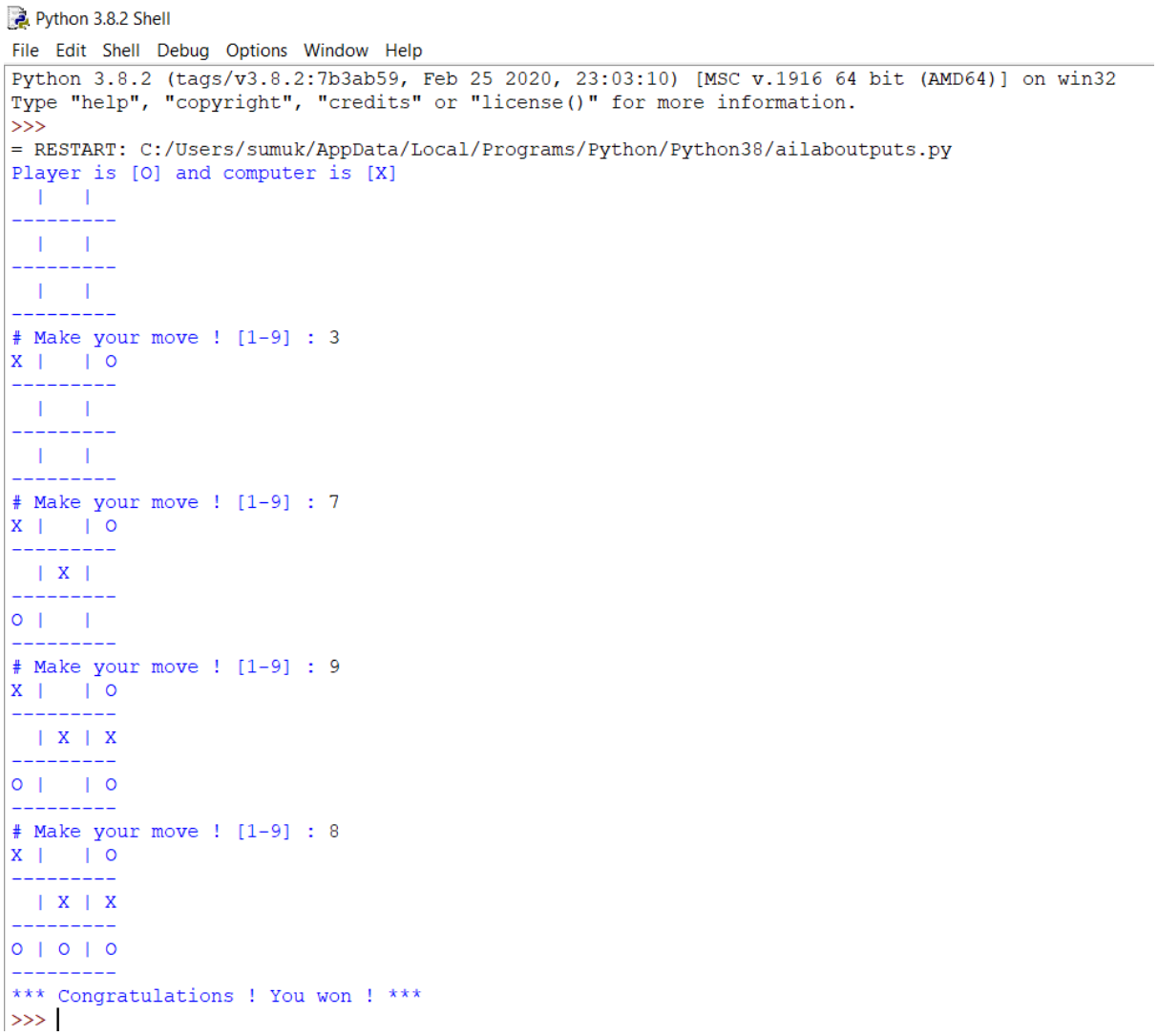
AI LAB PROGRAMS

OUTPUT SCREENSHOTS

1. Implementation of Tic-Tac-Toe game



2. Solving 8 puzzle problem

```
1 2 3
5 6 0
7 8 4

1 2 3
5 0 6
7 8 4

1 2 3
0 5 6
7 8 4

1 2 3
7 5 6
0 8 4

1 2 3
7 5 6
8 0 4

1 2 3
7 5 6
8 4 0

1 2 3
7 5 0
8 4 6

1 2 3
7 0 5
8 4 6

1 2 3
7 0 5
8 4 6

1 2 3
7 4 5
8 0 6

1 2 3
7 4 5
0 8 6

1 2 3
0 4 5
7 8 6

1 2 3
4 0 5
7 8 6

1 2 3
4 5 0
7 8 6

1 2 3
4 5 6
7 8 0
```

3. Implementation of vacuum cleaner agent

Python 3.8.2 Shell

File Edit Shell Debug Options Window Help

```
Python 3.8.2 (tags/v3.8.2:7b3ab59, Feb 25 2020, 23:03:10) [MSC v.1916 64 bit (AMD64)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>>
>>>
= RESTART: C:/Users/sumuk/AppData/Local/Programs/Python/Python38/ailaboutputs.py
{'A': 0, 'B': 0}
Vacuum is randomly placed at Location A.
Moving to Location B...
{'A': 0, 'B': 0}
Performance Measurement: -1
>>>
= RESTART: C:/Users/sumuk/AppData/Local/Programs/Python/Python38/ailaboutputs.py
{'A': 1, 'B': 0}
Vacuum is randomly placed at Location A.
Location A is Dirty.
Location A has been Cleaned.
Moving to Location B...
{'A': 0, 'B': 0}
Performance Measurement: 0
>>>
```

4. Implementation of A* search algorithm

```
[5, 3, 4]
[2, 0, 8]
[1, 6, 7]

D
[5, 3, 4]
[2, 6, 8]
[1, 0, 7]

R
[5, 3, 4]
[2, 6, 8]
[1, 7, 0]

U
[5, 3, 4]
[2, 6, 0]
[1, 7, 8]

L
[5, 3, 4]
[2, 0, 6]
[1, 7, 8]

U
[5, 0, 4]
[2, 3, 6]
[1, 7, 8]

L
[0, 5, 4]
[2, 3, 6]
[1, 7, 8]

D
[2, 5, 4]
[0, 3, 6]
[1, 7, 8]

D
[2, 5, 4]
[1, 3, 6]
[0, 7, 8]

R
[2, 5, 4]
[1, 3, 6]
[7, 0, 8]

R
[2, 5, 4]
[1, 3, 6]
[7, 8, 0]

U
[2, 5, 4]
[1, 3, 0]
[7, 8, 6]

U
[2, 5, 0]
[1, 3, 4]
[7, 8, 6]

L
[2, 0, 5]
[1, 3, 4]
[7, 8, 6]

D
[2, 3, 5]
[1, 0, 4]
[7, 8, 6]

R
[2, 3, 5]
[1, 4, 0]
[7, 8, 6]

U
[2, 3, 0]
[1, 4, 5]
[7, 8, 6]

L
[2, 0, 3]
[1, 4, 5]
[7, 8, 6]

L
[0, 2, 3]
[1, 4, 5]
[7, 8, 6]

D
[1, 2, 3]
[0, 4, 5]
[7, 8, 6]

R
[1, 2, 3]
[4, 0, 5]
[7, 8, 6]

R
[1, 2, 3]
[4, 5, 0]
[7, 8, 6]

D
[1, 2, 3]
[4, 5, 6]
[7, 8, 0]
>>>
```

5. Implementing iterative deepening search to solve 8 puzzle problem

```
0 1 2   1 2 0   1 2 5   1 2 5   1 2 5   1 2 5   1 2 5   1 2 5   2 0 5   2 3 5   1 0 2
3 4 5   3 4 5   3 4 0   3 0 8   3 4 0   3 4 0   3 4 8   3 0 8   1 3 8   6 1 8   3 4 5
6 7 8   6 7 8   6 7 8   6 4 7   6 7 8   6 7 8   6 7 0   6 4 7   6 4 7   4 0 7   6 7 8

1 0 2   1 0 2   1 2 0   1 2 5   1 2 0   1 2 0   1 2 5   1 2 5   0 2 5   2 3 5   0 1 2
3 4 5   3 4 5   3 4 5   3 4 8   3 4 5   3 4 5   3 4 0   3 4 8   1 3 8   6 1 8   3 4 5
6 7 8   6 7 8   6 7 8   6 0 7   6 7 8   6 7 8   6 7 8   6 0 7   6 4 7   0 4 7   6 7 8

0 1 2   0 1 2   1 0 2   1 2 5   1 0 2   1 0 2   1 2 0   1 2 5   1 2 5   2 3 5   2 3 0
3 4 5   3 4 5   3 4 5   3 4 8   3 4 5   3 4 5   3 4 5   3 4 8   0 3 8   0 1 8   6 1 5
6 7 8   6 7 8   6 7 8   6 7 0   6 7 8   6 7 8   6 7 8   6 7 0   6 4 7   6 4 7   4 7 8

1 2 0   1 2 5   0 1 2   1 2 5   0 1 2   0 1 2   1 0 2   1 2 5   1 2 5   2 3 5   2 3 5
3 4 5   3 4 8   3 4 5   3 4 0   3 4 5   3 4 5   3 4 5   3 4 0   3 0 8   1 0 8   6 1 0
6 7 8   6 0 7   6 7 8   6 7 8   6 7 8   6 7 8   6 7 8   6 7 8   6 4 7   6 4 7   4 7 8

1 0 2   1 2 5   1 2 5   1 2 0   2 3 5   2 3 5   0 1 2   1 2 0   1 2 5   2 0 5   2 3 5
3 4 5   3 4 8   0 3 8   3 4 5   0 1 8   6 1 8   3 4 5   3 4 5   3 4 8   1 3 8   6 1 8
6 7 8   6 7 0   6 4 7   6 7 8   6 4 7   0 4 7   6 7 8   6 7 8   6 0 7   6 4 7   4 7 0

0 1 2   1 2 5   1 2 5   1 0 2   2 3 5   2 3 5   2 3 5   1 0 2   1 2 5   0 2 5   2 3 5
3 4 5   3 4 0   3 0 8   3 4 5   1 0 8   0 1 8   6 1 8   3 4 5   3 4 8   1 3 8   6 1 8
6 7 8   6 7 8   6 4 7   6 7 8   6 4 7   6 4 7   4 0 7   6 7 8   6 7 0   6 4 7   4 0 7

1 2 5   1 2 0   1 2 5   0 1 2   2 0 5   2 3 5   2 3 5   0 1 2   1 2 5   1 2 5   2 3 5
3 4 0   3 4 5   3 4 8   3 4 5   1 3 8   1 0 8   6 1 8   3 4 5   3 4 0   0 3 8   6 1 8
6 7 8   6 7 8   6 0 7   6 7 8   6 4 7   6 4 7   0 4 7   6 7 8   6 7 8   6 4 7   0 4 7

1 2 0   1 0 2   1 2 5   2 3 5   0 2 5   2 0 5   2 3 5   2 3 5   1 2 0   1 2 5   2 3 5
3 4 5   3 4 5   3 4 8   1 0 8   1 3 8   1 3 8   0 1 8   6 1 8   3 4 5   3 0 8   0 1 8
6 7 8   6 7 8   6 7 0   6 4 7   6 4 7   6 4 7   6 4 7   4 7 0   6 7 8   6 4 7   6 4 7

1 0 2   0 1 2   1 2 5   2 0 5   1 2 5   0 2 5   2 3 5   2 3 5   1 0 2   1 2 5   2 3 5
3 4 5   3 4 5   3 4 0   1 3 8   0 3 8   1 3 8   1 0 8   6 1 8   3 4 5   3 4 8   1 0 8
6 7 8   6 7 8   6 7 8   6 4 7   6 4 7   6 4 7   6 4 7   4 0 7   6 7 8   6 0 7   6 4 7

0 1 2   1 2 5   1 2 0   0 2 5   1 2 5   1 2 5   2 0 5   2 3 5   0 1 2   1 2 5   2 0 5
3 4 5   3 0 8   3 4 5   1 3 8   3 0 8   0 3 8   1 3 8   6 1 8   3 4 5   3 4 8   1 3 8
6 7 8   6 4 7   6 7 8   6 4 7   6 4 7   6 4 7   6 4 7   0 4 7   6 7 8   6 7 0   6 4 7

1 2 5   1 2 5   1 0 2   1 2 5   1 2 5   1 2 5   0 2 5   2 3 5   2 3 5   1 2 5   0 2 5
3 4 8   3 4 8   3 4 5   0 3 8   3 4 8   3 0 8   1 3 8   0 1 8   6 1 0   3 4 0   1 3 8
6 7 0   6 0 7   6 7 8   6 4 7   6 0 7   6 4 7   6 4 7   6 4 7   4 7 8   6 7 8   6 4 7

1 2 5   1 2 5   0 1 2   1 2 5   1 2 5   1 2 5   1 2 5   2 3 5   2 3 5   1 2 0   1 2 5
3 4 0   3 4 8   3 4 5   3 0 8   3 4 8   3 4 8   0 3 8   1 0 8   6 1 8   3 4 5   0 3 8
6 7 8   6 7 0   6 7 8   6 4 7   6 7 0   6 0 7   6 4 7   6 4 7   4 7 0   6 7 8   6 4 7
```

```
1 2 5   2 3 5   0 1 2   0 2 5   2 3 5   1 2 5
3 0 8   6 1 8   3 4 5   1 3 8   6 1 0   0 3 8
6 4 7   0 4 7   6 7 8   6 4 7   4 7 8   6 4 7

1 2 5   2 3 5   0 2 3   1 2 5   2 3 5   1 2 5
3 4 8   0 1 8   6 1 5   0 3 8   6 1 8   3 0 8
6 0 7   6 4 7   4 7 8   6 4 7   4 7 0   6 4 7

1 2 5   2 3 5   2 0 3   1 2 5   2 3 5   1 2 5
3 4 8   1 0 8   6 1 5   3 0 8   6 1 8   3 4 8
6 7 0   6 4 7   4 7 8   6 4 7   4 0 7   6 0 7

1 2 5   2 0 5   2 3 0   1 2 5   2 3 5   1 2 5
3 4 0   1 3 8   6 1 5   3 4 8   6 1 8   3 4 8
6 7 8   6 4 7   4 7 8   6 0 7   0 4 7   6 7 0

1 2 0   0 2 5   2 3 5   1 2 5   2 3 5   1 2 5
3 4 5   1 3 8   6 1 0   3 4 8   0 1 8   3 4 0
6 7 8   6 4 7   4 7 8   6 7 0   6 4 7   6 7 8

1 0 2   1 2 5   2 3 5   1 2 5   2 3 5   1 2 0
3 4 5   0 3 8   6 1 8   3 4 0   1 0 8   3 4 5
6 7 8   6 4 7   4 7 0   6 7 8   6 4 7   6 7 8

0 1 2   1 2 5   2 3 5   1 2 0   2 0 5   1 0 2
3 4 5   3 0 8   6 1 8   3 4 5   1 3 8   3 4 5
6 7 8   6 4 7   4 0 7   6 7 8   6 4 7   6 7 8

2 0 3   1 2 5   2 3 5   1 0 2   0 2 5   0 1 2
6 1 5   3 4 8   6 1 8   3 4 5   1 3 8   3 4 5
4 7 8   6 0 7   0 4 7   6 7 8   6 4 7   6 7 8

2 3 0   1 2 5   2 3 5   0 1 2   1 2 5   6 2 3
6 1 5   3 4 8   0 1 8   3 4 5   0 3 8   0 1 5
4 7 8   6 7 0   6 4 7   6 7 8   6 4 7   4 7 8

2 3 5   1 2 5   2 3 5   2 0 5   1 2 5   0 2 3
6 1 0   3 4 0   1 0 8   1 3 8   3 0 8   6 1 5
4 7 8   6 7 8   6 4 7   6 4 7   6 4 7   4 7 8

2 3 5   1 2 0   2 0 5   0 2 5   1 2 5   2 0 3
6 1 8   3 4 5   1 3 8   1 3 8   3 4 8   6 1 5
4 7 0   6 7 8   6 4 7   6 4 7   6 0 7   4 7 8

2 3 5   1 0 2   0 2 5   1 2 5   1 2 5   2 3 0
6 1 8   3 4 5   1 3 8   0 3 8   3 4 8   6 1 5
4 0 7   6 7 8   6 4 7   6 4 7   6 7 0   4 7 8
```

```
1 2 5
3 4 0
6 7 8

1 2 0
3 4 5
6 7 8

1 0 2
3 4 5
6 7 8

0 1 2
3 4 5
6 7 8

Total number of moves: 209
Total searching time: 0.13 seconds
```

6. Create a knowledge base using prepositional logic and show that the given query entails the knowledge base or not

7. Convert the given first order logic statement into conjunctive normal form (CNF)

```
>>>
= RESTART: C:/Users/sumuk/AppData/Local/Programs/Python/Python38/fol_to_cnf.py =
^ for and, + for or, ! for not, > for implies, = for biconditional
Enter the expressiona>(b^c)
Applying implication elimination
!(a)+((b^c))
>>>
= RESTART: C:/Users/sumuk/AppData/Local/Programs/Python/Python38/fol_to_cnf.py =
^ for and, + for or, ! for not, > for implies, = for biconditional
Enter the expressiona>(b+c)
Applying implication elimination
!(a)+((b+c))
>>>
```

8. Implementation of unification in first order logic

```
= RESTART: C:/Users/sumuk/AppData/Local/Programs/Python/Python38/unificationAI.py
=========PROGRAM FOR UNIFICATION=========
Enter Number of Predicates:2
Enter Predicate  1  :
p
Enter No.of Arguments for Predicate  p  :
2
Enter argument  1  :
a
Enter argument  2  :
b
Enter Predicate  2  :
p
Enter No.of Arguments for Predicate  p  :
2
Enter argument  1  :
c
Enter argument  2  :
b
=======PREDICATES ARE======
p (a,b)
p (c,b)
======SUBSTITUTION IS======
c / a
Do you want to continue(y/n):
```

9. Create a knowledge base consisting of first order logic statements and prove the query using forward reasoning

```
>>>
=== RESTART: C:\Users\sumuk\AppData\Local\Programs\Python\Python38\forward.py ==
Hostile?
[{x: Nono}, {x: Jojo}, {x: Coco}]

Criminal?
[{x: West}]

>>>
```

10. Demonstrate decision tree learning for a given set of training examples and test data

```
Dataset Length:  625
Dataset Shape:  (625, 5)
Dataset:     0  1  2  3  4
0  B  1  1  1  1
1  R  1  1  1  2
2  R  1  1  1  3
3  R  1  1  1  4
4  R  1  1  1  5
Results Using Entropy:
Predicted values:
['R' 'L' 'R' 'L' 'R' 'L' 'R' 'L' 'R' 'R' 'R' 'R' 'L' 'L' 'R' 'L' 'R' 'L'
 'L' 'R' 'L' 'R' 'L' 'L' 'R' 'L' 'R' 'L' 'R' 'L' 'R' 'L' 'R' 'L' 'L' 'L'
 'L' 'L' 'R' 'L' 'R' 'L' 'R' 'L' 'R' 'R' 'L' 'L' 'R' 'L' 'L' 'R' 'L' 'L'
 'R' 'L' 'R' 'R' 'L' 'R' 'R' 'R' 'L' 'L' 'R' 'L' 'L' 'R' 'L' 'L' 'L' 'R'
 'R' 'L' 'R' 'L' 'R' 'R' 'R' 'L' 'R' 'L' 'L' 'L' 'L' 'R' 'R' 'L' 'R' 'L'
 'R' 'R' 'L' 'L' 'L' 'R' 'R' 'L' 'L' 'L' 'R' 'L' 'L' 'R' 'R' 'R' 'R' 'R'
 'R' 'L' 'R' 'L' 'R' 'R' 'L' 'R' 'R' 'L' 'R' 'R' 'L' 'R' 'R' 'R' 'L' 'L'
 'L' 'L' 'L' 'R' 'R' 'R' 'R' 'L' 'R' 'R' 'R' 'L' 'L' 'R' 'L' 'R' 'L' 'R'
 'L' 'R' 'R' 'L' 'L' 'R' 'L' 'R' 'R' 'R' 'R' 'R' 'L' 'R' 'R' 'R' 'R' 'R'
 'R' 'L' 'R' 'L' 'R' 'R' 'L' 'R' 'L' 'R' 'L' 'R' 'L' 'L' 'L' 'L' 'L' 'R'
 'R' 'R' 'L' 'L' 'L' 'R' 'R' 'R']
Confusion Matrix:  [[ 0  6  7]
 [ 0 63 22]
 [ 0 20 70]]
Accuracy :  70.74468085106383

Report :               precision    recall  f1-score   support

           B       0.00      0.00      0.00        13
           L       0.71      0.74      0.72        85
           R       0.71      0.78      0.74        90

    accuracy                           0.71       188
   macro avg       0.47      0.51      0.49       188
weighted avg       0.66      0.71      0.68       188
```