ieeta instituto de engenharia electrónica e telemática de aveiro

universidade de aveiro

Departamento de Eletrónica, Telecomunicações e Informática

Machine Learning

Lecture 1 : Introduction

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PROGRAM

Supervised learning
Linear (univariate/ multivariate) regression
Logistic regression. Regularization
Artificial Neural Networks (ANN)
Support Vector Machines (SVM)
Decision Tree (DT);
Naive Bayes classifier
k-Nearest Neighbor (k-NN) classifier

Unsupervised learning
K-means clustering
Data dimensionality reduction
Principal components analysis (PCA)
Multivariate Gaussian approach for Anomaly Detection

Deep Learning
Deep Learning architectures :
CNN (Convolutional Neural Networks);
YOLO (You Only Look Once) neural network
LSTM (Lond Short Term Memory) neural network

Evaluation

Lectures & labs: 3 hours per week. Initially on zoom
https://videoconf-colibri.zoom.us/j/2293635043

Practical component - 50% of the final grade

Practical component consists of 2 projects, developed in a group of two students.

The first project is evaluated based on a submitted report (IEEE format) and a short (10-15 min.) oral presentation.

The second project is evaluated based on a submitted report (IEEE format).

The students are encouraged to use Latex text editor.
Overleaf is a convenient platform for collaborative writing and publishing using Latex (https://www.overleaf.com/) .

Theoretical Component – 50% of the final grade

Final individual exam during the last class.

Why ML ?

- Grew out of work in Artificial Intelligence and increasing computational resources.

- Exponential growth of data – need for data mining
  (IoT, medical records, biology, engineering, etc.)

- Applications can't be explicitly programed by hand.

  - ✓ Autonomous driving;
  - ✓ Computer Vision;
  - ✓ Natural Language Processing (Speech recognition, Machine translation)
  - ✓ User behaviour monitoring (Sentiment classification, Video activity recognition) .

Why ML ?

- Hardware get smaller.
- Sensors get cheaper, widely available IoT devices with high sample-rate.
- Inexpensive microcontroller for processing - even with noisy, high variation data.
- Data sources: sound, vibration, image, electrical signals, accelerometer, temperature, pressure, LIDAR, etc.

- **Short term goal:** Build analytics by teaching a machine to detect and classify events happening in real-time.

- **Long term goal:** Build intelligent machines (sensing the world, perception, reasoning, make decisions/predictions).

A bit of history

- **1950,** Alan Turing: "Computing Machinery and Intelligence" define the question "Can machines think?“ =>Turing test.

- **1956** –The field of Artificial Inteligente (AI) formally established at the conference in Dartmouth College.

- **1959,** Arthur Samuel: “ Field of study that gives computers the ability to learn without being explicitly programmed ".

- **1998,** Tom M. Mitchell: “ Can the computer program learn from experience ? “.

Machine Learning – “definition”

„A computer program is said to learn from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E.“
(T. Mitchell 1998)

- **Given**
  - a task T (e.g. classify spam/regular emails)
  - a performance measure P (weighted sum of mistakes)
  - some experience E with the task (e.g. hand-sorted emails)

- **Goal**
  - generalize the experience in a way that allows to improve the machine performance on the task

Learning to classify documents

Web page:
Company, Personal, University, etc.

Articles:
Sport,Political, History, etc.

Computer Vision

Learning to detect & recognize faces

Computer Vision Tasks

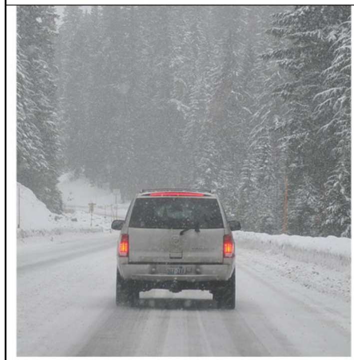
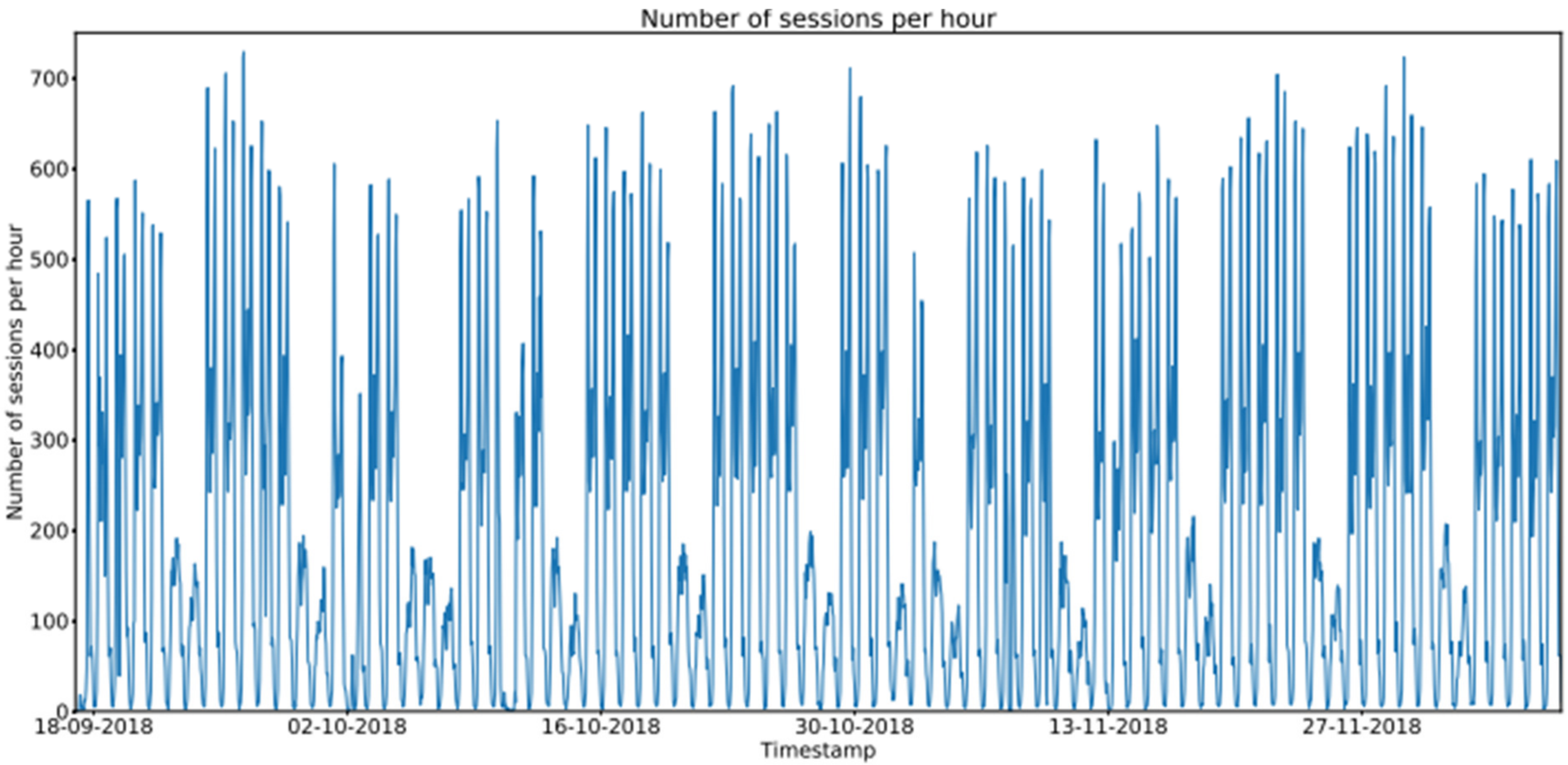
Image classification	Classification & Localization	Detection
	 b_x, b_y, b_h, b_w	

Image classification: input a picture into the model and get the class label (e.g. person, bike, car, background, etc.)

Classification & localization: the model outputs not only the class label of the object but also draws a bounding box (the coordinates) of its position in the image.

Detection: the model detects and outputs the position of several objects.

Time Series (TS) Forecasting

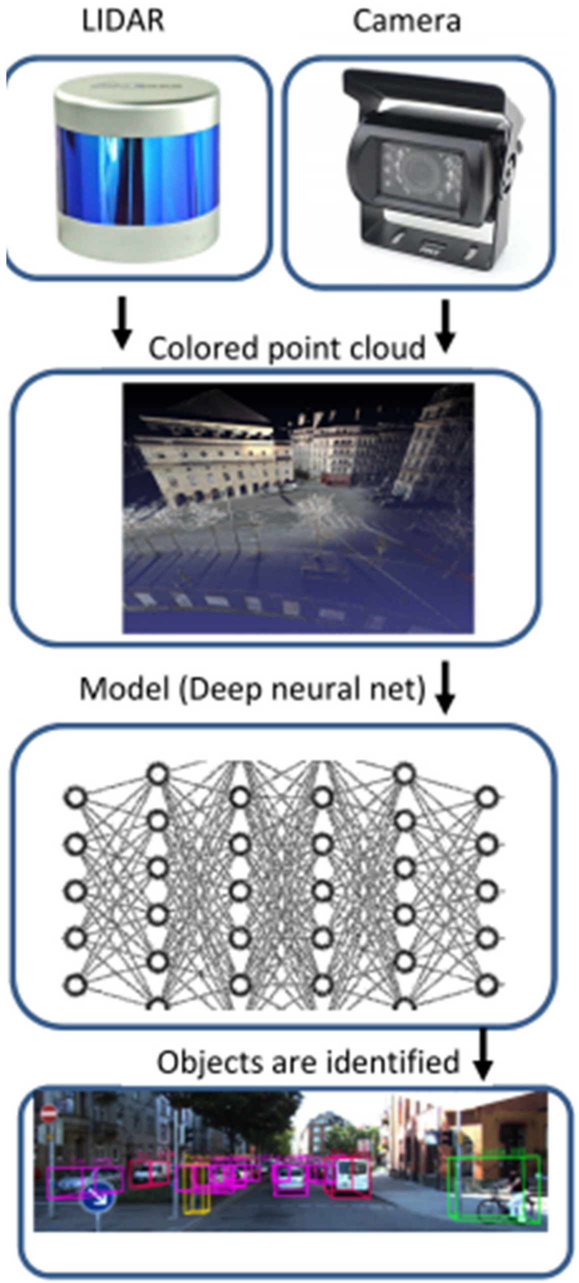


o tempo é importante!!!!

Time Series - collection of data points indexed based on the time they were collected . Most often, data are recorded at regular time intervals.

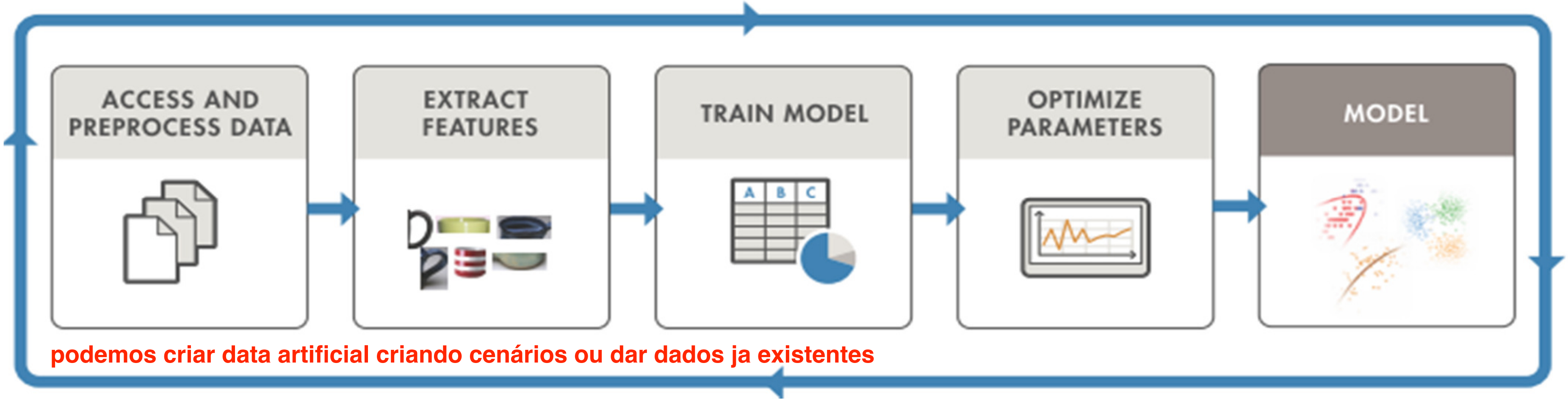
Based on past data, predict future trends, seasonality, anomalies, etc.

Object Detection (sensor fusion)



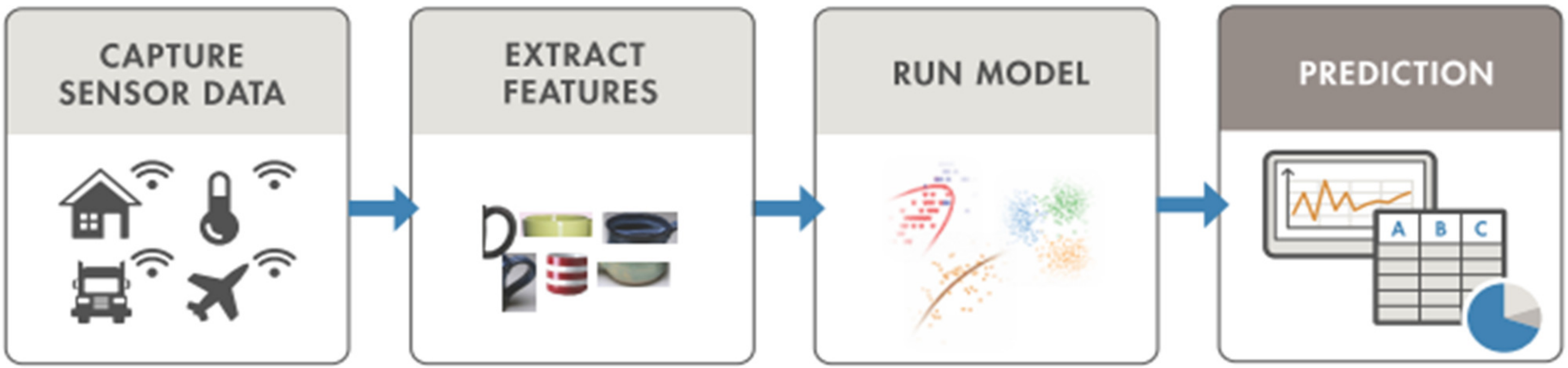
ML workflow

Train: Iterate until achieve satisfactory performance (**usually off-line**)



podemos criar data artificial criando cenários ou dar dados ja existentes

Predict: Integrate trained models into applications **(on-line)**



Machine Learning Approaches

Supervised Learning

Given examples with "correct answer" (labeled examples)

(e.g. given dataset with spam/not-spam labeled emails)

Unsupervised Learning

Given examples without answers (no labels).

Deep Learning

Automatically extract hidden features (in contrast to hand-crafted features). Need a lot of data (Big data) . Need for very high computational resources (GPUs).

Reinforcement Learning

On-line (on the fly) learning, by trial and error.

Supervised Learning

Requires labeled data (examples with “correct answer”).

Regression: The model output is a real number.

Ex. Predict the house price (output) based on data for the house area and number of bedrooms (features).

Living area ($feet^2$)	#bedrooms	Price (1000$s)
2104	3	400
1600	3	330
2400	3	369
1416	2	232
3000	4	540
⋮	⋮	⋮

Classification: The model output is a label (integer numbers).

Ex. Predict normal (0) or abnormal (1) state of data center computers:

Features: memory use of computer ; number of disc accesses /sec; CPU load ; network traffic; silence

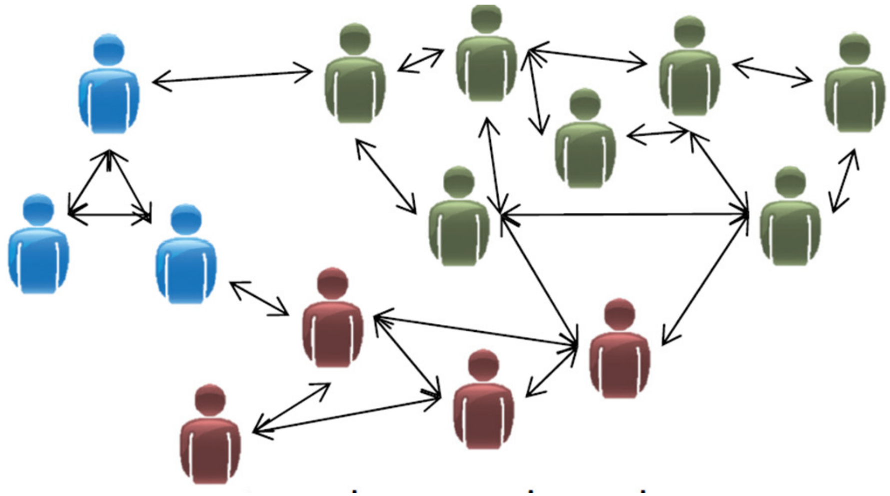
Unsupervised Learning

Given unlabeled data (NO answers)

Features: education, job, age, marital status, etc.

Market segmentation

Social network analysis



Clustering: Given a collection of examples (e.g. user profiles with a number of features). Each example is a point in the multidimensional space of features. Find a similarity measure that separates the points into clusters.

-K-means clustering

Why Deep Learning ?

Hardware get smaller.
Sensors get cheaper, widely available IoT devices with high sample-rate.
Data sources: sound, vibration, image, electrical signals, accelerometer, temperature, pressure, LIDAR, etc.

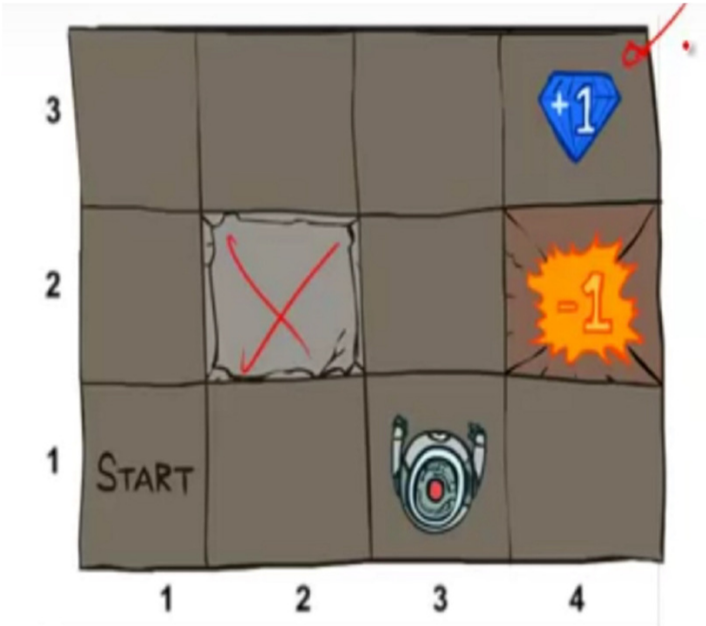
Big Data: Exponential growth of data, (IoT, medical records, biology, engineering, etc.)

How to deals with **unstructured data** (image, voice, text, EEG, ECG, etc.) =>
What are the best feature ? Não sabemos exatamente as features

Deep Neural Networks: first extract (automatically) the hidden features, then solve ML tasks (classification, regression)

Reinforcement Learning

On-line learning by taking actions and getting rewards/penalties.
intelligent robotics =>



Little vs. Lots of Data

Most ML applications lay somewhere in this spectrum:

Little data <--> Lots of data

We have lots of data for speech recognition;
Reasonable large data for image recognition (cats or dogs) ;
and much less data for object detection (bounding boxes) .

If Lots of data: the best way to get good performance is to build deep models (several layers), playing with network architectures, but less hand-engineering.

If Litte data: the best way to get good performance is hand-engineering – very difficult and skilful task that requires a lot of inside (expert) knowledge.

Data Types

1. **Numeric (Quantitative) features**
   - Integer numbers
   - Floats (decimals) - temperature, height, weight, humidity, etc.

2. **Boolean** – True/False

3. **Categorical features -** gender, days of the week, seasons, country of birth, colors, etc.

   How to deal with categorical features ? - One-hot encoding (1,0) transforms n categories into n features

Color
Red
Red
Yellow
Green
Yellow

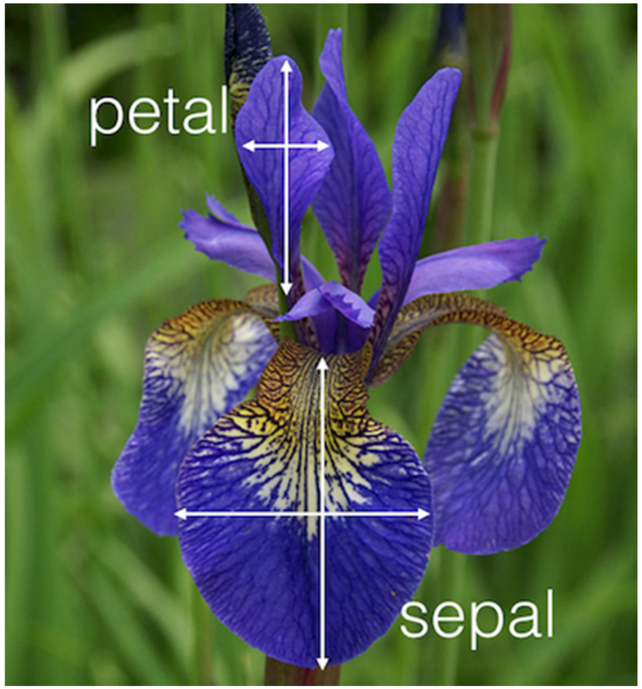
Red	Yellow	Green
1	0	0
1	0	0
0	1	0
0	0	1

Iris Plant data

- Iris Plant data – benchmark dataset for illustration of ML methods.
  - UCI Machine Learning Repository
    http://www.ics.uci.edu/~mlearn/MLRepository.html

  - 3 flower types (classes):
    - Setosa
    - Virginica
    - Versicolour

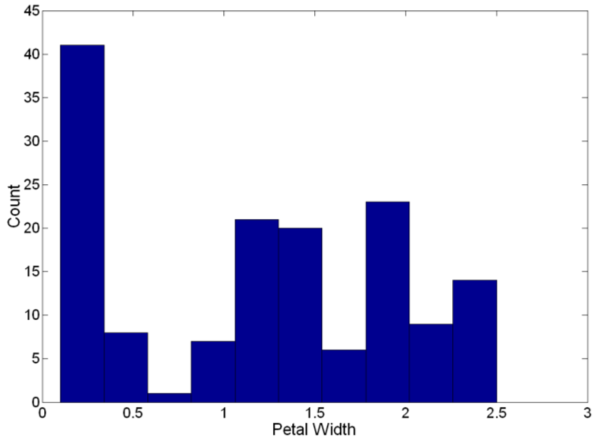
  - 4 attributes (features)
    - Sepal width and length
    - Petal width and length

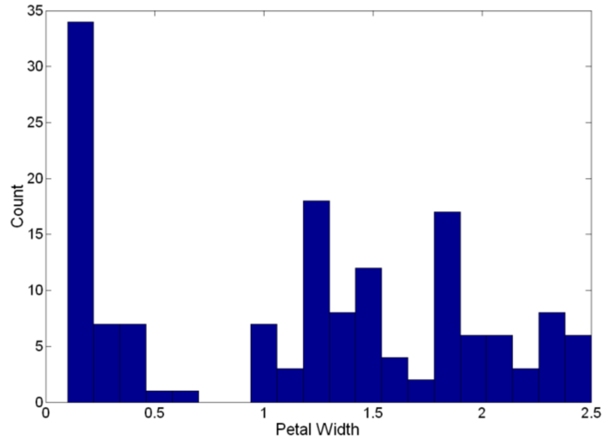


Data Visualization (1)

- **Histograms**
  - Show the distribution of values of a single feature
  - Divide the range of values of a single feature into bins and show bar plots of the number of examples in each bin.
  - Histogram shape depends on the number of bins

- Example: Petal Width (10 and 20 bins, respectively)





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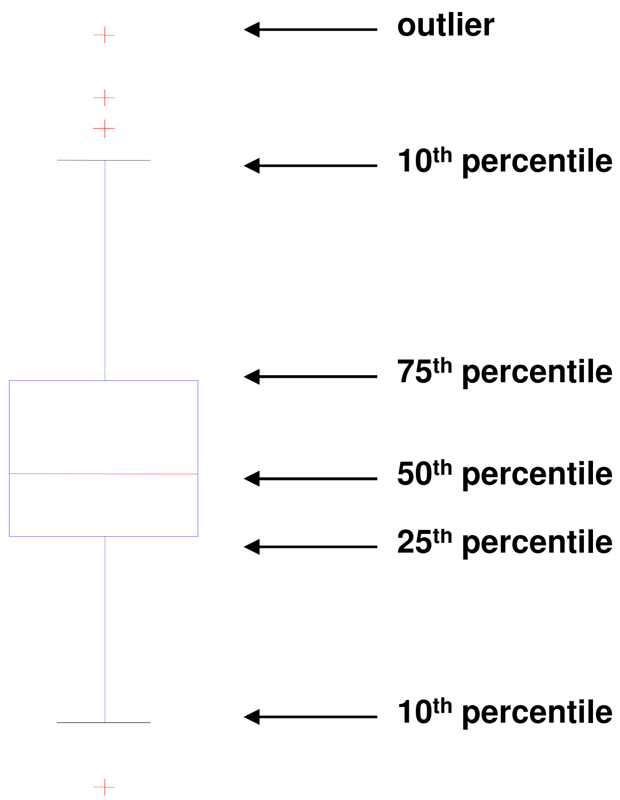
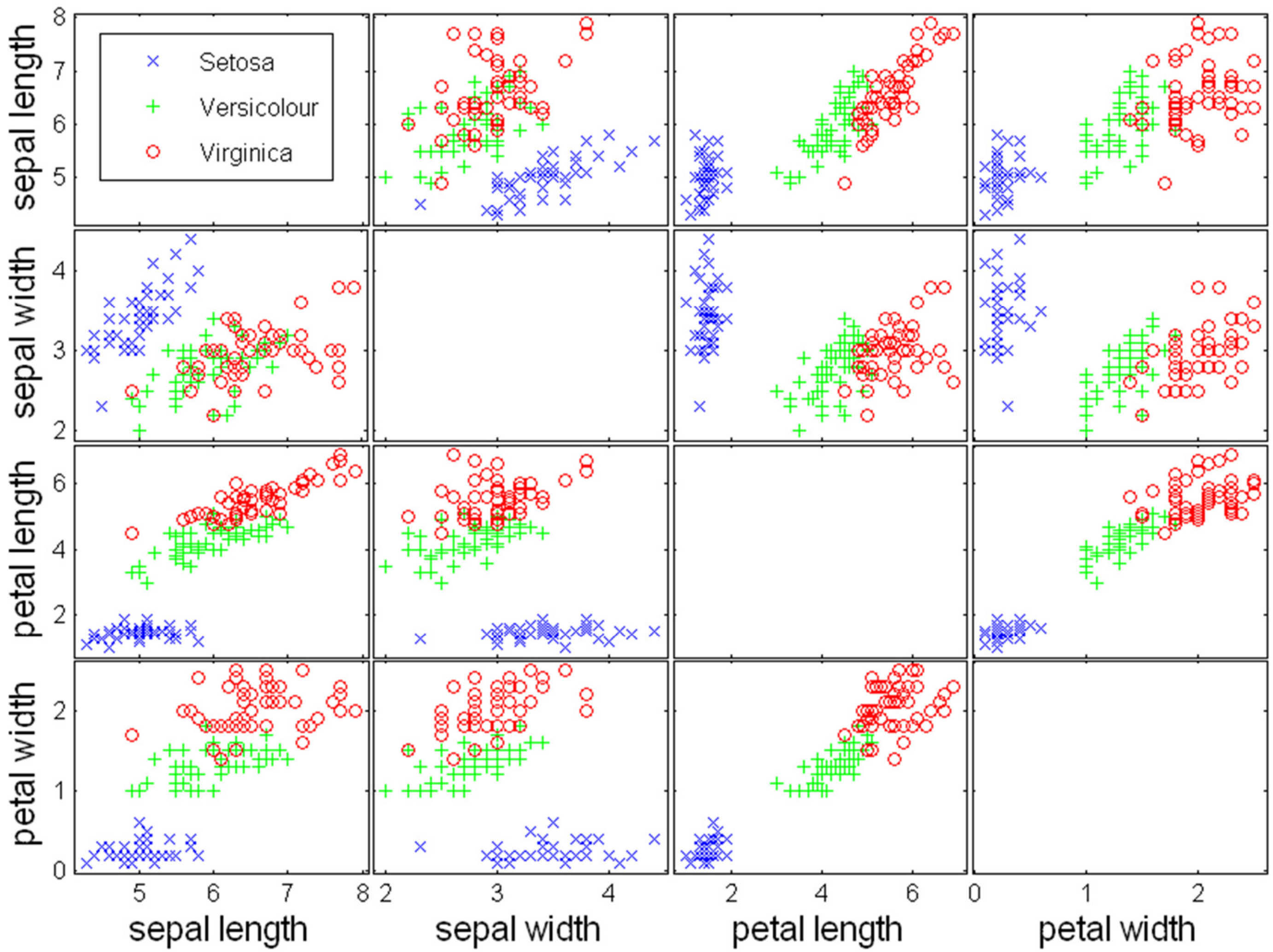
Data Visualization (2)

- **<u>Box Plots</u>**
  - Another way of displaying the distribution of data



Data Visualization (3)

Scatter Plot Array



RECOMMENDED BIBLIOGRAPHY

- Tom Mitchell, Machine Learning. McGraw-Hill, 1997.
- Christopher Bishop, Pattern Recognition and Machine Learning. Springer, 2006.
- David Barber, Bayesian Reasoning and Machine Learning, Cambridge University Press , 2012, (available on-line *http://web4.cs.ucl.ac.uk/staff/D.Barber/textbook/091117.pdf*).
- http://cs229.stanford.edu/ (project ideas)
- MOOC (Massive Open Online Courses)

  e.g. https://www.coursera.org/

Food for Thought

Don’t forget the ethical issues that the advances of Artificial Intelligence and Machine Learning raise !!!

How ethics and human values could be embedded into the ML algorithms used in AI ?

One hundred year study of AI, Stanford University, August, 2016
ttps://ai100.stanford.edu/

Google, Facebook, Amazon, IBM and Microsoft created Partnership on Artificial Intelligence to Benefit People and Society

https://www.partnershiponai.org/ => **Socially responsible AI**

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ML as part of AI

Presence of AI in mainstream technologies:

- robot motion planning and navigation
- computer vision (e.g. object recognition)
- natural language processing and speech recognition

Recent future of AI:

- autonomous vehicles (e.g. drones, self-driving cars)
- medical diagnosis and treatment
- physical assistance for elderly

AI challenges for economy & society:

- Potential threat to humankind (?)
- AI experts have different opinions (?)
- Jobs are missing due to AI (!)
- Militarized AI is a commonly shared concern (!)

ANACONDA 3

1) Install Anaconda 3 for Python 3:

https://www.anaconda.com/distribution/

2) Learn how to use Jupyter Notebook (part of Anaconda)

https://www.dataquest.io/blog/jupyter-notebook-tutorial/

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