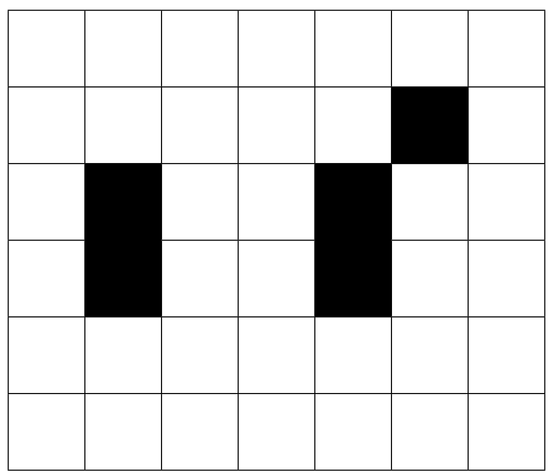
Artificial Intelligence: Programming 2 (P2)
HMM

Instructor: Dr. Shengquan Wang

Due Time: 10PM, 8/7/2022

In this assignment, we aim to implement Robot Localization with the `HMM` algorithm.

1 Instructions



We assume that a robot aims to locate itself in the windy maze as shown in the above. The robot will perform two kinds of actions: `sensing` and `moving`.

- **Sensing**: In a square, the robot will sense the four directions to see if there is an obstacle in this direction. We assume that the whole maze is surrounded by obstacles and the black squares are also obstacle. However, the sensing is not perfect. We assume that the robot can detect the obstacle with 85% if there is and might mistake an open square as a obstacle with 5%. The detections in all directions are done independently.
- **Moving**: In the windy situation, the robot can drift to the left or the right with probability 0.1. If the drifting direction is an obstacle, it will be bounced back to the original position. For example, in the square of left bottom, if the robot moves northward, it will reach the square to the north with 80% and reach the square to the east with 10% and be bounced back to the original position with 10%.

We assume that the robot initially stays in one open square, but it doesn't know its exact location except that it knows that it can't be in any obstacle square. Then the robot performs the following sequence of actions:

1. Sensing: [0, 0, 0, 0]
2. Moving: N
3. Sensing: [1, 0, 0, 0]
4. Moving: N
5. Sensing: [1, 0, 0, 0]
6. Moving: W
7. Sensing: [1, 0, 0, 0]
8. Moving: N
9. Sensing: [0, 0, 0, 0]

where (W,N,E,S) indicates the observation at Directions (Westward, Northward, Eastward, Southward), respectively. "0" indicates no obstacle is observed and "1" indicates an obstacle is observed.

You are expected to report all the prior and posterior probabilities of the latest robot location at each square after each action as follows (2.70 means 2.70%):

```
  Initial Location Probabilities
  2.70    2.70    2.70    2.70    2.70    2.70    2.70

  2.70    2.70    2.70    2.70    2.70    ####    2.70

  2.70    ####    2.70    2.70    ####    2.70    2.70

  2.70    ####    2.70    2.70    ####    2.70    2.70

  2.70    2.70    2.70    2.70    2.70    2.70    2.70

  2.70    2.70    2.70    2.70    2.70    2.70    2.70

Filtering after Evidence [0, 0, 0, 0]
  0.29    1.81    1.81    1.81    1.81    0.29    0.29

  1.81    1.81   11.46   11.46    0.29    ####    0.29

  0.29    ####    1.81    1.81    ####    0.29    1.81

  0.29    ####    1.81    1.81    ####    1.81    1.81

  1.81    1.81   11.46   11.46    1.81   11.46    1.81

  0.29    1.81    1.81    1.81    1.81    1.81    0.29
```

```
Prediction after Action N
  1.89    3.11   10.98   10.98    1.89    0.44    0.51

  0.59    1.33    2.78    2.62    1.17    ####    1.51

  0.29    ####    1.81    1.81    ####    1.89    1.66

  1.51    ####    9.53    9.53    ####    9.53    1.81

  0.59    4.22    2.78    2.78    5.19    1.81    1.56

  0.21    0.21    0.36    0.36    0.36    0.21    0.21


Filtering after Evidence [1, 0, 0, 0]
  1.22    0.12    0.42    0.42    0.07    0.00    0.00

  2.41    0.05    0.67    0.63    0.01    ####    0.97

  0.18    ####    7.40    0.07    ####    1.22    0.06

  0.97    ####   38.95    0.36    ####   38.95    0.07

  2.41    0.16    0.67    0.67    0.20    0.44    0.06

  0.14    0.01    0.01    0.01    0.01    0.01    0.00

Prediction after Action N
  3.04    0.30    0.92    0.89    0.10    0.01    0.78

  0.39    0.31    5.98    0.12    0.06    ####    0.24

  0.81    ####   31.90    1.04    ####   32.26    0.18

  2.12    ####    4.46    4.46    ####    4.25    3.95

  0.37    0.44    0.09    0.10    0.28    0.03    0.05

  0.01    0.01    0.00    0.00    0.00    0.00    0.00


Filtering after Evidence [1, 0, 0, 0]
  1.00    0.01    0.02    0.02    0.00    0.00    0.00

  0.82    0.01    0.73    0.02    0.00    ####    0.08

  0.27    ####   66.54    0.02    ####   10.62    0.00
```

0.70	####	9.31	0.09	####	8.86	0.08
0.76	0.01	0.01	0.01	0.01	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00

Prediction after Action W

0.99	0.02	0.09	0.00	0.00	0.00	0.01
0.79	0.59	6.67	0.00	0.00	####	0.07
0.37	####	54.25	0.01	####	10.45	0.02
0.66	####	14.17	0.00	####	8.21	0.00
0.69	0.01	0.94	0.01	0.00	0.89	0.01
0.08	0.00	0.00	0.00	0.00	0.00	0.00

Filtering after Evidence [1, 0, 0, 0]

0.19	0.00	0.00	0.00	0.00	0.00	0.00
0.98	0.01	0.49	0.00	0.00	####	0.01
0.07	####	67.30	0.00	####	2.05	0.00
0.13	####	17.58	0.00	####	10.19	0.00
0.85	0.00	0.07	0.00	0.00	0.06	0.00
0.02	0.00	0.00	0.00	0.00	0.00	0.00

Prediction after Action N

0.96	0.03	0.39	0.00	0.00	0.00	0.01
0.16	0.15	53.84	0.05	0.00	####	0.00
0.12	####	20.80	6.73	####	9.99	0.20
0.71	####	1.81	1.76	####	1.07	1.02
0.10	0.09	0.00	0.01	0.01	0.00	0.01
0.00	0.00	0.00	0.00	0.00	0.00	0.00

```
Filtering after Evidence [0, 0, 0, 0]
  0.04    0.01    0.10    0.00    0.00    0.00    0.00

  0.04    0.04   90.32    0.08    0.00    ####    0.00

  0.00    ####    5.51    1.78    ####    0.42    0.05

  0.03    ####    0.48    0.47    ####    0.28    0.27

  0.03    0.02    0.00    0.01    0.00    0.00    0.00

  0.00    0.00    0.00    0.00    0.00    0.00    0.00
```

2 Submission

Form a group on Canvas if you want to work with another student. Specify the contribution made by each member if you work as a group.

In your report, please provide the screenshots of all outcomes, and the highlighted code segments and the detailed explanation on how you implement the followings:

- Transitional probability;
- Evidence conditional probability;
- Filtering;
- Prediction.

Each screenshot should include your usernames and the current time, which show that you did it by yourselves. If your output is different from the expected one, provide a reason for the cause. Comment your code in details so that the grader can understand it well.

Your assignment will be graded based on the above guideline and the rubric on Canvas. The report should be written in a ".docx", ".doc", or ".pdf" format. Submit the report and the source code to the assignment folder P2 on Canvas. Any compression file format such as `.zip` is not permitted.