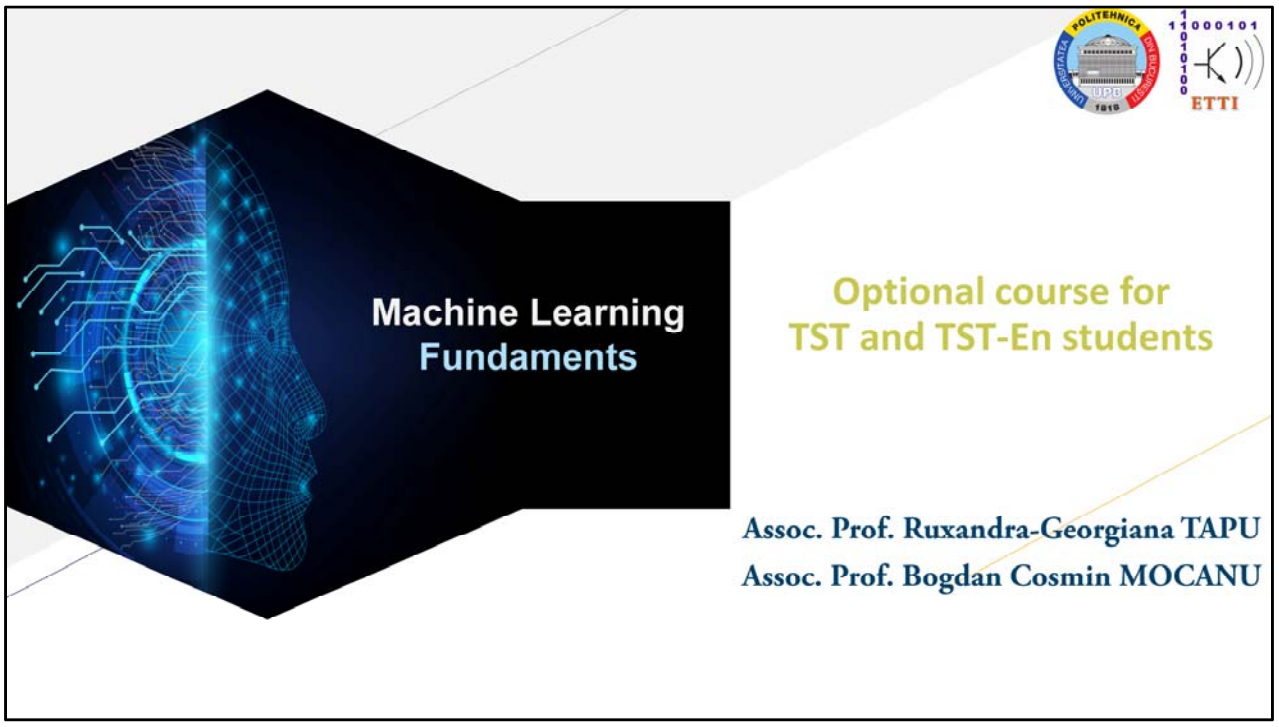
Machine Learning
Fundaments
Optional course for
TST and TST-En students
Assoc. Prof. Ruxandra-Georgiana TAPU
Assoc. Prof. Bogdan Cosmin MOCANU
ETTI

Content

- Image classification
  - Goal
  - The challenge
  - Data driven approaches
  - The pipeline
  - Evaluation
- The Nearest Neighbor Classifier
  - Image classification using Nearest Neighbor (NN)
  - Image classification using k - Nearest Neighbor (k - NN)
  - Validation sets for hyper-parameter tuning
  - Pros and Cons of Nearest Neighbor classifier

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Summary

➡ **Activities:**

- ❖ Course: Thursday: 11 - 13
- ❖ Laboratory: Thursday: 09 - 11 - Your attendance is mandatory!

➡ **Evaluation:**

- ❖ Continuous evaluation based on lab assignments (50%) – The deadline for submitting the laboratory report is on Thursday: 19.00 – NO EXTENSION!
- ❖ Exam - multiple answer questions (50%) – the test is fixed on the 12 week of the semester
- ❖ All activities will be performed on-line!

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Image classification

❖ The task of assigning an input image one label from a fixed set of categories:

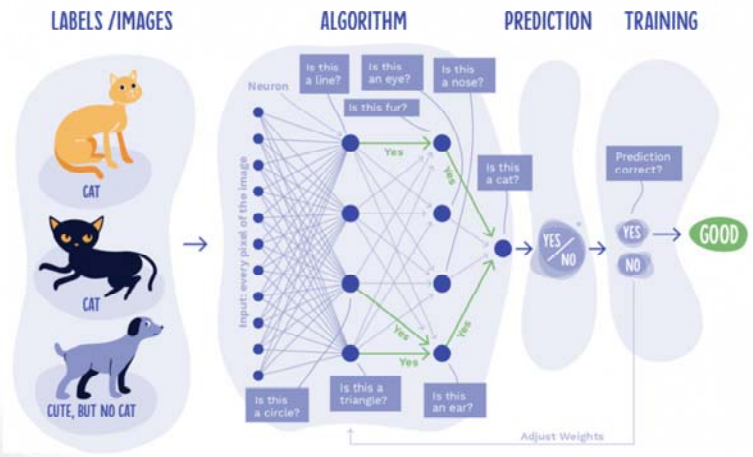


Image classification

- **Goal**

❖ An image classification model takes a single image and assigns the probability to belong to a specific class!

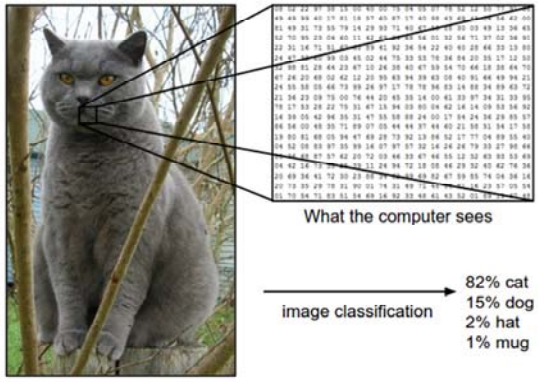
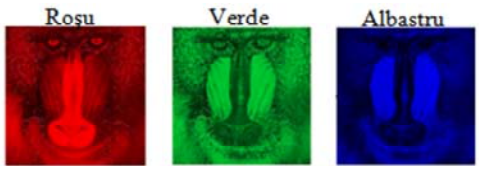


Image classification

- **Goal**

❖ Image representation - 3-dimensional arrays of integers from 0 to 255, of size Width x Height x 3.



❖ Color spaces

RGB
Additive

CMYK
Subtractive

Image classification

- The challenge
  - ❖ Viewpoint variation:

  - ❖ Deformation:

  - ❖ Scale variation:

  - ❖ Occlusion:

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Image classification

- The challenge
  - ❖ Illumination conditions:

  - ❖ Background clutter:

  - ❖ Intra-class variation:

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Image classification

- **Data driven approaches**
  - ❖ Provide the computer with many examples of each class and then develop algorithms able to learn about the visual appearance of each class:

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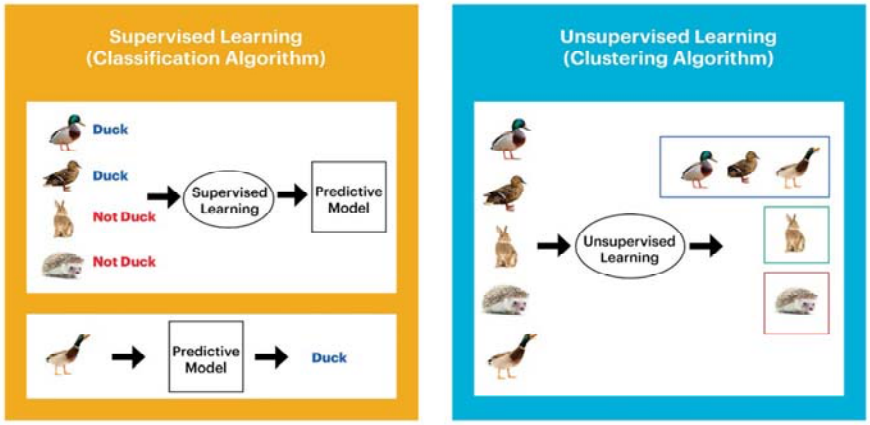
Image classification

- The pipeline

❖ Input data
❖ Learning rule
❖ Evaluation



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The Nearest Neighbor Classifier

- **Image classification using Nearest Neighbor (NN)**
  - The nearest neighbor algorithm was one of the first algorithms used to solve the travelling salesman problem.

- Initialize all vertices as unvisited
- Select an arbitrary vertex, set it as the current vertex *u*. Mark *u* as visited
- Find out the shortest edge connecting the current vertex *u* and an unvisited vertex *v*
- Set *v* as the current vertex *u*. Mark *v* as visited
- If all the vertices in the domain are visited, then terminate. Else, go to step 3.

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The Nearest Neighbor Classifier

- **Image classification using Nearest Neighbor (NN)**

❖Example: Consider the following points A(0, 8), B(5, 8), C(5, 8) and D(10, 20). Determine the minimum distance needed to be traveled in order to visit all points by using the NN algorithm.

❖Can you find a shorter path?

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The Nearest Neighbor Classifier

- Image classification using Nearest Neighbor (NN)

❖CIFAR-10 Dataset

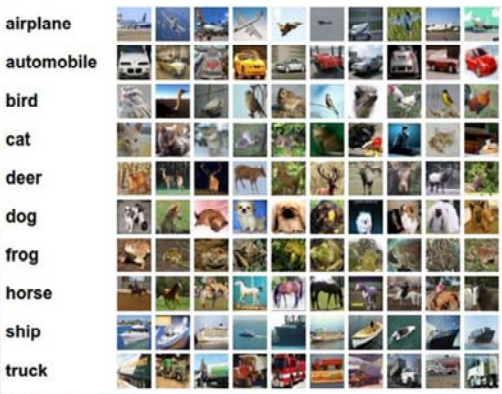

Image classification using NN

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The Nearest Neighbor Classifier

- **Image classification using Nearest Neighbor (NN)**

❖Image distances : L1

$$d_1(I_1, I_2) = \sum_p |I_1^p - I_2^p|$$

❖Image distances : L2

$$d_2(I_1, I_2) = \sqrt{\sum_p (I_1^p - I_2^p)^2}$$

In other words we would be computing the pixel-wise difference as before, but this time we square all of them, add them up and finally take the square root.

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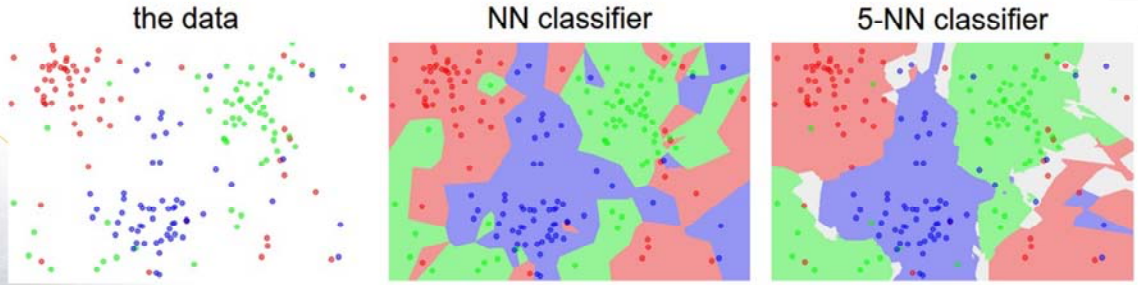
The Nearest Neighbor Classifier

- **Image classification using k - Nearest Neighbor (k - NN)**

❖ Instead of finding the single closest image in the training set, we will find the top k closest images, and have them vote on the label of the test image.



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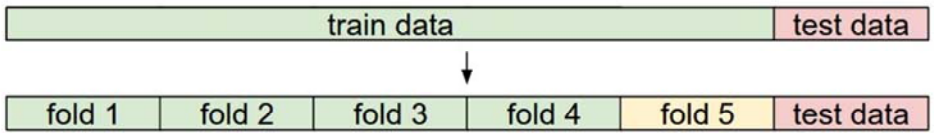
The Nearest Neighbor Classifier

▪ Validation sets for hyper-parameter tuning

❖ These choices of hyper-parameters is very often in the design of many Machine Learning algorithms that learn from data

❖ Cross-validation:



❖In practice: 3-fold, 5-fold or 10-fold cross-validation.

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The Nearest Neighbor Classifier

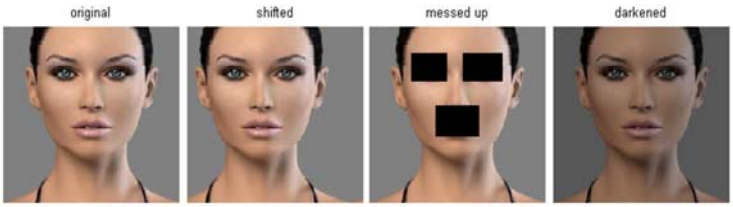
▪ Pros and Cons of Nearest Neighbor classifier

❖ Advantages:

- ✓ Very simple to implement and understand
- ✓ No training is required

❖ Disadvantages:

- ✓ The computational cost at test time
- ✓ Reduce performances
- ✓ Similar L2 distance for different images



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