COMP-424: Artificial intelligence

Homework 3
Due on myCourses March 11, 11:59pm.

General instructions.

• This is an individual assignment. You can discuss solutions with your classmates, but should only exchange information orally, or else if in writing through the discussion board on myCourses. All other forms of written exchange are prohibited.
• Unless otherwise mentioned, the only sources you should need to answer these questions are your course notes and the textbook. Any other source used should be acknowledged with proper referencing style.
• Submit a single pdf document containing all your pages of your written solution on your McGill’s myCourses account.

Question 1: Designing a Bayes Net

Your goal is to design a Bayes Net that can explain how various factors (variables) are related to cancer. Include at a minimum the following variables:

• A = Anxiety
• C = Cancer
• Ch = Chemotherapy
• D = Depression
• E = Environmental Factors
• F = Fatigue
• N = Nutrition
• P = Pain
• R = Radiation
• S = Smoking

(a) Draw a Bayes Net structure that captures plausible conditional dependencies between this set of variables.

(b) Provide reasonable estimates for all relevant conditional probabilities. For this part, you are encouraged to use sources outside of the course notes and textbook. Cite your sources in your write-up. (It may be helpful to not include too many edges in your graph.)
Question 2: Inference in a Bayes Net

Consider the following Bayes Net (reproduced from\(^1\)):

\[
\begin{align*}
\text{P}(\text{rush\_hour}) &= 0.2 \\
\text{P}(\text{bad\_weather}) &= 0.05 \\
\text{P}(\text{accident} \mid \text{bad\_weather}) &= 0.3 \\
\text{P}(\text{accident} \mid \sim\text{bad\_weather}) &= 0.1 \\
\text{P}(\text{sirens} \mid \text{accident}) &= 0.9 \\
\text{P}(\text{sirens} \mid \sim\text{accident}) &= 0.2 \\
\text{P}(\text{traffic\_jam} \mid \text{rush\_hour}, \text{bad\_weather}, \text{accident}) &= 0.95 \\
\text{P}(\text{traffic\_jam} \mid \text{rush\_hour}, \text{bad\_weather}, \sim\text{accident}) &= 0.95 \\
\text{P}(\text{traffic\_jam} \mid \text{rush\_hour}, \sim\text{bad\_weather}, \text{accident}) &= 0.95 \\
\text{P}(\text{traffic\_jam} \mid \text{rush\_hour}, \sim\text{bad\_weather}, \sim\text{accident}) &= 0.5 \\
\text{P}(\text{traffic\_jam} \mid \sim\text{rush\_hour}, \text{bad\_weather}, \text{accident}) &= 0.95 \\
\text{P}(\text{traffic\_jam} \mid \sim\text{rush\_hour}, \text{bad\_weather}, \sim\text{accident}) &= 0.3 \\
\text{P}(\text{traffic\_jam} \mid \sim\text{rush\_hour}, \sim\text{bad\_weather}, \text{accident}) &= 0.6 \\
\text{P}(\text{traffic\_jam} \mid \sim\text{rush\_hour}, \sim\text{bad\_weather}, \sim\text{accident}) &= 0.1
\end{align*}
\]

Compute the following terms using basic axioms of probability and conditional independence properties encoded in the above graph. You can also use Bayes Ball properties to reduce the complexity of inference (i.e. eliminate variables that are conditionally independent, in order to simplify computation).

(a) \(\text{P}(\text{rush\_hour}, \text{sirens})\)
(b) \(\text{P}(\text{rush\_hour}, \sim\text{accident})\)
(c) \(\text{P}(\text{accident} \mid \text{rush\_hour})\)
(d) \(\text{P}(\text{traffic\_jam} \mid \text{sirens}, \sim\text{bad\_weather})\)
(e) MAP of \(\text{P}(\text{traffic\_jam} \mid \text{accident}, \sim\text{rush\_hour})\)
(f) MAP of \(\text{P}(\text{accident, rush\_hour} \mid \text{sirens}, \sim\text{traffic\_jam})\)

Question 3: Variable elimination

For the graph above, compute \(\text{P}(\text{sirens} \mid \sim\text{rush\_hour})\) using variable elimination with the following order: \(\text{rush\_hour}, \text{bad\_weather}, \text{accident}, \text{traffic\_jam}, \text{sirens}\). Clearly explain each step. For each of the intermediate factors created, explain what probabilistic function it represents.

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\(^1\) http://jliszka.github.io/2013/12/18/bayesian-networks-and-causality.html.