Exam in
Neural Networks and Learning Systems
TBMI26 / 732A55
Home exam - Part I

Date:	2021-03-19
Time:	**14.00 - 16.00** (part 1) and 14.00 - 18.00 (part 2)
Teacher:	Magnus Borga, Phone: 013-28 67 77

Read the instructions before answering the questions!

The full exam consists of two parts:

Part 1 Consists of ten 1-point and five 2-point questions. The questions test general knowledge and basic understanding of central concepts in the course. The answers should be short and given on the blank space after each question or in the indicated figure. **Note that this part needs to be submitted no later than 16:00!**

Part 2 Consists of four 5-point questions. These questions test deeper understanding and the ability to apply the knowledge to solve problems. All assumptions and calculations made should be presented. Reasonable simplifications may be done in the calculations. Part 2 needs to be submitted before 18.00

Students with approved extended examination time (förlängd skrivtid) may divide this extended time between the two parts at their own discretion.

Write your answers by hand and then scan them using a scanner or mobile phone, or write the answers in a separate file using a word processor. The answers may be given in English or Swedish. **If you write by hand, please write clearly using block letters! (Do not use cursive writing.) Answers that are difficult to read, will be dismissed.** The exam should be submitted before the deadline in PDF format. Each part should be handed in as one single PDF file. The PDF files should be named with your LiU-ID followed by a the number of the part of the exam, e.g. 'abcde132-2'.

The maximum sum of points is 20 on each part. To pass the exam (grade 3/C) at least 13 points are required on part 1. For grade 4/B, an additional 10 points on part 2 are required and for grade 5/A, 15 points are required on part 2, in addition to pass part 1.

Note that all forms of collaboration or communication with any person except the course staff is strictly forbidden during the exam!

The result will be reported at 2021-04-13 at the latest.

GOOD LUCK!

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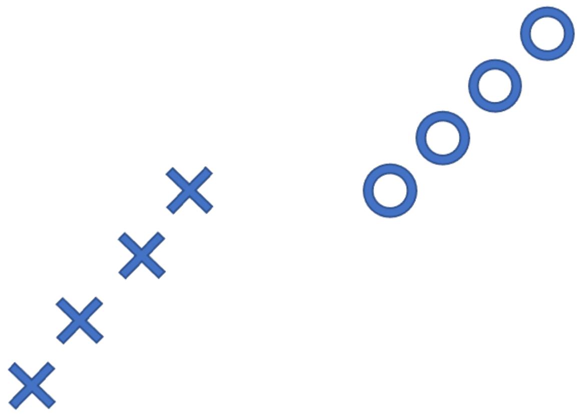
One-point questions

1. Describe the difference in terms of training data between supervised- and un-supervised learning

2. Draw the line for which the discriminant function $f(\mathbf{x}) = 0$ for a linear SVN without slack variables and mark the support vectors in the figure below



3. Draw the line for which the discriminant function $f(\mathbf{x}) = 0$ for a single perceptron with a linear activation function and also for a sigmoid activation function. Mark which is which.

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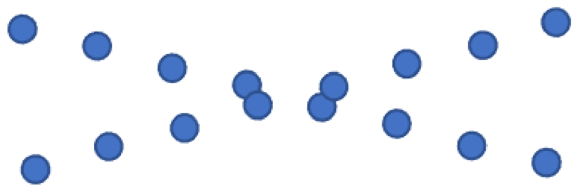
4. Draw the first principal component of the distribution in the figure below!



5. Why is the function $f(s) = \frac{s}{|s|}$ not useful as activation function in a multi-layer back propagation network?

6. What are networks called where some layers are trained to learn $f(\mathbf{x}) - \mathbf{x}$?

7. The following update rule is sometimes used in gradient search:

$$\Delta w_{ji}(t) = \alpha \Delta w_{ji}(t-1) - \frac{\partial \epsilon(t)}{\partial w_{ji}}$$

What is the term $\alpha \Delta w_{ji}(t-1)$ called?

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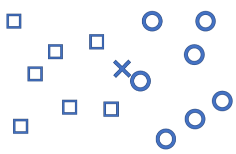
8. What has happened when the validation error is much larger than the training error?

9. Consider the following non-linear mapping from the N-dimensional input space to a non-linear feature space:

$$\varphi(\mathbf{x}) = \begin{pmatrix} e^{-x_1^2} \\ e^{-x_2^2} \\ \vdots \\ e^{-x_N^2} \end{pmatrix}$$

Write the corresponding kernel function $k(\mathbf{x}, \mathbf{y})$.

10. Which class does the data sample 'x' belong to using a k-Nearest Neighbor classifier with $k = 1$ and $k = 3$ respectively?



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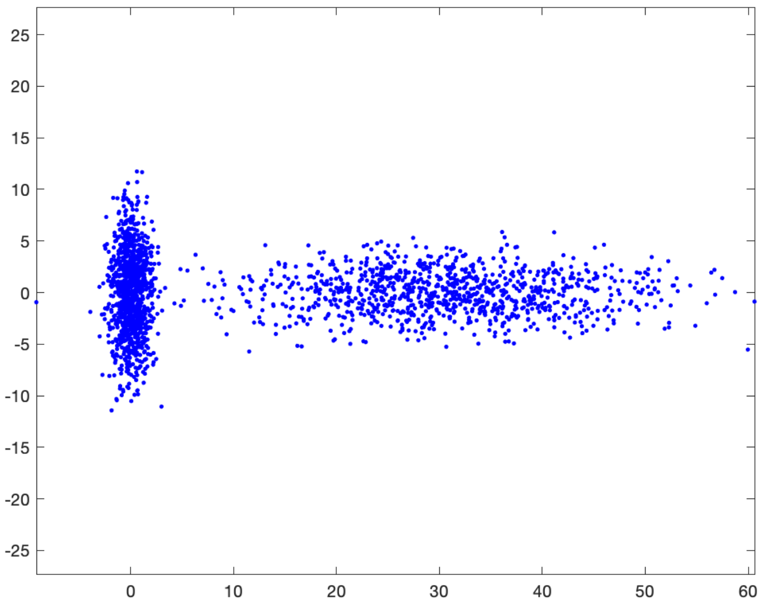
Two-point questions

11. Write a 3-by-3 convolution kernel that detects horizontal lines in an image. The kernel should not be sensitive to the mean intensity of the image neighborhood.

12. Draw the approximate cluster centers and the border between the two classes after successful convergence for (1) a k-means and (2) mixuture of gaussians, assuming two classes (k=2) in both cases. The number of points in each distribution is equal.



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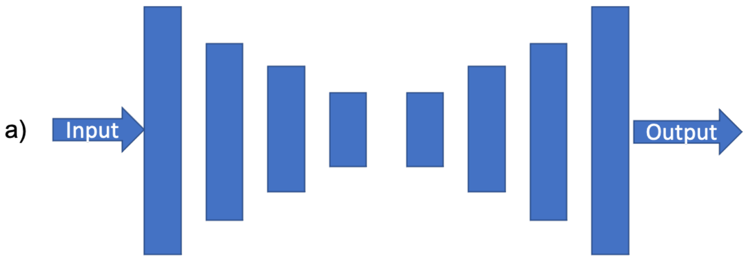
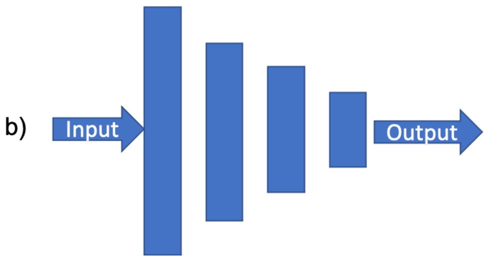
13. Assume you know that the optimal discriminant function for a particular classification problem can be defined as

$$f(\mathbf{x}) = \begin{cases} 1, \text{for } ||\mathbf{x} - \mathbf{k}|| \leq \rho \\ 0, \text{else} \end{cases}$$

Suggest another discriminant function that can be used if you want to adapt the function to your data using gradient descent and write the update equation for the parameters in that function.

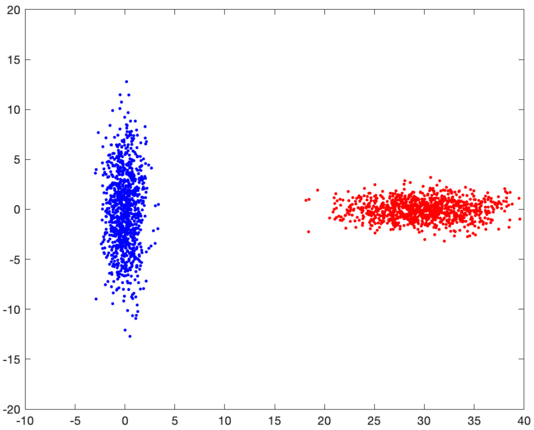
14. Consider the two different network architectures below. The height of each box indicates the size of each layer. Which one could be used for an image classification task and which one could be used for image segmentation? Motivate your answer!





15. Consider the two classification tasks below. In (a), the two classes have the same shape of their distributions except that they are rotated 90 degrees relative to each other. In (b), both classes have isotropic distributions. Show analytically that linear discriminant analysis will give the same solution in (a) and (b). The distributions in (a) and (b) have the same mean.

a)



b)