AirplanesAirports_JoseGarban

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0.0.1 Sistemas Multiagente.

0.0.2 Máster Universitario en Ingeniería del Software e Inteligencia Artificial.

0.0.3 Curso 2021/22

2ª Convocatoria ordinaria

Nombre: José Garbán

1 Sistema Multiagente para la simulación del tráfico aéreo

Características del modelo:

El modelo fue elaborado en MESA (Python), que es el lenguaje más conocido por el autor. Se utilizó un Jupyter Notebook para guardar los resultados de forma que se puedan ver los estados paso a paso. Está basado en un ejemplo del mismo paquete MESA llamado "boid_flockers", un simulador del movimiento de enjambres de aves que evitan chocar entre sí.

En "boid.py" se encuentran los modelos de los aviones (subclase del modelo de las aves en el ejemplo "boid_flockers") y de los aeropuertos. El código está disponible en: https://github.com/josegarban/mesa-airport.

```
[4]: from model import AirplaneFlockers
     import paths
     import numpy as np
     import matplotlib.pyplot as plt
     from pprint import pprint
     %matplotlib inline
     %load_ext autoreload
     %autoreload 2
```

The autoreload extension is already loaded. To reload it, use:
  %reload_ext autoreload

```
[5]: # Definición de los aeropuertos. Cada tupla (x,y) es un aeropuerto. Los
     ↪recorridos se forman más adelante con pares de tuplas
     AIRPORTS = ((20, 20), (30, 30), (10, 15), (10, 20), (80, 15), (80, 80), (50,
     ↪60), (40, 25))
```

```python
[6]:  # Definición de las rutas para llegar de un aeropuerto a otro en línea recta
      worldmap, route_solutions = paths.main(AIRPORTS, width=100, height=100)
```

```python
[7]:  # Mostrar las rutas
      for p in route_solutions: print(p)
```

```
[(20, 20), (20, 21), (20, 22), (20, 23), (20, 24), (20, 25), (20, 26), (20, 27),
 (20, 28), (21, 28), (22, 28), (23, 28), (24, 28), (25, 28), (26, 28), (27, 28),
 (28, 28), (29, 28), (30, 28), (30, 29), (30, 30)]
[(10, 15), (10, 16), (10, 17), (10, 18), (10, 19), (10, 20)]
[(80, 15), (80, 16), (80, 17), (80, 18), (80, 19), (80, 20), (80, 21), (80, 22),
 (80, 23), (80, 24), (80, 25), (80, 26), (80, 27), (80, 28), (80, 29), (80, 30),
 (80, 31), (80, 32), (80, 33), (80, 34), (80, 35), (80, 36), (80, 37), (80, 38),
 (80, 39), (80, 40), (80, 41), (80, 42), (80, 43), (80, 44), (80, 45), (80, 46),
 (80, 47), (80, 48), (80, 49), (80, 50), (80, 51), (80, 52), (80, 53), (80, 54),
 (80, 55), (80, 56), (80, 57), (80, 58), (80, 59), (80, 60), (80, 61), (80, 62),
 (80, 63), (80, 64), (80, 65), (80, 66), (80, 67), (80, 68), (80, 69), (80, 70),
 (80, 71), (80, 72), (80, 73), (80, 74), (80, 75), (80, 76), (80, 77), (80, 78),
 (80, 79), (80, 80)]
[(50, 60), (50, 59), (50, 58), (49, 58), (49, 57), (49, 56), (49, 55), (48, 55),
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 (46, 48), (46, 47), (46, 46), (45, 46), (45, 45), (45, 44), (45, 43), (44, 43),
 (44, 42), (44, 41), (44, 40), (43, 40), (43, 39), (43, 38), (43, 37), (43, 36),
 (42, 36), (42, 35), (42, 34), (42, 33), (41, 33), (41, 32), (41, 31), (41, 30),
 (41, 29), (41, 28), (41, 27), (41, 26), (41, 25), (40, 25)]
```

```python
[8]:  # Función para dibujar los mapas

      def draw_boids(model):
          airport_x , airport_y  = [], []
          airplane_x, airplane_y = [], []

          airplanes = [x for x in model.schedule.agents if x.type == "airplane"]
          airports  = [x for x in model.schedule.agents if x.type == "airport" ]

          for a in airports:
              x, y = a.pos
              airport_x.append(x)
              airport_y.append(y)
          for a in airplanes:
              x, y = a.pos
              airplane_x.append(x)
              airplane_y.append(y)

          fig = plt.figure(figsize=(10,10))

          ax = fig.add_subplot(111)
```

```
    ax.scatter(airplane_x, airplane_y, marker="2")
    ax.scatter(airport_x, airport_y, alpha=0.5, edgecolors='black')

    for (x,y) in zip(airplane_x, airplane_y):
        label = "  {:.0f}".format(airplane_x.index(x)) + "({0}, {1})".
→format(x,y)
        plt.annotate(label, (x,y))

    plt.xlim([0, 100])
    plt.ylim([0, 100])
```

[9]:
```
# Llamada al modelo AirplaneFlockers en model.py.

model = AirplaneFlockers(population=0,
                         width=100, height=100,
                         routes=route_solutions)
```

```
[20 20]
[10 15]
[80 15]
[50 60]
```

[10]:
```
"""
Mostrar el movimiento de los aviones (algunos pasos). Los aviones son los␣
 →triángulos azules, y los aeropuertos son los círculos rojos.
Por medio de las gráficas puede verse que los aviones van y vuelven entre dos␣
 →aeropuertos.
"""

for i in list(range(200)):
    model.step()
    if i%10 == 0:
        print("Step:", 20)
        draw_boids(model)
```

```
Plane 2 at position 0 ([80 15]) in direction 1
Plane 1 at position 0 ([10 15]) in direction 1
Plane 3 at position 0 ([50 60]) in direction 1
Plane 0 at position 0 ([20 20]) in direction 1
0
Step: 20
Plane 2 at position 1 ([80 16]) in direction 1
Plane 0 at position 1 ([20 21]) in direction 1
Plane 3 at position 1 ([50 59]) in direction 1
Plane 1 at position 1 ([10 16]) in direction 1
1
Plane 0 at position 2 ([20 22]) in direction 1
```

```
Plane 3 at position 2 ([50 58]) in direction 1
Plane 2 at position 2 ([80 17]) in direction 1
Plane 1 at position 2 ([10 17]) in direction 1
2
Plane 0 at position 3 ([20 23]) in direction 1
Plane 3 at position 3 ([49 58]) in direction 1
Plane 2 at position 3 ([80 18]) in direction 1
Plane 1 at position 3 ([10 18]) in direction 1
3
Plane 2 at position 4 ([80 19]) in direction 1
Plane 1 at position 4 ([10 19]) in direction 1
Plane 0 at position 4 ([20 24]) in direction 1
Plane 3 at position 4 ([49 57]) in direction 1
4
Plane 1 at position 5 ([10 20]) in direction 1
Plane 0 at position 5 ([20 25]) in direction 1
Plane 3 at position 5 ([49 56]) in direction 1
Plane 2 at position 5 ([80 20]) in direction 1
5
Plane 0 at position 6 ([20 26]) in direction 1
Plane 1 at position 5 ([10 20]) in direction -1
Plane 2 at position 6 ([80 21]) in direction 1
Plane 3 at position 6 ([49 55]) in direction 1
6
Plane 2 at position 7 ([80 22]) in direction 1
Plane 0 at position 7 ([20 27]) in direction 1
Plane 1 at position 4 ([10 19]) in direction -1
Plane 3 at position 7 ([48 55]) in direction 1
7
Plane 3 at position 8 ([48 54]) in direction 1
Plane 0 at position 8 ([20 28]) in direction 1
Plane 2 at position 8 ([80 23]) in direction 1
Plane 1 at position 3 ([10 18]) in direction -1
8
Plane 1 at position 2 ([10 17]) in direction -1
Plane 0 at position 9 ([21 28]) in direction 1
Plane 2 at position 9 ([80 24]) in direction 1
Plane 3 at position 9 ([48 53]) in direction 1
9
Plane 1 at position 1 ([10 16]) in direction -1
Warning. Airport at [10 15] is full.
Plane 3 at position 10 ([48 52]) in direction 1
Plane 2 at position 10 ([80 25]) in direction 1
Plane 0 at position 10 ([22 28]) in direction 1
10
Step: 20
Plane 3 at position 11 ([47 52]) in direction 1
Plane 2 at position 11 ([80 26]) in direction 1
```

```
Plane 1 at position 0 ([10 15]) in direction -1
Plane 0 at position 11 ([23 28]) in direction 1
11
Plane 3 at position 12 ([47 51]) in direction 1
Plane 1 at position 0 ([10 15]) in direction 1
Plane 2 at position 12 ([80 27]) in direction 1
Plane 0 at position 12 ([24 28]) in direction 1
12
Plane 1 at position 1 ([10 16]) in direction 1
Plane 2 at position 13 ([80 28]) in direction 1
Plane 0 at position 13 ([25 28]) in direction 1
Plane 3 at position 13 ([47 50]) in direction 1
13
Plane 2 at position 14 ([80 29]) in direction 1
Plane 1 at position 2 ([10 17]) in direction 1
Plane 3 at position 14 ([47 49]) in direction 1
Plane 0 at position 14 ([26 28]) in direction 1
14
Plane 2 at position 15 ([80 30]) in direction 1
Plane 1 at position 3 ([10 18]) in direction 1
Plane 3 at position 15 ([46 49]) in direction 1
Plane 0 at position 15 ([27 28]) in direction 1
15
Plane 0 at position 16 ([28 28]) in direction 1
Plane 3 at position 16 ([46 48]) in direction 1
Plane 1 at position 4 ([10 19]) in direction 1
Plane 2 at position 16 ([80 31]) in direction 1
16
Plane 3 at position 17 ([46 47]) in direction 1
Plane 1 at position 5 ([10 20]) in direction 1
Plane 2 at position 17 ([80 32]) in direction 1
Plane 0 at position 17 ([29 28]) in direction 1
17
Plane 0 at position 18 ([30 28]) in direction 1
Plane 1 at position 5 ([10 20]) in direction -1
Plane 2 at position 18 ([80 33]) in direction 1
Plane 3 at position 18 ([46 46]) in direction 1
18
Plane 3 at position 19 ([45 46]) in direction 1
Plane 2 at position 19 ([80 34]) in direction 1
Plane 0 at position 19 ([30 29]) in direction 1
Warning. Airport at [30 30] is full.
Plane 1 at position 4 ([10 19]) in direction -1
19
Plane 2 at position 20 ([80 35]) in direction 1
Plane 1 at position 3 ([10 18]) in direction -1
Plane 3 at position 20 ([45 45]) in direction 1
Plane 0 at position 20 ([30 30]) in direction 1
```

```
20
Step: 20
Plane 3 at position 21 ([45 44]) in direction 1
Plane 0 at position 20 ([30 30]) in direction -1
Plane 2 at position 21 ([80 36]) in direction 1
Plane 1 at position 2 ([10 17]) in direction -1
21
Plane 0 at position 19 ([30 29]) in direction -1
Plane 2 at position 22 ([80 37]) in direction 1
Plane 3 at position 22 ([45 43]) in direction 1
Plane 1 at position 1 ([10 16]) in direction -1
Warning. Airport at [10 15] is full.
22
Plane 2 at position 23 ([80 38]) in direction 1
Plane 0 at position 18 ([30 28]) in direction -1
Plane 1 at position 0 ([10 15]) in direction -1
Plane 3 at position 23 ([44 43]) in direction 1
23
Plane 1 at position 0 ([10 15]) in direction 1
Plane 3 at position 24 ([44 42]) in direction 1
Plane 0 at position 17 ([29 28]) in direction -1
Plane 2 at position 24 ([80 39]) in direction 1
24
Plane 1 at position 1 ([10 16]) in direction 1
Plane 3 at position 25 ([44 41]) in direction 1
Plane 0 at position 16 ([28 28]) in direction -1
Plane 2 at position 25 ([80 40]) in direction 1
25
Plane 0 at position 15 ([27 28]) in direction -1
Plane 2 at position 26 ([80 41]) in direction 1
Plane 1 at position 2 ([10 17]) in direction 1
Plane 3 at position 26 ([44 40]) in direction 1
26
Plane 3 at position 27 ([43 40]) in direction 1
Plane 1 at position 3 ([10 18]) in direction 1
Plane 0 at position 14 ([26 28]) in direction -1
Plane 2 at position 27 ([80 42]) in direction 1
27
Plane 0 at position 13 ([25 28]) in direction -1
Plane 3 at position 28 ([43 39]) in direction 1
Plane 2 at position 28 ([80 43]) in direction 1
Plane 1 at position 4 ([10 19]) in direction 1
Warning. Airport at [10 20] is full.
28
Plane 2 at position 29 ([80 44]) in direction 1
Plane 3 at position 29 ([43 38]) in direction 1
Plane 1 at position 5 ([10 20]) in direction 1
Plane 0 at position 12 ([24 28]) in direction -1
```

```
29
Plane 3 at position 30 ([43 37]) in direction 1
Plane 0 at position 11 ([23 28]) in direction -1
Plane 2 at position 30 ([80 45]) in direction 1
Plane 1 at position 5 ([10 20]) in direction -1
30
Step: 20
Plane 0 at position 10 ([22 28]) in direction -1
Plane 3 at position 31 ([43 36]) in direction 1
Plane 2 at position 31 ([80 46]) in direction 1
Plane 1 at position 4 ([10 19]) in direction -1
31
Plane 3 at position 32 ([42 36]) in direction 1
Plane 1 at position 3 ([10 18]) in direction -1
Plane 2 at position 32 ([80 47]) in direction 1
Plane 0 at position 9 ([21 28]) in direction -1
32
Plane 0 at position 8 ([20 28]) in direction -1
Plane 3 at position 33 ([42 35]) in direction 1
Plane 2 at position 33 ([80 48]) in direction 1
Plane 1 at position 2 ([10 17]) in direction -1
33
Plane 3 at position 34 ([42 34]) in direction 1
Plane 2 at position 34 ([80 49]) in direction 1
Plane 0 at position 7 ([20 27]) in direction -1
Plane 1 at position 1 ([10 16]) in direction -1
Warning. Airport at [10 15] is full.
34
Plane 1 at position 0 ([10 15]) in direction -1
Plane 3 at position 35 ([42 33]) in direction 1
Plane 0 at position 6 ([20 26]) in direction -1
Plane 2 at position 35 ([80 50]) in direction 1
35
Plane 0 at position 5 ([20 25]) in direction -1
Plane 1 at position 0 ([10 15]) in direction 1
Plane 2 at position 36 ([80 51]) in direction 1
Plane 3 at position 36 ([41 33]) in direction 1
36
Plane 2 at position 37 ([80 52]) in direction 1
Plane 0 at position 4 ([20 24]) in direction -1
Plane 3 at position 37 ([41 32]) in direction 1
Plane 1 at position 1 ([10 16]) in direction 1
37
Plane 2 at position 38 ([80 53]) in direction 1
Plane 1 at position 2 ([10 17]) in direction 1
Plane 0 at position 3 ([20 23]) in direction -1
Plane 3 at position 38 ([41 31]) in direction 1
38
```

```
Plane 0 at position 2 ([20 22]) in direction -1
Plane 3 at position 39 ([41 30]) in direction 1
Plane 2 at position 39 ([80 54]) in direction 1
Plane 1 at position 3 ([10 18]) in direction 1
39
Plane 1 at position 4 ([10 19]) in direction 1
Warning. Airport at [10 20] is full.
Plane 2 at position 40 ([80 55]) in direction 1
Plane 3 at position 40 ([41 29]) in direction 1
Plane 0 at position 1 ([20 21]) in direction -1
Warning. Airport at [20 20] is full.
40
Step: 20
Plane 1 at position 5 ([10 20]) in direction 1
Plane 3 at position 41 ([41 28]) in direction 1
Plane 2 at position 41 ([80 56]) in direction 1
Plane 0 at position 0 ([20 20]) in direction -1
41
Plane 2 at position 42 ([80 57]) in direction 1
Plane 0 at position 0 ([20 20]) in direction 1
Plane 3 at position 42 ([41 27]) in direction 1
Plane 1 at position 5 ([10 20]) in direction -1
42
Plane 1 at position 4 ([10 19]) in direction -1
Plane 3 at position 43 ([41 26]) in direction 1
Plane 0 at position 1 ([20 21]) in direction 1
Plane 2 at position 43 ([80 58]) in direction 1
43
Plane 2 at position 44 ([80 59]) in direction 1
Plane 1 at position 3 ([10 18]) in direction -1
Plane 0 at position 2 ([20 22]) in direction 1
Plane 3 at position 44 ([41 25]) in direction 1
Warning. Airport at [40 25] is full.
44
Plane 2 at position 45 ([80 60]) in direction 1
Plane 1 at position 2 ([10 17]) in direction -1
Plane 0 at position 3 ([20 23]) in direction 1
Plane 3 at position 45 ([40 25]) in direction 1
45
Plane 1 at position 1 ([10 16]) in direction -1
Warning. Airport at [10 15] is full.
Plane 0 at position 4 ([20 24]) in direction 1
Plane 3 at position 45 ([40 25]) in direction -1
Plane 2 at position 46 ([80 61]) in direction 1
46
Plane 3 at position 44 ([41 25]) in direction -1
Plane 0 at position 5 ([20 25]) in direction 1
Plane 1 at position 0 ([10 15]) in direction -1
```

```
Plane 2 at position 47 ([80 62]) in direction 1
47
Plane 2 at position 48 ([80 63]) in direction 1
Plane 0 at position 6 ([20 26]) in direction 1
Plane 3 at position 43 ([41 26]) in direction -1
Plane 1 at position 0 ([10 15]) in direction 1
48
Plane 3 at position 42 ([41 27]) in direction -1
Plane 0 at position 7 ([20 27]) in direction 1
Plane 2 at position 49 ([80 64]) in direction 1
Plane 1 at position 1 ([10 16]) in direction 1
49
Plane 3 at position 41 ([41 28]) in direction -1
Plane 1 at position 2 ([10 17]) in direction 1
Plane 0 at position 8 ([20 28]) in direction 1
Plane 2 at position 50 ([80 65]) in direction 1
50
Step: 20
Plane 3 at position 40 ([41 29]) in direction -1
Plane 0 at position 9 ([21 28]) in direction 1
Plane 1 at position 3 ([10 18]) in direction 1
Plane 2 at position 51 ([80 66]) in direction 1
51
Plane 2 at position 52 ([80 67]) in direction 1
Plane 1 at position 4 ([10 19]) in direction 1
Warning. Airport at [10 20] is full.
Plane 3 at position 39 ([41 30]) in direction -1
Plane 0 at position 10 ([22 28]) in direction 1
52
Plane 1 at position 5 ([10 20]) in direction 1
Plane 0 at position 11 ([23 28]) in direction 1
Plane 2 at position 53 ([80 68]) in direction 1
Plane 3 at position 38 ([41 31]) in direction -1
53
Plane 1 at position 5 ([10 20]) in direction -1
Plane 0 at position 12 ([24 28]) in direction 1
Plane 3 at position 37 ([41 32]) in direction -1
Plane 2 at position 54 ([80 69]) in direction 1
54
Plane 1 at position 4 ([10 19]) in direction -1
Plane 0 at position 13 ([25 28]) in direction 1
Plane 2 at position 55 ([80 70]) in direction 1
Plane 3 at position 36 ([41 33]) in direction -1
55
Plane 1 at position 3 ([10 18]) in direction -1
Plane 2 at position 56 ([80 71]) in direction 1
Plane 3 at position 35 ([42 33]) in direction -1
Plane 0 at position 14 ([26 28]) in direction 1
```
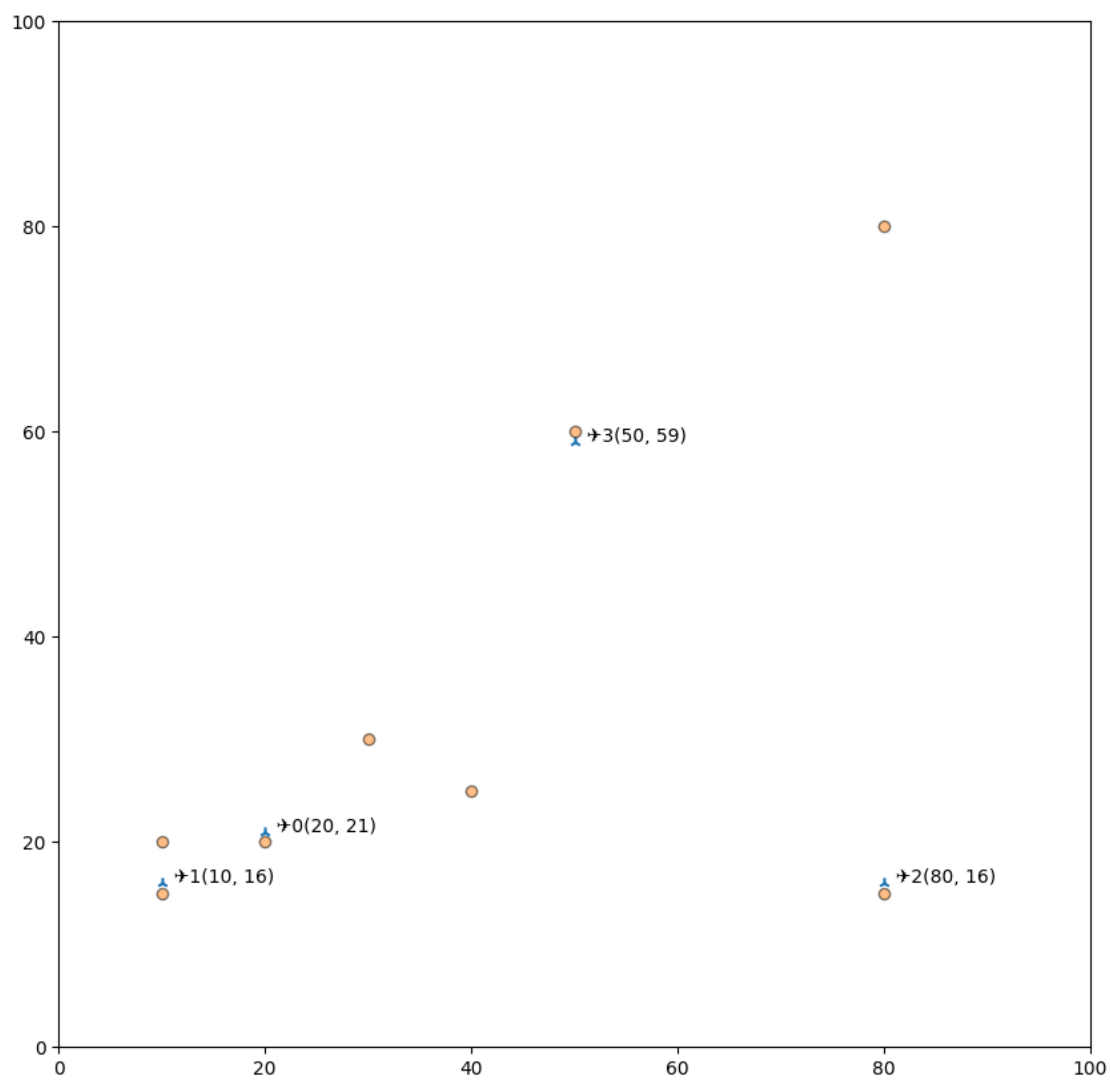
56
Plane 1 at position 2 ([10 17]) in direction -1
Plane 3 at position 34 ([42 34]) in direction -1
Plane 2 at position 57 ([80 72]) in direction 1
Plane 0 at position 15 ([27 28]) in direction 1
57
Plane 2 at position 58 ([80 73]) in direction 1
Plane 1 at position 1 ([10 16]) in direction -1
Warning. Airport at [10 15] is full.
Plane 0 at position 16 ([28 28]) in direction 1
Plane 3 at position 33 ([42 35]) in direction -1
58
Plane 1 at position 0 ([10 15]) in direction -1
Plane 0 at position 17 ([29 28]) in direction 1
Plane 2 at position 59 ([80 74]) in direction 1
Plane 3 at position 32 ([42 36]) in direction -1
59
Plane 1 at position 0 ([10 15]) in direction 1
Plane 2 at position 60 ([80 75]) in direction 1
Plane 3 at position 31 ([43 36]) in direction -1
Plane 0 at position 18 ([30 28]) in direction 1
60
Step: 20
Plane 0 at position 19 ([30 29]) in direction 1
Plane 1 at position 1 ([10 16]) in direction 1
Plane 2 at position 61 ([80 76]) in direction 1
Plane 3 at position 30 ([43 37]) in direction -1
61
Plane 3 at position 29 ([43 38]) in direction -1
Plane 1 at position 2 ([10 17]) in direction 1
Plane 2 at position 62 ([80 77]) in direction 1
Plane 0 at position 20 ([30 30]) in direction 1
62
Plane 1 at position 3 ([10 18]) in direction 1
Plane 2 at position 63 ([80 78]) in direction 1
Plane 3 at position 28 ([43 39]) in direction -1
Plane 0 at position 20 ([30 30]) in direction -1
63
Plane 3 at position 27 ([43 40]) in direction -1
Plane 1 at position 4 ([10 19]) in direction 1
Warning. Airport at [10 20] is full.
Plane 2 at position 64 ([80 79]) in direction 1
Warning. Airport at [80 80] is full.
Plane 0 at position 19 ([30 29]) in direction -1
64
Plane 0 at position 18 ([30 28]) in direction -1
Plane 2 at position 65 ([80 80]) in direction 1
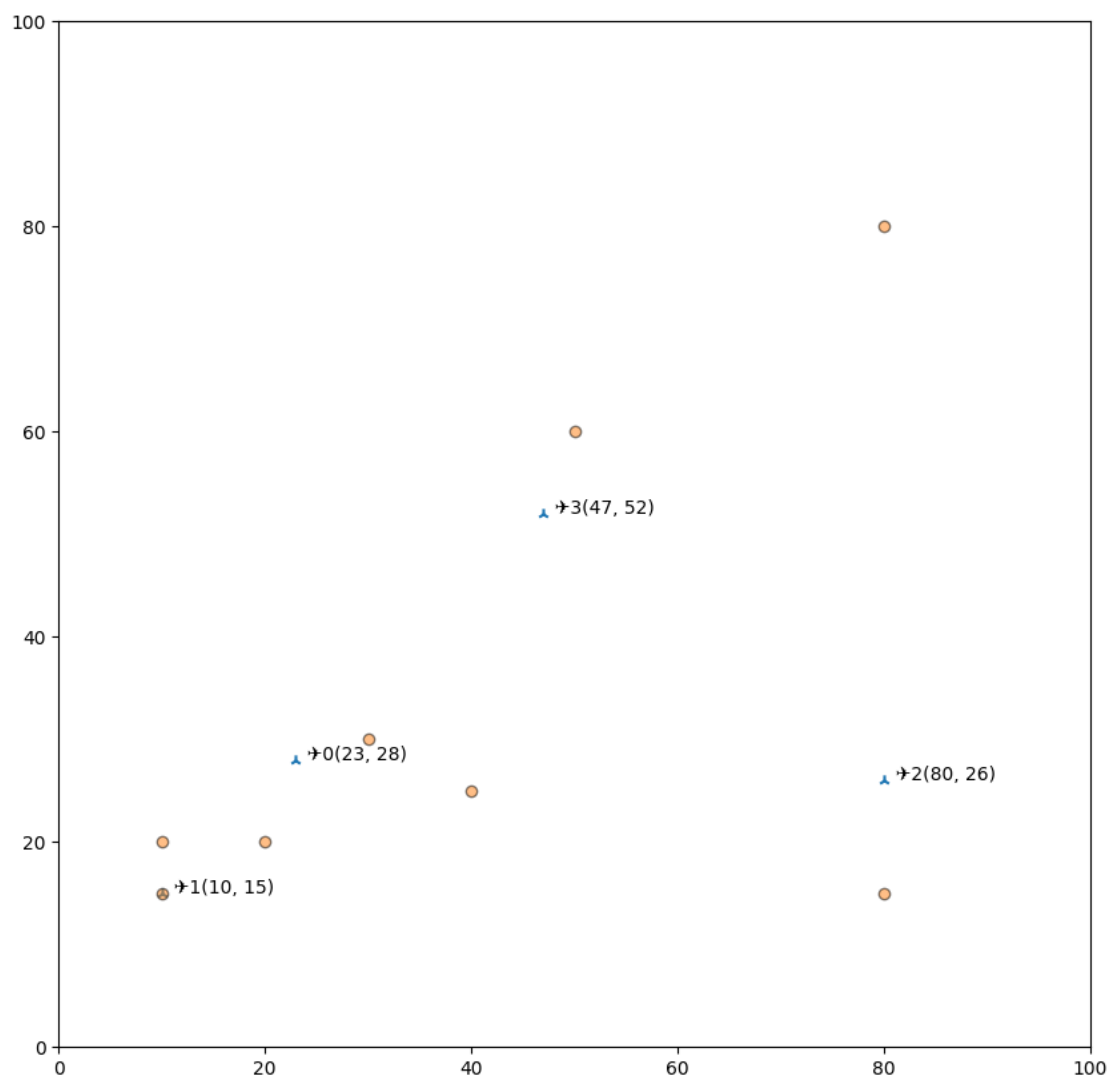Plane 3 at position 26 ([44 40]) in direction -1

```
Plane 1 at position 5 ([10 20]) in direction 1
65
Plane 3 at position 25 ([44 41]) in direction -1
Plane 1 at position 5 ([10 20]) in direction -1
Plane 0 at position 17 ([29 28]) in direction -1
Plane 2 at position 65 ([80 80]) in direction -1
66
Plane 2 at position 64 ([80 79]) in direction -1
Plane 0 at position 16 ([28 28]) in direction -1
Plane 1 at position 4 ([10 19]) in direction -1
Plane 3 at position 24 ([44 42]) in direction -1
67
Plane 2 at position 63 ([80 78]) in direction -1
Plane 3 at position 23 ([44 43]) in direction -1
Plane 1 at position 3 ([10 18]) in direction -1
Plane 0 at position 15 ([27 28]) in direction -1
68
Plane 3 at position 22 ([45 43]) in direction -1
Plane 2 at position 62 ([80 77]) in direction -1
Plane 1 at position 2 ([10 17]) in direction -1
Plane 0 at position 14 ([26 28]) in direction -1
69
Plane 0 at position 13 ([25 28]) in direction -1
Plane 1 at position 1 ([10 16]) in direction -1
Warning. Airport at [10 15] is full.
Plane 3 at position 21 ([45 44]) in direction -1
Plane 2 at position 61 ([80 76]) in direction -1
70
Step: 20
Plane 3 at position 20 ([45 45]) in direction -1
Plane 0 at position 12 ([24 28]) in direction -1
Plane 1 at position 0 ([10 15]) in direction -1
Plane 2 at position 60 ([80 75]) in direction -1
71
Plane 2 at position 59 ([80 74]) in direction -1
Plane 3 at position 19 ([45 46]) in direction -1
Plane 1 at position 0 ([10 15]) in direction 1
Plane 0 at position 11 ([23 28]) in direction -1
72
Plane 3 at position 18 ([46 46]) in direction -1
Plane 2 at position 58 ([80 73]) in direction -1
Plane 0 at position 10 ([22 28]) in direction -1
Plane 1 at position 1 ([10 16]) in direction 1
73
Plane 2 at position 57 ([80 72]) in direction -1
Plane 3 at position 17 ([46 47]) in direction -1
Plane 0 at position 9 ([21 28]) in direction -1
Plane 1 at position 2 ([10 17]) in direction 1
```
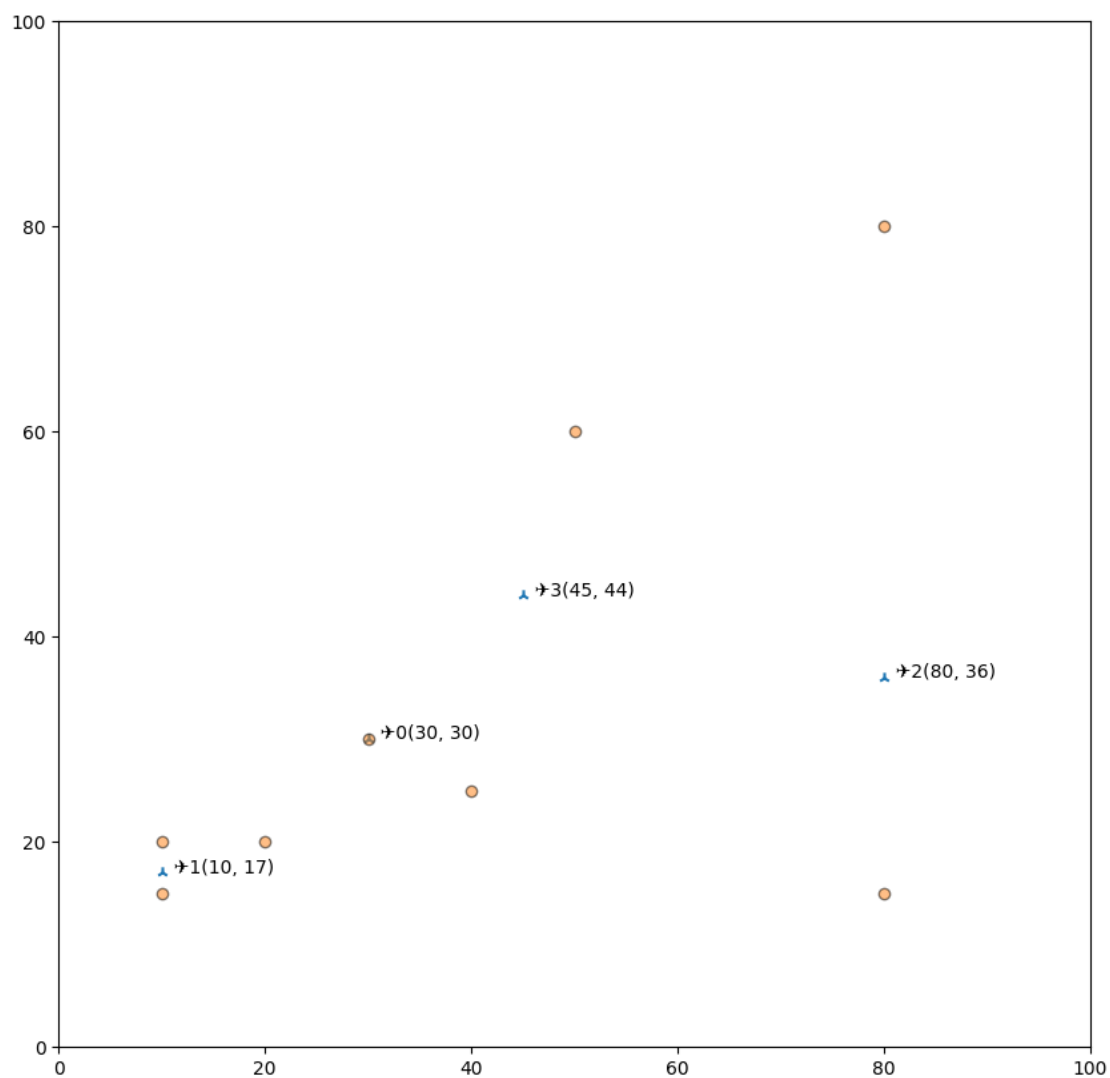
74
Plane 0 at position 8 ([20 28]) in direction -1
Plane 2 at position 56 ([80 71]) in direction -1
Plane 1 at position 3 ([10 18]) in direction 1
Plane 3 at position 16 ([46 48]) in direction -1
75
Plane 2 at position 55 ([80 70]) in direction -1
Plane 3 at position 15 ([46 49]) in direction -1
Plane 1 at position 4 ([10 19]) in direction 1
Warning. Airport at [10 20] is full.
Plane 0 at position 7 ([20 27]) in direction -1
76
Plane 2 at position 54 ([80 69]) in direction -1
Plane 1 at position 5 ([10 20]) in direction 1
Plane 0 at position 6 ([20 26]) in direction -1
Plane 3 at position 14 ([47 49]) in direction -1
77
Plane 2 at position 53 ([80 68]) in direction -1
Plane 1 at position 5 ([10 20]) in direction -1
Plane 0 at position 5 ([20 25]) in direction -1
Plane 3 at position 13 ([47 50]) in direction -1
78
Plane 0 at position 4 ([20 24]) in direction -1
Plane 1 at position 4 ([10 19]) in direction -1
Plane 2 at position 52 ([80 67]) in direction -1
Plane 3 at position 12 ([47 51]) in direction -1
79
Plane 1 at position 3 ([10 18]) in direction -1
Plane 2 at position 51 ([80 66]) in direction -1
Plane 3 at position 11 ([47 52]) in direction -1
Plane 0 at position 3 ([20 23]) in direction -1
80
Step: 20
Plane 2 at position 50 ([80 65]) in direction -1
Plane 0 at position 2 ([20 22]) in direction -1
Plane 1 at position 2 ([10 17]) in direction -1
Plane 3 at position 10 ([48 52]) in direction -1
81
Plane 0 at position 1 ([20 21]) in direction -1
Warning. Airport at [20 20] is full.
Plane 3 at position 9 ([48 53]) in direction -1
Plane 1 at position 1 ([10 16]) in direction -1
Warning. Airport at [10 15] is full.
Plane 2 at position 49 ([80 64]) in direction -1
82
Plane 3 at position 8 ([48 54]) in direction -1
Plane 2 at position 48 ([80 63]) in direction -1
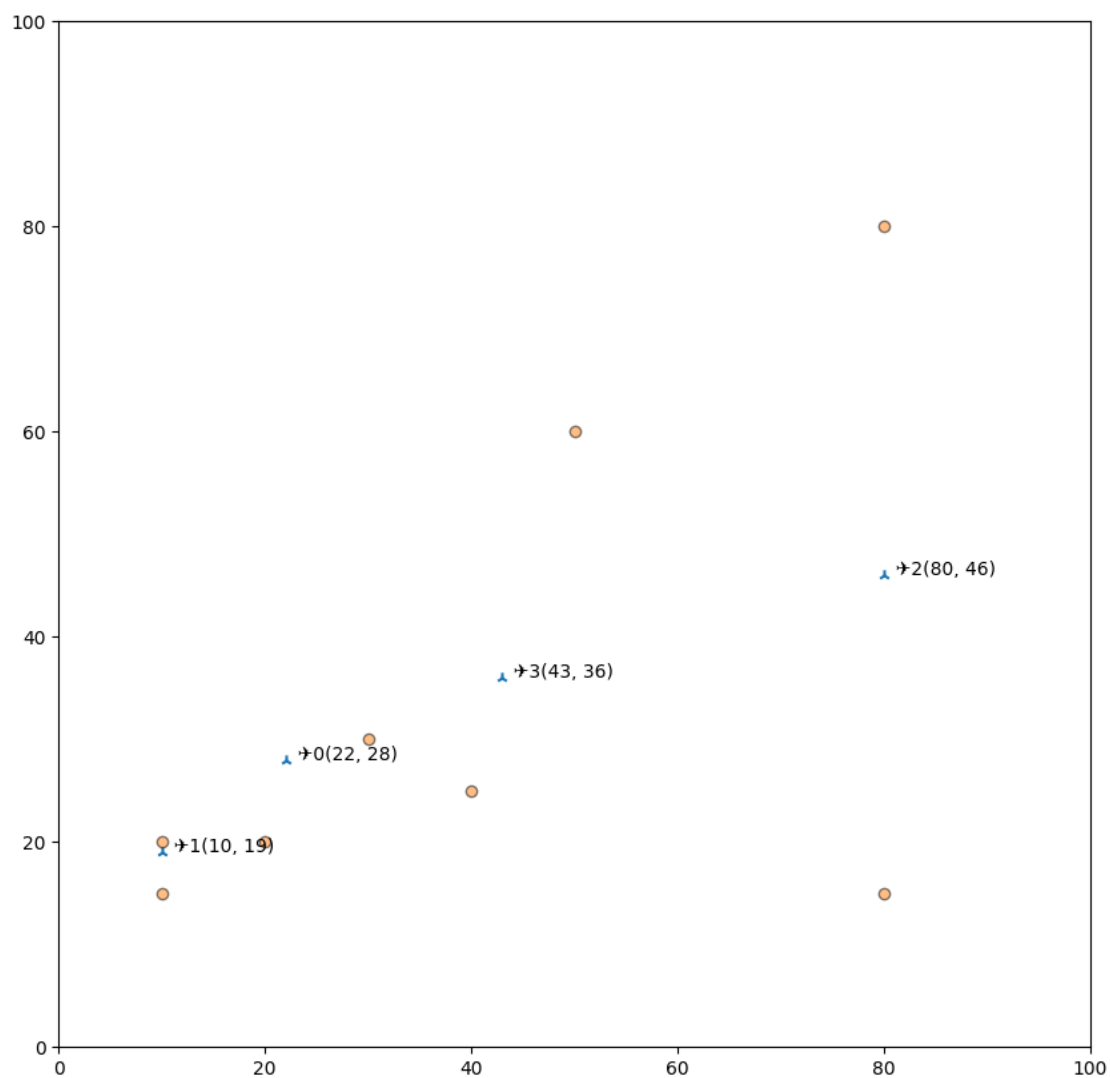Plane 1 at position 0 ([10 15]) in direction -1

```
Plane 0 at position 0 ([20 20]) in direction -1
83
Plane 0 at position 0 ([20 20]) in direction 1
Plane 3 at position 7 ([48 55]) in direction -1
Plane 1 at position 0 ([10 15]) in direction 1
Plane 2 at position 47 ([80 62]) in direction -1
84
Plane 3 at position 6 ([49 55]) in direction -1
Plane 0 at position 1 ([20 21]) in direction 1
Plane 2 at position 46 ([80 61]) in direction -1
Plane 1 at position 1 ([10 16]) in direction 1
85
Plane 2 at position 45 ([80 60]) in direction -1
Plane 3 at position 5 ([49 56]) in direction -1
Plane 0 at position 2 ([20 22]) in direction 1
Plane 1 at position 2 ([10 17]) in direction 1
86
Plane 1 at position 3 ([10 18]) in direction 1
Plane 2 at position 44 ([80 59]) in direction -1
Plane 3 at position 4 ([49 57]) in direction -1
Plane 0 at position 3 ([20 23]) in direction 1
87
Plane 0 at position 4 ([20 24]) in direction 1
Plane 3 at position 3 ([49 58]) in direction -1
Plane 2 at position 43 ([80 58]) in direction -1
Plane 1 at position 4 ([10 19]) in direction 1
Warning. Airport at [10 20] is full.
88
Plane 3 at position 2 ([50 58]) in direction -1
Plane 2 at position 42 ([80 57]) in direction -1
Plane 0 at position 5 ([20 25]) in direction 1
Plane 1 at position 5 ([10 20]) in direction 1
89
Plane 0 at position 6 ([20 26]) in direction 1
Plane 3 at position 1 ([50 59]) in direction -1
Warning. Airport at [50 60] is full.
Plane 1 at position 5 ([10 20]) in direction -1
Plane 2 at position 41 ([80 56]) in direction -1
90
Step: 20
Plane 1 at position 4 ([10 19]) in direction -1
Plane 3 at position 0 ([50 60]) in direction -1
Plane 0 at position 7 ([20 27]) in direction 1
Plane 2 at position 40 ([80 55]) in direction -1
91
Plane 0 at position 8 ([20 28]) in direction 1
Plane 1 at position 3 ([10 18]) in direction -1
Plane 3 at position 0 ([50 60]) in direction 1
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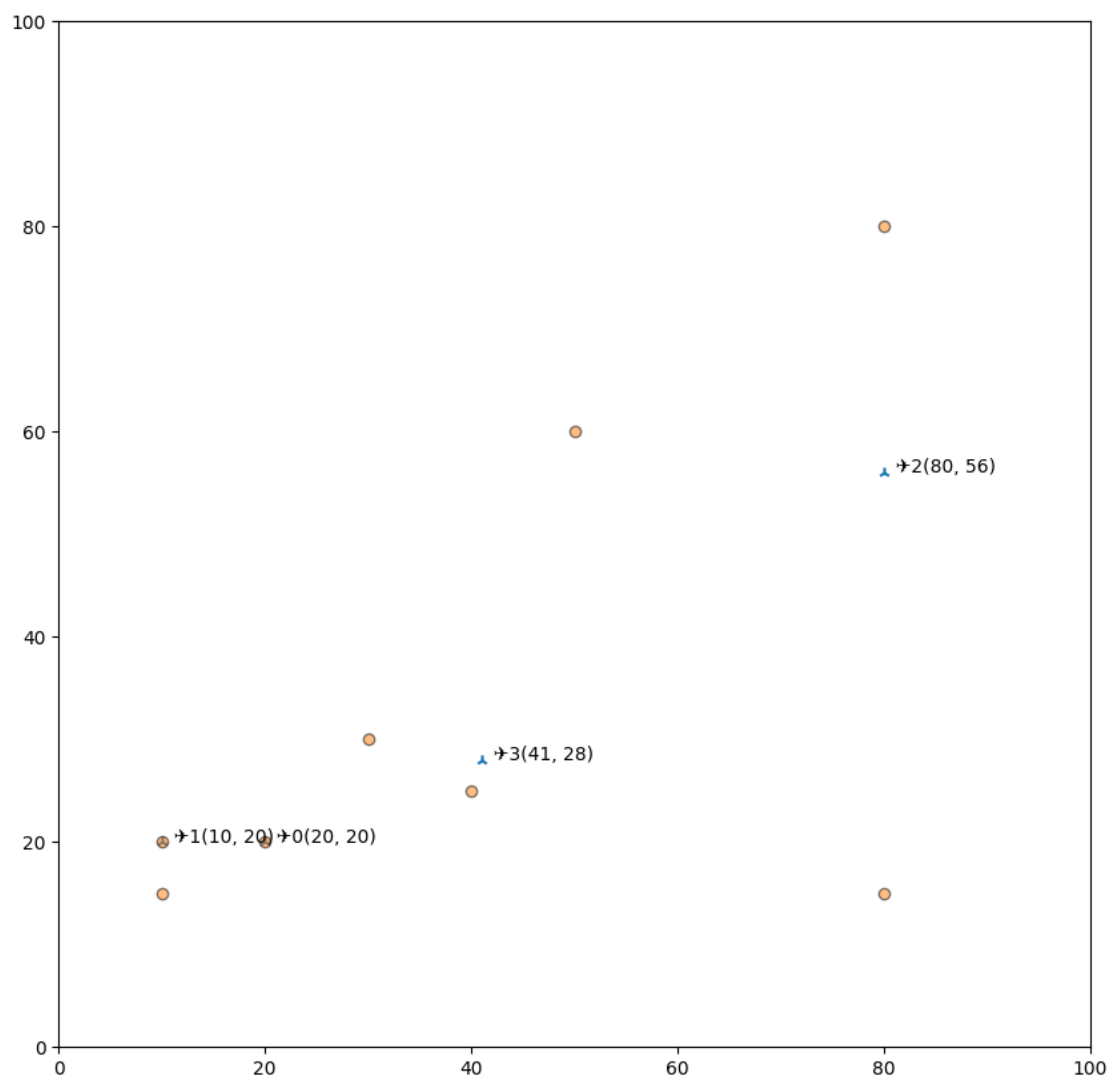
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Plane 2 at position 39 ([80 54]) in direction -1
92
Plane 1 at position 2 ([10 17]) in direction -1
Plane 2 at position 38 ([80 53]) in direction -1
Plane 0 at position 9 ([21 28]) in direction 1
Plane 3 at position 1 ([50 59]) in direction 1
93
Plane 1 at position 1 ([10 16]) in direction -1
Plane 0 at position 10 ([22 28]) in direction 1
Plane 2 at position 37 ([80 52]) in direction -1
Plane 3 at position 2 ([50 58]) in direction 1
94
Plane 2 at position 36 ([80 51]) in direction -1
Plane 1 at position 0 ([10 15]) in direction -1
Plane 0 at position 11 ([23 28]) in direction 1
Plane 3 at position 3 ([49 58]) in direction 1
95
Plane 0 at position 12 ([24 28]) in direction 1
Plane 1 at position 0 ([10 15]) in direction 1
Plane 2 at position 35 ([80 50]) in direction -1
Plane 3 at position 4 ([49 57]) in direction 1
96
Plane 0 at position 13 ([25 28]) in direction 1
Plane 1 at position 1 ([10 16]) in direction 1
Plane 2 at position 34 ([80 49]) in direction -1
Plane 3 at position 5 ([49 56]) in direction 1
97
Plane 0 at position 14 ([26 28]) in direction 1
Plane 2 at position 33 ([80 48]) in direction -1
Plane 3 at position 6 ([49 55]) in direction 1
Plane 1 at position 2 ([10 17]) in direction 1
98
Plane 3 at position 7 ([48 55]) in direction 1
Plane 0 at position 15 ([27 28]) in direction 1
Plane 1 at position 3 ([10 18]) in direction 1
Plane 2 at position 32 ([80 47]) in direction -1
99
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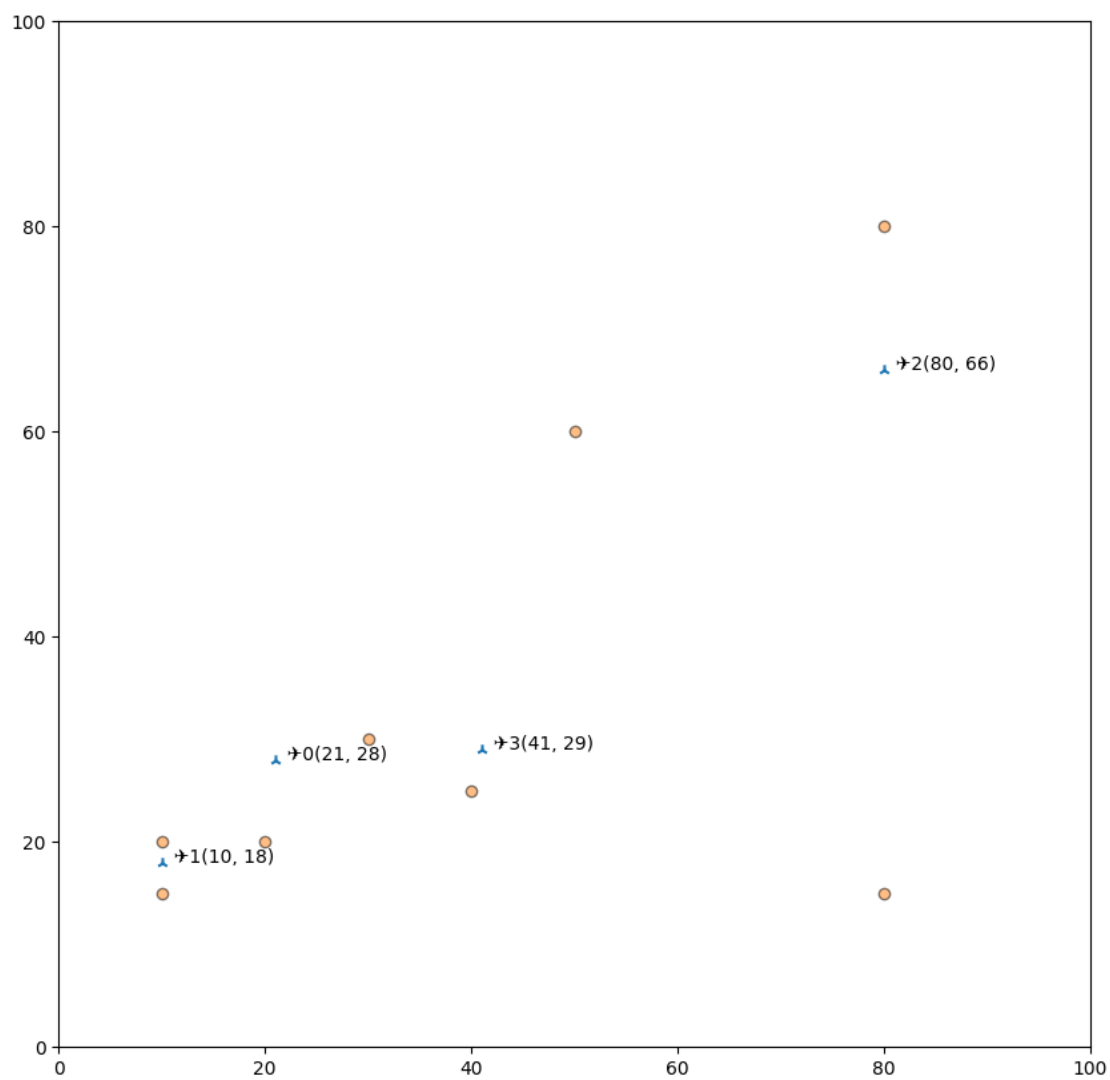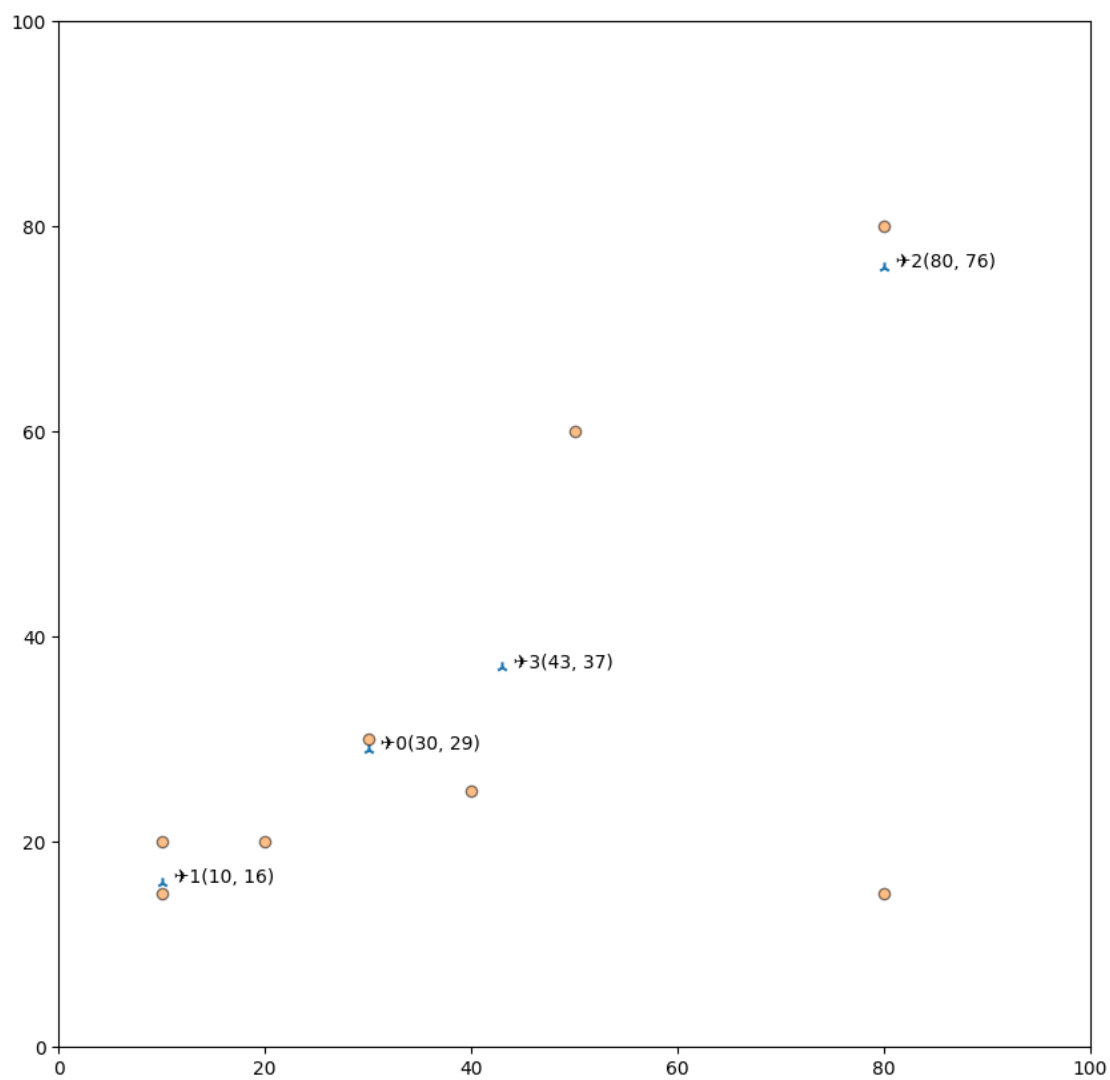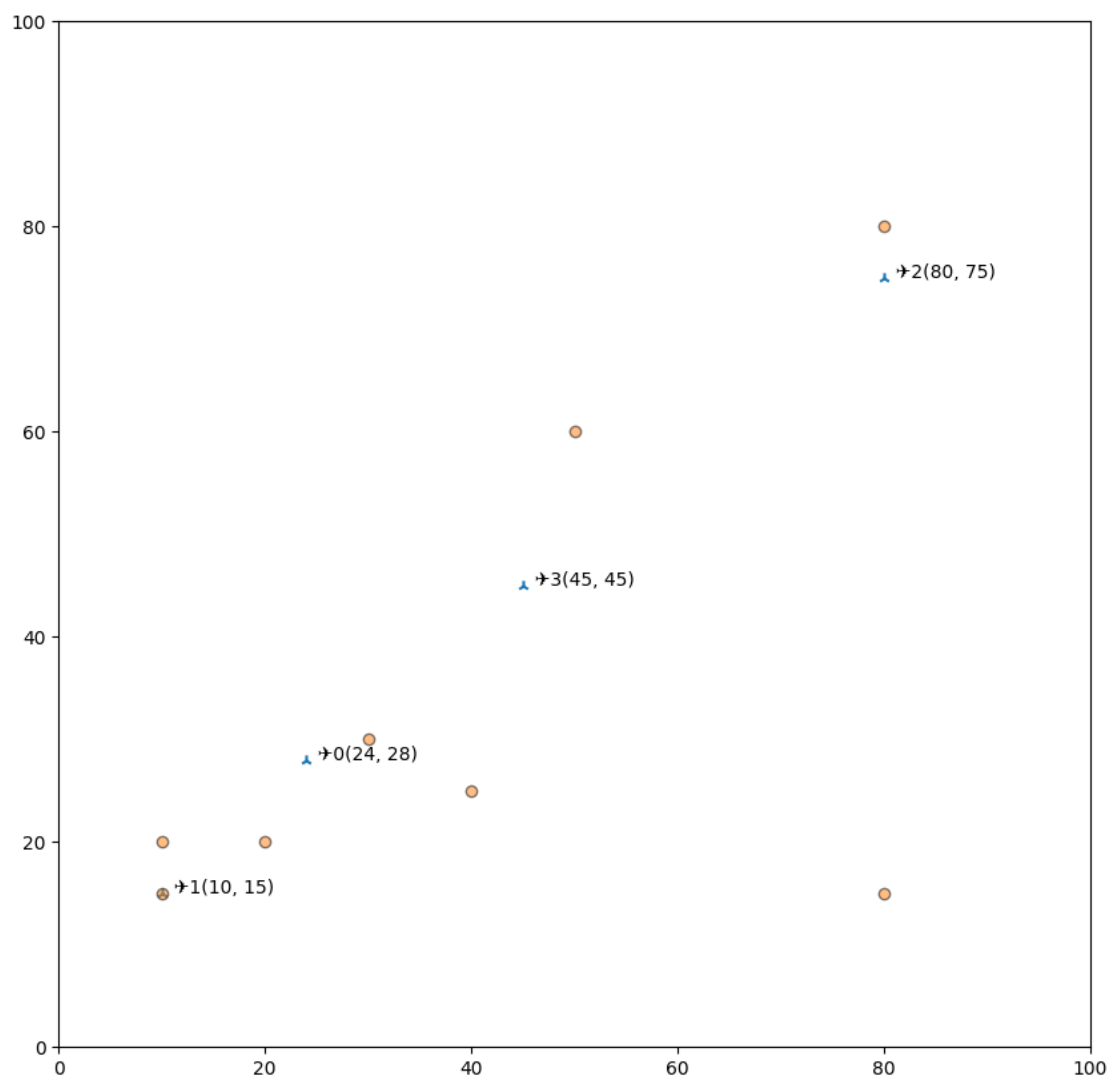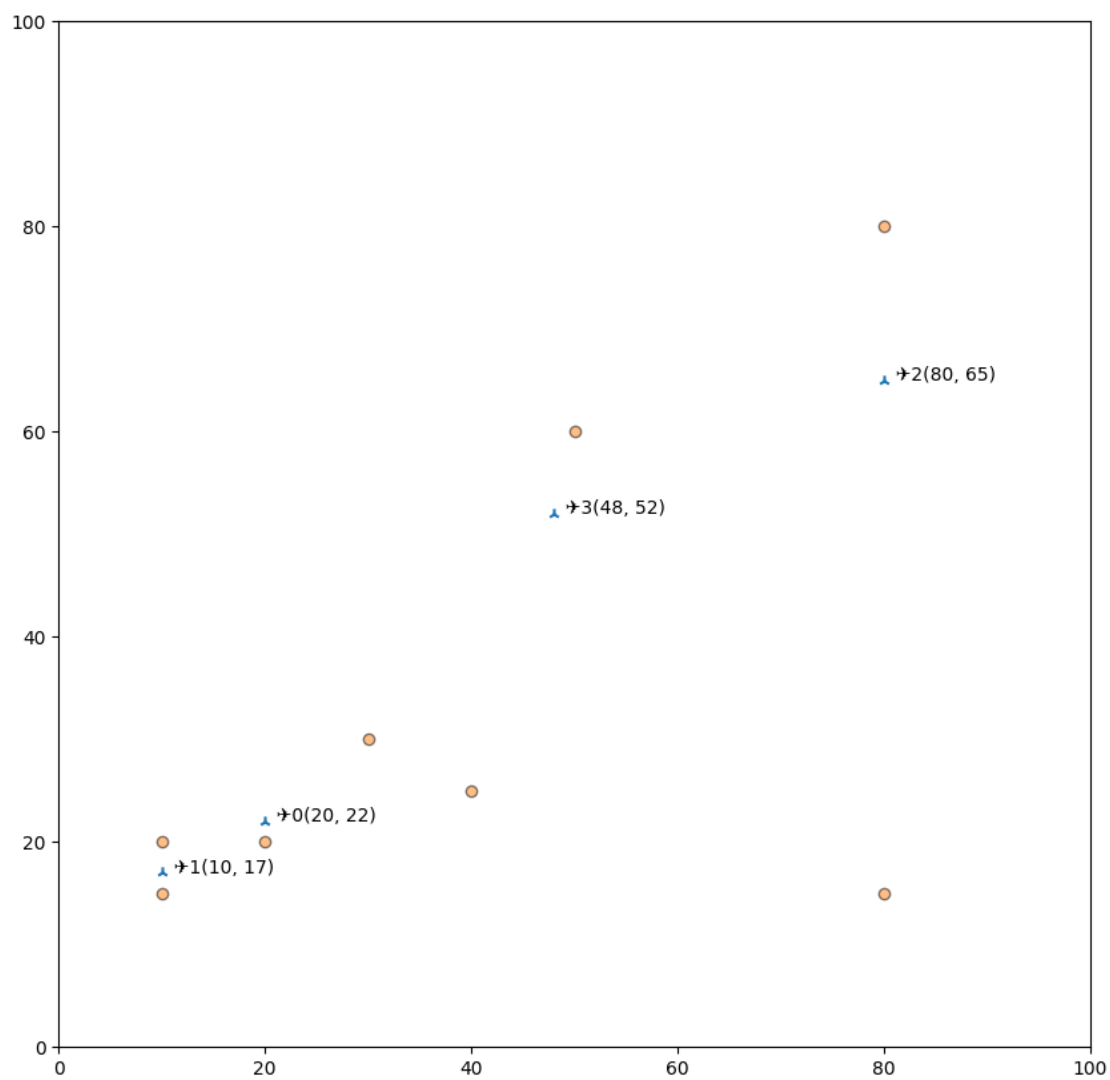
✈2(80, 75)

✈3(45, 45)

✈0(24, 28)

✈1(10, 15)