

Deep Learning - Homework 1

99222 - Frederico Silva, 99326 - Sebastião Carvalho

December 8, 2023

Contents

1 Question 1

Medical image classification with linear classifiers and neural networks.

1.1 Question 1.1

1.1.1 Question 1.1 a)

1.1.2 Question 1.1 b)

1.2 Question 1.2

1.2.1 Question 1.2 a)

1.2.2 Question 1.2 b)

2 Question 2

Medical image classification with an autodiff toolkit.

2.1 Question 2.1

2.2 Question 2.2

2.2.1 Question 2.2 a)

2.2.2 Question 2.2 b)

2.2.3 Question 2.2 c)

3 Question 3

3.1 Question 3.1

3.1.1 Question 3.1 a)

Answer To demonstrate that the specified Boolean function cannot be computed by a single perceptron, let's consider a simple case where $D = 2$, $A = -1$, and $B = 1$. The function f is defined as:

$$f(x) = \begin{cases} 1 & \text{if } \sum_{i=1}^D x_i \in [-1, 1], \\ -1 & \text{otherwise} \end{cases}$$

In this setup:

- For $x = (+1, +1)$, the sum $\sum x_i = 2$. Since 2 is not in the range $[-1, 1]$, $f(x) = -1$.
- For $x = (-1, -1)$, the sum $\sum x_i = -2$. Since -2 is also not in the range $[-1, 1]$, $f(x) = -1$.
- For $x = (-1, +1)$ or $x = (+1, -1)$, the sum $\sum x_i = 0$. This falls within the range $[-1, 1]$, so $f(x) = 1$ for these inputs.

The visual representation of the points can be seen in Figure ???. The red points represent the inputs that should be classified as +1 and the blue points represent the inputs that should be classified as -1.

The critical point here is that a single perceptron is fundamentally a linear classifier, which means it can only separate data points using a straight line in the feature space. However, in this example, there is no straight line that can separate these points accordingly in a 2D space to satisfy the function f .

This example thus serves as a counter-example proving that the given function cannot generally be computed with a single perceptron, as it requires a non-linear decision boundary which a single perceptron cannot provide.

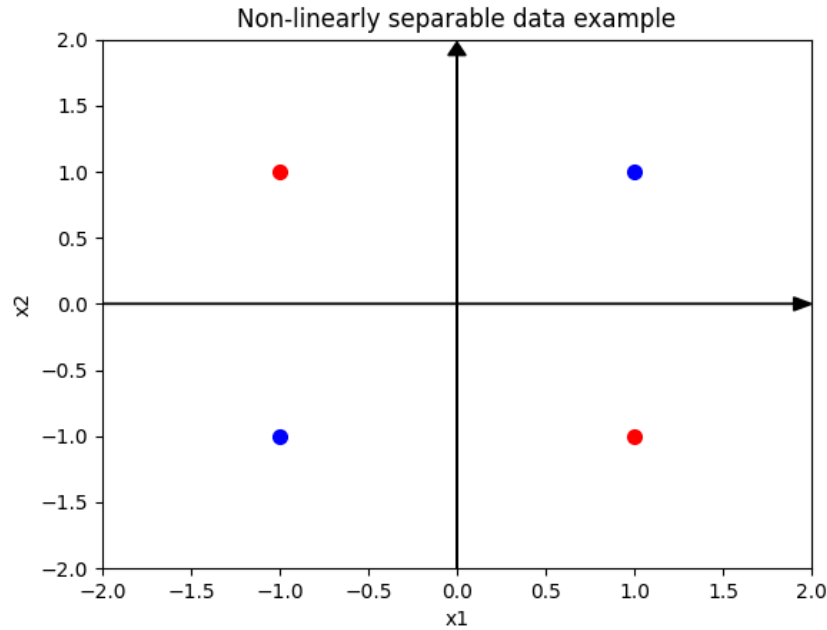


Figure 1: Classification of points using the function f

3.1.2 Question 3.1 b)

3.1.3 Question 3.1 c)