

# Automated and data- driven chemistry

LECTURE 6:  
Elements of Robotics  
Interfacing Equipment

Pascal Miéville  
Stefano Di Leone  
Edy Mariano  
Jean-Charles Cousty

01

What is Automation ?

02

Sensors & Actuators

03

Robots

04

Safety Aspects



# 1. What is Automation ?

## EPFL What is Automation ?

According to IBM

*“Automation is the use of technology to **perform tasks** where **human input is minimized.**”*

According to ISA

*“The creation and application of technology to **monitor and control** the production and delivery of products and services”*

## EPFL Examples of Automated Systems



Washing Machine  
Coffee Machine



Analytical Machine  
LC, NMR, ...



Assembly Line  
Robots



Mail spam sorting  
Updates



Barcode reader  
Card payment



Almost everywhere  
in everyday life

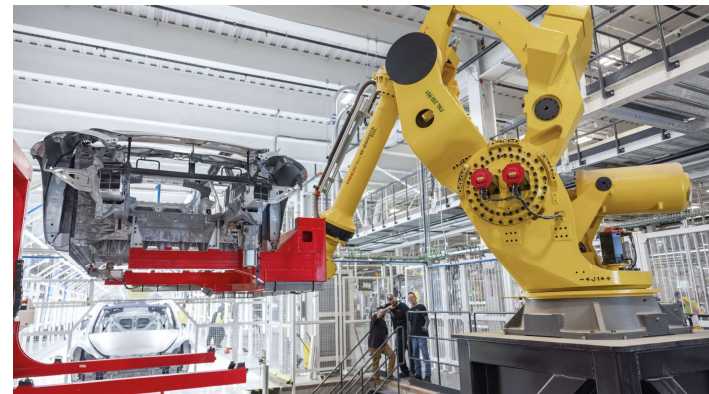
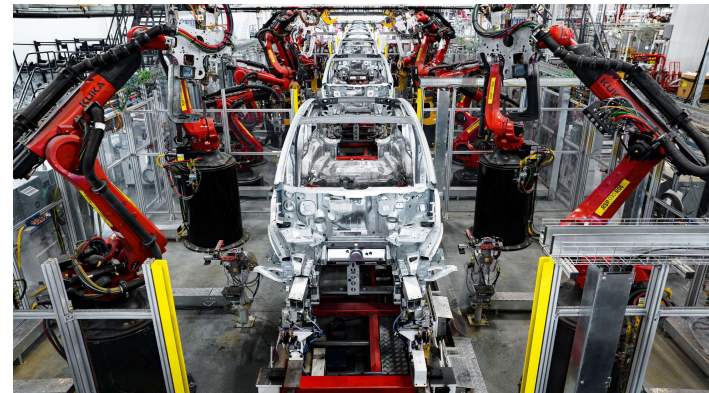
# EPFL Industrial Automation Example

## Fordism



- Standardization
- Assembly Line
- Human operator

## Tesla Gigafactory



# EPFL Industrial Automation Example

## Warehouse (Amazon)



## Chemistry (Novartis / Merck)



## Specialized Machine (Bobst)

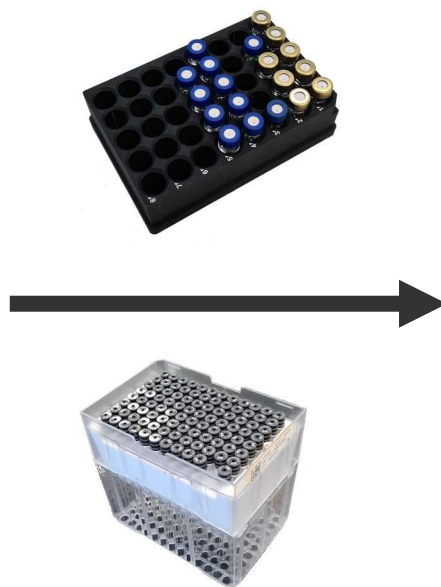


■ Automated and data-driven chemistry



# EPFL Lab Automation – Use Case

■ Automated and data-driven chemistry



# EPFL Lab Automation - Challenges



Semi-automated analytical devices



Chemical & equipment safety



Human-robot interaction



Laboratory constant evolution



**EPFL** Lab Automation – Thurow and Fleischer

OPEN

VS

CLOSE

CENTRALIZED

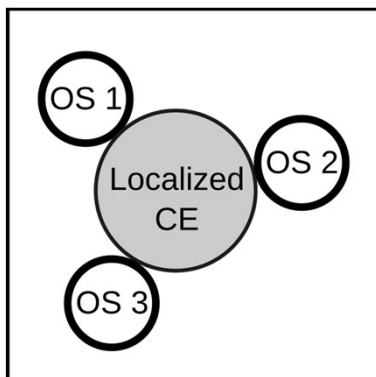
VS

DECENTRALIZED

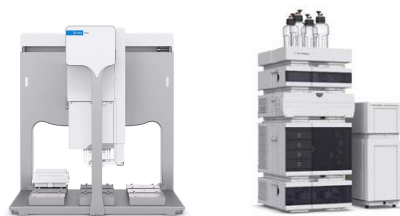
# EPFL Lab Automation - Thurow and Fleischer

CE : Connecting Element  
 OS (WS) : Working Station  
 AS : Automation system

CCAS



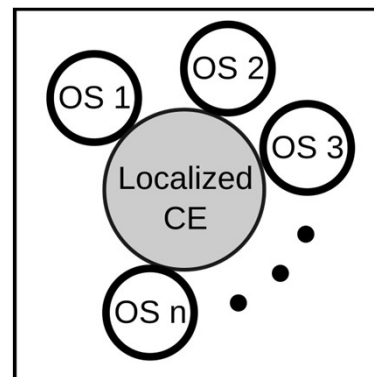
a. Closed / Centralized



Agilent Bravo

LS-MS

OCAS

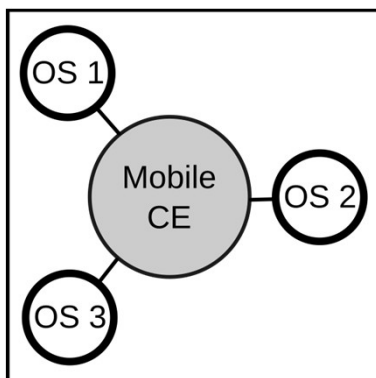


b. Open / Centralized



Chemputer

CDAS

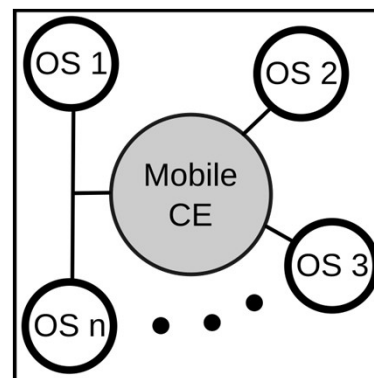


c. Closed / Decentralized



FlexShuttle

ODAS



d. Open / Decentralized

1 - mobile robot as a transport system

2 - mobile robot as a transport system with a transfer function

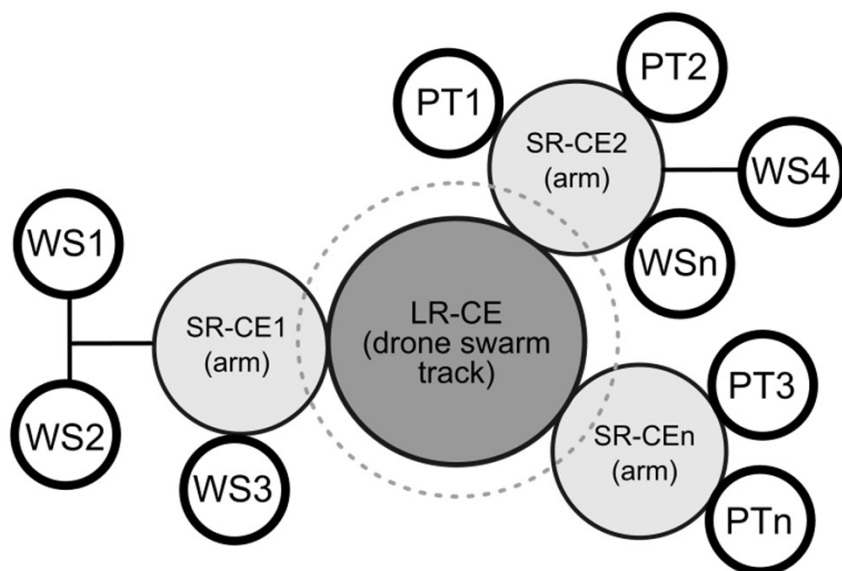
3 - mobile robot as transport system and manipulator

■ Automated and data-driven chemistry

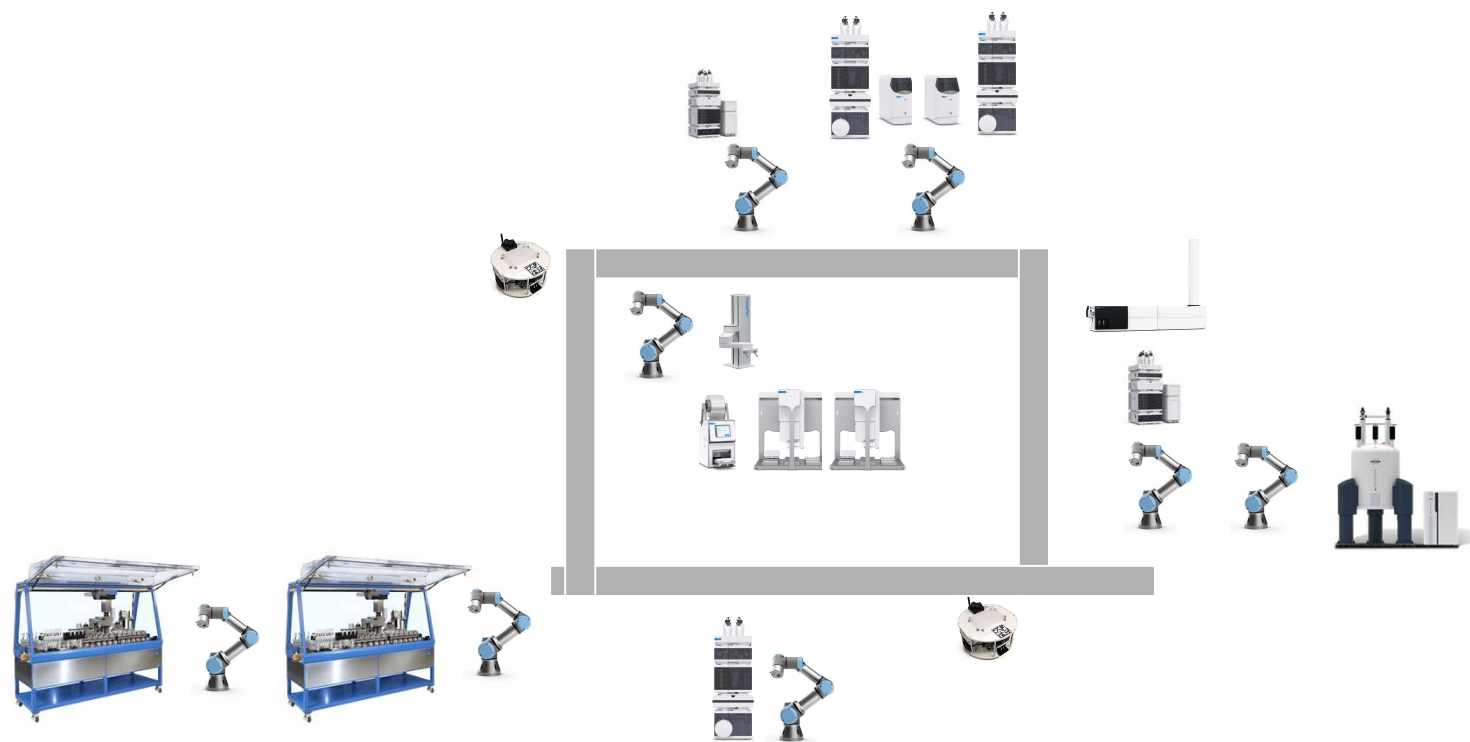


# EPFL Lab Automation – SwissCAT+ ODAS

WS : Working Station  
PT : Processing Task  
SR : Short Range  
LR : Long Range



# EPFL Lab Automation – SwissCAT+ ODAS



■ Automated and data-driven chemistry





# 1. Sensors & Actuators

# EPFL Components of Automated Systems



Sensors

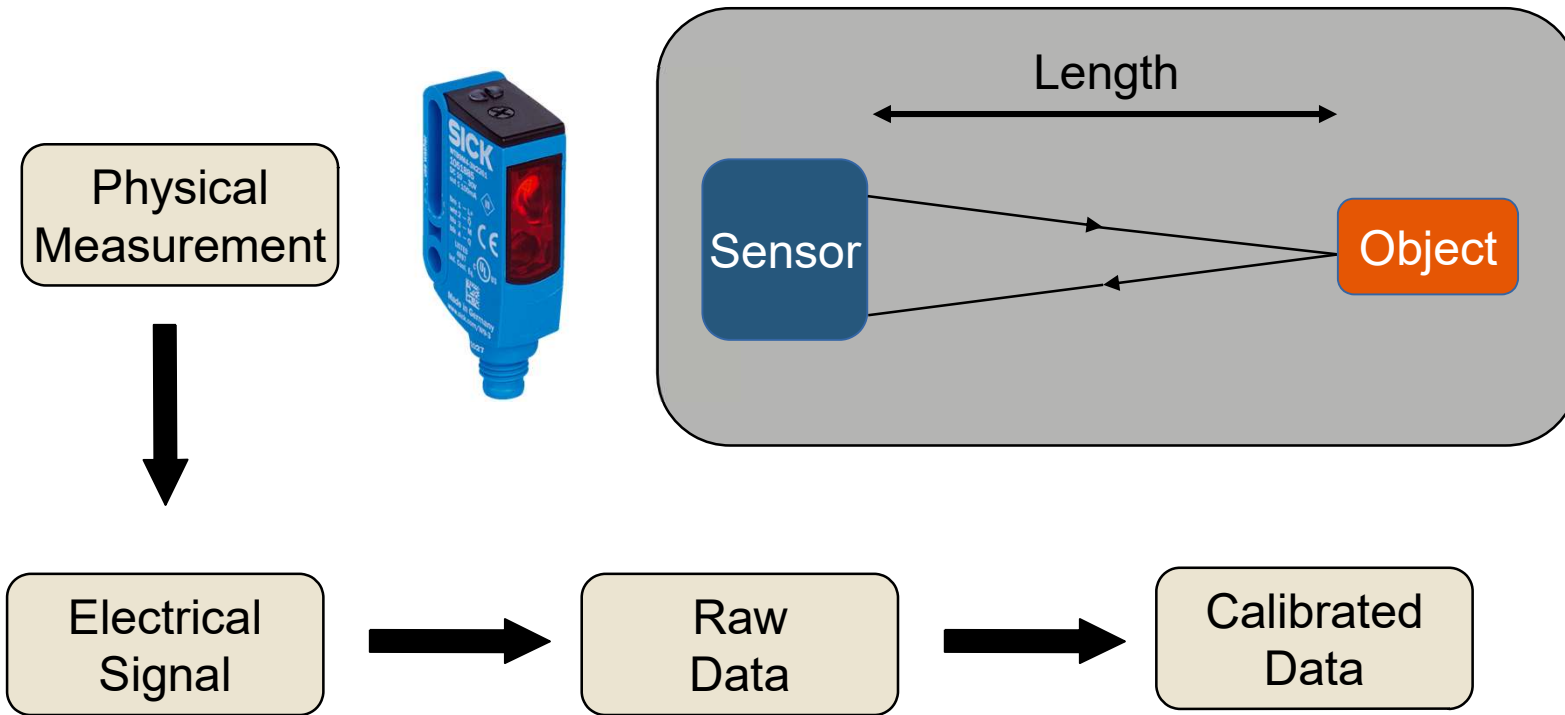


Controllers



Actuators

# EPFL Sensors How does it work ?



■ Automated and data-driven chemistry

# EPFL Sensors Types

Proximity

Force

Temperature

Pressure

Vision

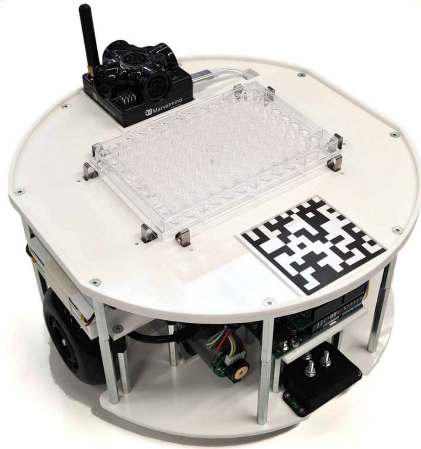


GPS

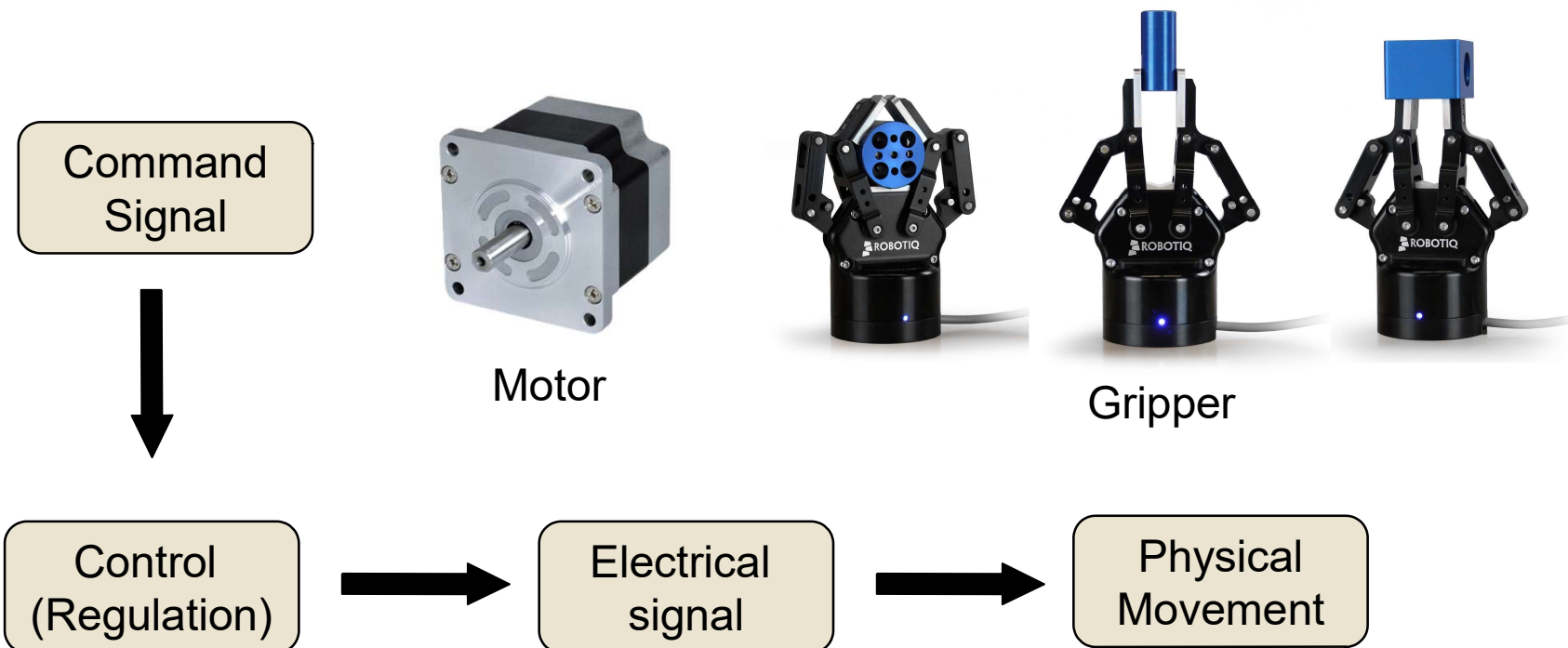
Orientation

Vision

Speed



# EPFL Actuators How does it work ?



# EPFL Types of Actuators

Electrical Motor



Pneumatic



Hydraulic



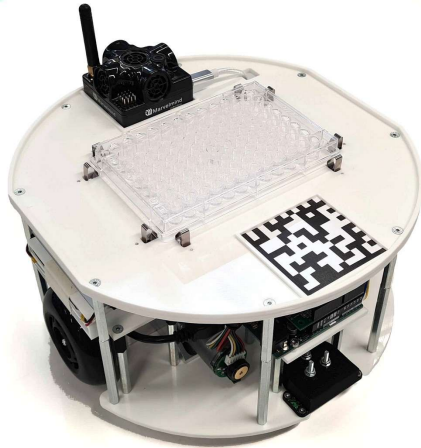
Heater



LED



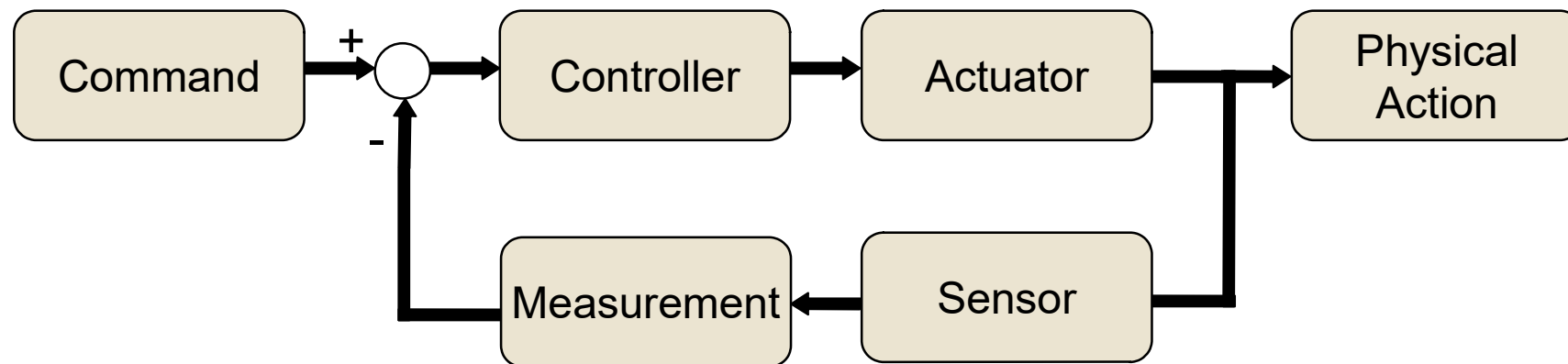
LED



Wheel Motor

Charger

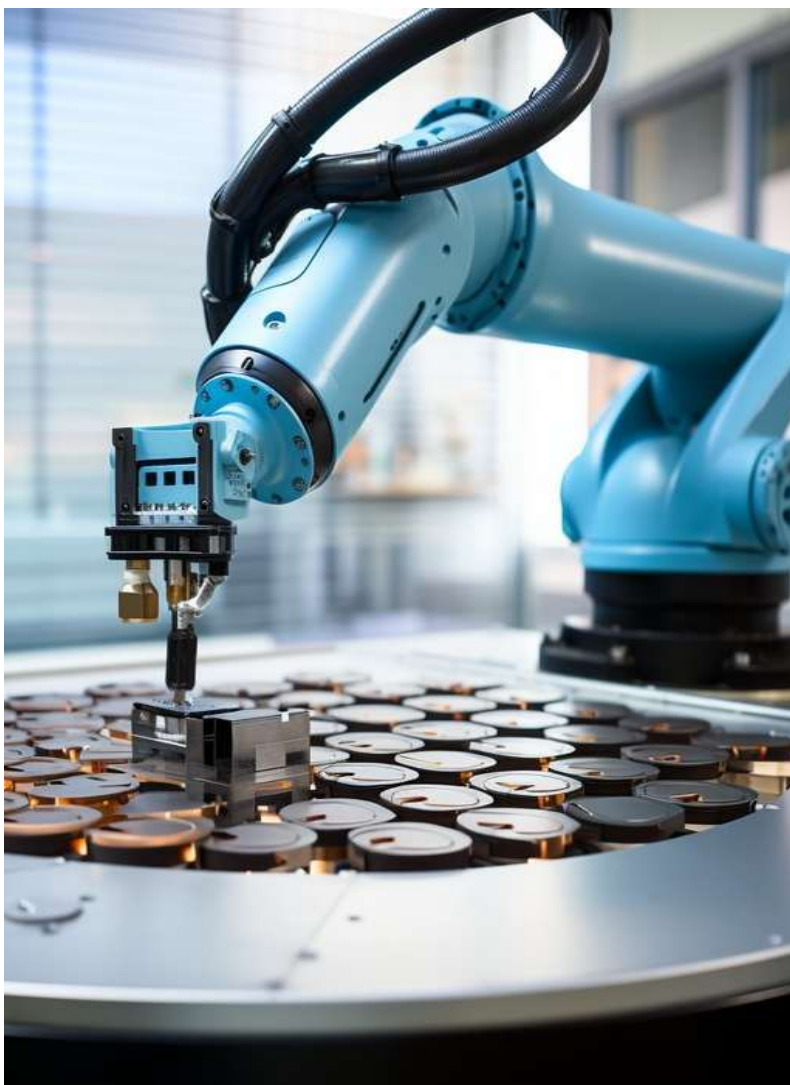
# EPFL Control-Loop



# EPFL HMI – Human Machine Interface



■ Automated and data-driven chemistry



# 1. Robots

## EPFL What is a Robot ?

Mix of **sensors, actuators and controllers**

Perform **complex tasks**, such as the ones that are usually done by humans



# EPFL Types of Robots

Manipulators

Cartesian

Delta

Six Axis

Scara  
(Cylindrical)

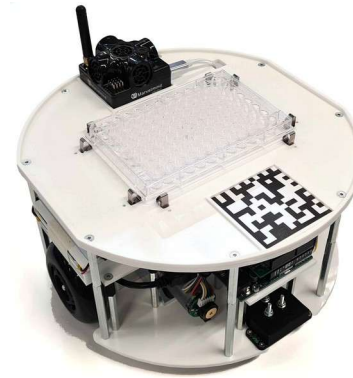


Mobile

Wheeled

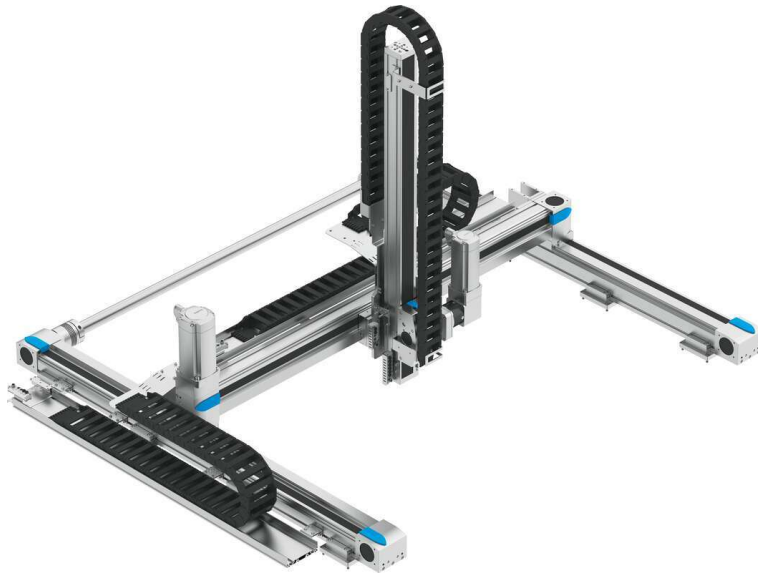
Legged

Flying



# EPFL Manipulators – Cartesian & Delta

Cartesian Robot



Delta Robot



## EPFL Manipulators – Cartesian & Delta



■ Automated and data-driven chemistry



# EPFL Manipulators – Six Axis Arms

Industrial Arm



Collaborative Arm



## EPFL Manipulators – Six Axis Arms



■ Automated and data-driven chemistry



# EPFL Manipulators – SCARA

Industrial Scara



Collaborative Scara



■ Automated and data-driven chemistry



# EPFL Manipulators – SCARA



■ Automated and data-driven chemistry



# EPFL Mobile Platform

Wheeled

Legged

Flying



# EPFL Mobile Platform



■ Automated and data-driven chemistry



# EPFL Humanoid robots

Ameca





# 1. Safety Aspects

# EPFL Safety Aspects



■ Automated and data-driven chemistry

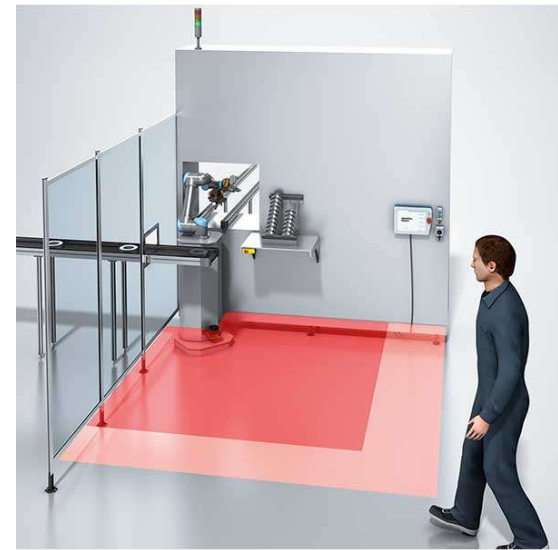
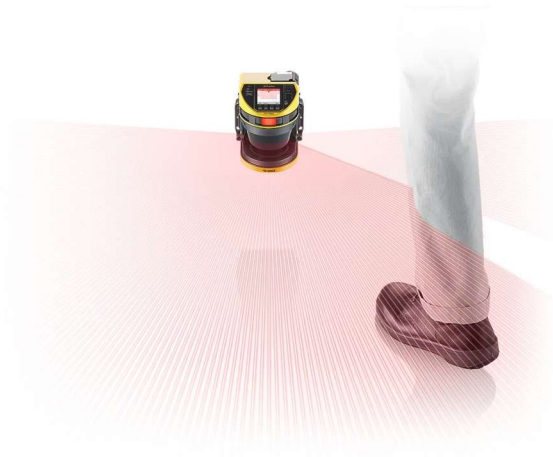


# EPFL Safety Aspects

Collaborative Robot

Proximity Sensor

Reduced speed

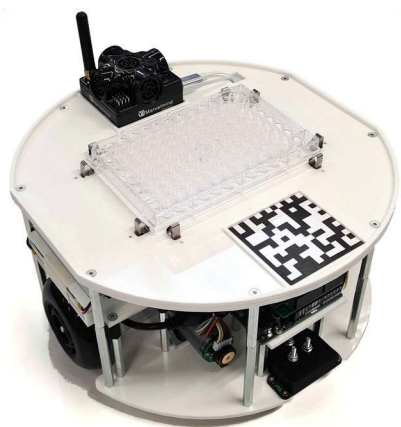


■ Automated and data-driven chemistry



# EPFL Safety Aspects

Plate Holder



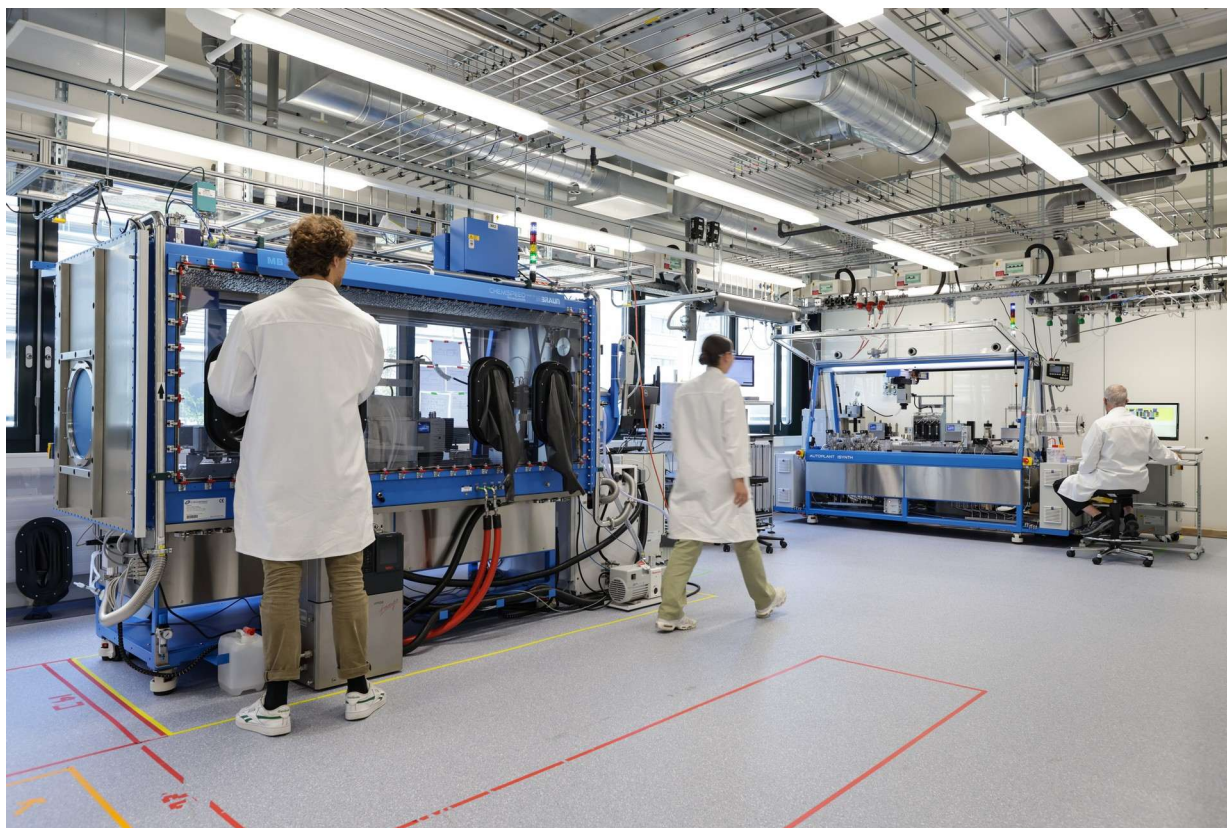
Presence Sensor



Vision



# EPFL Safety Aspects



■ Automated and data-driven chemistry

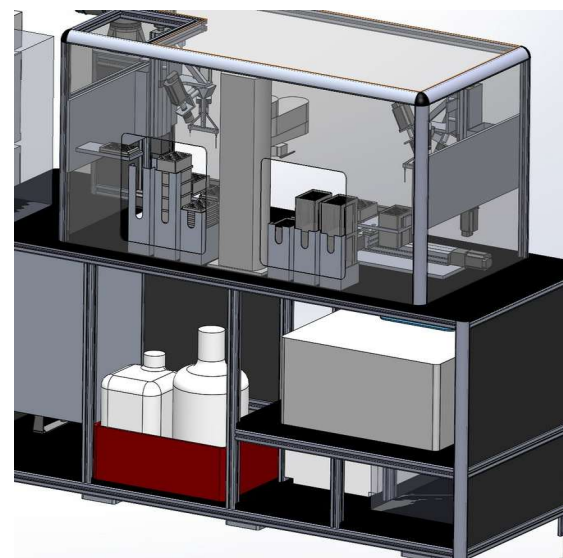
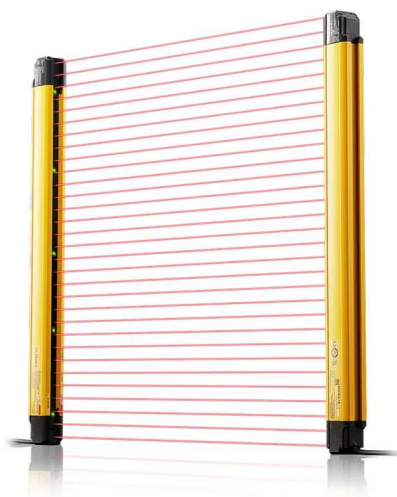


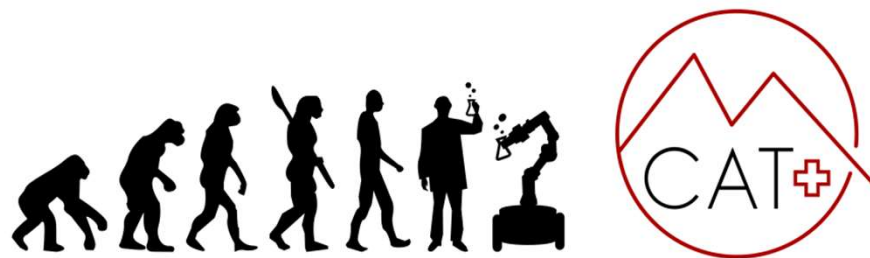
# EPFL Safety Aspects

Safety Button

Light Curtain

Protective Cage





# Automated and data- driven chemistry

LECTURE 6 – Part 2:  
Interfacing Equipment

Pascal Miéville  
Stefano Di Leone  
Edy Mariano  
Jean-Charles Cousty

01

Signal Types & Transmissions

02

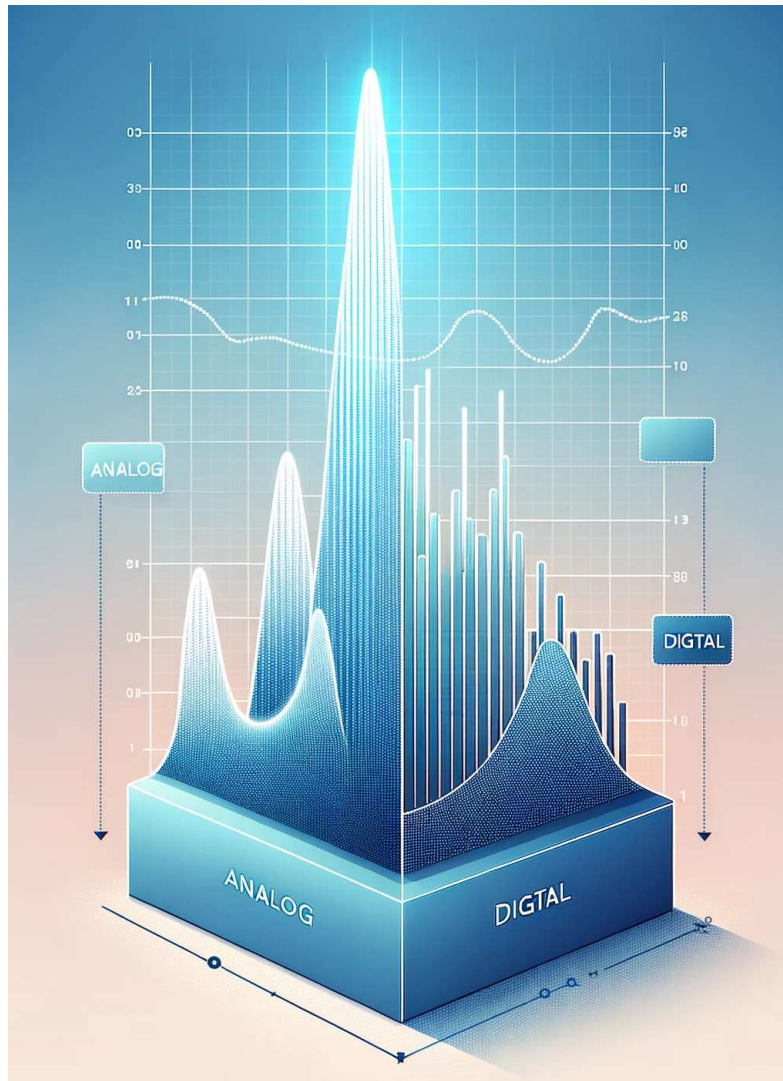
Communication Tools

03

Interfacing Devices

04

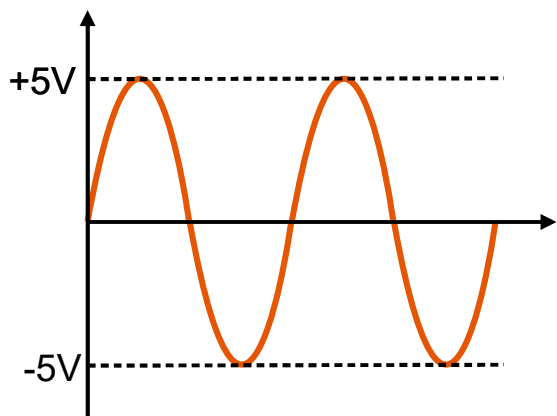
API



# 1. Signal Types & Transmissions

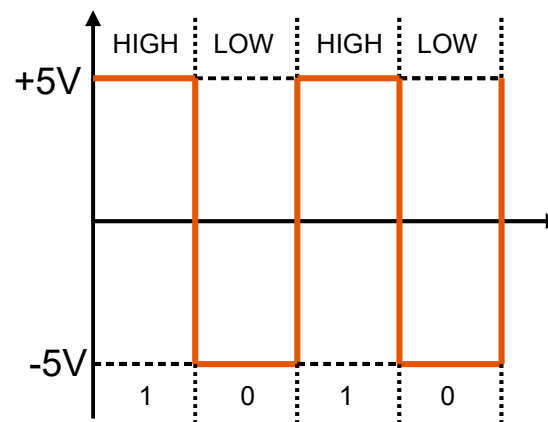
# EPFL Digital & Analog

Analog



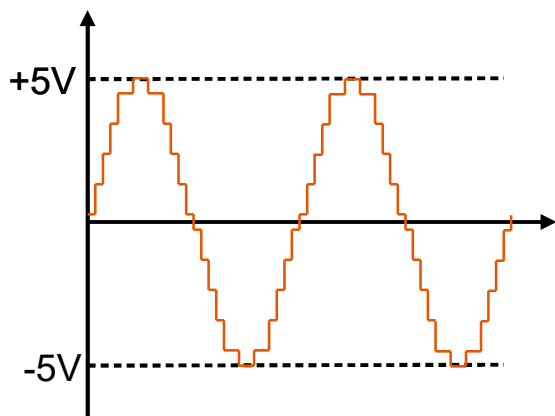
Continuous signal

Digital



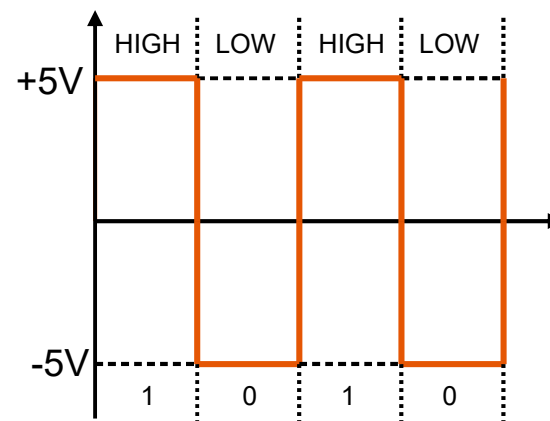
Discrete signal

Digitalized Analog



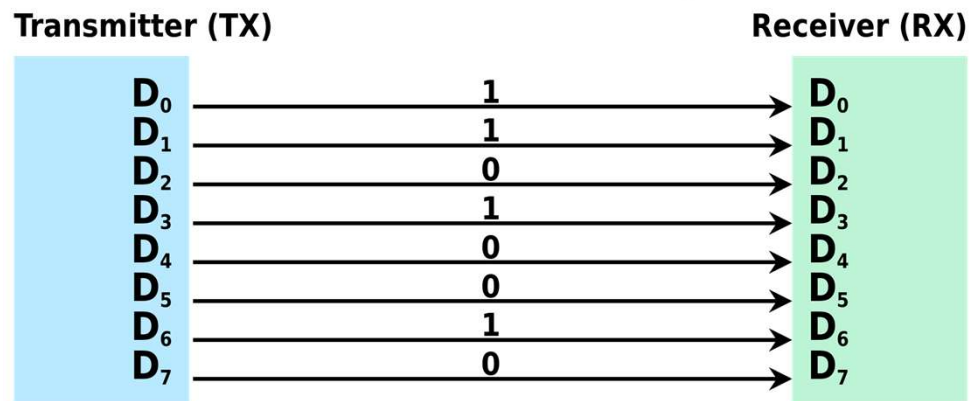
Discrete signal

Digital

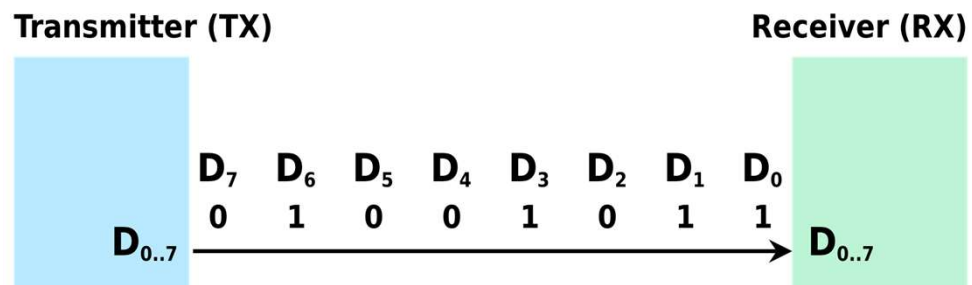


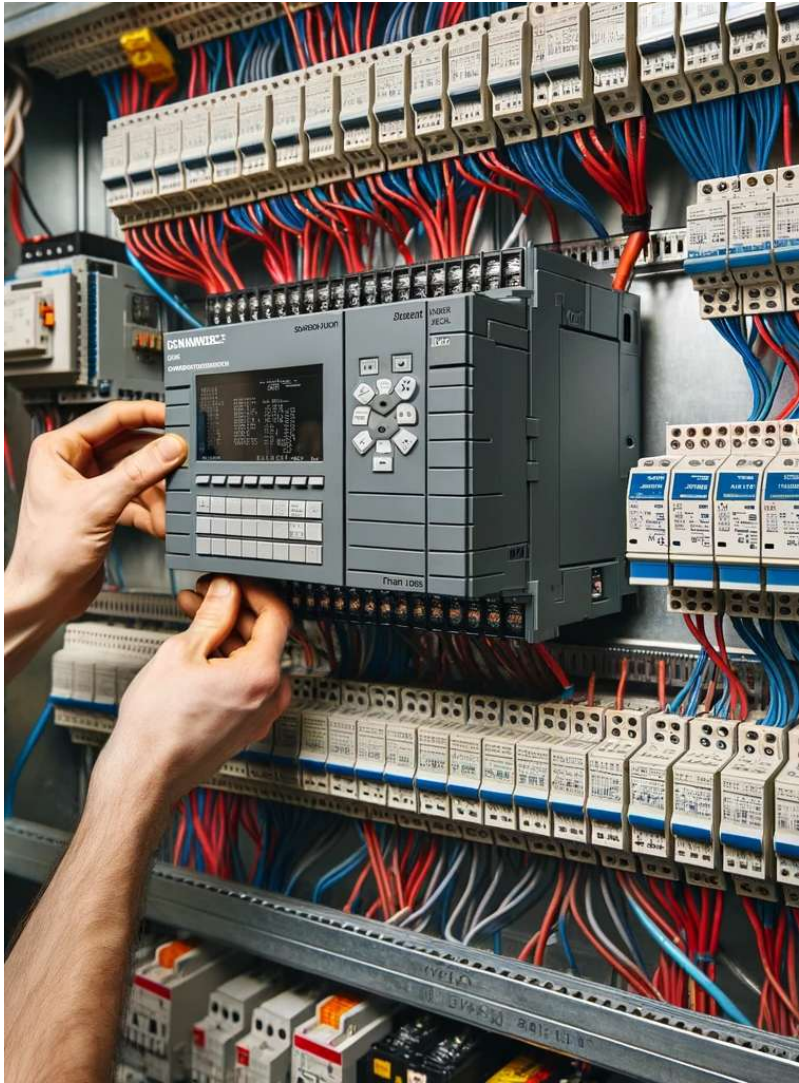
Discrete signal

### Parallel interface example



### Serial interface example





## 2. Communication Tools

## EPFL Communication

- To communicate between each others, devices need communication standards. It is a set of rules and conventions that devices must follow to communicate with each other

### Cables

USB

RJ45

HDMI

### Protocoles

TCP/IP

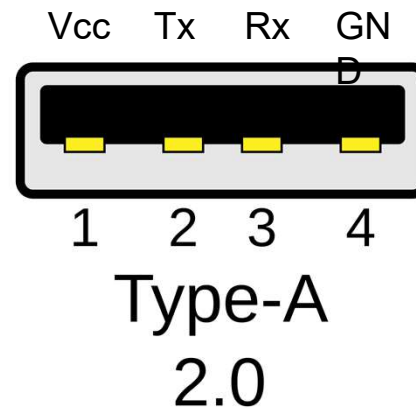
UART

Bluetooth

# EPFL Communication

USB 

- Universal Serial Bus
- A dozen of type of USB port exists
- Short distance (a few meters)
- 4 wires (9 in newer version)
- Not robust (except rs232 which is old model)
- Transmitter (Tx) and Receiver (Rx)






## RJ45 (Ethernet)



- Designed for Network communication
- Parallel communication (8 wires)
- Send by packets of data in any order
- Long distance (up to 100 m)
- Widely used in industrial setup (Automation)
- Dozens of protocols (TCP/IP, EtherCAT, ModBUS, ProfiNET, ...)
- Stable in complex environment
- Safe

## EPFL Communication



- Designed and optimized for Audio and Video signals
- Easily adaptable to each others with adapters
- With the high number of device in the lab, if possible, Remote Access Desktop should be privileged
- Many protocole exists, such as RDP (Windows) or VNC 

■ Automated and data-driven chemistry

## Display Port (DP)



## HDMI



## EPFL Power Cable 200-250V (in Europe)



**C13/C14**  
• Max 10A



**C19/C20**  
• Max 16A

## CEE Industrial

- 200-250V



- 380-480V



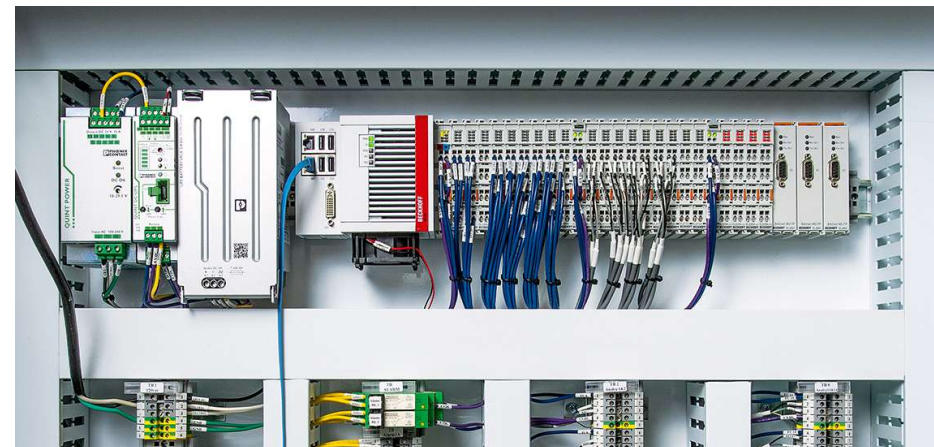
- Max 16A, 32A (and more Amp but rarely used in lab)

# EPFL PLC



- Industrial controller
- Safe, durable, works in harsh environment
- Plug & Play connectors
- Allows to easily program and connect tons of sensors and actuators
- Lots of standard communication

- Installed in Electrical Cabinet
- Requires special training
- Lots of norm to respect
- Dangerous to operate when on
- Proprietary software
- Expensive and long delivery time



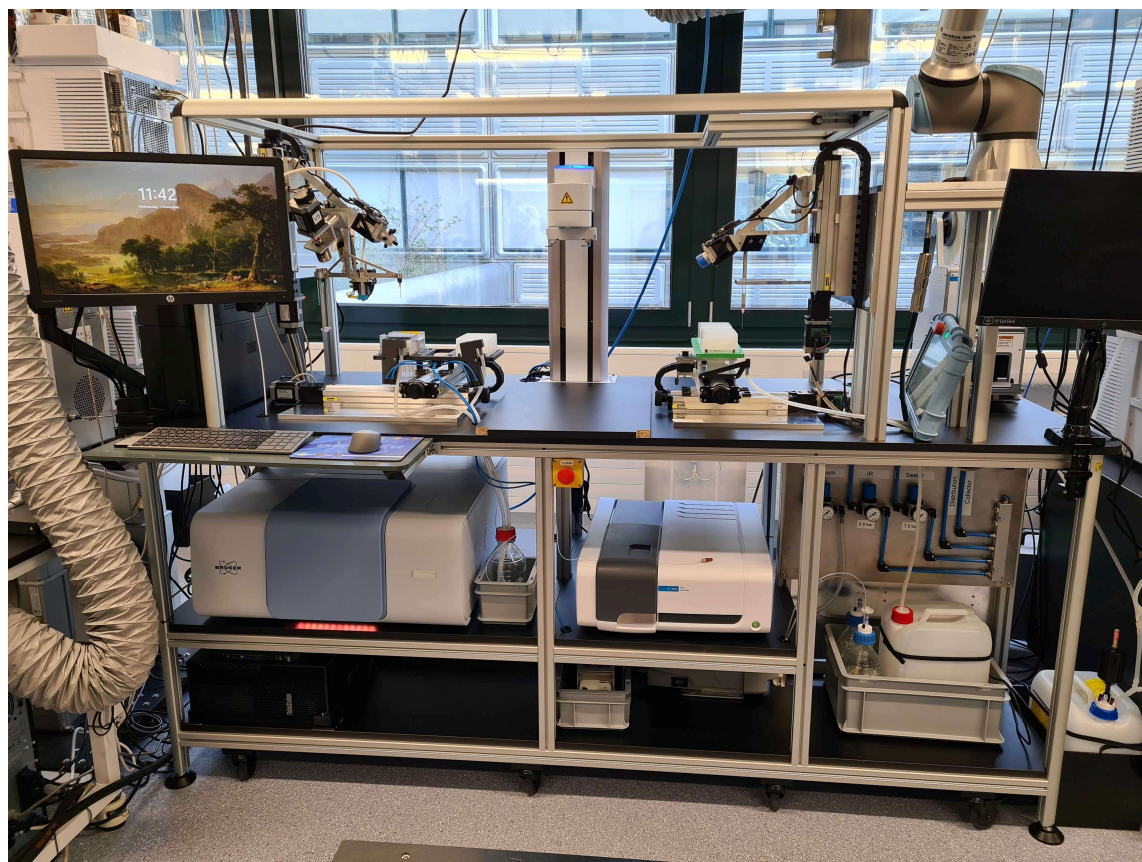
# EPFL OmniFire



■ Automated and data-driven chemistry



# EPFL OmniFire



■ Automated and data-driven chemistry



# EPFL OmniFire

■ Automated and data-driven chemistry





## 2. Interfacing Devices

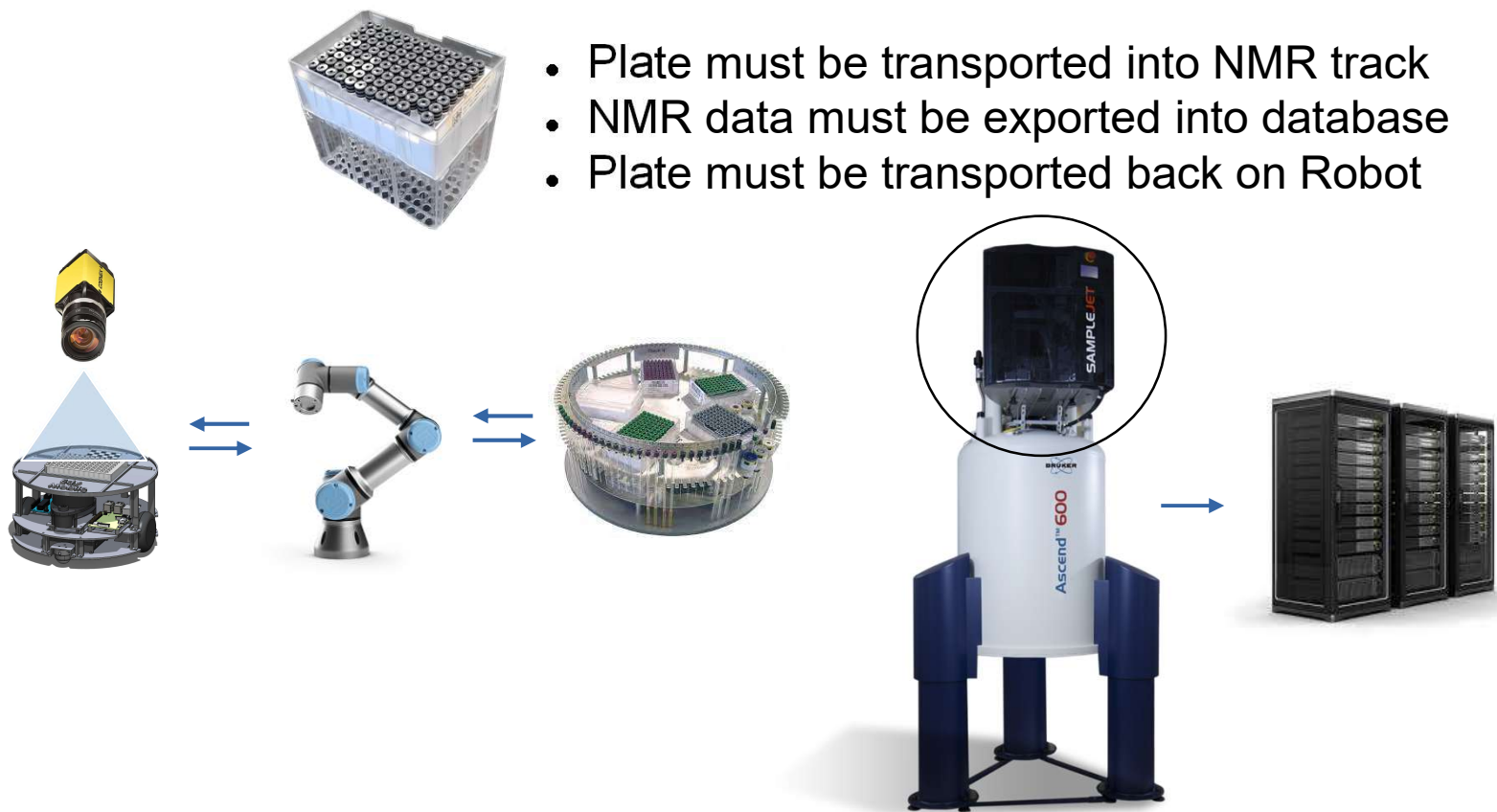
EPFL Now.. How do we interface all the devices...?



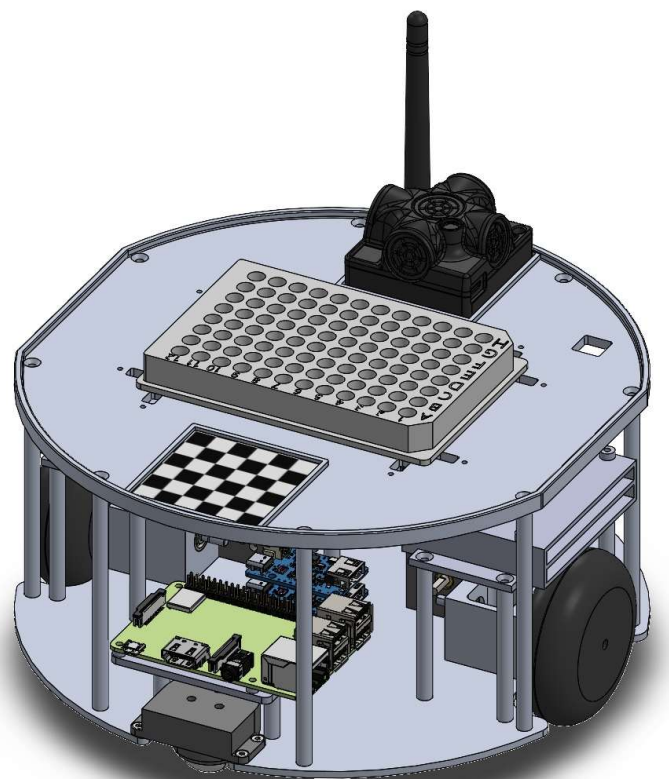
■ Automated and data-driven chemistry



# EPFL NMR Example



## EPFL NMR Example

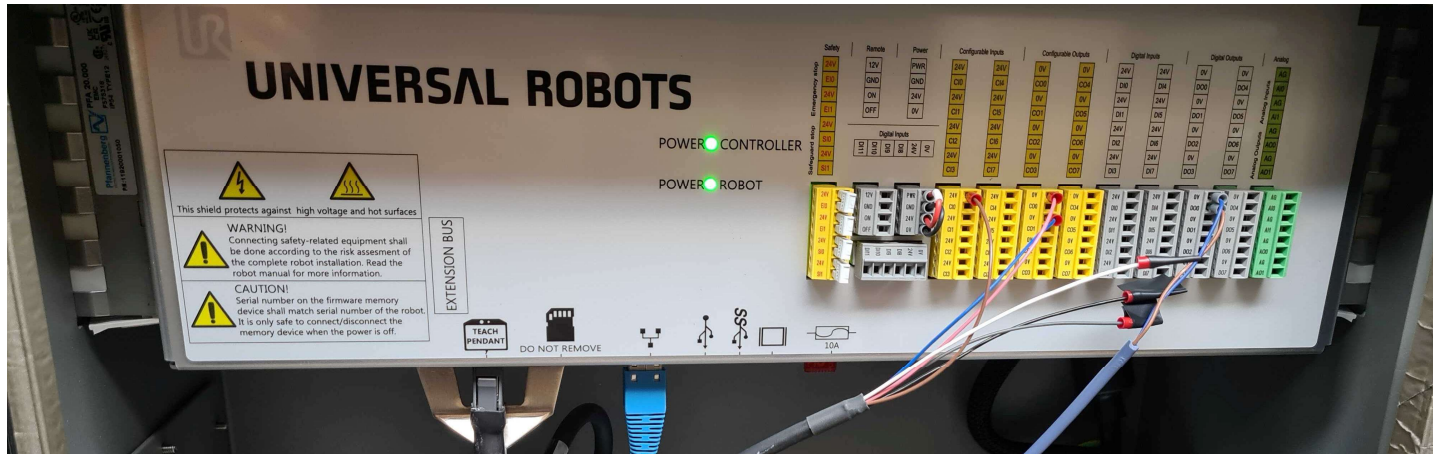


- Onboard PC has WiFi
- Arduino is connected through USB, sending sensors value and receiving motor speed command.
- GPS is connected through USB, sending sensor position

# EPFL NMR Example

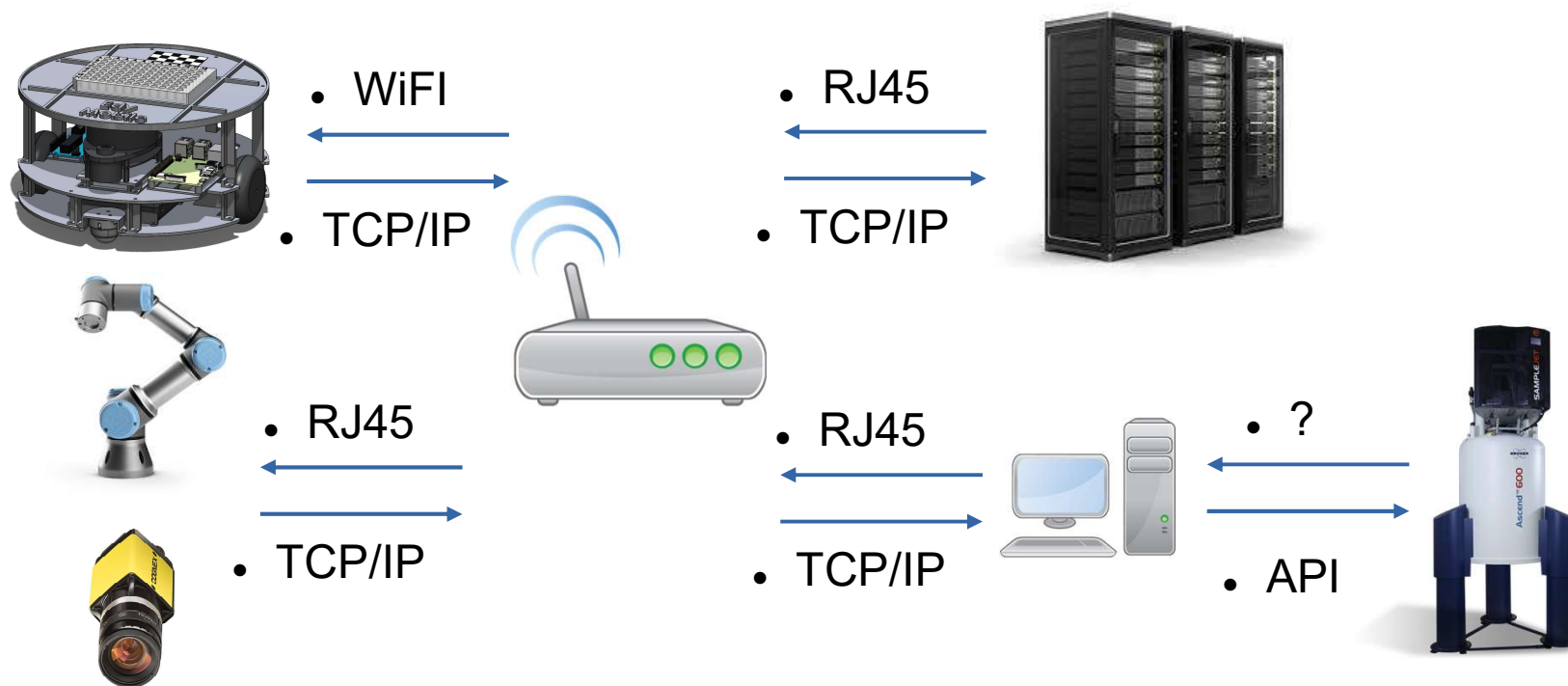


- Controller with Input & Outputs to control Sensors & Actuators (like a PLC)
- Ethernet port with TCP/IP to communicate with it



# EPFL NMR Example

■ Automated and data-driven chemistry

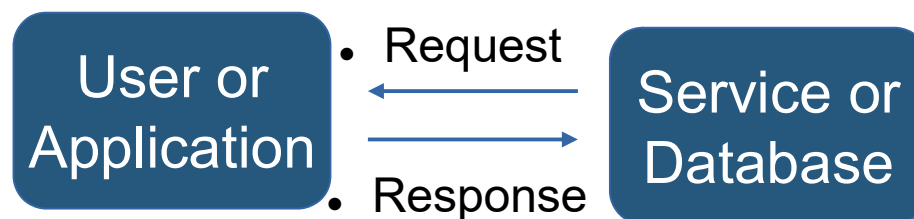




# 1. API

## EPFL API

API (Application Programming Interface) is a set of rules and protocols that allows different software entities to communicate with each other.



APIs enable seamless integration and data exchange between systems, making them essential for modern software development.

## EPFL NMR API Features

- **Move Rack Holder** : It will move the rack holder to the selected position, allowing the robot to put the rack
- **Measure Sample** : It will charge the sample into the NMR, make the measurement depending on the selected method, uncharge the sample and return the measurement data

# EPFL API Interface

## Scale API 1.0.0 OAS 3.0

API for managing a scale with tare, weight, door, and temperature functions

### default ^

POST	<code>/scale/tare</code>	Tare the Scale	▼
GET	<code>/scale/weight</code>	Get Weight	▼
POST	<code>/scale/close-door</code>	Close the Door	▼
GET	<code>/scale/temperature</code>	Get Temperature	▼
POST	<code>/scale/stabilize</code>	Stabilize Weight	▼

- Rest API or Soap API for examples are widely used to easily interface two devices in the same network

Thank you for your attention.

## Thanks to



Swiss CAT+ team & partners



Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra



ETH-RAT

**EPFL**



Innosuisse

Gimp, Ubuntu Foundation



Practical Session

<https://www.arduino.cc/en/software>

