Name:

Birth Date:

Matriculation Number:

Exam
Artificial Intelligence 2

Feb. 13., 2019

	To be used for grading, do not write here														
prob.	1.1	1.2	1.3	2.1	2.2	3.1	3.2	3.3	4.1	4.2	4.3	5.1	5.2	Sum	grade
total	4	3	7	12	12	4	3	8	4	8	8	5	6	84	
reached															

Exam Grade: Bonus Points: Final Grade:

Organizational Information

Please read the following directions carefully and acknowledge them with your signature.

1. Please place your student ID card and a photo ID on the table for checking
2. The grading information on the cover sheet holds with the proviso of further checking.
3. no resources or tools are allowed except for a pen.
4. You have 90 min(sharp) for the test
5. You can reach 84 points if you fully solve all problems. You will only need 80 points for a perfect score, i.e. 4 points are bonus points.
6. Write the solutions directly on the sheets.
7. If you have to abort the exam for health reasons, your inability to sit the exam must be certified by an examination at the University Hospital. Please notify the exam proctors and have them give you the respective form.
8. Please make sure that your copy of the exam is complete (20 pages including cover sheet and organizational information pages) and has a clear print. **Do not forget to add your personal information on the cover sheet and to sign this declaration (next page).**

Declaration: With my signature I certify having received the full exam document and having read the organizational information above.

Erlangen, Feb. 13., 2019 .....

(signature)

Organisatorisches

Bitte lesen die folgenden Anweisungen genau und bestätigen Sie diese mit Ihrer Unterschrift.

1. Bitte legen Sie Ihren Studentenausweis und einen Lichtbildausweis zur Personenkontrolle bereit!
2. Die angegebene Punkteverteilung gilt unter Vorbehalt.
3. Es sind keine Hilfsmittel erlaubt außer eines Stifts.
4. Die Lösung einer Aufgabe muss auf den vorgesehenen freien Raum auf dem Aufgabenblatt geschrieben werden; die Rückseite des Blatts kann mitverwendet werden. Wenn der Platz nicht ausreicht, können bei der Aufsicht zusätzliche Blätter angefordert werden.
5. Wenn Sie die Prüfung aus gesundheitlichen Gründen abbrechen müssen, so muss Ihre Prüfungsunfähigkeit durch eine Untersuchung in der Universitätsklinik nachgewiesen werden. Melden Sie sich in jedem Fall bei der Aufsicht und lassen Sie sich das entsprechende Formular aushändigen.
6. Die Bearbeitungszeit beträgt 90 min.
7. Sie können 84 Punkte erreichen, wenn Sie alle Aufgaben vollständig lösen. Allerdings zählen 80 Punkte bereits als volle Punktzahl, d.h. 4 Punkte sind Bonuspunkte.
8. Überprüfen Sie Ihr Exemplar der Klausur auf Vollständigkeit (20 Seiten inklusive Deckblatt und Hinweise) und einwandfreies Druckbild! **Vergessen Sie nicht, auf dem Deckblatt die Angaben zur Person einzutragen und diese Erklärung zu unterschreiben!**

Erklärung: Durch meine Unterschrift bestätige ich den Empfang der vollständigen Klausurunterlagen und die Kenntnisnahme der obigen Informationen.

Erlangen, Feb. 13., 2019 .....

(Unterschrift)

Please consider the following rules; otherwise you may lose points:

- If you continue an answer on another page, please indicate the problem number on the new page and give a page reference on the old page.
- Always justify your statements (we would like to give poins for incorrect answers). Unless you are explicitly allowed to, do not just answer "yes", "no", or "42".
- If you write program code, give comments!

1 Bayesian Reasoning

Problem 1.1 (Bayesian Rules)
Name four of the basic rules in Bayesian inference and explain each with a short sentence and formula. 4 pt

Problem 1.2 (Conditional Independence)
Define *conditional independence*. 3 pt

Problem 1.3 (Medical Bayesian Network 2)

Both smoking and living in a city with high air pollution can cause lung cancer, which can be indicated by a patient coughing up blood. We consider the following random variables for a given patient: 7 pt

- *Smoke*: The patient is a smoker.
- *Smog*: The patient lives in a polluted city.
- *Blood*: The patient is coughing up blood.
- *LC*: The patient has lung cancer.

1. Draw the corresponding Bayesian network for the above data using the algorithm presented in the lecture, assuming the variable order $Smoke, Smog, Blood, LC$. Explain rigorously(!) the exact criterion for whether to insert an arrow between two nodes.
2. Which arrows are causal and which are diagnostic? Which order of variables would be better suited for constructing the network?
3. How do we compute the probability the patient is a smoker, given that they have lung cancer? State the query variables, hidden variables and evidence and write down the equation for the probability we are interested in.

This page was intentionally left blank for extra space

2 Decision Theory

Problem 2.1 (Markov Decision Procedures)

12 pt

1. How do Markov decision procedures differ from (simple) decision networks?
2. How does the value iteration algorithm work? (Give an actual equation and explain its role in the algorithm)
3. What is the disadvantage of value iteration that is "fixed" by policy iteration?
4. How can we reduce *partially observable Markov decision procedures* to normal MDPs?

Problem 2.2 (Decision Network)

You try to decide on whether to take an umbrella to Uni. Obviously, it's useful to do so if it rains when you go back home, but it's annoying to carry around if it doesn't even rain. You look at the weather forecast, which hast three possible values: sunny, cloudy and rainy. 12 pt

1. Draw the decision network for bringing/leaving an umbrella depending on whether it does or doesn't rain later.

2. Explain *formally* how to compute whether or not to take an umbrella, assuming you know $P(rain = b | forecast = x)$ for all $b \in \texttt{Bool}, x \in \{\texttt{sunny}, \texttt{cloudy}, \texttt{rainy}\}$.

This page was intentionally left blank for extra space

3 Markov Models

Problem 3.1 (Bellman Equation)
State the Bellman Equation and explain 1) every symbol in the equation and 2) what the 4 pt
equation is used for and how.

Problem 3.2 (Stationary)
Define what it means for a Markov model to be *stationary*, and why we are interested in stationarity. 3 pt

Problem 3.3 (Sleeping Patterns Predictions)

Your room mate tends to keep you up by blasting music whenever they are awake. Notably, they tend to sleep a lot less when they are stressed (binary variable St), but since you don't talk to each other you never know when they are. You only observe whether they sleep a lot (Sl) or little ($\neg Sl$). Stress seems to come in phases and last for a couple of days, so if they are stressed at day t, they will more likely be stressed at day $t+1$ as well (and analogously for $\neg St$). 8 pt

1. Model this situation as a Markov Model and explain what the *prediction*, *filtering* and *smoothing* algorithms compute in this scenario.

2. Give the underlying equations for the first two of these algorithms and explain what each variable in the equation represents.

This page was intentionally left blank for extra space

4 Learning

Problem 4.1 (Overfitting)
Explain what *overfitting* means and why we want to avoid it. 4 pt

Problem 4.2 (Home Decisions)

Eight people go sunbathing. Some of them got a sunburn, others didn't: 8 pt

Name	Hair	Height	Weight	Lotion	Result
Sarah	Blonde	Average	Light	No	Sunburned
Dana	Blonde	Tall	Average	Yes	None
Alex	Brown	Short	Average	Yes	None
Annie	Blonde	Short	Average	No	Sunburned
Julie	Blonde	Average	Light	No	None
Pete	Brown	Tall	Heavy	No	None
John	Brown	Average	Heavy	No	None
Ruth	Blonde	Average	Light	No	None

Explain how the information-theoretic decision tree learning algorithm would proceed on this table (up to two iterations). Explicitly state how to compute the information gain (and what that means).

Note that you do not need to compute any actual values; if it is helpful for your explanation, you may guess any values you might want to use.

Note that *Name* is only an index, not a (meaningful) attribute!

Problem 4.3 (Backpropagation)

Explain what *Backpropagation* means in the context of Neural Networks, when and why we need it, and how to do it using an example. 8 pt

This page was intentionally left blank for extra space

5 Communication with Natural Language

Problem 5.1 (Ambiguity)

5 pt

1. Explain the concept of ambiguity of natural languages.
2. Give two examples of different kinds of ambiguity and explain the readings.

Problem 5.2 (Language Identification)

You are given an English, a German, a Spanisch, and a French text corpus of considerable size, and you want to build a language identification algorithm A for the EU administration. Concretely A takes a string as input and classifies it into one of the four languages $\ell^* \in \{English, German, Spanish, French\}$. The prior probability distribution for the strings being English/German/Spanisch/French, is $\langle 0.4, 0.2, 0.15, 0.15\rangle$. 6 pt

How would you proceed to build algorithm A? Specify the general steps and give/derive the formula for computing ℓ given a string $\mathbf{c}_{1:N}$.

This page was intentionally left blank for extra space

This page was intentionally left blank for extra space

This page was intentionally left blank for extra space