OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG

INF FAKULTÄT FÜR INFORMATIK

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Computational Intelligence
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Written exam “Bayesian Networks”

Name, first name:	Faculty:	Course:	Matriculation no.:
Type of exam: ☐ First attempt ☐ Second attempt ☐ Certificate	Signature invigilator:		#Sheets:

Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Sum
/10	/9	/16	/11	/8	/6	/60

Task 1 Bayesian Theorem $(5 + 5 = 10$ 20 min)

a) In a given population, 0.5% of all persons suffer from a certain disease. Let a test have the property that it correctly recognizes an ill person with 95% probability whereas the rate of correctly revealing a healthy person is 80%. What is the probability that a person does (not) suffer from the disease if the test does (not) reveal the disease?

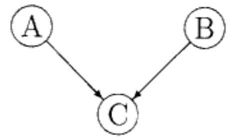
b) Alice, Bob and Carol are programmers in a local IT-company. Together they are writing code for a large project. To the present day Alice wrote 60% of the code, Bob 30% and Carol the remaining 10%. After the middle of the project the code was reviewed by an external expert. While 3% of Alices code contained errors, Bobs code was wrong in 7% of all lines, whereas only 5% of Carols code were wrong.

- How many percent of the code is wrong?
- When a bug was found, what's the probability that the bug was produced by Alice (Bob, Carol)?

Task 2 Bayesian Networks (9 15 min)

Consider the following three-dimensional probability distribution:

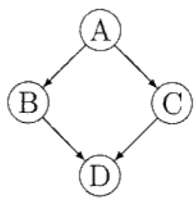
p_{ABC}	$A = a_1$		$A = a_2$	
	$B = b_1$	$B = b_2$	$B = b_1$	$B = b_2$
$C = c_1$	$^1/_{30}$	$^1/_{30}$	$^3/_{10}$	$^1/_5$
$C = c_2$	$^2/_{15}$	$^1/_{20}$	$^1/_5$	$^1/_{20}$



Check whether the graph depicted next to the table can be the underlying network structure describing the distribution! If yes, specify the probability distributions that are needed to define the Bayesian network!

Task 3 Probabilistic Propagation (5 + 11 = 16 30 min)

Consider the following Bayesian network and the corresponding (conditional) probability distributions:



$P(A)$	$A = a_1$	$A = a_2$
	0.3	0.7

$P(B\|A)$	$A = a_1$	$A = a_2$
$B = b_1$	0.2	0.7
$B = b_2$	0.8	0.3

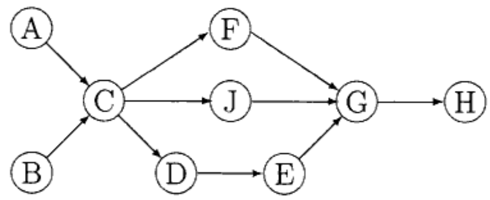
$P(C\|A)$	$A = a_1$	$A = a_2$
$C = c_1$	0.4	0.9
$C = c_2$	0.6	0.1

$P(D \mid BC)$	$B = b_1$		$B = b_2$	
	$C = c_1$	$C = c_2$	$C = c_1$	$C = c_2$
$D = d_1$	0.4	0.9	0.2	0.3
$D = d_2$	0.6	0.1	0.8	0.7

a) Determine the a-priori distribution for all four variables!

b) It becomes evident that variable D assumes value d_2. Propagate this evidence across the network with the tree-based propagation algorithm presented in the lecture, i.e., compute all four a-posteriori distributions!

Task 4 Construction of Clique Trees ($2+2+2+2+3=11$ 10 min)



Construct for the depicted Bayesian network

a) the moral graph,
b) a triangulated moral graph
c) a perfect ordering using maximum cardinality search, and
d) a clique tree/join tree!
e) Check the Running Intersection Property!

At which steps of the construction do you have multiple options to proceed?

Task 5 Structure from Independences (8 30 min)

Assume the following conditional independencies between the attributes A, B, C, D, E, F, G and H (as in former exercises, the notation $X \perp\!\!\!\perp Y \mid Z$ states that X is independent of Y given Z):

$A \perp\!\!\!\perp EG \mid DH$	$ABCDFH \perp\!\!\!\perp E \mid G$	$ABFH \perp\!\!\!\perp EG \mid CD$
$ACDEG \perp\!\!\!\perp BF \mid H$	$AD \perp\!\!\!\perp C \mid H$	$B \perp\!\!\!\perp F \mid \emptyset$
$BFH \perp\!\!\!\perp D \mid A$	$BFH \perp\!\!\!\perp EG \mid AC$	$C \perp\!\!\!\perp D \mid A$

Assume further that only these independencies as well as those that are deducible by the graphoid axioms hold true (i.e. the symmetric counterparts $EG \perp\!\!\!\perp A \mid DH$ etc. are satisfied). All other conditional independencies do not hold true. Which conditional independence graph over the four attributes can be read from this information?
(Hint: Remember the special properties of converging edges.)

Task 6 Multiple-Choice ($2+2+2=6$ 10 min)

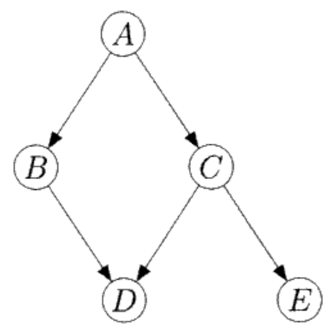
Please answer the following questions with yes (statement is correct) or no (statement is wrong). Every right decision yields 1/2 point, every wrong decision costs 1/2 point. You cannot get less then 0 points for a single subtask. You can also choose not to answer a question (means 0 points).

a) Graph structure

yes	no	
☐	☐	Every graph can be the graph of a Bayesian Network
☐	☐	Only directed graphs can be the graph of a Bayesian Networks
☐	☐	Only acyclic graphs can be the graph of a Bayesian Networks
☐	☐	Every directed acyclic tree can be the graph of a Bayesian Network

b) Given the Bayesian Network to the right, which probability calculations (factorizations) are correct?

yes	no	
☐	☐	$P(A,B,C,D,E) = P(B) \cdot P(A\|B) \cdot P(D\|A,B) \cdot P(C\|A,B,D) \cdot P(E\|A,B,C,D)$
☐	☐	$P(A,B,C,D,E) = P(A) \cdot P(B\|A) \cdot P(C\|A) \cdot P(D\|B,C) \cdot P(E\|C)$
☐	☐	$P(D) = P(D\|B,C) \cdot P(B) \cdot P(C)$
☐	☐	$P(E) = P(E\|C) \cdot P(C\|A) \cdot P(A)$



c) Propagation

yes	no	
☐	☐	Simple Tree Propagation can propagate evidence in every Bayesian Network
☐	☐	Clique Tree Propagation can propagate evidence in every Bayesian Network
☐	☐	Only single evidence can be handled by Simple Tree Propagation, because π and λ-messages can only hold one piece of evidence information
☐	☐	Evidence always has to be propagated through the whole network.