Master Thesis

Optimization of Neural Network

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Declaration of Authorship

I, Martin Bulín MSc., declare that this thesis titled, "Optimization of Neural Network" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.

Signed:

Date:

"*Look deep into nature, and then you will understand everything better.*"

A. Einstein

UNIVERSITY OF WEST BOHEMIA

Abstract

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Engineer (Ing.)

Optimization of Neural Network

by Martin Bulín MSc.

abstract text...

Acknowledgements

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AI	**A**rtificial **I**ntelligence
ANN	**A**rtificial **N**eural **N**etwork

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State of the art text... (Rosenblatt, 1958) (Reed, 1993)

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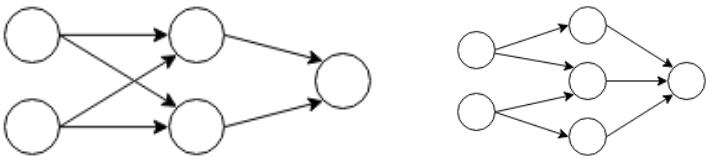
3.1 2D-problem A: XOR function

The standard Exclusive OR (XOR) function is defined by truth Table 3.1. Based on this function one can set a classification problem with two features and two classes.

x_1	x_2	y
0	0	0
0	1	1
1	0	1
1	1	0

TABLE 3.1: Standard XOR function.

This problem serves perfectly for demonstration of network optimization methods, as two optimal architectural solutions producing the XOR function are known (Fig. 3.1).



(A) Solution in 2D. (B) Solution in 3D.

FIGURE 3.1: Optimal network architectures producing the XOR function.

With this knowledge we can proove that the pruning algorithm is (or is not) able to find the optimal solution. If the method is correct, it should end up with one of the shown architectures (Fig. 3.1a or Fig. 3.1b).

The truth Table 3.1 ruled the generation of a 2D dataset illustrated in Fig. 3.2. The two classes are linearly separable and each class consists of 1000 samples. Each sample was randomly assigned to one of the two possible points belonging to its class (e.g. (0,0) or (1,1) for class 0) and then randomly placed in the surounding area within a specified range ($r = \frac{\sqrt{2}}{4}$).

The samples of each class were then splitted into three sets in the following manner: 80% to a training set, 10% to a validation set and 10% to a testing set.

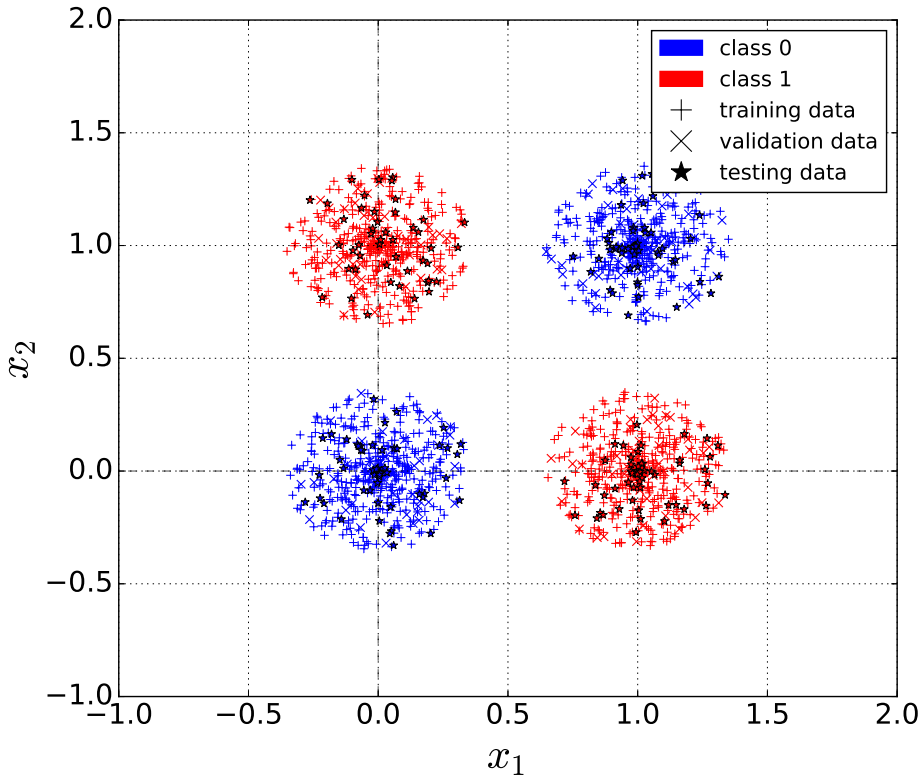


FIGURE 3.2: The XOR dataset.

3.2 2D-problem B: Unbalanced Features

Karnin data...

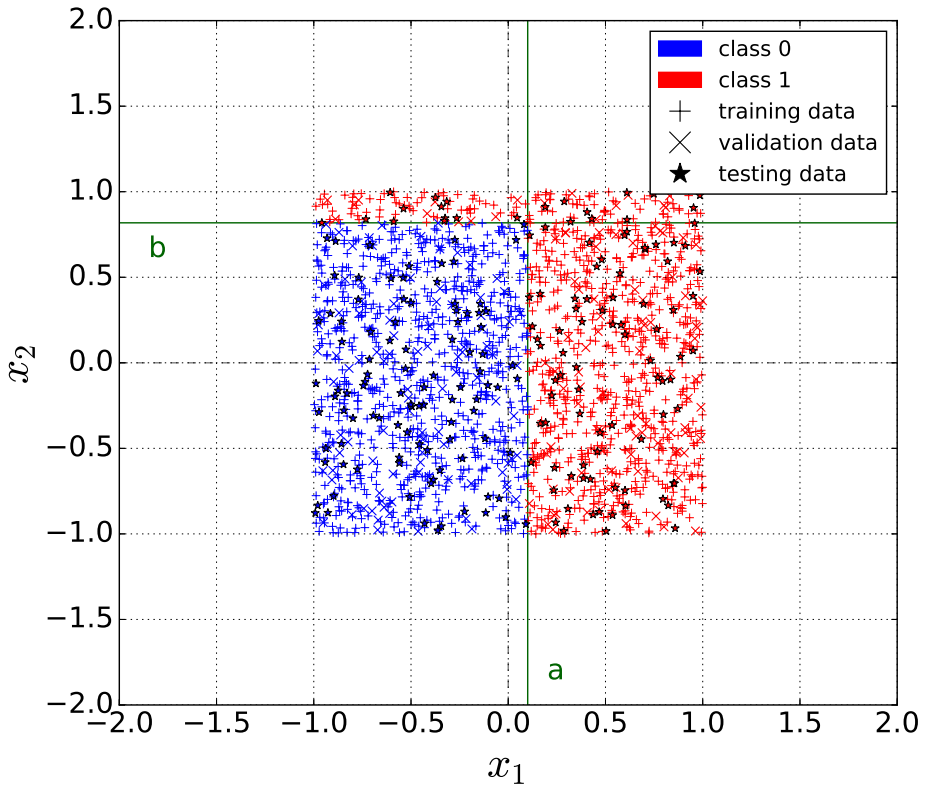


FIGURE 3.3: The dataset with unbalanced features.

3.3 Rule-plus-Exception Problem

RPE data...

3.4 The Train Problem

The Michalski's train problem...

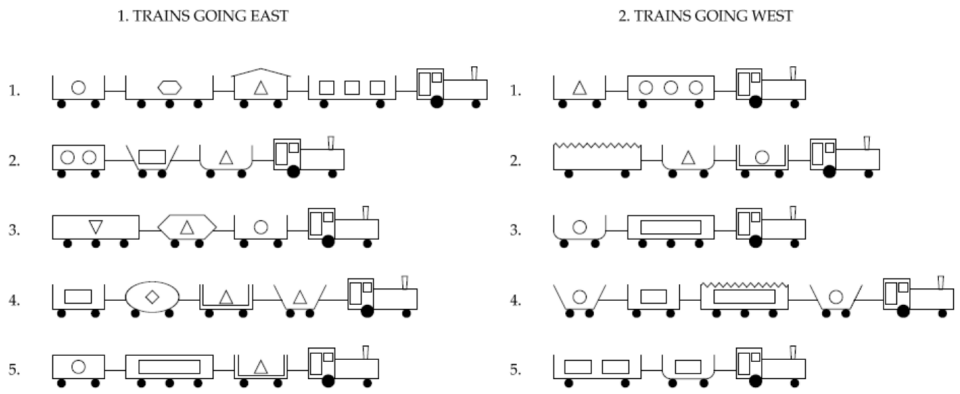


FIGURE 3.4: Michalski's train problem.

3.5 Handwritten digits (MNIST)

MNIST data... (LeCun and Cortes, 1998)

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PHONES data...

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Discussion text...

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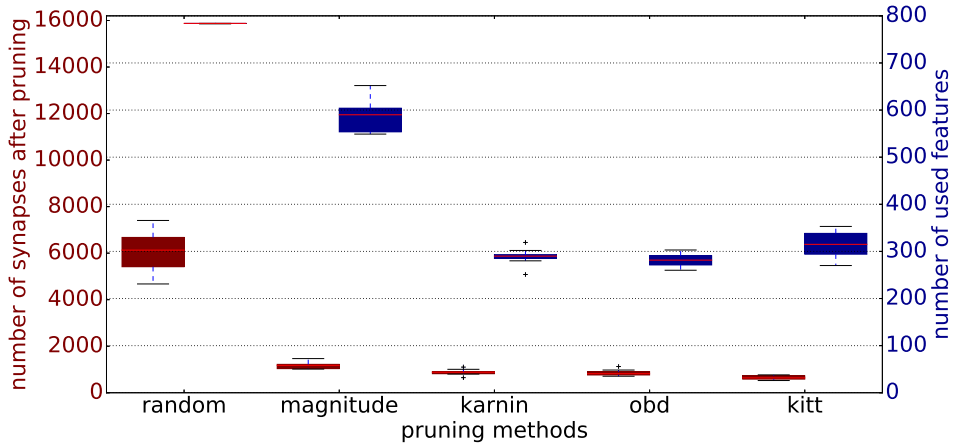

FIGURE 4.1: Caption

Chapter 5

Conclusion and Outlook

Conclusion text...

Outlook text...

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[1] Frank Rosenblatt. “The perceptron: A probabilistic model for information storage and organization in the brain”. In: *Psychological Review* 65 (1958), pp. 386–408.

[2] R. Reed. “Pruning Algorithms - A Survey”. In: *IEEE Transactions on Neural Networks (Volume:4 , Issue: 5)* (Sept. 1993), pp. 740–747. URL: http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=248452.

[3] Yann LeCun and Corinna Cortes. *The MNIST database of handwritten digits*. 1998. URL: http://yann.lecun.com/exdb/mnist/.

Appendix A1

Structure of the Workspace

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