JADS Jheronimus Academy of Data Science

# Introduction to Sensors

JADS Course: **Data-Driven Food Value Chain**

Lecture 3 – Robin van Emden, JADS | robin@pwy.nl

# Introduction to sensors: Schedule

8:45 – 9:35 Whirlwind tour from sensors to server (Robin van Emden, JADS)

9:35 – 10:00 Coffee break

Enter student e-mails into https://zensie.30mhz.com/

You can delete your account when you are done.

Opt-out if you want.

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10:00 – 10:35 Steven Madern of 30Mhz talks about sensors in horticulture

10:30 – 10:45 Coffee break

10:45 – 12:30 Put theory into practice

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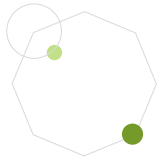

# Introduction to Sensors: Data and code repository


**https://github.com/robinvanemden/sensors**

# Introduction to Sensors: Exercises in DropBox


**https://www.dropbox.com/request/Hpfx5C86LnM3XOawEzW1**

# About Me

**Robin van Emden**
Research at JADS

## Academic background

- Cognitive neuroscience
- Computer science

Research at JADS at prof M. Kaptein's
**Computational Personalization Lab**


# About Me

Robin van Emden
30+ years R&D

For example…

## Tear Detection

With: Tilburg and Rijeka Uni
Problem: Tears nearly invisible
Sensor: Thermal sensor array

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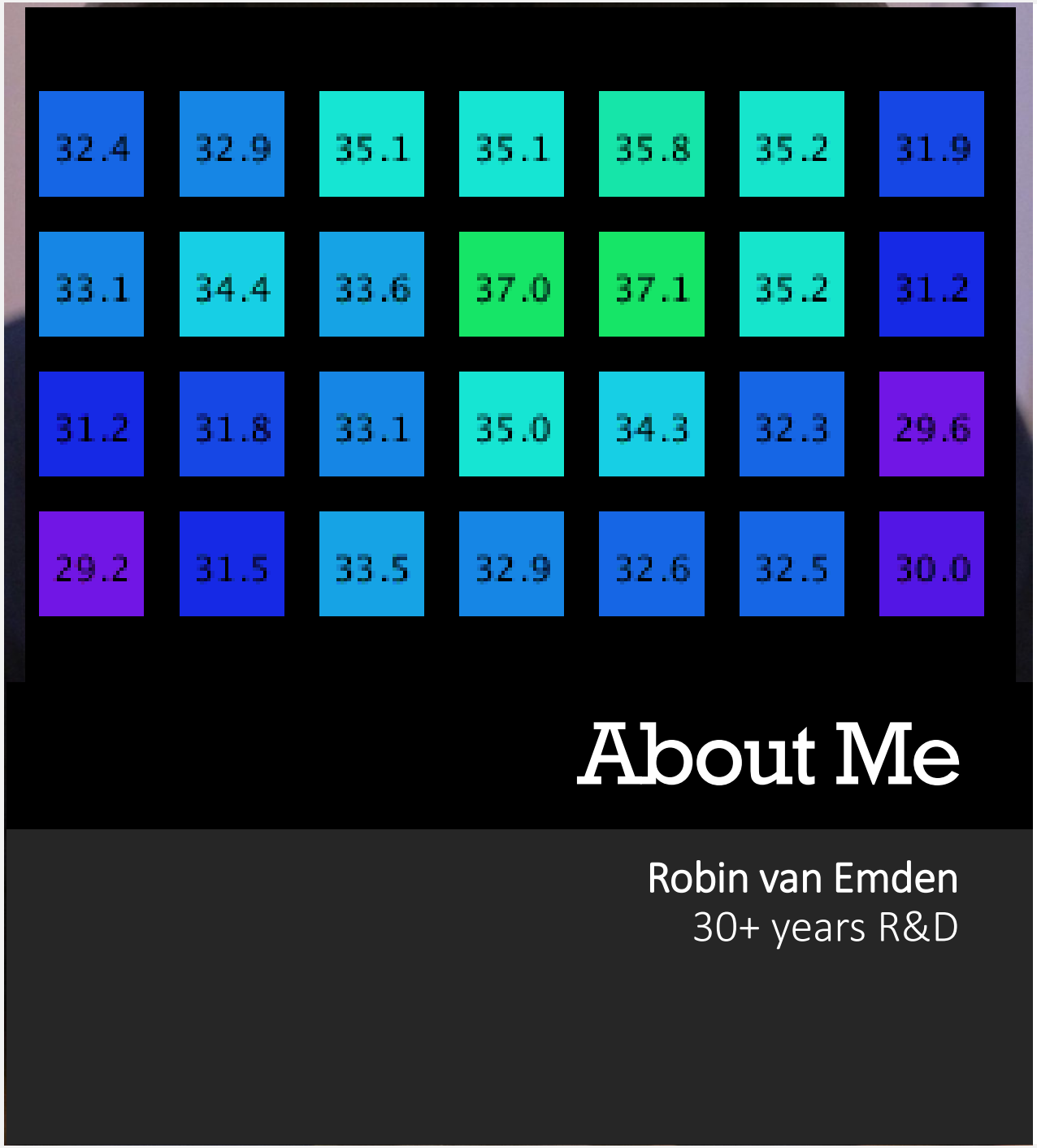


# About Me

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For example…

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# About Me

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30+ years R&D

For example…

## Bird Solar Backpack

With: Max Planck Institute
Problem: Tracking migrating birds
Sensor: Bluetooth transceiver

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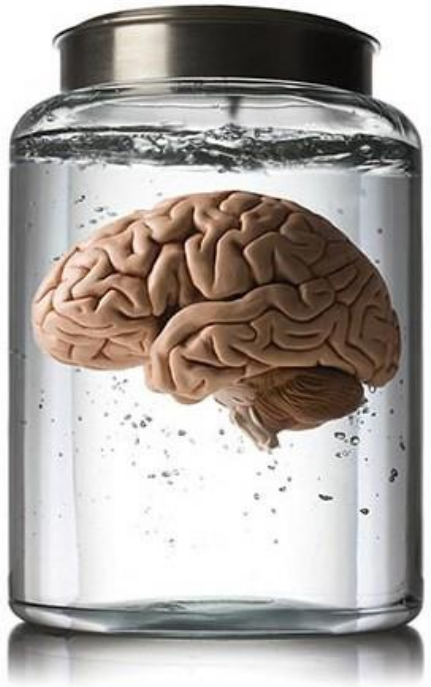
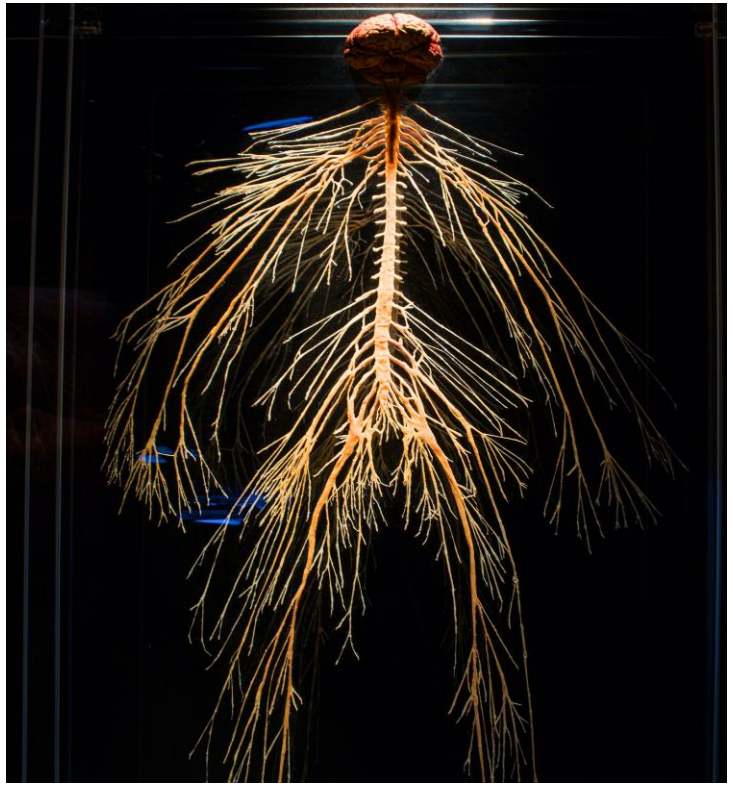
# Usual data science perspective…

# As a neuroscientist: we're not a brain in a vat…



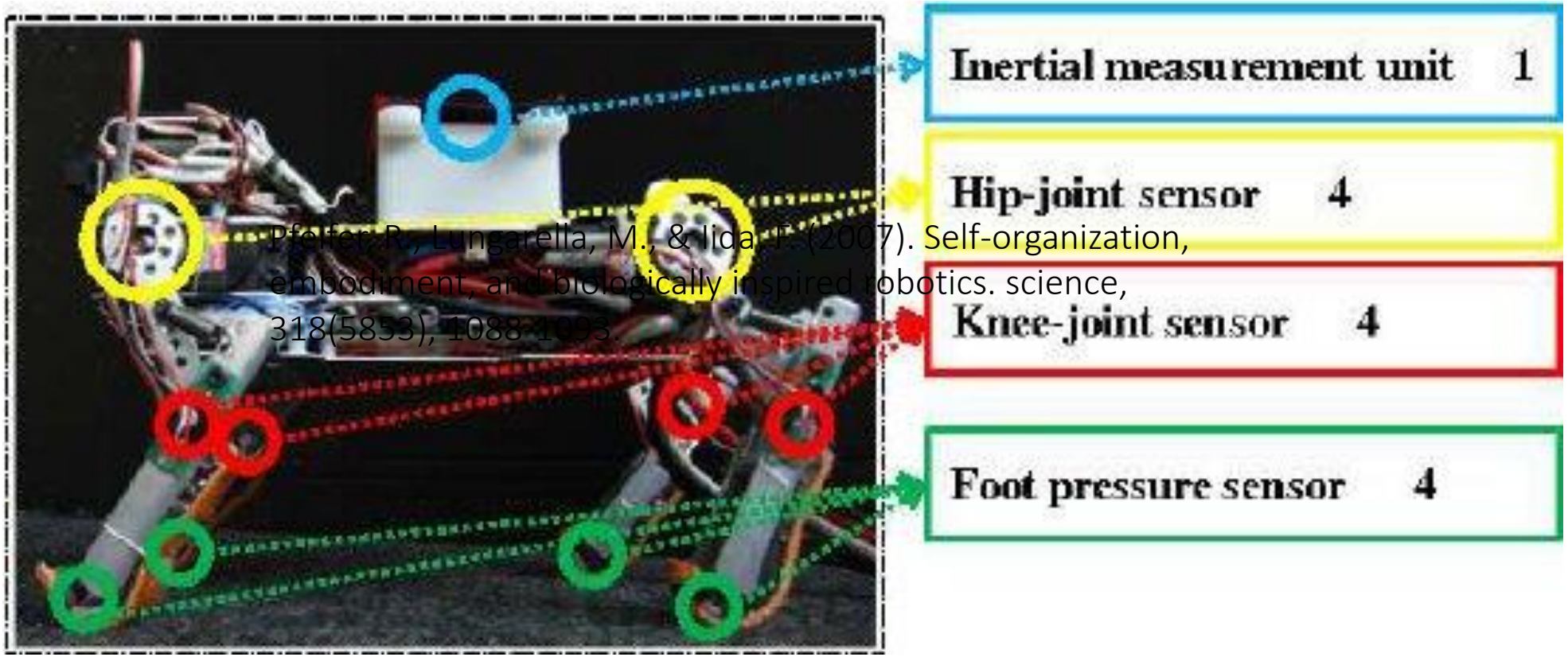
Brain in a vat



Nervous system

Shapiro, L. (2019). *Embodied cognition*. Routledge.

# Embodied cognition as inspiration for new generation robots




Pfeifer, R., Lungarella, M., & Iida, F. (2007). Self-organization, embodiment, and biologically inspired robotics. science, 318(5853), 1088-1093.

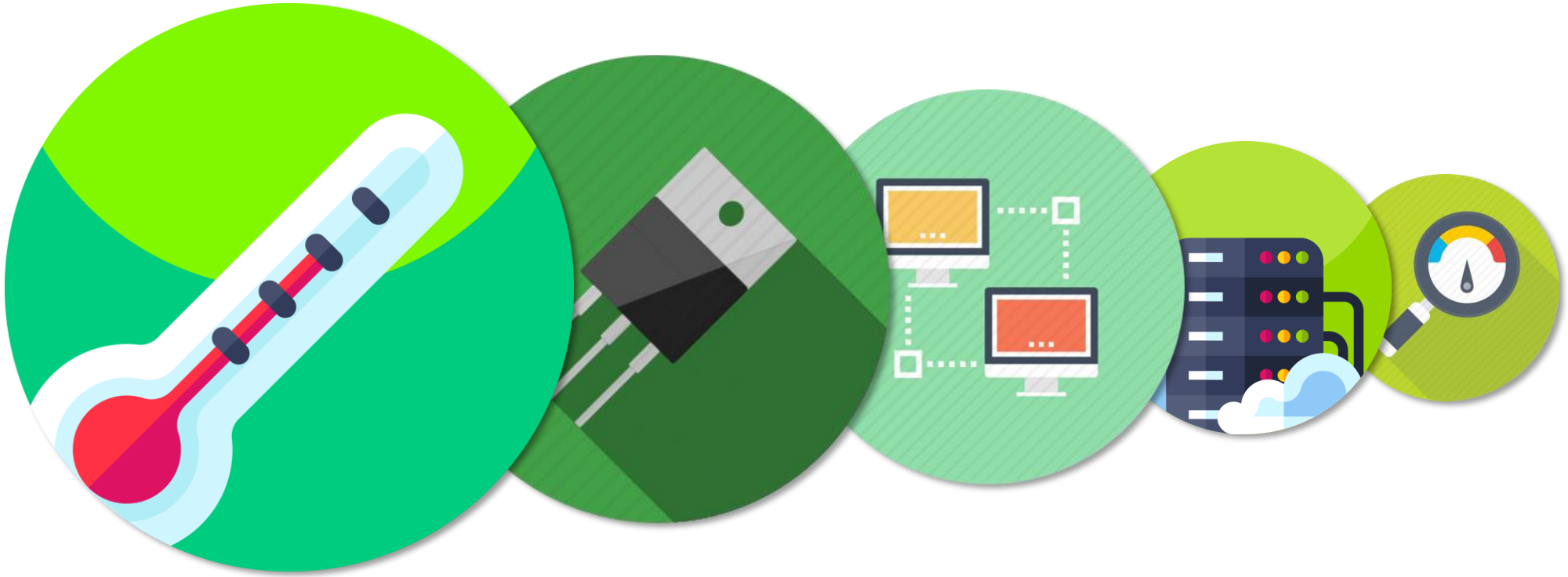
Pfeifer, R., Lungarella, M., & Iida, F. (2007).
Self-organization, embodiment, and biologically inspired robotics. *science*, *318*(5853), 1088-1093.

# Ever since robots took a more embodied approach…

Honda Asimo


Boston Dynamics

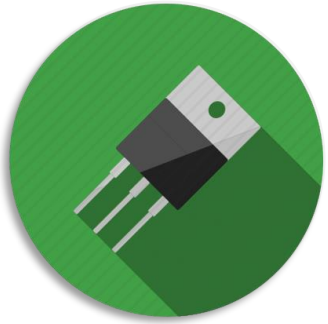
# So.. let's invert the perspective for today!



# Sensor related projects involve the following area's:

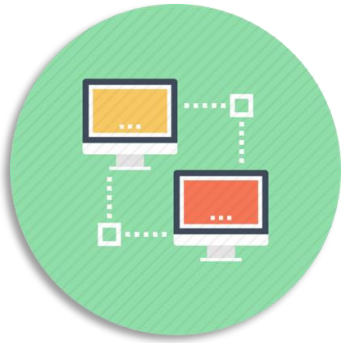
**Sensors**

Generally, the most electronics focused part. A lot of uncharted area's here!



**Microprocessors**

The signal from the sensor needs to be converted into digital, most often by an MCU.



**Communication protocols**

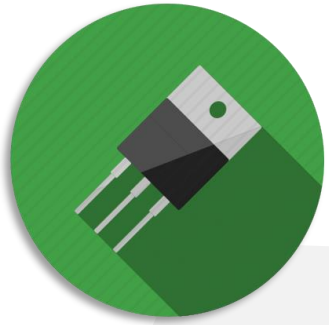
The data needs to be transported from the MCU(s) to a data store.

**Data storage**

The data needs to be aggregated or stored.

**Data analysis, Data visualization**

The data has to be shown to others.



# From sensor to data

- We will be using a simple plant measurement device to go over some basic sensor principles and to show how to get your data from an electronic sensor on an MCU to a database.

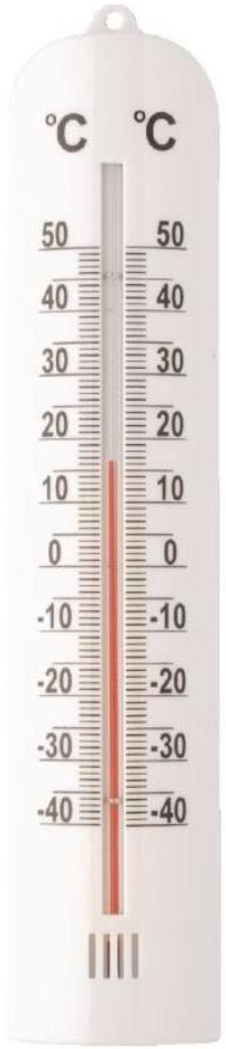




# Sensor data analysis

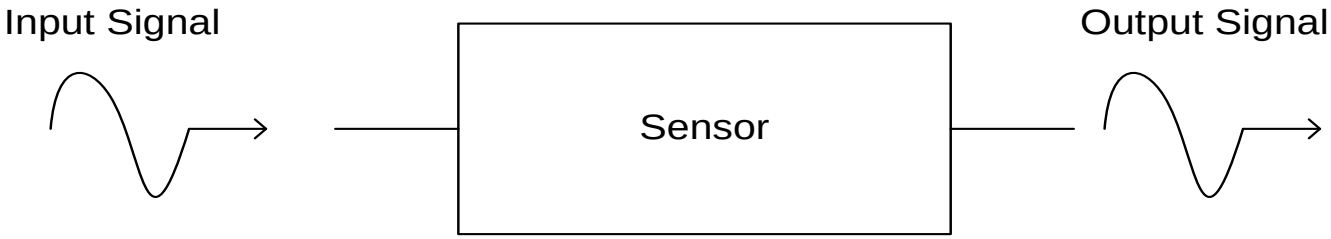
- We will be doing data analysis on live data from a greenhouse at 30Mhz, a Dutch company that builds a data platform for horticulture.

# From sensor to data: What is a sensor?




- American National Standards Institute (ANSI) Definition:

  "A device which provides a usable output in response to a specified measurand"

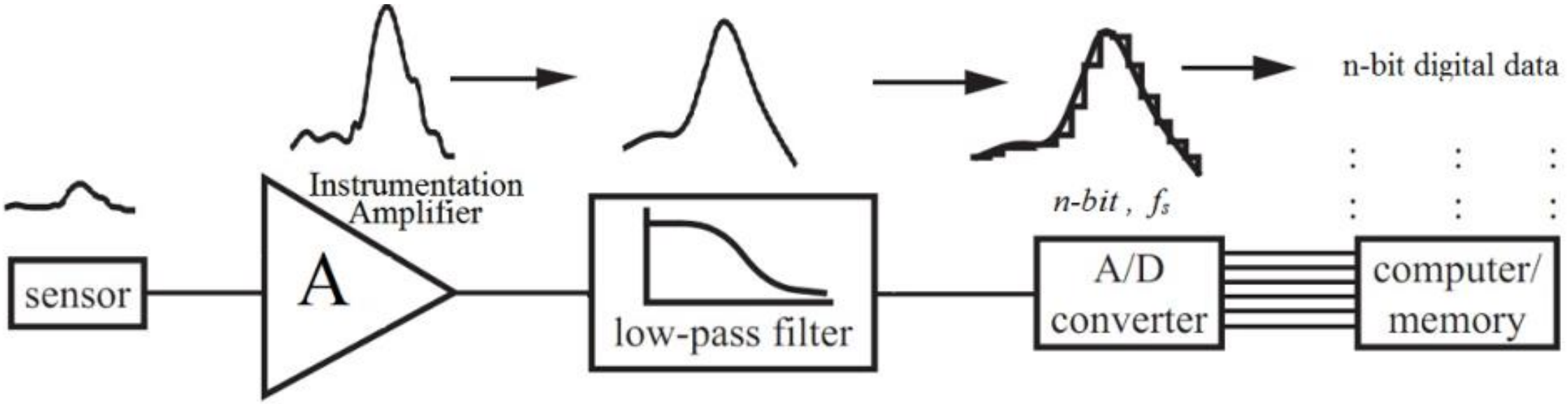



- General definition:

  A sensor acquires a physical parameter and converts it into a signal suitable for processing (e.g. optical, electrical, mechanical)

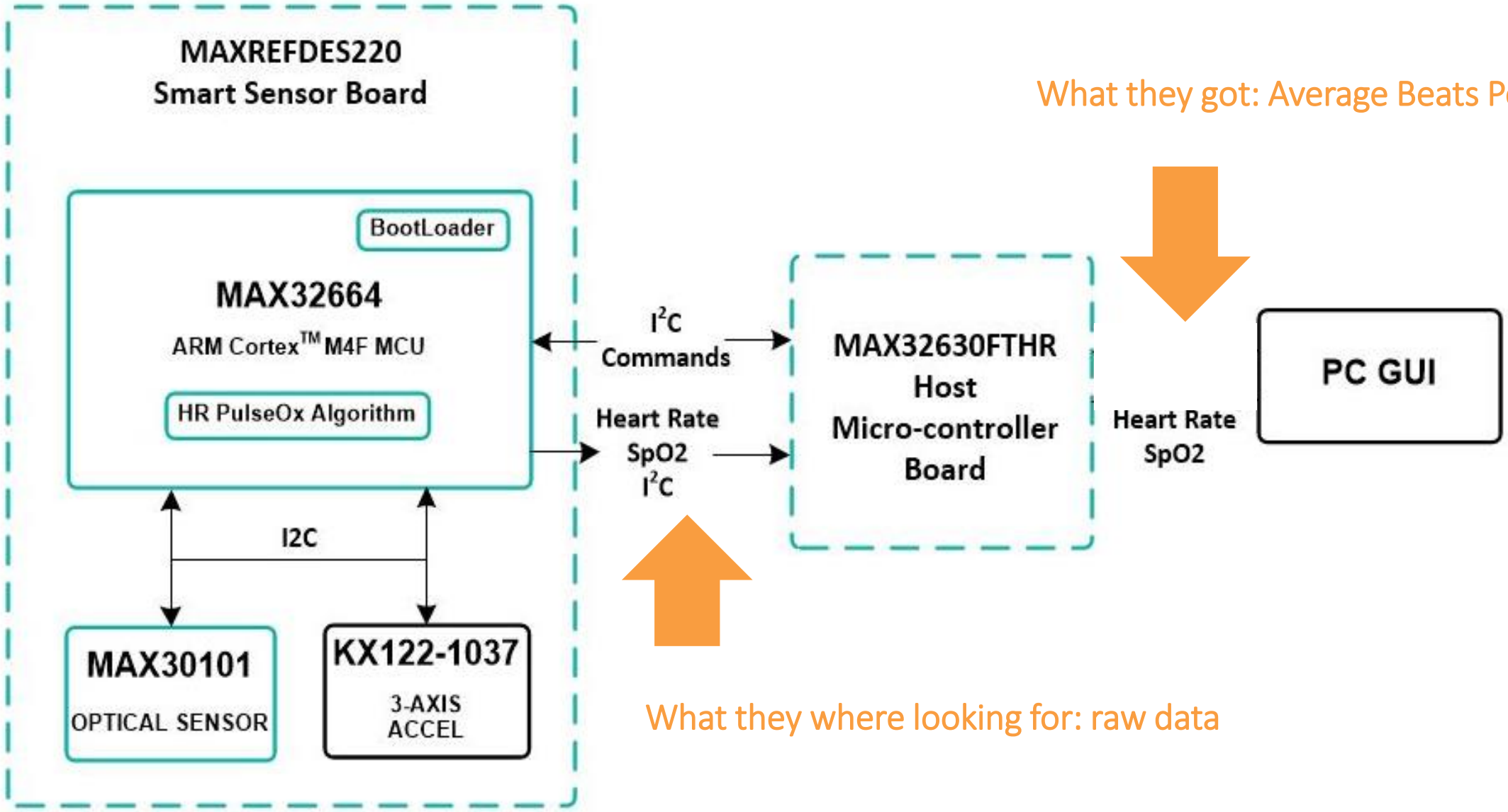
# From sensor to data: Measurement systems

A sensor is generally part of a **measurement system.**



# From sensor to data: Careful! Premature filtering…

# From sensor to data: …can be a bad thing.




What they got: Average Beats Per Minute

What they where looking for: raw data

# From sensor to data: Measurement systems

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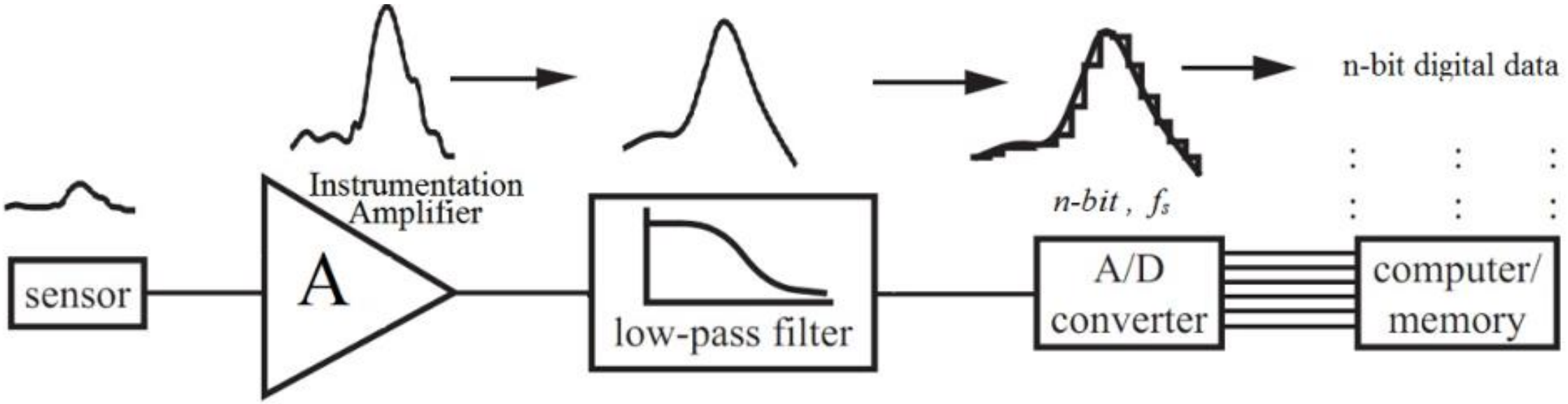
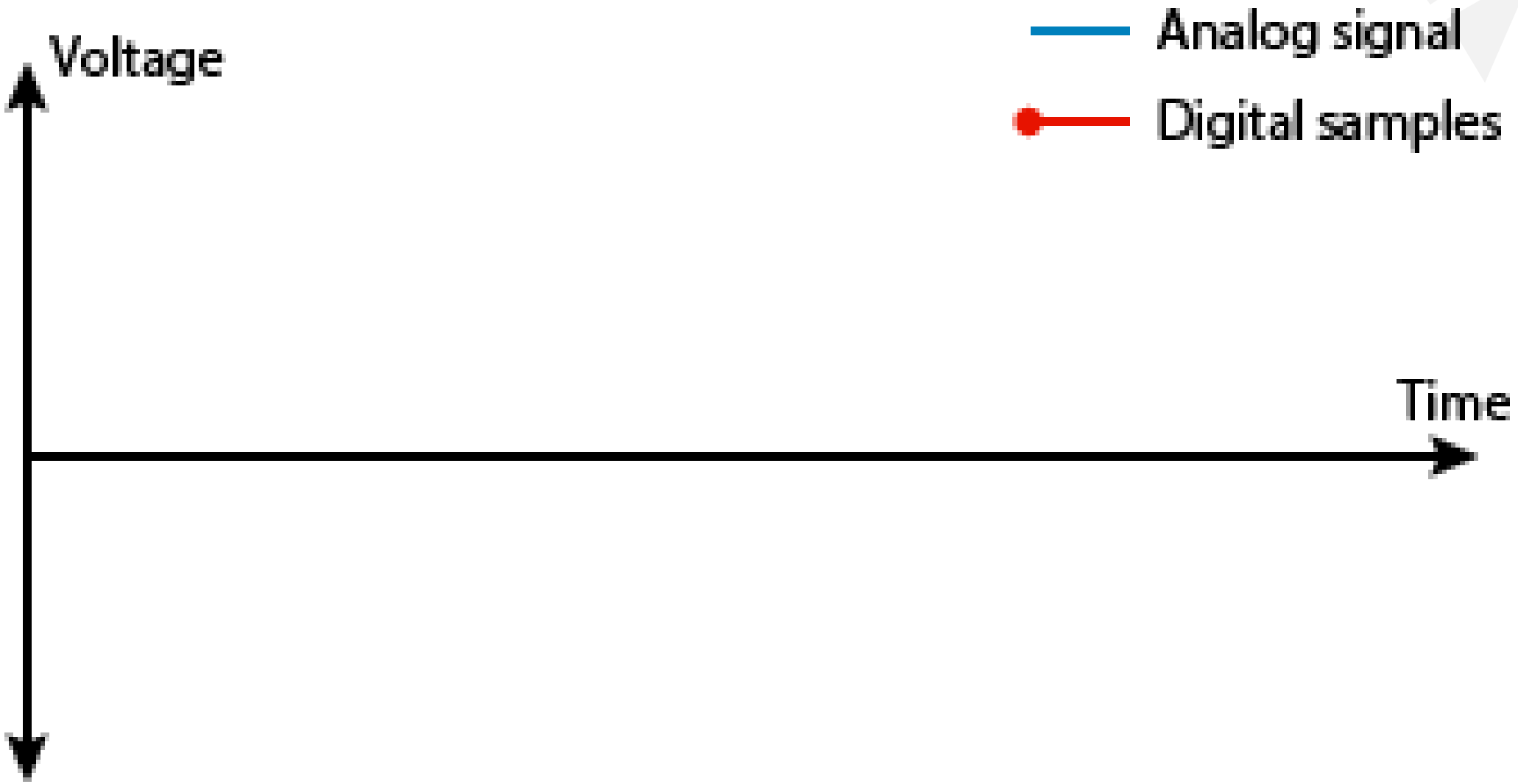
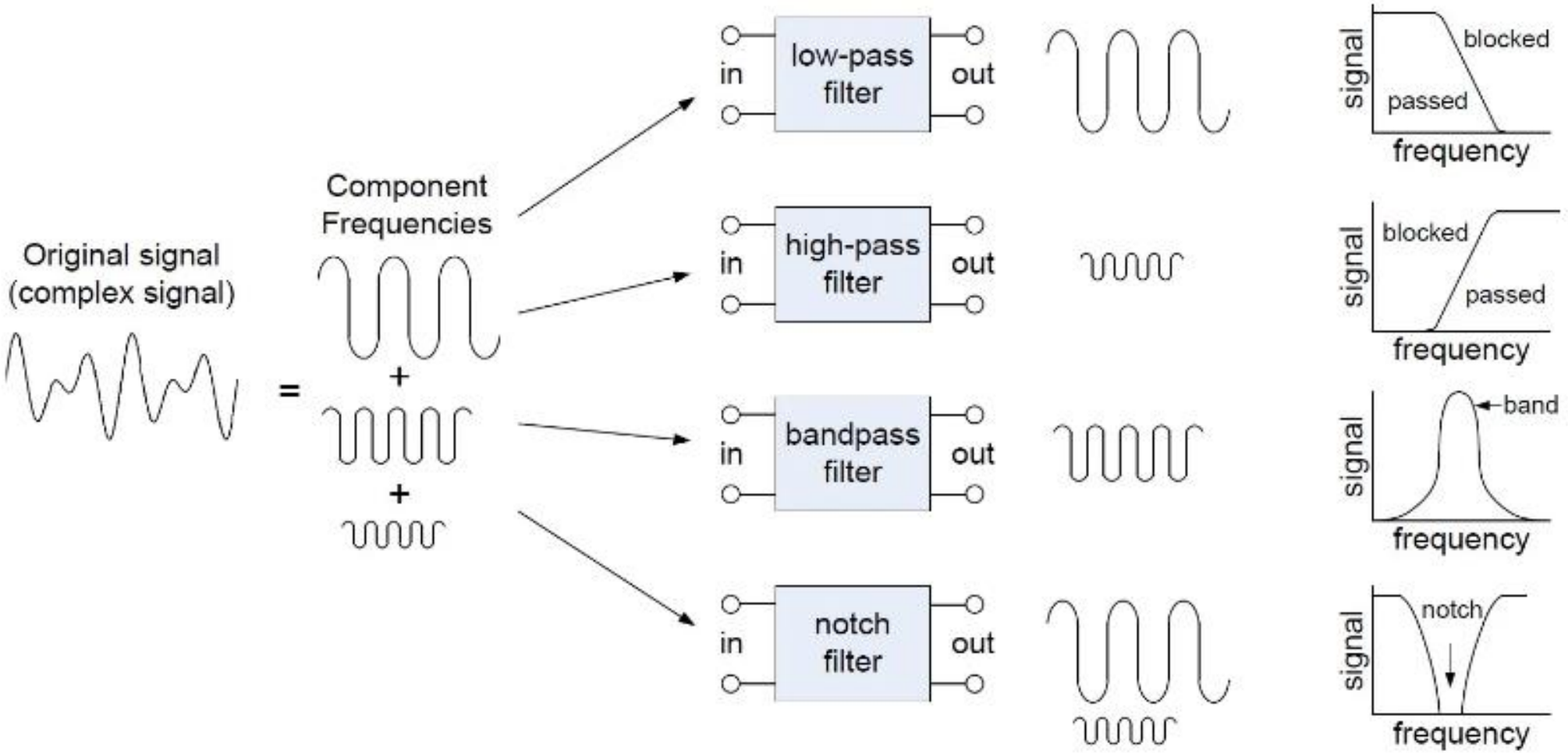


# From sensor to data: DSP1 - Analog to Digital Converter



# From sensor to data: DSP2 - Signal filtering

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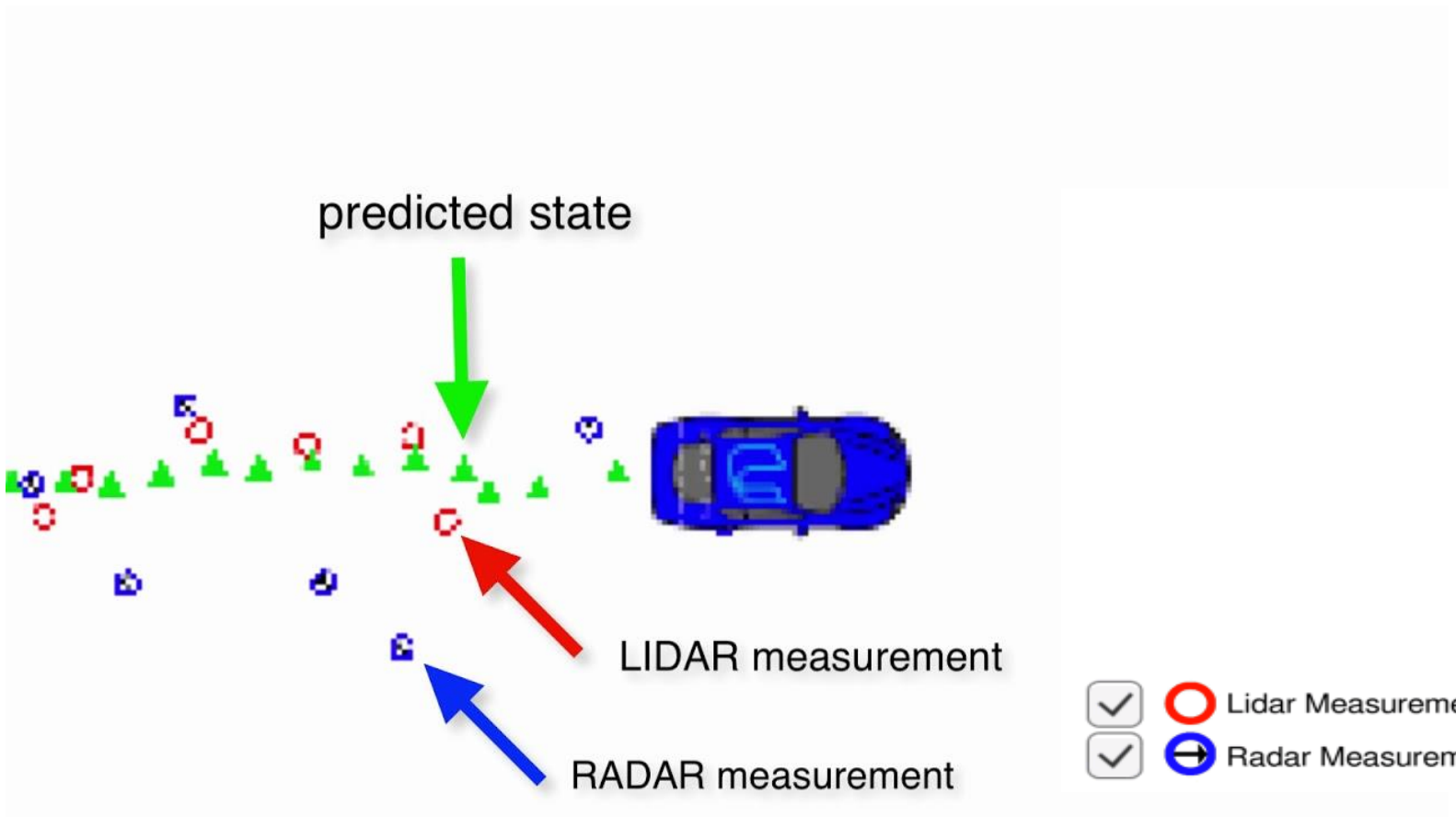
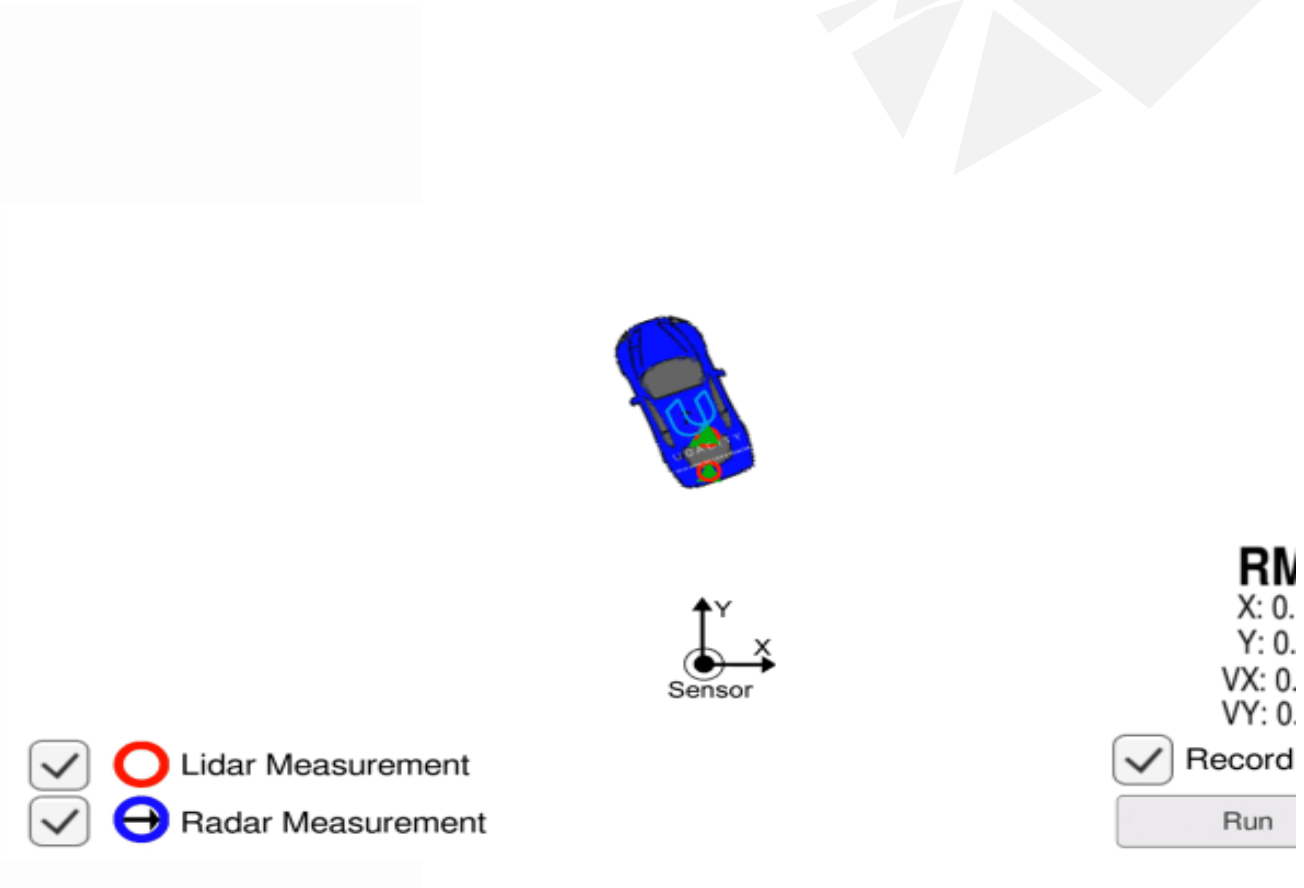
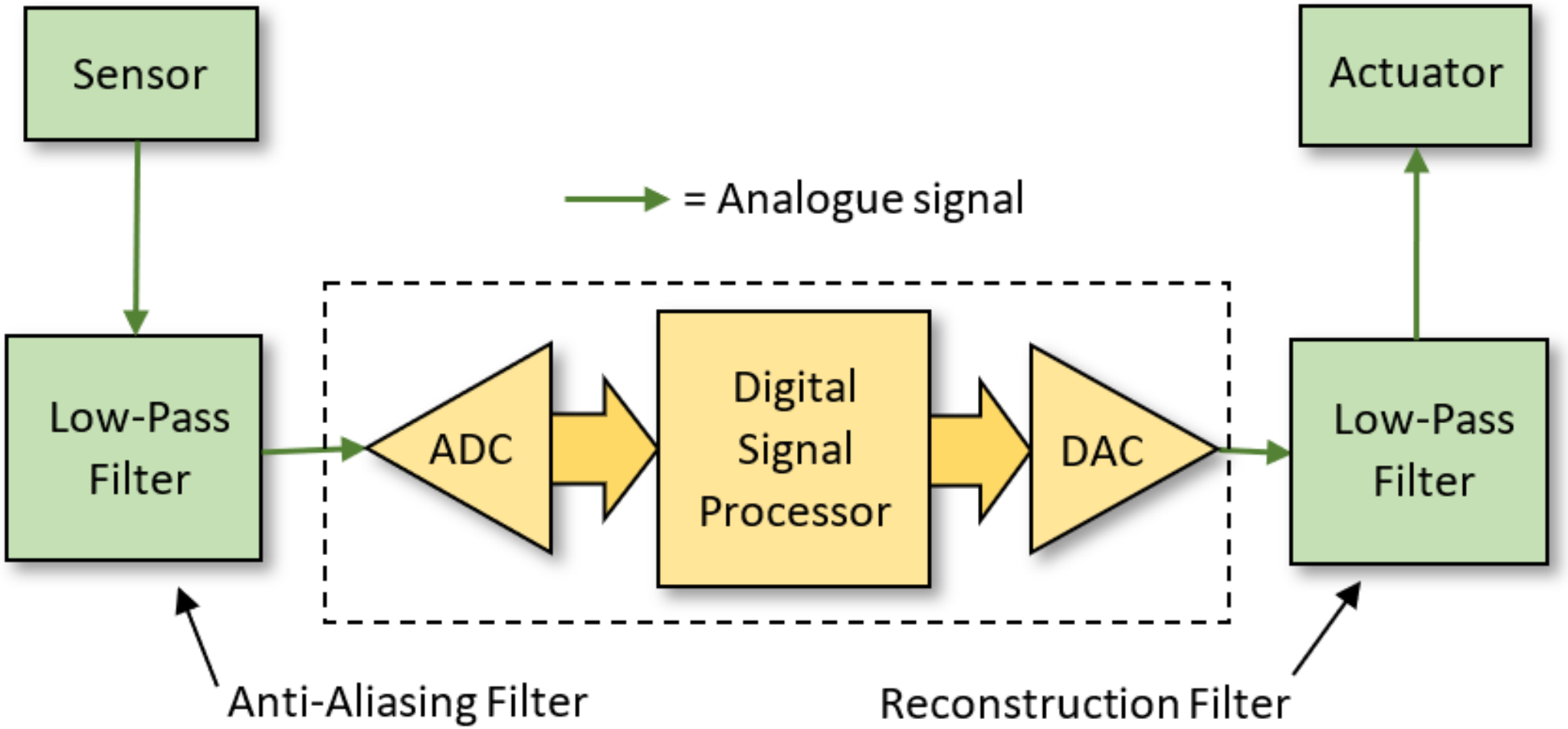
# From sensor to data: DSP3 - sensor fusion (Kalman Filter)




https://junshengfu.github.io/tracking-with-Extended-Kalman-Filter/

# From sensor to data: Digital Signal Processing (DSP)



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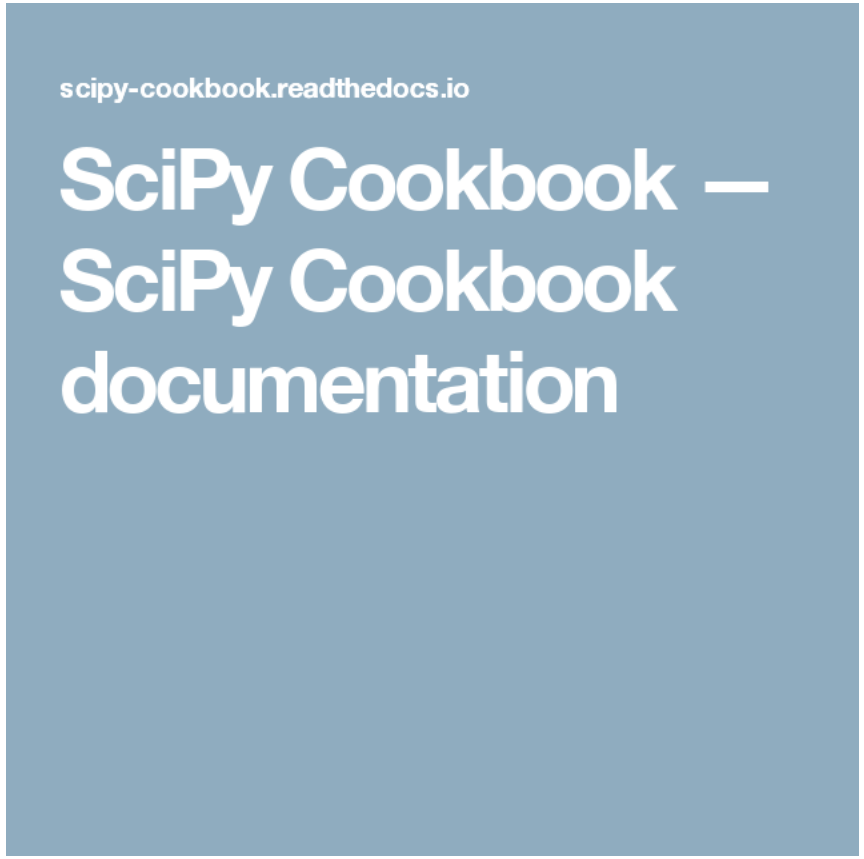
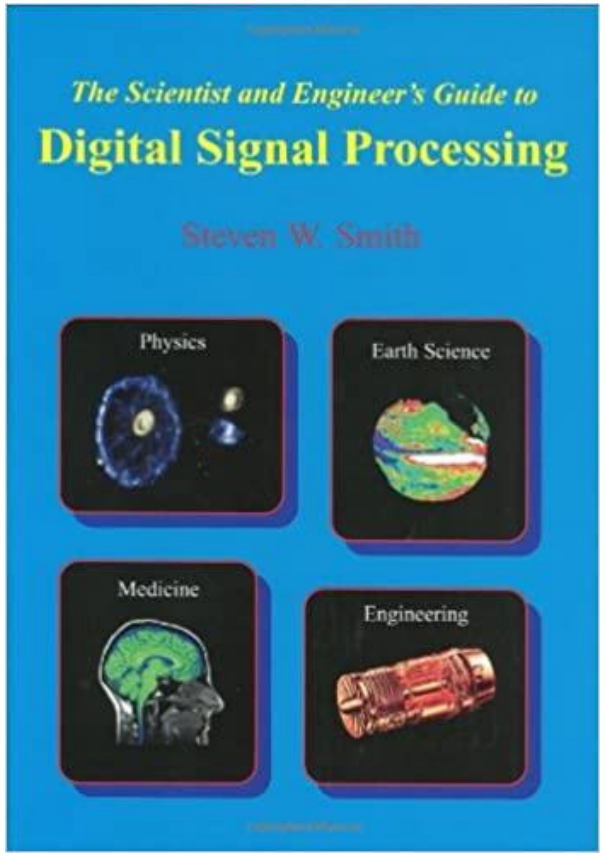



https://scipy-cookbook.readthedocs.io/items/idx_signal_processing.html




https://www.amazon.com/Scientist-Engineers-Digital-Signal-Processing/dp/0966017633/ref=sr_1_2?dchild=1&keywords=digital+signal+processing+book&qid=1600529672&sr=8-2

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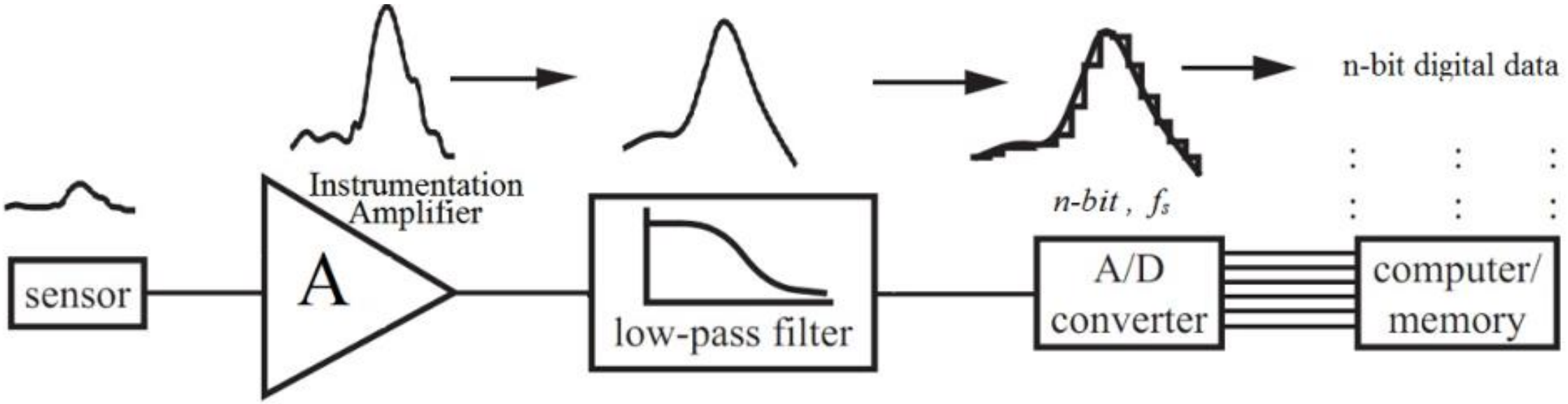
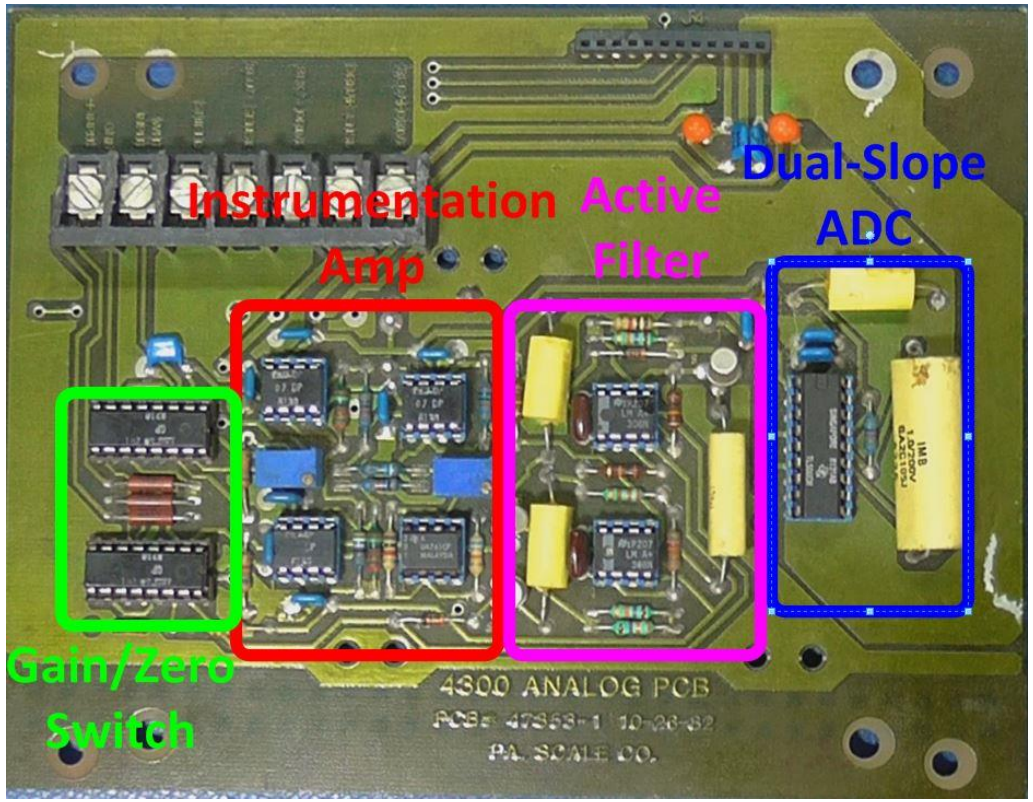
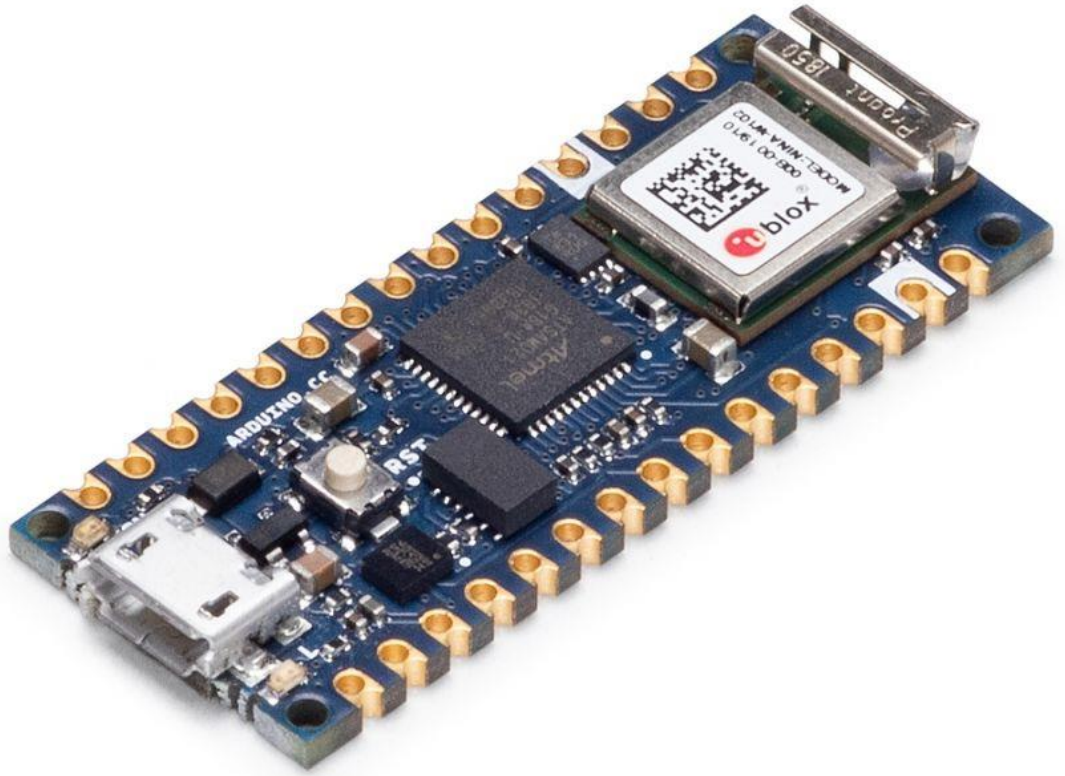


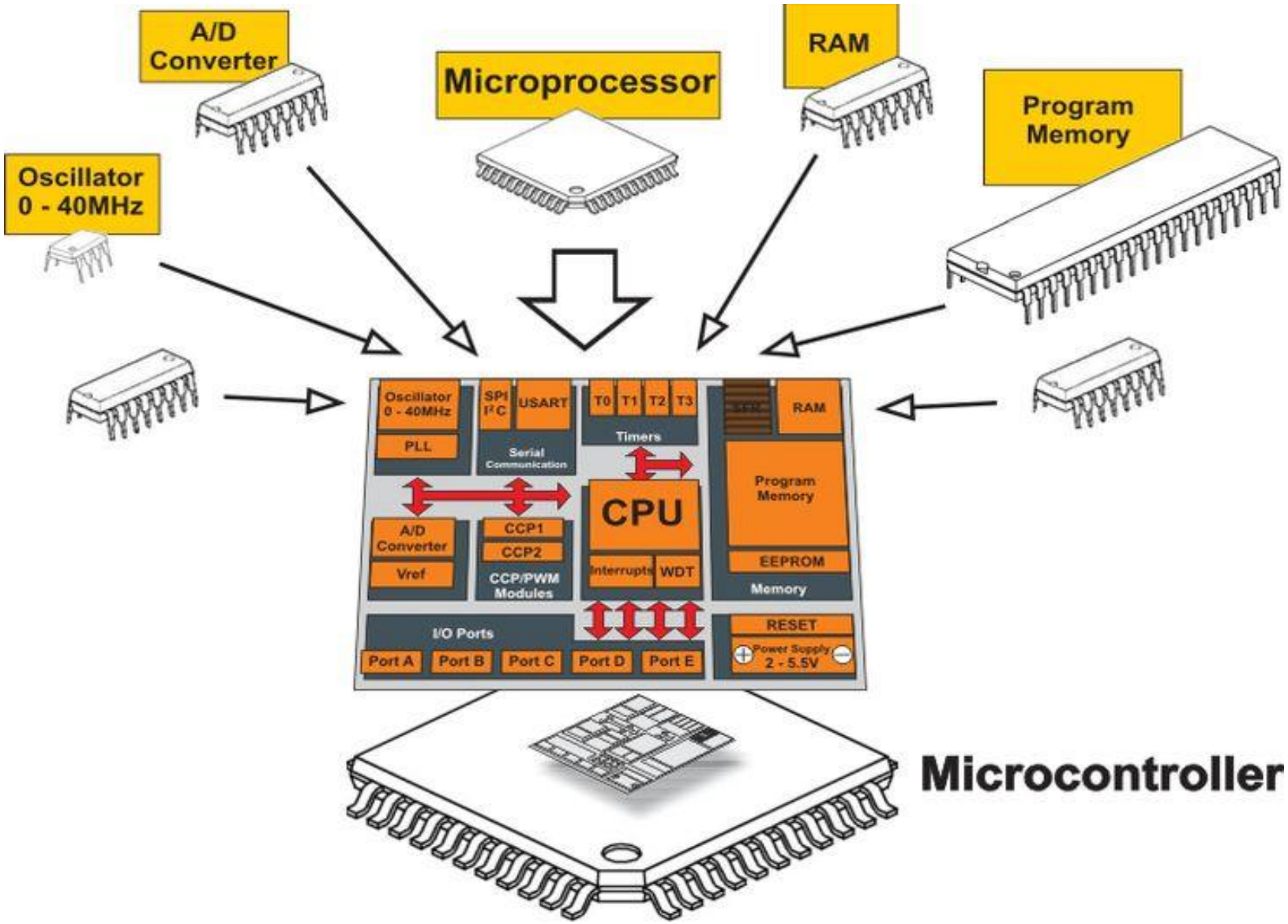
# From sensor to data: Measurement systems

From hardwired to microprocessor-based measurement systems



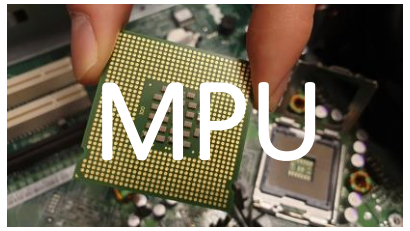



# From sensor to data: What is a microcontroller



# From sensor to data: Microcontroller vs Microprocessor

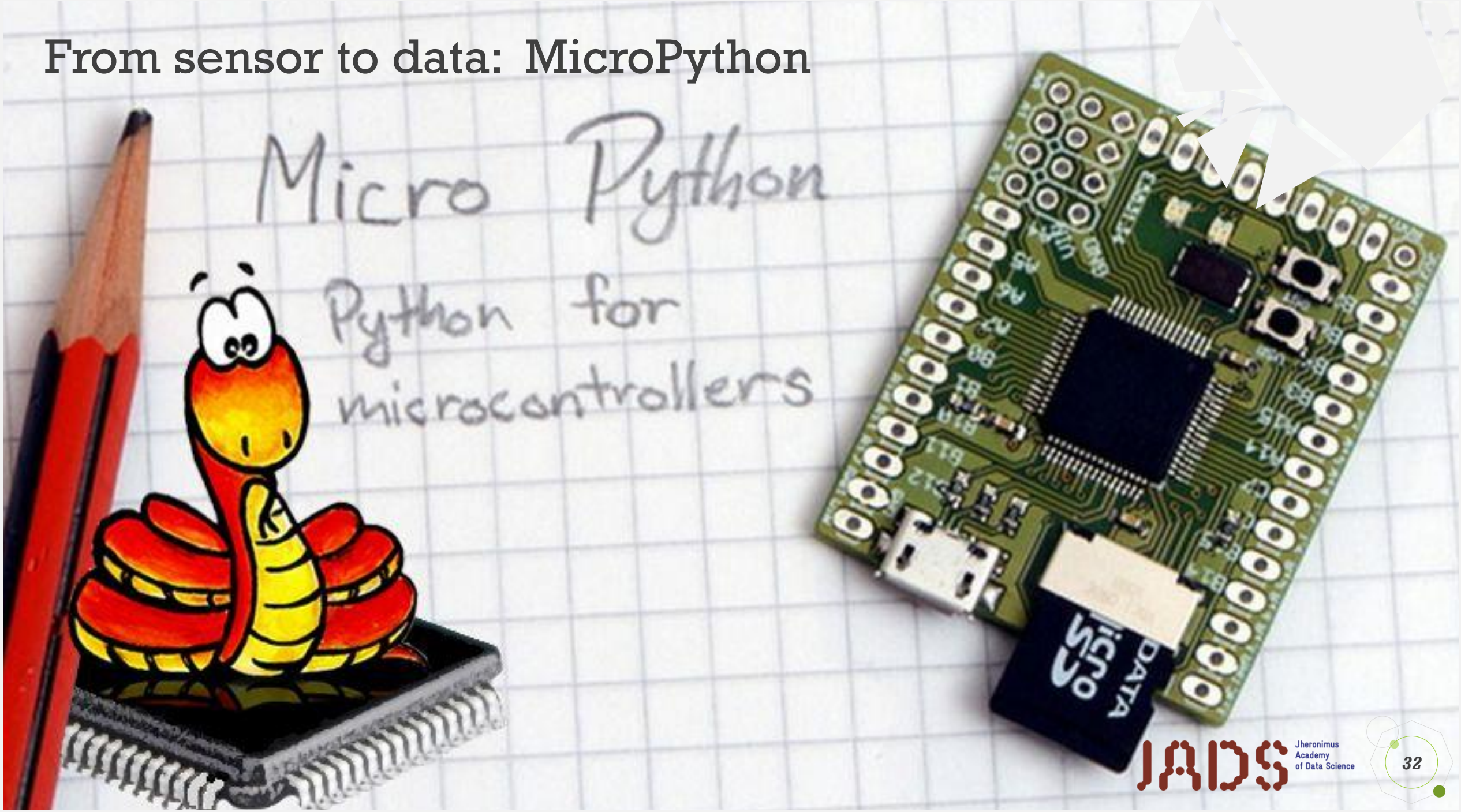

- CPU, RAM, ROM, I/O and Timer all on a single chip
- Fixed amount of on-chip RAM, ROM, IO ports
- For applications in which cost, power, and space are critical
- Single purpose
- Relatively slow, fewer resources




- CPU is standalone - RAM, ROM, I/O and timer are separate
- Designer can decide on amount of RAM, ROM, IO ports
- Versatile
- General purpose
- More expensive
- Faster, more resources


Choice
is yours:
Arduino or RTOS,
ESP32 or STM32 …

# From sensor to data: MicroPython



```
MicroPython cd2f742 on 2017-11-29; unicorn with Cortex-M3
Type "help()" for more information.
>>>
```

```
# Welcome to MicroPython on Unicorn!

# The terminal beside this is no ordinary REPL.
# It utilizes the Unicorn CPU emulator converted
# to Javascript by Unicorn.js in order to run MicroPython
# "bare metal" on an ARM CPU emulation.

# MicroPython on Unicorn is completely open source so
# make sure to report bugs to the issue tracker!.

# Source: https://github.com/micropython/micropython-unicorn

# The user and reset buttons along with the LEDs and pins
# on the pyboard below are fully functional. Unfortunately
# that's not quite the case for the clock speed approximation
# when delayed.

# Try to write a script, paste some code or run a demo!

```

BINARY : PYBOARD RAM : 64KB STACK : 8KB RESET RUN SCRIPT CHOOSE A DEMO...

CLOCK SPEED 0.00 MHz

PERIPHERALS :

- ☐ LED
- ☐ I2C LCD
- ☐ SERVO
- ☐ ADC

https://micropython.org/unicorn/

# From Sensor to data

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# Sensor data analysis

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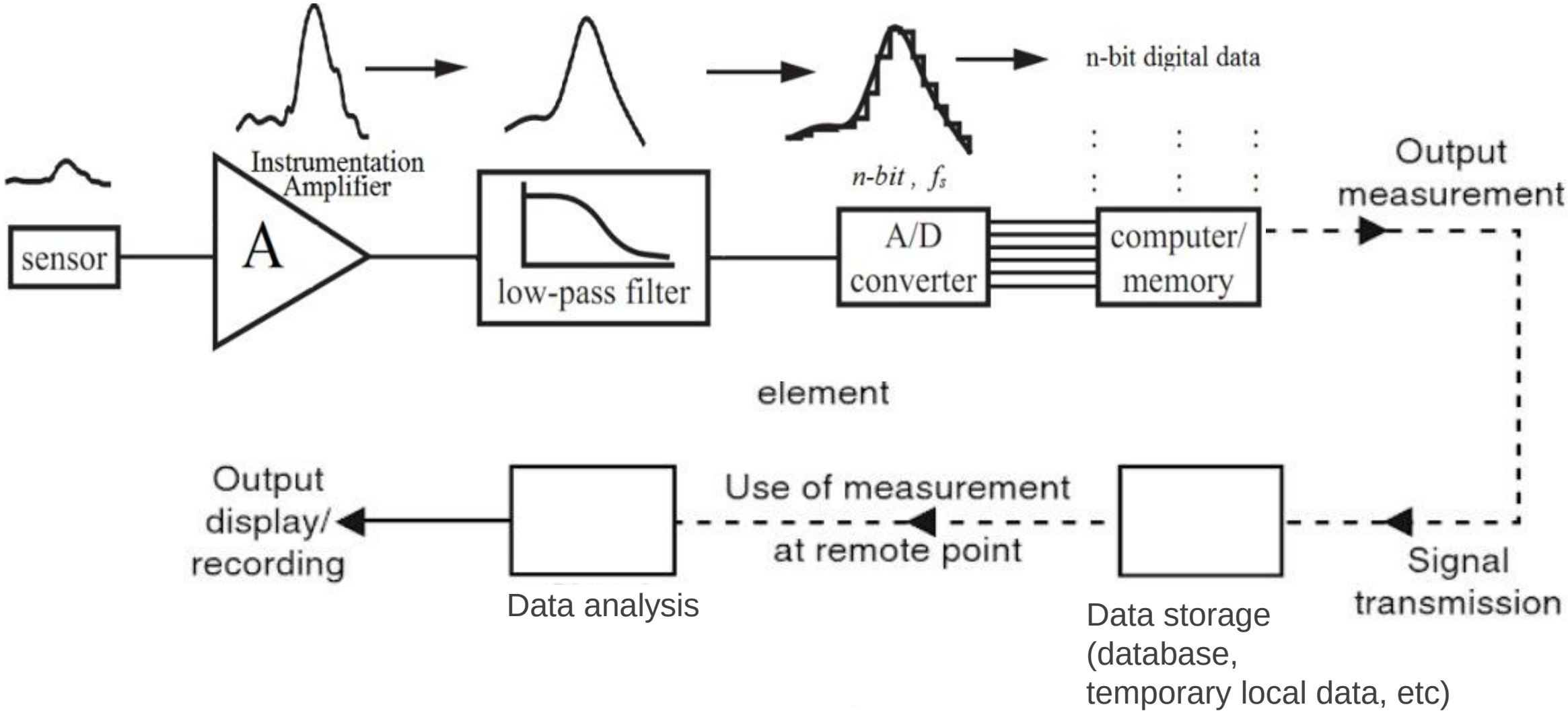
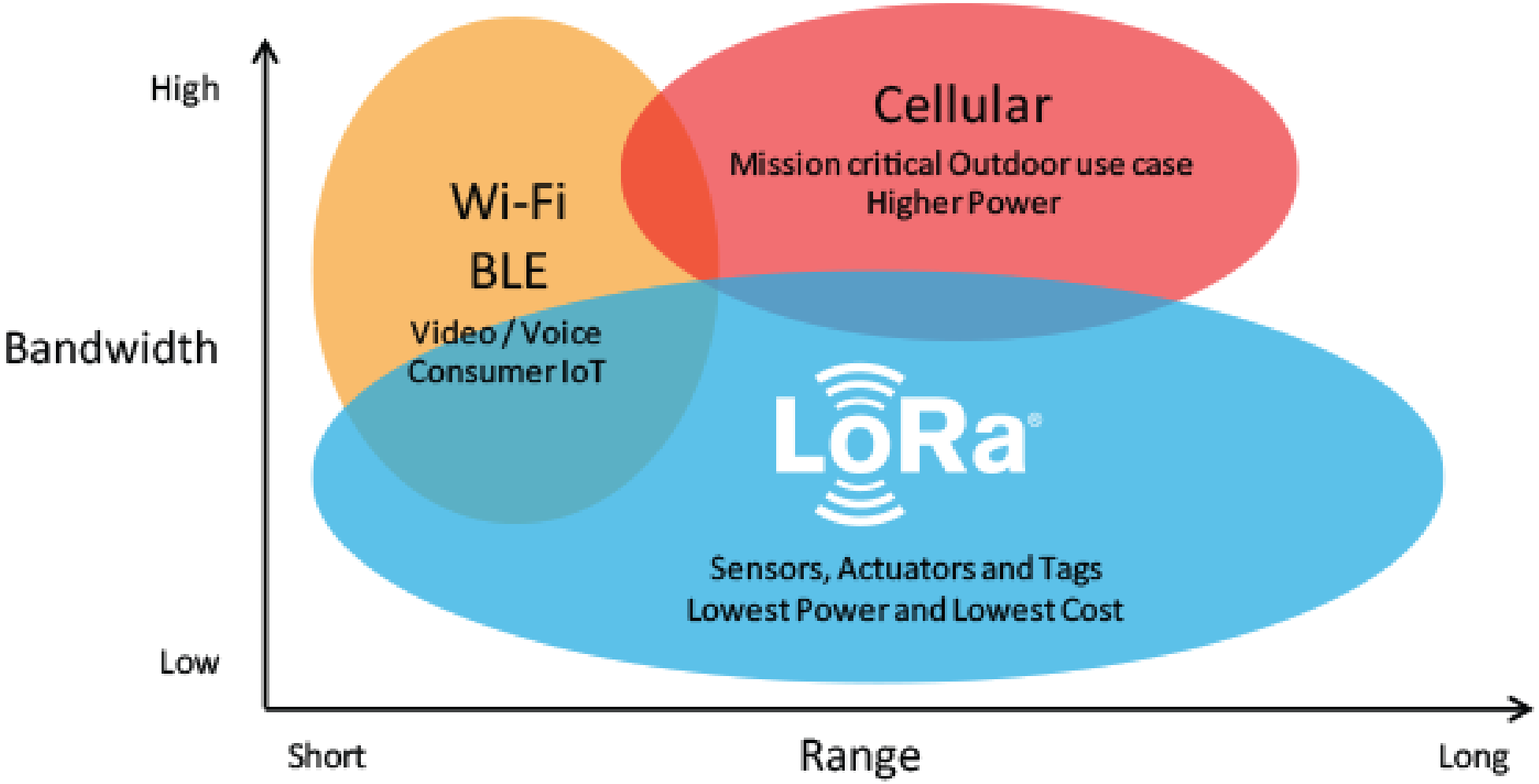
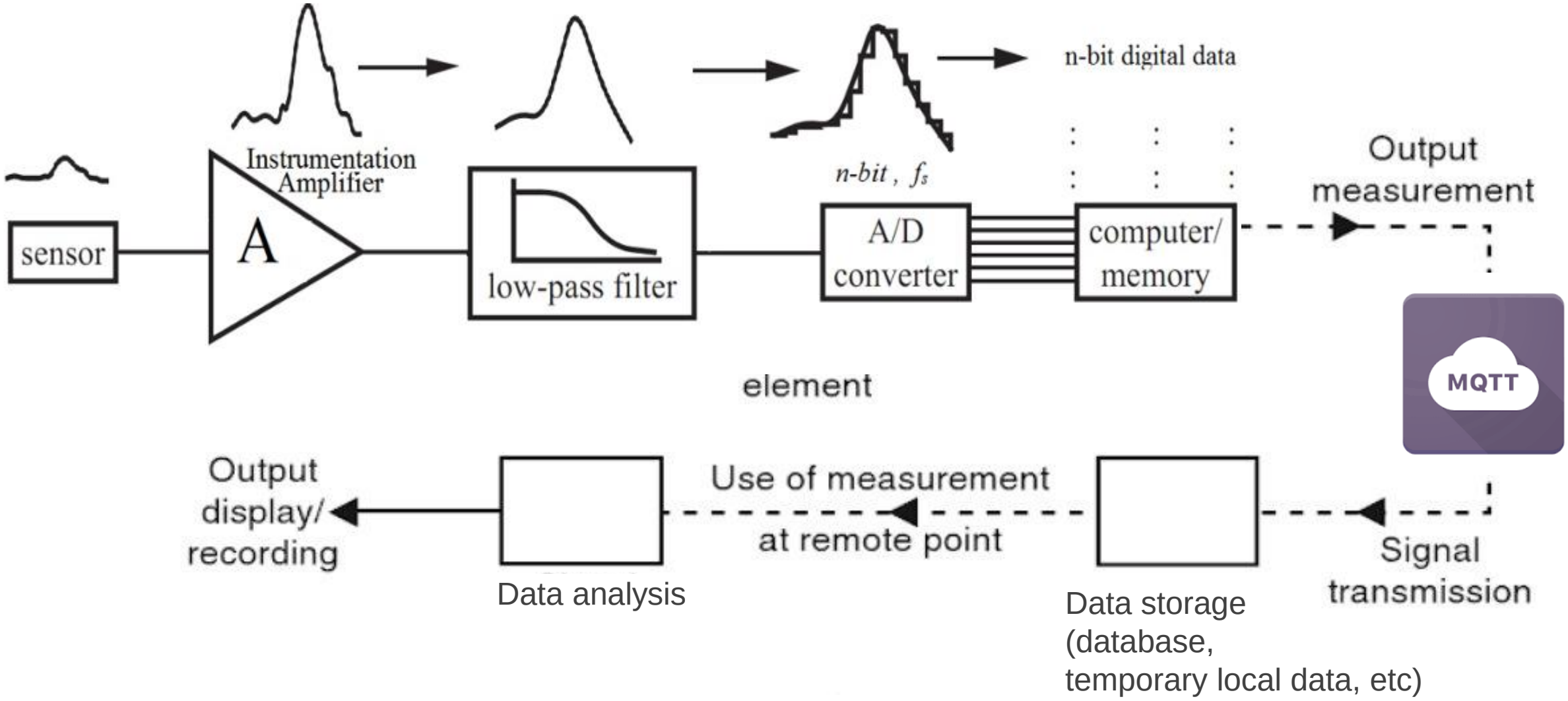
# From data to analysis: From measurement system to analysis



# From sensor to data: Wireless protocols

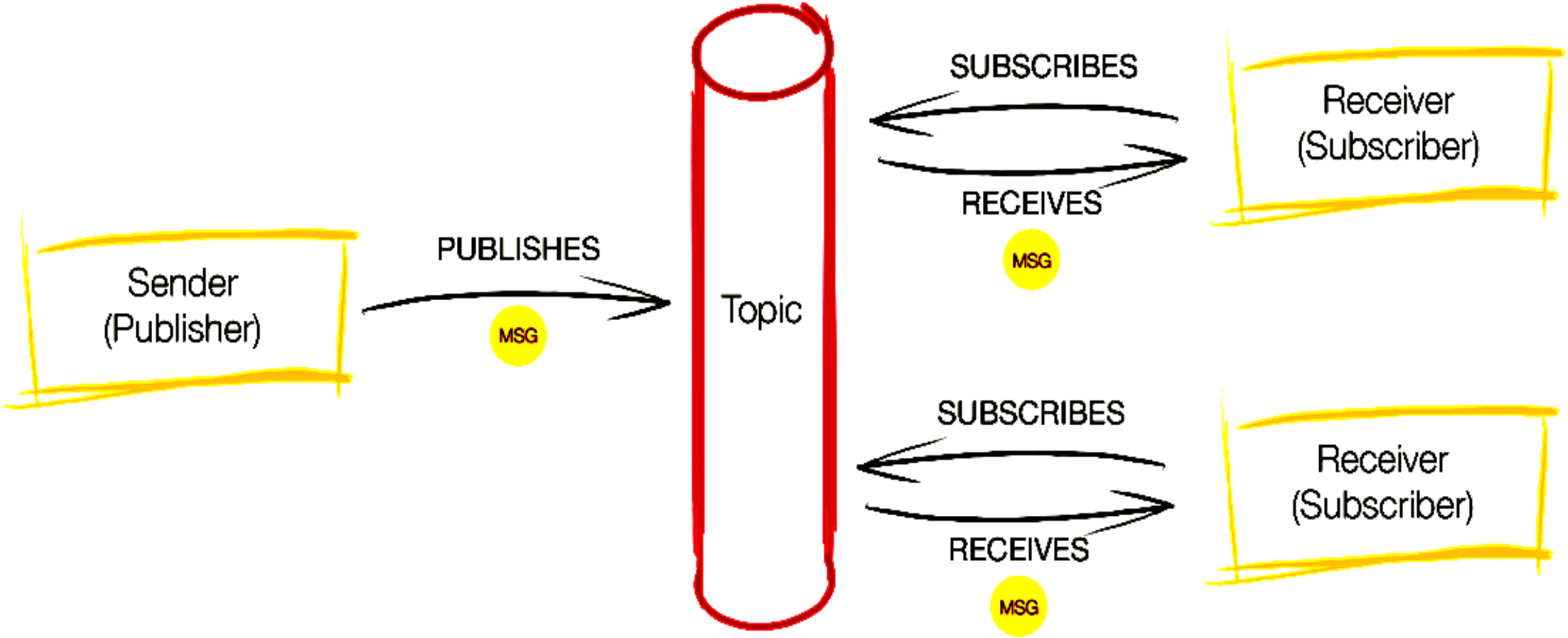


# From data to analysis: Network protocol




https://mqtt.org/

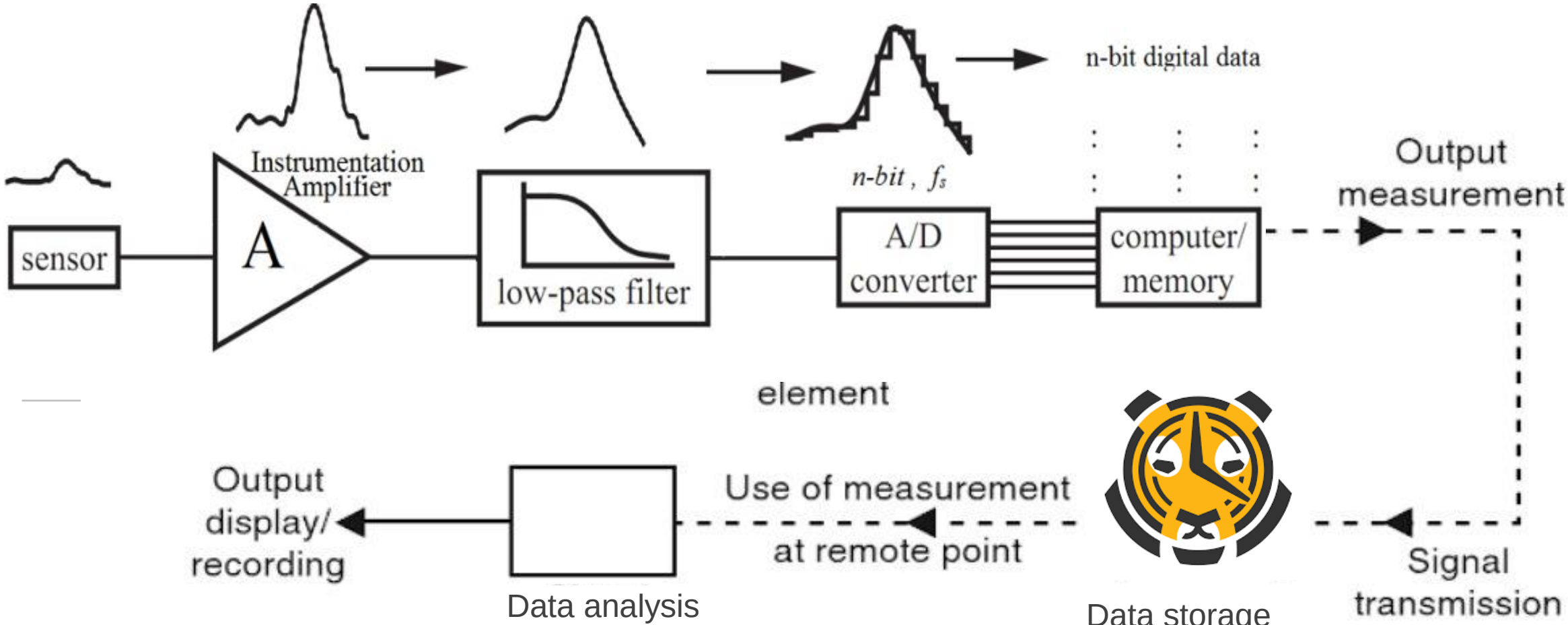
# From data to analysis: MQTT Publish/Subscribe




https://www.ev3dev.org/docs/tutorials/sending-and-receiving-messages-with-mqtt/

https://pypi.org/project/paho-mqtt/

# From data to analysis: Network protocol



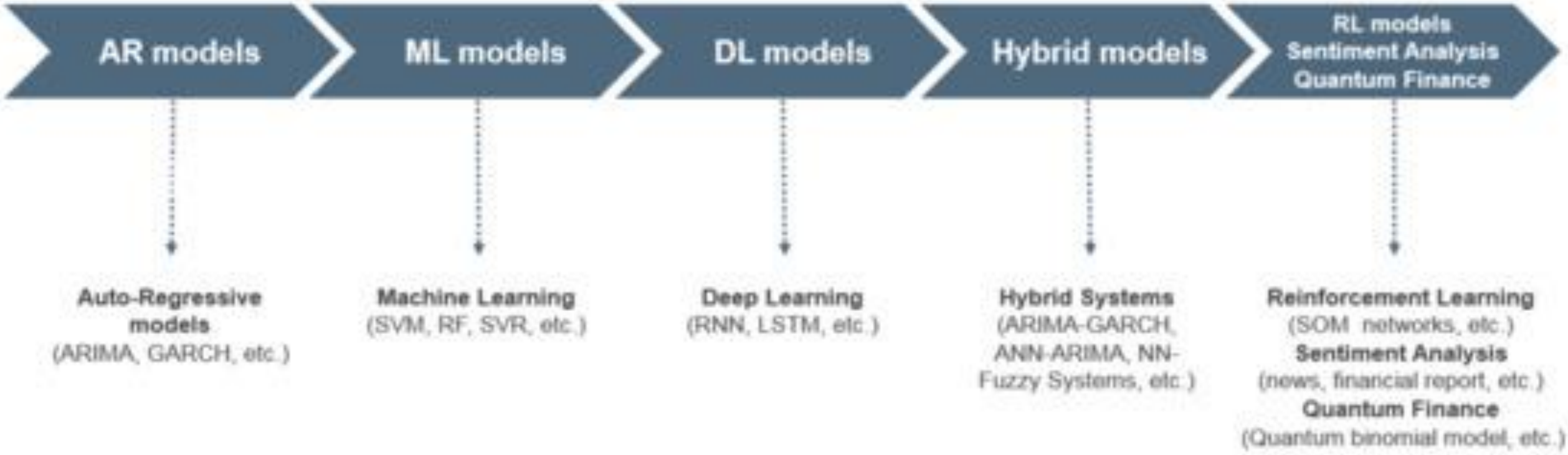
# From data to analysis: Timeseries databases


influxdb

TIMESCALE

https://www.timescale.com/ https://www.influxdata.com/

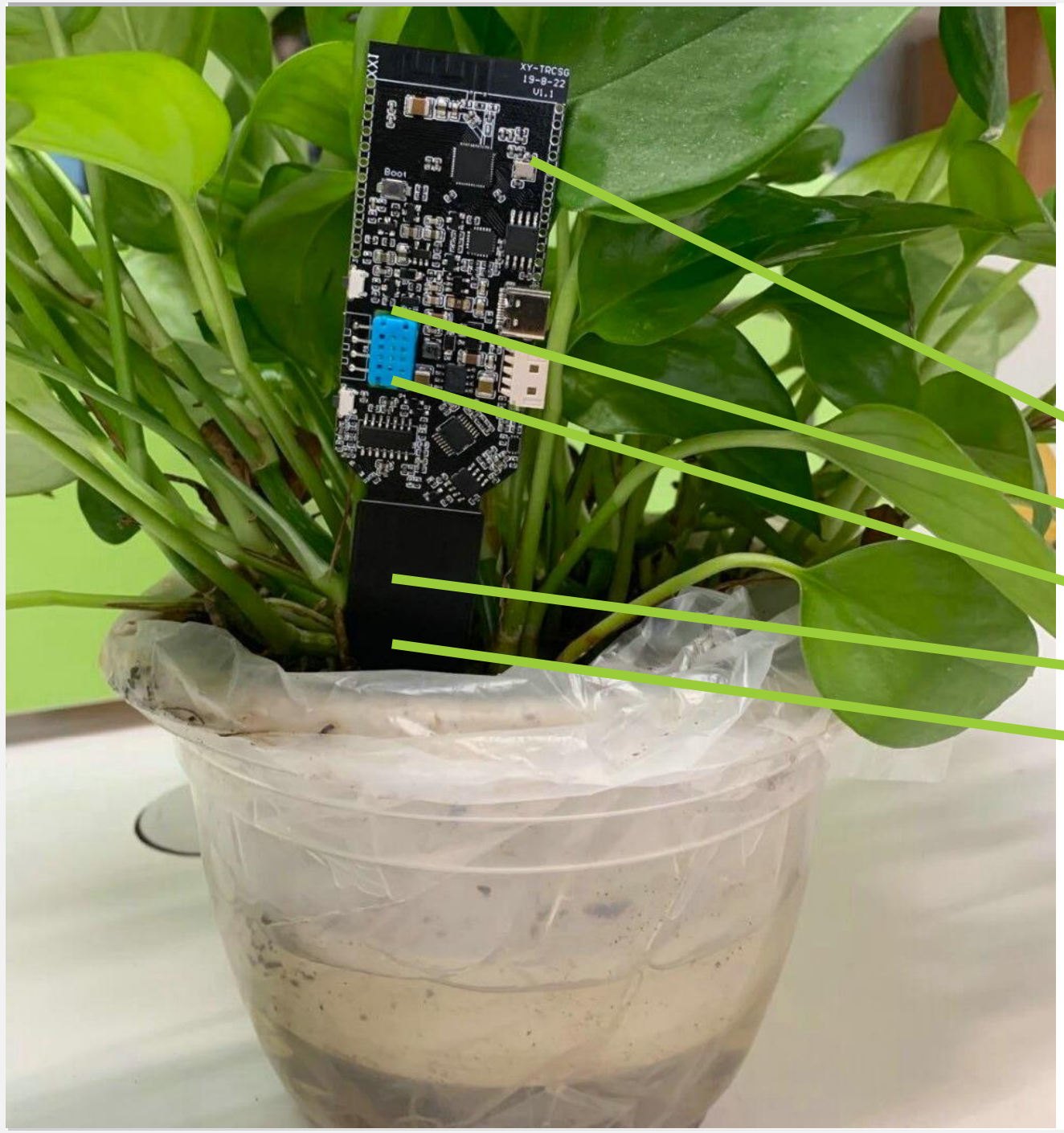
# From data to analysis: Timeseries analysis



# From sensor to data

# TTGO HiGrow


https://docs.google.com/forms/d/e/1FAIpQLSfceR17DqjP0DpjnG46QbSU0IGBpZmOJrJCPBP1OFRGTNkaTg/viewform




# From Sensor to data

## LilyGo TTGO T-Higrow

TinyTronics.nl

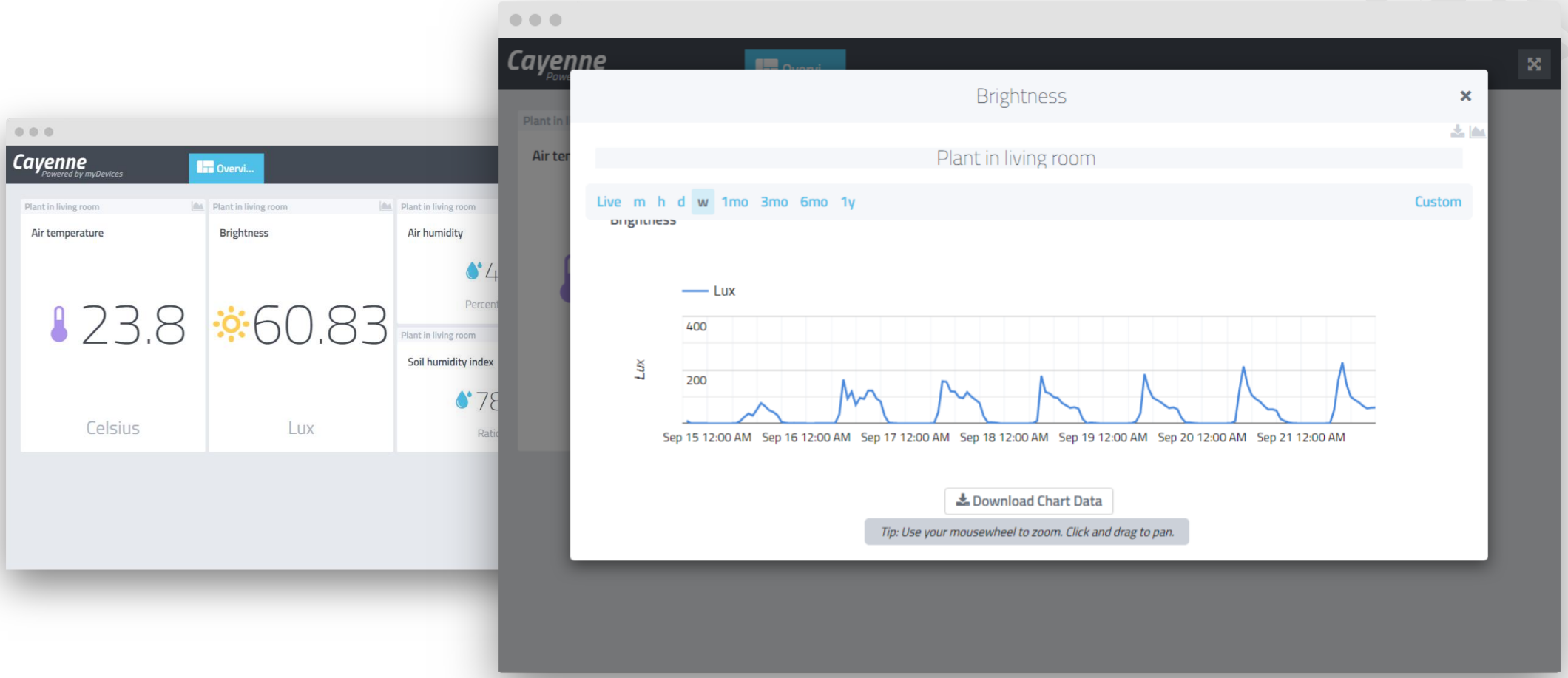
### Sensors:

- Photometric
- Temperature
- Air humidity
- Soil humidity
- Electrolyte sensor

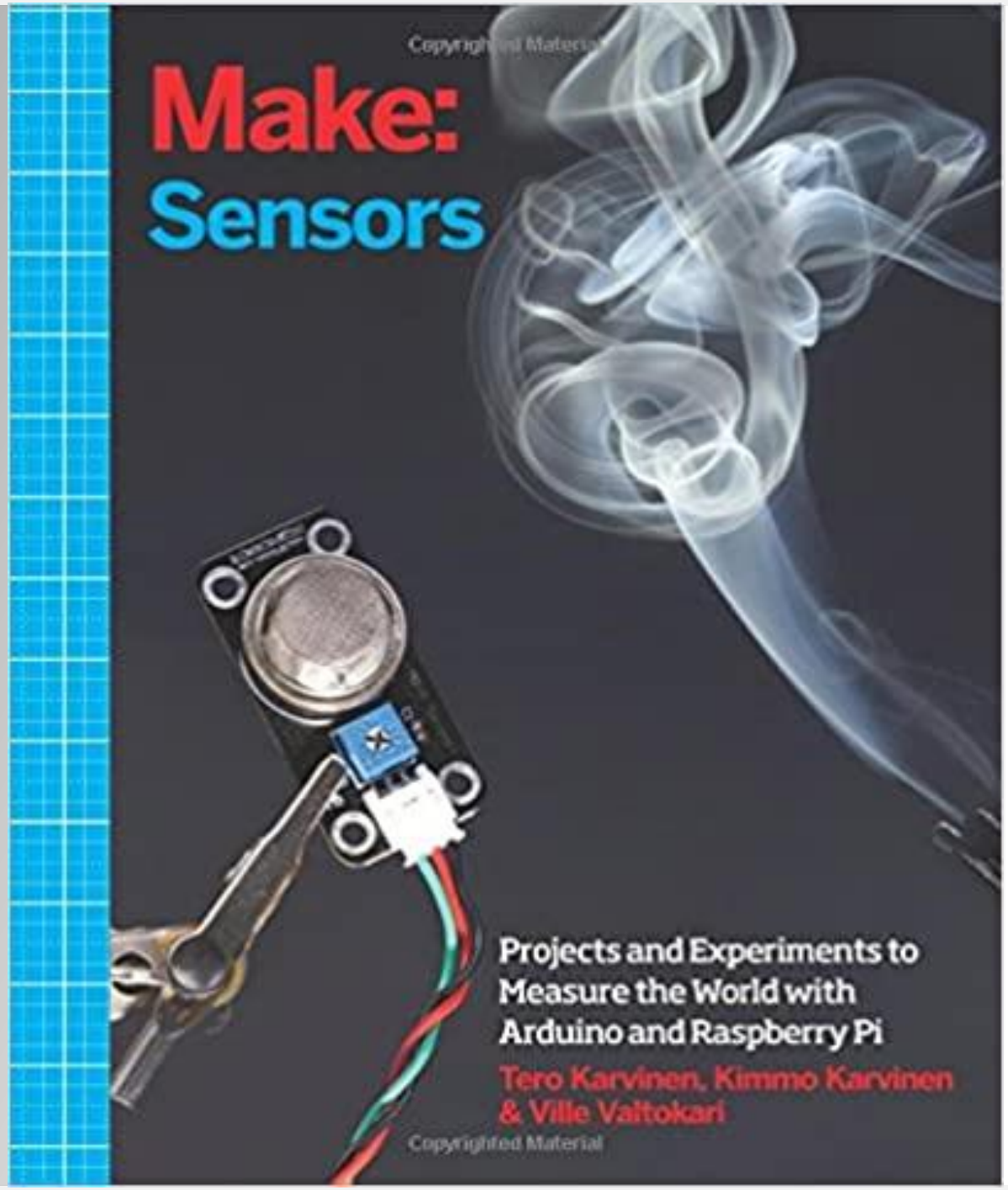
### Microprocessor:

- ESP32

# From data to analysis: Cayenne Dashboard




https://cayenne.mydevices.com/shared/5f5d15c82130755bb2a55562/project/e9af04f1-b554-4317-b4fb-5e5d4d831b7d

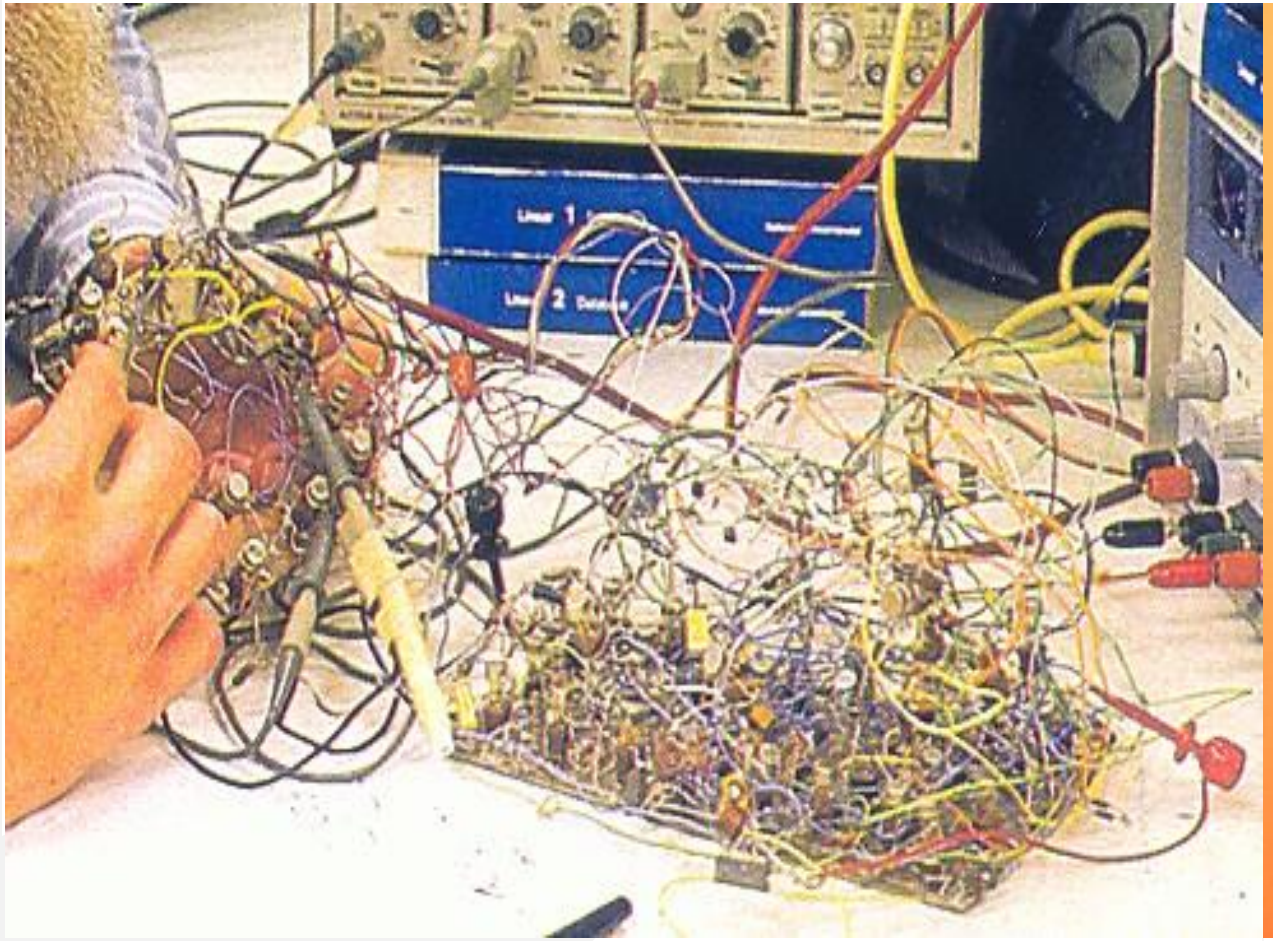


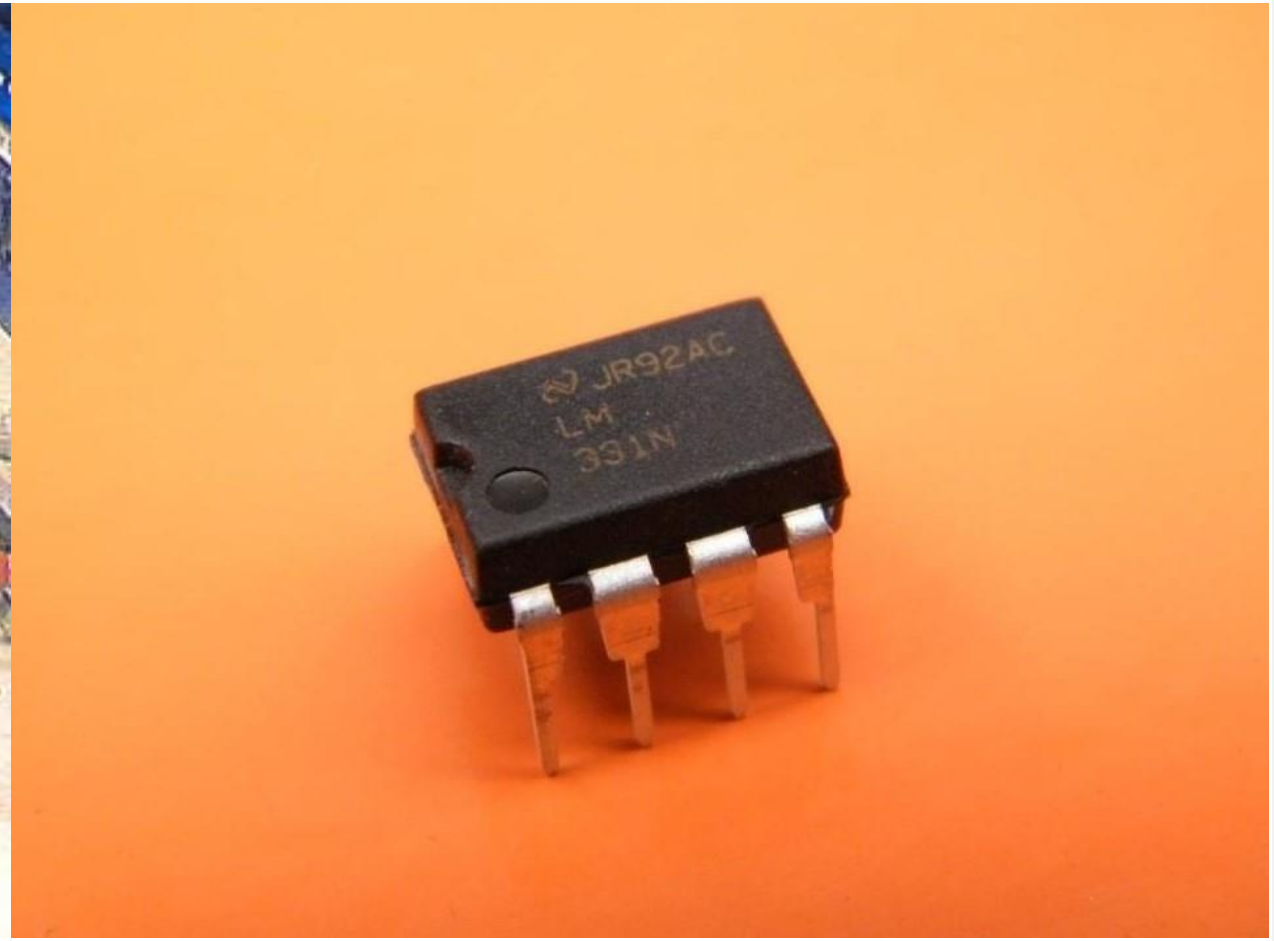

# Or build your own…

Start with:

Make: Sensors: A Hands-On Primer for Monitoring the Real World with Arduino and Raspberry Pi
by Karvinen & Valtokari

# …don’t optimize early (left Bob Pease famous LM131 design)





# From Sensor to data

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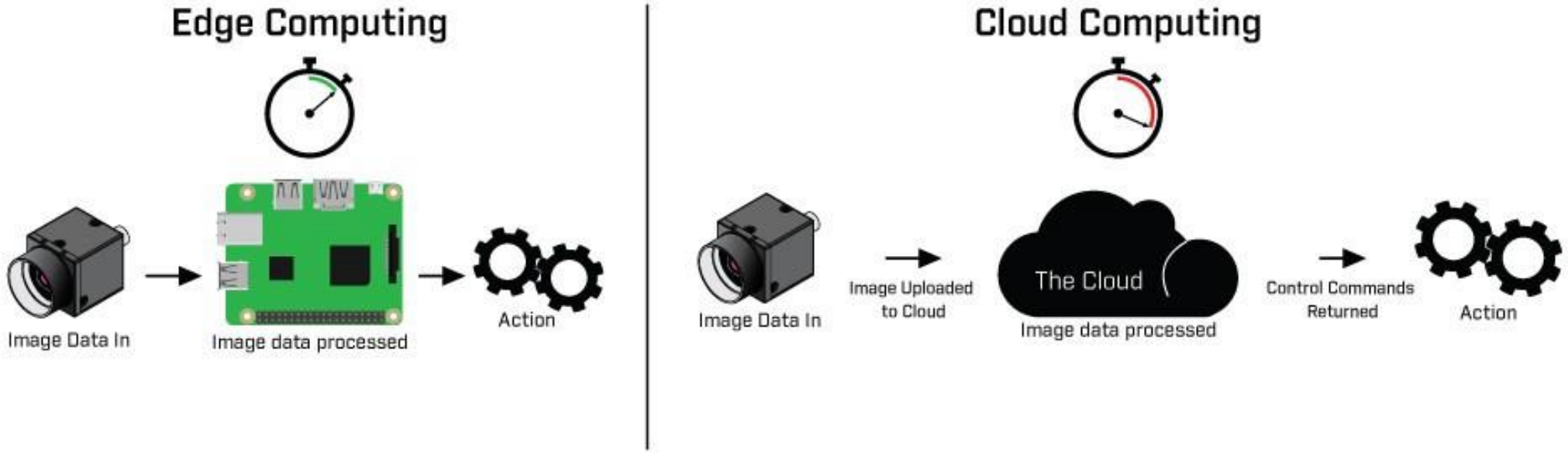
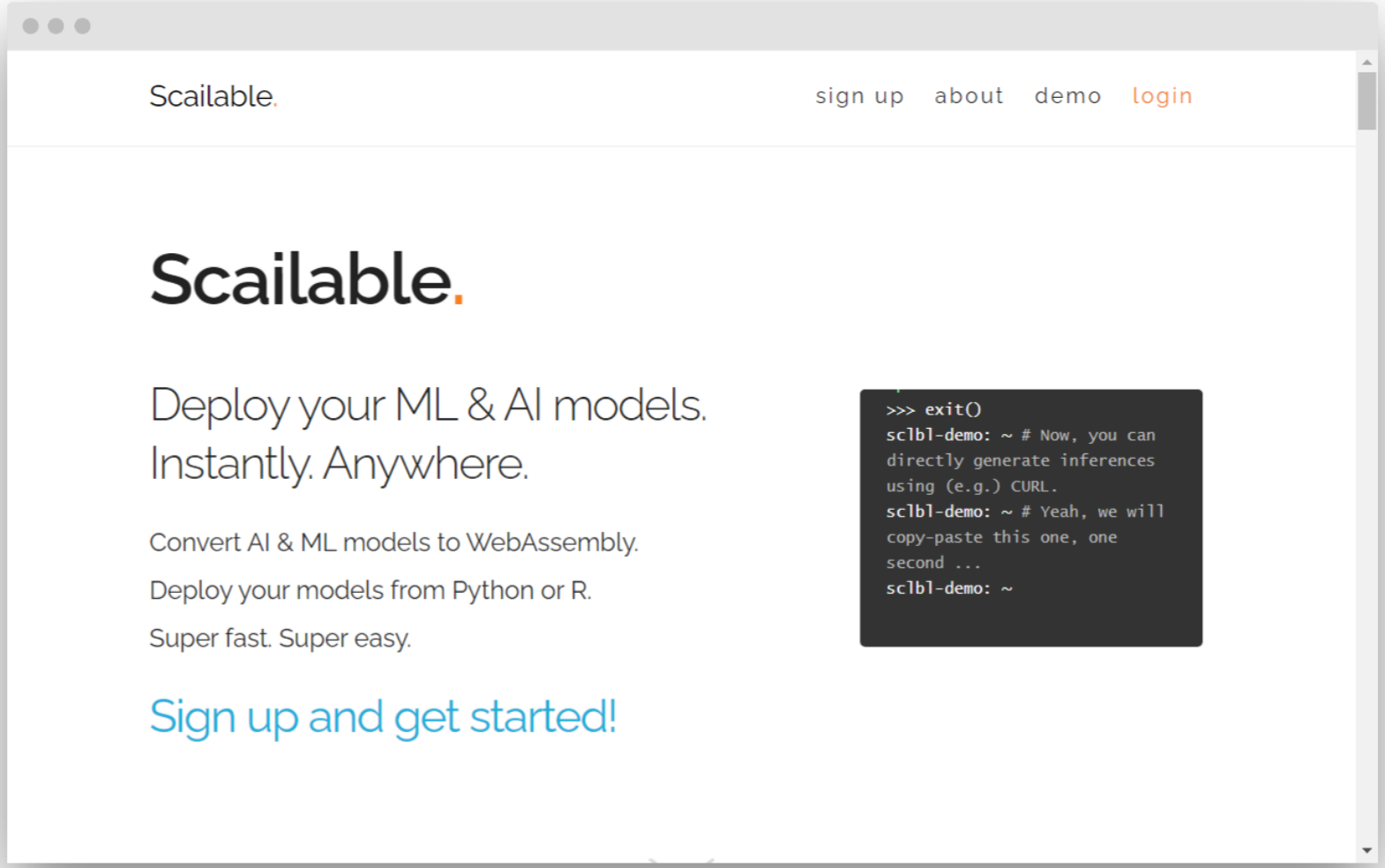
# Edge Computing …

# From data to analysis: Edge Computing



# From data to analysis: Edge Computing with Scailable



# Thank You

JADS Jheronimus Academy of Data Science


Robin van Emden

R.A.vanEmden@tilburguniversity.edu

www.jads.nl