Assignment3 – Decisions

Given: May 15 Due: May 20

Problem 3.1 (Bayesian Networks in Python)

The goal of this exercise is to *implement* inference by enumeration in Bayesian networks in Python. You can find the necessary files at `https://kwarc.info/teaching/AI/resources/AI2/bayes/`.

Your task is to *implement* the `query` function in `bayes.py`. Use `test.py` for testing your *implementation*.

Important: We will test your code automatically. So please make sure that:

- The tests in `test.py` work on your code (without any modifications to `test.py`)
- You use a recent Python version (≥ 3.5)
- You don't use any libraries
- You only upload a single file `bayes.py` with your *implementation* of `query`

Otherwise you risk getting no points.

Hint: First *implement* a function for the *full joint probability distribution*.

Problem 3.2 (Decision Network)

You try to decide on whether to take an umbrella (boolean variable M) to Uni. Obviously, it is useful (numeric variable U for the utility) to do so if it rains (boolean variable W) when you go back home, but it is annoying to carry around if it does not even rain. You decide based on whether the weather forecast predicts rain (boolean variable F).

1. Draw the decision network for bringing/leaving an umbrella depending on the weather forecast and the actual weather. Explain the four variables M, U, W, and F and what to store in their probability tables.
2. Explain formally how to compute whether or not to take an umbrella, assuming you know the probability that the forecast is correct.

Problem 3.3 (Decision Preferences)

1. Name and state three of the axioms for *preferences* (i.e. $\succ$).
2. How are preferences related to *value functions*?

Problem 3.4 (Decision Network)

You need a new car. Your local dealership has two models on offer

- C_1 for \$1500 with market value \$2000
- C_2 for \$1150 with market value \$1400

Either car can be of good quality or bad quality, and you have no information about that. If C_1 is of bad quality, repairing it will cost \$700, if C_2 is of bad quality repairing it will cost \$150.

You have the choice between two tests:

1. $Test_1$ at cost \$50: This will confirm that C_1 is of good quality (if it is) with certainty 85% probability, and that it is of bad quality (if it is) with certainty 65%.

2. $Test_2$ at cost \$20: This will confirm that C_2 is of good quality (if it is) with 75% certainty, and that it is of bad quality (if it is) with certainty 70%.

The a priori probability (without any tests) that a car is of good quality is 70% for C_1 and 65% for C_2.

The utility function is the monetary value, i.e., the difference of the market value of the acquired car and the amount of money spent on test, car, and repair.

1. Decision networks in general have three kinds of nodes. Explain the differences regarding the probability tables of the three kinds.
2. Now regarding the concrete network used here, explain the random variables of all nodes and their domains.
3. Draw the decision network for which test to apply and which car to buy in either case. This should include:
   - an action node for the test decision (no test, Test1, or Test2)
   - an action node for which car to buy
   - utility nodes for each of the two cars
   - chance nodes for the quality of the cars and the outcomes of the tests
4. Assume we have chosen to do $Test_1$ and the outcome was good. Compute which car to buy.
5. How would we choose which test to do?