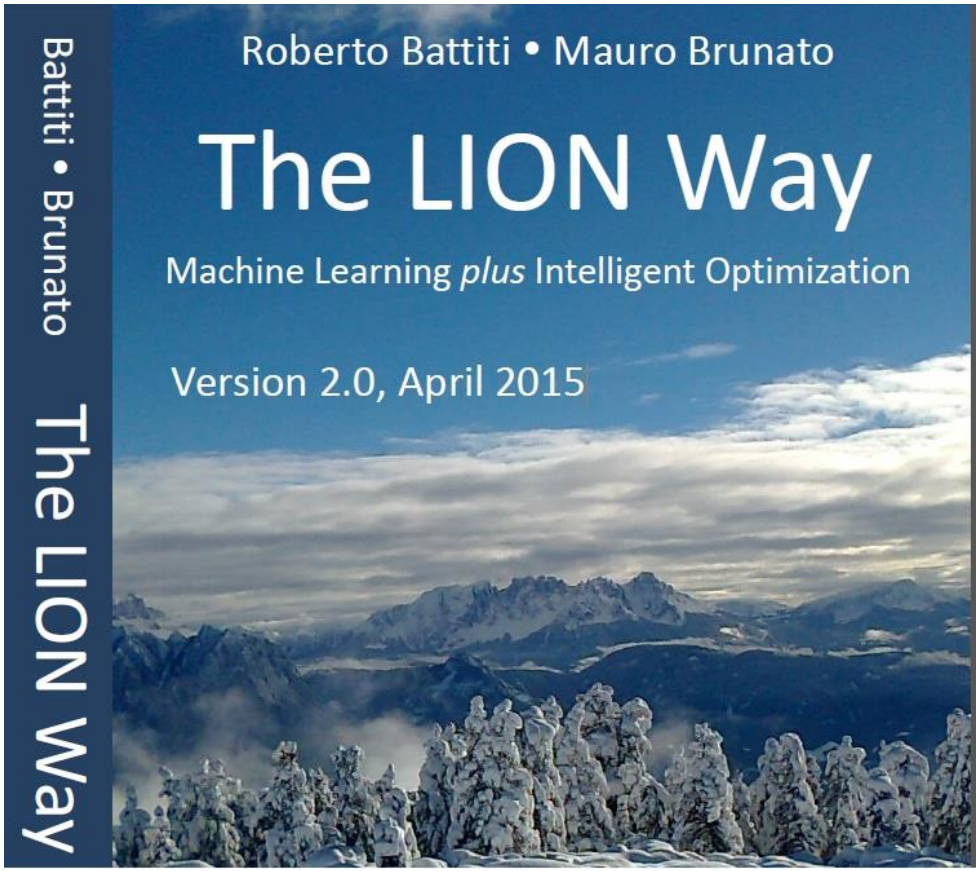
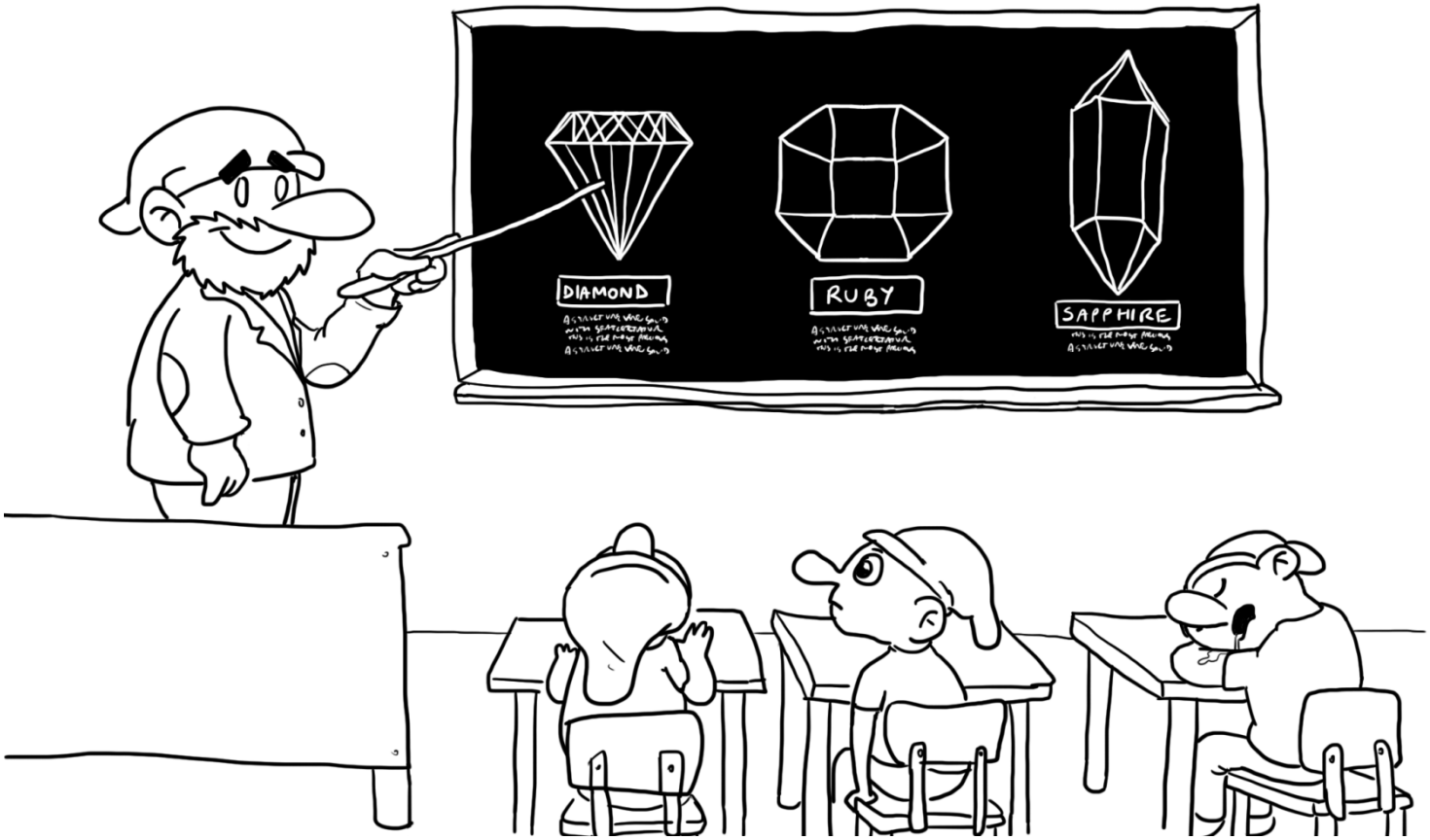


ROBERTO BATTITI, MAURO BRUNATO.
The LION Way: Machine Learning plus *Intelligent Optimization*.
LIONlab, University of Trento, Italy,
Apr 2015

http://intelligent-optimization.org/LIONbook

Chap.2 Lazy learning: nearest neighbors

Natura non facit saltus
Nature does not make jumps



Learning from examples

- written characters (“a”,“b”,“c”. . .)
- labeled examples
- Memorization is different from extracting the underlying patterns and regularities

- Generalization is the key

Learning from examples

Mushroom hunting requires classifying edible and poisonous species.

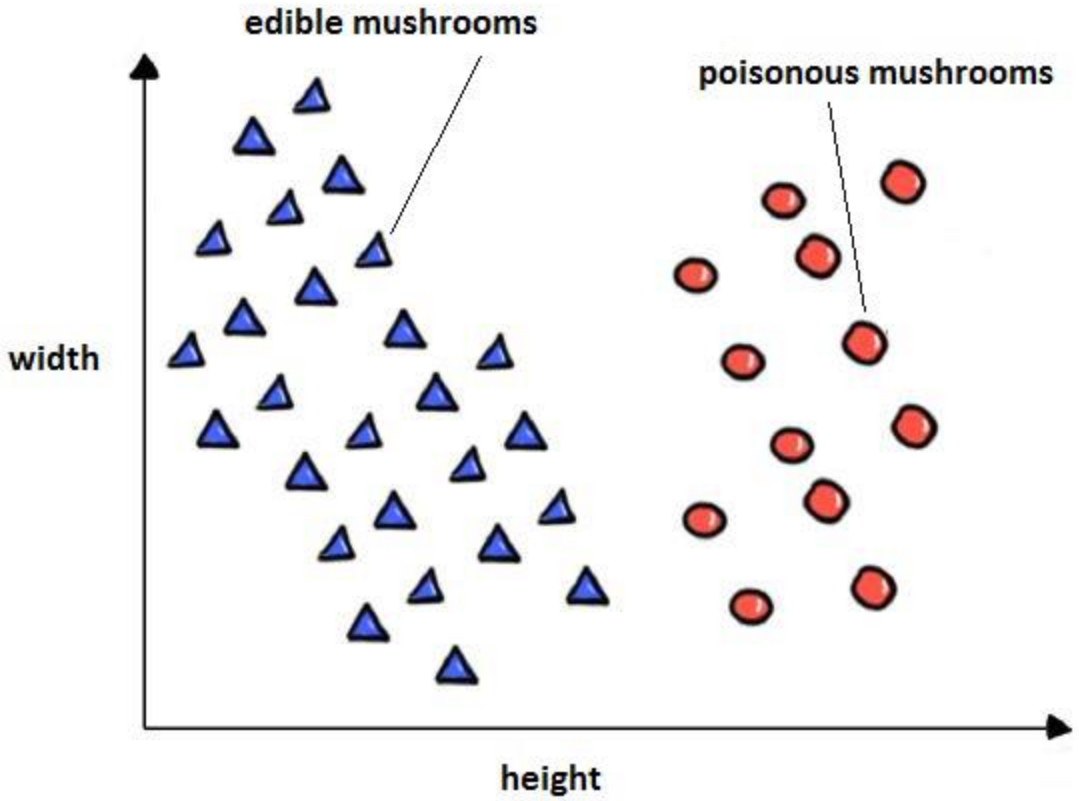
Learning from examples

- In supervised learning a system is trained by a supervisor (teacher) giving labeled examples.

- Each example is an array, a vector of input parameters x called features with an associated output label y.

Lazy “nearest neighbor” method of machine learning.

- Lazy beginners in mushroom picking



Nearest-Neighbors Methods

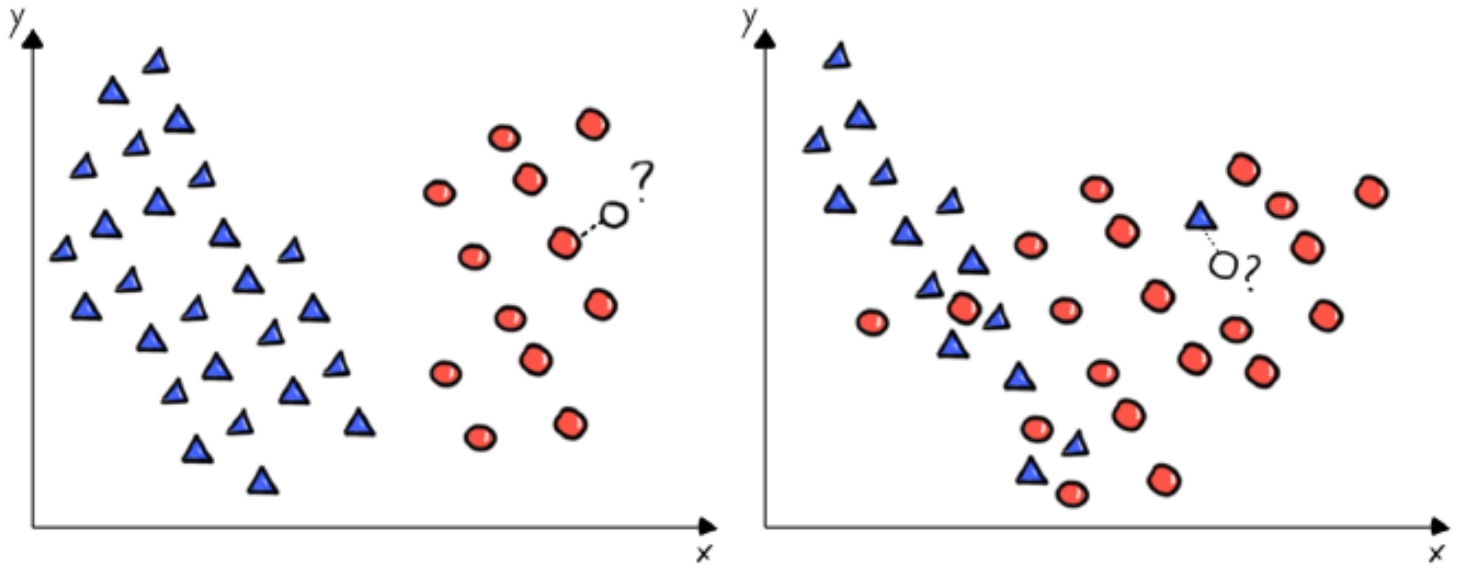
- nearest-neighbors basic form of learning, also related to **instance-based learning**, **case-based or memory-based, pattern patching**

- Classify a new example according to the nearest neighbor (considering input values)

Neighbor → Neigbors

k-nearest-neighbors (KNN)

Majority or unanimity rule



Regression

- regression (the prediction of a real number, like the content of poison in a mushroom), the output can be obtained as a simple average

Weighted K-nearest neighbors (WKNN)

Closer neighbors receive a higher weight (and more influence to derive the output value)

$$y = \frac{\sum_{j=1}^{k} \frac{y_{i_j}}{d(\boldsymbol{x}_{i_j}, \boldsymbol{x}) + d_0}}{\sum_{j=1}^{k} \frac{1}{d(\boldsymbol{x}_{i_j}, \boldsymbol{x}) + d_0}};$$

Kernels and locally weighted regression

- Kernel methods and locally-weighted regression can be seen as flexible and smooth generalizations of the nearest-neighbors idea
- Instead of applying a brute exclusion of the distant points, **all points contribute to the output but with a significance ("weight") related to their distance from the query point**.

Gist

KNN (K Nearest Neighbors) is a primitive and lazy form of machine learning: just store all training examples into memory.

When a new input to be evaluated appears, search in memory for the K closest examples stored. Read their output and derive the output for the new input by majority or averaging. Laziness during training causes long response times when searching a very large memory storage.

KNN works in many real-world cases because **similar inputs are usually related to similar outputs**, a basic hypothesis in machine learning. It is similar to some **“case-based” human reasoning processes**. Although simple and brutal, it can be surprisingly effective in many cases.