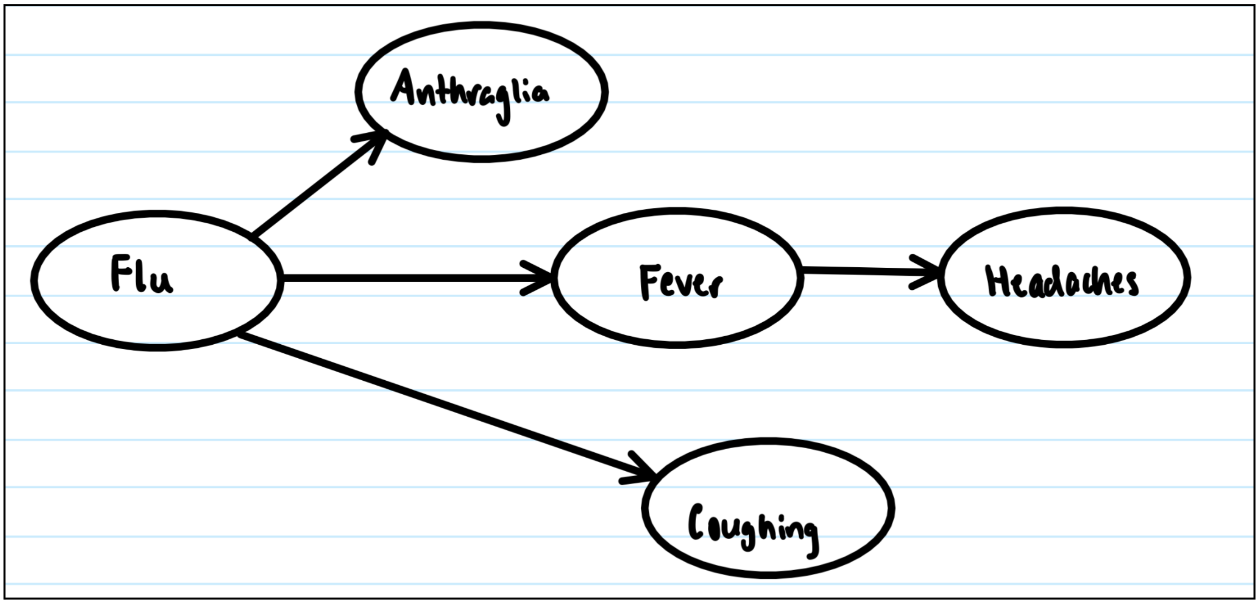
Question 1

Recall that the naïve Bayes assumption is that no effects of a cause are also causes of each other. If two effects are correlated it is because they are related to the same, underlying cause. The naïve Bayes model provides an alternative representation for diagnostic inference. Draw a Bayes net representing the naïve Bayes model for diagnosing *Flu* given its symptoms (assume the symptoms of *Flu* are every successor of *Flu* in the Bayes net in Figure 1). Which model (the Bayes net in Figure 1 or the naïve Bayes model that you've constructed) is a richer representation? That is to say, is there anything we can represent with one model that we cannot represent with the other model?

Question 1 Answer:



The Bayes Net in figure 1 is a richer representation because it offers us more context for which certain effects stem from different causes. For example, in the first graph it is given that coughing is the effect of the cold, a node which is not present here. If we were just going off of this graph, we would assume that the flu is solely the cause of coughing and nothing else. As well as within our model, we are missing certain relationships such as headaches being the effects of coughing. According to this graph, we would think that a fever alone is what causes headaches.

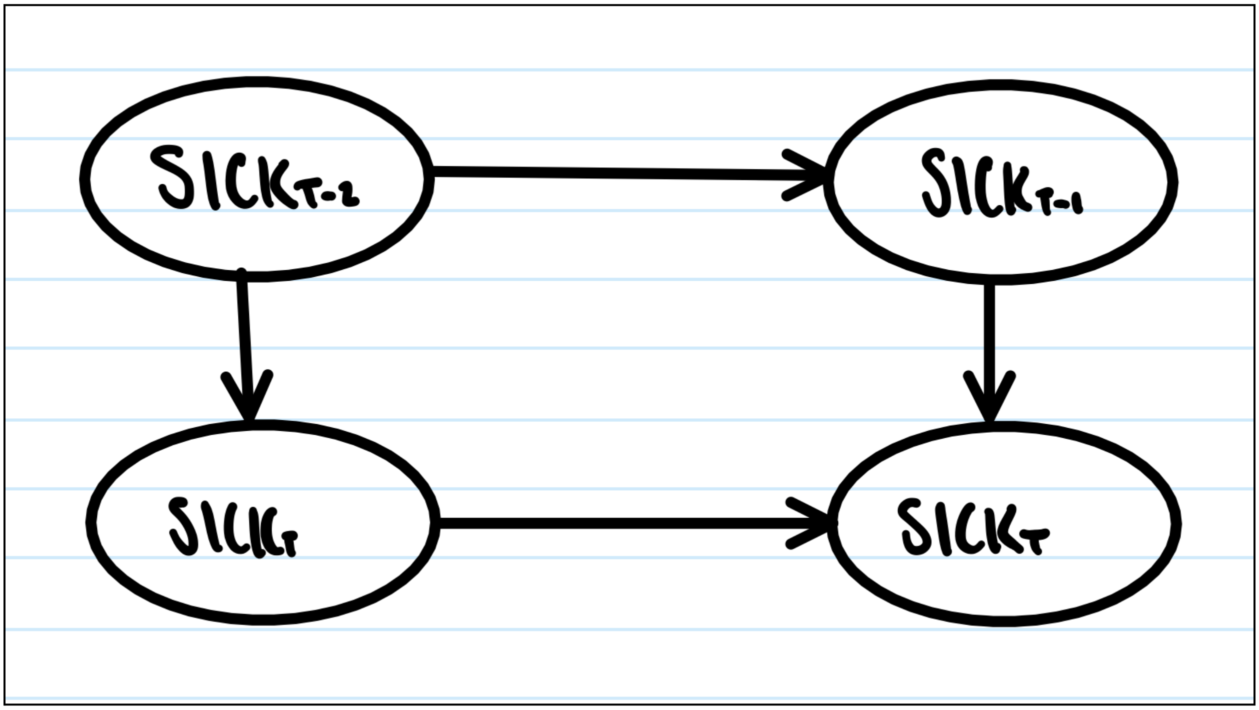
$SICK_{t-1}$	$P(SICK_t = T \mid SICK_{t-1})$	$P(SICK_t = F \mid SICK_{t-1})$
T	0.7	0.3
F	0.5	0.5

Table 1: Transition Probabilities

Figure 2: First Order Markov Dynamic Bayes Net

The traditional Dynamic Bayes Net has an unobservable random variable X_t that has a single parent of the value of X_{t-1}, which is the value of X at the previous time step. For example, SICK$_t$ is conditioned on SICK$_{t-1}$. This can capture a relationship such as "when one is sick, the probability is high that one is still sick at the next time step, and when one is not sick, one can become sick or stay well with equal probability". See the image for an example. However, if one were to use this Bayes network to predict the future, the model may conclude that people become sick randomly and then stay sick. This setup does not account for second-order effects, such as: "after one is sick for a while, the probability is high that one stops being sick". A 2-Markov assumption states that an unobservable random variable X_t is conditioned on X_{t-1} and X_{t-2}. **Using a time step equal to a week, draw a 2-Markov Dynamic Bayes Network that captures the intuition that one can become sick at any time**. When one is sick one is likely to remain sick unless they have been sick for two weeks, at which time they are likely to cease being sick. When one is sick, the probability of cough is high and when one is not sick, the probability of cough is low. **Show all the conditional probability tables; make up reasonable numbers to express the relationships described above.**

Question 2 Answer:



$SICK_{T-1}$	$P(SICK_T = T \mid SICK_{T-1})$	$P(SICK_T = F \mid SICK_{T-1})$
T	0.80	0.20
F	0.50	0.50

$SICK_{T-2}$	$P(SICK_T = T \mid SICK_{T-2})$	$P(SICK_T = F \mid SICK_{T-2})$
T	0.20	0.80
F	0.50	0.50

Question 3

Medical diagnosis with Bayesian networks are currently used as a *decision support systems* by healthcare professionals. An expert can input patient information and observed symptoms, and the decision support system outputs a set of possible diagnoses with associated likelihoods, but the final diagnosis decision is up to the medical professional. Why should we require a human supervisor to accept or override the decision of the AI diagnosis system? Name two (2) potential sources of error or unaccounted for situations for these Bayes net diagnosis models that are mitigated by having a trained healthcare professional make the final diagnosis decision.

Question 3 Answer: One potential source of error would be new or unprecedented symptoms that may occur within that specific patient, which is something that may not appear on the diagnosis models. In the event of a new symptom appearing, it would require creating a new model for it and accounting for all those new probabilities. Another potential source of error would be not accounting for the patient's previous medical history as part of the problem. Maybe the patient is very sensitive to a certain phenomenon or has some prior medical condition that isn't logged into the model because it isn't seen as relevant but this could unknowingly throw a wrench into the entire diagnosis. Overall, it's important to consider a human professional's opinion in sensitive situations like these.

Question 4

Publicly accessible online services often use databases and symptom matching to inform users of possible medical conditions given a list of symptoms. These services do not provide diagnosis likelihoods. Could providing a free online service with Bayes-net-based medical diagnosis have negative impacts on human behavior? Could they have positive impacts? If you answered yes to either question, give one example. If you answered no, explain why not.

Question 4 Answer: Yes there can be both positive and negative impacts with this online service. An example would be a user inputting their information and they would receive a huge list of connected information about their diagnosis which, while not 100% medically accurate, can spark interest in the user to pursue their medical history further and gain better insights about their health and wellbeing. Optimistically, this can help the user to learn more about their specific conditions by pointing them in the right direction.