COMP9414: Artificial Intelligence
Tutorial Week 5: Reasoning with Uncertainty

1. Show how to derive Bayes' Rule from the definition $P(A \wedge B) = P(A|B).P(B)$.

2. Suppose you are give the following information

   Mumps causes fever 75% of the time
   The chance of a patient having mumps is $\frac{1}{15000}$
   The chance of a patient having fever is $\frac{1}{1000}$

   Determine the conditional probability of a patient suffering from mumps given that they have don't have a fever, i.e. $P(Mumps|\neg Fever)$.

3. Consider the following statements

   Headaches and blurred vision may be the result of sitting too close to a monitor. Headaches may also be caused by bad posture. Headaches and blurred vision may cause nausea. Headaches may also lead to blurred vision.

   (i) Represent the causal links in a Bayesian network. Let H stand for "headache", B for "blurred vision", S for "sitting too close to a monitor", P for "bad posture" and N for "nausea". In terms of conditional probabilities, write a formula for the event that all five variables are true, i.e. $P(H \wedge B \wedge S \wedge P \wedge N)$.

   (ii) Suppose the following probabilities are given

   $P(H|S,P) = 0.8$ $\quad P(H|\neg S,P) = 0.4$
   $P(H|S,\neg P) = 0.6$ $\quad P(H|\neg S,\neg P) = 0.02$
   $P(B|S,H) = 0.4$ $\quad P(B|\neg S,H) = 0.3$
   $P(B|S,\neg H) = 0.2$ $\quad P(B|\neg S,\neg H) = 0.01$
   $P(S) = 0.1$
   $P(P) = 0.2$
   $P(N|H,B) = 0.9$ $\quad P(N|\neg H,B) = 0.3$
   $P(N|H,\neg B) = 0.5$ $\quad P(N|\neg H,\neg B) = 0.7$

   Furthermore, assume that some patient is suffering from headaches but not from nausea. Calculate joint probabilities for the 8 remaining possibilities (that is, according to whether S, B, P are true or false).

   (iii) What is the probability that the patient suffers from bad posture given that they are suffering from headaches but not from nausea?

4. Consider the "burglar alarm" Bayesian network from the lectures. Derive, using Bayes' Rule, an expression for $P(Burglary|Alarm)$ in terms of the conditional probabilities represented in the network. Then calculate the value of this probability.

   Is this number what you expected? Explain what is going on.

   Check your answer using the AIPython program `probVE.py`. Answers to method calls such as `bn4v.query(B,{A:True})` are in a list form [F,T] giving the probability that B is false and the probability that B is true, in conjunction with the list of conditions (here that A is true). The desired answer is then calculated by normalization. The Bayesian network is encoded as `bn4` in `probGraphicalModels.py`.

5. Prove the conditional version of Bayes' Rule: $P(B|A,C) = \frac{P(A|B,C)P(B|C)}{P(A|C)}$. Here C is an added condition to all terms in the original version of Bayes' Rule.

6. **Programming.** Try out the bigram tagger from NLTK. Here you can load a corpus of text, create the bigram model (this can take several seconds), and then use the model to tag a given sentence. The example below from the NLTK book uses the Brown corpus. You can also print co-occurring words in a window around a given word.

```
import nltk
from nltk.corpus import brown
text = nltk.Text(word.lower() for word in nltk.corpus.brown.words())

brown_tagged_sents = brown.tagged_sents(categories='news')
brown_sents = brown.sents(categories='news')
size = int(len(brown_tagged_sents) * 0.9)
train_sents = brown_tagged_sents[:size]
bigram_tagger = nltk.BigramTagger(train_sents)
print(bigram_tagger.tag(brown_sents[2007]))

print(text.similar('woman'))
```