

Introduction to Artificial Intelligence

Programming Assignment 4

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In this assignment we implemented an algorithm for sequential decision making under uncertainty using belief-state MDP for decision-making: the Hurricane Evacuation problem.

We implemented the Value iteration algorithm using dynamic programming, where we iterate through the belief states of our problem, and try to update the utility using the bellman equations. The convergence criteria is checking whether the change in the values of the states is below a certain threshold, indicating that the algorithm has found the optimal values and therefore found the optimal policy.

In our implementation we keep the action that updates each utility for later use (the creation of the optimal policy).

Here are some example runs of our code:

First Example:

the input: (should be familiar to you)

#V 7 ; number of vertices n in graph (from 1 to n)

#E1 1 2 W1 ; Edge from vertex 1 to vertex 2, weight 3

#E2 2 3 W10 ; Edge from vertex 2 to vertex 3, weight 2

#E3 3 4 W10 ; Edge from vertex 3 to vertex 4, weight 3, probability of blockage 0.3

#E4 4 5 W10 ; Edge from vertex 4 to vertex 5, weight 1

#E5 5 6 W1 ; Edge from vertex 2 to vertex 4, weight 4

#E6 6 7 W50

#E7 2 7 W1000

#E8 1 5 W40

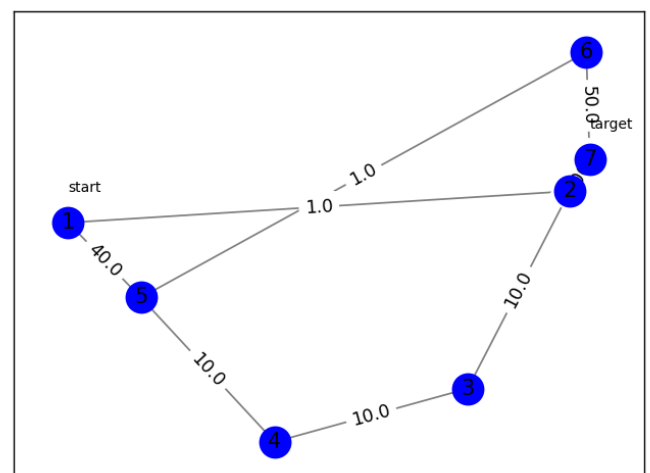
#B 3 0.5 ; Blocakge at vertex 2 with probability 0.3

#B 4 0.5 ; Blockage at vertex 3 with probability 0.8

#B 6 0.5

#Start 1

#Target 7



Run print out:

States:

(1, True, True, True) U: -1001.0
(1, True, True, False) U: -91.0
(1, True, True, None) U: -586.0
(1, True, False, True) U: -1001.0
(1, True, False, False) U: -91.0
(1, True, False, None) U: -586.0
(1, True, None, True) U: -1001.0
(1, True, None, False) U: -91.0
(1, True, None, None) U: -586.0
(1, False, True, True) U: -1001.0
(1, False, True, False) U: -91.0
(1, False, True, None) U: -586.0
(1, False, False, True) U: -1001.0
(1, False, False, False) U: -82.0
(1, False, False, None) U: -571.5
(1, False, None, True) U: -1001.0
(1, False, None, False) U: -91.0
(1, False, None, None) U: -583.25
(1, None, True, True) U: -1001.0
(1, None, True, False) U: -91.0
(1, None, True, None) U: -586.0
(1, None, False, True) U: -1001.0
(1, None, False, False) U: -87.5
(1, None, False, None) U: -579.75
(1, None, None, True) U: -1001.0
(1, None, None, False) U: -91.0
(1, None, None, None) U: -586.0
(2, True, True, True) U: -1000.0
(2, True, True, False) U: -92.0
(2, True, True, None) U: -587.0
(2, True, False, True) U: -1000.0
(2, True, False, False) U: -92.0
(2, True, False, None) U: -587.0
(2, True, None, True) U: -1000.0
(2, True, None, False) U: -92.0
(2, True, None, None) U: -587.0
(2, False, True, True) U: -1000.0
(2, False, True, False) U: -92.0
(2, False, True, None) U: -587.0
(2, False, False, True) U: -1000.0
(2, False, False, False) U: -81.0
(2, False, False, None) U: -570.5
(2, False, None, True) U: -1000.0
(2, False, None, False) U: -92.0
(2, False, None, None) U: -584.25

(2, None, True, True) U: -1000.0
(2, None, True, False) U: -92.0
(2, None, True, None) U: -587.0
(2, None, False, True) U: -1000.0
(2, None, False, False) U: -81.0
(2, None, False, None) U: -573.25
(2, None, None, True) U: -1000.0
(2, None, None, False) U: -92.0
(2, None, None, None) U: -587.0
(3, True, True, True) U: unreachable
(3, True, True, False) U: unreachable
(3, True, True, None) U: unreachable
(3, True, False, True) U: unreachable
(3, True, False, False) U: unreachable
(3, True, False, None) U: unreachable
(3, True, None, True) U: unreachable
(3, True, None, False) U: unreachable
(3, True, None, None) U: unreachable
(3, False, True, True) U: -1010.0
(3, False, True, False) U: -102.0
(3, False, True, None) U: -597.0
(3, False, False, True) U: -1010.0
(3, False, False, False) U: -71.0
(3, False, False, None) U: -560.5
(3, False, None, True) U: -1010.0
(3, False, None, False) U: -71.0
(3, False, None, None) U: -563.25
(3, None, True, True) U: -1010.0
(3, None, True, False) U: -102.0
(3, None, True, None) U: -597.0
(3, None, False, True) U: -1010.0
(3, None, False, False) U: -71.0
(3, None, False, None) U: -563.25
(3, None, None, True) U: -1010.0
(3, None, None, False) U: -71.0
(3, None, None, None) U: -564.625
(4, True, True, True) U: unreachable
(4, True, True, False) U: unreachable
(4, True, True, None) U: unreachable
(4, True, False, True) U: -1051.0
(4, True, False, False) U: -61.0
(4, True, False, None) U: -556.0
(4, True, None, True) U: -1051.0
(4, True, None, False) U: -61.0
(4, True, None, None) U: -556.0
(4, False, True, True) U: unreachable
(4, False, True, False) U: unreachable
(4, False, True, None) U: unreachable

(4, False, False, True) U: -1020.0
(4, False, False, False) U: -61.0
(4, False, False, None) U: -550.5
(4, False, None, True) U: -1020.0
(4, False, None, False) U: -61.0
(4, False, None, None) U: -553.25
(4, None, True, True) U: unreachable
(4, None, True, False) U: unreachable
(4, None, True, None) U: unreachable
(4, None, False, True) U: -1020.0
(4, None, False, False) U: -61.0
(4, None, False, None) U: -556.0
(4, None, None, True) U: -1020.0
(4, None, None, False) U: -61.0
(4, None, None, None) U: -556.0
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(5, True, True, False) U: -51.0
(5, True, True, None) U: -51.0
(5, True, False, True) U: -1041.0
(5, True, False, False) U: -51.0
(5, True, False, None) U: -51.0
(5, True, None, True) U: -1041.0
(5, True, None, False) U: -51.0
(5, True, None, None) U: -51.0
(5, False, True, True) U: -1041.0
(5, False, True, False) U: -51.0
(5, False, True, None) U: -51.0
(5, False, False, True) U: -1030.0
(5, False, False, False) U: -51.0
(5, False, False, None) U: -51.0
(5, False, None, True) U: -1030.0
(5, False, None, False) U: -51.0
(5, False, None, None) U: -51.0
(5, None, True, True) U: -1041.0
(5, None, True, False) U: -51.0
(5, None, True, None) U: -51.0
(5, None, False, True) U: -1041.0
(5, None, False, False) U: -51.0
(5, None, False, None) U: -51.0
(5, None, None, True) U: -1041.0
(5, None, None, False) U: -51.0
(5, None, None, None) U: -51.0
(6, True, True, True) U: unreachable
(6, True, True, False) U: -50.0
(6, True, True, None) U: -50.0
(6, True, False, True) U: unreachable
(6, True, False, False) U: -50.0
(6, True, False, None) U: -50.0

(6, True, None, True) U: unreachable
(6, True, None, False) U: -50.0
(6, True, None, None) U: -50.0
(6, False, True, True) U: unreachable
(6, False, True, False) U: -50.0
(6, False, True, None) U: -50.0
(6, False, False, True) U: unreachable
(6, False, False, False) U: -50.0
(6, False, False, None) U: -50.0
(6, False, None, True) U: unreachable
(6, False, None, False) U: -50.0
(6, False, None, None) U: -50.0
(6, None, True, True) U: unreachable
(6, None, True, False) U: -50.0
(6, None, True, None) U: -50.0
(6, None, False, True) U: unreachable
(6, None, False, False) U: -50.0
(6, None, False, None) U: -50.0
(6, None, None, True) U: unreachable
(6, None, None, False) U: -50.0
(6, None, None, None) U: -50.0
(7, True, True, True) U: 0
(7, True, True, False) U: 0
(7, True, True, None) U: 0
(7, True, False, True) U: 0
(7, True, False, False) U: 0
(7, True, False, None) U: 0
(7, True, None, True) U: 0
(7, True, None, False) U: 0
(7, True, None, None) U: 0
(7, False, True, True) U: 0
(7, False, True, False) U: 0
(7, False, True, None) U: 0
(7, False, False, True) U: 0
(7, False, False, False) U: 0
(7, False, False, None) U: 0
(7, False, None, True) U: 0
(7, False, None, False) U: 0
(7, False, None, None) U: 0
(7, None, True, True) U: 0
(7, None, True, False) U: 0
(7, None, True, None) U: 0
(7, None, False, True) U: 0
(7, None, False, False) U: 0
(7, None, False, None) U: 0
(7, None, None, True) U: 0
(7, None, None, False) U: 0
(7, None, None, None) U: 0

final utility: -586.0

Optimal policy:

Go to 5

If reached state (5, None, True, True) :

Go to 1

Go to 2

If reached state (2, True, True, True) :

Go to 7

If reached state (2, False, True, True) :

Go to 7

If reached state (5, None, True, False) :

Go to 6

Go to 7

If reached state (5, None, False, True) :

Go to 1

Go to 2

If reached state (2, True, False, True) :

Go to 7

If reached state (2, False, False, True) :

Go to 7

If reached state (5, None, False, False) :

Go to 6

Go to 7

Second example:

the input:

#V 5 ; number of vertices n in graph (from 1 to n)

#E1 1 2 W3 ; Edge from vertex 1 to vertex 2, weight 3

#E2 2 3 W2 ; Edge from vertex 2 to vertex 3, weight 2

#E3 3 4 W3 ; Edge from vertex 3 to vertex 4, weight 3, probability of blockage 0.3

#E4 4 5 W1 ; Edge from vertex 4 to vertex 5, weight 1

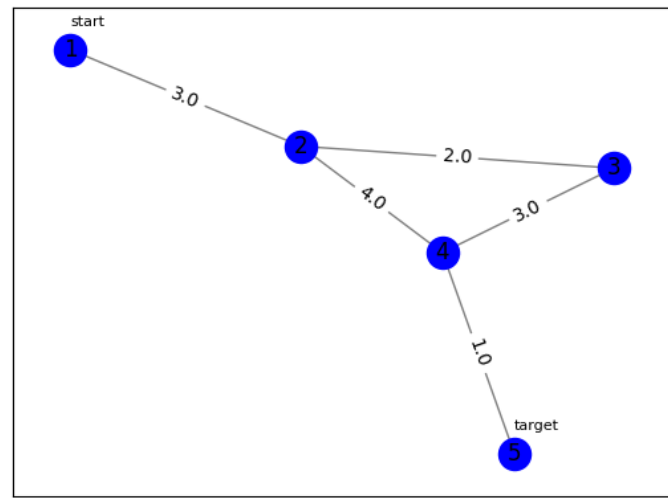
#E5 2 4 W4 ; Edge from vertex 2 to vertex 4, weight 4

#B 2 0.3 ; Blockage at vertex 2 with probability 0.3

#B 3 0.8 ; Blockage at vertex 3 with probability 0.8

#Start 1

#Target 5



States:

(1, True, True) U: -10000.0

(1, True, False) U: -10000.0

(1, True, None) U: -10000.0

(1, False, True) U: -8.0

(1, False, False) U: -8.0

(1, False, None) U: -8.0

(1, None, True) U: -8.0

(1, None, False) U: -8.0

(1, None, None) U: -8.0

(2, True, True) U: unreachable

(2, True, False) U: unreachable

(2, True, None) U: unreachable

(2, False, True) U: -5.0

(2, False, False) U: -5.0

(2, False, None) U: -5.0

(2, None, True) U: -5.0

(2, None, False) U: -5.0

(2, None, None) U: -4.999999999999999

(3, True, True) U: unreachable

(3, True, False) U: unreachable

(3, True, None) U: unreachable

(3, False, True) U: unreachable

(3, False, False) U: -4.0

(3, False, None) U: -4.0

(3, None, True) U: unreachable

(3, None, False) U: -4.0
(3, None, None) U: -4.0
(4, True, True) U: unreachable
(4, True, False) U: unreachable
(4, True, None) U: unreachable
(4, False, True) U: -1.0
(4, False, False) U: -1.0
(4, False, None) U: -1.0
(4, None, True) U: -1.0
(4, None, False) U: -1.0
(4, None, None) U: -1.0
(5, True, True) U: 0
(5, True, False) U: 0
(5, True, None) U: 0
(5, False, True) U: 0
(5, False, False) U: 0
(5, False, None) U: 0
(5, None, True) U: 0
(5, None, False) U: 0
(5, None, None) U: 0

final utility: -8.0

Optimal policy:

Go to 2

If reached state (2, None, True) :

Go to 4

If reached state (4, True, True) :

Go to 5

If reached state (4, False, True) :

Go to 5

If reached state (2, None, False) :

Go to 4

If reached state (4, True, False) :

Go to 5

If reached state (4, False, False) :

Go to 5