TDDC17-Lab3

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Part II
5.
a)
No observations, P(meltdown) = 0.02578
P(meltdown|icyweather) = 0.03472

b)
The risk of a meltdown if there is an actual water leak and pump failure is greater since
the probability of a meltdown is conditioned by the variables 'water leak' and 'pump failure'.

P(Meltdown | PumpFailureWarning, WaterLeakWarning) = 0.15
P(Meltdown | PumpFailure, WaterLeak) = 0.20

c)
Because some of the probabilities are in practice impossible to estimate by observing live situations
- they can only be estimated by doing artificial reconstructions of real life scenarios through
experiments. How well these experiments mirror the real world scenarios might be hard to know for
certain, such as those for Meltdown, PumpFailure or WaterLeak. Also, the variable IcyWeather
might be hard to correctly estimate. A third component is the cost of conducting the experiments,
some might be very expensive.

d)
Changing the IcyWeather variable to Temperature would mean we don't have a binary set of values
for the variable, but rather an interval of values for different temperatures. This would mean we
need more observations in for the network to establish probabilities that are conditioned by the
Temperature variable.

6.
a)
The probability of all the possible outcomes.

b)
What is a joint probability distribution?
The probabilities of all combinations of values for the variables in the distribution.

P(-Icy)=0.95
P(-PF)=0.9
P(-WL)=0.9
P(-PFW)=0.87
P(-WLW)=0.86
P(-M)=0.97

P(Meltdown=F, PumpFailureWarning=F, PumpFailure=F, WaterLeakWaring=F, WaterLeak=F,
IcyWeather=F) = P(M=F|PF=F ∧ WL=F)* P(-PF) * P(-PFW|-PF) * P(WLW=F|WL=F) * P(-WL|-
Icy) * P(-Icy) = 0.999 * 0.9 * 0.95 * 0.95 * 0.9 * 0.95 = 0.694

We can see that this is a common state for the nuclear plant to be in (almost 70% of the time).

c)
The probability of a meltdown when observing both a water leak and a pump failure is 20%. Meltdown is conditioned on water leak and a pump failure, so it does not matter if water leak warning and a pump failure warning are changed, since we have already observed that there is both a pump failure and water leak.

d)
Since all values except PF are given, we know the probability for meltdown and not meltdown given these values and the only unknown variable is PumpFailure. We also have PumpFailureWarning being conditioned on PumpFailure, so the we add this variable to the calculations when doing the inference.

e = (true, false), $\sum$ sums over e.

$\alpha * (\sum_e(P(M \mid -WL, PF = e) * P(-PFW \mid PF = e) * P(PF = e) * P(-WLW \mid -WL) * P(-WL \mid -IW) * P(-IW)) + \sum_e(P(-M \mid -WL, PF = e) * P(-PFW \mid PF = e) * P(PF = e) * P(-WLW \mid -WL) * P(-WL \mid -IW) * P(-IW))) = 1$

$\alpha * ((0.15 * 0.1 * 0.1 * 0.95 * 0.9 * 0.95) + (0.001 * 0.95 * 0.9 * 0.95 * 0.9 * 0.95)$
    $(0.85 * 0.1 * 0.1 * 0.95 * 0.9 * 0.95) + (0.999 * 0.95 * 0.9 * 0.95 * 0.9 * 0.95)) = 1$

$=> \alpha * 0.7025962499999999 = 1$
$=> \alpha = 1 / 0.7025962499999999$
$=> \alpha = 1.423292538210957$

P(Meltdown) given the defined problem/made observations is therefore:
$\alpha * ((0.15 * 0.1 * 0.1 * 0.95 * 0.9 * 0.95) + (0.001 * 0.95 * 0.9 * 0.95 * 0.9 * 0.95)) =$
$1.423292538210957 * (0.0012183749999999998 + 0.00069447375) =$
0.0027225433526011558

Part III
2.
a)
The probability of surviving decreases since the probability of the variable radio is conditioned by the variable battery - observing the value of radio as false raises the probability of not having battery, which in turn effects subsequent variables conditioned by the variable battery, making the probability of the variable 'survives' decrease.

b)
P(Survive) before bicycle = 0.99004
P(Survive after introducing the bicycle = 0.99506

We see that the probability of survival increases marginally after introducing the bicycle into the network.

c)
It can be very complex to do exact inference in a bayesian network, since it is at the same order of complexity as a SAT problem, i.e. the a problem that is not solvable in polynomial time since solving the problem takes $O(2^n)$ time. Alternatives to exact inference would be relaxing the problem if you can tell that it is conditioned on something that is very likely to be either false or true.

Part IV

2.
a)
Depending on the probabilities set for Mr.HS failing to react properly to the warnings, and depending on the new, lower probability for a pump failure with a new pump, a new and better pump could potentially compensate for Mr HS's lack of competence and reaction. However, when tuning the parameters in our model we found that a minor change of Mr. HS's reactivity and competence will reduce the probability more significantly than what a new pump can do.

b)
The probability that Homer survives with a car is P(Survives | WarningDisjunction = T) = 0.9214. We answer this question by adding a 'WarningDisjunction' node that represent the disjunction "PumpFailureWarning or WaterLeakWarning". We also added all the nodes representing the car from the previous network.

c)
That prior observations that are the basis of assumptions for probabilities will also hold in the future. People are not static, i.e. they change over time as does their skills and behaviours, unlike the probability of something like icy weather in a certain location at a certain time of the year.

d)
We make the probability of P(IcyWeatherAtDay) be conditioned on several other nodes IcyWeatherAtDay-n, where n is number of days before IcyWeatherAtDay (all these nodes "point" to IcyWeatherAtDay). These nodes are in turn conditioned on all nodes IcyWeatherAtDay-n, which have an 'n' smaller than itself. The idea is that icy weather at any given day is conditioned on all the previous days before it that we track.