University of Lübeck
Institute for Neuro- und Bioinformatics

Madany Mamlouk / Martinetz
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Neuroinformatics (CS4405) • SS 2018

FCT 2

Place and Time: **Ü1**: Thursdays, 09:00-10:00, PC Pool 1+2 (building 64, floor)
Ü2: Thursdays, 10:00-11:00, PC Pool 1+2 (building 64, floor)
Ü3: Fridays, 14:00-15:00, PC Pool 1+2 (building 64, floor)
Website: `https://moodle.uni-luebeck.de/`

Visualization of Linear Classifiers.

Exercise 2.1

Data Visualization. Please download the data file `ueb21.mat` from the moodle-page and load it into MATLAB workspace (see `help load`). The columns in matrix `X` represent N vectors $\vec{x}_i \in \mathbb{R}^2$, their corresponding class labels are found in `Y` with:

$$y_i = \begin{cases} 1 & \text{, if } \vec{x}_i \text{ belongs to class „red circle“} \\ -1 & \text{, if } \vec{x}_i \text{ belongs to class „blue cross“} \end{cases}$$

- Visualize the data in `X` according to `Y` (`help plot`) as red circles resp. blue crosses!

Exercise 2.2

A linear model of a neuron. We are now looking at a linear model of a neuron without temporal dynamics. In this model, the neuron computes the weighted sum of the input values (the components of the input vector $\vec{x}$) and compares this sum to a threshold θ. The output value $y(\vec{x})$ (the state of the neuron) is calculated as follows:

$$y(\vec{x}) = \sigma(\vec{w}^T\vec{x} - \theta)$$

where

$$\sigma(x) = \begin{cases} 1 & \text{, if } x \geq 0 \\ -1 & \text{, if } x < 0 \end{cases}$$

- Implement a MATLAB function `C = neuron_classify(X, w, theta)`, that uses a given weight vector $\vec{w}$ and threshold θ to compute the state $y(\vec{x}_i)$ for each data point $\vec{x}_i$ of `X` . The N-dimensional output vector `C` should contain the neuron states for all data points $\vec{x}_i,\ i = 1, ..., N$.
- Try different values for $\vec{w}$ and θ and visualize the results.
- What is the geometrical influence of the weight vector $\vec{w}$ and threshold θ on the classification? What is the relation between the direction of $\vec{w}$ and the class assignments? What is happening, when you invert the direction of the weight vector?
- How do you need to choose $\vec{w}$ and θ to get a classification `C` for the data points `X` that is equal to the real class labels `Y` (for both `ueb21.mat` and `ueb22.mat`)?

Exercise 2.3

Visualization of a neuron's classification boundary.

For d-dimensional inputs, the weight vector $\vec{w}$ and threshold θ of the neuron model in exercise 2.1 characterize a linear $(d-1)$-dimensional hyperplane in $\mathbb{R}^d$ as classification line. For $\mathbb{R}^2$, implement a MATLAB function `plot_classline(h, w, theta)` that plots the exact classification line in a MATLAB figure. The figure is defined by the figure handle `h` (e.g. `1` for figure 1 or `gcf` for the current figure).
Combine `plot_classline(h, w, theta)` and the given function `plotData` for the data points from `ueb21.mat` to check whether your implementation is correct.

Hints:

- First of all: How is the classification line defined? Think of what formula the points located on the line have to fulfill.
- The window size (i.e. `xmin, xmax, ymin, ymax`) of the figure should not be changed when you plot the classification line (`help axis`).
- A line is defined with two distinct points (`help line`). The intersection points of the line with the figure edges could be a good choice. Think of how you could determine these points. What are possible positions of the classification line in the figure window, i.e. which figure edges could be crossed by the line?

If you have any problems or questions, please contact us via mail or moodle.