National University of Singapore
School of Computing

Semester 1, AY2023-24

CS3263 Foundations of Artificial Intelligence

Issued: 10 Oct 2023

Tutorial 6: Mid-Term Review

Guidelines

You may discuss the content of the questions with your classmates. But everyone should work on and be ready to present ALL the solutions.

Problem 1: Tour Group Management

Mom, Dad, Baby, Student, Teacher, and Guide are lining up next to each other in six linear spots labeled 1 to 6, one to each spot. Baby needs to line up between Mom and Dad. Student and Teacher need to be next to each other. Guide needs to be at one end, in spot 1 or 6. Formulate this problem as a CSP: list the variables, their domains, and the constraints. Encode unary constraints as a constraint rather than pruning the domain. (No need to solve the problem, just provide variables, domains and constraints.)

Problem 2: Logic Entailment

Which of the following are correct (i.e, the sentence is true)?

a) $False \models True$

b) $(A \wedge B) \models (A \Leftrightarrow B)$.

c) $(A \wedge B) \Rightarrow C \models (A \Rightarrow C) \vee (B \Rightarrow C)$

d) $(A \vee B) \wedge (\neg C \vee \neg D \vee E) \models (A \vee B) \wedge (\neg D \vee E)$

e) $(A \vee B) \wedge \neg(A \Rightarrow B)$ is satisfiable.

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Try to make both sides false, the
model outputs everything in domain
excluding the false substitution
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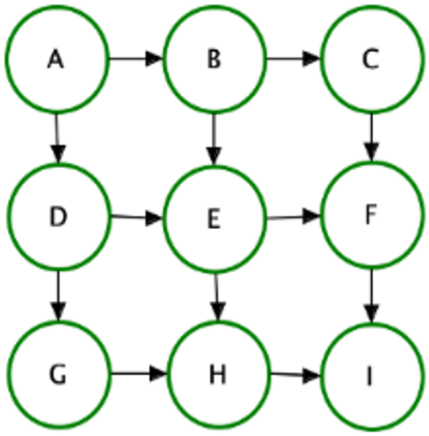
Problem 3: Conditional Independence and D-Separation

Consider the Bayesian network below with 9 nodes, denoting random variables A to I.



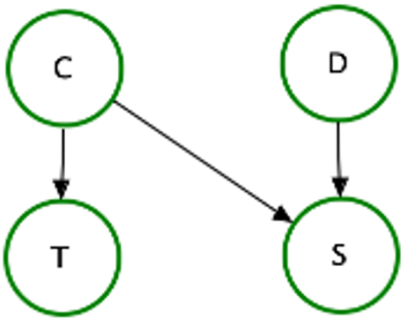
a Which random variables are independent of G? (Write ”NIL” if there are none)
Ans: 1

b Which random variables are conditionally independent of G given A? (Write ”NIL” if there are none.)
Ans: 2

c Which variables are conditionally independent of G given A and I? (Write ”NIL” if there are none.)
Ans: 3

Problem 4: Reasoning Under Uncertainty

1. The Bayesian network below shows the situation of two different diseases, C and D, that can cause a common symptom S of ”blue toes.” Disease C is usually rare, and its presence can be tested by a test T.



Assuming that each variable takes either T or F values, given the probabilities below:

- $P(+c) = 0.1$
- $P(+d) = 0.5$
- $P(+t|+c) = 1.0$
- $P(+t|-c) = 0.2$
- $P(+s|+c,+d) = 1.0$
- $P(+s|+c,-d) = 0.8$
- $P(+s|-c,+d) = 1.0$
- $P(+s|-c,-d) = 0.0$

a What is the probability that a patient has disease D, (and) does not have disease C, (and) has symptom S, (and) has test T returning negative?

Ans: The probability is _1_ (up to 2 decimal points)

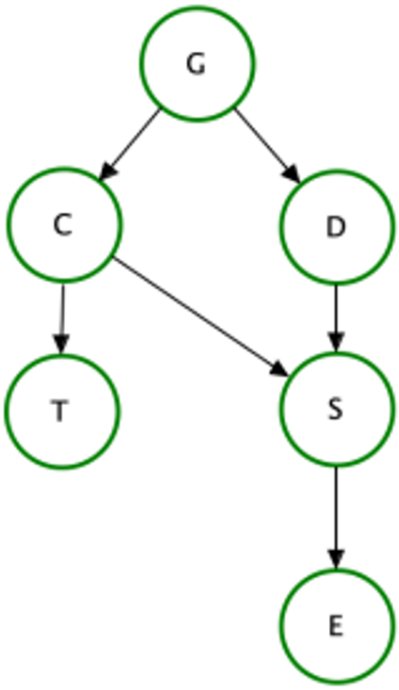
b What is the probability that a patient has disease C given that he has disease D?

Ans: The probability is _2_ (up to 2 decimal points)

c What is the probability that a patient has disease C given that he has symptom S and test T returns positive?

Ans: The probability is _3_ (up to 2 decimal points)

2. Suppose that both diseases C and D become more likely if a person has a genetic trait (G) of "green nose", and that the presence of symptom S of "blue toes" can be detected only through the use of a Toe-Color-Detector (E); the detector E will return a positive result if "blue toes" are detected. The revised Bayesian network is shown below. The additional/revised conditional probability tables are **not** given.



For this new situation, indicate if each of the following statement is True, False, or Undetermined (i.e. cannot be determined based on the available information).

a C is independent of D.

Ans: 4

b C is conditionally independent of D given G.

Ans: 5

c C is conditionally independent of D given G and E.

Ans: 6