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: Data and code repository

https://github.com/robinvanemden/sensors

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

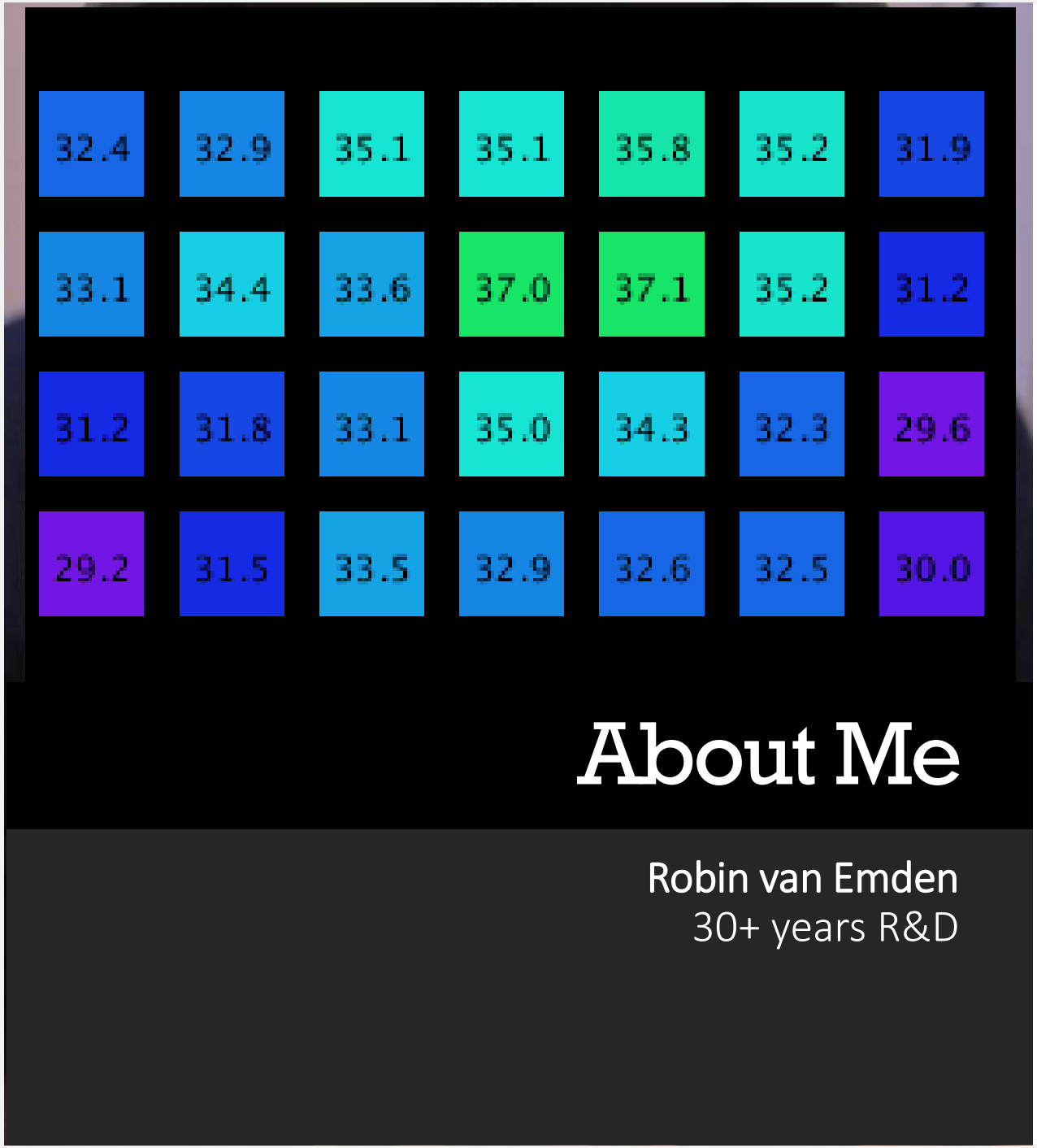
About Me

Robin van Emden
30+ years R&D

For example…

Tear Detection

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



About Me

Robin van Emden
30+ years R&D

For example…

Tear Detection

With: Tilburg and Rijeka Uni
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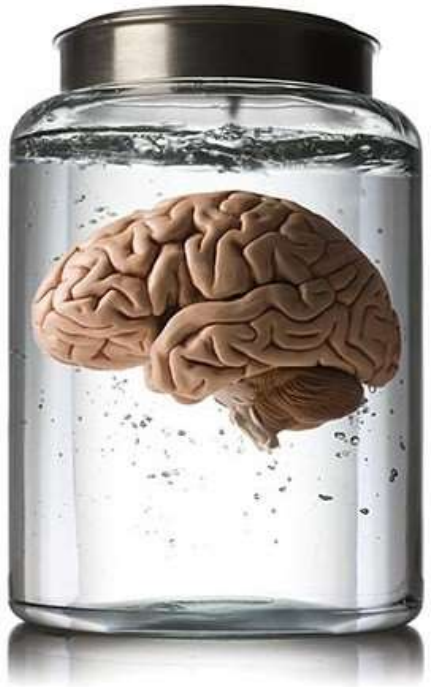
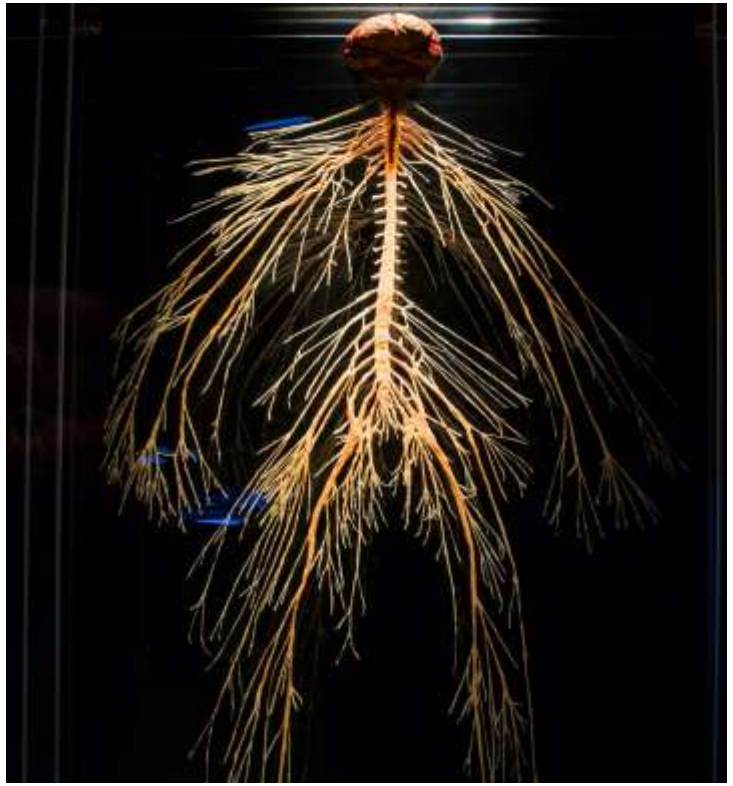
Usual data science perspective…

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



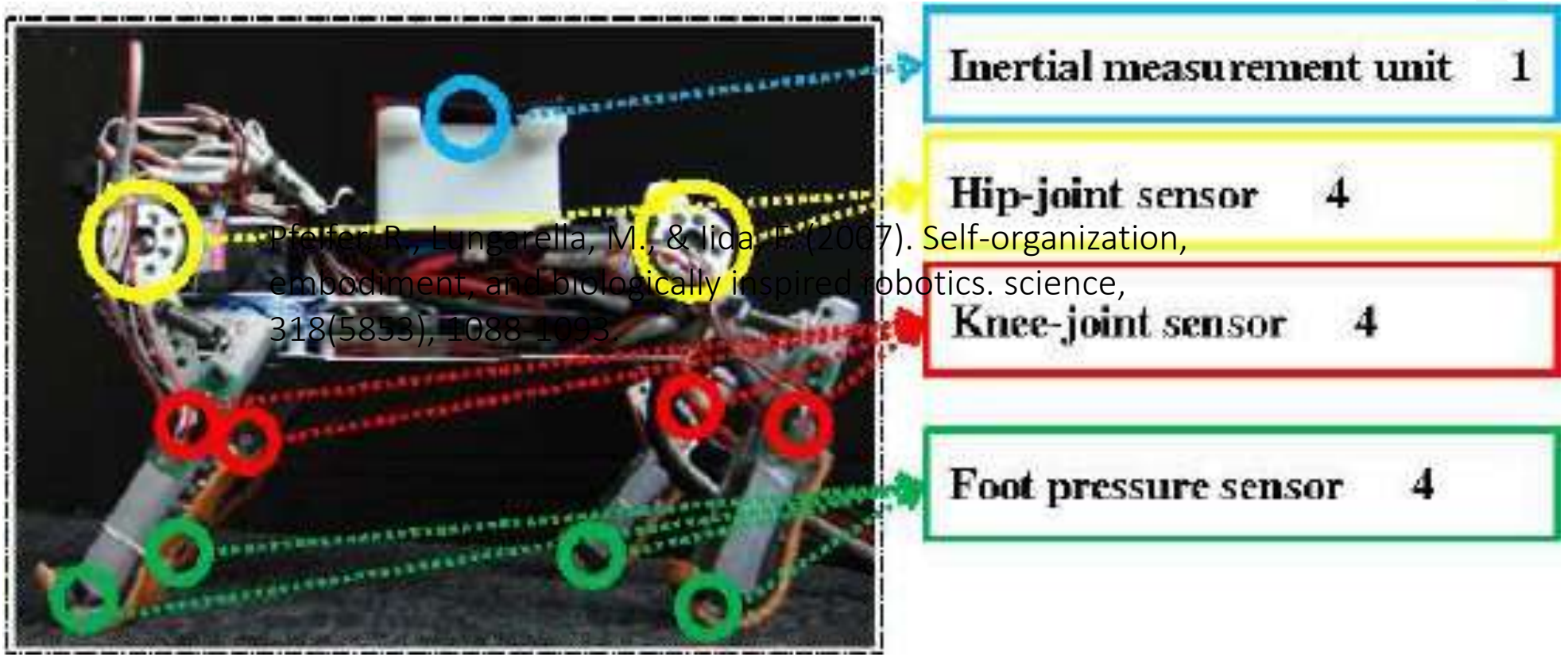
Brain in a vat



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.

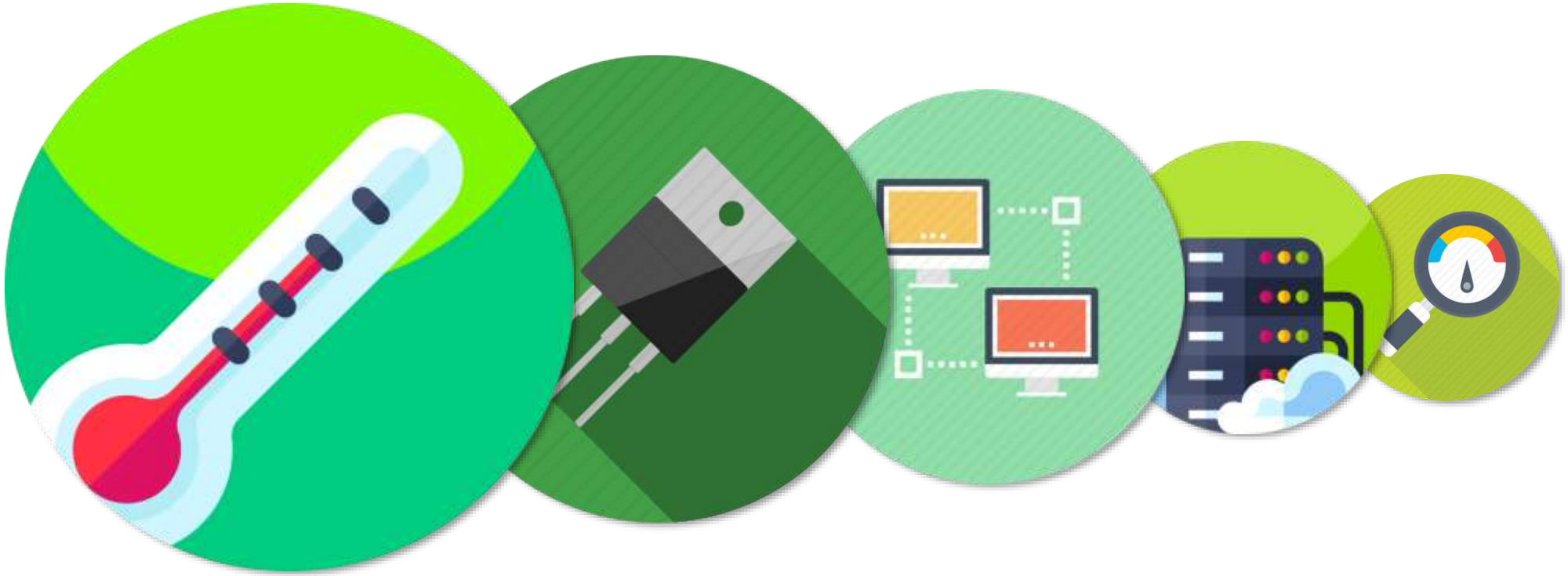
Pfeifer, R., Lungarella, M., & Iida, F. (2007).
Self-organization, embodiment, and biologically inspired robotics. *science*, *318*(5853), 1088-1093.

Ever since robots took a more embodied approach…

Honda Asimo

Boston Dynamics

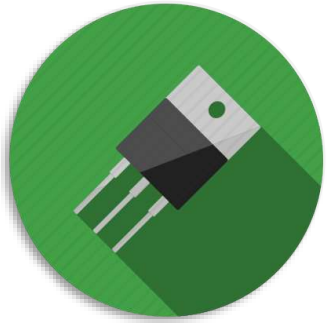
So.. let's invert the perspective for today!



Sensor related projects involve the following area's:

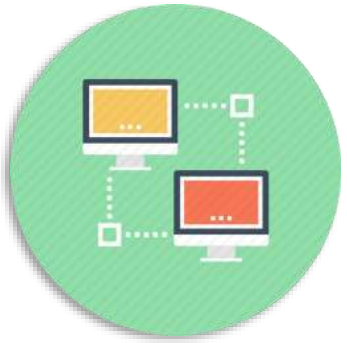
Sensors

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

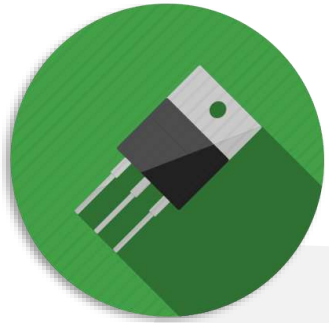
The data needs to be transported from the MCU(s) to a data store.

Data storage

The data needs to be aggregated or stored.

Data analysis, Data visualization

The data has to be shown to others.



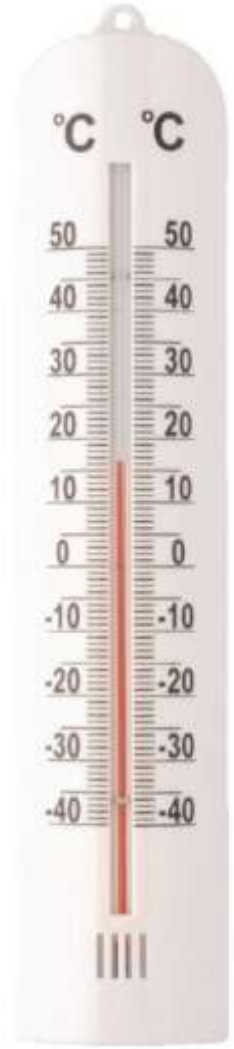
From sensor to data

- 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

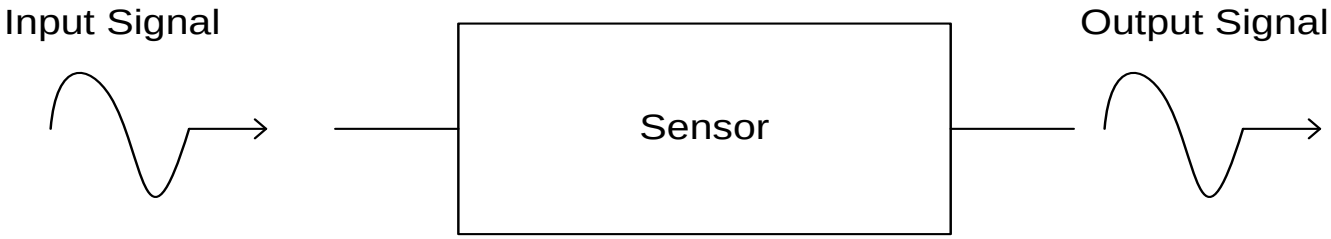
- We will be doing data analysis on live data from a greenhouse at 30Mhz, a Dutch company that builds a data platform for horticulture.

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"

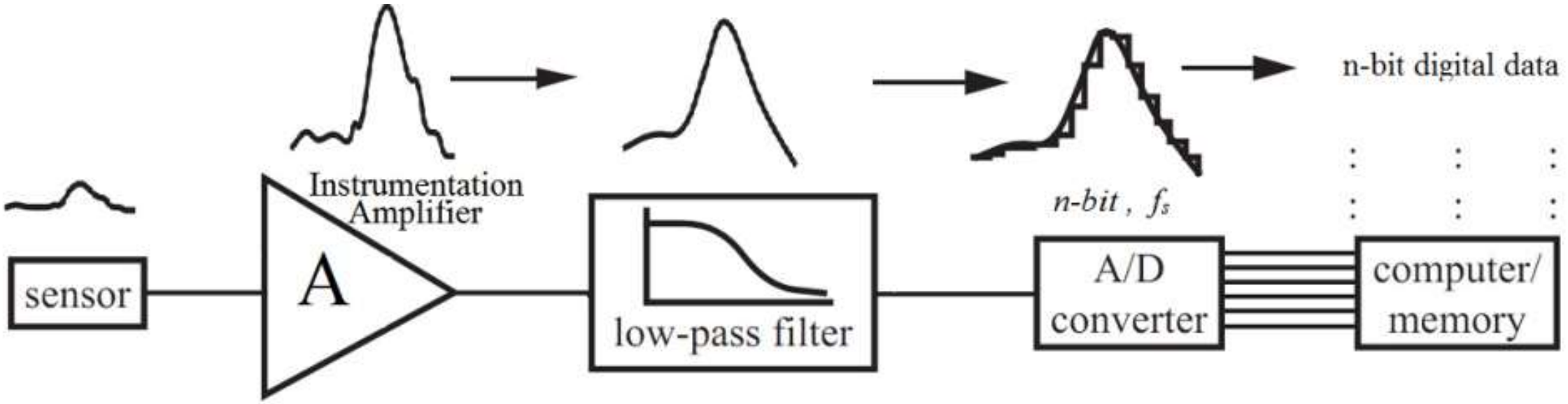


- General definition:

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

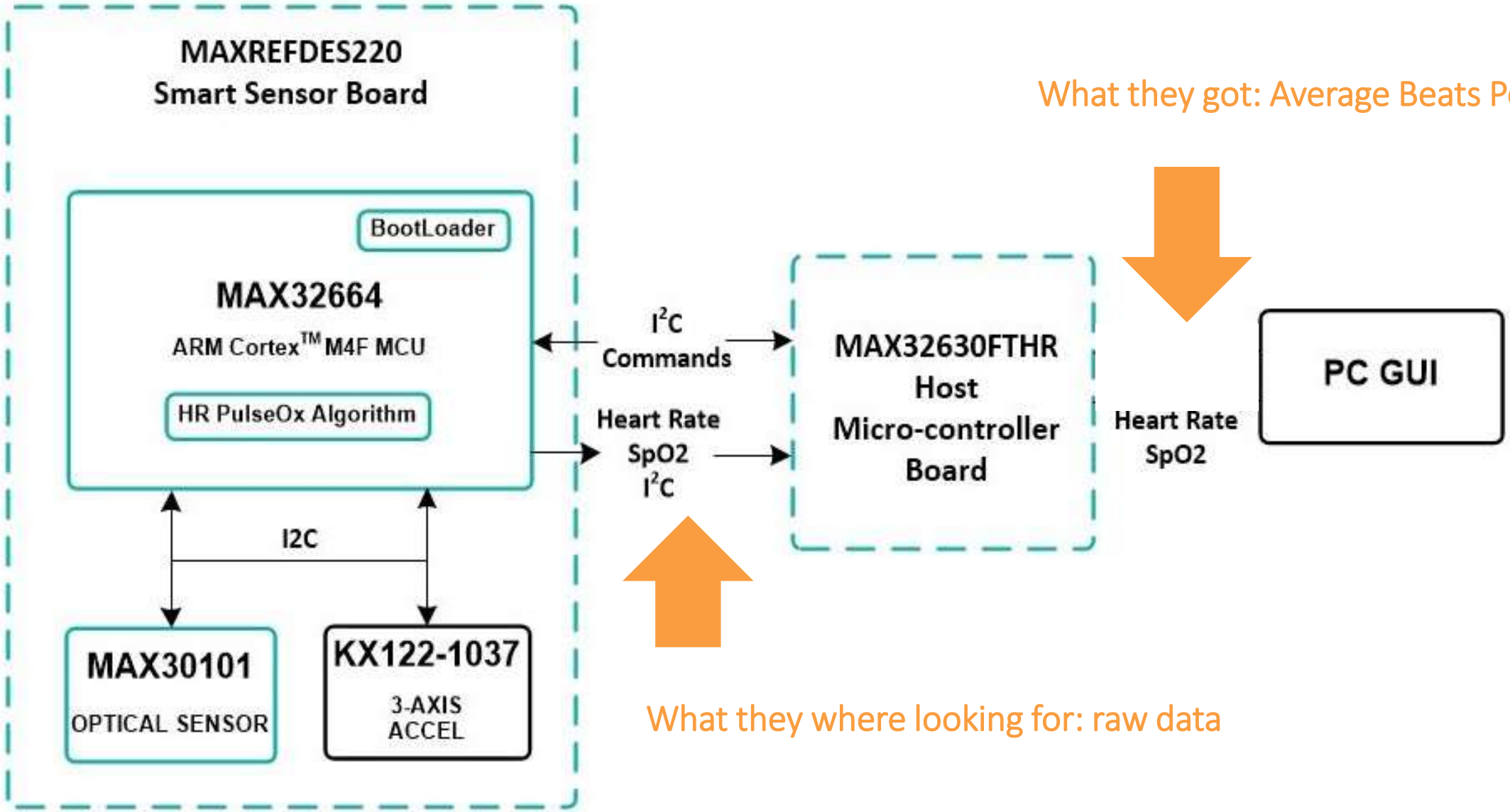
From sensor to data: Measurement systems

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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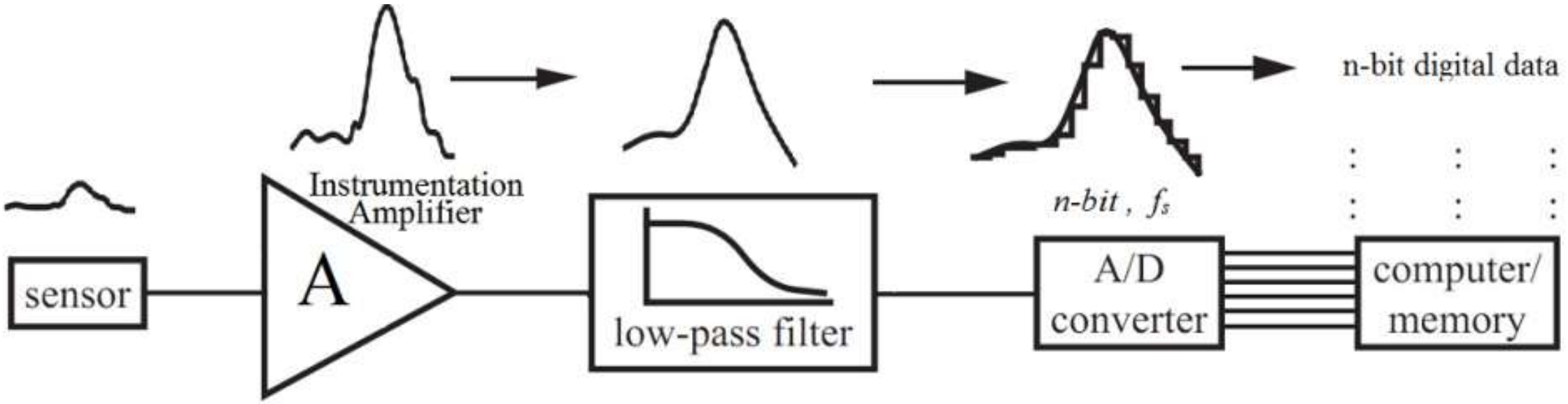
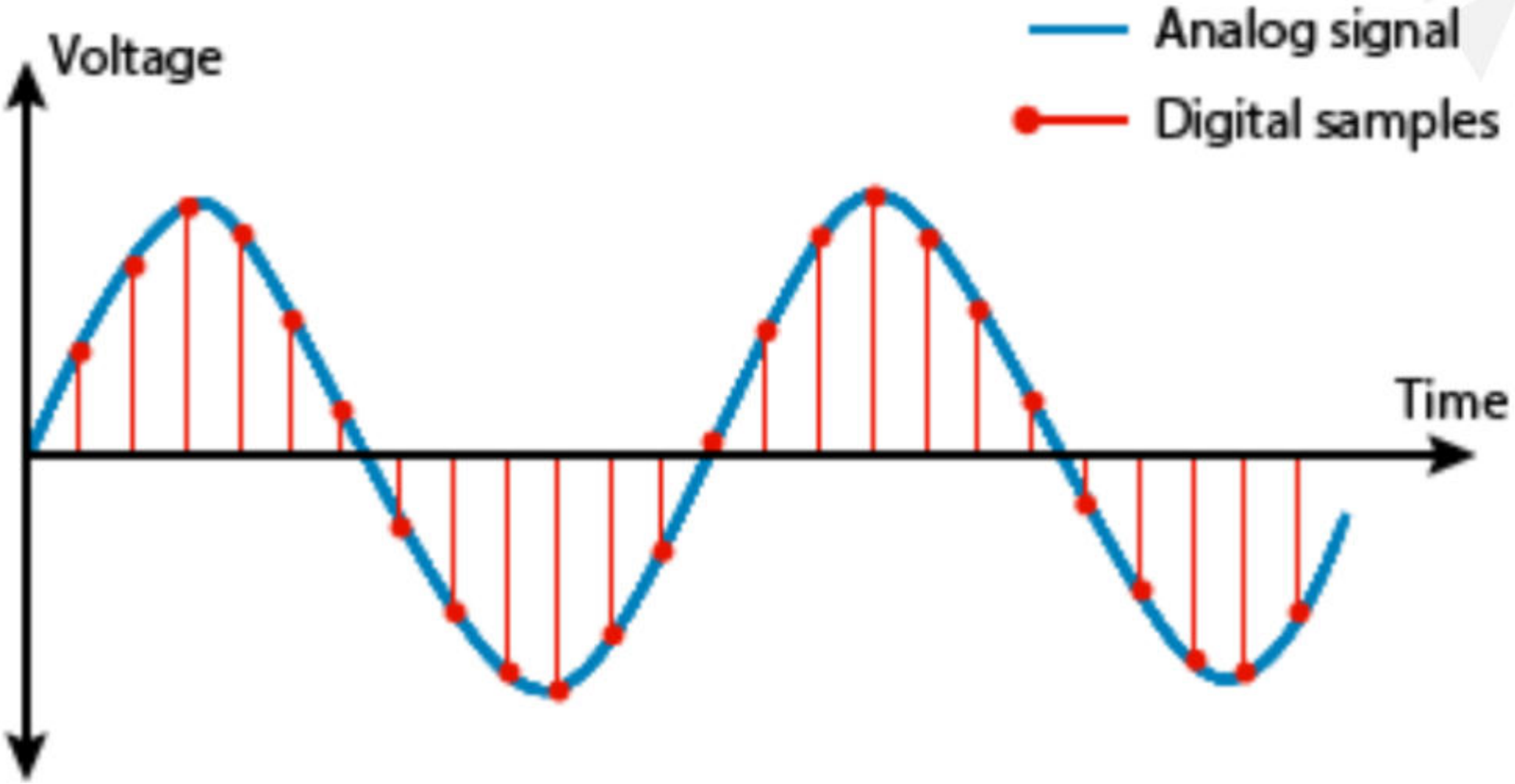
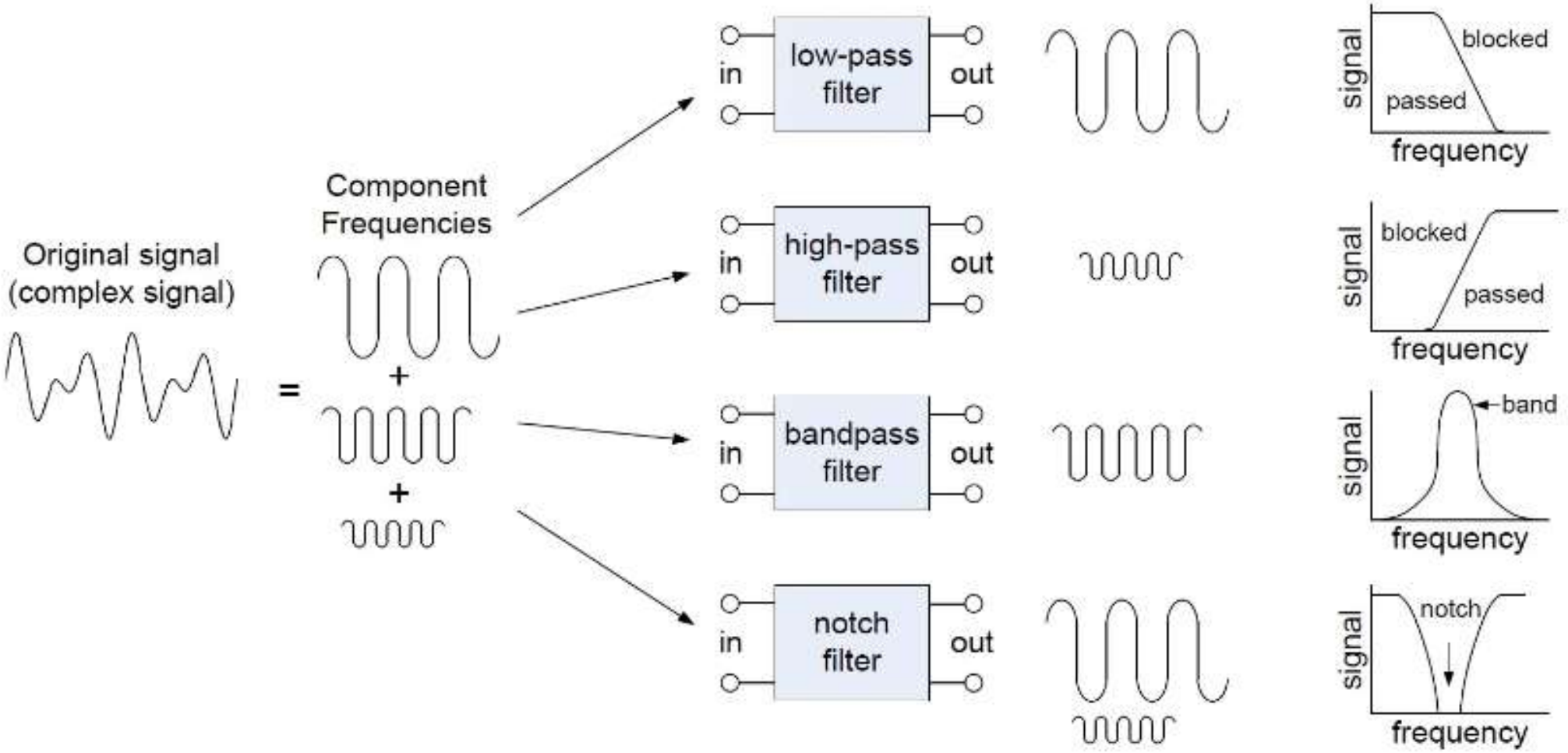


From sensor to data: DSP1 - Analog to Digital Converter



From sensor to data: DSP2 - Signal filtering



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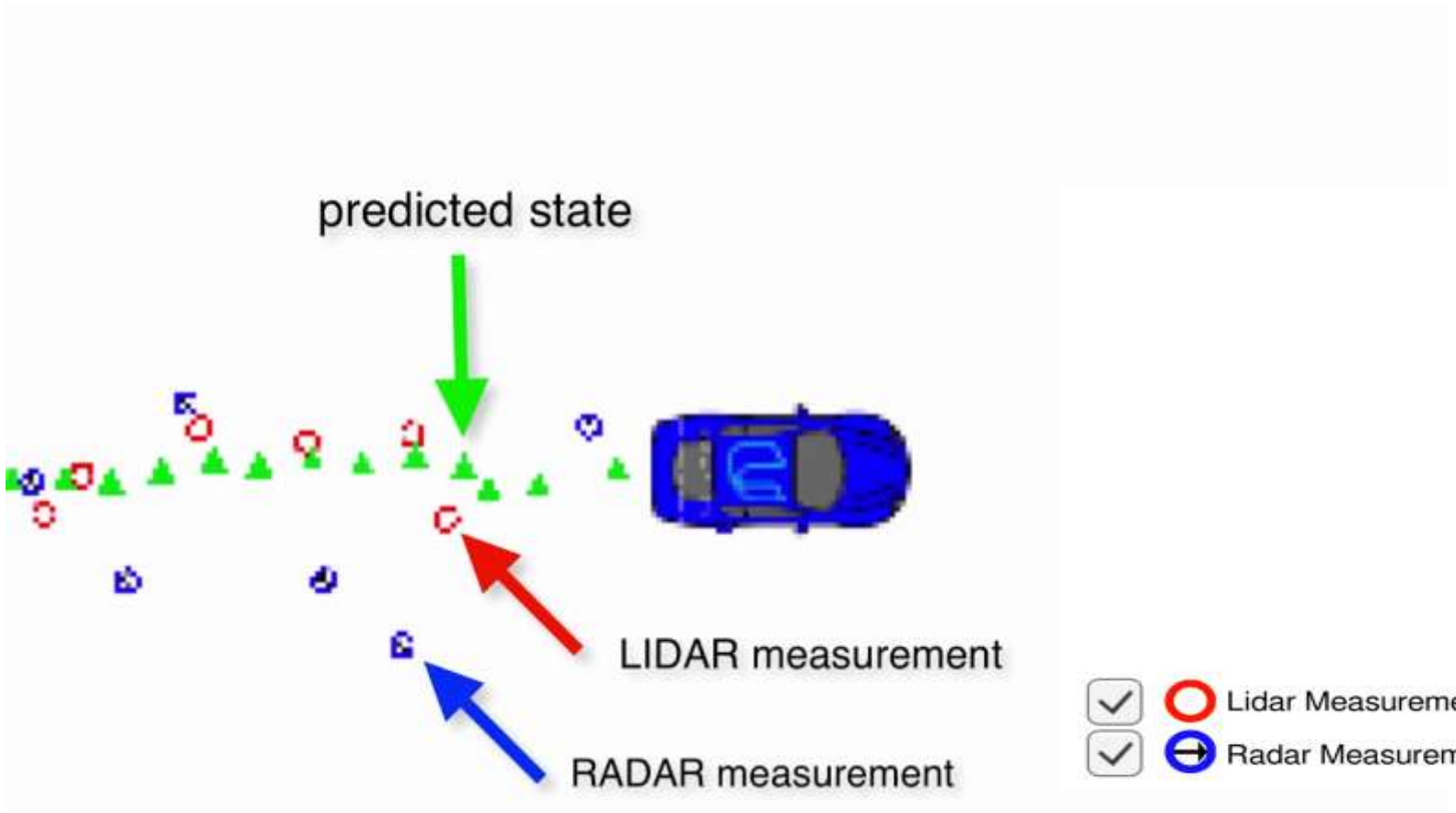
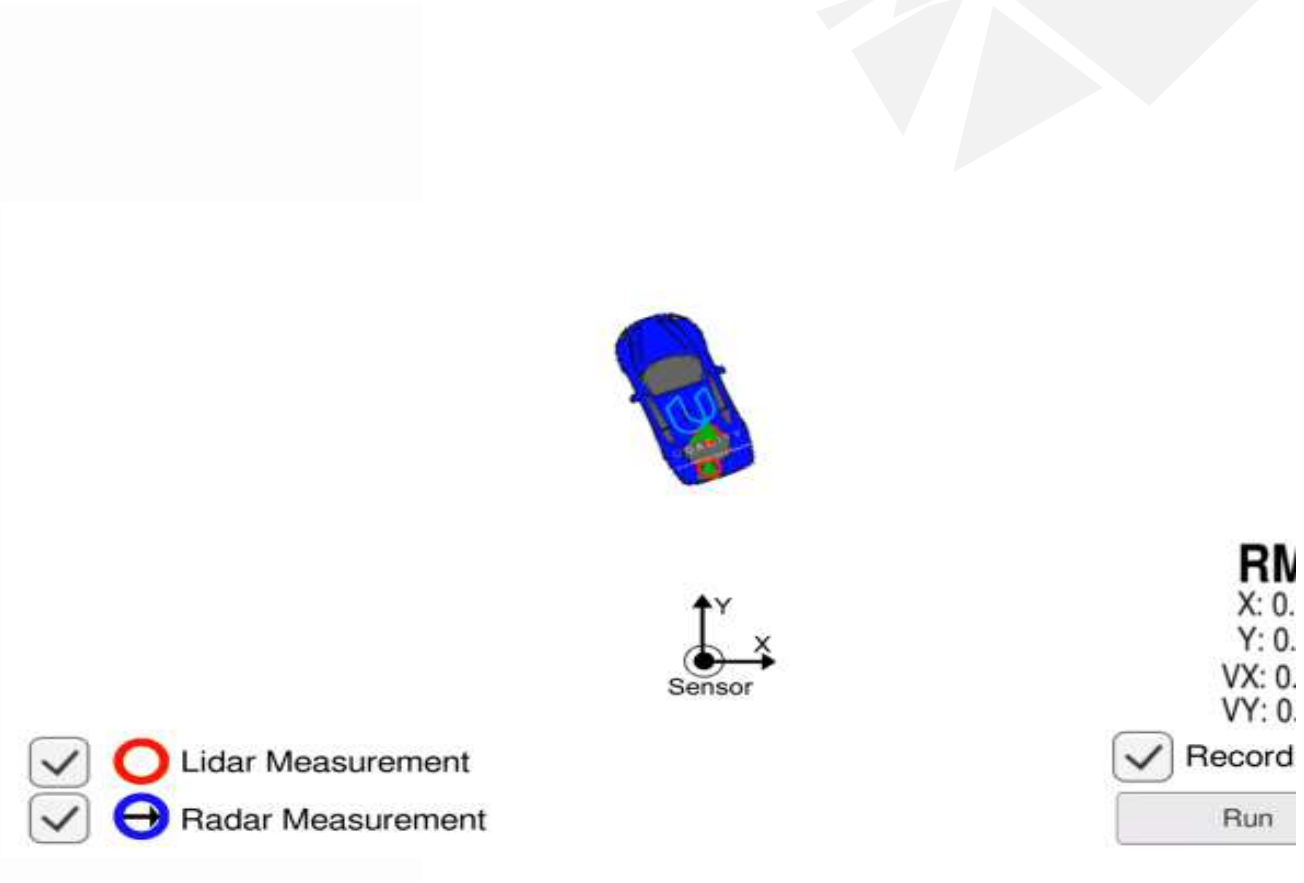
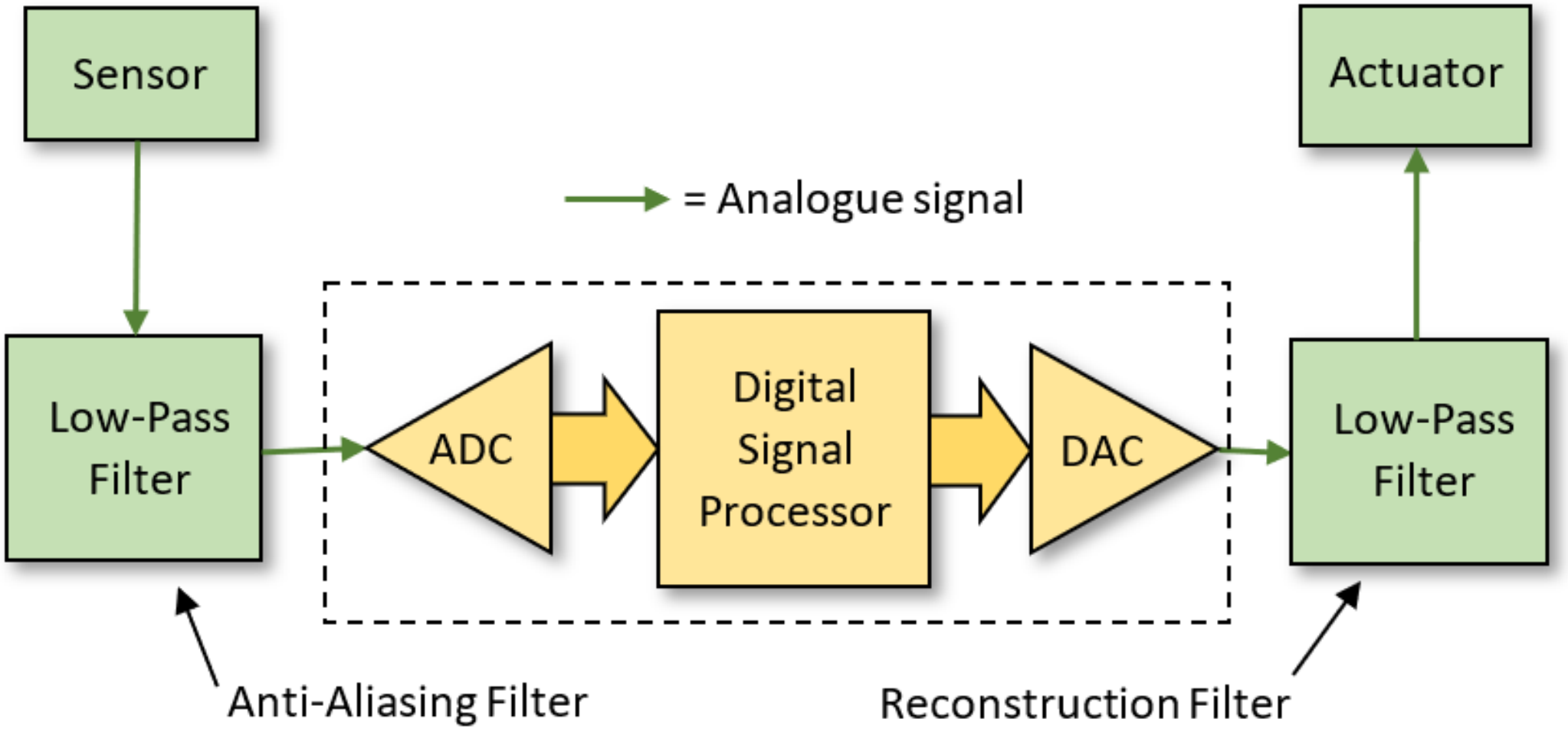
From sensor to data: DSP3 - sensor fusion (Kalman Filter)





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

From sensor to data: Digital Signal Processing (DSP)



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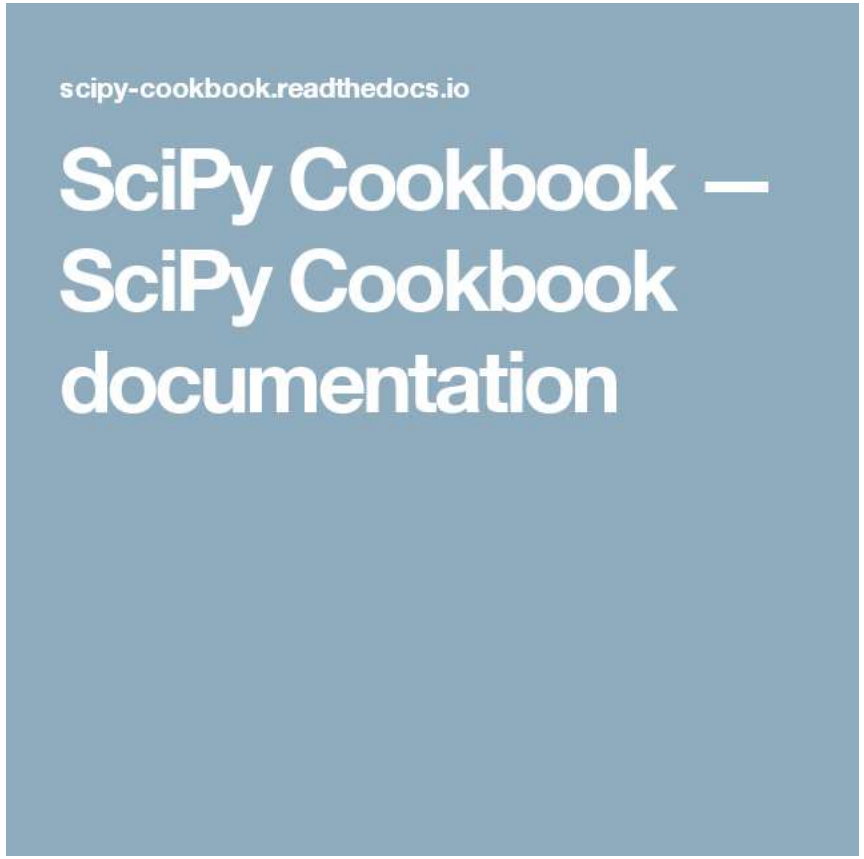
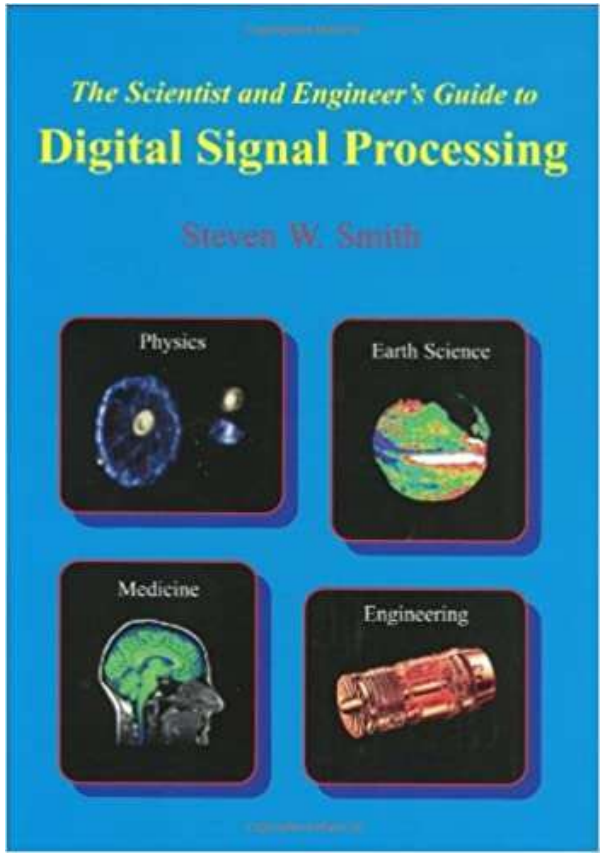
From sensor to data: Digital Signal Processing (DSP)



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

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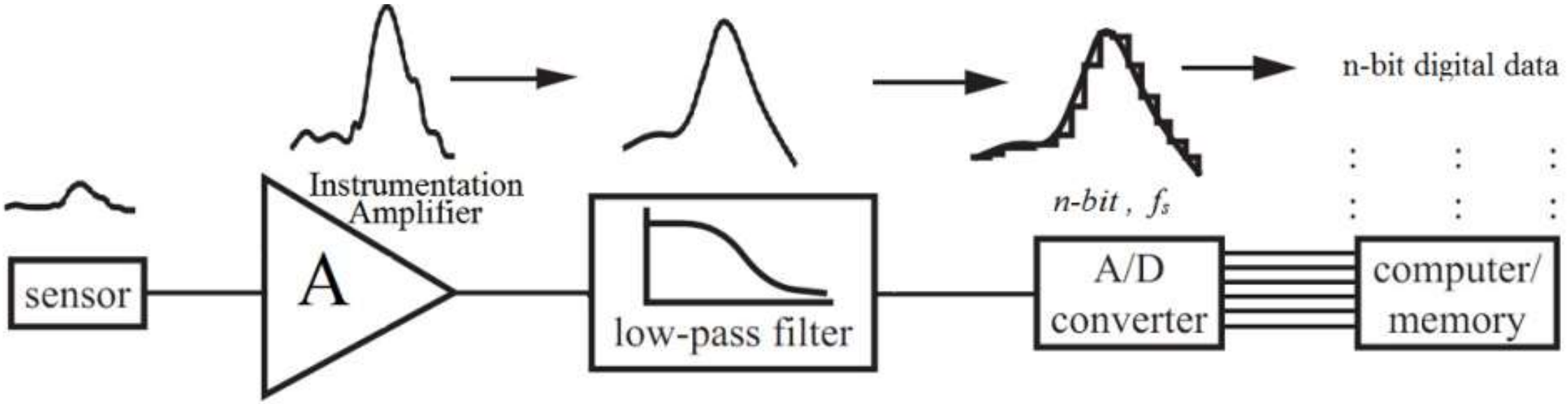
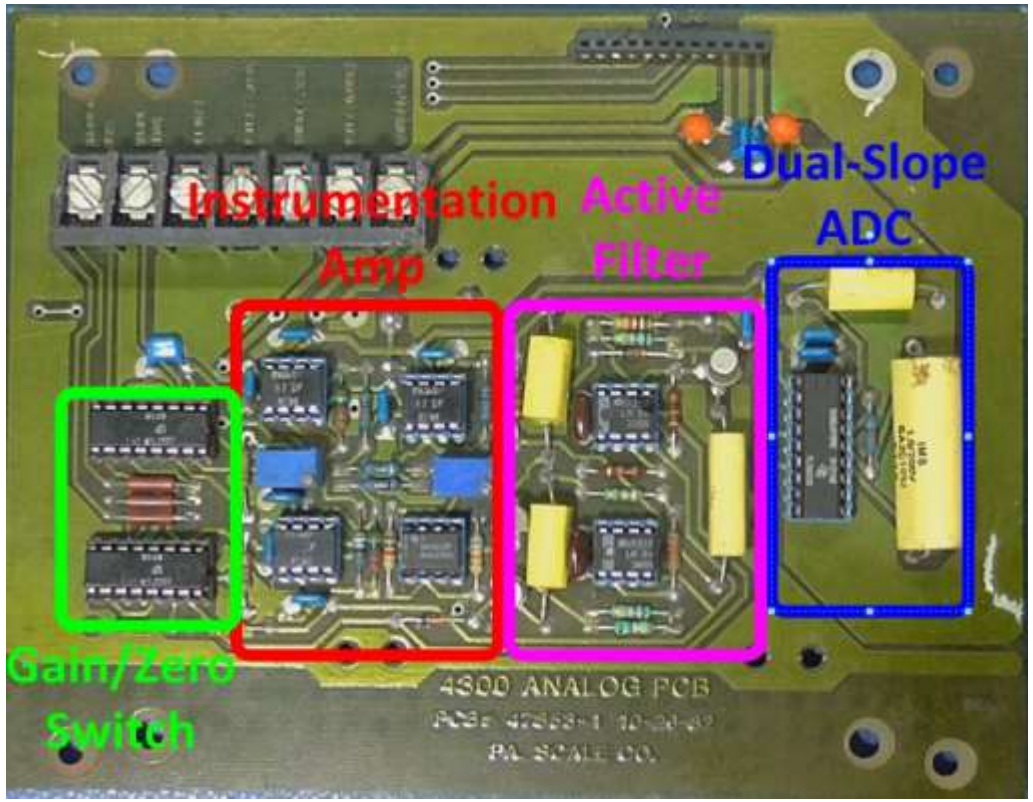
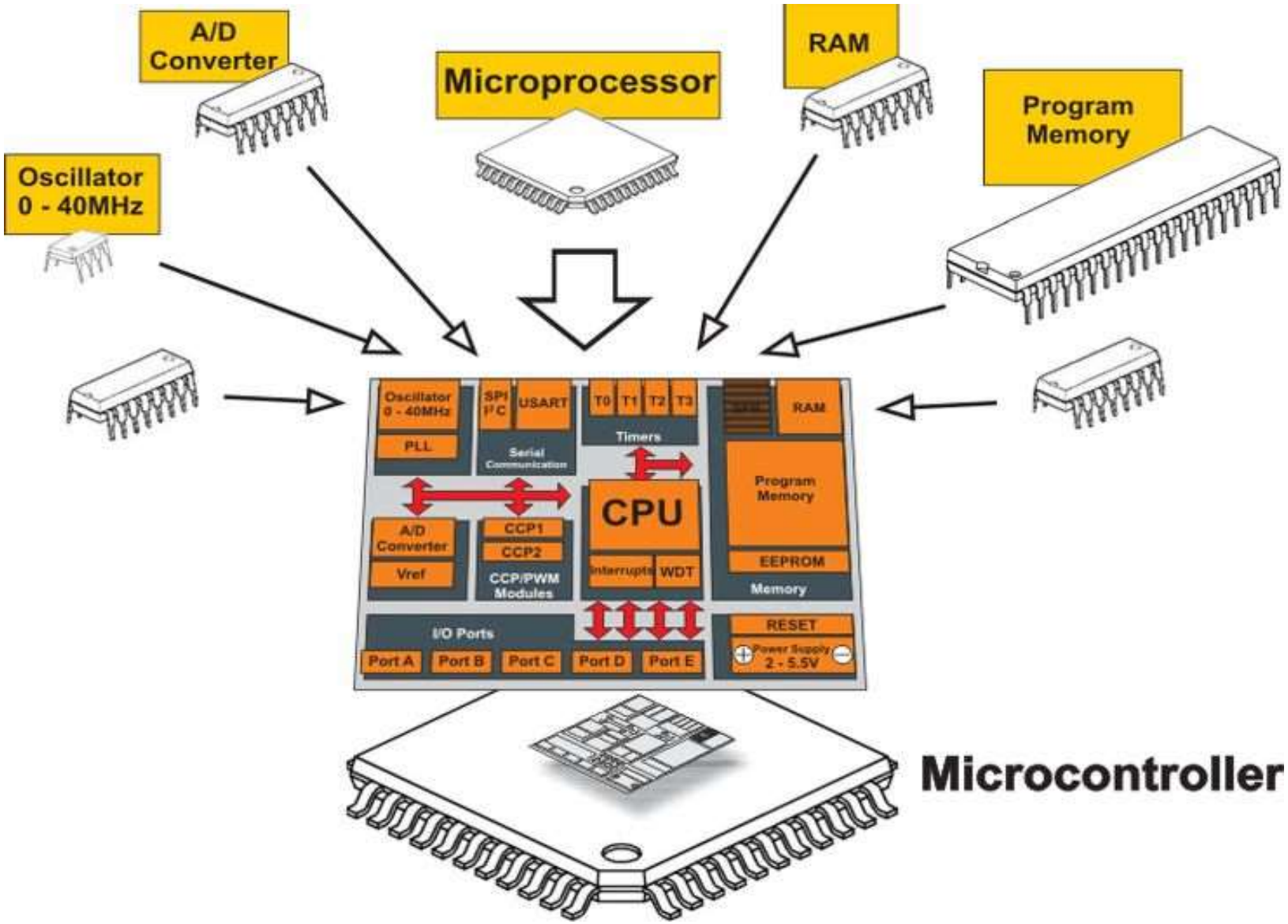


From sensor to data: Measurement systems

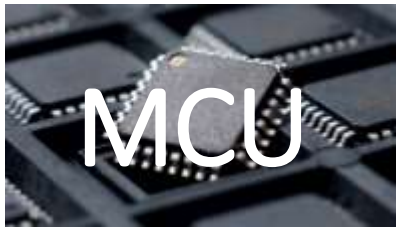
From hardwired to microprocessor-based measurement systems



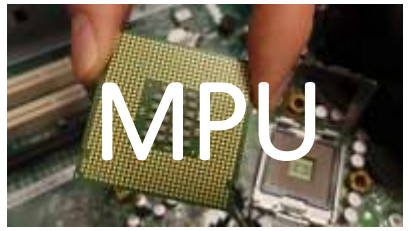
From sensor to data: What is a microcontroller



From sensor to data: Microcontroller vs Microprocessor



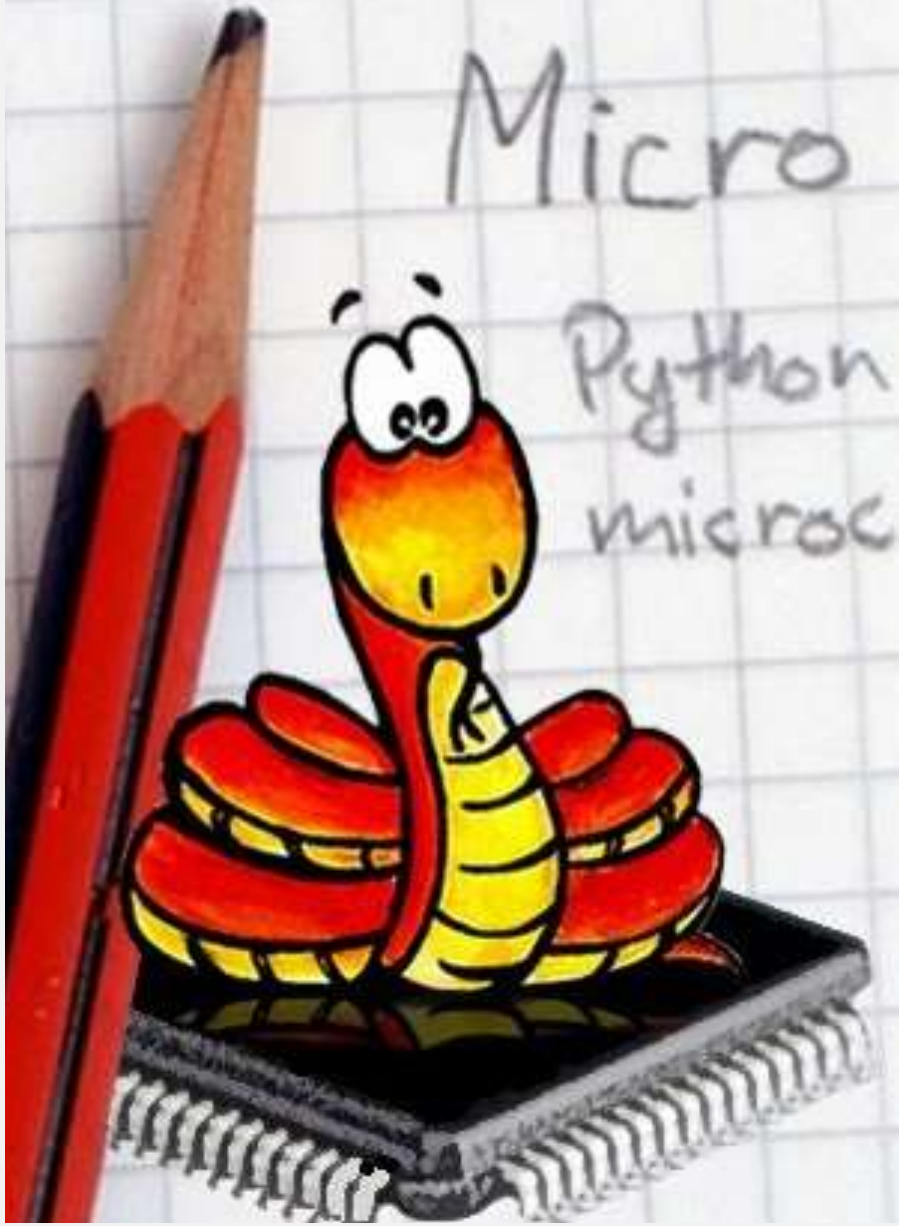
- CPU, RAM, ROM, I/O and Timer all on a single chip
- Fixed amount of on-chip RAM, ROM, IO ports
- For applications in which cost, power, and space are critical
- Single purpose
- Relatively slow, fewer resources

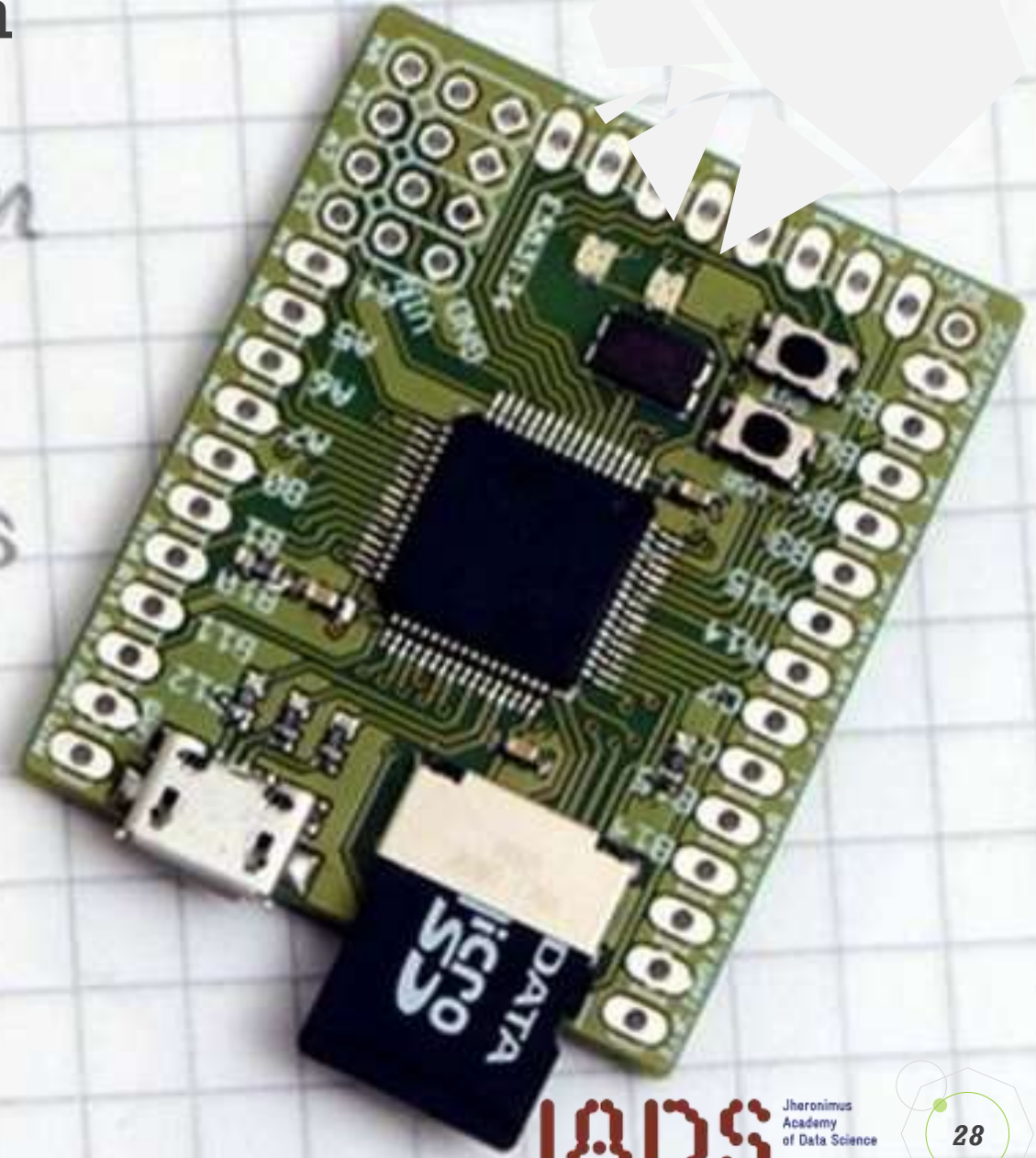


- CPU is standalone - RAM, ROM, I/O and timer are separate
- Designer can decide on amount of RAM, ROM, IO ports
- Versatile
- General purpose
- More expensive
- Faster, more resources

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!

```

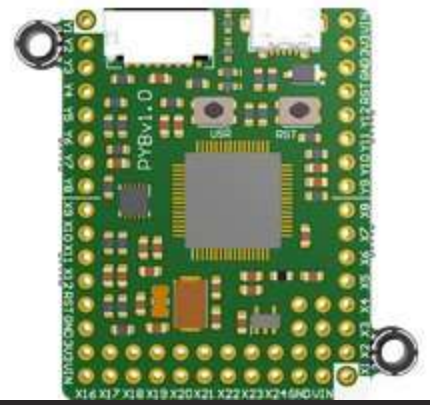
BINARY : PYBOARD RAM : 64KB STACK : 8KB RESET RUN SCRIPT CHOOSE A DEMO...

CLOCK SPEED 0.00 MHz

PERIPHERALS :

- ☐ LED ☐ I2C LCD
- ☐ SERVO
- ☐ ADC

https://micropython.org/unicorn/



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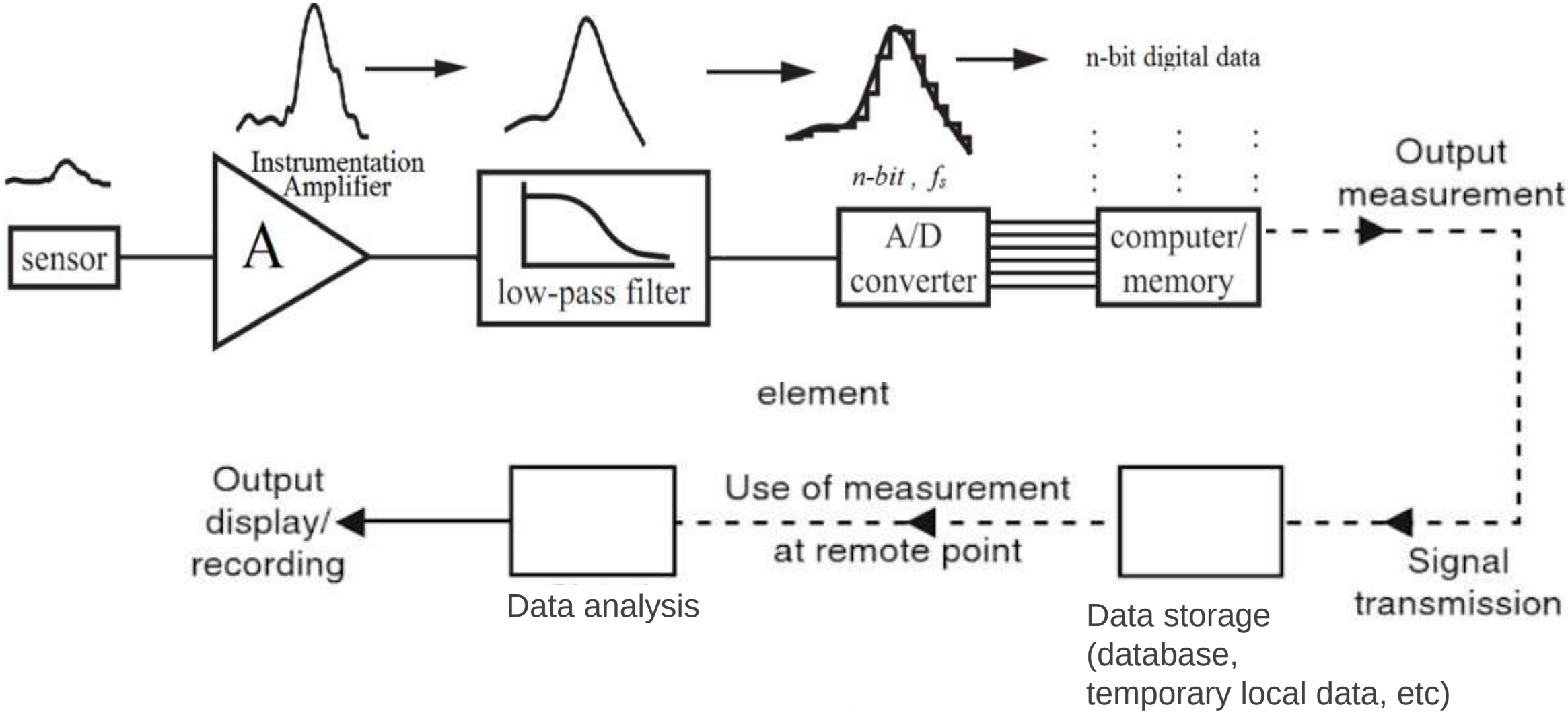
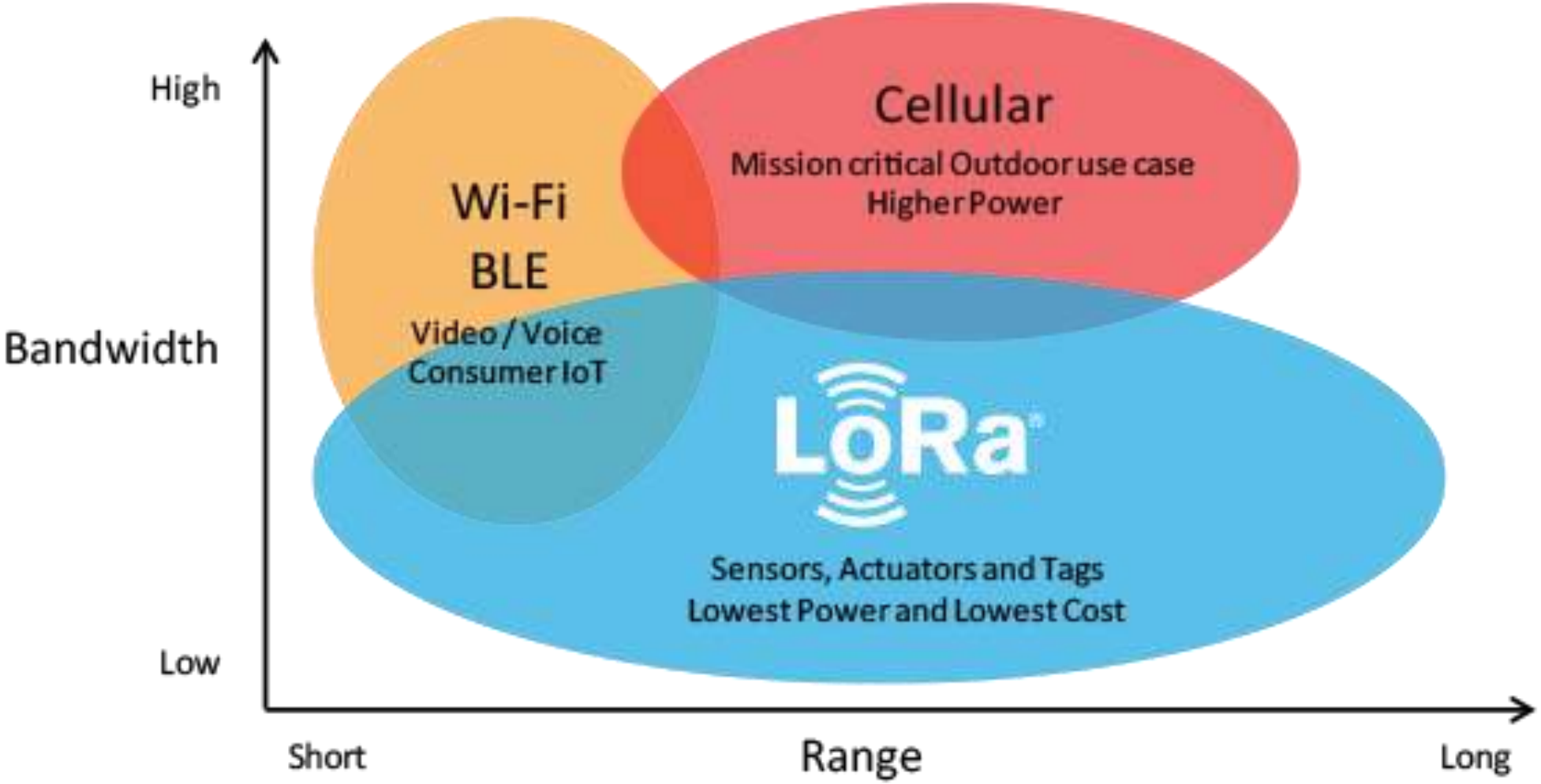
From data to analysis: From measurement system to analysis



From sensor to data: Wireless protocols



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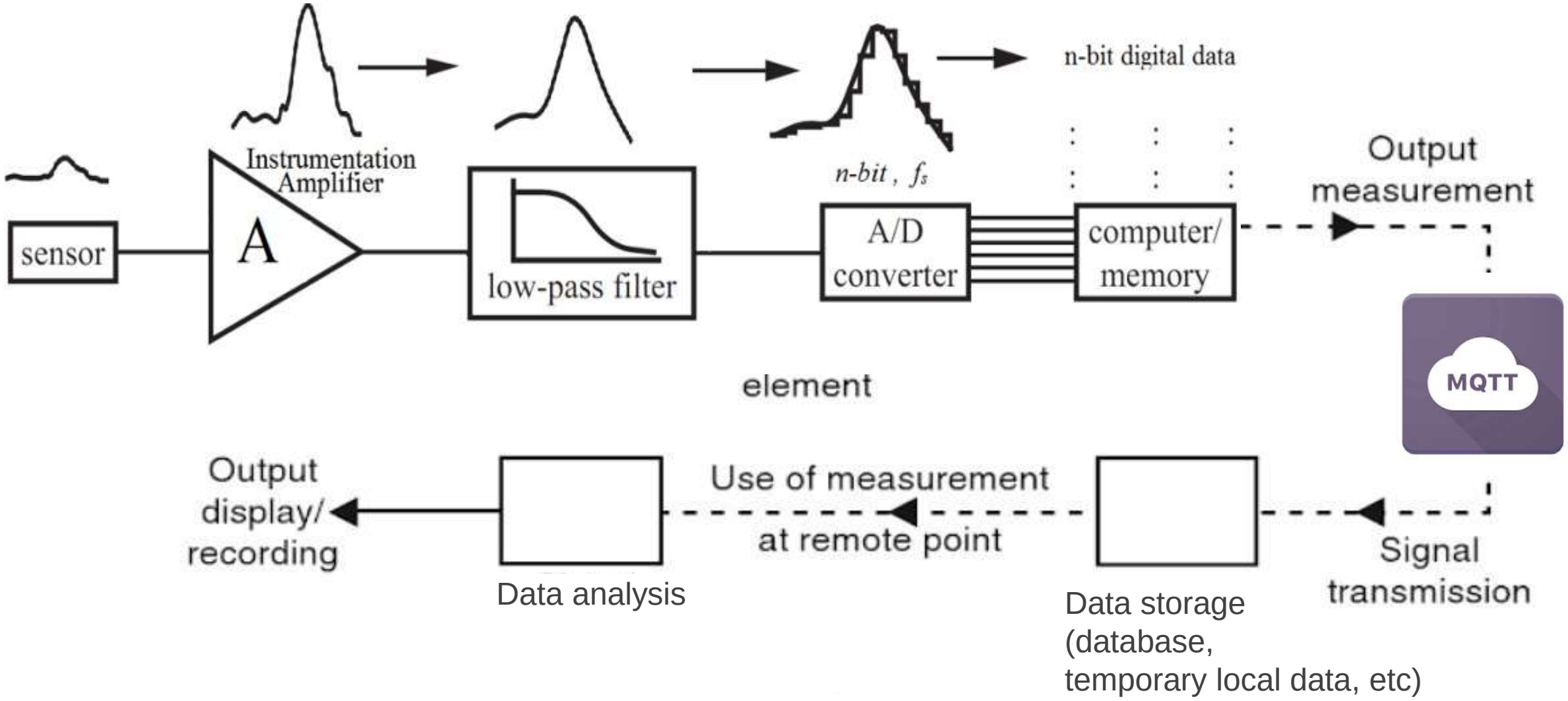
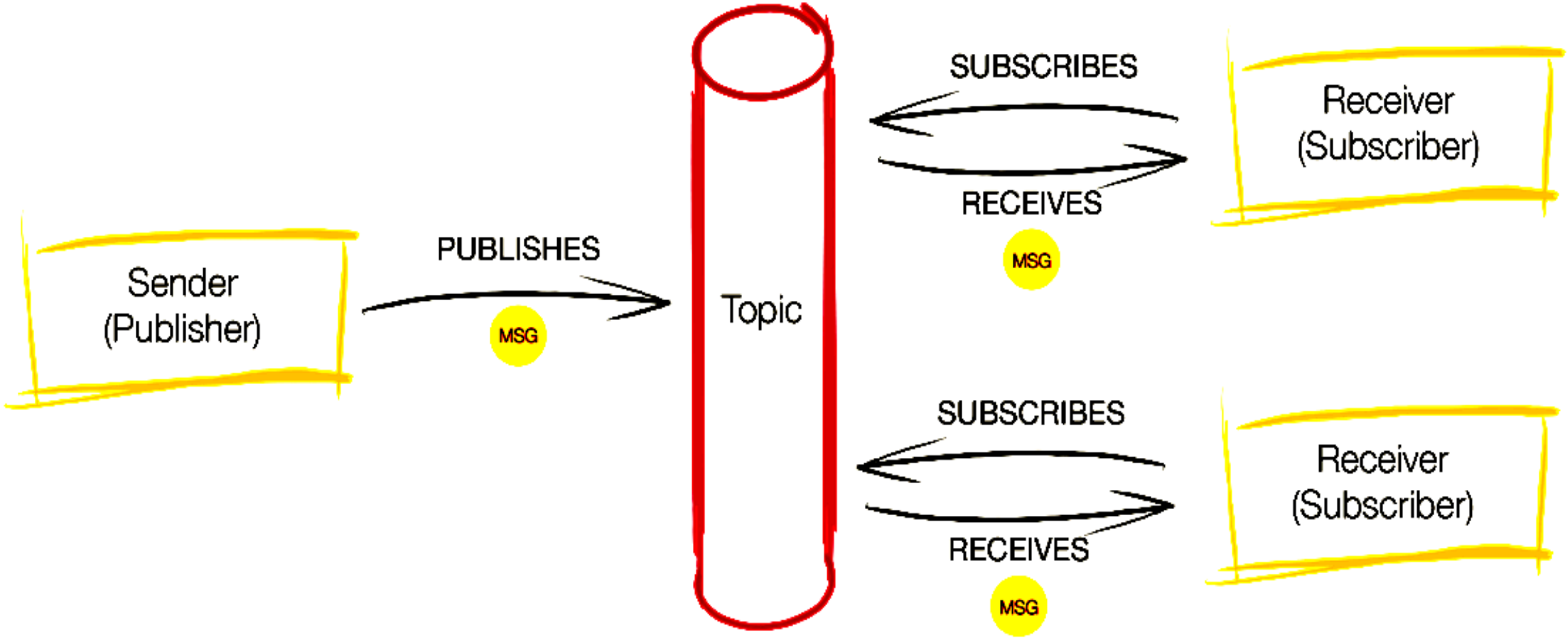
From data to analysis: Network protocol



https://mqtt.org/

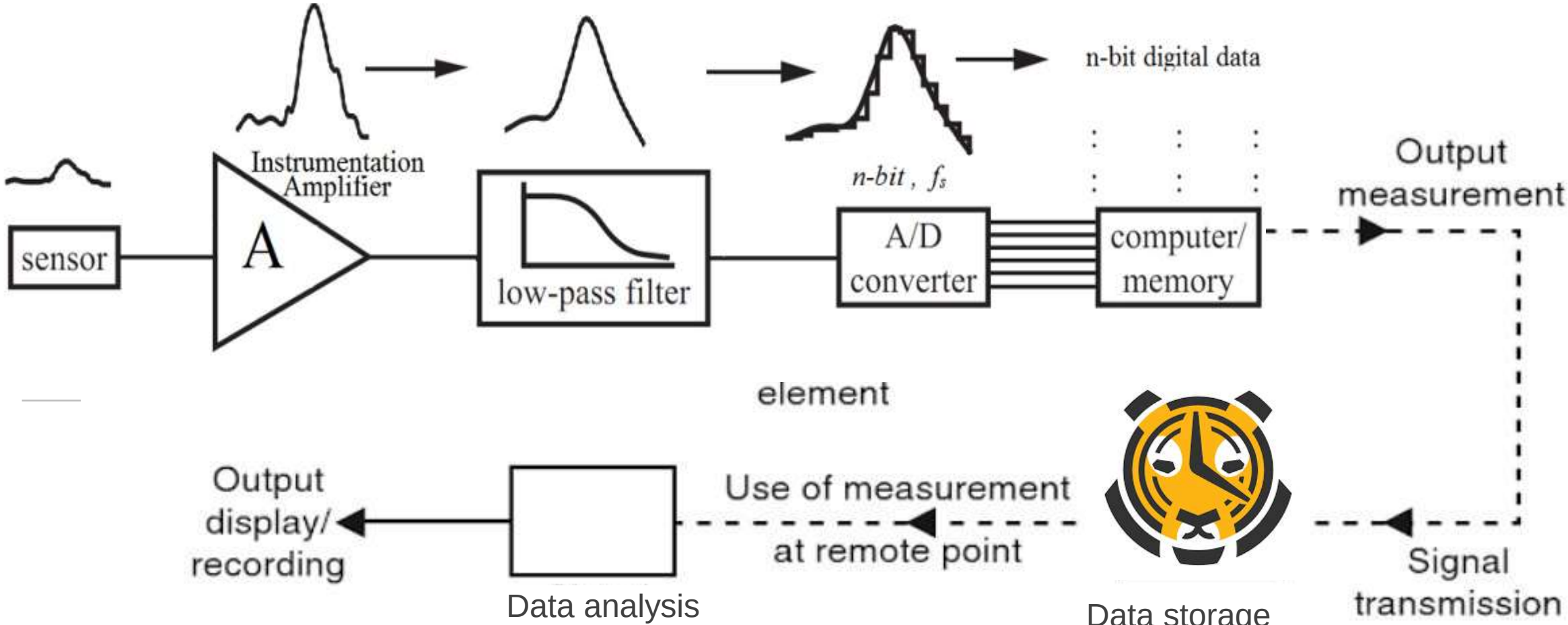
From data to analysis: MQTT Publish/Subscribe



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

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

From data to analysis: Network protocol



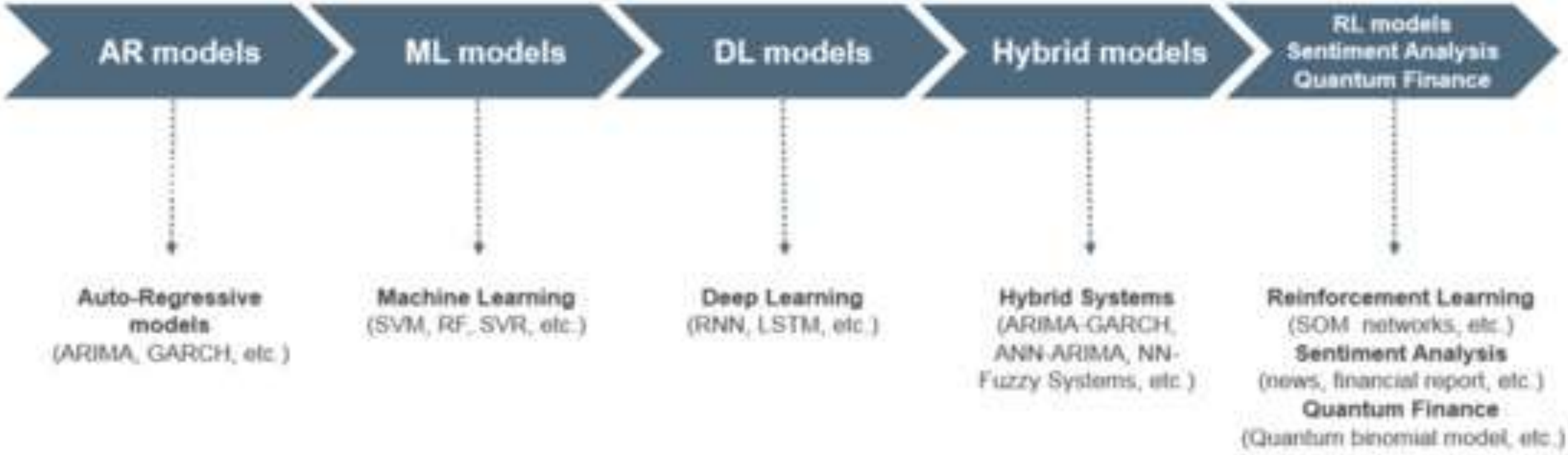
From data to analysis: Timeseries databases

influxdb

TIMESCALE

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

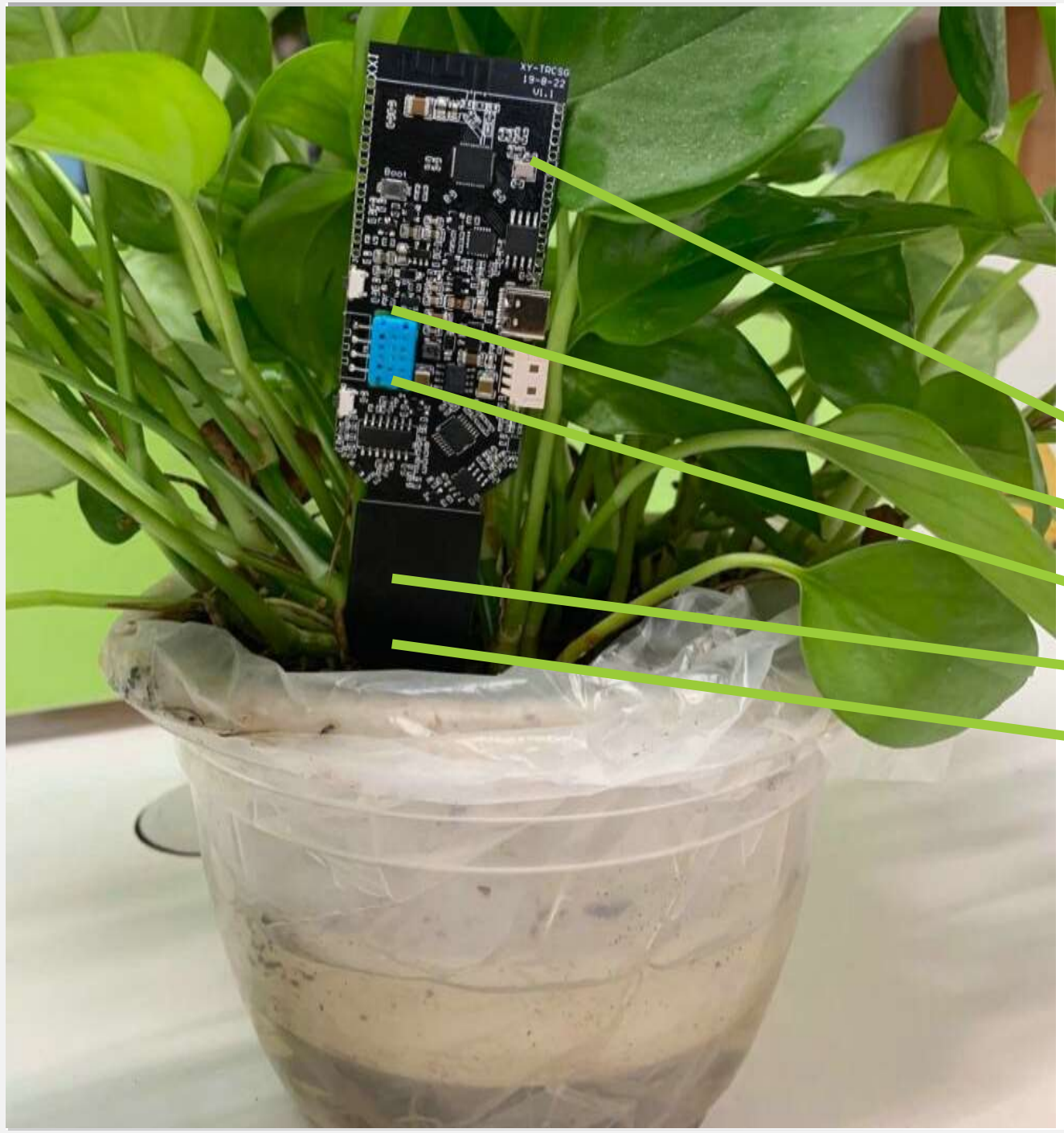
From data to analysis: Timeseries analysis



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

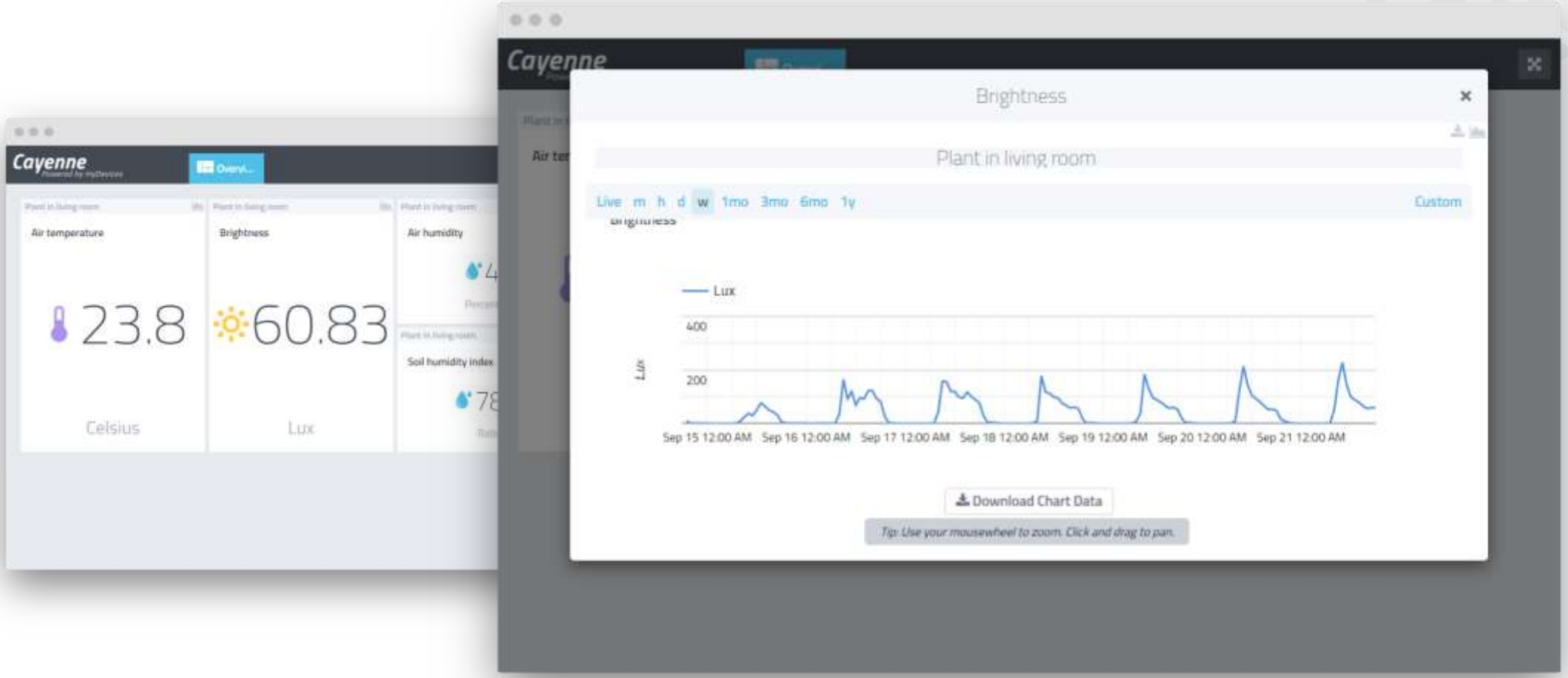
Sensors:

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

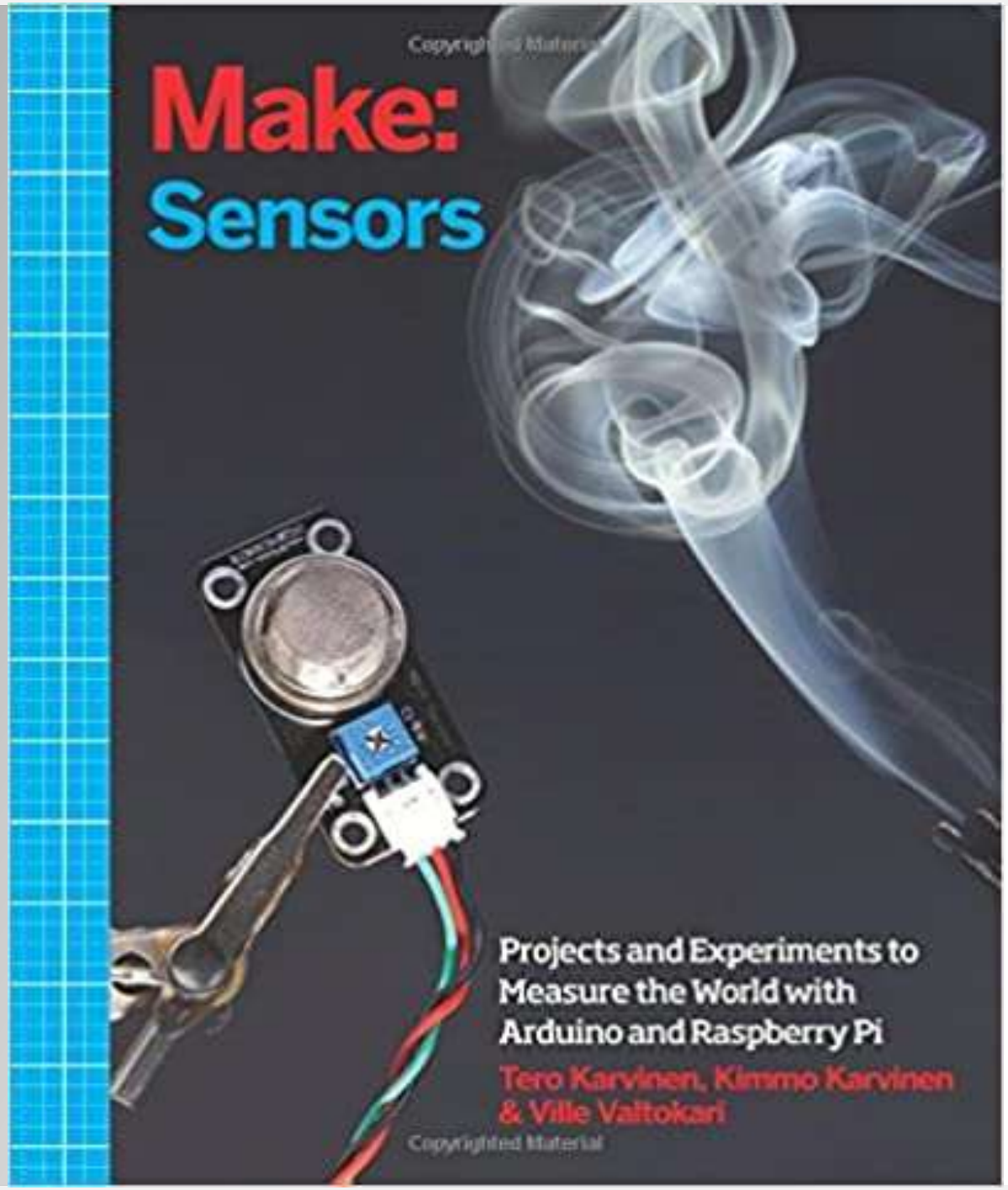
Microprocessor:

- ESP32

From data to analysis: Cayenne Dashboard



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

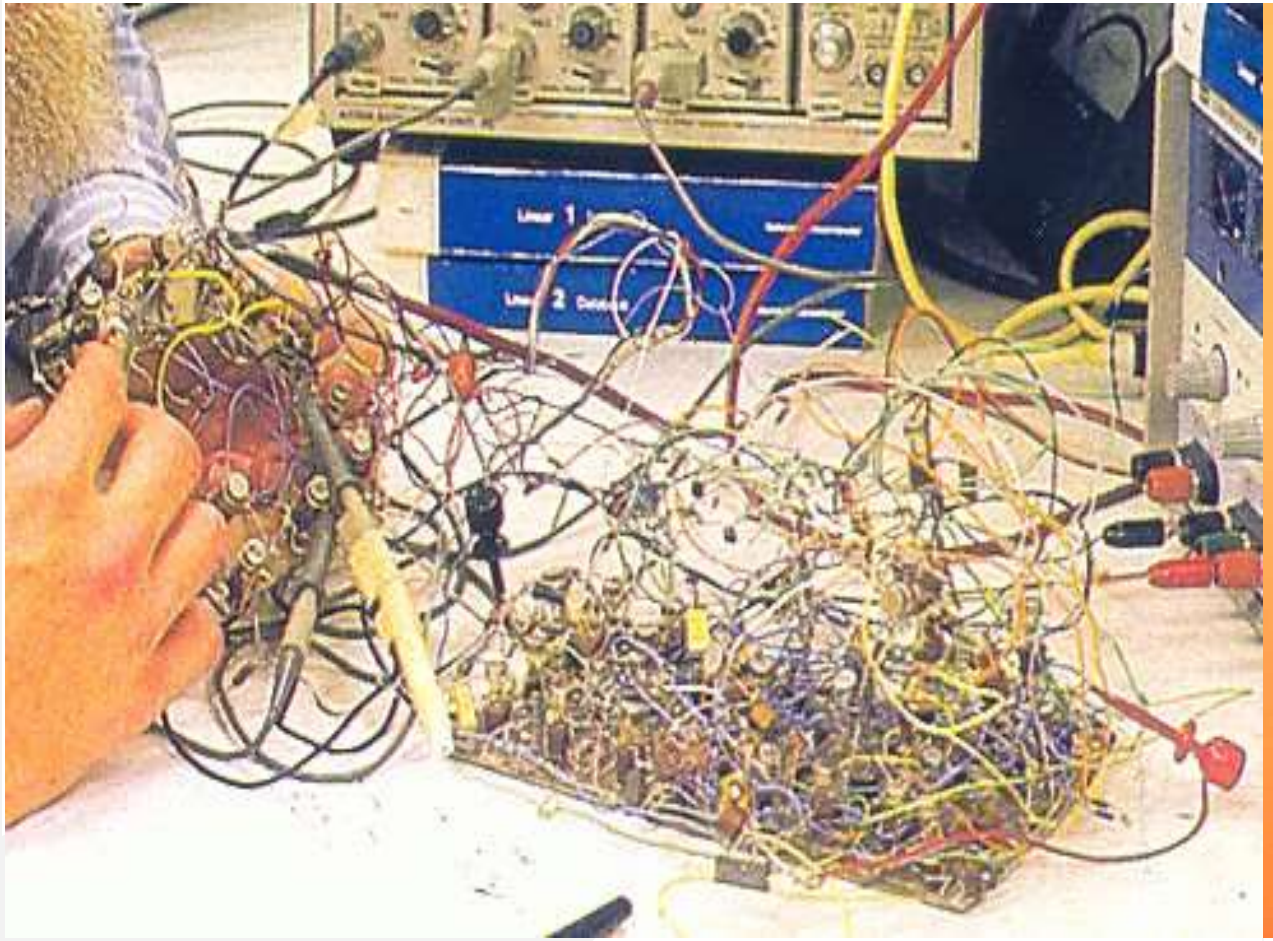


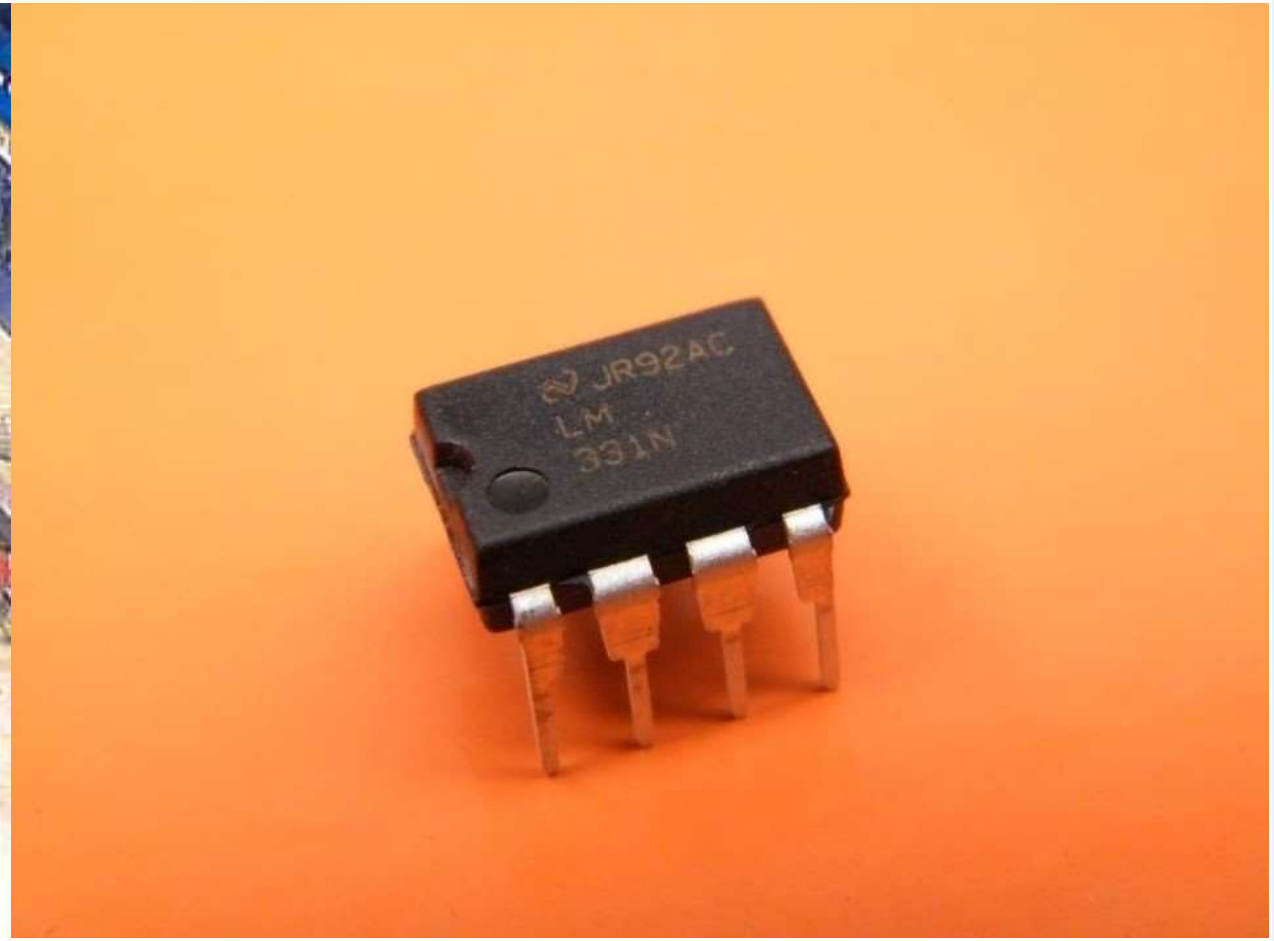
Or build your own…

Start with:

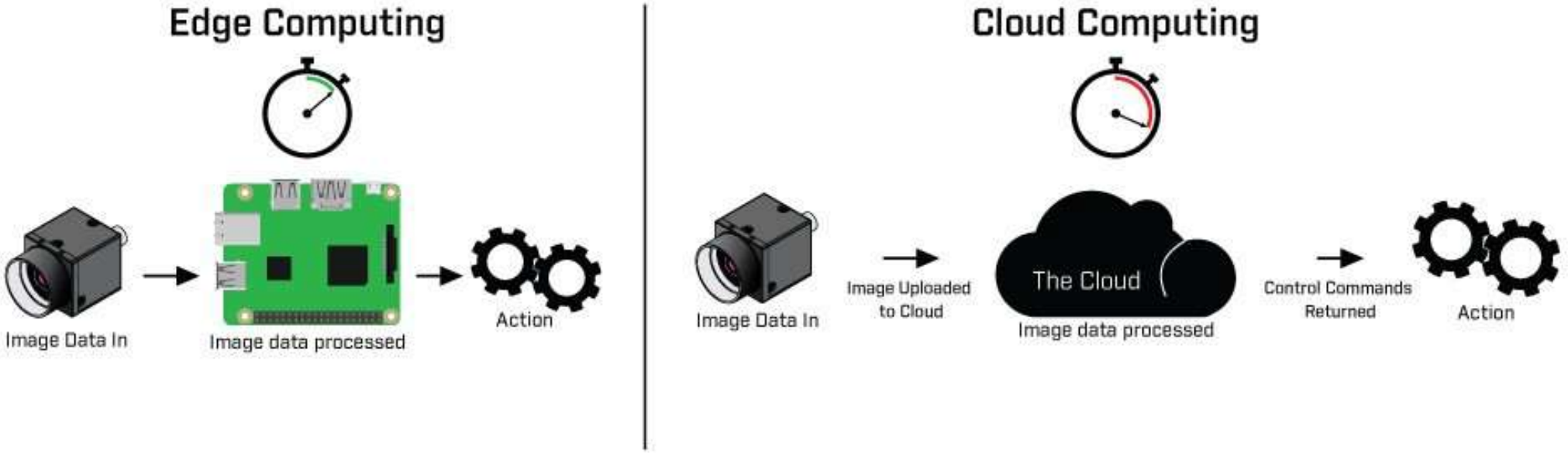
Make: Sensors: A Hands-On Primer for Monitoring the Real World with Arduino and Raspberry Pi
by Karvinen & Valtokari

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

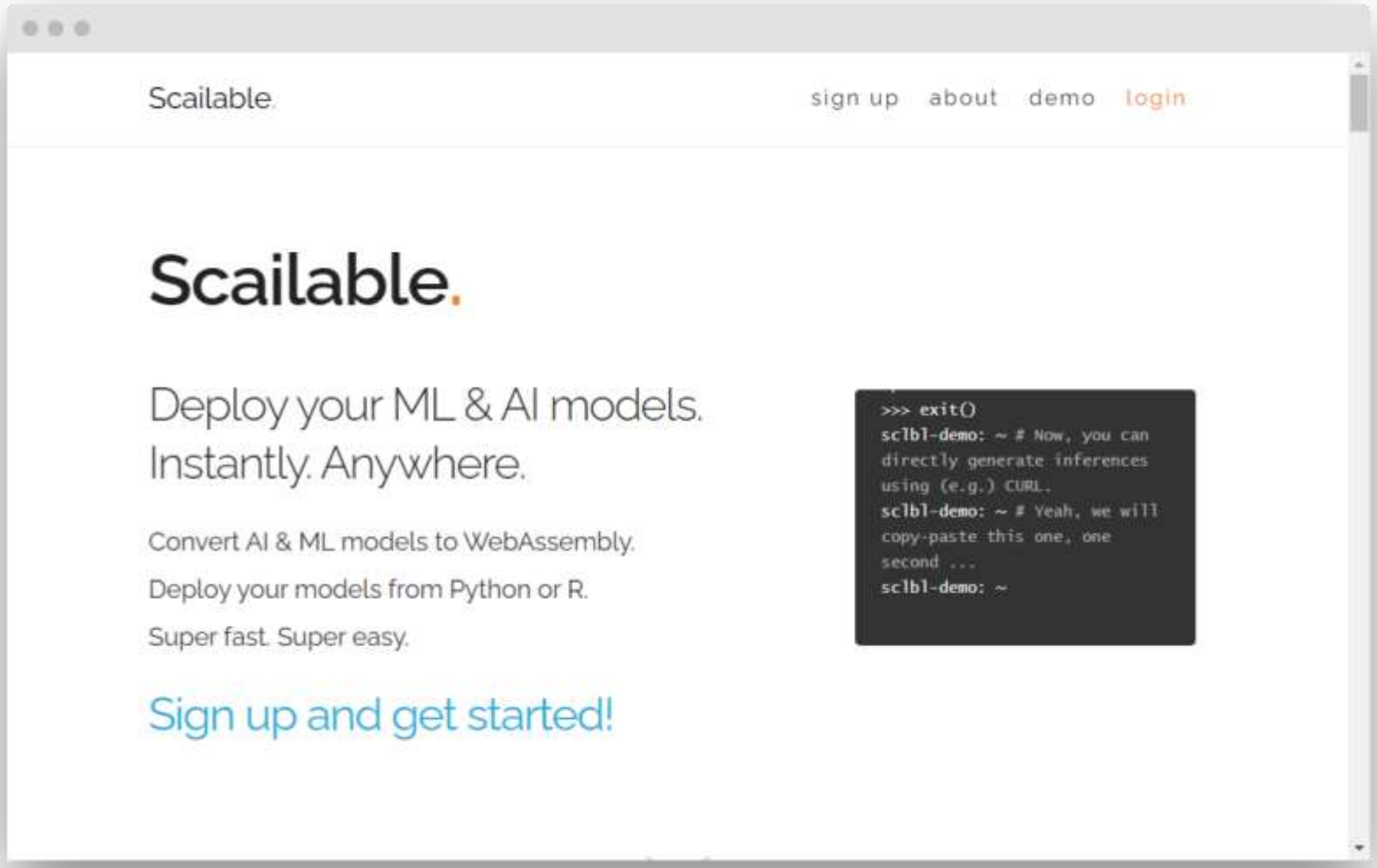




From data to analysis: Edge Computing



From data to analysis: Edge Computing with Scailable



Thank You

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