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Artificial Intelligence and Decision Systems (IASD)
Mini-projects, 2019/2020

Assignment #2

Version 1.0 (15-Nov-2019)

The museum is on fire!

1 Introduction

In September 2nd of 2018 a huge fire consumed more than 93% of the National Museum of Brasil collection, built over a period of two centuries. It is believed that the bad condition of the electrical system was the major cause of this tragic event. Moreover, there were plans to reform the fire prevention system, which were not implemented in due time.

This mini-project addresses the problem of fire detection in a museum, taking into account a simple fire propagation model and the uncertainty associated with the fire detectors spread over the building.

The problem is formulated as follows. Let the museum building be modeled by an undirected graph, where the nodes are the rooms, $\mathcal{R} = \{r_1, \ldots, r_N\}$, and the edges are the doors/stars connecting adjacent rooms, $\mathcal{C} = \{(r_i, r_j), \ldots\}$ where $r_i, r_j \in \mathcal{R}$. Some of these rooms are equipped with sensors, $\mathcal{S} = \{s_1, \ldots, s_M\}$, $M \leq N$, where the map $l : \mathcal{S} \to \mathcal{R}$ specifies the room covered by each sensor.

Each one of these sensors is characterized by two parameters[1]:

TPR — True Positive Rate, also known as *hit rate* or *recall*, is the probability of detecting a fire in case of a real fire, and

FPR — False Positive Rate, also known as *false alarm rate*, is the probability of detecting a fire in case of no fire.

Consider a set of discrete time steps, $\mathcal{T} = \{1, \ldots, T\}$, where for each time step, the output of only a subset of the sensors is known (e.g., due to poor sensor network). Moreover, we consider the following fire propagation law:

if room $r_i \in \mathcal{R}$ is on fire at time step t, it will continue on fire at $t+1$;

[1]Fawcett, T. (2006). An introduction to ROC analysis. *Pattern recognition letters,* 27(8), 861-874.

or else , it will catch fire with probability P at time step $t+1$ when any of the adjacent rooms was on fire at t, and 0 otherwise.

Finally, assume that at the first time instant, $t = 1$, we have absolutely no knowledge about which room(s) is(are) on fire.

2 Objectives

The objective of this project is to determine the room that is most probable to be on fire at time step T, as well as the probability value, given a set of measurements in the form (t, s, z) where $t \in \mathcal{T}$ is the time step, $s \in \mathcal{S}$ is the sensor, and $z \in \{True, False\}$ is a boolean representing whether the sensor detected a fire or not. The problem should be modeled using a Bayesian network, and solved using the variable elimination algorithm for probabilistic inference.

3 Input file format

The problem is specified in a text file format where each line contains a list of space separated fields, where the first field should be one of the following characters:

R — the set of rooms, $\mathcal{R}$

C — the set of connections, $\mathcal{C}$, where the remaining fields are comma-separated pairs of room names

S — the set of sensors, $\mathcal{S}$, together with the corresponding rooms, having each field has the form $s : r : TPR : FPR$ where $r = l(s)$ is the room where sensor $s \in \mathcal{S}$ is located, and TPR and FPR are its true positive and false positive rates

P — the propagation probability $P \in [0, 1]$

M — a measurement where each one of the remaining fields have the form $s : z$ where $s \in \mathcal{S}$ is the sensor and $z \in \{True, False\}$ is the measurement.

Multiple measurement lines may be provided, each one corresponding to a time step, starting at 1 and incrementing for each subsequent line. Therefore, T is given by the total amount of measurement lines.

Example, mildly inspired by the excellent Museum of Fine Arts of Boston:

```
R americas europe asia africa ancient contemporary hall
C americas,europe europe,asia asia,africa africa,ancient \
asia,ancient ancient,contemporary contemporary,americas \
hall,americas hall,contemporary
```

```
S s1:hall:0.9:0.01 s2:ancient:0.7:0.1 s3:europe:0.8:0.05
P 0.7
M s1:F s2:F
M s1:F s3:F
M s1:F s2:T
M s2:T s3:T
```

(**Remark:** the backslashes above are not part of the syntax, rather, they are used here to denote line continuation)

4 Notes

- Project submission is done in Moodle, as in the previous mini-projects. The submissions consists of the code and the answers to a questionnaire.
- The code should use the implementation of Bayes networks and variable elimination algorithm of the AIMA repository[2].
- The implementation should be done in Python version 3. No extra modules, besides the Python Standard Library and the AIMA library mentioned above, are not allowed.
- The code should implement a function called `solve(input_file)` taking as input a opened file object and returning a tuple `(room, likelihood)` where `room` is the most likely room to be on fire, with probability `likelihood`. Check the appendix for a template (which will also be available on Moodle)

5 Evaluation

The grade is computed in the following way:

- 40% from the public tests
- 40% from the private tests
- 20% from the questionnaire

Deadline: 15-Dec-2019 (Projects submitted after the deadline will not be considered for evaluation.)

[2]Class `BayesNet` and function `elimination_ask` of the file `probability.py` in the GitHub repository `https://github.com/aimacode/aima-python`.

Code template

```
import probability

class Problem:

    def __init__(self, fh):
        # Place here your code to load problem from opened file object fh
        # and use probability.BayesNet() to create the Bayesian network

    def solve(self):
        # Place here your code to determine the maximum likelihood solution
        # returning the solution room name and likelihood
        # use probability.elimination_ask() to perform probabilistic inference
        return (room, likelihood)

def solver(input_file):
    return Problem(input_file).solve()
```