CSCE A405/A605 (Adv) Artificial Intelligence
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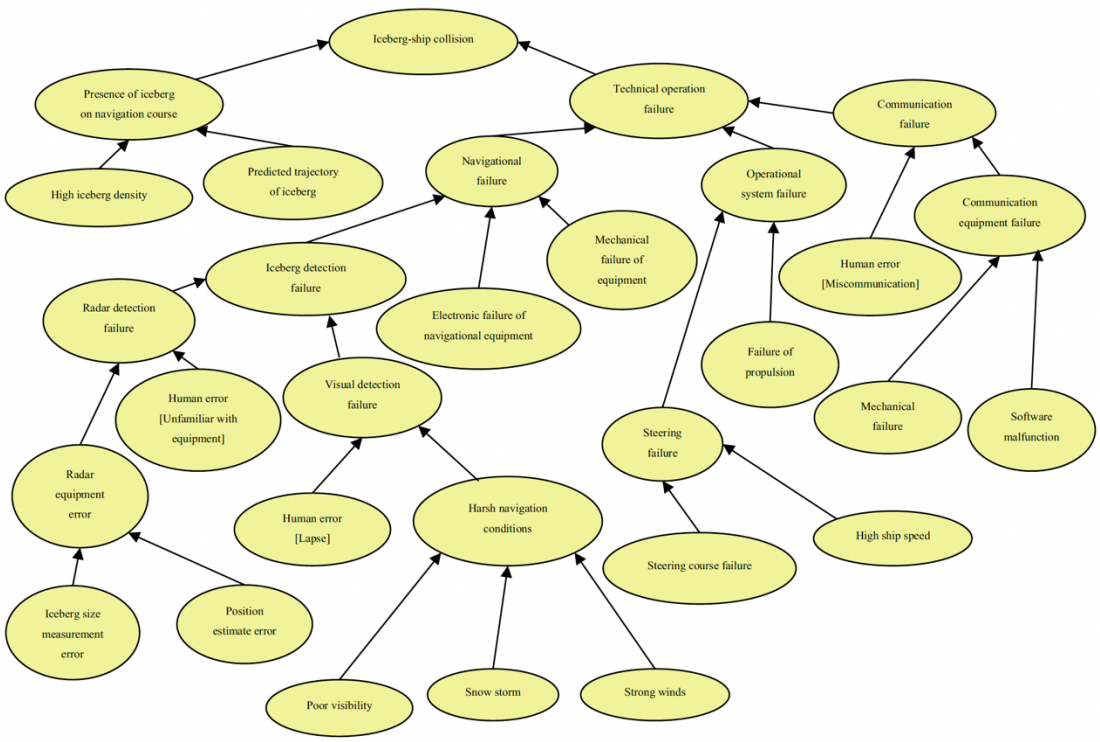
Homework 3, Chapter 13: Probabilistic Reasoning
Note: For all questions, describe your approach in detail.

The following article provided a Bayesian network for a collision between a ship and an iceberg (Fig. 5): Afenyo, Mawuli, et al. "Arctic shipping accident scenario analysis using Bayesian Network approach." *Ocean Engineering* 133 (2017): 224-230.



Q1. [20 pts] Which of the following independencies is guaranteed in the above Bayes net?

Q1. a) "Steering course failure" ⊥ "High ship speed" | "Operational system failure" Not guaranteed.
Q1. b) "Communication failure" ⊥ "Presence of iceberg on navigation course" | "High iceberg density" independent
Q1. c) "Mechanical failure" ⊥ "Iceberg-ship collision" | "Technical operation failure" Not Guaranteed
Q1. d) "Mechanical failure" ⊥ "Iceberg-ship collision" | "Navigational failure"
Not Guaranteed

Be careful
mech fail ≠ mech fail of equipment

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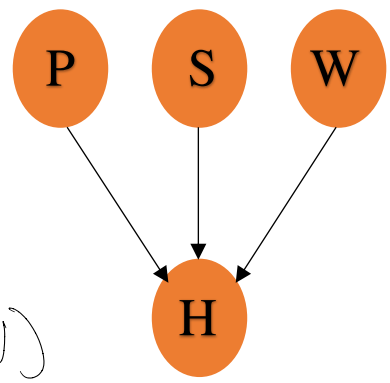
Q2. [20 pts] Let's consider a subset of variables for simplicity:

Poor visibility: P
Snow storm: S
Strong winds: W
Harsh navigation conditions: H



$P(H,P,W) = P(H|P,W)P(P)P(W)$

Assuming the domain of each variable to be {True, False}, and the following CPTs, compute p(H | P=True, W=True). Run iceberg.ipynb and confirm your results.

It says it worked & outputs the same

P	p(P=True)
True	0.4

S	p(S=True)
True	0.3

W	p(W=True)
True	0.5

P	S	W	p(H=True|P,S,W)	p(H=False|P,S,W)
False	False	False	0.1	0.9
False	False	True	0.2	0.8
False	True	False	0.2	0.8
False	True	True	0.4	0.6
True	False	False	0.2	0.8
True	False	True	0.4	0.6
True	True	False	0.4	0.6
True	True	True	0.8	0.2

Q3. [20 pts] Run the last two cells in the iceberg.ipynb.
Find p(H|S=0) using the generated samples.
Explain your findings and that which algorithms these cells implement.

Similar results however if you give them both the same seed

$$P(H \mid P, W) = \frac{P(H, P, W)}{P(P, W)}$$

$$=$$

problem 2

P	S	W	p(H=True|P,S,W)	p(H=False|P,S,W)
False	False	False	0.1	0.9
False	False	True	0.2	0.8
False	True	False	0.2	0.8
False	True	True	0.4	0.6
True	False	False	0.2	0.8
True	False	True	0.4	0.6
True	True	False	0.4	0.6
True	True	True	0.8	0.2

$$P(H \mid P, W)$$

$$= \frac{P(H, P, W)}{P(P, W)} = \frac{P(S)P(H,P,W \mid S) + P(\sim S)P(H,P,W \mid \sim S)}{P(P)P(W)P(S) + P(P)P(W)P(\sim S)}$$

$$= \frac{1.2}{2.0} = .6$$

$$.3 \cdot .8 + .7 \cdot .4$$

$$= .4$$

P	P(0)	P(0)	P(0)	P(0)	P(1)	P(1)	P(1)	P(1)
S	S(0)	S(0)	S(1)	S(1)	S(0)	S(0)	S(1)	S(1)
W	W(0)	W(1)	W(0)	W(1)	W(0)	W(1)	W(0)	W(1)
H(0)	0.9	0.8	0.8	0.6	0.8	0.6	0.6	0.2
H(1)	0.1	0.2	0.2	0.4	0.2	0.4	0.4	0.8

it's the same

#3

Forward Sampling randomly pulls samples from parent to child

rejection sampling = forward xpart if no evidence

Likelihood weighted sampling } then calculate the sample corrected for probability of getting that value?

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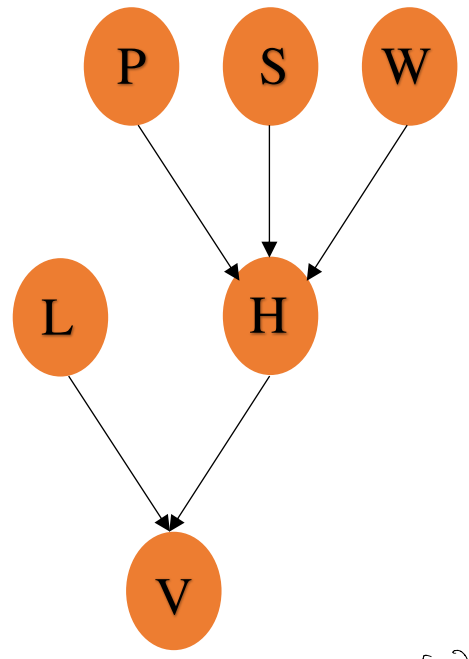
Q4. Modify the program iceberg.ipynb to include two other variables L and V as follows.
Q4. a) [15 pts] Submit your modified notebook or a screenshot of it.
Q4. b) [5 pts] Find P(V|L,¬S).
Q4. c) [5 pts] Write the joint probability distribution p(P, S, W, L, H, V) in terms of conditional probabilities. (Reminder: Similar to what we did in the lectures, Example 1: p(T,J,R,S) = p(T|R,S)p(J|R)p(R)p(S))



L	p(L=True)
True	0.1

L	H	p(V=True|L,H)	p(V=False|L,H)
False	False	0.1	0.9
True	False	0.6	0.4
False	True	0.6	0.4
True	True	0.8	0.2

$$P(x_1, \dots x_n) = \prod_{i=1} P(x_i \mid \text{parents}(i))$$

$$P(P, S, W, L, H, V) =$$

$$P(P \mid \text{Parents}(P))\, P(S \mid \text{Parents}(S))\, P(W \mid \text{Parents}(W))\, P(L \mid \text{Parents}(L)) \cdot P(H \mid \text{Parents}(H)) \cdot P(V \mid \text{Parents}(V))$$

$$= P(P)\, P(S)\, P(W)\, P(L)\, P(H \mid P, S, W)\, P(V \mid L, H)$$

$$.4 \quad .3 \quad .5 \quad 0.1 \quad (0.4) \quad 0.6 = 0.00384$$

Q5. [15 pts] A doctor gives a patient a (D)rug dependent on their (A)ge and (G)ender. Whether or not the patient (R)ecovers depends on all D,A,G. In addition A⊥ G|∅.

dom(D) = {drug,no drug}
dom(A) = {old, young}
dom(G) = {female,male}
dom(R) = {recovers, doesn't recover}

Q5. 1. Draw a Bayesian network for the above situation.
Q5. 2. Explain how to compute p(recover|drug) → inference
Q5. 3. Explain how to compute p(recover|drug,young)

by enumeration
→ marginal inference ?

Assignment 2- part 2. Go through three Assignment 2, discussion forums and give them <u>constructive</u> feedback. Your feedback can contain questions too. For example, *it is not clear to me why do you think a search algorithm is able to solve this problem given that the environment is partially observable?* You will be evaluated based on your feedback so be a rational agent (reviewer).

$$P(R|d) = \frac{P(R|d,\text{old},\text{male}) + P(R|d,\text{old},\text{female}) + P(R|d,\text{young},\text{male}) + P(R|d,\text{young},\text{female})}{P(d)}$$

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dom(R) = {recovers, doesn't recover}

Q5. 1. Draw a Bayesian network for the above situation.
Q5. 2. Explain how to compute p(recover|drug)
Q5. 3. Explain how to compute p(recover|drug,young)

Assignment 2- part 2. Go through three Assignment 2, discussion forums and give them <u>constructive</u> feedback. Your feedback can contain questions too. For example, *it is not clear to me why do you think a search algorithm is able to solve this problem given that the environment is partially observable?* You will be evaluated based on your feedback so be a rational agent (reviewer).

$$P(R \mid D, Y) = \frac{P(R \mid d, \text{male}, \text{young}) + P(R \mid d, \text{female}, \text{young})}{P(d, y)}$$