Lucerne University of
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ML: Logistic Regression - Exercises

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Please write down to solution of the exercises in a consise but comprehensible way (including intermediate results). Numerical results should be accurate to 4 digits. Sketches should be correct qualitatively.

At least 75% of the exercises have to be solve satisfactorily. Due time is April 24th, 2019. Prepare one (and only one) PDF-File which contains all solutions to this exercise. Word- or ZIP-Files will not be acceptet! Deposit the file in the directory **Übungsabgabe** which resides in the same directory as this exercise.

Exercise 1: Sigmoid Function

During the lectures we derived the first derivative of the **Logistic Function**

$$\sigma(z) = \frac{1}{1+e^{-z}},\ z \in \mathbb{R}.$$

We have verified, that the first derivative can be written as

$$\sigma'(z) = \sigma(z)\left(1-\sigma(z)\right),\ z \in \mathbb{R}.$$

Using the above result show, that the second derivative can be written as

$$\sigma''(z) = \sigma(z)\left(1-\sigma(z)\right)\left(1-2\sigma(z)\right),\ z \in \mathbb{R}.$$

Note: Use the appropriate rules for differentiation in particular the product, quotient and chain rule! You should do this by hand!

Exercise 2: Partial Derivative

Compute (by hand) the following partial derivative

$$\frac{\partial}{\partial \theta_k}\sigma\left(\boldsymbol{x}^T\boldsymbol{\theta}\right),\ k = 0,1,2,\ldots,m,$$

where

$$\boldsymbol{x}^T\boldsymbol{\theta} = \begin{bmatrix} x_0 = 1,\ x_1,\ x_2,\ \cdots,\ x_m \end{bmatrix} \begin{bmatrix} \theta_0 \\ \theta_1 \\ \theta_2 \\ \vdots \\ \theta_m \end{bmatrix} = \theta_0 + \theta_1 x_1 + \theta_2 x_2 + \cdots \theta_m x_m.$$

and σ is the sigmoid function from above. Note: use the derivative of $\sigma(z)$ from above.

Exercise 2: Very simple Example

Try to understand the computations in the Jupyter notebook `Logistic_Regression_Ex01.ipynb` and answer the questions at the end of this notebook.

Exercise 3: Simple Example

Fill in the missing sections in the first part (1D example) of `logistic_regression_gap.ipynb` and make the Jupyter notebook runnable.

Exercise 4: Real World Examples

Fill in the missing sections in the seconde part (Real World Example) of `logistic_regression_gap.ipynb` and make the Jupyter notebook runnable.

Happy Machine Learning !