Exam

When and Where:

- **When:** March, 26. 08:00 - 10:00 (duration is 90 min, starting from 08:30.) **Be there at 08:00!**
- **Where:** Zelt auf dem Forum (großes Zelt)

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Karlsruhe Institute of Technology

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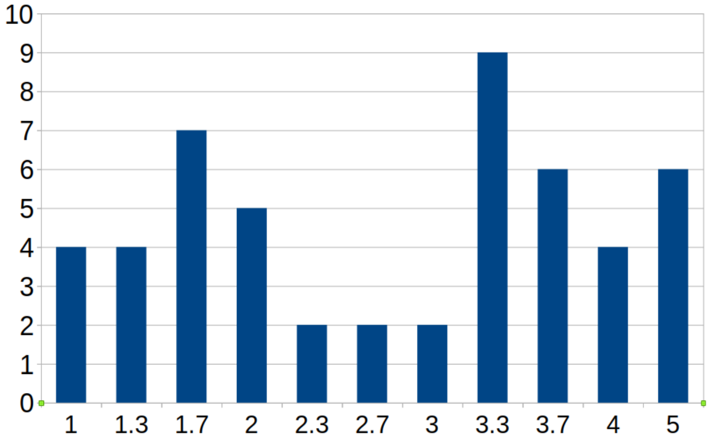
Rules:

- There will be 30 questions - see examples on following slides.
- You can bring a cheat-sheet. One A4-sheet, handwritten, you can write on both sides!
- There will **not** be python in the exam.

Overview Results Last Year



This was without bonus!

Example Question 1

Question:
Under which assumptions is the least squares objective from linear regression equivalent to a maximum likelihood objective?

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Answer:
Gaussian likelihood with linear mean and constant noise.

Example Question 2

Question:
Write down the objective of linear binary logistic regression. The samples are given by $\boldsymbol{x}_i$ and the labels by $c_i \in \{0, 1\}$.
How is $p(c_i|\boldsymbol{x}_i)$ assumed to be distributed in binary logistic regression?

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Write down the objective of linear binary logistic regression. The samples are given by $\boldsymbol{x}_i$ and the labels by $c_i \in \{0, 1\}$.
How is $p(c_i|\boldsymbol{x}_i)$ assumed to be distributed in binary logistic regression?

Answer:

$$\text{argmax}_{\boldsymbol{w}} \sum_{i=1}^{N} c_i \log(\sigma(\boldsymbol{w}^T\boldsymbol{x}_i)) + (1 - c_i)\log(1 - \sigma(\boldsymbol{w}^T\boldsymbol{x}_i))$$

Logistic regression assumes $p(c_i|\boldsymbol{x}_i)$ to be Bernoulli distributed

Example Question 3

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Question:

What are the hyperparameters for choosing the model complexity for each of the following algorithms. Name at least one hyperparameter for every algorithm.

- Neural Networks
- Support Vector Machines
- Gaussian Processes
- Decision Trees?

Example Question 3

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Answer:

- Neural Networks: number of layers, number of neurons
- Support Vector Machines: which features to choose (also kernel bandwidth included), regularization
- Gaussian Processes: kernel bandwidth , prior
- Decision Trees: maximum depth, number of leaves

Example Question 4

Question:

Name at least two advantages and two disadvantages of decision trees.

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Answer:

Advantages:

- Applicable to both regression and classification problems.
- Handle categorical predictors naturally.
- Computationally simple and quick to fit, even for large problems.
- No formal distributional assumptions (non-parametric).
- Can handle highly non-linear interactions and classification boundaries.
- Very easy to interpret if the tree is small.

Disadvantages:

- Accuracy: current methods, such as support vector machines and ensemble classifiers often have 30% lower error rates than CART.
- Instability: If we change the data a little, the tree picture can change a lot. So the interpretation is not as straightforward as it appears.

Example Question 5

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Answer:
KD-Trees
Building the tree:

- Choose dimension (e.g., longest hyper-rectangle).
- Choose median as pivot
- Split node according to (pivot, dimension)

Example Question 6

Question:

First, explain the intuition behind slack-variables in support vector machine training.

Second, for a single data-point $(\boldsymbol{x}_i, c_i)$ the margin condition with slack variable ξ_i is given as

$$c_i(\boldsymbol{w}^T \boldsymbol{x}_i + b) \geq 1 - \xi_i.$$

- Assuming $0 \leq \xi_i \leq 1$, is $\boldsymbol{x}_i$ classified correctly?
- Assuming $\xi_i > 1$, is $\boldsymbol{x}_i$ classified correctly?

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- Assuming $\xi_i > 1$, is $\boldsymbol{x}_i$ classified correctly?

Answer: One of the following

- Allow violation of margin condition
- Act as regularization, avoid over-fitting
- Make constraint optimization problem solvable, even if the data is not linearly separable

Other Questions

- Yes, (but margin is violated)
- No

Example Question 7

Question:

You are given the following optimization problem:

$$\underset{a}{\operatorname{argmax}}\ a^2 h$$
$$s.t.\ \ S_{max} \geq 2a^2 + 4ah$$

Write down the Lagrangian. Derive the optimal value for a depending on your lagrangian multiplier.

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Question:

You are given the following optimization problem:

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Write down the Lagrangian. Derive the optimal value for a depending on your lagrangian multiplier.

Answer:

$$L = a^2 h + \lambda(S_{max} - 2a^2 - 4ah)$$
$$\frac{dL}{da} = 2ah - 4\lambda a - 4\lambda h$$
$$a^* = \frac{4\lambda h}{2h - 4\lambda}$$

(The sign in the Lagrangian may change. But the following equations should be correct according to the Lagrangian.)

Example Question 8

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What is the key idea behind second order optimization methods? What are their benefits? Why are second order optimization methods usually not applicable for Deep Neural Networks?

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Answer:

- To use the second derivative (Hessian) of the objective and directly step towards the minimum of the quadratic approximation.
- No learning rate needs to be tuned and they need fewer function evaluations.
- Because the Hessian is huge and needs to be inverted.

Example Question 9

Question:
Why is it not feasible to use fully connected layer for images? How do convolutional neural networks solve this problem and which property of an image do they exploit.

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Answer:

- They have to many parameters
- less parameters by parameter sharing
- They exploit spatial structure

Example Question 10

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Gaussian Processes(GP) are also referred to as a ”Bayesian Kernel Regression” approach. Why?

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Answer:
You can derive Gaussian Processes by using the Kernel Trick from Bayesian Linear Regression, as in Kernel Regression.