

Assignment Seven: Probabilistic Inference

Due: 11:59pm, Monday 9 November 2020.

Solving following problems requires using the <http://aispace.org> belief and decision networks applet (you may need to download the jar file) and/or the Python code at http://aipython.org/aipython_322.zip (which now includes reasoning with uncertainty and planning with uncertainty).

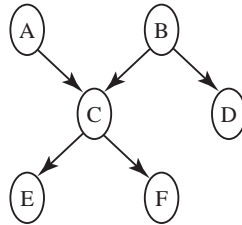
This can be done in groups of size 1, 2 or 3. Working alone is not recommended. All members of the group need to be able to explain the group's answer.

Submit your answers in individual files using Canvas. Use proper sentences in your answers.

Ask questions on Canvas discussion board. Feel free to answer them too.

Question One

Consider the belief network of Figure 1, with Boolean variables (we write $A = \text{true}$ as a and $A = \text{false}$ as $\neg a$, and similarly for the other variables).



$P(a) = 0.1$	$P(d b) = 0.1$
$P(b) = 0.8$	$P(d \neg b) = 0.8$
$P(c a, b) = 0.9$	$P(e c) = 0.7$
$P(c a, \neg b) = 0.8$	$P(e \neg c) = 0.2$
$P(c \neg a, b) = 0.3$	$P(f c) = 0.2$
$P(c \neg a, \neg b) = 0.4$	$P(f \neg c) = 0.9$

Figure 1: Belief Network for Question 1

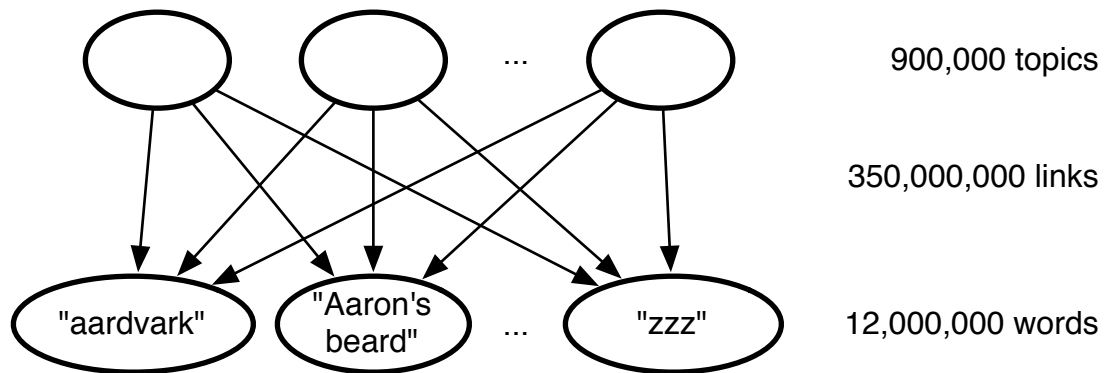
- (a) Consider computing $P(e)$ using variable elimination. (Please try to work out which factors are created and removed at each step by hand, then check it with the AISpace applet.) Do not do any pruning. Explain what conditional probability each initial factor represents and for each factor created specify which factors were multiplied and which variable was summed out to create the factor. You do not need to show the tables.
- (b) Consider computing $P(e | \neg f)$ using variable elimination. How much of the previous computation can be reused? Show only what is different.
- (c) Find each of the following:
 - i) $P(a)$

- ii) $P(a \mid d)$
- iii) $P(a \mid \neg f)$
- iv) $P(a \mid \neg f \wedge d)$
- v) $P(a \mid \neg f \wedge b \wedge d)$
- vi) $P(a \mid \neg f \wedge b)$

(d) Explain in what circumstances (in terms of observing other variables) observing d affects the probability of a . (Be as specific as possible.) Hint: this has something to do with whether A and D are dependent or independent given X for some set of variables X . The probabilities in the previous part should help you.

Question Two

- (a) Chris and Sam were playing with a mock-up help system based on Example 8.35 at <https://artint.info/2e/html/ArtInt2e.Ch8.S5.SS6.html>. Their example for the AIspace belief network tool is at <https://artint.info/tutorials/helpsystem.xml> For the query “Cannot find file”, Sam was conditioning on “cannot”, “find” and “file” being true, and was querying the “HelpPage” variable. Chris claimed that this was not correct because we also need to condition on the other words being false. Who was right? Explain to the other person why one of them is right. Use an example in your explanation.
- (b) What are the independence assumptions made in the naive Bayes classifier for the help system? Use “words” and “help pages” or “topics” in you ansswer (i.e., explain the indepedencies in terms of the domain).
- (c) Are these independence assumptions reasonable? Explain why or why not.
- (d) What are the independence assumptions made in the topic-model network:



Specify all of the independencies and dependencies in this model (in terms of words and topics; you don't need to mention “aarvark”, “zzz”, etc).

- (e) Give an example of where the topics would not be expected to be independent.

Question Three

For each question, specify how long you spend on it, and what you learned. How was the work in the team allocated? Was the question reasonable? (This questions is worth marks, so please do it!)