CMPE480 - 2024 Fall - HW3

In this homework, you will implement the following algorithms:

- Filtering
- Prediction
- Smoothing

Submit a single Python file named student-id.py.

Given a robot environment as a text file (map.txt) and a query (in query.txt), you will provide the output (in output.txt). map.txt and query.txt will be in the same directory.

Example map.txt and query.txt files will be dısprovided soon.

map.txt includes ‘ ‘ characters for empty grids and ‘x’ characters for obstacles.

An example map.txt is as follows. Note that maps are always square, enclosed with walls.

```
xxxxxx
x  x   x
x  xx  x
x  xx  x
x      x
xxxxxx
```

Row and column numbers start from the top-left corner.

The agent’s initial location is unknown. The agent might be facing one of the four directions, however its initial direction is also unknown.

The robot has 3 actions:

- forward (move forward),
- ccw (rotate counter-clockwise),
- cw (rotate clockwise)

The robot has two directional proximity sensors:

- f: forward proximity sensor
- b: backward proximity sensor

Each proximity sensor can read 3 different values:

- 0: No obstacle
- 1: Obstacle in the next grid
- 2: Obstacle in the next-next grid

Filtering

query.txt includes the filtering query in the following format:

```
Filtering at t=3: bf:00; forward, bf:02; forward, bf:11; ccw, bf:22
```

- Explanation
    - bf:00 : No obstacle with back and front sensors
    - Take action forward
    - bf:02 : No obstacle with back sensor, an obstacle in the next-next grid with the front sensor
    - Take action forward
    - bf:11 : Obstacle in the next grid with back sensor, obstacle in the next grid with front sensor
    - Take action ccw
    - bf:22 : Obstacle in the next-next grid with back sensor, an obstacle in the next-next grid with the front sensor

output.txt should include the (col, row) number of the grid with the highest filtering probability along with the probability value. An example output.txt is as follows:

```
(4, 3): 0.324
```

Prediction

query.txt includes the prediction query in the following format:

```
Prediction at t=6: bf:00; forward, bf:02; forward, bf:11; ccw, bf:22; ccw; forward; forward
```

- Explanation
    - bf:00 : No obstacle with back and front sensors
    - Take action forward
    - bf:02 : No obstacle with back sensor, obstacle in the next-next grid with front sensor
    - Take action forward
    - bf:11 : Obstacle in the next grid with back sensor, obstacle in the next grid with front sensor
    - Take action ccw
    - bf:22 : Obstacle in the next-next grid with back sensor, an obstacle in the next-next grid with the front sensor
    - Take actions ccw, forward, forward

output.txt should include the (col, row) number of the grid with the highest prediction probability along with the probability value. An example output.txt is as follows:

```
(6, 2): 0.213
```

Smoothing

query.txt includes the prediction query in the following format:

```
Smoothing at t=2: bf:00; forward, bf:02; forward, bf:11; ccw, bf:22; ccw, bf:11
```

- Explanation
    - bf:00 : No obstacle with back and front sensors
    - Take action forward
    - bf:02 : No obstacle with back sensor, an obstacle in the next-next grid with the front sensor
    - Take action forward
    - bf:11 : Obstacle in the next grid with back sensor, obstacle in the next grid with front sensor
    - Take action ccw
    - bf:22 : Obstacle in the next-next grid with back sensor, an obstacle in the next-next grid with front sensor
    - Take action ccw
    - bf:11 : Obstacle in the next grid with back sensor, obstacle in the next grid with front sensor

output.txt should include the (col, row) number of the grid with the highest smoothing probability along with the probability value. An example output.txt is as follows:

```
(2, 4): 0.111
```

Sensor Dynamics:

- The following rules are applicable to both proximity sensors.
- If there is an obstacle in the next grid, the sensor value is 1 for sure.
- Otherwise, given dist=distance to the closest obstacle in the respective direction (found by subtracting the row/column indices):
    - Sensor value is 1 with probability $1/dist^2$
    - Sensor value is 2 with probability $2/dist^2$
    - Sensor value is 0 with the remaining probability

Environment Dynamics:

- The environment becomes more slippery in the south. Given any action, the probability of the agent making no move is:
    - rowNo / (2 . nRows)
- The environment becomes more windy in the east. Given any action, the probability of the agent drifting to the grid on the right/east is
    - colNo / (2 . nCols)
- The probability of the actual action bringing the robot forward or rotating in the respective orientation is the remaining one.