Test Knowledge Representation_2020 - 20 Oct

Knowledge Representation (Vrije Universiteit Amsterdam)

Test Knowledge Representation

Number of questions: 24
Session period: 20 october 2020 18:45 - 22:30
Duration: 195 minutes

Instruction

Welcome to the exam of the course Knowledge Representation (XM_0059).

The exam was originally designed for 2 hours, but has been shortened given the proctoring constraints. You should be able to easily finish it within 90 minutes, but you will have plenty of time to finish it until 21.30.

The following tools are permitted:
- Calculator
- Scrap paper (nothing written or printed on it)
- Check here for the cheat sheet

There are 24 questions, including one open questions for which you can gain 10 points. In total you can earn 61 points.

For questions about the content of the test you can contact us **after the exam.** In case you believe a question is incorrect or vague, please answer according to your interpretation, and make a note of the question number and your assumption.
We can then later discuss these cases. Information about the review of the exam is provided via Canvas.

If you have **not** signed up for this exam, you will not receive a result. Through VUnet you can object to the fact that you can no longer sign up after the expiry of the registration deadline (and the fact that you will not receive a result for this exam). Submit your appeal online within one week after the exam. More information can be found at www.vu.nl/intekenen.

The official guideline of the proctored exam says that toilet visits are not allowed. In view of the long time slot of almost 3 hours, if needed, you can take such a short break. Please mention this in the camera.

Logic general

Two short questions about Knowledge Engineering and Logics in general for 5 points in total.
Answering those questions should take about 5 minutes.

Question 1 – Multiple choice – Question-ID: 198701 (1 point)

In a proof by contradiction, such as DPLL or tableau, I can prove that a formula F is entailed by a knowledge base KB by showing that

A the knowledge base KB and the negation of the formula are unsatisfiable.

B the knowledge base KB and the formula F are together unsatisfiable.

C the knowledge base is unsatisfiable, which implies that the formula F must be entailed.

D the formula F is unsatisfiable, which implies that it must be entailed by the KB.

Question 2 – Multiple choice – Question-ID: 198897 (4 points)

Consider a language L defined as follows

•Syntax
- {1,2,3} ∈ L
- If F1, F2 ∈ L then "(F1+F2+F3)" ∈ L

•Semantics: let I be an interpretation function:
- I(1)=a, I(2)=b, I(3)=c
- I(F1+F2+F3) = I(F3).I(F2).I(F1)

What is I((1+2+(1+2+3))?

A 3.2.1.2.1

B a.b.a.b.c

C c.b.a.b.a

D 9

Propositional Logic

7 questions on Propositional Logic, with 16 points in total. The 5th and 6th question of this block are a bit more complex and are worth 4 points each.
You will probably need 20 minutes for this block.

Question 3 – Fill in (multiple) – Question-ID: 98411 (2 points)

Fill in the truth value of the following formulas under the assumption that A,B,C and D are all false. Fill in the truth values of the formulas (use the words "True, False").

(A & B) v -C v -D is _____

(A & B) v (-C & D) is _____
(A->B) v (C->D) is _____
(-A->B) v (-C->D) is _____

Question 4 – Multiple choice – Question-ID: 198702 (2 points)

Which of the following is true?
The propositional statement (P&Q) -> (PvQ)

A is valid

B neither valid, satisfiable nor a contradiction

C is a contradiction

D is satisfiable, but not valid

Question 5 – Multiple choice – Question-ID: 83998 (2 points)

(2 points) Automated reasoning can often be seen as search procedure, that tries to find an order of rules to formulas in a knowledge base.
Which of the following statements about the DPLL (Davis–Putnam–Logemann–Loveland) Algorithm and Search is correct?

A DPLL cannot be seen as a search procedure, it only randomly assigns values to propositions until it finds an assignment that satisfies all the clauses.

B DPLL exhaustively applies a set of transformation rules to produce a contradiction

C DPLL iteratively searches through the set of all clauses for one that is satisfied by a given interpretation.

D DPLL recursively searches through all possible variable assignments for a model, i.e. an interpretation that satisfies all the clauses.

Question 6 – Multiple choice – Question-ID: 198733 (1 point)

In DPLL, each variable is always assigned true or false at any iteration of the algorithm. True or false?

A True

B False

Question 7 – Fill in (multiple) – Question-ID: 98462 (4 points)

Given a clause set
{ AvB,
-AvBv-C,
-Av-BvC,
-AvBvC,
Av-B}

Fill in the gaps to prove satisfiability or unsatisfiability with DPLL. Hereby apply an alphabetical order (startng with A), and assing False before True to the variables. Please keep the clauses in the order given above and do not leave spaces before, between or after propositions. .

Assigning the value False to variable A results in the clause set:
[ ]
[ ]
which is a contradiction. So we need to backtrack and assign the value [ ] to [ ].
This results in the knowledge base:
[ ]
[ ]
[ ]

Assign the value [ ] to variable [ ], which results in the clause set:
[ ]
[ ]
which is again a contradition. So, after this we backtrack on [ ] and give it the value [ ], which results in a single clause
[ ]
This means that the knowledge base is [ ] with an assignment A=[ ], B=[ ] and C=[ ].

Question 8 – Fill in (multiple) – Question-ID: 198703 (4 points)

Consider the following knowledge base (set of clauses):
1.P∨Q∨R
2.P∨¬Q∨¬R
3.P∨¬W
4.¬Q∨¬R∨¬W
5.¬P∨¬Q∨R
6.U∨X
7.U∨¬X
8.Q∨¬U
9.¬R∨¬U
and show whether the knowledge base is satisfiable or not

Use the following order: unit, pure, split alphabetic with a positive value.

There is no [ ] clause, but a pure literal. Therefore you will have to assign the value [ ] to variable [ ].
After this, you get a new clause set, that does not contain unit clauses or pure literals. Therefore, you split on P=1, which gives the new clause set:
5*.¬Q∨R
6* .U∨X
7* .U∨¬X
8* .Q∨¬U
9* .¬R∨¬U
As there are no unitclauses or pure literals you have to split again, now on Q=1.
After simplication we have to assign a value [ ] to variable [ ], In the next step, again we know the value of [ ] has to be [ ].
We are now left with two clauses that are inconsistent, so we need to backtrack to the most recent split on Q.
With a new value 0 for Q, we rerun the DPLL procedure.
After several steps, we end up with either a contradiction or a model. Please type "contradiction" or "model" in this field [ ].

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Question 9 – Multiple choice – Question-ID: 198734 (1 point)

GSAT is sound w.r.t Propositional Logic satisfiability True or false?

A False

B True

Description Logics

5 questions on Description Logics worth 20 points. The third question takes a bit more time (and is worth 5 points), the last one is the only open question of the exam and is worth 10 points. The entire block should take about 20 minutes.

Question 10 – Multiple choice – Question-ID: 198715 (2 points)

Which of the following English sentences is a faithful paraphrase of the following formula:

HappyParent = Parent ⊓ ∀ hasChild.(Doctor ⊔ ∃ hasChild.Doctor)

A Parents of doctors, or of children who have a doctor as a child, are happy parents

B Happy parents are precisely those parents all of whose children are either doctors or have a child who is a doctor

C All happy parents have a child that is a doctor, or the parent of a doctor

D Happy parents are precisely doctors with children who are doctors

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Question 11 – Multiple choice – Question-ID: 198818 (2 points)

Which of the following ALC statements corresponds to the English statement
Grandparents are people who have at least one child that has at least one child

A Grandparents= people⊔∃ Child.(∃ Child.⊤)

B Grandparents⊓ people = ∃ Child.(∃ Child.⊤)

C Grandparents= people⊓∃ Child.(∃ Child.⊤)

D Grandparents= people⊓∀ Child.(∀ Child.⊤)

Question 12 – Fill in (multiple) – Question-ID: 198724 (5 points)

Given the following interpretation with domain {alice, bob, clair, c1, b1, l1} and a table that clarifies who and what are in the interpretation of the loves relation.

alice	bob	clair
c1	c1	b1
b1		l1
l1		

Here c1 is in the interpretation of the concept **cars**, b1 in the interpretation of the concept **bicycles** and l1 in the interpretation of concept **lion**.

We also have information that cars, bikes and lions are disjoint classes.

Give the value of the interpretation (set of persons) of each of the following formulas. Write the full names with commas (but not spaces) in alphabetic order:

a) ∃ loves.cars
b) ∀ loves.cars
c) ¬ ∃ loves.cars
d) ∀ loves.¬ cars
e) ∀ loves.¬ (cars ⊔ bikes)

Question 13 – Multiple choice – Question-ID: 198821 (1 point)

All reasoning tasks in ALC are reducible to Concept Subsumption w.r.t. a TBox. True or false?

A True

B False

Question 14 – Open-ended – Question-ID: 198710 (10 points)

Use a tableau algorithm to test whether ∃S.C ⊓ ¬ ∃ S.(C ⊓ D) ⊆ ∀ R.¬ C. (where ⊆ stands for DL subsumption)

Describe all the necessary steps in detail.

In case you have trouble typing the symbols use E for ∃, V for ∀, v, &, - for disjunction, conjunction and negation as usual.

PGMs

10 questions on Probabilistic Graphical Models. These questions come in 4 blocks,
1. three knowledge questions (1 point each),
2. four questions with (2 points each)
3. one question with 4 parts about d-separation for 4 points
4. 2 questions calculating with Bayesian networks.(2 and 3 points)

Question 15 – Multiple choice – Question-ID: 198898 (1 point)

If $I_{Pr}(X,W,Y)$ and $I_{Pr}(X,W,Z)$, then $I_{Pr}(X,W,Z \cup Y)$. True or false?

A False

B True

Question 16 – Multiple choice – Question-ID: 198899 (1 point)

A convergent valve (→ W ←) is open iff either variable W or any of its descendants appears in Z. True or false?

A True

B False

Question 17 – Multiple choice – Question-ID: 198900 (1 point)

In case of MAP-queries, the basic idea is that, we first sum-out all the non-MAP variables, and then maximise-out the MAP variables. True or false?

A True

B False

Question 18 – Multiple choice – Question-ID: 198901 (2 points)

If$\alpha| = \beta$ and $Pr(\beta)=0$, then $Pr(\alpha)=0$. True or False?

A False

B True

Question 19 – Multiple choice – Question-ID: 198902 (2 points)

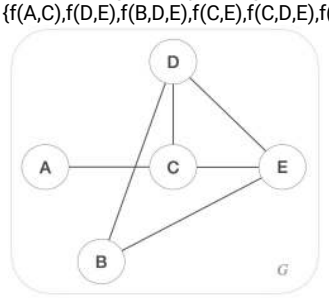
If$\alpha| = \alpha \wedge \beta$, then $Pr(\alpha \vee \beta) \leq Pr(\alpha)$. True or false?

A False

B True

Question 20 – Multiple choice – Question-ID: 198995 (2 points)

The following corresponding interaction graph G corresponds to the set of factors:
{f(A,C),f(D,E),f(B,D,E),f(C,E),f(C,D,E),f(A,E),f(B,D)} . True or false?

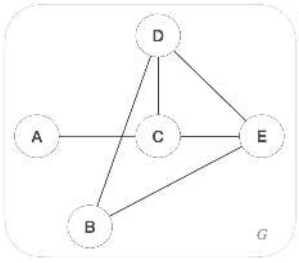


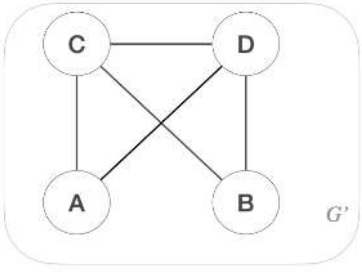
A True

B False

Question 21 – Multiple choice – Question-ID: 198996 (2 points)

If we eliminate node E from graph G, we get the interaction graph G'. True or false?



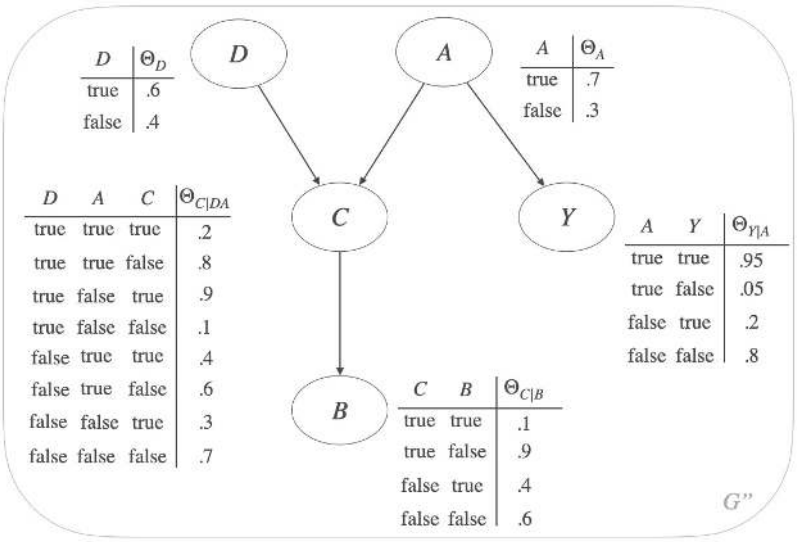


A False

B True

Question 22 – Fill in (multiple) – Question-ID: 198997 (4 points)

Consider the following Bayesian network, below. (Recall that dsep(X, Z, Y) denotes "X and Y are d-separated by Z").

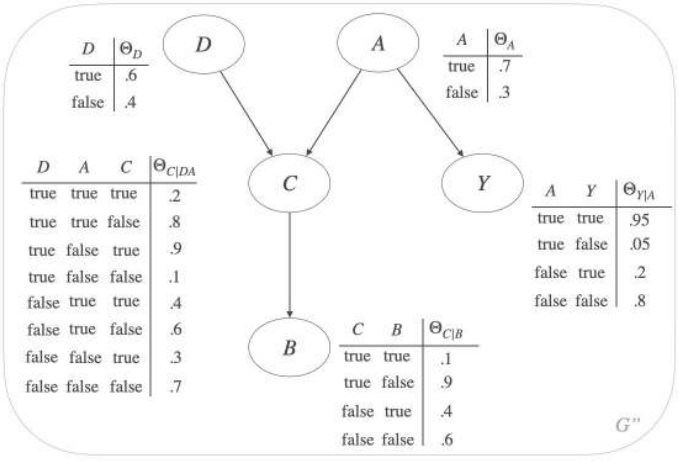


Label each of the following as True or False

a) dsep(B,C,A)
b) dsep(Y,C,D)
c) dsep(D,B,A)
d) dsep(Y,C,B)

Question 23 – Fill in (multiple) – Question-ID: 199000 (2 points)

Given the Bayesian network in the previous questiona) Write out the formula that calculates Pr(C=true, Y=false | D=false, A=true) using the chain rule.



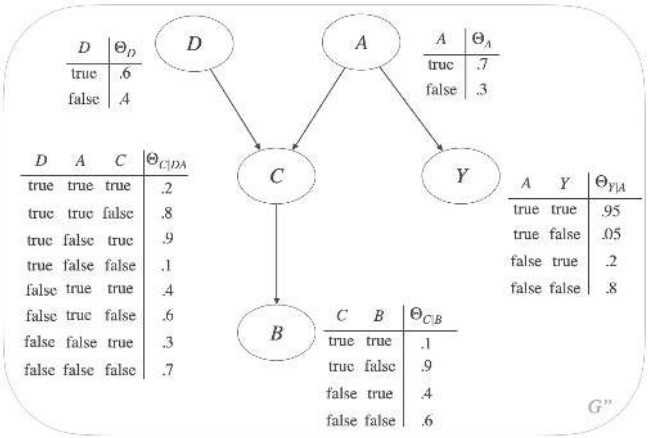
You can use the following way of writing up your result but we will check for the correct answers manually...

(Typing hint: For any variable Y,
"Y = true" denoted as "y"
"Y = false" denoted as "-y" .
Sum is "sum", multiplication is "times" and division is /.
Parentheses can be used as in usual arithmetic.
Example: $(\sum_{XY} \Theta_X \cdot \Theta_{Y|ZW} \cdot \Theta_{b|c})/\Theta_A$ can be typed as
"(sum_XY theta_X times theta_Y | ZW times theta'b|-c)/theta_A)"

Please write the formula here:

Question 24 − Fill in (numerical) − Question-ID: 198999 (3 points)

Given the Bayesian network from the previous question



What is the result of Pr(C=true, Y=false | D=false, A=true) ?

End of test Knowledge Representation