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

Date: 2020-08-29
Time: **8.00 - 10.00** (part 1) and 9.30 - 12.00 (part 2)
Teacher: 8.00 - 10.00: Magnus Borga, Phone: 013-28 67 77
10.00 - 12.00: Martin Hulman, Phone: 013-28 68 57

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 10:00!**

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. **This part will be published at 9:30.**

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 2020-09-18 at the latest. The exams will then be available at "studerandeexpeditionen" at IMT.

GOOD LUCK!

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One-point questions

1. Machine learning is often divided into the categories Supervised, Unsupervised and Reinforcement learning. Categorize the following three learning methods accordingly:

   - Q-leaerning
   - k-means
   - kNN (k nearest neighbors)

2. Mention a classifier that uses the *maximum margin* principle.

3. Which of these functions can be used in the hidden layers of a back-prop network?

   - $y = s$
   - $y = \tanh(s)$
   - $y = \frac{s}{\|s\|}$
   - $y = e^{(-s^2)}$

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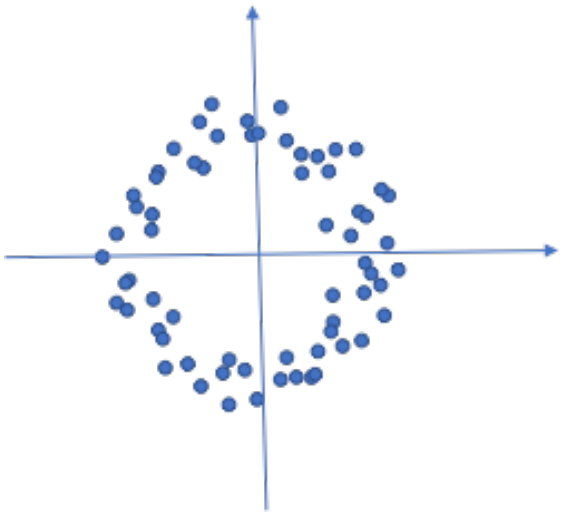
4. What can be said (approximately) about the two eigenvalues of the data covariance matrix for the data points in the distribution below?



5. We want to train a single-layer perceptron to separate objects into two classes. A pre-processing step measures the hight and width of each object and the classification should be based on these features. How many parameters do we have to optimize when we train the perceptron?

6. Assume you have 100 data points in a one-dimensional feature space and you want to cluster the points into three clusters using Mixture of Gaussians. How many scalar numbers need to be estimated in the optimization, disregarding the set membership variables S_i?

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7. What is defined by a kernel function?

8. How can you notice if a supervised machine learning algorithm has overtrained?

9. Mention a classifier that does not use a parameterized discriminant function.

10. If you have 100 training examples and perform a 4-fold cross-validation to evaluate the performance of a classifier, how many times must you train the classifier?

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Two-point questions

11. Consider a polynomial kernel function $\kappa(\mathbf{x}_1, \mathbf{x}_2) = 1 + (\mathbf{x}_1^T \mathbf{x}_2)^2$. What is the distance between two feature vectors

$$\mathbf{x}_1 = \begin{pmatrix} 1 \\ 1 \end{pmatrix} \text{ and } \mathbf{x}_2 = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$$

in the new feature space defined by this kernel function?

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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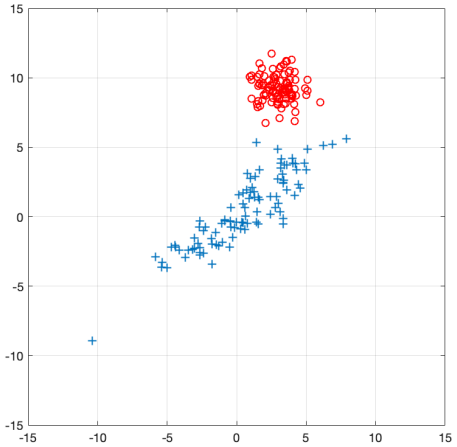
13. We want to train a simple classifier on the data in the figure below. Draw the approximate zero-crossing of the resulting discriminant function if (a) a linear perceptron is used and (b) a linear SVM is used.



14. ReLU activation functions are more and more used in neural networks instead of the tanh activation function. Draw both activation functions and give a) an advantage of the ReLU function compared to the tanh function. b) a disadvantage of the ReLU function compared to the tanh function.

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

$$y = \begin{cases} -1, \text{ for } (x < -1) \text{ OR } (x > 1) \\ 1, \text{else} \end{cases}$$