S6-ESE-AI

MACHINE LEARNING BASICS

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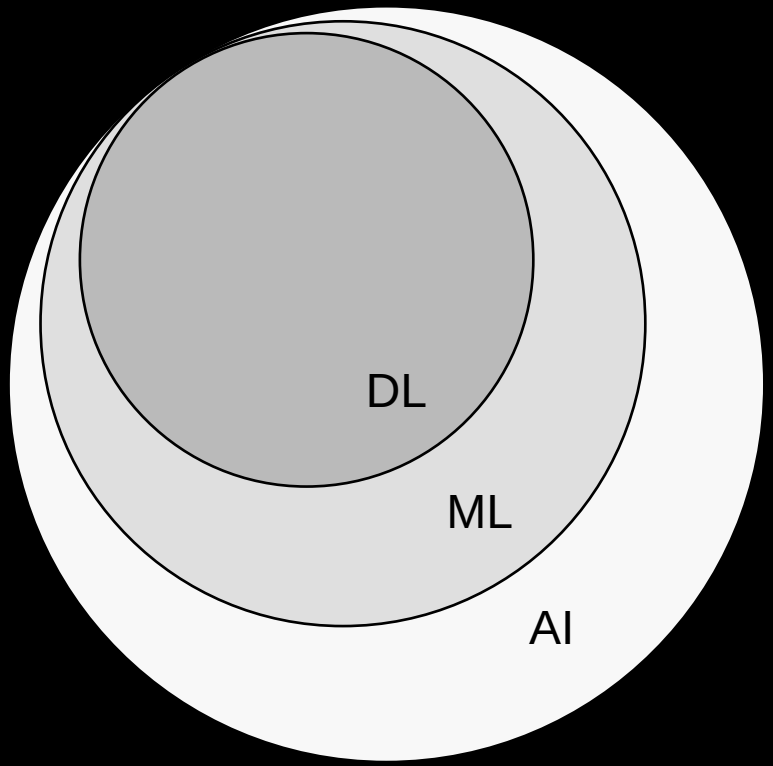
AGENDA

- Introduction
- Machine learning approaches
- Workflow
- Workshop organization
- Assignment
- Report template
- k Nearest Neighbor (kNN)
- Setting up your environment

DEFINING AI, DL & ML



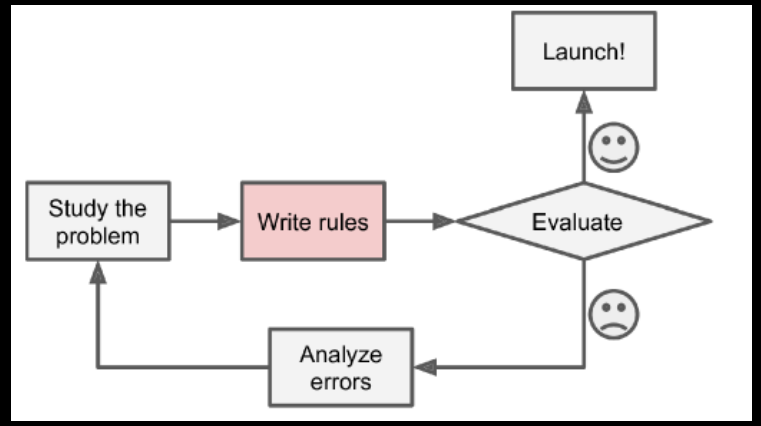
- Strong AI vs Applied AI
- Cognitive replication
- Rational process

Machine learning

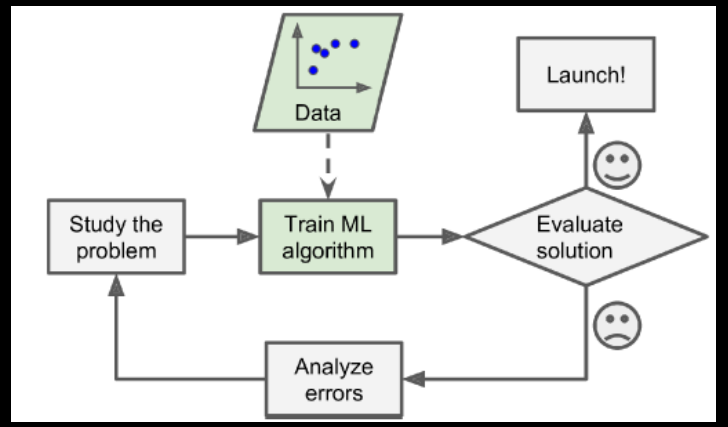
- Performs predictive analysis
- Just fancy math & pattern matching

WHY MACHINE LEARNING?

- Automated analytical model building
- Deal with fluctuating environments by adapting to new data.
- Getting insights about complex problems and large amounts of data.



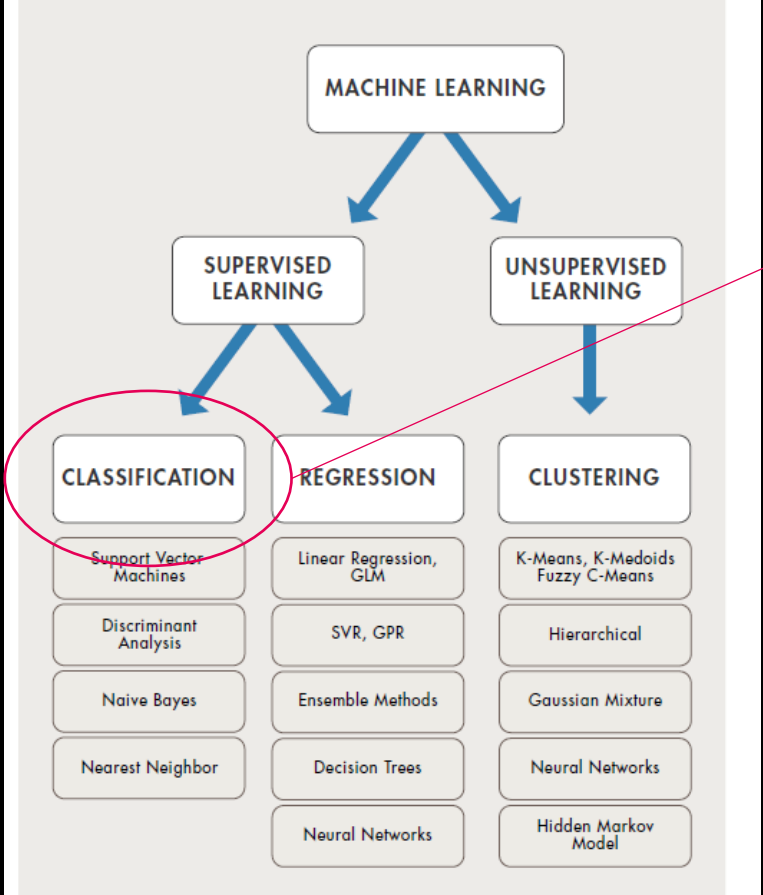
Traditional approach

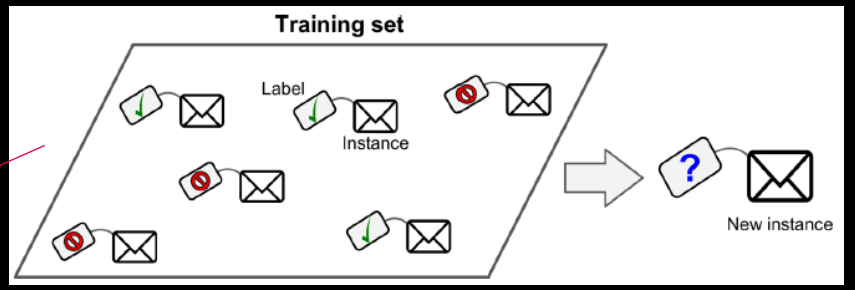


ML approach

Source: Géron, ISBN: 9781492032632

MACHINE LEARNING APPROACHES





classification

APPLES AND ORANGES

- https://www.youtube.com/watch?v=cKxRvEZd3Mw&feature=youtu.be

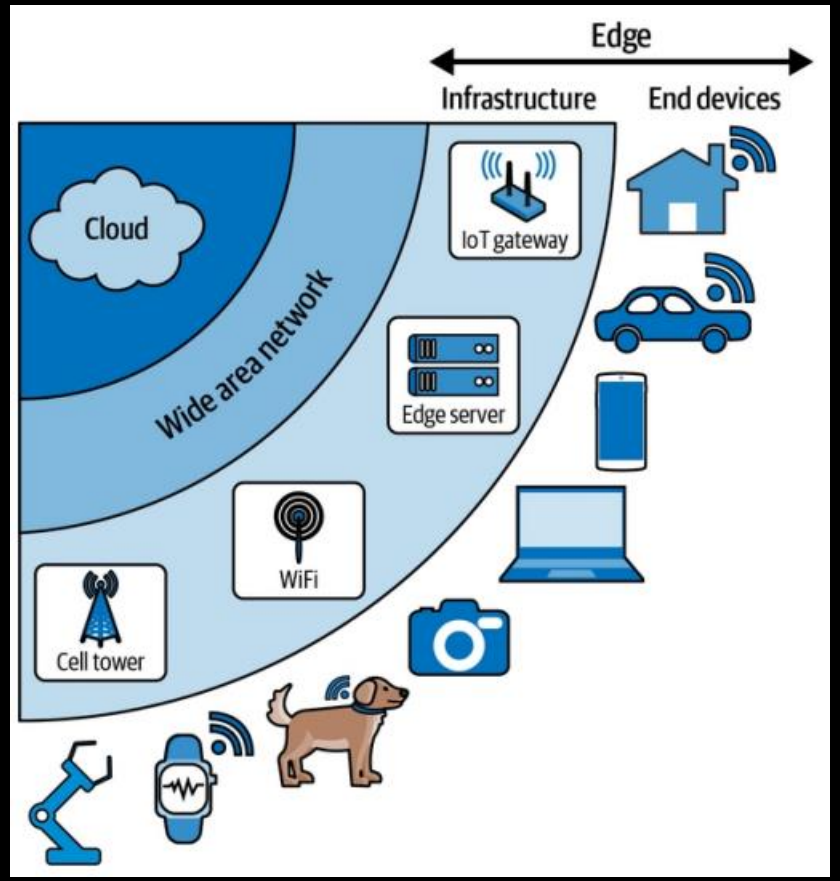
examples

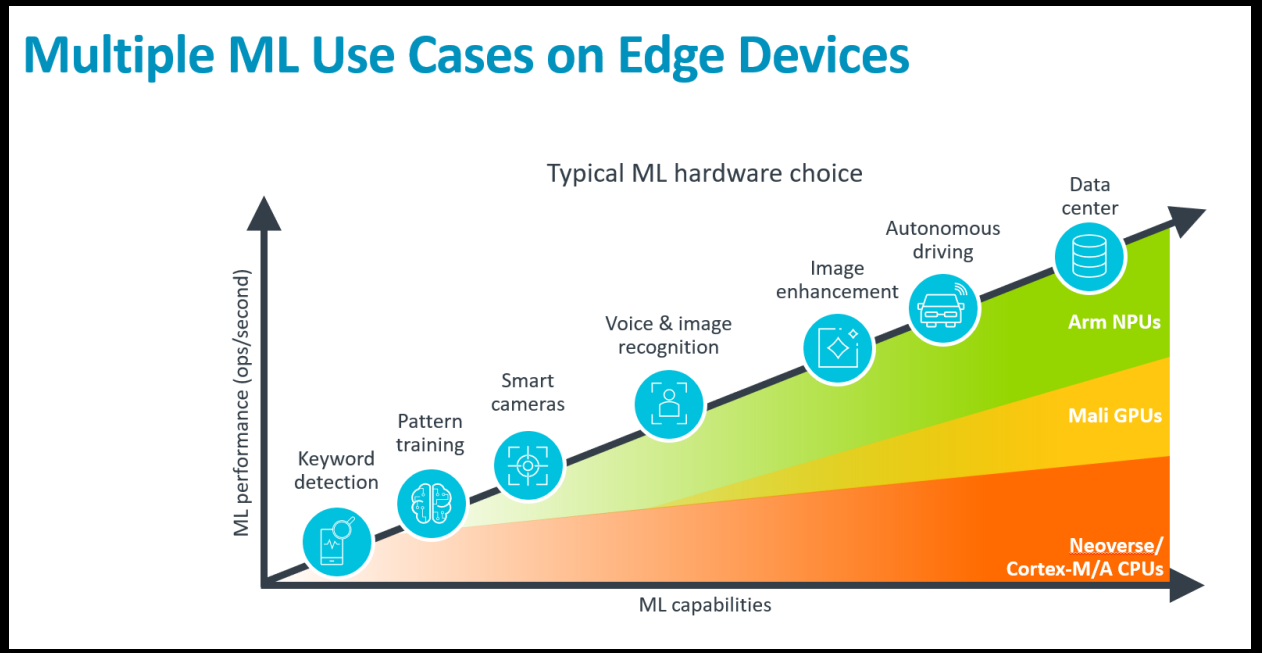
Weight	Texture	Label
150 g	Bumpy	Orange
170g	Bumpy	Orange
140g	Smooth	Apple
130g	Smooth	Apple
…	…	…

features

labels

ML AT THE EDGE





Source: Arm NN: the Easy Way to Deploy Edge ML, Steve Roddy, January 2019

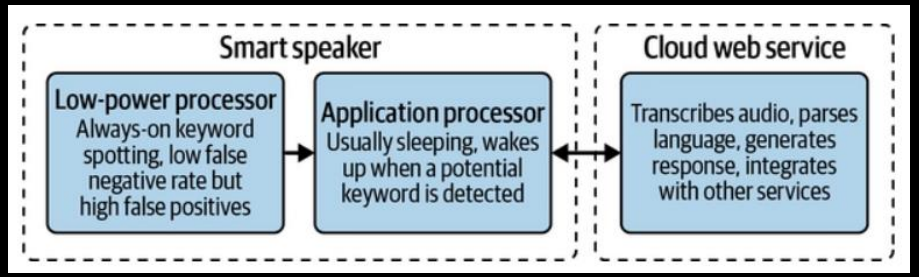
Bandwidth Latency Economics Reliability Privacy

Source: AI at the Edge, Daniel Situnayake, Jenny Plunkett, January 2023, O'Reilly Media, Inc. ISBN: 9781098120207

ML AT THE EDGE

- Focus on sensor data
- Small models
- Just inference, no training
- Evolving field

Source: IRNAS



Source: AI at the Edge, Daniel Situnayake, Jenny Plunkett, January 2023, O'Reilly Media, Inc. ISBN: 9781098120207

APPLICATIONS

- Sensory and STM’s VoiceActivated AI Technologies

2023 EDGE AI TECHNOLOGY REPORT, Wevolver

AI-POWERED ENDOSCOPY

- Medtronic’s GIGenius, NVIDIA Holoscan

2023 EDGE AI TECHNOLOGY REPORT, Wevolver

ADVANCED PERFORMANCE FOR HEARING AIDS

- Starkey Livio Edge AI

2023 EDGE AI TECHNOLOGY REPORT, Wevolver

ORGANIZATION OF THE WORKSHOP

- ..\schedule\schedule.xls

ASSIGNMENT

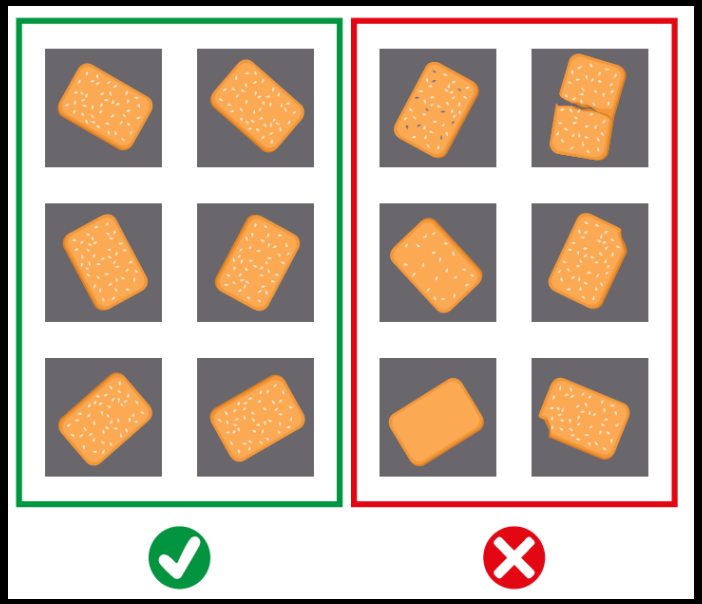
- A project team will consist of 3 students.
- Report building using template
- Individually deliver report via HandIn
- Templates and schedule on Gitlab

REPORT TEMPLATE AND ASSESSMENT

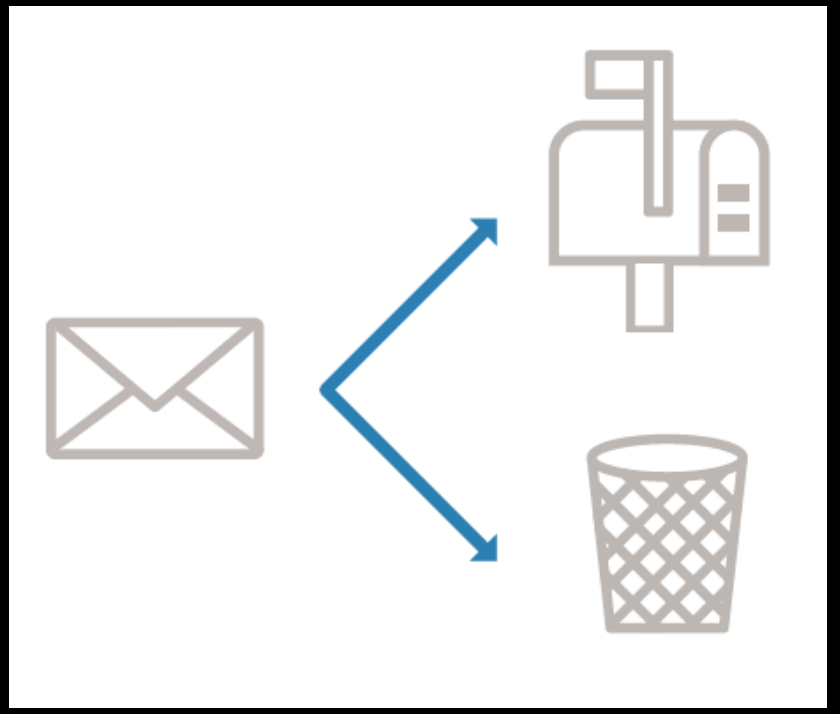
- ..\template\{YEAR}_{YOUR GROUP_NUMBER}_AI_report_{YOUR_NAME}_{YOUR_STUDENT_NUMBER}.docx

BINARY CLASSIFICATION

- Sample falls in either of 2 classes



Source: Basler, Artificial Intelligence in Image Processing

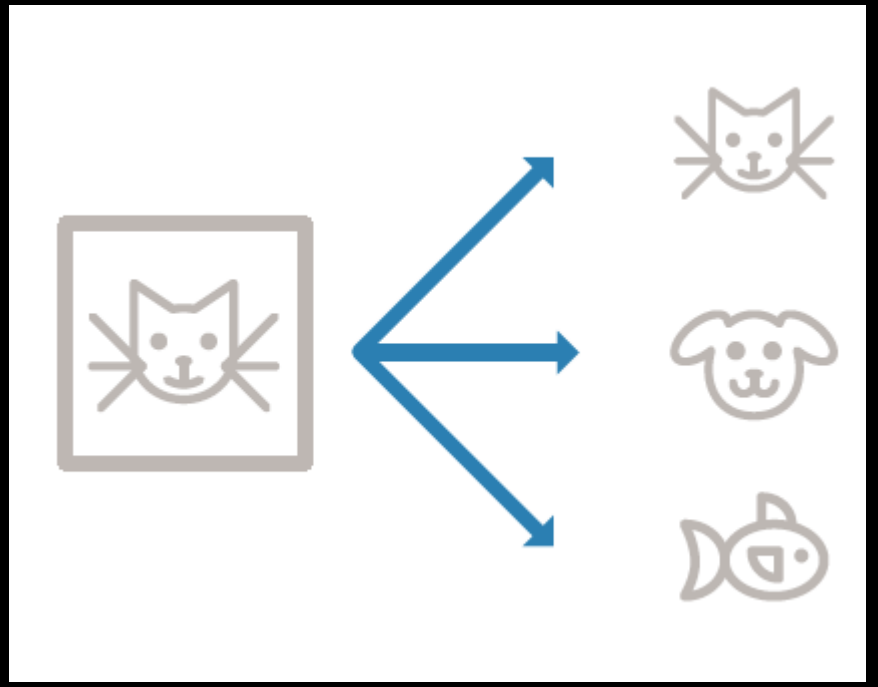


Source: Mathworks, Applying Supervised Learning

MULTI-CLASS CLASSIFICATION

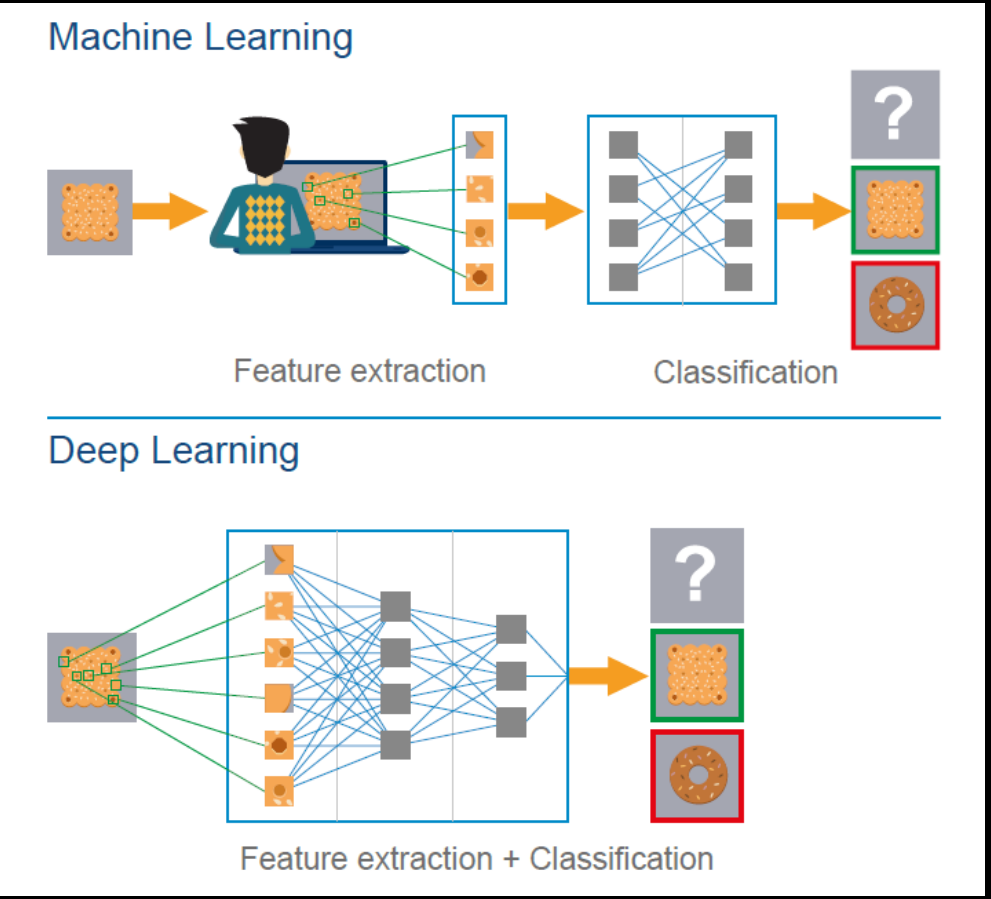
- Sample falls in either of 3 or more classes

Source: MNIST dataset



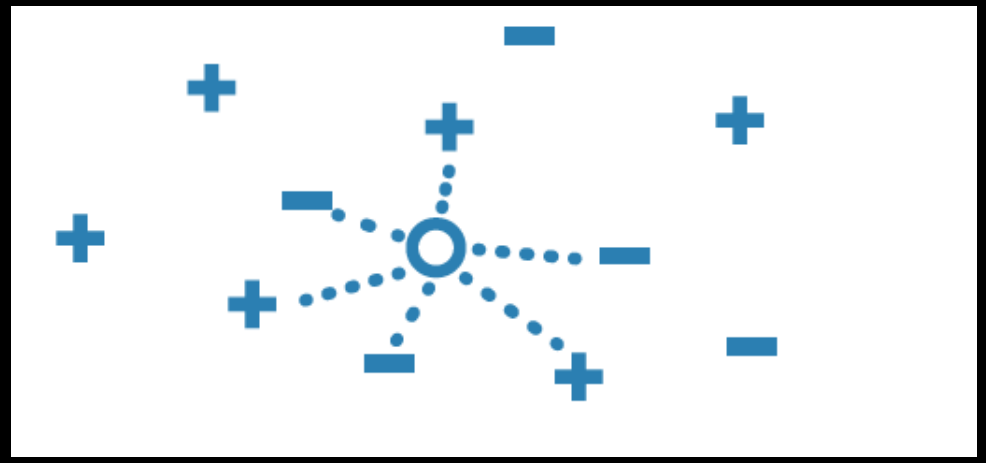
Source: Mathworks, Applying Supervised Learning

MACHINE LEARNING VS DEEP LEARNING



K NEAREST NEIGHBOR (KNN)

- The simplest classifier
- Assume feature vectors near each other are similar
- Categorizes objects based on the classes of their nearest neighbors
- No training required
- Intuitive
- Benchmark



Source: Mathworks, Applying Supervised Learning

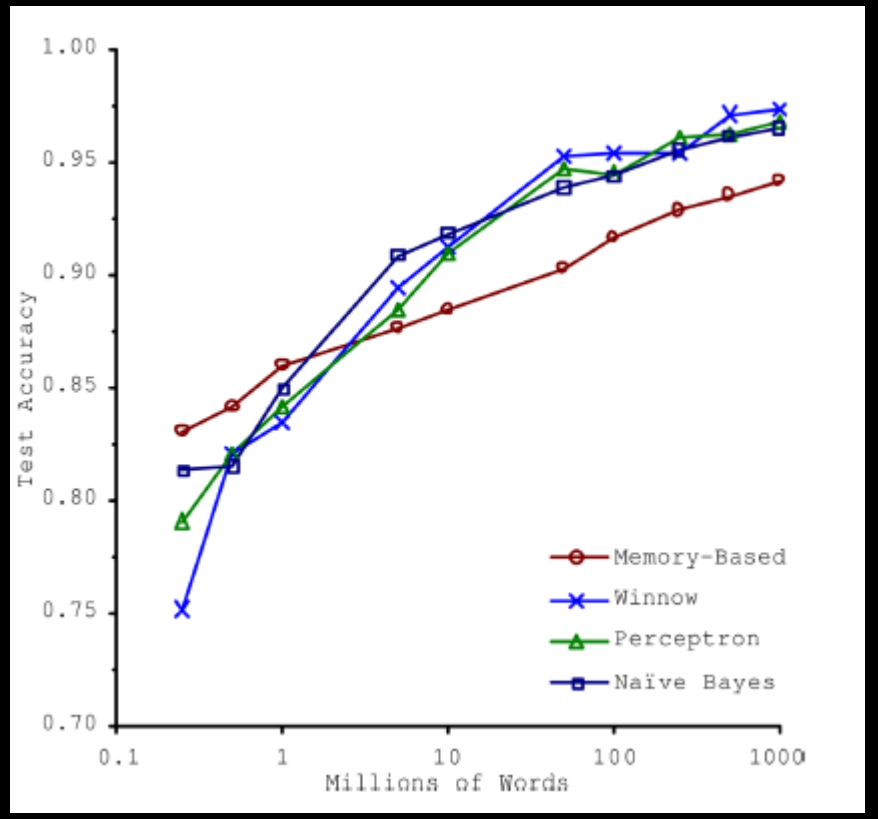
"Tell me who your neighbors are, and I'll tell you who you are"

- https://www.youtube.com/watch?v=AoeEHqVSNOw&t=194s

DATA

- Data matters more than algorithms!

- Massive amounts of training data is needed
- Labelling is tedious and error prone



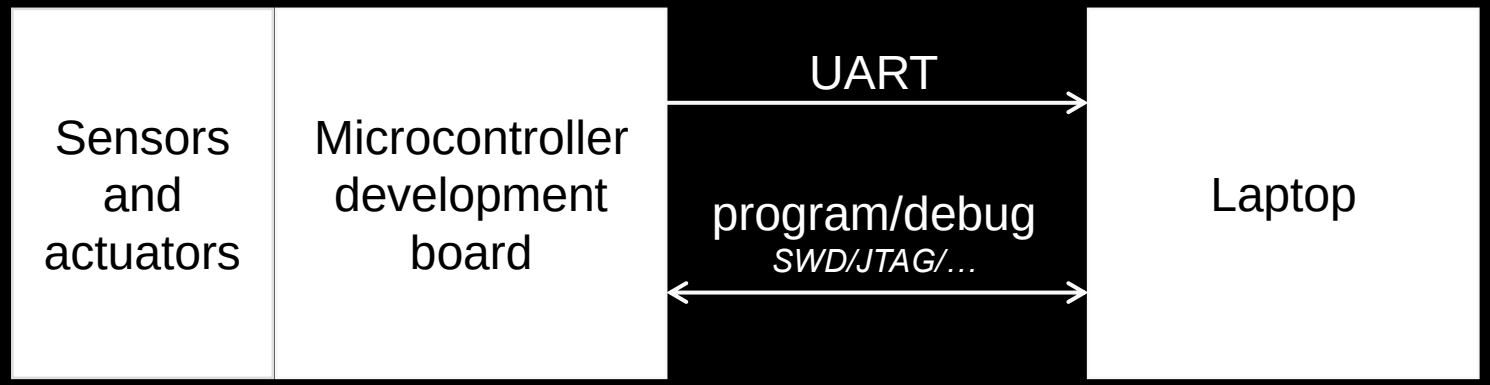
Source: Peter Norvig et al 2009

WRAP-UP

- Why AI, ML at the edge, ML Workflow
- Workshop organization, Assignment, Report template
- Classification, k Nearest Neighbor (kNN)

- Next week: data collection and analysis

SETTING UP YOUR ENVIRONMENT



GitLab

python

Visual Studio Code

KEIL™ Tools by ARM

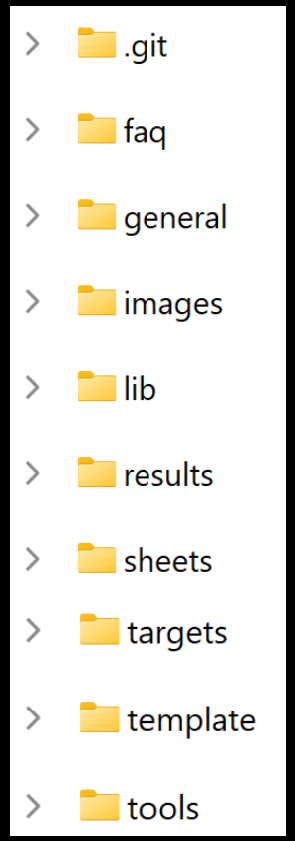
STM32 CubeIDE

ARDUINO

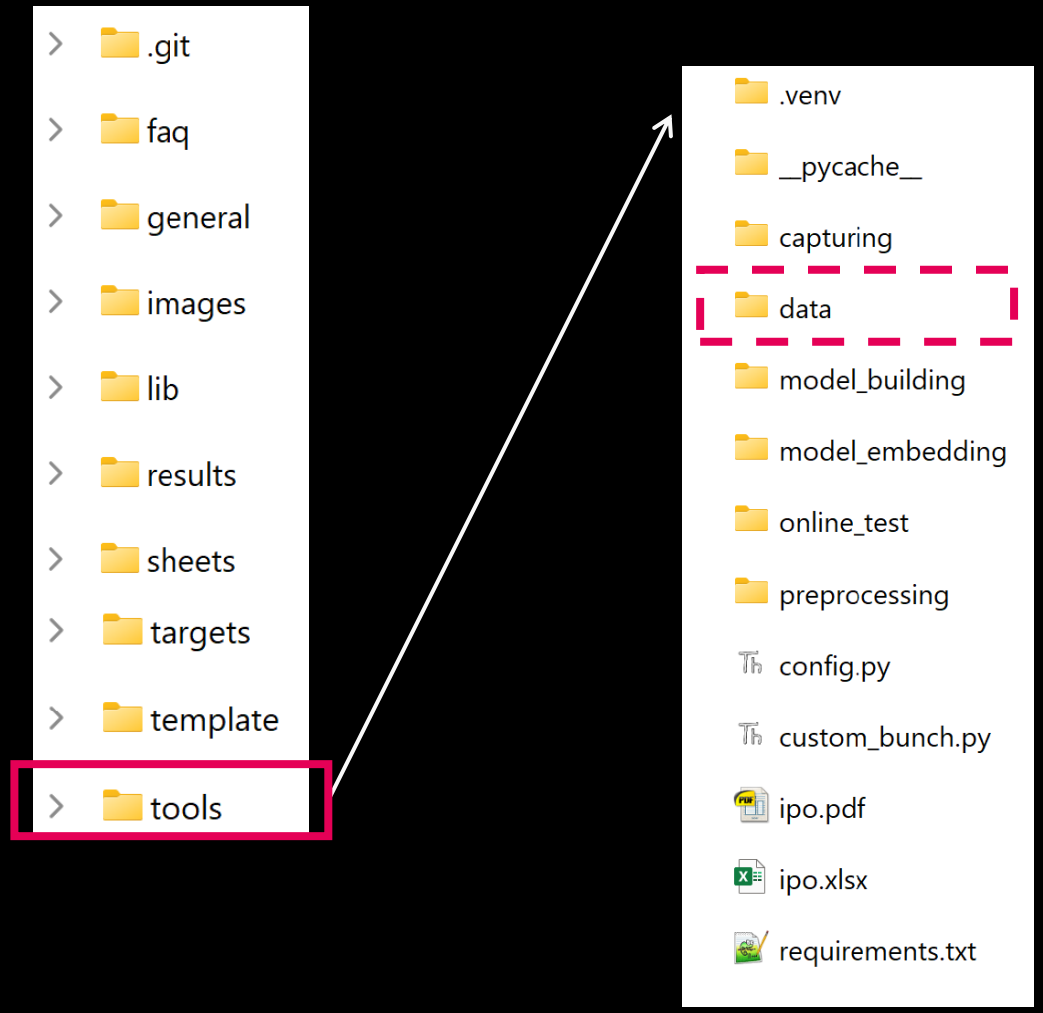
MCUXpresso IDE

…

SETTING UP YOUR ENVIRONMENT



SETTING UP YOUR ENVIRONMENT



SETTING UP YOUR ENVIRONMENT

SETTING UP YOUR ENVIRONMENT

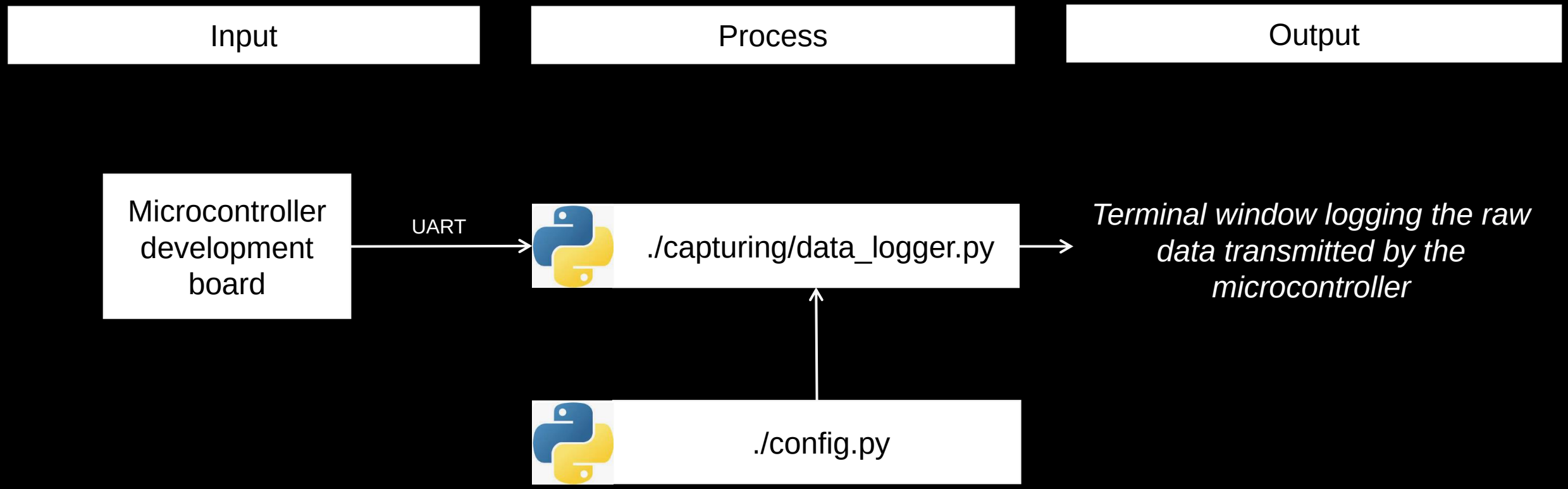
Process	Output
./config.py	data captured model model_embedding preprocessed features filters normalizations

SETTING UP YOUR ENVIRONMENT

./tools/ipo.pdf

A comprehensive overview of all Python scripts

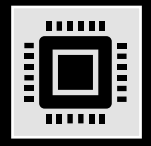
CAPTURE APPLICATION DESIGN



TODO

*Set global project settings, such as **COMPORT** and **BAUDRATE**.*

EMBED



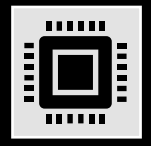
main.c – RAW example

```
// Handle the data as soon as new data is available
// mma8451 accelerometer Output Data Rate (ODR) is set to 100 Hz
if(mma8451_ready_flag)
{
    // Set initial timestamp
    ms1 = ms;

    // Clear the flag
    mma8451_ready_flag = false;

    // Reads the data in three global variables: x_out_mg, y_out_mg and
    // z_out_mg
    mma8451_read();
```

EMBED

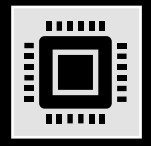


main.c – RAW example at every sample time

```
    // Set final timestamp
    ms2 = ms;

    // Send the data
    // Send the raw data
    printf("%d,%d,%.3f,%.3f,%.3f\n",
        ms1,
        ms2,
        (double)(x_out_mg),
        (double)(y_out_mg),
        (double)(z_out_mg));
```

EMBED



main.c – RAW example at every sample time

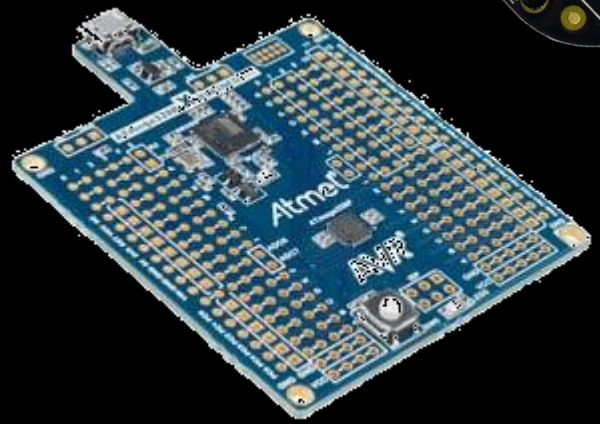
```
    // TODO Implement filter function as required by the application.

    // TODO Implement normalization function as required by the
    //      application.

    // TODO Finish this example by designing an ML model and implement the
    //      generated C code.
}
```

SETTING UP YOUR ENVIRONMENT

- .git
- faq
- general
- images
- lib
- results
- sheets
- targets
- template
- tools



RUN

Terminal

```
Opened COM13 @ 115200bps
10912,10912,-1.221,1.465,998.047
10922,10922,-0.732,0.488,997.314
10931,10932,0.244,0.000,998.779
10941,10941,-0.977,1.221,998.535
10951,10951,0.000,1.709,1000.000
10961,10961,-0.244,0.488,997.803
10970,10971,-0.977,0.977,998.291
10980,10980,0.000,1.465,998.779
10990,10990,-0.488,1.709,997.070
11000,11000,-0.977,-0.244,997.314
11009,11010,-0.244,1.465,998.291
11019,11020,-0.488,-0.244,999.268
```

RUN

Terminal

```
Opened COM13 @ 115200bps
10912,10912,-1.221,1.465,998.047
10922,10922,-0.732,0.488,997.314
10931,10932,0.244,0.000,998.779
10941,10941,-0.977,1.221,998.535
10951,10951,0.000,1.709,1000.000
10961,10961,-0.244,0.488,997.803
10970,10971,-0.977,0.977,998.291
10980,10980,0.000,1.465,998.779
10990,10990,-0.488,1.709,997.070
11000,11000,-0.977,-0.244,997.314
11009,11010,-0.244,1.465,998.291
11019,11020,-0.488,-0.244,999.268
```

Communication settings (or error message if the comport could not be opened)

RUN

Terminal

```
Opened COM13 @ 115200bps
10912,10912,-1.221,1.465,998.047
10922,10922,-0.732,0.488,997.314
10931,10932,0.244,0.000,998.779
10941,10941,-0.977,1.221,998.535
10951,10951,0.000,1.709,1000.000
10961,10961,-0.244,0.488,997.803
10970,10971,-0.977,0.977,998.291
10980,10980,0.000,1.465,998.779
10990,10990,-0.488,1.709,997.070
11000,11000,-0.977,-0.244,997.314
11009,11010,-0.244,1.465,998.291
11019,11020,-0.488,-0.244,999.268
```

Transmitted by microcontroller at every sample time

RUN

Terminal

```
Opened COM13 @ 115200bps
10912,10912,-1.221,1.465,998.047
10922,10922,-0.732,0.488,997.314
10931,10932,0.244,0.000,998.779
10941,10941,-0.977,1.221,998.535
10951,10951,0.000,1.709,1000.000
10961,10961,-0.244,0.488,997.803
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10980,10980,0.000,1.465,998.779
10990,10990,-0.488,1.709,997.070
11000,11000,-0.977,-0.244,997.314
11009,11010,-0.244,1.465,998.291
11019,11020,-0.488,-0.244,999.268
```

ms1 and ms2 values
(comma separated)

RUN

Terminal

```
Opened COM13 @ 115200bps
10912,10912,-1.221,1.465,998.047
10922,10922,-0.732,0.488,997.314
10931,10932,0.244,0.000,998.779
10941,10941,-0.977,1.221,998.535
10951,10951,0.000,1.709,1000.000
10961,10961,-0.244,0.488,997.803
10970,10971,-0.977,0.977,998.291
10980,10980,0.000,1.465,998.779
10990,10990,-0.488,1.709,997.070
11000,11000,-0.977,-0.244,997.314
11009,11010,-0.244,1.465,998.291
11019,11020,-0.488,-0.244,999.268
```

One or more sensor values (comma separated)