

Q1. Bayes Nets, Fire, and Dangerous Things

This problem requires the AIspace.org Bayes net tool. Point your browser to: <http://www-inst.eecs.berkeley.edu/~cs188/sp11/bayes/bayes.jar>, and then load the Bayes net here: <http://www-inst.eecs.berkeley.edu/~cs188/sp11/bayes/network.xml>.

The Bayes net is three nodes, which correspond to three events: Alarm = the fire alarm in your apartment sounds, Fire = there was a fire in your apartment, and Tampering = your smoke detector was tampered with. Fire affects Alarm (a fire increases the probability of the alarm sounding) and Tampering also affects Alarm (if someone tampered with your smoke detector, your alarm is more likely to sound when there is no fire, and less likely to sound when there is a fire). The probabilities in the Bayes net you were given correspond to these tables:

$P(\text{Tampering} = T)$	$P(\text{Tampering} = \bar{T})$
0.02	0.98

$P(\text{Fire} = T)$	$P(\text{Fire} = \bar{T})$
0.01	0.99

	$P(\text{Alarm} = T \mid \text{Tampering}, \text{Fire})$	$P(\text{Alarm} = F \mid \text{Tampering}, \text{Fire})$
Tampering=T, Fire=T	0.5	0.5
Tampering=T, Fire=F	0.85	0.15
Tampering=F, Fire=T	0.99	0.01
Tampering=F, Fire=F	0.0	1.0

Use the Bayes net tool to answer the following questions:

- (a) What is the marginal probability that your fire alarm will sound?

- (b) Let's assume that you've observed that your smoke detector has not been tampered with. What's the posterior probability that the alarm will sound?

- (c) Still assuming that you've observed that your smoke detector has not been tampered with, what's the posterior probability that there was a fire in your apartment?

- (d) Now let's assume that you've observed that your smoke detector has not been tampered with, and that the fire alarm has sounded. What's the posterior probability that there was a fire in your apartment?

You will now expand on the Bayes net we have provided to you to include three more events: Smoke (there is smoke in your apartment), Evacuation (your apartment building is evacuated), and Report (the local newspaper writes a report about the evacuation of your apartment). The probability of smoke when there's fire is 0.9, the probability of smoke when there's no fire is 0.01. When your apartment building has a fire alarm, there's a 0.88 probability that there were be an evacuation, but there's never an evacuation when there is no fire alarm. If there is an evacuation, there's a 0.75 probability that the newspaper will write a report on it, and if there's no evacuation there's a 0.99 probability that the newspaper wont report it. Add the necessary nodes and edges to your Bayes net, input the proper conditional probability tables, and then use the expanded Bayes net to answer the following questions:

- (e) What's the marginal probability that your smoke detector has been tampered with?
- (f) What's the marginal probability that there will be a news report tomorrow?
- (g) Let's assume that you've observed that there is smoke in your apartment. What is your posterior probability that there will be a news report tomorrow?
- (h) Let's assume that you've observed that there is **no** smoke in your apartment. What is your posterior probability that your smoke detector has been tampered with? What conditional independence property could help you here?
- (i) Let's assume that you've observed that there has been a news report about your apartment, and there is no smoke in your apartment. What is your posterior probability that your smoke detector has been tampered with? Given that the news report was observed, why does observing the absence of smoke affect your belief of whether or not your smoke alarm was tampered with?
- (j) Let's assume that you've observed that there was no fire, and that there was a news report about your apartment. What is your posterior probability that your smoke detector has been tampered with?
- (k) Let's assume that you've observed that there was no fire, that there was a news report about your apartment, and that there is smoke in your apartment. What is your posterior probability that your smoke detector has been tampered with? How does observing whether or not there is smoke affect your belief of whether or not your smoke detector has been tampered with? Why?
- (l) Use the tool to check the following (conditional) independence properties, and state whether they are true or false. Note: it is not possible to assert a dependence between variables given just the graph structure, but we are able to assert dependence here because we have access to the actual conditional probability tables.

Tampering $\perp\!\!\!\perp$ Evacuation
 Tampering $\perp\!\!\!\perp$ Evacuation | Alarm
 Tampering $\perp\!\!\!\perp$ Evacuation | Smoke
 Tampering $\perp\!\!\!\perp$ Fire
 Tampering $\perp\!\!\!\perp$ Fire | Alarm
 Alarm $\perp\!\!\!\perp$ Smoke
 Smoke $\perp\!\!\!\perp$ Report
 Smoke $\perp\!\!\!\perp$ Tampering
 Smoke $\perp\!\!\!\perp$ Tampering | Alarm
 Smoke $\perp\!\!\!\perp$ Tampering | Report