Introduction to AI - assignment 4

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1 Introduction

In this assignment we provide a Bayesian Network for the hurricane problem from assignment 1.

2 Bayesian Network construction

We built our BN in the following manner. The nodes of the BN are as described in the assignment:
3 types of variables (BN nodes): **blockages** (one for each edge) **flooding** (one for each vertex,) and **evacuees** present (one for each vertex).
Each **flooding** node of vertex v point to all **blockage** nodes of edges $\{\{v, u\} : u \in V\}$.
All **blockage** nodes of edges $\{\{v, u\} : v, u \in V\}$ point to **evacuees** nodes of vertices u and v.

3 Probabilistic reasoning algorithm

Our algorithm is somehow similar to the simple *Enumeration Algorithm*. The main idea is to exploit the Law of total probability. Meaning, in order to calculate a probability of a specific BN node/s we iterate over all **relevant** BN nodes, and calculate the probability given they are true/ false and multiply by the probability of them being true/ false respectively. The algorithm is presented herein: 1

Algorithm 1 TotalProbability

procedure TotalProbability(ConditionalProbFunc, ListOfNoisyBooleanVariables)
  $value \longleftarrow 0$
  for assignment $\in$ possible True/ False assignments to ListOfNoisyBooleanVariables **do**
    $P(assignment) = 1$
    for $NoisyBooleanVariable \in ListOfNoisyBooleanVariables$ **do**
      $P(assignment)$ *= $P(NoisyBooleanVariable \in assignment)$
    end for
    $value$ += $ConditionalProbFunc(assingment) * P(assignment)$
  end for
  return $value$
end procedure

We will describe our probabilistic reasoning method on each of the following cases:

1. What is the probability that each of the vertices contains evacuees?
   (a) We use the total probability procedure (1):
   (b) We give the relevant **blockages** nodes as $ListOfNoisyBooleanVariables$,
   (c) and the conditional noisy or distribution that was given for the **evacuees** as $ConditionalProbFunc$.
2. What is the probability that each of the vertices is flooded?
   (a) We assume that this information is given as input.
3. What is the probability that each of the edges is blocked?
   (a) We use the total probability procedure (1):
   (b) We give the relevant **flooding** nodes as $ListOfNoisyBooleanVariables$,
   (c) and the conditional noisy or distribution that was given for the **blockage** as $ConditionalProbFunc$.
4. What is the probability that a certain path (set of edges) is free from blockages? (Note that the distributions of blockages in edges are NOT necessarily independent.)
   (a) We use the total probability but with a little difference:
   (b) We calculate the probability of each assignment by multiplying the probabilities of all the **flooding** nodes.
      i. For each assignment, we calculate the probability by multiplying all the probabilities of not having a **blockage** given the **flooding** nodes, with the the conditional noisy or distribution that was given for the blockage.

4 Run example

In both of the examples we check that the following path is free of blocked edges: 1,3

4.1 First example - the setting that was given in the assignment

4.1.1 Input

```
#V 4          ; number of vertices n in graph (from 1 to n)

#V 0 F 0.2    ; Vertex 1, probability flooding 0.2
#V 1 F 0.4    ; Vertex 2, probability flooding 0.4


#E1 0 1 1 ; Edge1 between vertices 1 and 2, weight 1
#E2 1 2 3 ; Edge2 between vertices 2 and 3, weight 3
#E3 2 3 3 ; Edge3 between vertices 3 and 4, weight 3
#E4 1 3 4 ; Edge4 between vertices 2 and 4, weight 4
```

4.1.2 Output

```
Vertex0
---------
P(Flood)=20.0%
P(!Flood)=80.0%
P(Evacuees|!Blockage1 )=0.1%
P(Evacuees|Blockage1 )=40.0%
P(!Evacuees|!Blockage1 )=99.9%
P(!Evacuees|Blockage1 )=60.0%
P(Evacuees|)=0.13334032000000004

Vertex1
---------
P(Flood)=40.0%
P(!Flood)=60.0%
P(Evacuees|!Blockage1 !Blockage2 !Blockage4 )=0.1%
P(Evacuees|!Blockage1 !Blockage2 Blockage4 )=40.0%
P(Evacuees|!Blockage1 Blockage2 !Blockage4 )=40.0%
P(Evacuees|!Blockage1 Blockage2 Blockage4 )=16.000000000000004%
P(Evacuees|Blockage1 !Blockage2 !Blockage4 )=40.0%
P(Evacuees|Blockage1 !Blockage2 Blockage4 )=16.000000000000004%
P(Evacuees|Blockage1 Blockage2 !Blockage4 )=16.000000000000004%
P(Evacuees|Blockage1 Blockage2 Blockage4 )=6.400000000000001%
P(!Evacuees|!Blockage1 !Blockage2 !Blockage4 )=99.9%
P(!Evacuees|!Blockage1 !Blockage2 Blockage4 )=60.0%
P(!Evacuees|!Blockage1 Blockage2 !Blockage4 )=60.0%
P(!Evacuees|!Blockage1 Blockage2 Blockage4 )=84.0%
P(!Evacuees|Blockage1 !Blockage2 !Blockage4 )=60.0%
P(!Evacuees|Blockage1 !Blockage2 Blockage4 )=84.0%
P(!Evacuees|Blockage1 Blockage2 !Blockage4 )=84.0%
P(!Evacuees|Blockage1 Blockage2 Blockage4 )=93.6%
P(Evacuees|)=0.15790008379891843

Vertex2
---------
P(Flood)=0.0%
P(!Flood)=100.0%
P(Evacuees|!Blockage2 !Blockage3 )=0.1%
P(Evacuees|!Blockage2 Blockage3 )=40.0%
P(Evacuees|Blockage2 !Blockage3 )=40.0%
P(Evacuees|Blockage2 Blockage3 )=16.000000000000004%
P(!Evacuees|!Blockage2 !Blockage3 )=99.9%
P(!Evacuees|!Blockage2 Blockage3 )=60.0%
P(!Evacuees|Blockage2 !Blockage3 )=60.0%
P(!Evacuees|Blockage2 Blockage3 )=84.0%
P(Evacuees|)=0.0335068966
```

```
Vertex3
---------
P(Flood)=0.0%
P(!Flood)=100.0%
P(Evacuees|!Blockage3 !Blockage4 )=0.1%
P(Evacuees|!Blockage3 Blockage4 )=40.0%
P(Evacuees|Blockage3 !Blockage4 )=40.0%
P(Evacuees|Blockage3 Blockage4 )=16.000000000000004%
P(!Evacuees|!Blockage3 !Blockage4 )=99.9%
P(!Evacuees|!Blockage3 Blockage4 )=60.0%
P(!Evacuees|Blockage3 !Blockage4 )=60.0%
P(!Evacuees|Blockage3 Blockage4 )=84.0%
P(Evacuees|)=0.025539676600000002

Edge1
----------
P(Blockage 1|!flood0 !flood1)=0.001
P(Blockage 1|!flood0 flood1)=0.6
P(Blockage 1|flood0 !flood1)=0.6
P(Blockage 1|flood0 flood1)=0.84
P(Blockage 1|)=0.3316800000000001
Edge2
----------
P(Blockage 2|!flood1 !flood2)=0.001
P(Blockage 2|!flood1 flood2)=0.19999999999999998
P(Blockage 2|flood1 !flood2)=0.19999999999999998
P(Blockage 2|flood1 flood2)=0.3599999999999999
P(Blockage 2|)=0.0806
Edge3
----------
P(Blockage 3|!flood2 !flood3)=0.001
P(Blockage 3|!flood2 flood3)=0.19999999999999998
P(Blockage 3|flood2 !flood3)=0.19999999999999998
P(Blockage 3|flood2 flood3)=0.3599999999999999
P(Blockage 3|)=0.001
Edge4
----------
P(Blockage 4|!flood1 !flood3)=0.001
P(Blockage 4|!flood1 flood3)=0.15
P(Blockage 4|flood1 !flood3)=0.15
P(Blockage 4|flood1 flood3)=0.2775000000000001
P(Blockage 4|)=0.0606

------------
The probability that the given path is free from blockages is 0.9194000000000001
```

4.2 Second example

4.2.1 Input

```
#V 4          ; number of vertices n in graph (from 1 to n)

#V 0 F 0.8    ; Vertex 1, probability flooding 0.8
#V 1 F 0.5    ; Vertex 2, probability flooding 0.5
#V 2 F 0.5    ; Vertex 3, probability flooding 0.5
#V 3 F 0.2    ; Vertex 4, probability flooding 0.2


#E1 0 1 1 ; Edge1 between vertices 1 and 2, weight 1
#E2 0 2 1 ; Edge2 between vertices 2 and 3, weight 3
#E3 2 3 1 ; Edge3 between vertices 3 and 4, weight 3
```

4.2.2 Output

```
Vertex0
---------
P(Flood)=80.0%
P(!Flood)=19.999999999999996%
P(Evacuees|!Blockage1 !Blockage2 )=0.1%
P(Evacuees|!Blockage1 Blockage2 )=40.0%
P(Evacuees|Blockage1 !Blockage2 )=40.0%
P(Evacuees|Blockage1 Blockage2 )=16.000000000000004%
P(!Evacuees|!Blockage1 !Blockage2 )=99.9%
P(!Evacuees|!Blockage1 Blockage2 )=60.0%
P(!Evacuees|Blockage1 !Blockage2 )=60.0%
P(!Evacuees|Blockage1 Blockage2 )=84.0%
P(Evacuees|)=0.25005356881

Vertex1
---------
P(Flood)=50.0%
P(!Flood)=50.0%
P(Evacuees|!Blockage1 )=0.1%
P(Evacuees|Blockage1 )=40.0%
P(!Evacuees|!Blockage1 )=99.9%
P(!Evacuees|Blockage1 )=60.0%
P(Evacuees|)=0.25480389999999997

Vertex2
---------
P(Flood)=50.0%
```

```
P(!Flood)=50.0%
P(Evacuees|!Blockage2 !Blockage3 )=0.1%
P(Evacuees|!Blockage2 Blockage3 )=40.0%
P(Evacuees|Blockage2 !Blockage3 )=40.0%
P(Evacuees|Blockage2 Blockage3 )=16.000000000000004%
P(!Evacuees|!Blockage2 !Blockage3 )=99.9%
P(!Evacuees|!Blockage2 Blockage3 )=60.0%
P(!Evacuees|Blockage2 !Blockage3 )=60.0%
P(!Evacuees|Blockage2 Blockage3 )=84.0%
P(Evacuees|)=0.25193323924

Vertex3
---------
P(Flood)=20.0%
P(!Flood)=80.0%
P(Evacuees|!Blockage3 )=0.1%
P(Evacuees|Blockage3 )=40.0%
P(!Evacuees|!Blockage3 )=99.9%
P(!Evacuees|Blockage3 )=60.0%
P(Evacuees|)=0.1543756

Edge1
----------
P(Blockage 1|!flood0 !flood1)=0.001
P(Blockage 1|!flood0 flood1)=0.6
P(Blockage 1|flood0 !flood1)=0.6
P(Blockage 1|flood0 flood1)=0.84
P(Blockage 1|)=0.6361
Edge2
----------
P(Blockage 2|!flood0 !flood2)=0.001
P(Blockage 2|!flood0 flood2)=0.6
P(Blockage 2|flood0 !flood2)=0.6
P(Blockage 2|flood0 flood2)=0.84
P(Blockage 2|)=0.6361
Edge3
----------
P(Blockage 3|!flood2 !flood3)=0.001
P(Blockage 3|!flood2 flood3)=0.6
P(Blockage 3|flood2 !flood3)=0.6
P(Blockage 3|flood2 flood3)=0.84
P(Blockage 3|)=0.3844

------------
The probability that the given path is free from blockages is 0.3639000000000001
------------
```

5 How to run

In order to run the program, you should run the file **main.py**. In order to change the path that is desired to be checked for being block-free: change the input list in the 7-th line in that file:

```
ui.path_free_of_blockages([0,2]))
```

or just use the querying user-interface system.