EMBEDDED VISION DESIGN 3

BASIC PRINCIPLES
HANDS-ON

JEROEN VEEN

HAN_UNIVERSITY
OF APPLIED SCIENCES

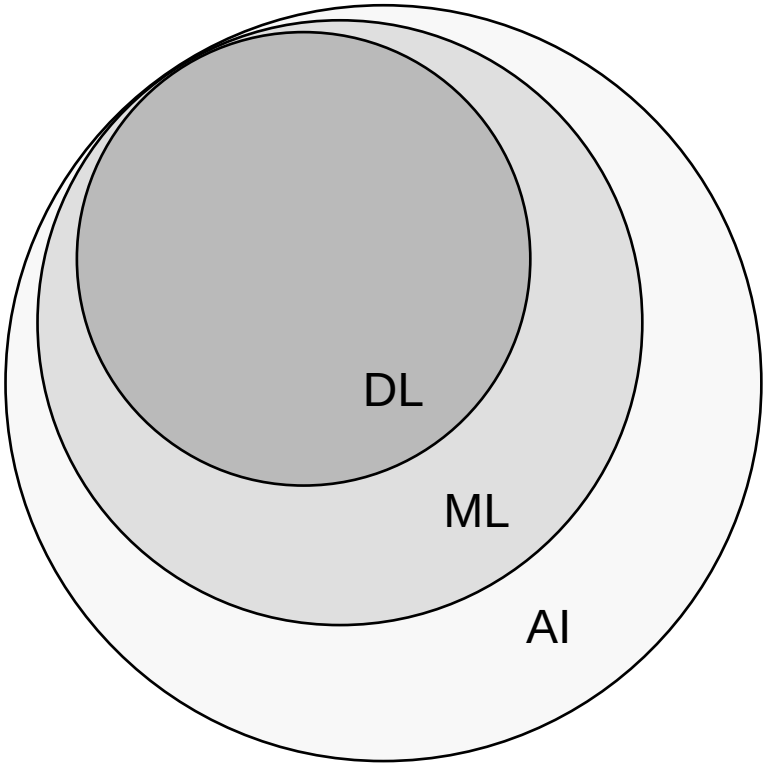
CONTENTS

- Introduction
- Workshop organization
- Assignment introduction
- ML portfolio template
- How to start? Conditioned acquisition and segmentation
- Set-up Raspberry Pi with OpenCV and sci-kit learn

WHAT IS MACHINE LEARNING?

- Human vs machine learning?
- Machines can perform predictive analytics on large amounts of data far faster than humans
- Machines maximize performance on a certain task
  Typically function approximations
- Learning does not imply intelligence
  if a machine can learn it is not necessarily aware

DEFINING AI, DL & ML

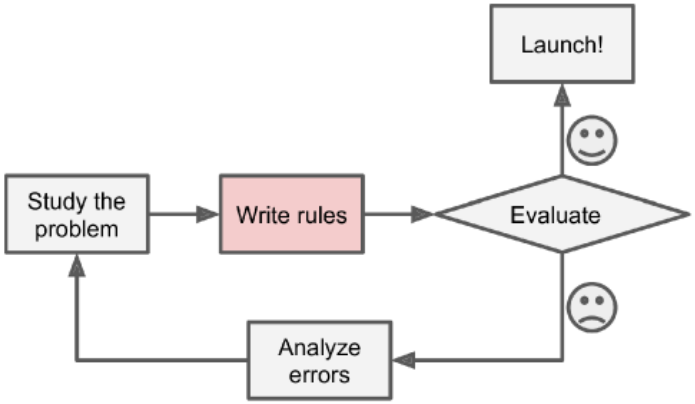


- Strong AI vs Applied AI
- Cognitive replication
- Rational process

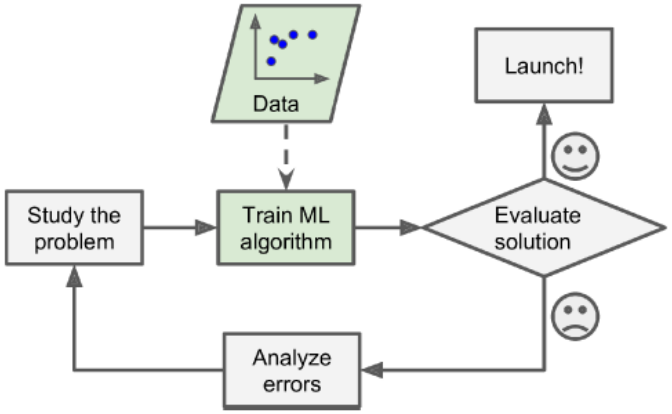
Machine learning

- Performs predictive analysis
- Just fancy math & pattern matching

WHY MACHINE LEARNING?



Traditional approach



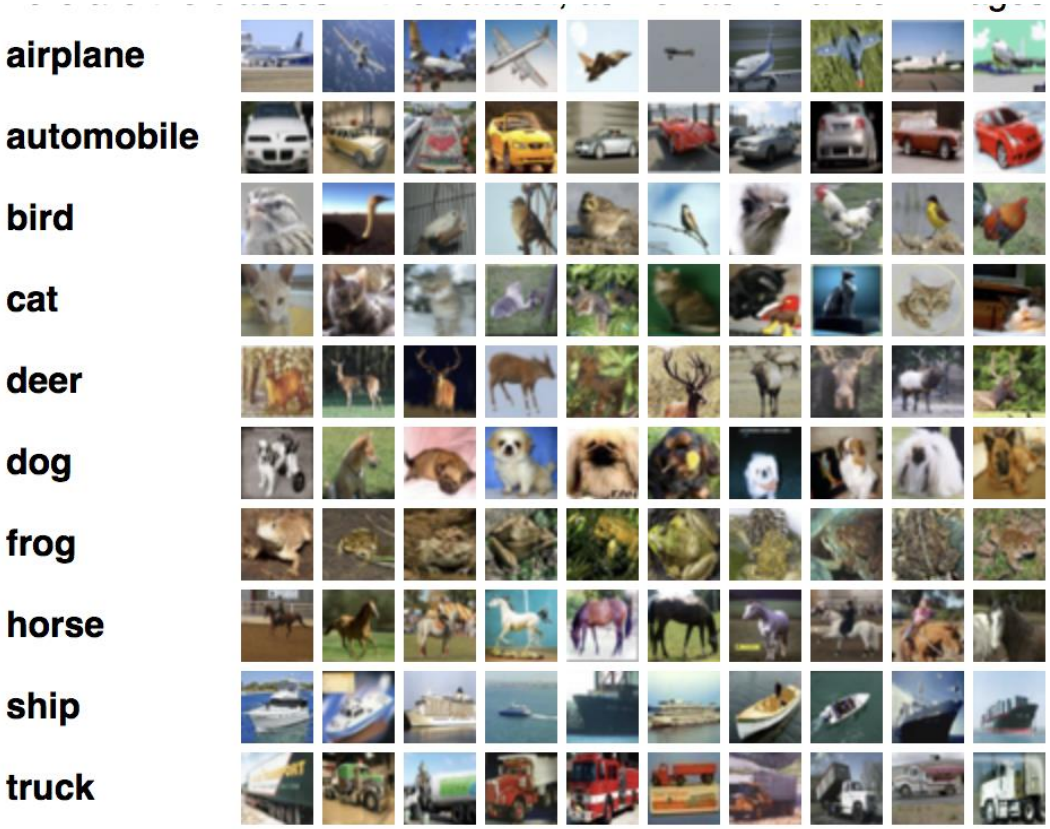
ML approach

Source: Géron, ISBN: 9781492032632

- Tackle problems for which existing solutions require a lot of fine-tuning or long lists of rules
- Deal with fluctuating environments by adapting to new data.
- Getting insights about complex problems and large amounts of data.

EXAMPLES OF MACHINE LEARNING

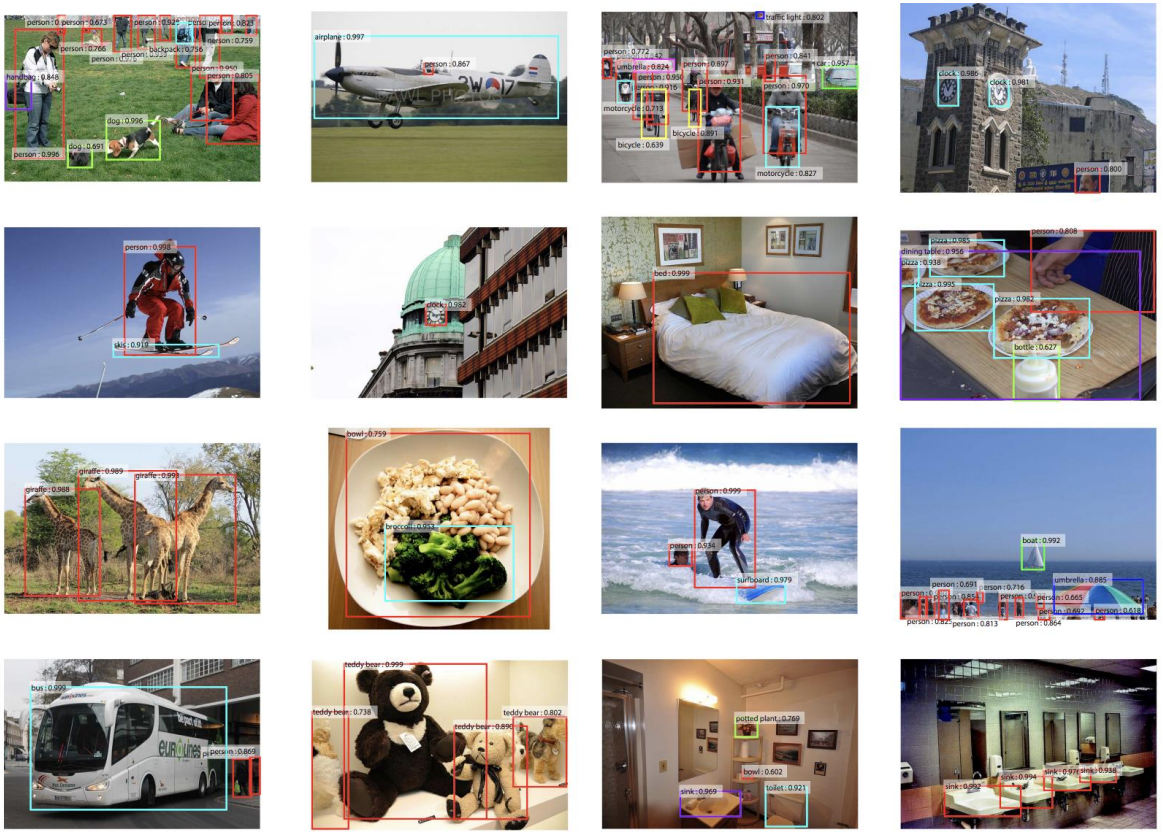
- Classification



Source: https://machinelearningmastery.com/applications-of-deep-learning-for-computer-vision/

EXAMPLES OF MACHINE LEARNING

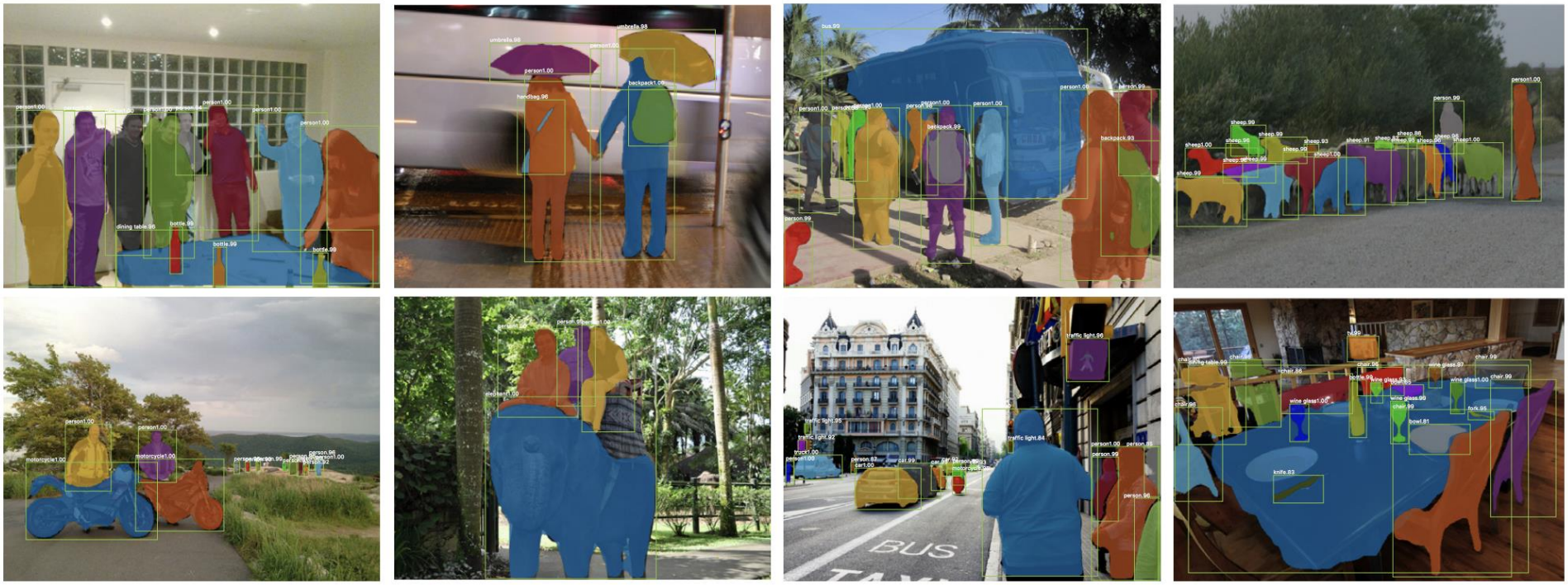
- Object detection



Source: https://machinelearningmastery.com/applications-of-deep-learning-for-computer-vision/

EXAMPLES OF MACHINE LEARNING

- segmentation

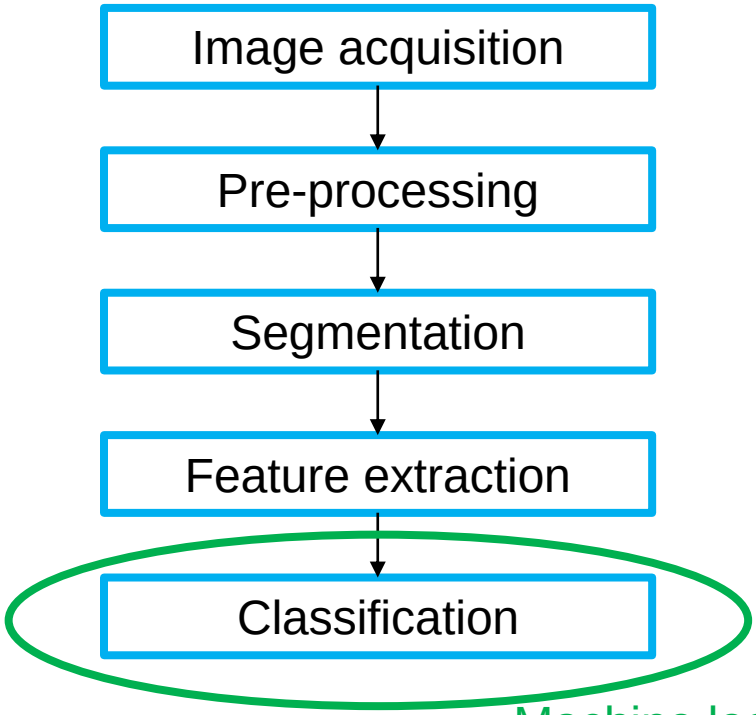


HAN_UNIVERSITY OF APPLIED SCIENCES

Source: https://machinelearningmastery.com/applications-of-deep-learning-for-computer-vision/

SHORT-CUT TO CLASSIFICATION

- Classical image processing



EVD3 ASSIGNMENTS

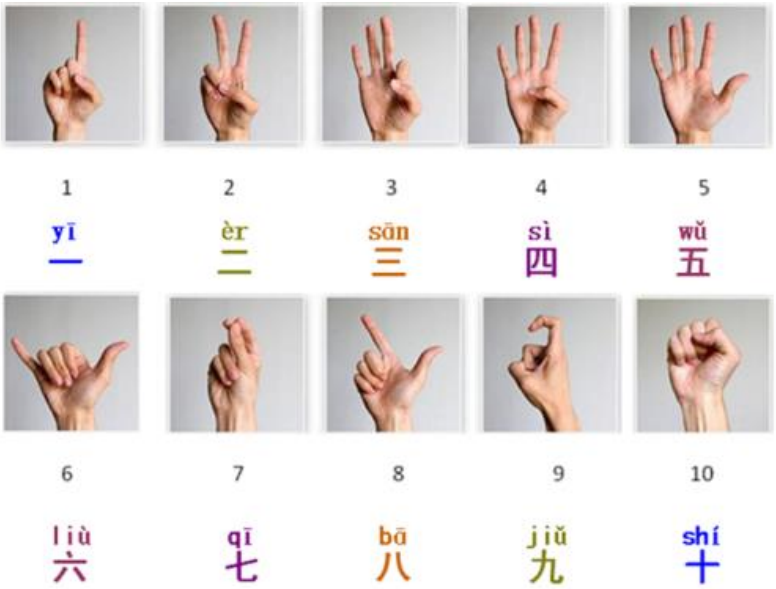
- A project team will consist of 3 students.
- Portfolio building using template
- Deliver intermediate results via HandIN
- Template and schedule on Gitlab

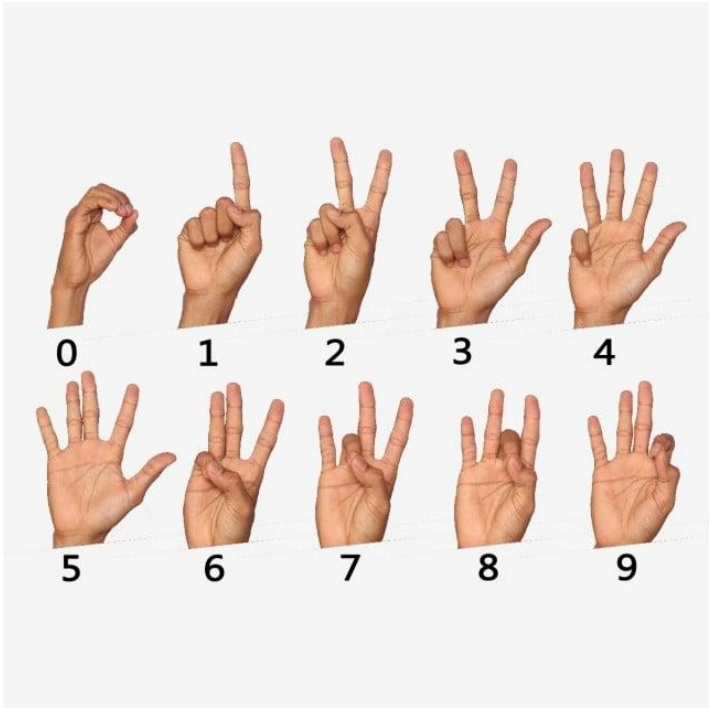
HAND GESTURE CLASSIFICATION

- E.g. sign language, rock-paper-scissors
- Min. 3 classes + unknown
- Pick silhouette gestures
- Alternatively, find a simple case within your main project, e.g. objects in autonomous robot

- Term1: solve with ML
- Term2: solve with DL

EXAMPLES


1
yī
一
2
èr
二
3
sān
三
4
sì
四
5
wǔ
五
6
liù
六
7
qī
七
8
bā
八
9
jiǔ
九
10
shí
十


0
1
2
3
4
5
6
7
8
9

ML PORTFOLIO TEMPLATE

1 INTRODUCTION 3

2 PROBLEM STATEMENT 4

3 DATA ACQUISITION AND EXPLORATION 5

4 MODEL SELECTION AND TRAINING 6

5 DEPLOY AND TEST 7

6 CONCLUSION 8

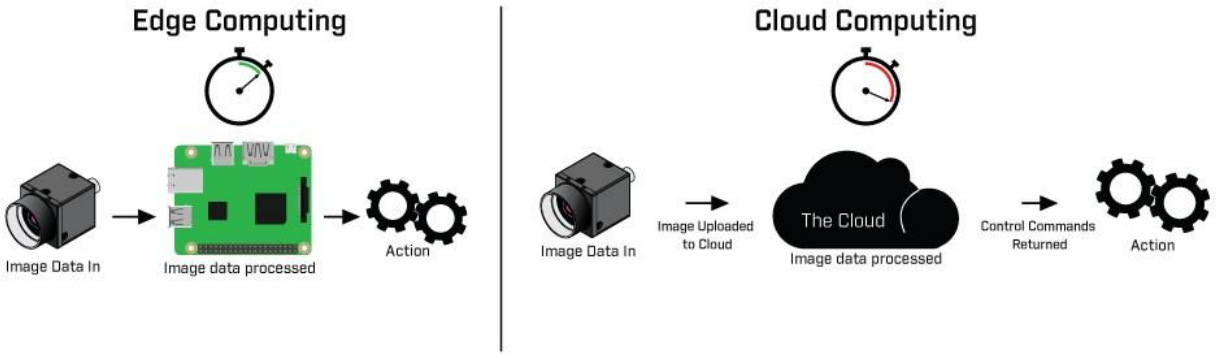
7 REFERENCES 9

CODE APPENDICES 10

TRAINING AND DEPLOYMENT

- Data exploration, model selection and training on embedded device or PC or even in the cloud (e.g. Google Colaboratory, Microsoft Azure)

- Data acquisition, model deployment and prediction testing on an embedded device, such as Raspberry Pi (sort of…)



CONDITIONED ACQUISITION

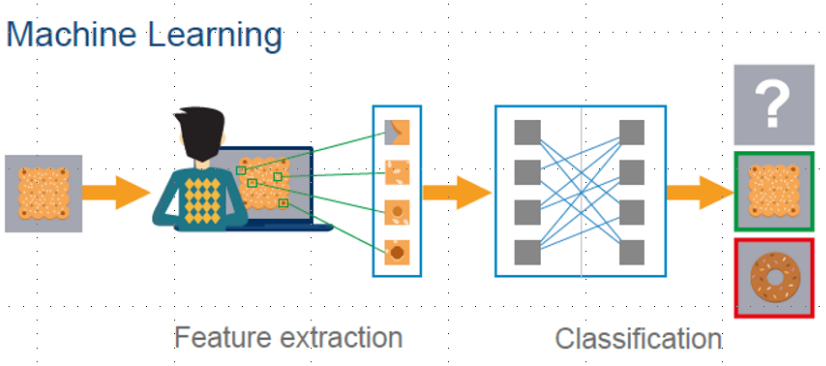
- Set-up image acquisition such that segmentation is easy
- Build a script to quickly collect >100 example images per class
- Study quality (and diversity) of your dataset
- Next week we'll discuss an example script

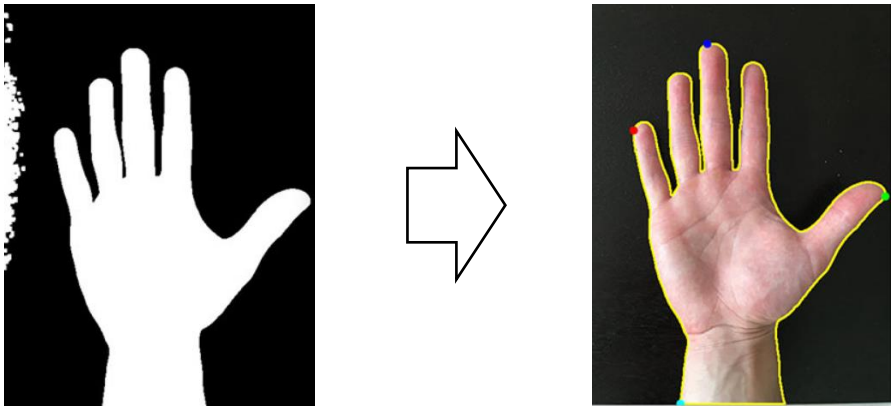
IMAGE ANNOTATION TOOLS

- VGG Image Annotator, LabelImg, OpenLabeler, or ImgLab, or perhaps a commercial tool like
- LabelBox or Supervisely.
- You may also want to consider crowdsourcing platforms such as Amazon Mechanical Turk if you have a very large number of images to annotate.

SIMPLE PREPROCESSING

- Build a script that transforms your images to feature vectors
- Use library functions, e.g. OpenCV





thresholding

feature extraction

Scripting?

PYTHON

- General-purpose language
- Interpreted (no compilation)
- Garbage collected (no memory management)
- Cross-platform: Linux, Mac OS X, Windows
- Weakly typed (duck typing)
- Object-oriented if you want it to
- Python's advantage is its extreme flexibility
- viable end solution for scientific computing, data analysis, plotting
- thanks to lots of efforts from the Open Source community, leading to the availability of mature 3rd-party tools e.g. numpy, scipy, matplotlib, ipython

ZEN OF PYTHON

“Readability counts.”
code is read much more often than it is written
Check out PEP 8 -- Style Guide for Python Code
https://www.python.org/dev/peps/pep-0008/

“Explicit is better than implicit.”

“Beautiful is better than ugly.”

“Simple is better than complex.”

…

LEARN PYTHON ONLINE

- https://www.youtube.com/watch?v=rfscVS0vtbw
- https://www.youtube.com/watch?v=sfhhk8m4mcQ
- https://docs.python.org/3/tutorial/
- https://www.learnpython.org/
- https://www.w3schools.com/python/
- https://www.tutorialspoint.com/python/index.htm/
- https://www.afterhoursprogramming.com/tutorial/python/python-overview/

- So many tutorials….

We will talk more about this next week, but pls start learning online

WINDOWS INSTALL

- Install the latest version of python3 via https://www.python.org/downloads/
- Pip should come with python3, if not install it https://pip.pypa.io/en/stable/installing/
- Install the necessary package from the command prompt

  pip install numpy scipy scikit-learn imutils opencv-python

  See e.g. https://pypi.org/project/opencv-python/

HEADLESS RASPBERRY PI INSTALL

- Raspberry Pi Imager
  https://www.raspberrypi.org/downloads/

- To enable SSH, create a file named `ssh` in boot partition

- Via ethernet (e.g. direct) SSH to hostname: raspberrypi.local
  login:pi, password=raspberry

- Open raspi-config

  ```
  sudo raspi-config
  ```

  and set
  - Interfacing options: enable VNC and camera
  - Advanced options: expand filesystem, memorysplit: 256MB to GPU

- Reboot

  ```
  sudo reboot
  ```

CONNECT TO “EDUROAM” WI-FI NETWORK

- Open terminal and change /etc/wpa_supplicant/wpa_supplicant.conf

```
network={
        ssid="eduroam"
        scan_ssid=1
        proto=RSN
        key_mgmt=WPA-EAP
        group=CCMP TKIP
        eap=TTLS PEAP
        identity="your_username@han.nl"
        password="your_password"
        phase2="auth=MSCHAPV2"
}
```

- Restart service

```
sudo wpa_supplicant -i wlan0 -c /etc/wpa_supplicant/wpa_supplicant.conf
```

- Check your connection

```
iwconfig
```

https://www.instructables.com/id/Access-Eduroam-on-a-Raspberry-Pi-in-Cambridge/

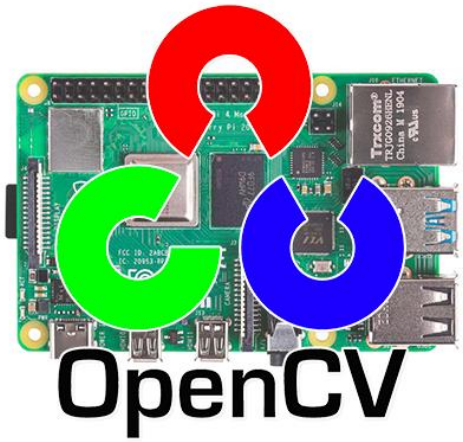
INSTALL OPENCV ON RASPBERRY PI

- https://www.pyimagesearch.com/2019/09/16/install-opencv-4-on-raspberry-pi-4-and-raspbian-buster/

- Choose simple pip-install method (take Step#2 and Step #4a)
  N.B. pip is the package installer for Python.
  You can use pip to install packages from
  the Python Package Index and other indexes.

- Test and check build information

```
python3
>> import cv2
>>> cv2.__version__
>>> print(cv2.getBuildInformation())
....
CPU/HW features : VFPV3 NEON
Parallel framework: pthreads
....
```



ALTERNATIVELY, INSTALL OPENCV 4

- Sept. ‘21 unfortunately no wheels or pip installer available
- So, you could build from source, see e.g.

  https://qengineering.eu/install-opencv-4.4-on-raspberry-pi-4.html

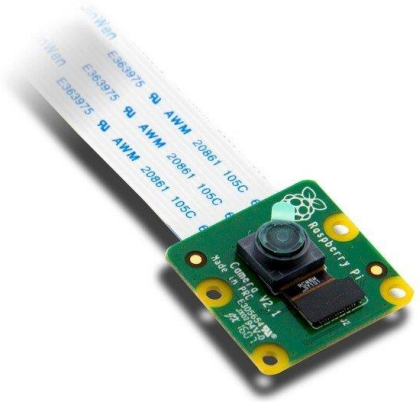
  https://learnopencv.com/build-and-install-opencv-4-for-raspberry-pi/

RASPBERRY PI CAMERA

- Pure Python interface to the Raspberry Pi camera
  https://picamera.readthedocs.io/en/release-1.13/

```
sudo pip3 install "picamera[array]"
```

- Newly released: Libcamera
  https://www.raspberrypi.org/documentation/linux/software/libcamera/README.md



INSTALL MORE PACKAGES

- Mathematics and image processing

```
sudo pip3 install numpy --upgrade
sudo pip3 install matplotlib
sudo pip3 install scipy==1.3.3
sudo pip3 install scikit-image
sudo pip3 install imutils
```

- Find latest successful builds for Raspbian here: https://www.piwheels.org/project/scipy/

SCIKIT-LEARN

- Finally, the ML package
  ```
  sudo pip3 install scikit-learn
  ```
- Free software machine learning library for Python
- Features various classification, regression and clustering algorithms
- Designed to interoperate with the Python numerical and scientific libraries NumPy and SciPy.

PICK YOUR FAVORITE IDE

- Anaconda
- Ipython
- Pycharm
- Spyder
- Thonny
- Atom
- Visual studio code
- Jupyter Notebook
- Colab

….

BUILT-IN DATA TYPES

Text Type:	str
Numeric Types:	int, float, complex
Sequence Types:	list, tuple, range
Mapping Type:	dict
Set Types:	set, frozenset
Boolean Type:	bool
Binary Types:	bytes, bytearray, memoryview

Note that almost *everything* in Python is an object

LISTS

```
my_list = [2, {'dog': ['Rex', 3]}, 'John', 3.14]
```

- Collection which is ordered and changeable (mutable)
  Slicing
  `x[start:stop:step]`
  indices can be negative
- Functions
  `len()` gives the length of a list
  `sorted()` returns a sorted version of a list
  `sum()` does what you might expect
- Methods
  `.append()` modifies a list by adding an item to the end
  `.pop()` removes and returns the last element of a list
  `.index()` searches index of element

FLOW CONTROL

```
fruits = ["apple", "banana", "cherry"]
for x in fruits:
  print(x)
```

- Indentation to mark blocks of code
- for iterates on elements from "iterables",
  default iterables: arrays, lists, tuples, dictionaries, strings
  The for loop specifies: the variable name to use, the set of values to loop over. You use the word "in" to link them together.
- Useful functions
  `range()` returns a sequence of numbers
  `enumerate()` returns item and index
  `zip()` returns combinations
- `while` loop iterates until some condition is met
- Note: no switch statement
  `break` exits a loop
  `continue` loops around
  `pass` does nothing

FUNCTIONS

```
def my_function():
  print("Hello from a function")
```

- Functions are defined by def
- Keyword arguments
- Default arguments
- Function recursion is accepted
- Functions Applied to Functions

https://www.w3schools.com/python/python_functions.asp

MODULES

```
from math import log, pi
```

- Collection of variables (a *namespace*, if you like) defined by someone else.
- You can import modules or packages
- E.g. importing `math` from the standard library
- Other libraries can be easily added
- We can see all the names in `math` using the built-in function `dir()`.
- Access functions and variables using dot syntax.
- Import module under a shorter alias to save some typing
- `import *` makes all the module's variables directly accessible (without any dotted prefix)
  but "star imports" can occasionally lead to weird, difficult-to-debug situations.
  convenient but name collisions possible - avoid if possible
- good compromise is to import only the specific things we'll need from each module

NUMPY

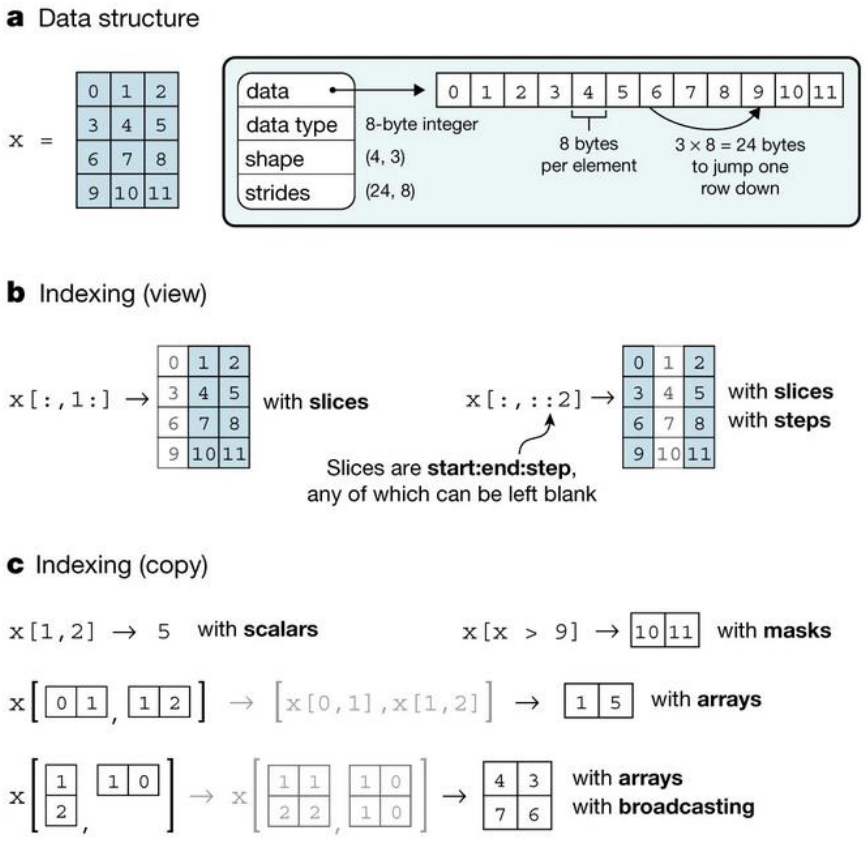
- Fundamental package for computing in Python
- Multidimensional array object
  and various derived objects (such as masked arrays and matrices)
- Assortment of routines for fast operations on arrays,
  including mathematical, logical, shape manipulation, sorting, selecting, I/O, discrete Fourier transforms, basic linear algebra, basic statistical operations, random simulation and much more
- Execute operations at near-C speed but with simple code
- Fully supports an object-oriented approach

Check out e.g.

- https://www.python-course.eu/numpy_numerical_operations_on_numpy_arrays.php
- https://towardsdatascience.com/20-numpy-operations-that-every-data-scientist-should-know-fb44bb52bde5

NDARRAY TYPE

- numpy's `ndarray` type is specialized for working with multi-dimensional data, e.g.
- Defines its own logic for indexing, allowing us to index by a tuple to specify the index at each dimension, e.g.
- Boolean indexing returns a new array (not a view), e.g.
  `y = x[x<2]`
- Overloaded operators, e.g.
  `+,-`
- Lots of very useful method, e.g.
  `x.shape()`



g Example

```
In [1]: import numpy as np

In [2]: x = np.arange(12)

In [3]: x = x.reshape(4, 3)

In [4]: x
Out[4]:
array([[ 0,  1,  2],
       [ 3,  4,  5],
       [ 6,  7,  8],
       [ 9, 10, 11]])

In [5]: np.mean(x, axis=0)
Out[5]: array([4.5, 5.5, 6.5])

In [6]: x = x - np.mean(x, axis=0)

In [7]: x
Out[7]:
array([[-4.5, -4.5, -4.5],
       [-1.5, -1.5, -1.5],
       [ 1.5,  1.5,  1.5],
       [ 4.5,  4.5,  4.5]])
```

From: Array programming with NumPy