IPA 2025W Lab Exercise 4 (15 Points)

Exercise due: January 18th, 2024, 23:55h

Overall a maximum of **15 points**

How to submit your report

Same procedure as for Lab 1. Please hand in via moodle:

- A report of the exercise as PDF document, containing all plots, with captions and a brief description what was done to obtain the plots;
- All code necessary to RUN your solution - please include a lot of comments in the code, and create one run file that generates all plots in your results.

A. Neural Network Decision Boundary

1. What is the decision boundary implemented by a neural network with **n** inputs, a single output neuron and no hidden layer? Explain. [Gonzales&Woods 13.18] ***(2 points)***

B. Classification with a perceptron

1. Create a data set of 2 Gaussians in 2 dimensional space, with 200 points for each of the Gaussians. Gaussians are centred at (1,1) and (3,2) with a standard deviation so that there is minimal overlap between the samples (***narrow data***). Repeat the same experiment with a wider distribution so that the overlap between the point clouds is more substantial (***wide data***).
   1.1. **Plot 1 a and b:** Plot the data (classes indicated by color) in two plots (for narrow and wide). ***(1 points)***
2. Implement
   2.1. a perceptron ***(2 points)***
   2.2. a gradient decent optimizer that trains the perceptron weights (w1w2,w3) based on given training data ***(2 points)***
3. Train the perceptron on each of the data sets, and experiment with different values for alpha (as used in the lecture slides and in Gonzalez & Woods). For each of the two data sets plot the following:
   3.1. **Plot 2 a and b:** values for w1, w2 and w3 over the training iterations for two values of alpha that show different behavior, for ***narrow data***. ***(1 points)***
   3.2. **Plot 3 a and b:** plot the same two plots with the same values of alpha for ***wide data***. ***(1 points)***
   3.3. **Plot 4 a and b:** choose one of the alphas and plot the data and final decision boundary for (a) narrow data and for (b) wide data. ***(1 points)***
4. Discuss your choice of alpha, the time until convergence and any other behavior you observed during the optimization. ***(2 points)***

B. Real data example

1. Download the Iris data set. It consists of features of 3 different plant types (Iris Setosa, Iris Versicolour, Iris Virginica), and each sample is described with a 4 dimensional feature vector (sepal length, sepal width, petal length, petal width):

photo Radomil

photo Kevo

photo D. Gordon E. Robertson

http://archive.ics.uci.edu/ml/datasets/Iris

2. Train a perceptron to classify two of those flower types based on the available features, and test which of the pairs are actually linearly separable (not all of them are).
3. For the pair that is linearly separable, train the perceptron on 80% of the cases, and report the mis-classification error on the remaining 20% of the data. ***(3 points)***