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

Date: 2020-03-20
Time: **14.00 - 15.30** (part 1) and 15.30 - 18.00 (part 2)
Teacher: Magnus Borga, Phone: 013-286777

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 15:30!**

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. **This part will be published at 15:30.**

You can either edit this PDF in a PDF editor or 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. The PDF files should be named with your LiU-ID followed by a the number of the part of the exam, e.g. "abcde132-1".

The maximum sum of points is 20 on each part. To pass the exam (grade 3/E) at least 15 points are required on part 1. For grade 4/C, 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 2020-04-03 at the latest. The exams will then be available at "studerandeexpeditionen" at IMT.

GOOD LUCK!

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One-point questions

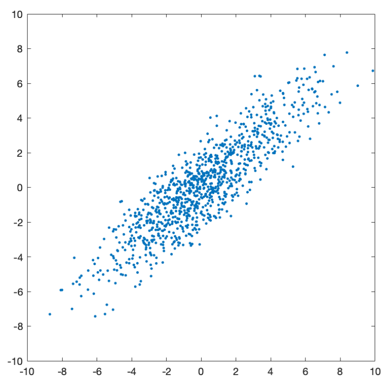
1. Which of the following methods are unsupervised learning methods:

    - Mixture of Gaussians
    - Back-propagation
    - k-NN
    - k-means
    - SVN (Support Vector Machines)
    - PCA (Principal Component Analysis)

2. What output will you get if you use one of the support vectors as input to a Support Vector Machine?

3. What are the two basic requirements on a function for being used as an activation function in the hidden layers of a multi-layer perceptron with back propagation?

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



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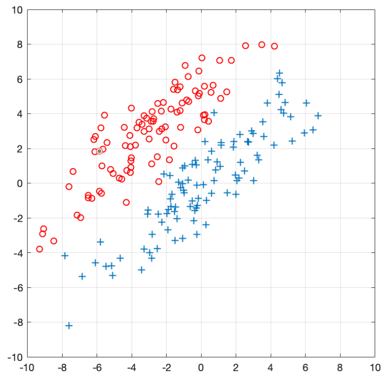
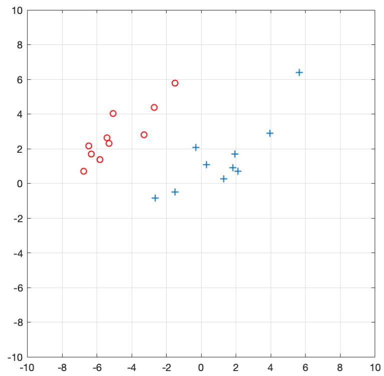
5. We want to train a perceptron to separate the two classes in the figure below. How many parameters w_i do we need to optimize?



6. Draw a plausible separating line and mark the support vectors for a linear SVN in the figure below



7. Assume you have a set of data points in a three-dimensional feature space and you want to cluster the points into two clusters using Mixture of Gaussians. How many scalar numbers need to be estimated in the optimization, disregarding the set membership variables S_i?

8. Consider the following non-linear mapping from the input space to a higher–dimensional feature space:
$$\varphi(x) = \begin{pmatrix} \sin(x) \\ \cos(x) \end{pmatrix}$$
Write the corresponding kernel function $k(x, y)$.

9. How do you measure the generalization error?

10. How should you change the value of k in k-NN if you want to decrease the risk of over-fitting?

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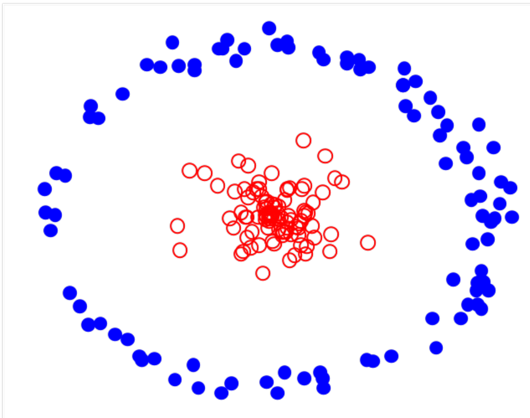
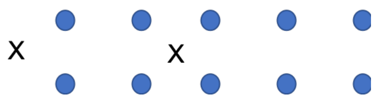
Two-point questions

11. Suggest two kernel functions that can be used to separate the two classes in the figure below by applying the kernel to a linear classifier.



12. Perform two iterations with k-means in the figure below. The dots indicate the data points and the crosses the two prototypes (k=2). Show both steps. Has the algoritm converged after these steps?



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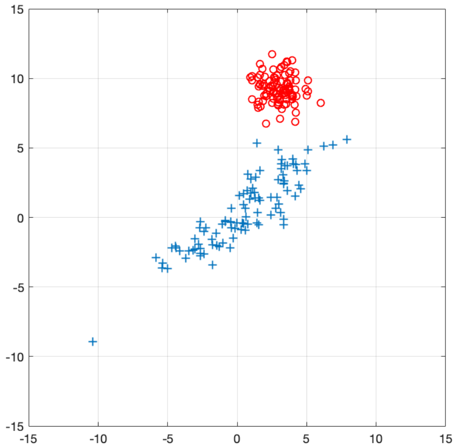
13. Are the two classes in the figure below linearly separable? How will linear discriminant analysis (LDA) perform on this task? Motivate!



14. ~~Draw a decision tree that implements the following discriminant function:~~

$$y = \begin{cases} -1, & \text{for } x_1 \times x_2 < 0 \\ 1, & \text{for } x_1 \times x_2 \geq 0 \end{cases}$$

15. The table below shows the Q-values for different states S_i and actions A_i. What are the value function values $V(S_i)$ for all states and what action will the system take in state 2 if it follows a greedy policy?

Q(S,A)	S_1	S_2	S_3	S_4
A_1	3	2	4	2
A_2	2	5	3	1
A_3	1	3	7	4