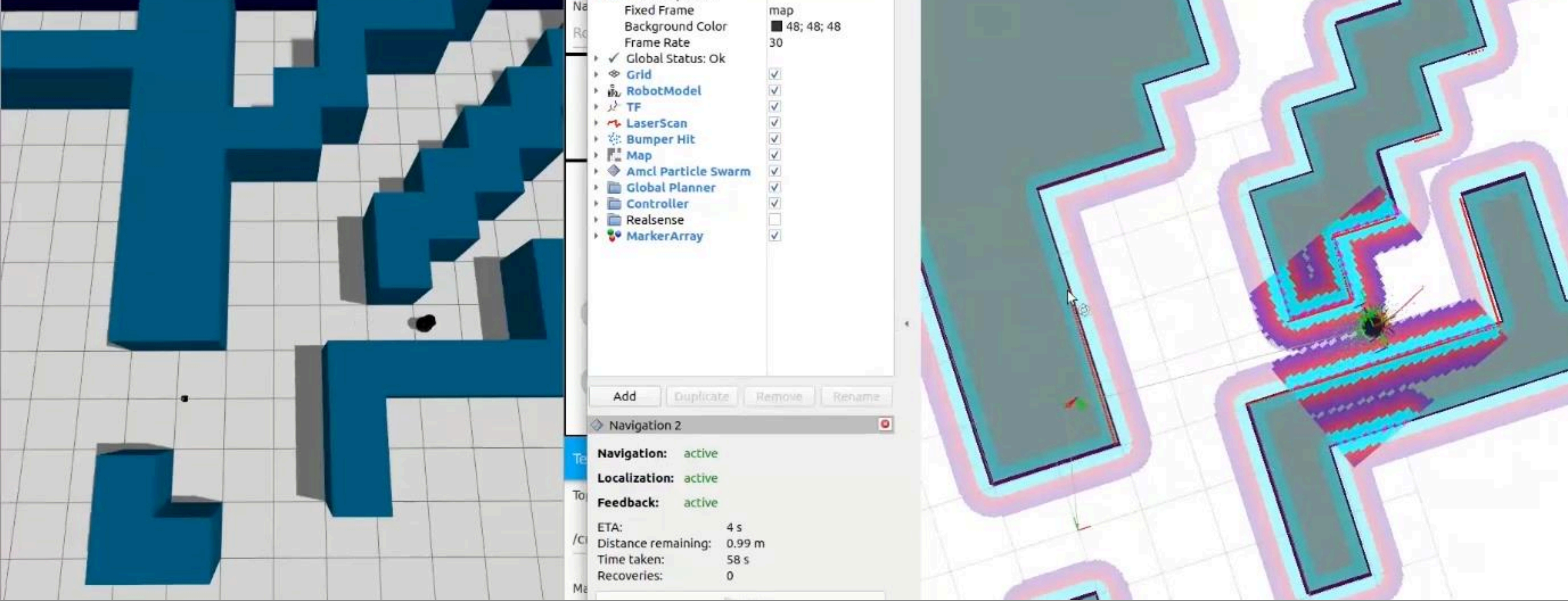

Robotics & XR

5 ECTS
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Robotics applications
November 4, 2024

Course contents

- Theme 1: The role of robotics in society and an introduction to ethical issues in robotics
- **Theme 2: Different types of robots and their application to real-world problems**
- Theme 3: Robot control theory
- Theme 4: Navigation
- Theme 5: Robotics & AI
- Theme 6: Extended Reality applications in robotics

Theme 2: Robotics applications

- *Week 45 (November 4 – 10)*
- Brief history of robotics
- Different type of robots and their applications in different fields
- Robotics frameworks and toolkits
- ROS2 application framework: Why and how?

ROS 2

A brief timeline of robotics applications

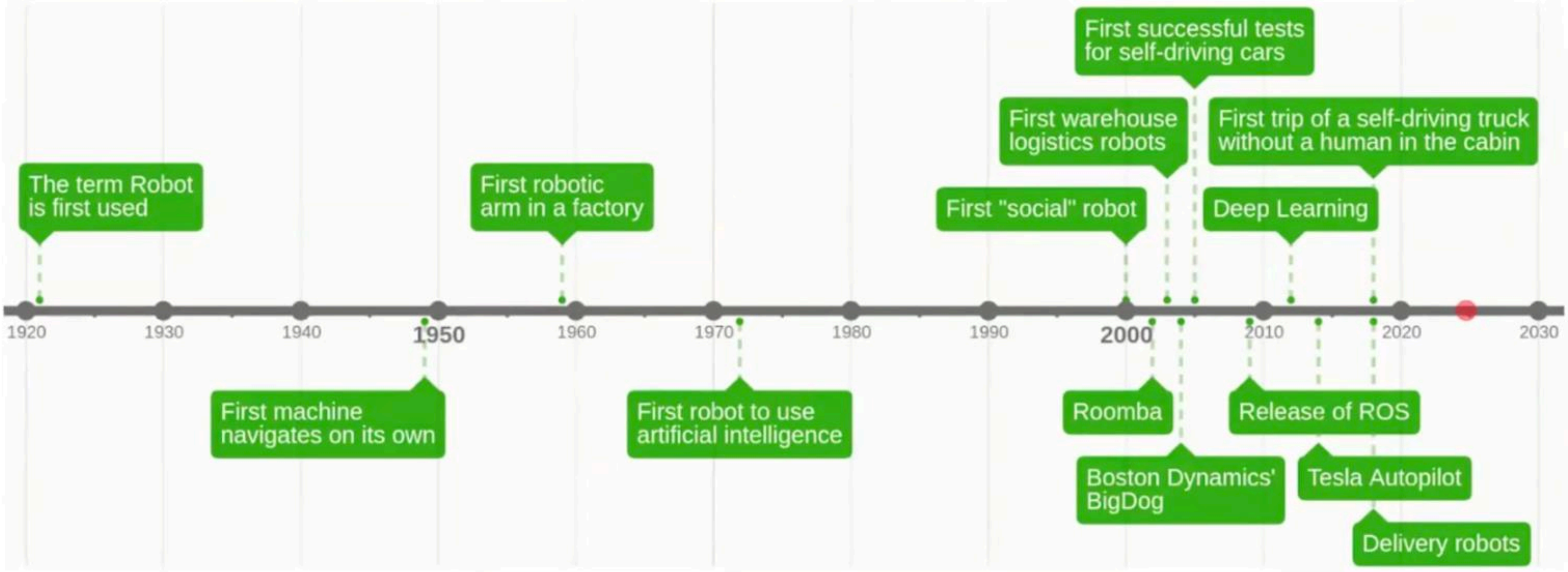
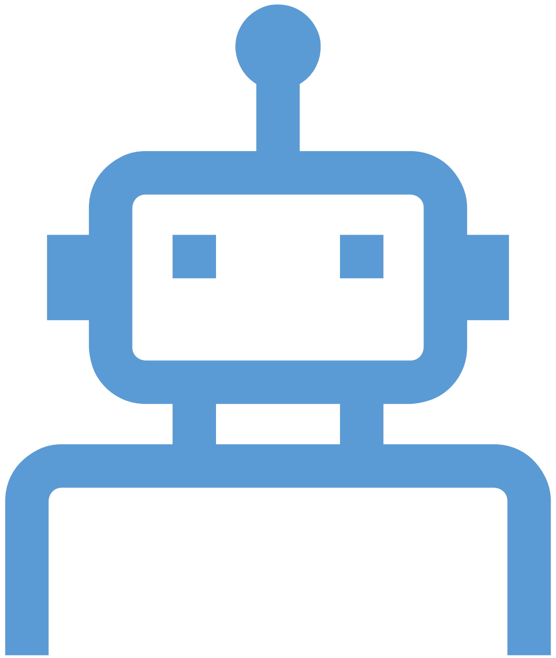


Image source: Karelics

Categorization of robots (one example)

- Mobile robots
- Collaborative robots (cobots)
- Industrial robots
- UAVs (Unmanned Aerial Vehicles)
- Human or animal shaped robots
- AUVs (Autonomous underwater vehicles)



Categorization by the use

- Autonomous cars
- Domestic robots
- Social robots
- Service robots
- Medical robots
- Drones (aerial or underwater)
- Agriculture robots
- And so on!

Definition of robotics systems

Robots shall consist of mechanical, electrical and electronic components

Actuators and sensors

Be physical agents affecting their environment

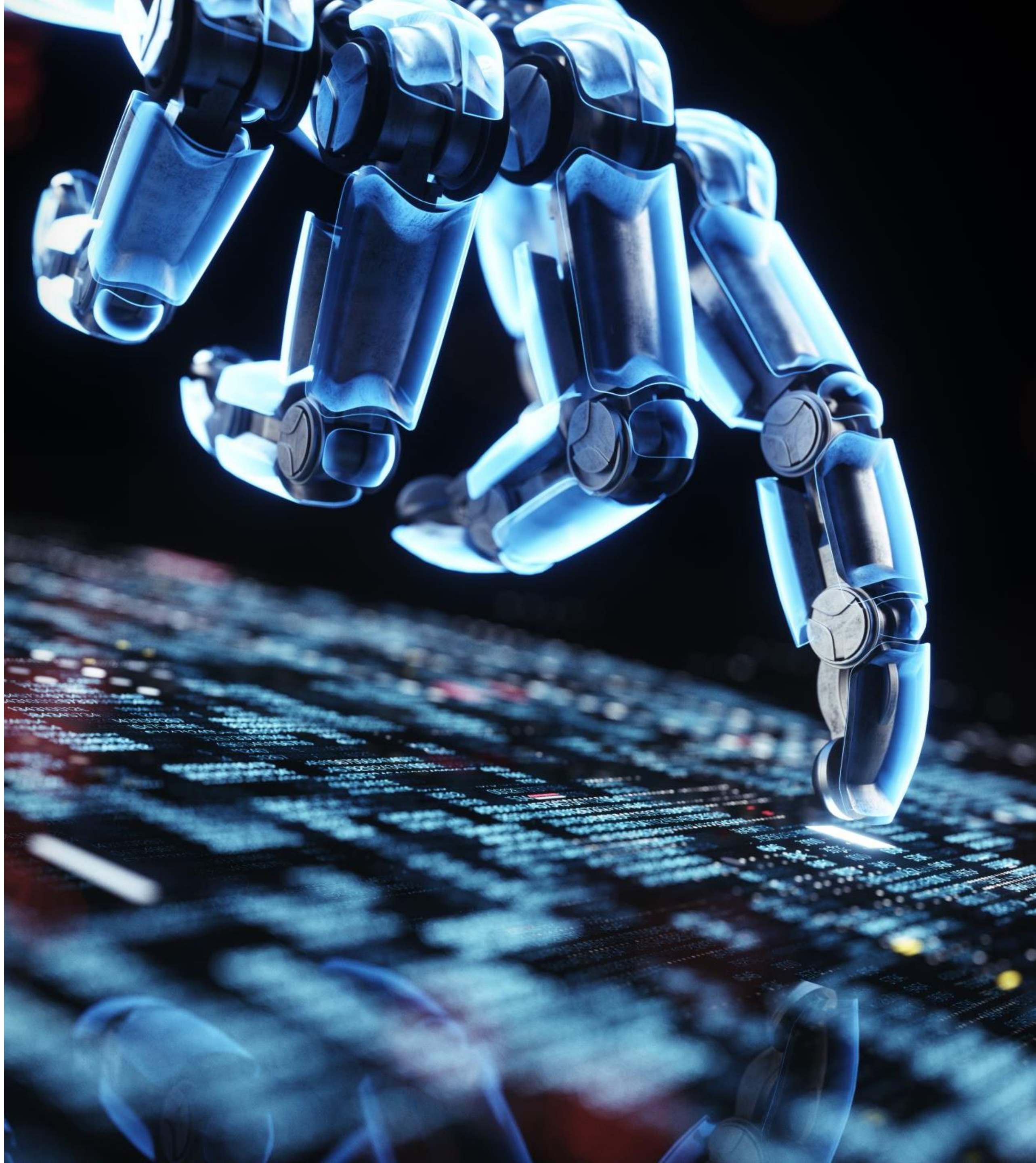
Capability to perform an action

Have a well-defined task, e.g., to perform locomotion, manipulation, positioning, reconnaissance or delivery

Tamas Haidegger, "*Taxonomy and Standards in Robotics*". In Marcelo H. Ang, Oussama Khatib, and Bruno Siciliano (eds), Encyclopedia of Robotics, Springer Nature, 2021

Robot definitions by formal standards

- ISO 8373 - Robots and robotic devices: *“programmed actuated mechanism with a degree of autonomy to perform locomotion, manipulation or positioning”*
- IEEE 1872 Standard Ontologies for Robotics and Automation: *”An agentive device in a broad sense, purposed to act in the physical world in order to accomplish one or more tasks. […] A robot is composed of suitable mechanical and electronic parts. Robots might form social groups, where they interact to achieve a common goal. A robot (or a group of robots) can form robotic systems together with special environments geared to facilitate their work.”*

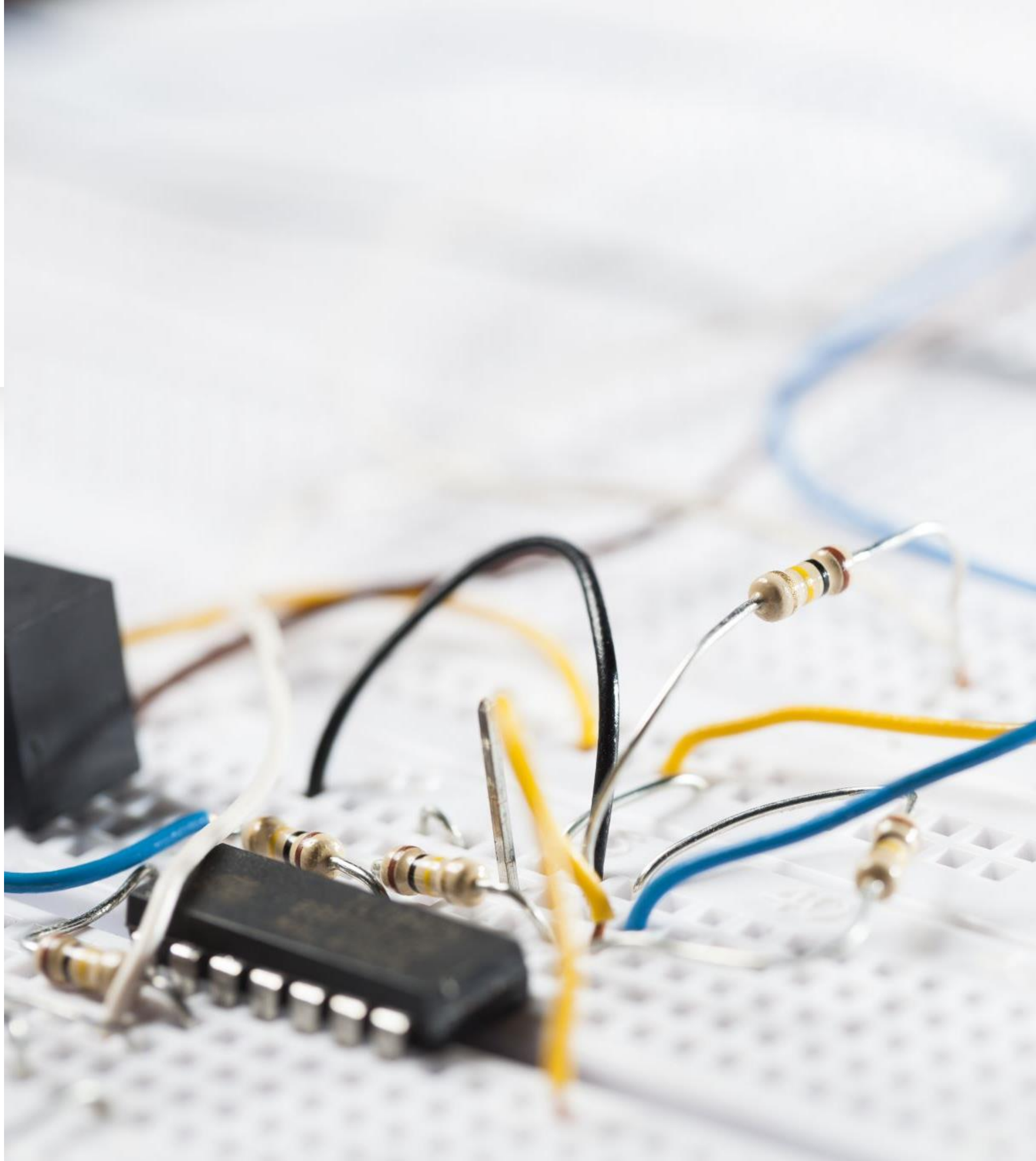


More definitions from ISO 1873

- Industrial robot: “*Automatically controlled, reprogrammable multipurpose manipulator(s), programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications”*
- Service robot: “*Robot that performs useful tasks for humans or equipment excluding industrial automation applications”*
- Medical robot: *“A robot with medical intended use”*

Which components a robot system is built on?

- Sensors
- Actuators
- Mechanical structure
- Power source
- Communication capabilities
- Computational devices



Sensors

- Sensors allow a robot to observe its surrounding
- Sensors ”replace” human or animal senses and provide a robot system with capabilities to react external stimulus
- Sensors are everywhere – mobile phones, computers, cars, access control system, elevators, traffic lights, home appliances, …
- Stimulus -> processing -> reaction
- Most typical sensors in robotics applications
  - Touch, distance, light, color, direction, IR, acceleration, tilting, sound, temperature, rotation, gyroscope
  - Laser-based range finders (LIDAR), stereo cameras, GPS

Actuators

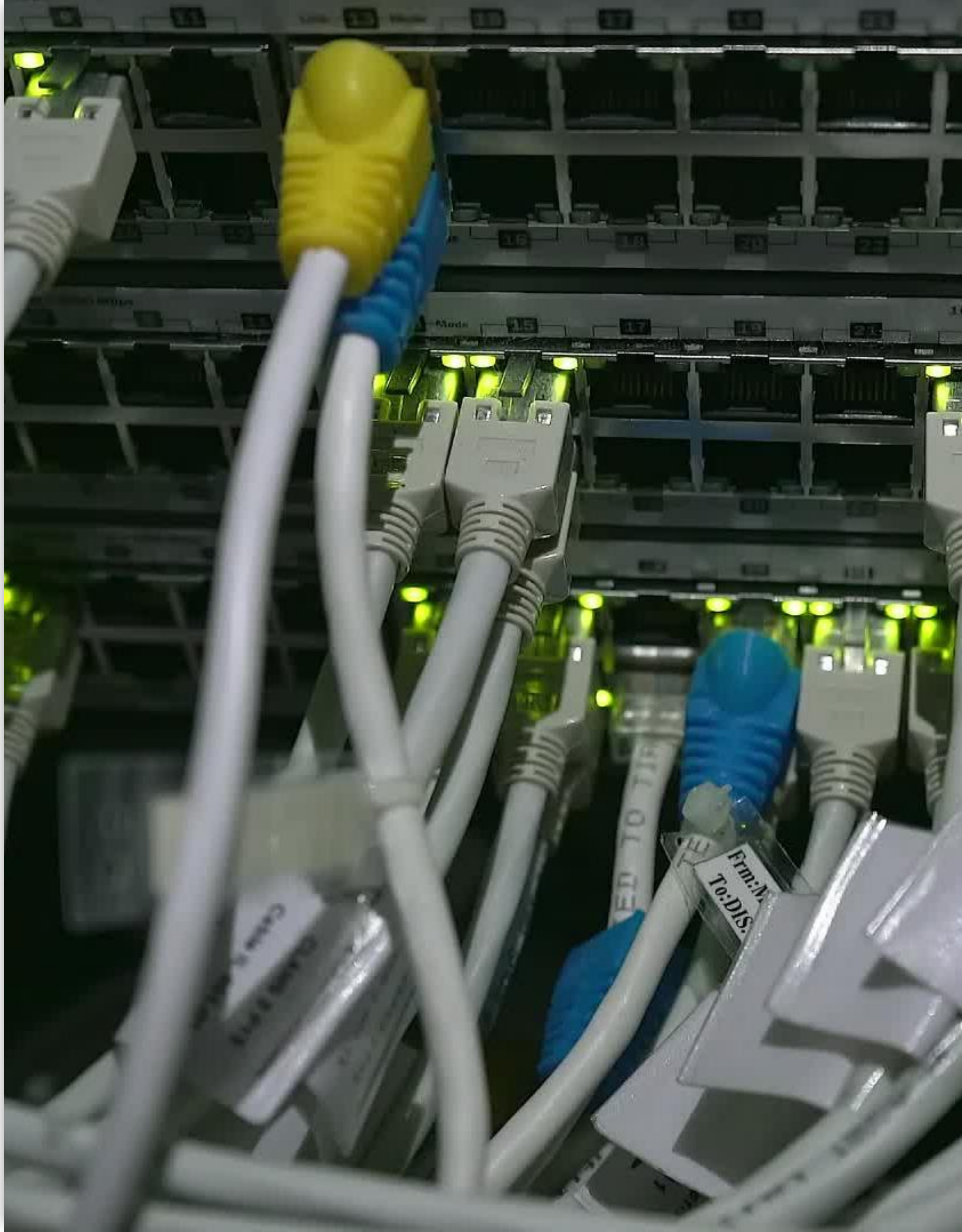
- Actuators convert energy (electricity) into physical motion
- Motors, linear actuators, solenoids, muscle wires, pneumatic and hydraulic
- Most robotics solutions have one or several type of motors
- Three main types of motors
    - DC motors, gear motors
    - Servo motors
    - Stepper motors

Mechanical structure and power source

- Motors allow mobile robots to move
  - Rotating wheels or belts
  - Moving joints of robot's legs
  - Spinning rotators of drones
- Robot chassis to hold and protect components
- Autonomous robots need power (in most cases electricity)
- Several different type of power supplies depending on the use case

Communication capabilities

- Short-range communication
    - Bluetooth, NFC, Zigbee, MQTT
- Long-range communication
    - TCP/IP based networks (WLAN, Ethernet), UDP, 4/5/6G, MODBUS
- Internal communication
    - Ethernet, DeviceNet (CAN), USB, serial port communication



Computing devices

- STM32F103xx
- ATmega328
  - Used widely in Arduinos
- PIC16xxxx
  - Probably most popular 8-bit microcontroller
- Attiny85
  - Small form-factor, ideal for small
- TI MSP430 series
  - Especially good for low-power applications
- ESP8266/ESP32
  - Built-in communication capabilities
  - Variety of built-in interfaces

- Microprocessor – just a chip with transistors for computing operations
- Microcontroller – Single IC (integrated circuit) with processor, memory, programmable general purpose I/Os (GPIO)
- SoC (System on Chip) – Integrates functionalities for one chip (CPU, memory, GPU, signal processing)
- SBC (Single Board Computer) – ”real” computers squeezed in small form factor (for example, Raspberry Pi, Nvidia Jetson series)
- Full PC:s in miniature size – Intel NUC, Apple Mac mini

How to develop a complex robotics system?

- Building and testing a comprehensive robotics system with multiple sensors, actuators, communication devices and protocols may be an exhaustive task
- Modularization, abstraction, interfacing
- Multi-robotics systems (synchronization, task management)
- Use of established frameworks help!

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ROS 2

Example: Making a robot to move

```
digitalWrite(6, HIGH);
digitalWrite(7, LOW);
analogWrite(10, 128);
```

Arduino with
L289N H-Bridge

Example: Making a robot to move

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Adafruit_DCMotor *leftMotor = AFMS.getMotor(1);
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Arduino with I2C motor driver

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ros2 topic pub -r 1 /cmd_vel
geometry_msgs/msg/Twist "{linear: {x: 0.5, y: 0.0,
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ROS2 topic for setting velocity for a robot

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ABSTRACTION

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APPLICATION

HARDWARE

What is ROS(2)?

- Robotics Operating System
- Open-source framework for building complex robotics solutions
- Strong community
  - Proven use cases
  - Fast delivery of patches and new features
  - Wide range of supported hardware
- Industry ”standard”
- Multi-platform
- Note ROS vs. ROS2

Next time… Wednesday Nov 7 at 8:15

- What is ROS?
- Why the command in the previous slide was so complicated?
- Should I learn it by heart?
- Why all this fuzz about ROS?
- *<put your question here – George and Janne will be in your service!>*