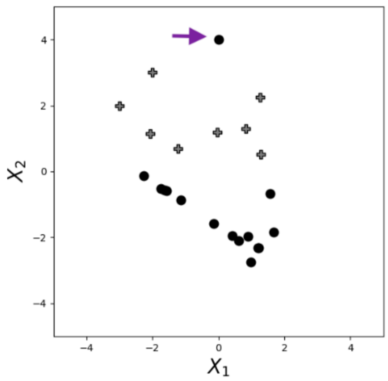
Exam exercises Methods in AI Research

Exam Exercises Machine Learning and NLP

1. Decision Boundaries

You have a training set with two classes. Each instance has two features. See the plot below:



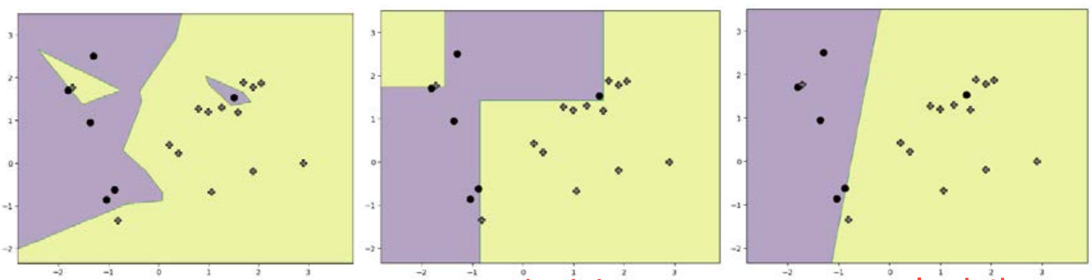
a. True or False: A classifier with a linear decision boundary will be able to achieve zero training error.

One point (marked with an arrow) seems to be an outlier. What will happen when we remove this point from the training set?

b. True or False: The decision boundary of a 3-nearest neighbor classifier will stay the same.

c. True or False: The decision boundary of a logistic regression classifier will stay the same.

d. The figures below show the decision boundaries of three classifiers: a logistic regression model, a decision tree, and a 1-nearest neighbor classifier. Match the classifiers with the decision boundaries (i.e. A=?, B=?, C=?).



n-nearest neighbour
A

decision tree
B

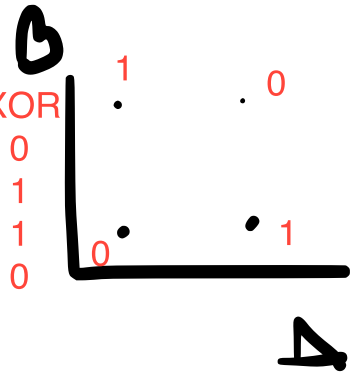
logistic regression (always linear)
C

2. Decision Trees and Logistic Regression

a. True or false: A decision tree with no maximum depth is more likely to overfit.

b. True or False: The Euclidean distance treats each feature as equally important.

A	B	XOR
0	0	0
1	0	1
0	1	1
1	1	0



c. True or False: The Manhattan distance treats each feature as equally important.

d. True or False: A classifier trained on more training data is more likely to overfit.

e. In the lecture we have seen the XOR problem (1pt).

1. True or False: A decision tree with level 2 (i.e. 2 levels of splits, resulting in four leaf nodes) can achieve zero training error.
2. True or False: A logistic regression model with no regularization can achieve zero training error.

2. Natural Language Processing

a. One preprocessing step in natural language processing is lowercasing (e.g. transforming ‘Hello’ to ‘hello’). Is this always a good idea? Explain why (not).

b. Provide a short description of two other preprocessing steps that are commonly used.

We have the following two sentences:

1) he eats breakfast
2) the dog eats

c. What is the Jaccard similarity between these two sentences? 1/5

d. What is the cosine similarity between these two sentences when each sentence is represented by a vector with the frequency counts of the words?

2. Speech Acts

a. “I will repay the money” is an assertive/commissive/directive/expressive/declaration according to Searle’s Speech Act taxonomy.

b. “Can you move, please” is an assertive/commissive/directive/expressive/declaration according to Searle’s Speech Act taxonomy.

EXAM EXERCISES COGNITIVE MODELING & EXPERIMENTATION

1. COGNITIVE MODELS

a. In the lecture on cognitive modelling, Chris Janssen explained what the benefits are of using such models. Please briefly state two general advantages of using user models for practice. (NB: I am looking for general advantages, not for specific case studies).

b. Cognitive models can be developed at different 'levels of abstraction' (see also Anderson, 2002; Cooper & Peebles, 2015; and Chris' class). Consider this case study: Bonnie wants to create a model of driver distraction. Her research question is: how does the car's lane deviation change as a function of the amount of time that a driver glances at their mobile phone and not at the road? She has access to experimental data from 20 participants on the following aspects:

- Eye-movement data: where do the participants look over time?
- Data on the participant's interaction with the car (e.g., pedal presses, steering wheel angle, gear shifts)
- Data on the car's position within the lane over time
- Data of what the participant sees and does on their smart phone (e.g., which screens are open, what buttons are being pressed)

Now, Bonnie wants to model this behavior at an appropriate level of abstraction. *Explain* which of *Newell's bands* is most appropriate to model human behavior for this situation.

2. EXPERIMENTATION

a. Draw the steps of the empirical cycle in a diagram, including the arrows

b. In Chris Janssen's second lecture and in the paper by Cairns (2016), you heard about the topic of validity. Consider this case study: Jane conducted an IQ test on 600 AI Bachelor students using a validated, standardized IQ test. She found that older participants had higher IQ scores than younger students. She concludes that older people have higher IQs in general.

Explain which *type of validity*, as discussed by Cairns, is breached when making this conclusion.

Exam exercises reasoning

1. Knowledge-based reasoning

a. Which class of human beings is described by the following concept?

$$(\exists\text{friend.Female}) \sqcap (\neg\exists\text{friend.Male})$$

b. Translate the concept in the previous exercise in FOL.

c. Translate the following FOL sentence in DL and describe the concept in natural language.

$$\forall y(friend(x,y) \rightarrow (Male(y) \wedge \exists z(friend(y,z) \wedge Female(z)))$$

d. Is any subset of the set of sentences that are valid in FOL undecidable? If yes, explain in three sentences. If not, provide a counter example.

e. Show using models that $\forall x\exists yR(x,y) \nvDash \exists x\forall yR(x,y)$.

f. Write a sentence that denotes the property "the domain has more than two elements", meaning a sentence that holds exactly in those models that have more than two elements.

g. Given a language with two unary predicates $P(x)$ and $R(x)$, write down in FOL the sentence "for all elements, if P holds for the element, there is another element for which R does not hold".

2. Symbolic vs Subsymbolic AI

Does DL belong to the symbolic or the sub-symbolic approach to AI?

3. Human reasoning

a. Describe the Wason Selection Task and two possible interpretations of the task.

b. Recall that the Syllogism Task uses the following abbreviations:

Axy - all x are y	Ixy - some x are y
Exy - no x is y	Oxy - some x are not y

Give an example of a syllogism about which human's reason differently than according to FOL.

3. Argumentation

a. Take the following logical statements. $Bird$ denotes *this animal is a bird*, $Penguin$ denotes *this animal is a penguin*, $Flies$ denotes *this animal can fly*. There are two ways in classical logic we can attempt to model *if this animal is a bird, it can fly, unless it is a penguin (in which case it cannot fly)*.

Attempt A:
$$Bird \rightarrow Flies$$
$$Bird \wedge Penguin \rightarrow \neg Flies$$

Attempt B:
$$Bird \wedge \neg Penguin \rightarrow Flies$$
$$Bird \wedge Penguin \rightarrow \neg Flies$$

What are the problems we run into when modeling the statement in the above two ways?

b. Using structured argumentation, we can model *if this animal is a bird, it can fly, unless it is a penguin in which case it cannot fly* as follows

Ruleset $\mathcal{R}_d$: $r_1: Bird \Rightarrow Flies$
$r_2: Penguin \Rightarrow \neg Flies$
$r_3: Penguin \Rightarrow \neg r_1$

Now, take the knowledge base $\mathcal{K} = \{Bird, Penguin\}$. Which arguments can we build? And how do these arguments attack each other?

c. Give the preferred extension(s) of the following three argumentation frameworks.