GWV – Grundlagen der Wissensverarbeitung
Tutorial 9 : Belief Networks

Class Exercise 9.1 : (weather prediction)

Suppose you could make exactly two observations about a given day: whether it is **s**unny or **r**ainy and whether it is **w**arm or **c**old.

You also know how likely these observations are, given the observations of the previous day (the two observations are statistically independent):

If it was sunny and warm, there is an 80% chance it will be warm again and a 70% chance it will be sunny again.

If it was sunny and cold, there is an 50% chance it will be cold again and a 60% chance it will be sunny again.

If it was rainy and warm, there is an 30% chance it will be warm again and a 60% chance it will be rainy again.

If it was rainy and cold, there is an 80% chance it will be cold again and a 80% chance it will be rainy again.

Today, it is sunny and warm. How likely is it that

- it will stay that way for three more days?
- it will stay sunny for three more days?

And – as always – formalize the problem first.

Exercise 9.2: (Language Modelling)

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- Write a program that describes a language as a Markov chain (the probability of the next word depends on the current word). It should be able to learn the probabilities from a text file (provided in the wiki) and generate random sequences of a given length from a given starting position. (3 Pt.)
- Describe properties of the resulting sequences: what are the similarities and differences to "real" texts? (1 Pt.)
- *Bonus:* Enhance your program to use trigrams / quadrograms instead of bigrams (no points, just for fun!)
- *Hint:* If you want randomly pick an element from a probability distribution, you can do the following:

```
r = [pick a random number between 0 and 1.]
sum_of_probs = 0
for word in words:
    sum_of_probs += P(word|context)
    if sum_of_probs >= r:
       return word
```

Exercise 9.3: (Diagnosis (cont.))

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Figure 1 shows the known car engine domain. Transform the knowledge encoded in that picture into a belief network. Assume that for each breakable component (that is any component in a grey box) a independent probability of 0.1 for that component being broken is given. Assume further that any component only works (and does so in all of the cases) if it is not broken and all the components necessary for it to work are also working.

Compute the following probabilities:

- The probability that the battery is working.
- The probability that the starter is working.
- The probability that the engine is working.
- The probability that the engine is working after making the observation that the pump is working.

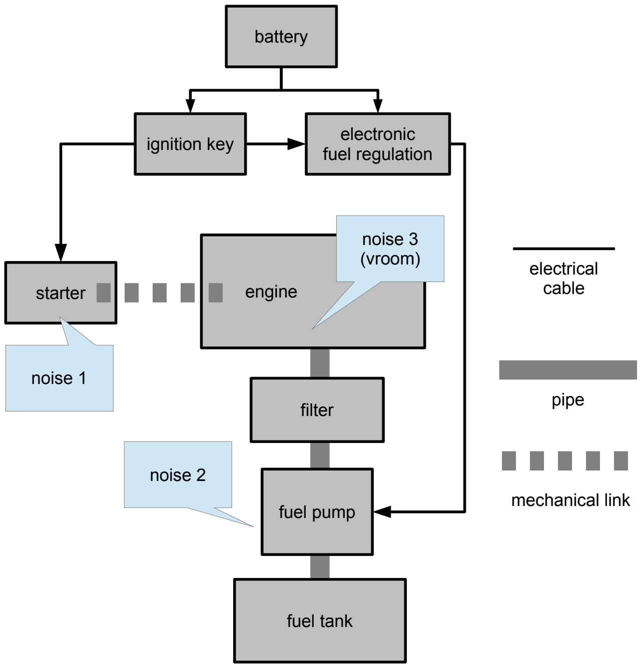

Figure 1: A car engine

Exercise 9.4 : (Bayesian Probabilities)

Turn the following scenario into a belief network:

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- The probability that a person controlled by the police is a smuggler is 0.01.
- The probability that a trained drug dog will bark at a smuggler is 0.8 – unfortunately these dogs also have false positive alarms. 1 out of every 20 persons sniffed by a drug dog will get the dog to bark even though that person is not a smuggler. (But maybe that person is a cat owner).
- Police not only rely on their dogs to identify smugglers. A smuggler will usually be nervous during a control and sweat a lot. Unfortunately there are also other reasons to sweat like having a fever. Police research showed the following results. If someone is not a smuggler nor has a fever then the likelihood that that person is sweating is zero. If it's a smuggler without fever then the likelihood of sweating is 0.4, it increases to 0.8 if that person also suffers from a fever. Unfortunately the probability for a person that is not a smuggler and heaving fever is also quite high with 0.6.
- Doctors claim that about 13 persons in 1000 is having a fever.

Now that you know all this, here are your tasks:

- Complete the missing probabilities and draw the probability network. (1 Pt.)

- Give an example of “explaining away” in the given network. (1 Pt.)
- Compute the following probabilities:
  - The probability that a person is a smuggler given the observation that the drug dog is barking (1 Pt.)
  - The probability that a suspect is sweating (without any prior observation) (1 Pt.)
  - The probability that a person is a smuggler given both the observations that that person is sweating and that the drug dog barked at him or her. (2 Pt.)

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Achievable score on this sheet: 12