Name:

Birth Date:

Matriculation Number:

Final Exam
Künstliche Intelligenz 2

Aug 01., 2017

	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	3.3	4.1	4.2	4.3	Sum	grade
total	8	6	14	8	8	8	20	8	16	8	8	6	20	138	
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 138 points if you fully solve all problems. You will only need 125 points for a perfect score, i.e. 13 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 (16 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, Aug 01., 2017 .....

(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 138 Punkte erreichen, wenn Sie alle Aufgaben vollständig lösen. Allerdings zählen 125 Punkte bereits als volle Punktzahl, d.h. 13 Punkte sind Bonuspunkte.
8. Überprüfen Sie Ihr Exemplar der Klausur auf Vollständigkeit (16 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, Aug 01., 2017 .....

(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. 8 pt

Problem 1.2 (Conditional Independence)
Define *conditional independence*. 6 pt

Problem 1.3 (Nuclear Test)

Assume it is your responsibility to monitor the Nuclear Test Ban treaty. You receive data from two different stations (seismometers), S_1 and S_2. Each S_i is modeled as a Boolean variable where "true" stands for "I detected a Nuclear test" and "false" stands for "I did not detect a Nuclear test". The seismometers are not fully reliable, however; they may not detect a Nuclear test even though there was one, and they may mistake an earthquake for a Nuclear test. We model this situation with two additional Boolean variables: N for Nuclear test, and E for Earthquake. 14 pt

Use the algorithm from the lecture to construct a Bayesian network for these 4 variables. More precisely:

1. State the exact formal condition for when the algorithm inserts an edge between two nodes. 6 pt
2. Execute the algorithm for the variable order $X_1 = N$, $X_2 = E$, $X_3 = S_1$, $X_4 = S_2$. 8 pt

Justify your decisions.

Problem 1.4 (Causal and Diagnostic)

State the difference between *causal* and *diagnostic* edges in (e.g.) a Bayesian network. Use no more than four sentences. 8 pt

2 Decision Theory

Problem 2.1 (Decision Preferences)

8 pt

1. Name and state three of the axioms for preferences (i.e. $\succ$).
2. How are preferences related to value functions?

Problem 2.2 (Expected Utility)

What is the formal(!) definition of *expected utility*? Explain every variable in the defining equation. 8 pt

Problem 2.3 (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. 20 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 conditional probabilities $P(P|B, M)$, $P(P|B, \neg M)$, $P(P|\neg B, M)$, $P(P|\neg B, \neg M)$, $P(M|B)$, $P(M|\neg B)$ are given.

1. Draw the decision network for this problem. 4 pt
2. Explain how to compute the utility of buying the book. State the equation underlying this algorithm explicitly. 6 pt

3 Markov Models

Problem 3.1 (Prediction, Filtering, Smoothing)
Explain the goals of *prediction, filtering* and *smoothing* in terms of conditional probabilities 8 pt

Problem 3.2 (Markov Mood Detection)

On any given day d, your roommate Moody is in one of two states – either he is happy (H_d) or he is in a bad mood (B_d). Usually when he's in a bad mood, it's because he had a fight with his boyfriend and those tend to go on for a couple of days, so $P(B_{d+1}|B_d) = 0.7$, but aside from that he's a cheery guy, so ($P(H_{d+1}|H_d) = 0.85$). 16 pt

Of course you try to avoid talking to people, but you can hear his music blasting all day which tends to shift depending on his mood. On a good day he usually listens to Jazz (i.e. $P(J_d|H_d) = 0.7$), on a bad day he slightly prefers Death Metal ($P(DM_d|B_d) = 0.6$). He has a limited taste in music, so it's always one of the two.

You know that he was in a good mood at day d_0. Assume he's been listening to death metal for n days straight since then. Explain how to compute the probability that he is in a bad mood on day d_{n+1}. State the equations underlying this algorithm explicitly.

Problem 3.3 (Bellman Equation)

State the Bellman Equation and explain 1) every symbol in the equation and 2) what the equation is used for and how. 8 pt

4 Learning

Problem 4.1 (Gradient Descent)
Explain a gradient descent algorithm. 8 pt

Problem 4.2 (Information Entropy)
Explain and define *information entropy.* 6 pt

Problem 4.3 (Home Decisions)

Eight people go sunbathing. Some of them got a sunburn, others didn't: 20 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

Apply the decision tree learning algorithm on this table to predict whether people will get sunburned based on the attributes provided.

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