**CPT\_S 570 HW5**

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**1.**

**Number of clusters: 3**

cluster 0 means: 5.50927940017642

cluster 0 variances: 1.0302576846296716

cluster 0 prior: 0.3333333337388757

cluster 1 means: 15.449160792031073

cluster 1 variances: 0.9671159353647738

cluster 1 prior: 0.3333333329309795

cluster 2 means: 25.486654429329228

cluster 2 variances: 0.9980966181791335

cluster 2 prior: 0.33333333333014475

Likelihood: -15099.771749646781

Avg. Likelihood: -2.5166286249411303

**Number of clusters: 4**

cluster 0 means: 5.509279394162657

cluster 0 variances: 1.0302576468035207

cluster 0 prior: 0.333333333428173

cluster 1 means: 12.048531761885632

cluster 1 variances: 0.008686091234332418

cluster 1 prior: 5.422213483603379E-4

cluster 2 means: 15.454701482561543

cluster 2 variances: 0.9498049856017315

cluster 2 prior: 0.33279111189147287

cluster 3 means: 25.486654429309432

cluster 3 variances: 0.9980966182497697

cluster 3 prior: 0.3333333333319937

Likelihood: -15096.32811698611

Avg. Likelihood: -2.5160546861643516

**Number of clusters: 5**

cluster 0 means: 5.50979740188862

cluster 0 variances: 1.0299095207020041

cluster 0 prior: 0.3318465206627056

cluster 1 means: 5.3936637533197604

cluster 1 variances: 1.094532598312054

cluster 1 prior: 0.0014868127115559137

cluster 2 means: 14.701574184320071

cluster 2 variances: 1.1034224683612144

cluster 2 prior: 0.026287842129142133

cluster 3 means: 15.51316575997191

cluster 3 variances: 0.9035001239058515

cluster 3 prior: 0.3070454911623241

cluster 4 means: 25.486654429284254

cluster 4 variances: 0.9980966183446949

cluster 4 prior: 0.33333333333427184

Likelihood: -15098.724466016689

Avg. Likelihood: -2.516454077669448

**2.**

(1) An agent for playing flappy bird would fit in reinforcement learning framework. The states are the different position of the bird. The action set is {jump, stay still}. If the bird died at some state via some action, then receiving negative reward otherwise receiving positive reward.

(2) Another example is the cleaning robot. The states are different positions with its cleaning status. The action set is {move, turn left, turn right, suck dirty}. If the position is clean the it has negative reward.

**3.**

(1) -greedy

When need 51659 iterations

When need 76453 iterations

When need 144846 iterations

(2) Boltzman exploration: Initial temperature is 10, until it reaches 0.001 it decreased by 0.001 for each iteration.

Q values for 

state(0,0,0): Qvalue = -2.0

state(0,0,1): Qvalue = 1.9761329143313016E-16

state(0,0,2): Qvalue = -2.0

state(0,0,3): Qvalue = 9.049966657274615E-17

state(0,1,0): Qvalue = 1.743644661776147E-17

state(0,1,1): Qvalue = 1.0406389375937523E-17

state(0,1,2): Qvalue = -2.0

state(0,1,3): Qvalue = 1.2377366898998668E-15

state(0,2,0): Qvalue = 1.2684744772595466E-16

state(0,2,1): Qvalue = 2.8572555798544923E-19

state(0,2,2): Qvalue = -2.0

state(0,2,3): Qvalue = 8.457353688383316E-17

state(0,3,0): Qvalue = 2.3737712249591484E-18

state(0,3,1): Qvalue = 6.128961451710941E-18

state(0,3,2): Qvalue = -2.0

state(0,3,3): Qvalue = -2.0

state(0,4,0): Qvalue = 2.8438510320014613E-19

state(0,4,1): Qvalue = 1.0185321666451942E-16

state(0,4,2): Qvalue = -2.0

state(0,4,3): Qvalue = 2.0453445162621063E-17

state(0,5,0): Qvalue = 3.9903296363365366E-18

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state(0,5,2): Qvalue = -2.0

state(0,5,3): Qvalue = 9.932252862026731E-16

state(0,6,0): Qvalue = 3.878222854305503E-17

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state(0,9,0): Qvalue = 6.361504675952877E-14

state(0,9,1): Qvalue = -2.0

state(0,9,2): Qvalue = -2.0

state(0,9,3): Qvalue = 3.990593919357771E-13

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state(1,0,3): Qvalue = 7.027397762934512E-16

state(1,1,0): Qvalue = 9.631962599391578E-17

state(1,1,1): Qvalue = 9.843178665273703E-17

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state(1,1,3): Qvalue = 7.386571951763495E-15

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state(1,3,1): Qvalue = 0.0

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state(1,3,3): Qvalue = 0.0

state(1,4,0): Qvalue = -2.0

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state(1,9,2): Qvalue = 1.2525305141478825E-14

state(1,9,3): Qvalue = 8.538055483859277E-12

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state(7,3,1): Qvalue = 0.0

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state(7,3,3): Qvalue = 0.0

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Q values for temperature = 10

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state(7,5,2): Qvalue = 0.0

state(7,5,3): Qvalue = 0.0

state(7,6,0): Qvalue = 0.0

state(7,6,1): Qvalue = 0.0

state(7,6,2): Qvalue = 0.003558846411611891

state(7,6,3): Qvalue = 0.0

state(7,7,0): Qvalue = 3.766935092785326E-4

state(7,7,1): Qvalue = 6.886571005599442E-7

state(7,7,2): Qvalue = -9.0E-5

state(7,7,3): Qvalue = 1.2947938062691454E-7

state(7,8,0): Qvalue = 3.875466491913367E-5

state(7,8,1): Qvalue = 0.0

state(7,8,2): Qvalue = 0.0

state(7,8,3): Qvalue = 0.0

state(7,9,0): Qvalue = 9.448987671771114E-7

state(7,9,1): Qvalue = -2.0

state(7,9,2): Qvalue = 1.0300872643244391E-9

state(7,9,3): Qvalue = 1.9404917869679078E-10

state(8,0,0): Qvalue = -2.0

state(8,0,1): Qvalue = 1.8543743820162182E-16

state(8,0,2): Qvalue = 2.2836267949328083E-19

state(8,0,3): Qvalue = 4.964397219017336E-17

state(8,1,0): Qvalue = 1.904832735400535E-21

state(8,1,1): Qvalue = 3.222232819245171E-15

state(8,1,2): Qvalue = 3.7703083883511685E-21

state(8,1,3): Qvalue = 2.9899086075342527E-15

state(8,2,0): Qvalue = 2.890715111951718E-16

state(8,2,1): Qvalue = -2.0

state(8,2,2): Qvalue = 4.879836481876634E-17

state(8,2,3): Qvalue = 2.4080828240525343E-14

state(8,3,0): Qvalue = 0.0

state(8,3,1): Qvalue = 0.0

state(8,3,2): Qvalue = 0.0

state(8,3,3): Qvalue = 0.0

state(8,4,0): Qvalue = -2.0

state(8,4,1): Qvalue = -0.0020969199482753186

state(8,4,2): Qvalue = 2.4749437518579593E-8

state(8,4,3): Qvalue = 4.2672687690052666E-12

state(8,5,0): Qvalue = -0.0585198505954395

state(8,5,1): Qvalue = -0.060262134243892866

state(8,5,2): Qvalue = -0.06793440238452969

state(8,5,3): Qvalue = -0.05851985059898292

state(8,6,0): Qvalue = -0.059662925682485185

state(8,6,1): Qvalue = -0.06793464308211904

state(8,6,2): Qvalue = -0.05851356855316088

state(8,6,3): Qvalue = -0.06793465209136187

state(8,7,0): Qvalue = -9.0E-5

state(8,7,1): Qvalue = 1.1595842809888944E-8

state(8,7,2): Qvalue = 4.266045054685727E-6

state(8,7,3): Qvalue = 1.546384833637624E-9

state(8,8,0): Qvalue = 0.0

state(8,8,1): Qvalue = 0.0

state(8,8,2): Qvalue = 1.2824698312206404E-6

state(8,8,3): Qvalue = 0.0

state(8,9,0): Qvalue = 1.0089475447567092E-8

state(8,9,1): Qvalue = -2.0

state(8,9,2): Qvalue = 1.1224831142396431E-8

state(8,9,3): Qvalue = 1.0297033724501839E-13

state(9,0,0): Qvalue = -2.0

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state(9,0,2): Qvalue = 1.2711417113555487E-17

state(9,0,3): Qvalue = -2.0

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state(9,1,1): Qvalue = 1.994658102052651E-14

state(9,1,2): Qvalue = 1.8462940705077656E-16

state(9,1,3): Qvalue = -2.0

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state(9,3,2): Qvalue = -2.0

state(9,3,3): Qvalue = -2.0

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state(9,5,0): Qvalue = 2.3109801800425407E-12

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state(9,5,3): Qvalue = -2.0

state(9,6,0): Qvalue = 9.860543715275947E-13

state(9,6,1): Qvalue = 2.491352128548653E-9

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state(9,6,3): Qvalue = -2.0

state(9,7,0): Qvalue = 2.3551688081207637E-12

state(9,7,1): Qvalue = 1.2919788279084852E-10

state(9,7,2): Qvalue = 1.1542981227273265E-7

state(9,7,3): Qvalue = -2.0

state(9,8,0): Qvalue = 5.251893166888257E-11

state(9,8,1): Qvalue = 9.661435097259959E-13

state(9,8,2): Qvalue = 1.3545112234023658E-8

state(9,8,3): Qvalue = -2.0

state(9,9,0): Qvalue = 6.048627518767603E-11

state(9,9,1): Qvalue = -2.0

state(9,9,2): Qvalue = 1.0213132232123957E-10

state(9,9,3): Qvalue = -2.0