School of Data and Computer Science, Sun Yat-sen University

E08 Bayesian Network

18340013 Conghao Chen

October 26, 2020

Contents

1 Pomegranate Installation **2**

2 Building Bayesian Network **2**

3 Tasks **2**

3.1 Burglary 2

3.2 Diagnosing 3

4 Codes **6**

5 Results **11**

1 Pomegranate Installation

Under Windows

You can also run `pip install pomegranate` if you have installed `pip`. If you don't know how to install `pip`, please click `https://jingyan.baidu.com/article/e73e26c0d94e0524adb6a7ff.html`.

For more, please click the homepage of Pomegranate - `https://github.com/jmschrei/pomegranate` for help.

```
PS C:\Users\Lau ChiuSui\Desktop\pomegranate-0.8.1> pip install pomegranate
Collecting pomegranate
  Downloading pomegranate-0.8.1-cp27-cp27m-win32.whl (3.4MB)
    100% |████████████████████████████████| 3.4MB 227kB/s
Collecting scipy>=0.17.0 (from pomegranate)
  Downloading scipy-1.0.0-cp27-none-win32.whl (26.4MB)
    100% |████████████████████████████████| 26.4MB 40kB/s
Collecting joblib>=0.9.0b4 (from pomegranate)
  Downloading joblib-0.11-py2.py3-none-any.whl (176kB)
    100% |████████████████████████████████| 184kB 957kB/s
Collecting networkx<2.0,>=1.8.1 (from pomegranate)
  Downloading networkx-1.11-py2.py3-none-any.whl (1.3MB)
    100% |████████████████████████████████| 1.3MB 463kB/s
Requirement already satisfied: numpy>=1.8.0 in d:\softwares\python27\lib\site-packages (from pomegranate)
Collecting decorator>=3.4.0 (from networkx<2.0,>=1.8.1->pomegranate)
  Downloading decorator-4.1.2-py2.py3-none-any.whl
Installing collected packages: scipy, joblib, decorator, networkx, pomegranate
  Found existing installation: networkx 2.0
    Uninstalling networkx-2.0:
      Successfully uninstalled networkx-2.0
Successfully installed decorator-4.1.2 joblib-0.11 networkx-1.11 pomegranate-0.8.1 scipy-1.0.0
```

2 Building Bayesian Network

Please refer to `Tutorial_4_Bayesian_Networks.pdf`. I will explain it in class.

3 Tasks

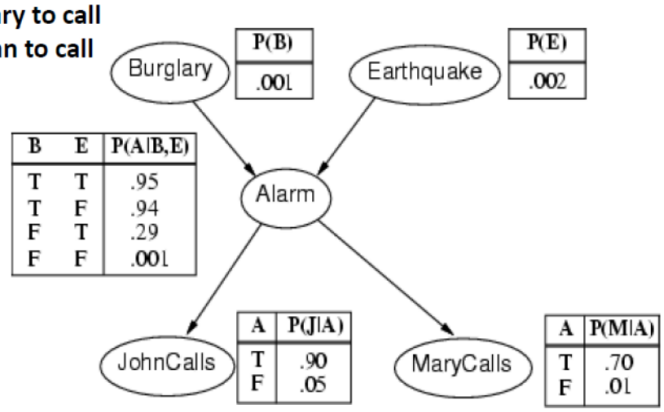
3.1 Burglary

Please code to calculate:

1. $P(A)$
2. $P(J\overline{M})$
3. $P(A|J\overline{M})$
4. $P(B|A)$
5. $P(B|J\overline{M})$
6. $P(J\overline{M}|\overline{B})$

- **A burglary can set the alarm off**
- **An earthquake can set the alarm off**
- **The alarm can cause Mary to call**
- **The alarm can cause John to call**

Note that these tables only provide the probability that Xi is true.
(E.g., Pr(A is true|B,E))
The probability that Xi is false is 1- these values



3.2 Diagnosing

Variables and their domains

(1) PatientAge:['0−30','31−65','65+']

(2) CTScanResult:['Ischemic Stroke','Hemmorraghic Stroke']

(3) MRIScanResult: ['Ischemic Stroke','Hemmorraghic Stroke']

(4) StrokeType: ['Ischemic Stroke','Hemmorraghic Stroke', 'Stroke Mimic']

(5) Anticoagulants: ['Used','Not used']

(6) Mortality:['True', 'False']

(7) Disability: ['Negligible', 'Moderate', 'Severe']

CPTs

Note: [CTScanResult, MRIScanResult,StrokeType] means:

P(StrokeType='...' | CTScanResult='...' ∧ MRIScanResult='...')

(1)

[PatientAge]

['0−30', 0.10],

['31−65', 0.30],

['65+', 0.60]

(2)

[CTScanResult]

['Ischemic Stroke',0.7],
['Hemmorraghic Stroke',0.3]

(3)
[MRIScanResult]

['Ischemic Stroke',0.7],
['Hemmorraghic Stroke',0.3]

(4)
[Anticoagulants]

[Used',0.5],
['Not used',0.5]

(5)
[CTScanResult, MRIScanResult,StrokeType])

['Ischemic Stroke','Ischemic Stroke','Ischemic Stroke',0.8],
['Ischemic Stroke','Hemmorraghic Stroke','Ischemic Stroke',0.5],
['Hemmorraghic Stroke','Ischemic Stroke','Ischemic Stroke',0.5],
['Hemmorraghic Stroke','Hemmorraghic Stroke','Ischemic Stroke',0],

['Ischemic Stroke','Ischemic Stroke','Hemmorraghic Stroke',0],
['Ischemic Stroke','Hemmorraghic Stroke','Hemmorraghic Stroke',0.4],
['Hemmorraghic Stroke','Ischemic Stroke','Hemmorraghic Stroke',0.4],
['Hemmorraghic Stroke','Hemmorraghic Stroke','Hemmorraghic Stroke',0.9],

['Ischemic Stroke','Ischemic Stroke','Stroke Mimic',0.2],
['Ischemic Stroke','Hemmorraghic Stroke','Stroke Mimic',0.1],
['Hemmorraghic Stroke','Ischemic Stroke','Stroke Mimic',0.1],
['Hemmorraghic Stroke','Hemmorraghic Stroke','Stroke Mimic',0.1],

(6)

[StrokeType, Anticoagulants, Mortality]

['Ischemic Stroke', 'Used', 'False',0.28],
['Hemmorraghic Stroke', 'Used', 'False',0.99],
['Stroke Mimic', 'Used', 'False',0.1],
['Ischemic Stroke','Not used', 'False',0.56],
['Hemmorraghic Stroke', 'Not used', 'False',0.58],
['Stroke Mimic', 'Not used', 'False',0.05],

['Ischemic Stroke', 'Used' ,'True',0.72],
['Hemmorraghic Stroke', 'Used', 'True',0.01],
['Stroke Mimic', 'Used', 'True',0.9],
['Ischemic Stroke', 'Not used' ,'True',0.44],
['Hemmorraghic Stroke', 'Not used', 'True',0.42],
['Stroke Mimic', 'Not used', 'True',0.95]

(7)

[StrokeType, PatientAge, Disability]

['Ischemic Stroke', '0-30','Negligible', 0.80],
['Hemmorraghic Stroke', '0-30','Negligible', 0.70],
['Stroke Mimic', '0-30', 'Negligible',0.9],
['Ischemic Stroke', '31-65','Negligible', 0.60],
['Hemmorraghic Stroke', '31-65','Negligible', 0.50],
['Stroke Mimic', '31-65', 'Negligible',0.4],
['Ischemic Stroke', '65+' , 'Negligible',0.30],
['Hemmorraghic Stroke', '65+' , 'Negligible',0.20],
['Stroke Mimic', '65+' , 'Negligible',0.1],

['Ischemic Stroke', '0-30' ,'Moderate',0.1],
['Hemmorraghic Stroke', '0-30' ,'Moderate',0.2],
['Stroke Mimic', '0-30' ,'Moderate',0.05],

```
['Ischemic Stroke',      '31-65','Moderate',0.3],
['Hemmorraghic Stroke', '31-65','Moderate',0.4],
['Stroke Mimic',         '31-65','Moderate',0.3],
['Ischemic Stroke',      '65+'  ,'Moderate',0.4],
['Hemmorraghic Stroke', '65+'  ,'Moderate',0.2],
['Stroke Mimic',         '65+'  ,'Moderate',0.1],

['Ischemic Stroke',      '0-30' ,'Severe',0.1],
['Hemmorraghic Stroke', '0-30' ,'Severe',0.1],
['Stroke Mimic',         '0-30' ,'Severe',0.05],
['Ischemic Stroke',      '31-65','Severe',0.1],
['Hemmorraghic Stroke', '31-65','Severe',0.1],
['Stroke Mimic',         '31-65','Severe',0.3],
['Ischemic Stroke',      '65+'  ,'Severe',0.3],
['Hemmorraghic Stroke', '65+'  ,'Severe',0.6],
['Stroke Mimic',         '65+'  ,'Severe',0.8]
```

Calculation

Please code to calculate the following probability value:

p1 = P(Mortality='True' | PatientAge='31-65' ∧ CTScanResult='Ischemic Stroke')

p2 = P(Disability='Moderate' | PatientAge='65+' ∧ MRIScanResult='Hemmorraghic Stroke')

p3 = P(StrokeType='Stroke Mimic' | PatientAge='65+' ∧ CTScanResult='Hemmorraghic Stroke' ∧ MRIScanResult='Ischemic Stroke')

p4 = P(Anticoagulants='Not used' | PatientAge='0-30')

Please solve the 2 tasks and hand in a file named E08_YourNumber.pdf, and send it to ai_2020@foxmail.com

4 Codes

burglary.py

```
from pomegranate import *

burglary = DiscreteDistribution( {'T':0.001, 'F':0.999} )
earthquake = DiscreteDistribution( {'T':0.002, 'F':0.998} )
alarm = ConditionalProbabilityTable(
```

```
[['T','T','T',0.95],
['T','F','T',0.94],
['F','T','T',0.29],
['F','F','T',0.001],
['T','T','F',0.05],
['T','F','F',0.06],
['F','T','F',0.71],
['F','F','F',0.999]], [burglary, earthquake])
johncalls = ConditionalProbabilityTable(
[['T','T',0.90],
['F','T',0.05],
['T','F',0.10],
['F','F',0.95]], [alarm])
marycalls = ConditionalProbabilityTable(
[['T','T',0.70],
['F','T',0.01],
['T','F',0.30],
['F','F',0.99]], [alarm])

s1 = State(burglary, name="burglary")
s2 = State(earthquake, name="earthquake")
s3 = State(alarm, name="alarm")
s4 = State(johncalls, name="johncalls")
s5 = State(marycalls, name="marycalls")

model = BayesianNetwork("Burglary")

model.add_states(s1,s2,s3,s4,s5)

model.add_transition(s1,s3)
model.add_transition(s2,s3)
model.add_transition(s3,s4)
model.add_transition(s3,s5)
```

```
model.bake()

marginals = model.predict_proba({})

print("P(A) = {}".format(marginals[2].parameters[0]["T"]))
jandnotm = model.predict_proba({'marycalls':'F'})[3].parameters[0]["T"]
    * marginals[4].parameters[0]["F"]
print("P(J && ~M) = {}".format(jandnotm))
print("P(A | J && ~M) =
    {}".format(model.predict_proba({'johncalls':'T','marycalls':'F'})[2].p
arameters[0]["T"]))
print("P(B | A) =
    {}".format(model.predict_proba({'alarm':'T'})[0].parameters[0]["T"]))
bwith_jandnotm =
    model.predict_proba({'johncalls':'T','marycalls':'F'})[0].parameters
[0]["T"]
print("P(B | J && ~M) = {}".format(bwith_jandnotm))
print("P(J && ~M | ~B) = {}".format((1-bwith_jandnotm) * jandnotm /
    marginals[0].parameters[0]["F"]))
```

diagnose.py

```
from pomegranate import *

PatientAge = DiscreteDistribution({'0-30':0.10, '31-65':0.30,
    '65+':0.60})
CTScanResult = DiscreteDistribution({'Ischemic Stroke':0.7,
    'Hemmorraghic Stroke':0.3})
MRIScanResult = DiscreteDistribution({'Ischemic Stroke':0.7,
    'Hemmorraghic Stroke':0.3})
Anticoagulants = DiscreteDistribution({'Used':0.5 ,'Not used':0.5})

StrokeType = ConditionalProbabilityTable(
[['Ischemic Stroke','Ischemic Stroke','Ischemic Stroke',0.8],
```

```
['Ischemic Stroke','Hemmorraghic Stroke','Ischemic Stroke',0.5],
['Hemmorraghic Stroke','Ischemic Stroke','Ischemic Stroke',0.5],
['Hemmorraghic Stroke','Hemmorraghic Stroke','Ischemic Stroke',0],
['Ischemic Stroke','Ischemic Stroke','Hemmorraghic Stroke',0],
['Ischemic Stroke','Hemmorraghic Stroke','Hemmorraghic Stroke',0.4],
['Hemmorraghic Stroke','Ischemic Stroke','Hemmorraghic Stroke',0.4],
['Hemmorraghic Stroke','Hemmorraghic Stroke','Hemmorraghic Stroke',0.9],
['Ischemic Stroke','Ischemic Stroke','Stroke Mimic',0.2],
['Ischemic Stroke','Hemmorraghic Stroke','Stroke Mimic',0.1],
['Hemmorraghic Stroke','Ischemic Stroke','Stroke Mimic',0.1],
['Hemmorraghic Stroke','Hemmorraghic Stroke','Stroke
   Mimic',0.1]],[CTScanResult,MRIScanResult])
Mortality = ConditionalProbabilityTable(
[['Ischemic Stroke','Used','False',0.28],
['Hemmorraghic Stroke','Used','False',0.99],
['Stroke Mimic','Used','False',0.1],
['Ischemic Stroke','Not used','False',0.56],
['Hemmorraghic Stroke','Not used','False',0.58],
['Stroke Mimic','Not used','False',0.05],
['Ischemic Stroke','Used','True',0.72],
['Hemmorraghic Stroke','Used','True',0.01],
['Stroke Mimic','Used','True',0.9],
['Ischemic Stroke','Not used','True',0.44],
['Hemmorraghic Stroke','Not used','True',0.42],
['Stroke Mimic','Not used','True',0.95]],[StrokeType, Anticoagulants])
Disability = ConditionalProbabilityTable(
[['Ischemic Stroke','0-30','Negligible',0.80],
['Hemmorraghic Stroke','0-30','Negligible',0.70],
['Stroke Mimic','0-30','Negligible',0.9],
['Ischemic Stroke','31-65','Negligible',0.60],
['Hemmorraghic Stroke','31-65','Negligible',0.50],
['Stroke Mimic','31-65','Negligible',0.4],
['Ischemic Stroke','65+','Negligible',0.30],
```

```
['Hemmorraghic Stroke','65+','Negligible',0.20],
['Stroke Mimic','65+','Negligible',0.1],
['Ischemic Stroke','0-30','Moderate',0.1],
['Hemmorraghic Stroke','0-30','Moderate',0.2],
['Stroke Mimic','0-30','Moderate',0.05],
['Ischemic Stroke','31-65','Moderate',0.3],
['Hemmorraghic Stroke','31-65','Moderate',0.4],
['Stroke Mimic','31-65','Moderate',0.3],
['Ischemic Stroke','65+','Moderate',0.4],
['Hemmorraghic Stroke','65+','Moderate',0.2],
['Stroke Mimic','65+','Moderate',0.1],
['Ischemic Stroke','0-30','Severe',0.1],
['Hemmorraghic Stroke','0-30','Severe',0.1],
['Stroke Mimic','0-30','Severe',0.05],
['Ischemic Stroke','31-65','Severe',0.1],
['Hemmorraghic Stroke','31-65','Severe',0.1],
['Stroke Mimic','31-65','Severe',0.3],
['Ischemic Stroke','65+','Severe',0.3],
['Hemmorraghic Stroke','65+','Severe',0.6],
['Stroke Mimic','65+','Severe',0.8]],[StrokeType,PatientAge])

s1 = State(PatientAge, name="PatientAge")
s2 = State(CTScanResult, name="CTScanResult")
s3 = State(MRIScanResult, name="MRIScanResult")
s4 = State(StrokeType, name="StrokeType")
s5 = State(Anticoagulants, name="Anticoagulants")
s6 = State(Mortality, name="Mortality")
s7 = State(Disability, name="Disability")

model = BayesianNetwork("Diagnose")

model.add_states(s1,s2,s3,s4,s5,s6,s7)
```

```
model.add_transition(s2,s4)
model.add_transition(s3,s4)
model.add_transition(s4,s6)
model.add_transition(s5,s6)
model.add_transition(s1,s7)
model.add_transition(s4,s7)

model.bake()

marginals = model.predict_proba({})
p1 = model.predict_proba({'PatientAge':'31-65','CTScanResult':'Ischemic
    Stroke'})[5].parameters[0]["True"]
p2 =
    model.predict_proba({'PatientAge':'65+','MRIScanResult':'Hemmorraghic
    Stroke'})[6].parameters[0]["Moderate"]
p3 =
    model.predict_proba({'PatientAge':'65+','CTScanResult':'Hemmorraghic
    Stroke','MRIScanResult':'Ischemic Stroke'})[3].parameters[0]["Stroke
    Mimic"]
p4 = model.predict_proba({'PatientAge':'0-30'})[4].parameters[0]["Not
    used"]
print("p1=",p1)
print("p2=",p2)
print("p3=",p3)
print("p4=",p4)
```

5 Results

第一张图片为文档给出的 burglary 问题的解, 第二张图片为我得到的 burglary 问题的解; 第三张图片为文档给出的 diagnose 问题的解, 第四张图片为我得到的 diagnose 问题的解. 虽然保留小数点后位数不同, 但可以看到结果是非常接近的, 证明我写的程序得到了正确解.

```
P(Alarm) =
0.002516442

P(J&&~M) =
0.050054875461

P(A |J&&~M) =
0.0135738893313

P(B |A) =
0.373551228282

P(B |J&&~M) =
0.0051298581334

P(J&&~M |~B) =
0.049847949
```

```
C:\Users\czh\.conda\envs\Pycharm\python.exe "D:/Pycharm/PyCharm 2020.2.2/burglary.py"
P(A) = 0.0025164420000009344
P(J && ~M) = 0.05005487546100036
P(A | J && ~M) = 0.013573889331311458
P(B | A) = 0.37355122828189946
P(B | J && ~M) = 0.005129858133403523
P(J && ~M | ~B) = 0.04984794900000027
```

```
ai2017@osboxes:~$ python diagnose.py
p1= 0.59485
p2= 0.26
p3= 0.1
p4= 0.5
```

```
C:\Users\czh\.conda\envs\Pycharm\python.exe "D:/Pycharm/PyCharm 2020.2.2/diagnose.py"
p1= 0.5948499999999999
p2= 0.2600000000000001
p3= 0.10000000000000042
p4= 0.5
```