Intro

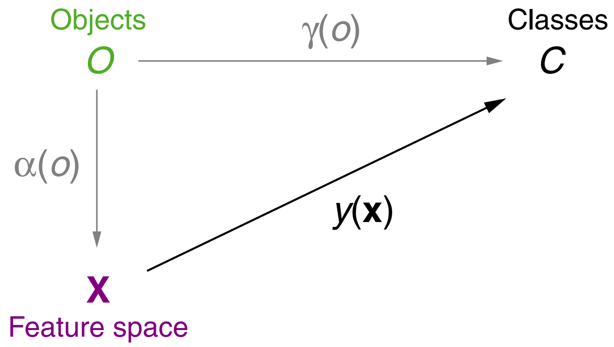
Exercise 1 : Machine Learning (general) File: ex-en-ml-introduction004

(a) Define the terms "supervised learning", "unsupervised learning", and "reinforcement learning".

(b) Sketch for each learning paradigm a typical problem together with a description of its technical realization.

Exercise 2 : Specification of Learning Tasks File: ex-en-ml-introduction001

The following picture from the lecture slides describes the relationship between Real World and Model World, when it comes to the specification of learning tasks.



Assume you are building a machine learning system that predicts whether a given mushroom is poisonous or edible. For the following list, decide which symbol from the picture most closely matches the given list item:

(a) A pile of Mushrooms.

(b) A table with the columns "size", "weight", and "color", as well as one row for each possible mushroom, and the respective measurements in the cells.

(c) A human mushroom expert who can tell whether any mushroom you show them is poisonous or edible.

(d) A device that measures size, weight and color of a mushroom.

(e) The set $\{\text{Poisonous}, \text{Edible}\}$

(f) The machine learning system that you are trying to build.

Exercise 3 : Linear Algebra File: ex-en-ml-prerequisites001

The three $(3, 2)$-matrices $\mathbf{A}, \mathbf{B}, \mathbf{C}$ are given as

$$\mathbf{A} = \begin{bmatrix} 3 & 5 & 2 \\ 1 & 4 & 0 \end{bmatrix}, \mathbf{B} = \begin{bmatrix} 2 & 1 & 2 \\ 5 & 8 & -1 \end{bmatrix}, \mathbf{C} = \begin{bmatrix} 1 & -1 & 2 \\ 5 & -2 & 0 \end{bmatrix}.$$

Evaluate the following expressions:

(a) $3\mathbf{A} + 2\mathbf{B} - 5\mathbf{C}$

(b) $3(\mathbf{B} - \mathbf{A})^T - \mathbf{C}^T$

(c) $\mathbf{A} \cdot \mathbf{C}^T$

Exercise 4 : Calculus File: ex-en-ml-prerequisites002

Calculate the first-order partial derivatives $\frac{\partial z}{\partial x}$ and $\frac{\partial z}{\partial y}$ of the following functions:

(a) $z = (2x - 3y^2)^5$

(b) $z = x^2 \cdot e^{-xy}$

Exercise 5 : Gradient Descent File: ex-en-ml-regression001

In this exercise you will be calculating one iteration of the LMS algorithm. The task is to fit a straight line given as $y(x) = w_0 + w_1 x$ through a given set of points D by adjusting the parameters w_0 and w_1. The pairs $(\mathbf{x}, c) \in D$ are given as $(4, 6), (-1, -3), (5, 10)$.

(a) Plot the line parametrized with $w_0 := 1$, $w_1 := 2$ as well as all samples from D into the same coordinate system.

(b) For the first iteration, $(4, 6)$ is ‘randomly’ selected as the ground-truth pair $(\mathbf{x}, c)$. Compute the loss w.r.t. $\mathbf{w}$, which is defined as

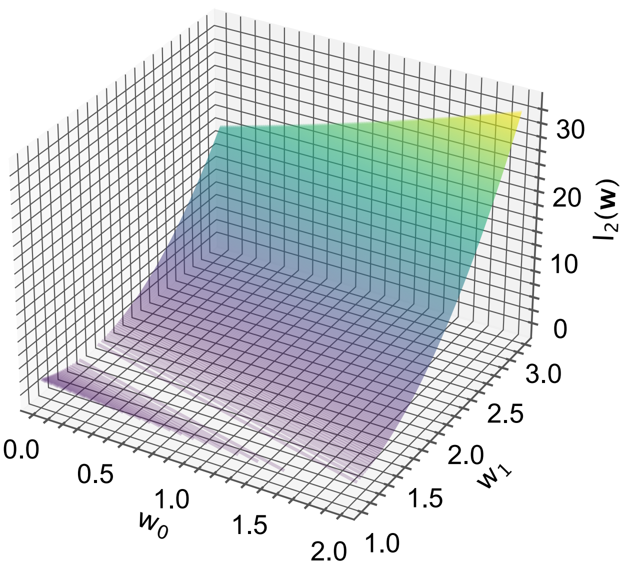
$$l_2(c, y(\mathbf{x})) = \frac{1}{2} \cdot (c - y(\mathbf{x}))^2.$$

(c) Derive the gradient

$$\begin{pmatrix} \frac{\partial l_2}{\partial w_0} \\ \frac{\partial l_2}{\partial w_1} \end{pmatrix}.$$

Verify that this is indeed $-\delta \cdot \mathbf{x}$.

(d) The following plot shows the loss landscape defined by l_2 with the current choice of $(\mathbf{x}, c) = (4, 6)$.



(d1) The model is initialized with $w_0 := 1$, $w_1 := 2$. Mark the current location of the model in the loss landscape, i.e., $\begin{pmatrix} w_0 \\ w_1 \end{pmatrix}$.

(d2) Draw the line of gradient descent, which is defined as

$$\underbrace{\left\{ \begin{pmatrix} w_0 \\ w_1 \end{pmatrix} - \eta \cdot \begin{pmatrix} \frac{\partial l_2}{\partial w_0} \\ \frac{\partial l_2}{\partial w_1} \end{pmatrix} \mid 0 \leq \eta \leq 0.03 \right\}}_{\mathbf{\Delta w} \text{ for increasing } \eta},$$

by connecting the start and end point from the set.