Name:

Birth Date:

Matriculation Number:

Exam
Artificial Intelligence 2

Feb. 14., 2019

	To be used for grading, do not write here												
prob.	1.1	1.2	1.3	1.4	2.1	2.2	2.3	3.1	3.2	4.1	4.2	Sum	grade
total	4	4	7	7	4	10	12	3	10	10	4	75	
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 75 points if you fully solve all problems. You will only need 125 points for a perfect score, i.e. -50 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 (17 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. 14., 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 75 Punkte erreichen, wenn Sie alle Aufgaben vollständig lösen. Allerdings zählen 125 Punkte bereits als volle Punktzahl, d.h. -50 Punkte sind Bonuspunkte.
8. Überprüfen Sie Ihr Exemplar der Klausur auf Vollständigkeit (17 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.

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(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 (Causal and Diagnostic)

State the difference between *causal* and *diagnostic* edges in (e.g.) a Bayesian network. Use no more than four sentences. 4 pt

Problem 1.3 (Medical Bayesian Network)

Dyspnea (shortness of breath) can be caused by several medical conditions; among them lung cancer, tuberculosis and bronchitis. Tuberculosis and cancer lead to abnormal x-ray results. Lung cancer and bronchitis can be caused by SMOKING, tuberculosis occurs more often in asia. We use the following random variables for some given patient: 7 pt

- $Asia$: The patient recently visited asia.
- $Smoke$: The patient is a smoker.
- TBC: The patient has tuberculosis.
- LC: The patient has lung cancer.
- $Bron$: The patient has bronchitis.
- $Xray$: The patient's X-ray result is abnormal.
- $Dysp$: The patient is short of breath.

Model the dependencies stated above as a bayesian network, choosing a suitable(!) ordering of the variables. **Justify** your choices.

Problem 1.4 (Stochastic Wumpus)

Robby lives in Wumpus world and wants to visit field F_1. He is pretty confident, that the Wumpus is not in field F_1 (call that event $\neg W_1$); in fact, he is 90% sure. He thinks the Wumpus is probably in field F_2 (call that event W_2) with 60% confidence. Robby also thinks, that places without a Wumpus should rarely stink (in only 20% of cases), whereas every field with a Wumpus stinks. 7 pt

Unfortunately, when Robbie approaches F_1, he notices a stench (call that event S_1).

1. Give that F_1 stinks, how should Robbie update his belief that the Wumpus is not in F_1? How does the probability change, that it is in F_2? *Do not compute actual values* - a formula how to compute them is sufficient!

2. Assume the updated values from the previous subexercise given. Just to be sure, Robbie takes a slight detour to F_2 and notices that it stinks there as well (call that event S_2). Given this new piece of information, how should Robbie update his beliefs, that a) the Wumpus is in F_2 and b) he is not in F_1? (Again, a formula is sufficient!)

3. Which random variables in this example are conditionally independent given which other random variable?

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2 Decision Theory

Problem 2.1 (Expected Utility)
What is the formal(!) definition of *expected utility*? Explain every variable in the defining equation. 4 pt

Problem 2.2 (Textbook Decisions)

Abby has to decide whether to buy Russell&Norveig for 100$. There are three boolean variables involved in this decision: B indicating whether Abby buys the book, M indicating whether Abby knows the material in the book perfectly anyway and P indicating that Abby passes the course. Additionally, we use a utility node U. 10 pt

Abbys utility function is additive, so $U(B) = -100$. Furthermore, she evaluates passing the course with a utility of $U(P) = 2000$. The course has an open book final exam, so B and P are not independent given M. Assume the following conditional probabilities as given:

- $P(P|B, M)$
- $P(P|B, \neg M)$
- $P(P|\neg B, M)$
- $P(P|\neg B, \neg M)$
- $P(M|B)$
- $P(M|\neg B)$

1. Draw the decision network for this problem.
2. Explain formally how to compute the expected utility of buying the book and of not buying it.

Problem 2.3 (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?

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3 Markov Models

Problem 3.1 (Stationary)
Define what it means for a Markov model to be *stationary*, and why we are interested in stationarity. 3 pt

Problem 3.2 (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 $\neg St$). 10 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.

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4 Learning

Problem 4.1 (Tennis Trees)
Consider the following decisions on whether or not to go play tennis. The target is "PlayTennis". 10 pt

Outlook	Temperature	Humidity	Wind	PlayTennis
Sunny	Hot	High	Weak	No
Overcast	Hot	High	Weak	Yes
Rain	Mild	High	Weak	Yes
Rain	Cool	Normal	Strong	No
Rain	Mild	Normal	Weak	Yes

Explain how to apply decision tree learning to this table. In particular, define the notion of *information entropy*.

Problem 4.2 (Overfitting)
Explain what *overfitting* means and why we want to avoid it. 4 pt

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