GA_sinaya_203191663

December 22, 2019

1 HW GA - Sinaya Nudel 203191663

```
In [1]: %matplotlib inline

        import pandas as pd
        import numpy as np
        import itertools
        import copy
        import matplotlib.pyplot as plt
```

1.0.1 Algorithm Settings

Maze

```
In [2]: all_maze_size = [10, 25, 50]
        obstacales = [0, 0.05, 0.1]
```

Algorithm

```
In [3]: generations_sizes = [25, 50, 100]

        max_generations= 50
        keep_from_previous = 0.25
        mutate_rate_in_population = 0.25
        mutate_rate_in_geneome = 0.4

        all_trials = list()
```

1.0.2 Algorithm Logic

Helping Functions

Move Functions

```
In [4]: move_left = lambda x,y: (x-1 , y)
        move_right = lambda x,y: (x + 1, y)
        move_up = lambda x,y: (x, y - 1)
        move_down = lambda x,y: (x, y + 1)
        def check_move(x, y, locations, maze, maze_size):
            for val in [x, y]:
                if val < 0 or val >= maze_size:
                    return 1
            if maze[x][y] == 1:
                return 2

            #if len(locations) >= np.power(maze_size,2):
            #    return 3
            if any([x == prev_x and y == prev_y for prev_x, prev_y in locations]):
                return 3

            return 0

        moves_options = [move_up, move_down, move_left, move_right]
```

Maze Generation

```
In [5]: def generate_maze(maze_size, obstacales_count):
            maze = np.zeros([maze_size, maze_size])
            maze[0,0] = 2
            maze[maze_size-1, maze_size-1] = 3
            possible_indices = pd.DataFrame(np.transpose(np.where(maze==0)), column
            possible_indices = possible_indices.sample(obstacales_count)
            obs_location = zip(possible_indices['x'].values, possible_indices['y'].
            for curr_x, curr_y in obs_location:
                maze[curr_x, curr_y] = 1
            return maze

        #generate_maze(5, 4)
```

Mutation Logic

```
In [6]: def mutate(generation, mutate_rate_in_population, mutate_rate_in_geneome, s
            for sample_ind, sample in enumerate(generation):
                if sample_ind >= size_to_keep:
                    if np.random.rand() < mutate_rate_in_population:
                        for item_ind in range(len(sample['moves_ind'])):
                            if np.random.rand() < mutate_rate_in_geneome:
                                new_move = np.random.choice([0,1,2,3], p=[0.35, 0.3
                                new_action = [move_down, move_right, move_up, move_
                                sample['moves_ind'][item_ind] = new_move
                                sample['moves_actions'][item_ind] = new_action
            return generation
```

Mixing Gene Function

```
In [7]: def mix_perents(x, y, maze_size):
            x_moves = x['moves_ind'].copy()
            y_moves = y['moves_ind'].copy()
            x_actions = x['moves_actions'].copy()
            y_actions = y['moves_actions'].copy()

            x_counter = x['counter']
            y_counter = y['counter']

            x_prob = y['score'] / float(x['score'] + y['score'])
            y_prob = x['score'] / float(x['score'] + y['score'])

            x_locations = x['locations'].copy()
            y_locations = y['locations'].copy()

            child_actions = list()
            child_moves = list()
            if np.random.rand() < 0.66:
                if x_counter >= y_counter and x_counter > (maze_size / 2.0):
                    #print('X major')
                    for _ in range(x_counter - 4):
                        child_actions.append(x_actions.pop(0))
                        child_moves.append(x_moves[0])
                        x_moves = x_moves[1:]
                        curr_location = x_locations.pop(0)
                        if any([(maze_size - x) < 4 for x in curr_location]):
                            break

                elif y_counter > x_counter and y_counter > (maze_size / 2.0):
                    #print('Y major')
                    for _ in range(y_counter - 4):
                        child_actions.append(y_actions.pop(0))
                        child_moves.append(y_moves[0])
                        y_moves = y_moves[1:]
                        curr_location = y_locations.pop(0)
                        if any([(maze_size - x) < 4 for x in curr_location]):
                            break

            #print('child action len - ' + str(len(child_actions)))
            for _ in range((maze_size * maze_size) - len(child_actions)):
                is_x_superior_option = True if x_actions[0] in [move_down, move_rig
                is_y_superior_option = True if y_actions[0] in [move_down, move_rig
                probs = [0.5, 0.5]
                if is_x_superior_option == True and is_y_superior_option == False:
                    probs = [0.9, 0.1]
                if is_x_superior_option == False and is_y_superior_option == True:
                    probs = [0.1, 0.9]
                next_item = np.random.choice([0,1], p=probs)

                if next_item == 0:
                    #print('from x')
                    child_actions.append(x_actions.pop(0))
                    child_moves.append(x_moves[0])
                    x_moves = x_moves[1:]
                else:
                    #print('from y')
                    child_actions.append(y_actions.pop(0))
                    child_moves.append(y_moves[0])
                    y_moves = y_moves[1:]

            child = {'moves_ind': child_moves,
                     'moves_actions': child_actions,
                     'locations': None,
                     'score':None,
                     'counter':None,
                     'is_valid':None,
                     'fit_score': None}
            return child
```

Generating Next Generation

```
In [8]: def generate_childrens(prev_gen=None, maze=None, gen_size=10, keep_prev_siz
            childrens = list()
            if prev_gen is None:
                # generating random childerens
                for curr_gen in range(gen_size):
                    moves_ind = np.random.randint(0, 4, maze_size * maze_size)
                    moves_actions = [moves_options[x] for x in moves_ind]
                    child = {'moves_ind': moves_ind,
                             'moves_actions': moves_actions,
                             'locations': None,
                             'counter': None,
                             'is_valid':None,
                             'score':None,
                             'fit_score': None}
                    childrens.append(child)
            else:
                for keep_sample in prev_gen[:int(keep_prev_size / 2)]:
                    childrens.append(copy.deepcopy(keep_sample))
                for _ in range(int(keep_prev_size / 2)):
                    keep_sample = np.random.choice(prev_gen)
                    childrens.append(copy.deepcopy(keep_sample))
                fit_scores = [x['fit_score'] for x in prev_gen]
                #print('fit scores')
                #print(fit_scores)
                for ind in range(gen_size - len(childrens)):

                    curr_fit_scores = fit_scores[ind+1:]
                    curr_fit_scores_sum = np.sum(curr_fit_scores)
                    curr_fit_scores = [x / curr_fit_scores_sum for x in curr_fit_sc
                    if ind == 0 or np.random.rand() < 0.1:
                        #second_sample_id = np.random.choice(range(len(prev_gen)),
                        second_sample_id = np.random.choice(range(len(prev_gen)))
                        childrens.append(mix_perents(prev_gen[ind], prev_gen[secon
                        #print('case 1: X id = ' + str(ind) + ' , Y id = ' + str(se
                    else:
                        curr_fit_scores_a = fit_scores[:ind]
                        curr_fit_scores_sum_a = np.sum(curr_fit_scores_a)
                        curr_fit_scores_a = [x / curr_fit_scores_sum_a for x in cur
                        first_sample_id = np.random.choice(range(ind), p=curr_fit_s
                        second_sample_id = np.random.choice(range(len(prev_gen)), p
                        if prev_gen[first_sample_id]['score'] == prev_gen[second_sa
                            #print('case 3: equal case')
                            childrens.append(mix_perents(np.random.choice(prev_gen)
                        else:
                            #print('case 2: X id = ' + str(first_sample_id) + ' , Y
                            childrens.append(mix_perents(prev_gen[first_sample_id],
            return childrens
```

Score Method for One Gene

```
In [9]: def score_one_sample(sample, maze, maze_size):
            start_point = (0, 0)
            end_point = (maze_size - 1, maze_size - 1)

            x, y = start_point
            locations = [start_point]
            counter = 0
            #print(sample['moves_ind'])
            for curr_action in sample['moves_actions']:
                x, y = curr_action(x, y)
                counter = counter + 1
                #print('location - ' + str([x, y]))
                move_result = check_move(x, y, locations, maze, maze_size)
                if move_result == 0:
                    locations.append((x, y))
                    if x == end_point[0] and y == end_point[1]:
                        sample['score'] = (counter / float(np.power(maze_size, 8)))
                        sample['counter'] = counter
                        sample['locations'] = locations
                        sample['is_valid'] = True
                        #print('valid ' + str([x,y]) + ' score ' + str(sample['scor
                        return sample
                else:
                    x_dist =  np.abs(x - end_point[0])
                    y_dist = np.abs(y - end_point[1])
                    min_item = np.min([x_dist, y_dist, 2])
                    max_item = np.max([x_dist, y_dist])
                    #dist_penalty = np.power(max_item, 2) + min_item
                    #dist_penalty = np.power(min_item, 2)/ float(counter * np.powe
                    dist_penalty = np.power(np.max([(max_item-min_item), 10]),2) *
                    if min_item < 3 and (max_item - min_item) > 4:
                        dist_penalty = dist_penalty * np.power((max_item), 2)
                    if min_item == 0 and max_item > 1:
                        dist_penalty = dist_penalty * np.power(2, np.min([max_item,
                    #dist_penalty = dist_penalty * ((max_item - min_item + 1) / flo
                    sample['score'] = dist_penalty
                    sample['counter'] = counter
                    sample['locations'] = locations
                    sample['is_valid'] = False
                    return sample
                    """
                    if move_result == 1:
                        #if min_item < 3:
                        #    sample['score'] = sample['score'] * 5
                        print('not_valid (out of bound) ' + str([x,y]) + ' counter
                    if move_result == 2:
                        #if min_item < 3:
                        #    sample['score'] = sample['score'] * 5
                        print('not_valid (block) ' + str([x,y]) + ' counter ' + st
                    if move_result == 3:
                        #if min_item < 3:
                        #    sample['score'] = sample['score'] * 5
                        print('not_valid (circle) ' + str([x,y]) + ' counter ' + st
                    """
```

Fit Function Calculation

```
In [10]: def score_generation(generation, maze, maze_size):
             scores = list()

             for sample in generation:
                 if sample is None:
                     print('here1')
                 sample = score_one_sample(sample, maze, maze_size)
                 if sample is None:
                     print('here2')
                 scores.append(1 / float(sample['score']))
             scores_sum = np.sum(scores)
             scores = [x / scores_sum for x in scores]

             for sample, sample_fit_score in zip(generation, scores):
                 sample['fit_score'] = sample_fit_score

             return sorted(generation, key=lambda d:d['fit_score'], reverse=True)
```

Test Converegence Method

```
In [11]: def check_convergence(gen, counter, value):
             if gen[0]['is_valid']:
                 if gen[0]['score'] < value:
                     return True, 0, gen[0]['score']
                 else:
                     return True, counter + 1, value
             else:
                 return False, 0, gen[0]['score']
```

Run Logic (The Algorithm) Iterating Over All the Options we want to Test

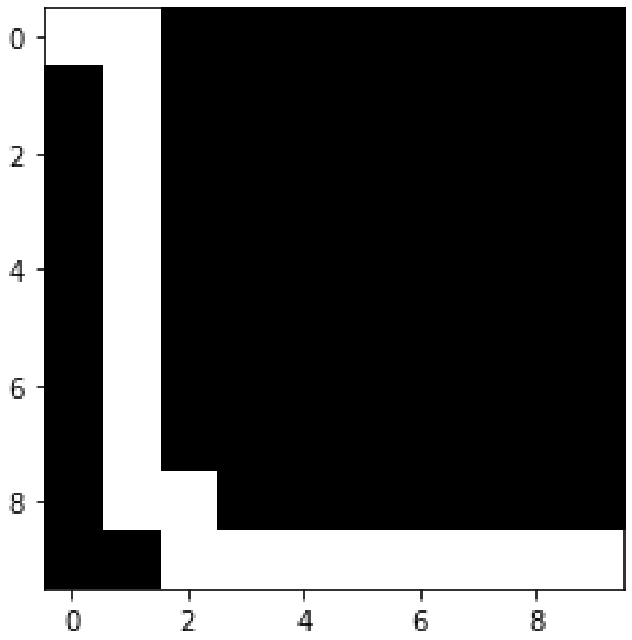
```
In [ ]: # iterating over all combinations
        for maze_size, obstacles_fraction, gen_size in itertools.product(all_maze_s
            print('Start Simulation ')
            obstacales_count = int(obstacles_fraction * (maze_size * maze_size))
            keep_from_previous_count = int(keep_from_previous * gen_size)
            print('    maze size = ' + str(maze_size))
            print('    generation size = ' + str(gen_size))
            print('    obstacales count = ' + str(obstacales_count))


            # for analysis
            curr_run = {'gen_size': gen_size,
                        'maze_size': maze_size,
                        'obstacle_count': obstacales_count,
                        'finish_gen': None,
                        'generations': list()}

            # start of actual algorithm
            prev_gen = None
            next_gen = None
            maze = generate_maze(maze_size, obstacales_count)
            print('Maze of size ' + str([maze_size, maze_size]) + ' is:')
            print(maze)

            all_generations = list()
            counter = 0
            best_value = maze_size
            for curr_gen in range(max_generations):
                #print('Start Generation ' + str(curr_gen))
                next_gen = generate_childrens(prev_gen,maze, gen_size, keep_from_pr
                next_gen = score_generation(next_gen, maze, maze_size)
                next_gen = mutate(next_gen, mutate_rate_in_population, mutate_rate_
                next_gen = score_generation(next_gen, maze, maze_size)
                is_done, counter, best_value = check_convergence(next_gen, counter,

                print('Generation - ' + str(curr_gen) +', best location - ' + str(r
                all_generations.append(next_gen)
                if is_done and counter > 10:
                    print('DONE!')
                    break
                else:
                    prev_gen = next_gen

            all_trials.append({
                'generations':all_generations,
                'len': len(all_generations),
                'best': all_generations[-1][0],
                'valid': all_generations[-1][0]['is_valid'],
                'gen_size': gen_size,
                'maze_size': maze_size,
                'obstacles': obstacales_count,
                'maze': maze
            })
```

1.0.3 Results Analysis

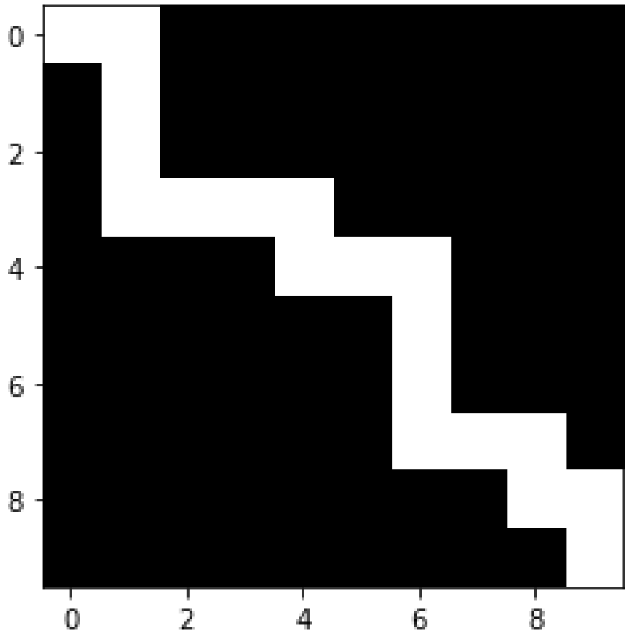
Visual Performance of Each Combination Tested

```
In [71]: for curr_trial in all_trials:
             print('\n' * 20 + '-' * 50 + '\n' + '-' * 50)
             print(' Gen Size - ' + str(curr_trial['gen_size']))
             print(' Maze Size - [' + str(curr_trial['maze_size']) + ' , ' + str(cu
             print(' Obstacles Count - ' + str(curr_trial['obstacles']))
             print(' End Location - ' + str(curr_trial['best']['locations'][-1]))
             print(' Was Solved - ' + str(curr_trial['valid']))
             curr_maze = curr_trial['maze'].copy()
             for x,y in curr_trial['best']['locations']:
                 curr_maze[y][x] = 2
             plt.figure()
             _ = plt.imshow(curr_maze, cmap='gray')
             plt.show()
```

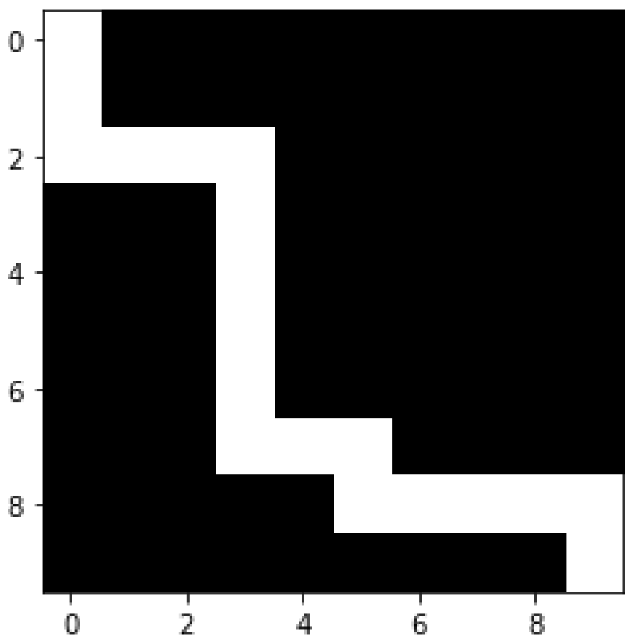
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 25
 Maze Size - [10 , 10]
 Obstacles Count - 0
 End Location - (9, 9)
 Was Solved - True
```



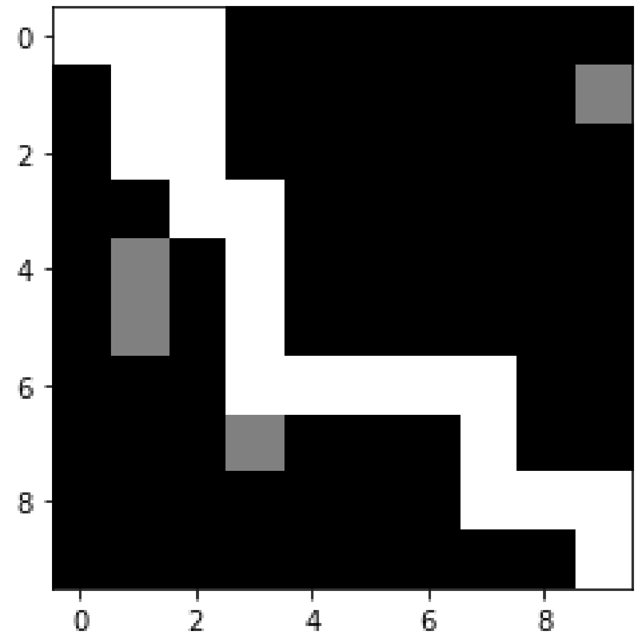
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 50
 Maze Size - [10 , 10]
 Obstacles Count - 0
 End Location - (9, 9)
 Was Solved - True
```



```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 100
 Maze Size - [10 , 10]
 Obstacles Count - 0
 End Location - (9, 9)
 Was Solved - True
```

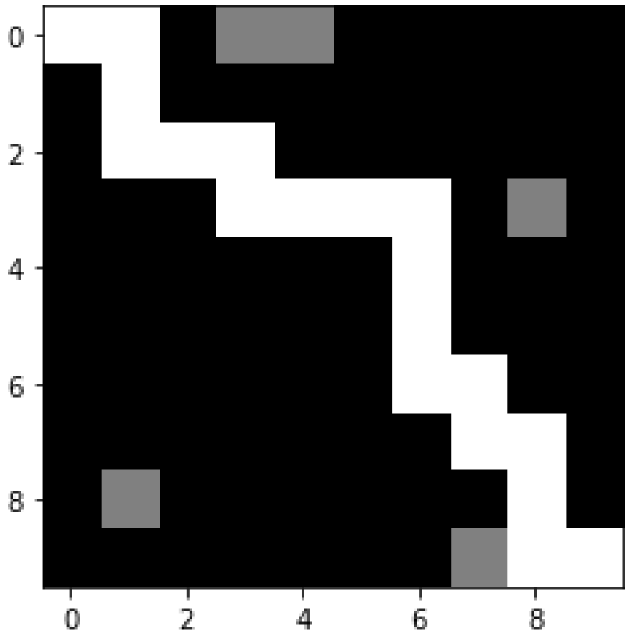


```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 25
 Maze Size - [10 , 10]
 Obstacles Count - 5
 End Location - (9, 9)
 Was Solved - True
```

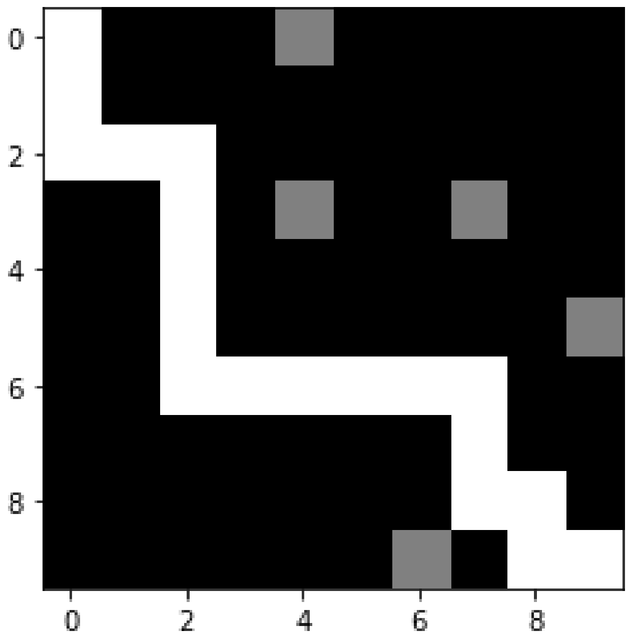


```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 50
```

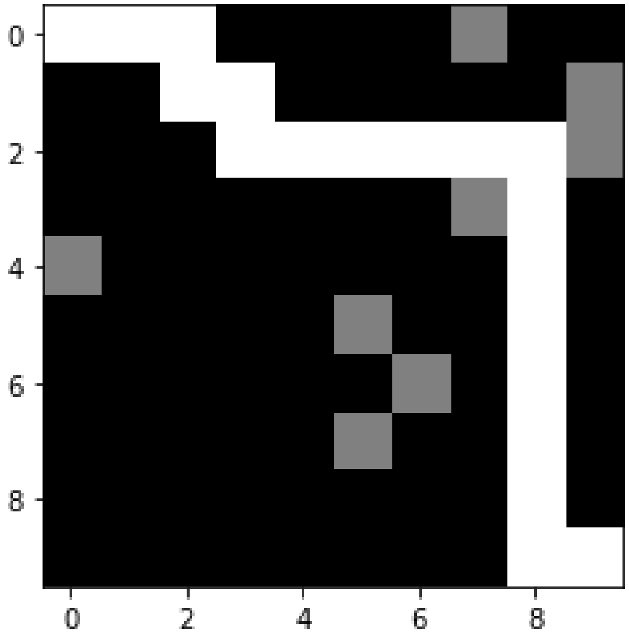
```
Maze Size - [10 , 10]
Obstacles Count - 5
End Location - (9, 9)
Was Solved - True
```



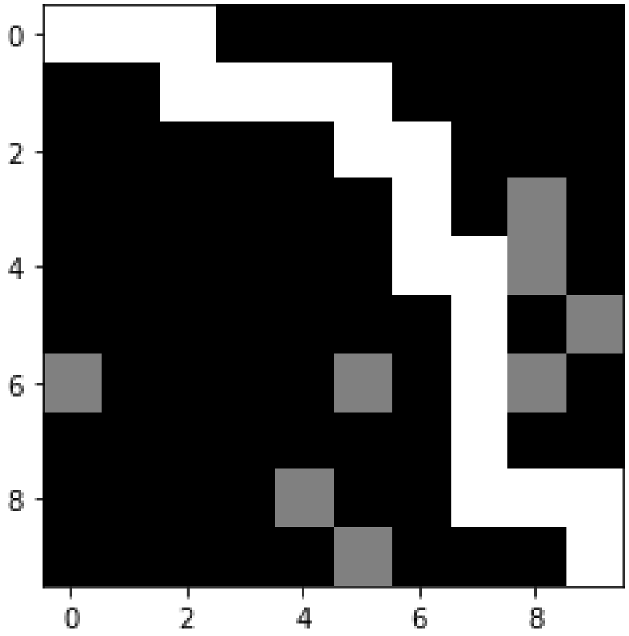
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 100
 Maze Size - [10 , 10]
 Obstacles Count - 5
 End Location - (9, 9)
 Was Solved - True
```



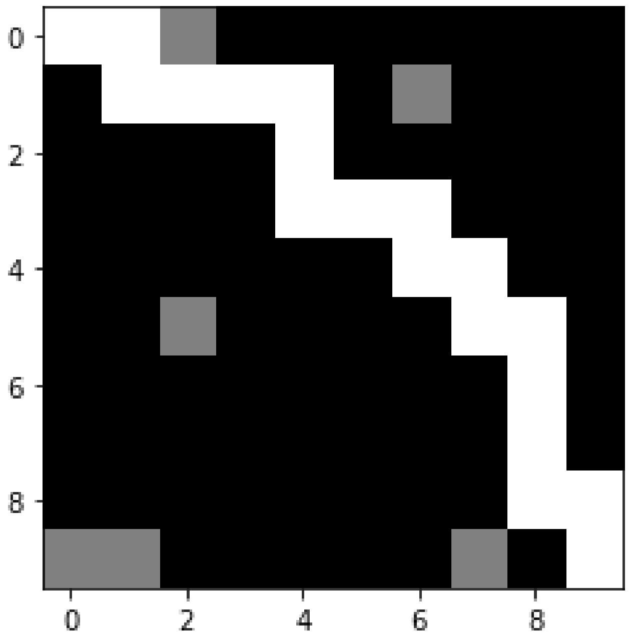
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 25
 Maze Size - [10 , 10]
 Obstacles Count - 10
 End Location - (9, 9)
 Was Solved - True
```



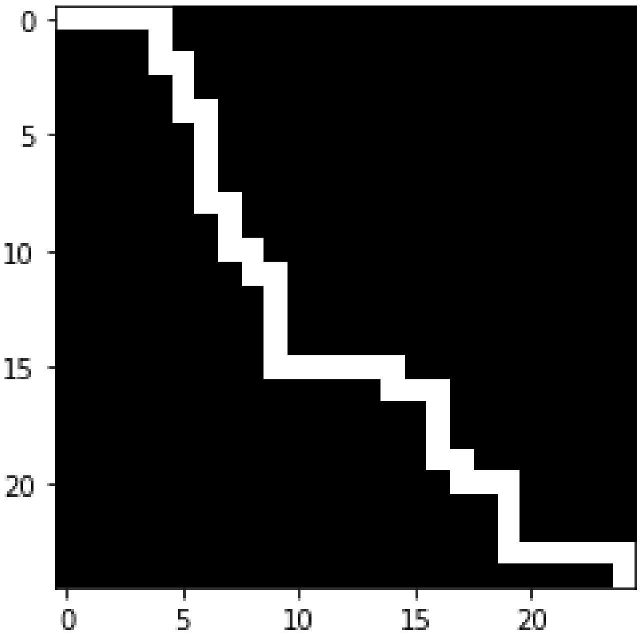
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 50
 Maze Size - [10 , 10]
 Obstacles Count - 10
 End Location - (9, 9)
 Was Solved - True
```



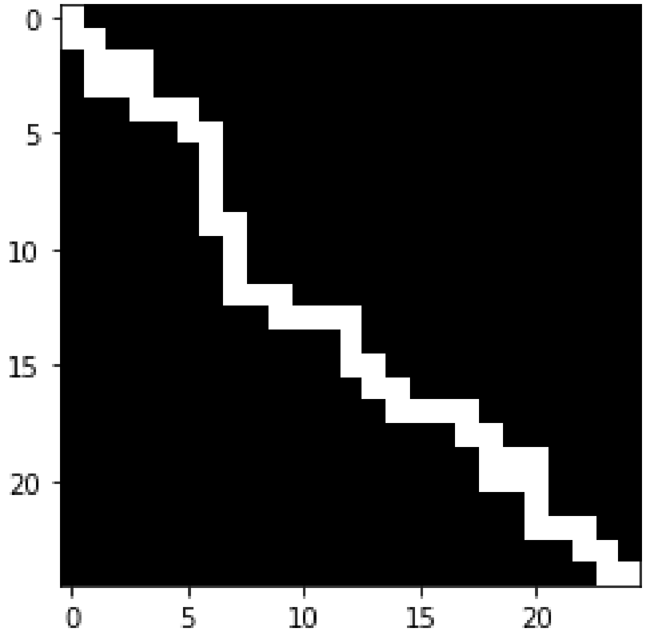
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 100
 Maze Size - [10 , 10]
 Obstacles Count - 10
 End Location - (9, 9)
 Was Solved - True
```



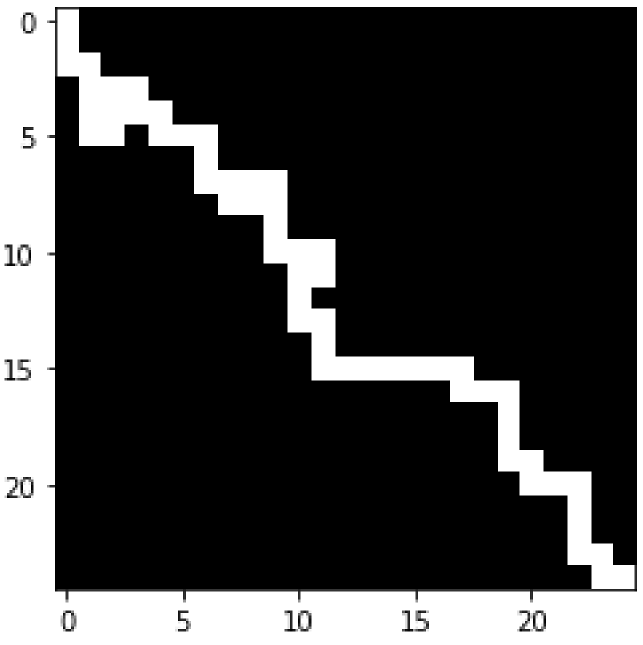
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 25
 Maze Size - [25 , 25]
 Obstacles Count - 0
 End Location - (24, 24)
 Was Solved - True
```



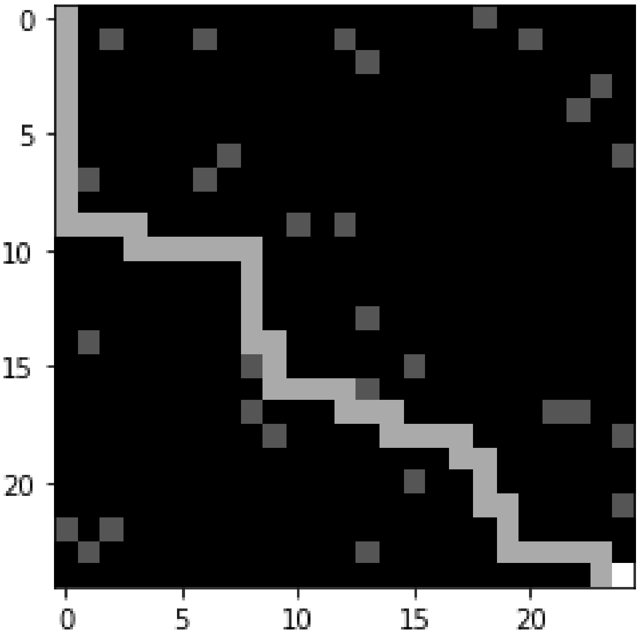
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 50
 Maze Size - [25 , 25]
 Obstacles Count - 0
 End Location - (24, 24)
 Was Solved - True
```



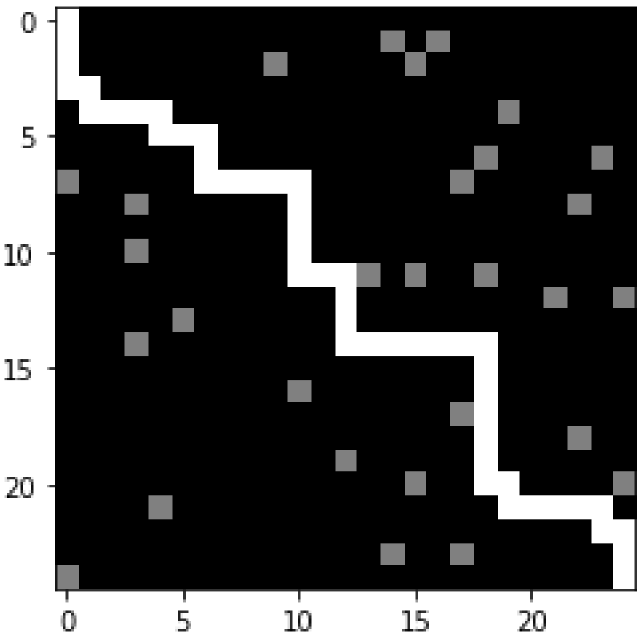
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 100
 Maze Size - [25 , 25]
 Obstacles Count - 0
 End Location - (24, 24)
 Was Solved - True
```



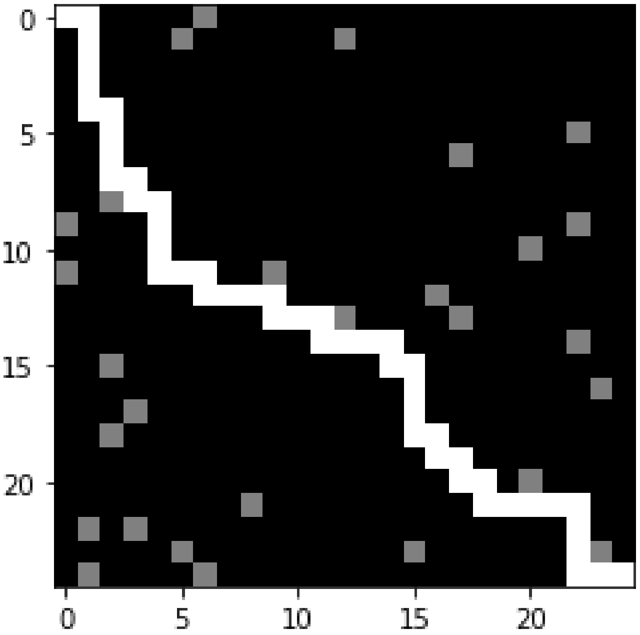
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 25
 Maze Size - [25 , 25]
 Obstacles Count - 31
 End Location - (23, 24)
 Was Solved - False
```



```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 50
 Maze Size - [25 , 25]
 Obstacles Count - 31
 End Location - (24, 24)
 Was Solved - True
```

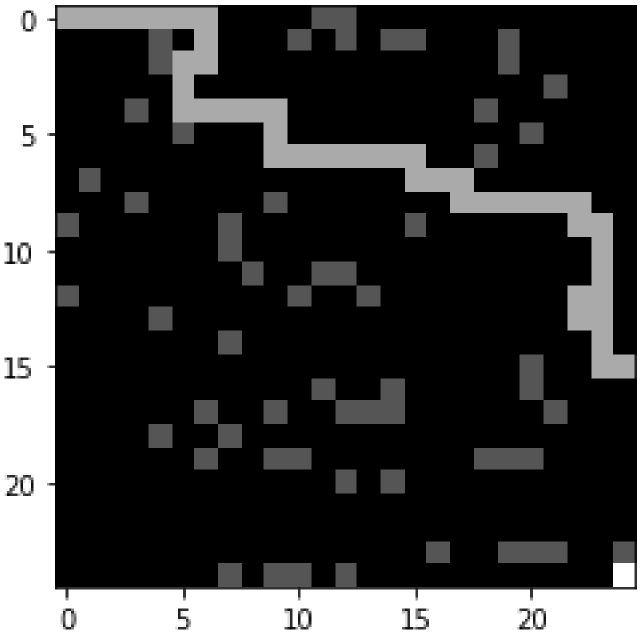


```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 100
 Maze Size - [25 , 25]
 Obstacles Count - 31
 End Location - (24, 24)
 Was Solved - True
```

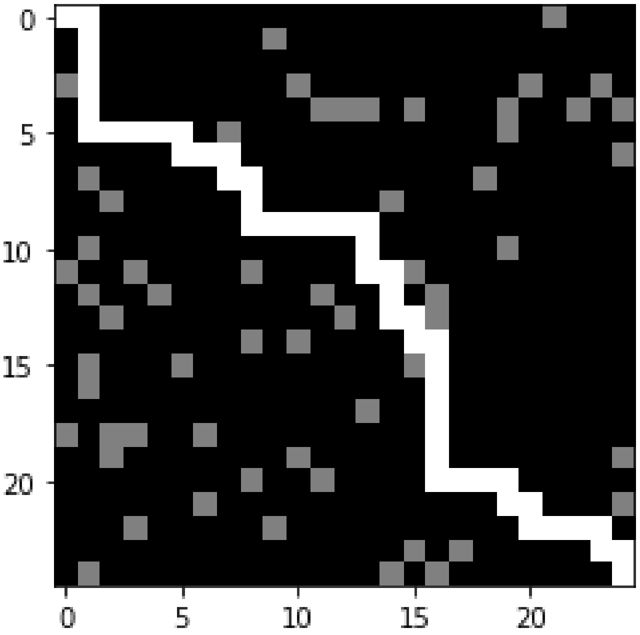


```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 25
```

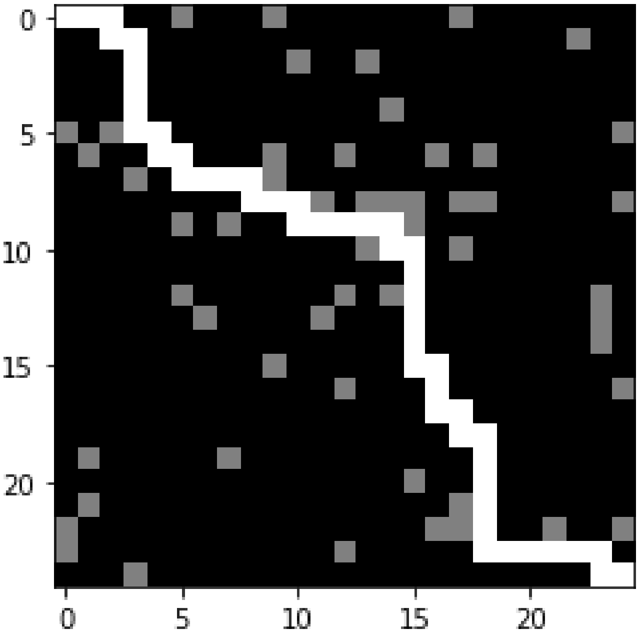
```
Maze Size - [25 , 25]
Obstacles Count - 62
End Location - (24, 15)
Was Solved - False
```



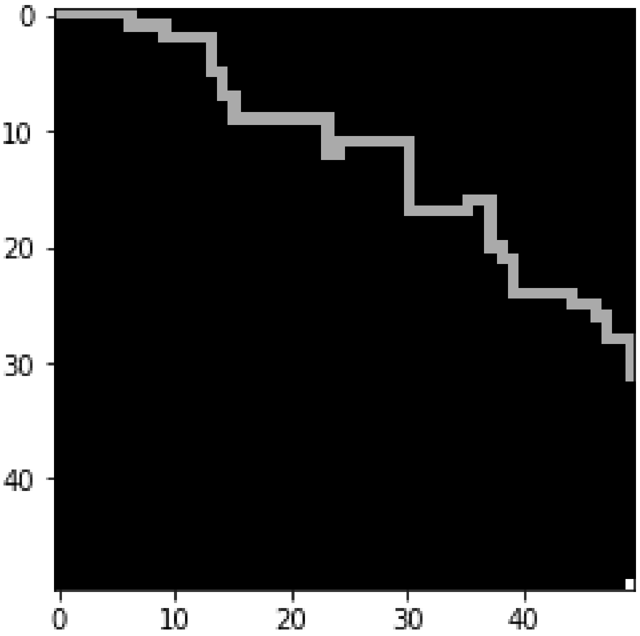
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 50
 Maze Size - [25 , 25]
 Obstacles Count - 62
 End Location - (24, 24)
 Was Solved - True
```



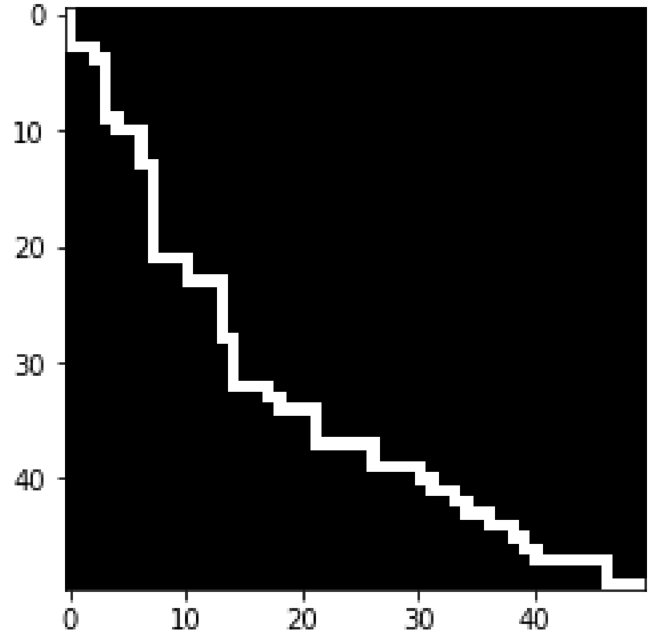
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 100
 Maze Size - [25 , 25]
 Obstacles Count - 62
 End Location - (24, 24)
 Was Solved - True
```



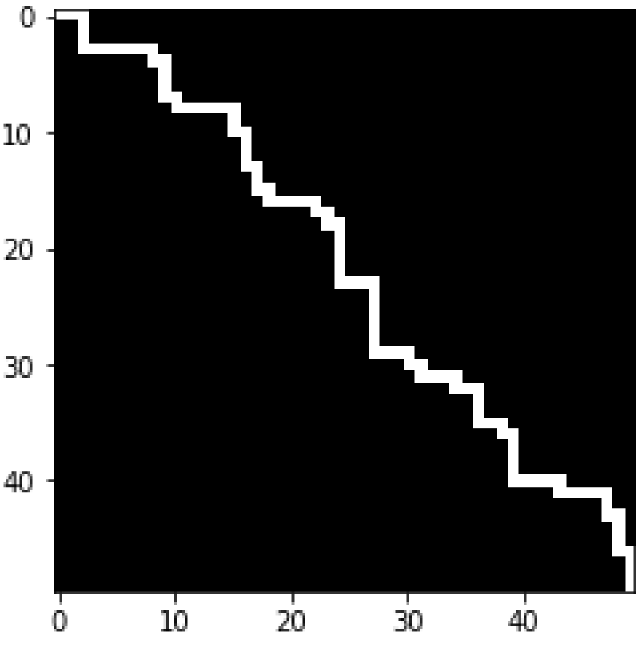
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 25
 Maze Size - [50 , 50]
 Obstacles Count - 0
 End Location - (49, 31)
 Was Solved - False
```



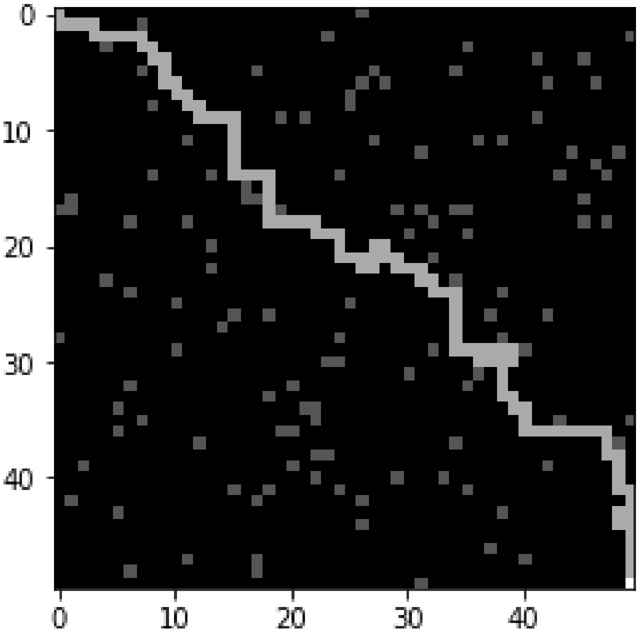
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 50
 Maze Size - [50 , 50]
 Obstacles Count - 0
 End Location - (49, 49)
 Was Solved - True
```



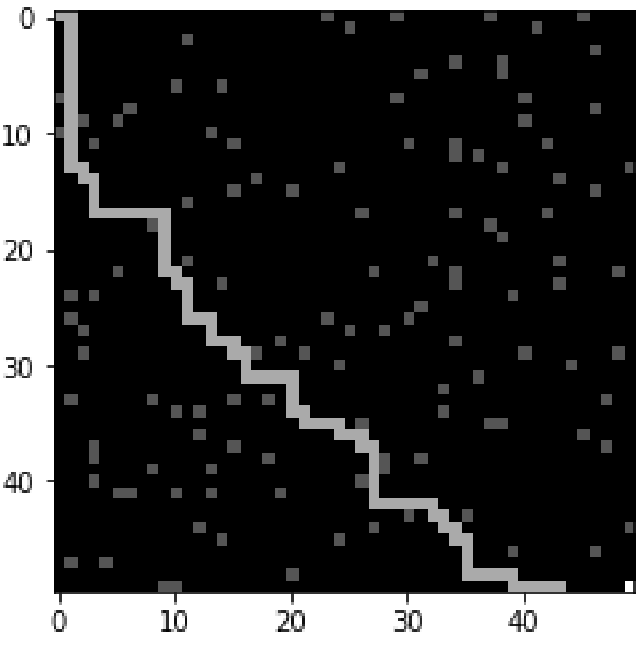
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 100
 Maze Size - [50 , 50]
 Obstacles Count - 0
 End Location - (49, 49)
 Was Solved - True
```



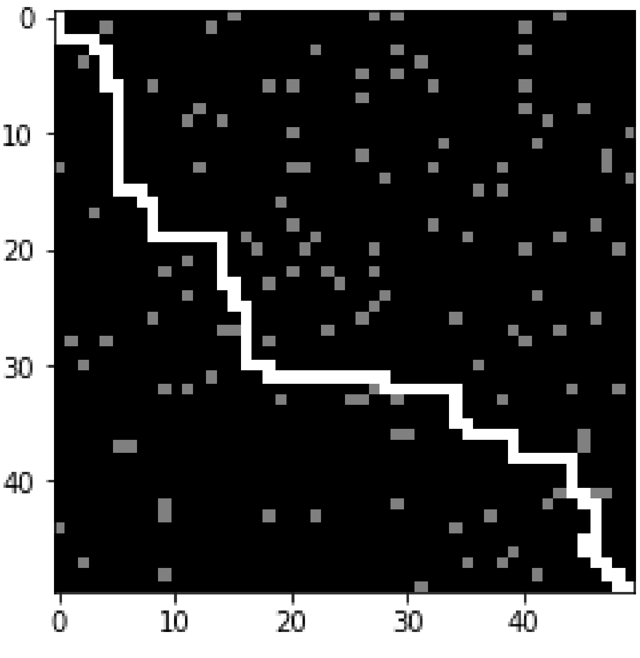
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 25
 Maze Size - [50 , 50]
 Obstacles Count - 125
 End Location - (49, 48)
 Was Solved - False
```



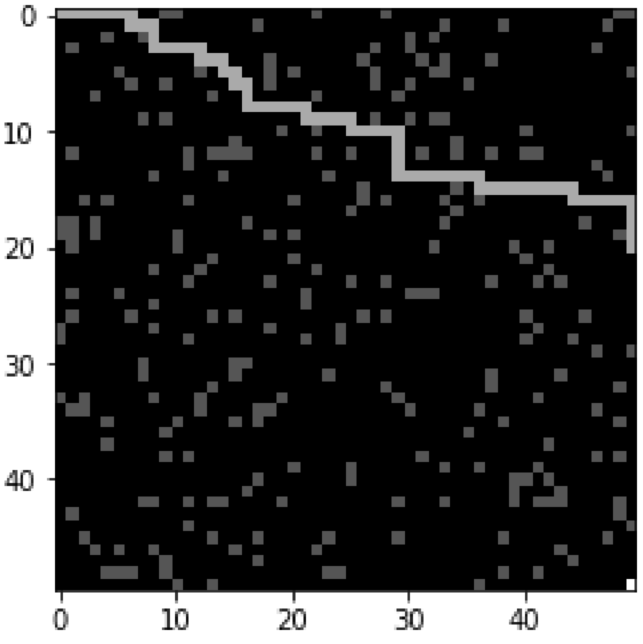
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 50
 Maze Size - [50 , 50]
 Obstacles Count - 125
 End Location - (43, 49)
 Was Solved - False
```



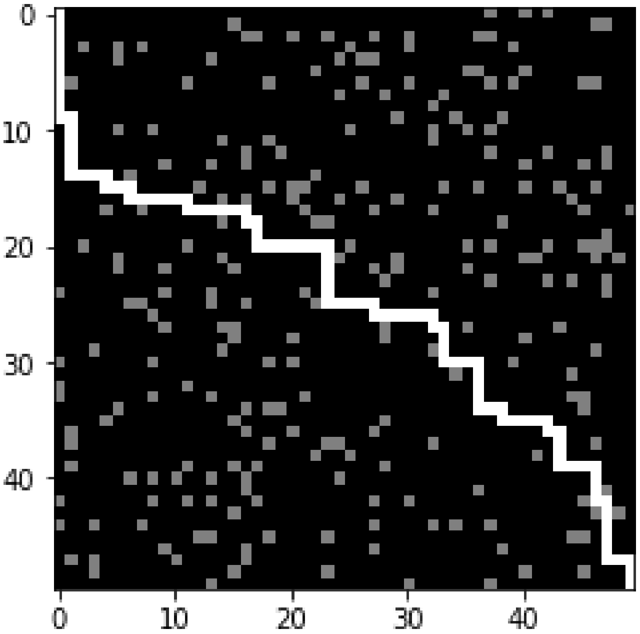
```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 100
 Maze Size - [50 , 50]
 Obstacles Count - 125
 End Location - (49, 49)
 Was Solved - True
```



```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 25
 Maze Size - [50 , 50]
 Obstacles Count - 250
 End Location - (49, 20)
 Was Solved - False
```

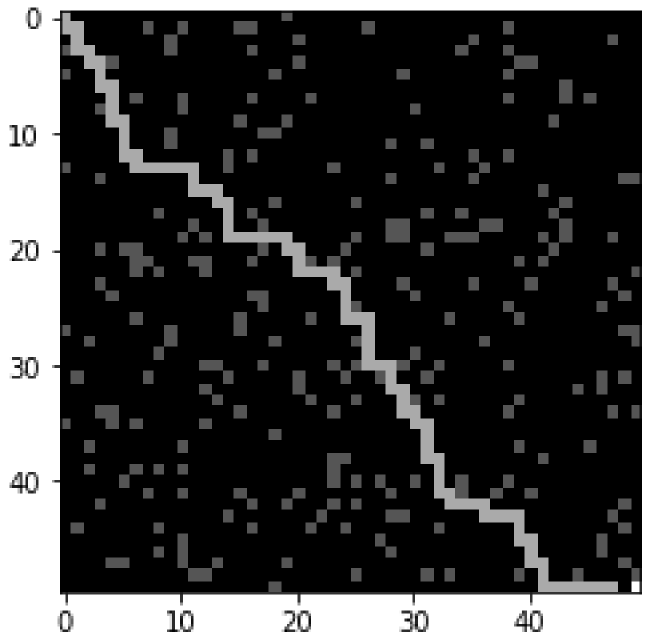


```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 50
 Maze Size - [50 , 50]
 Obstacles Count - 250
 End Location - (49, 49)
 Was Solved - True
```



```
--------------------------------------------------
--------------------------------------------------
 Gen Size - 100
```

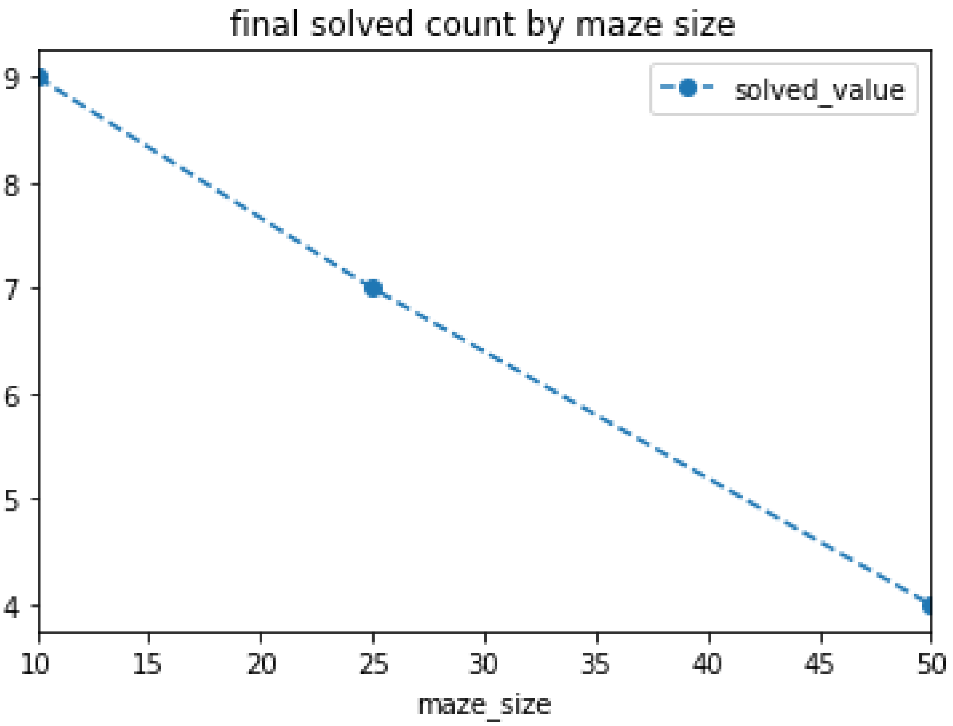
```
Maze Size - [50 , 50]
Obstacles Count - 250
End Location - (47, 49)
Was Solved - False
```



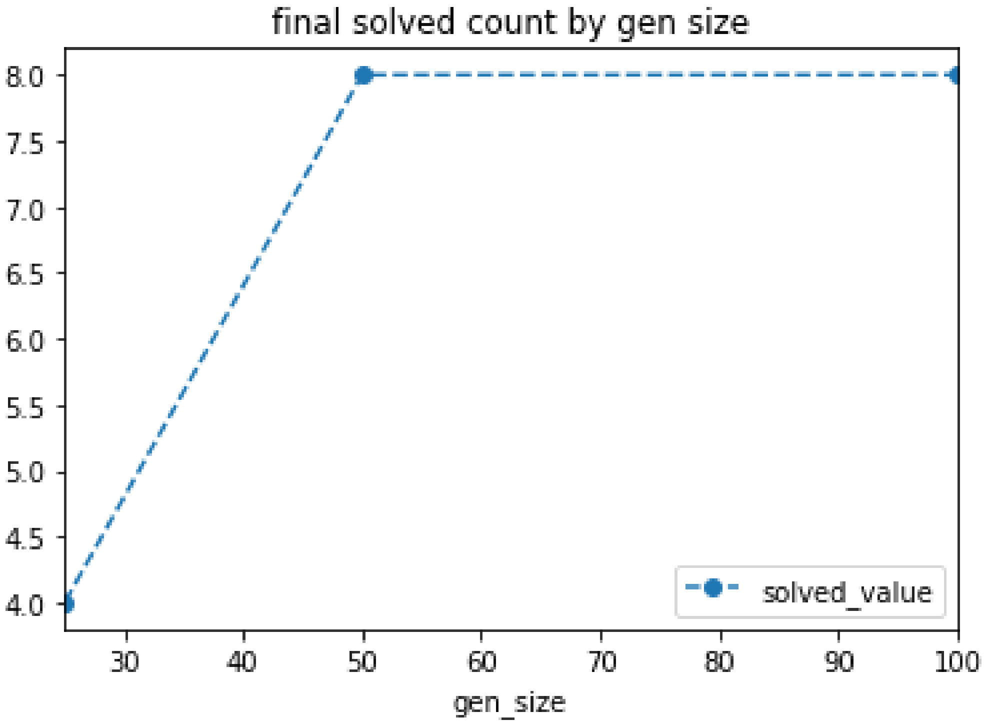
```
In [50]: results_list = list()
         for trial in all_trials:
             tmp = dict()
             tmp['count'] = trial['len']
             tmp['gen_size'] = trial['gen_size']
             tmp['maze_size'] = trial['maze_size']
             tmp['solved_value'] = 1 if trial['valid'] is True else 0
             tmp['solved'] = trial['valid']
             final_x, final_y = trial['best']['locations'][-1]
             tmp['final_dist'] = (trial['maze_size'] - final_x -1) + (trial['maze_s
             tmp['obstacles'] = trial['obstacles']
             results_list.append(tmp)

         results = pd.DataFrame(results_list)
```

Finish Sucessfully Maze Plots

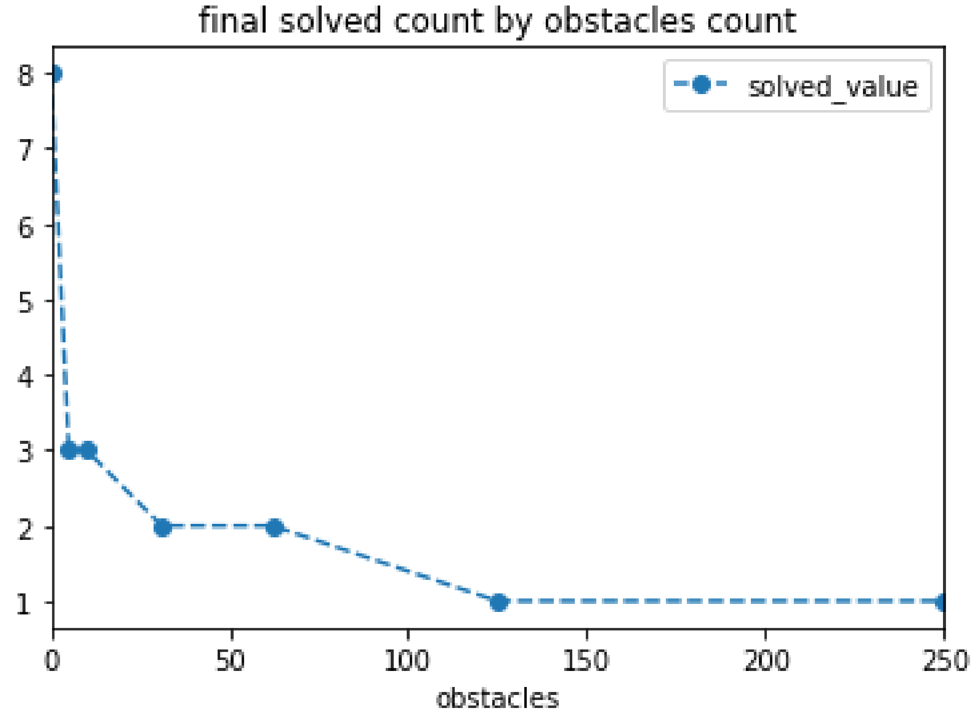
```
In [51]: _ = results[['maze_size','solved_value']].groupby('maze_size').sum().plot
```



```
In [52]: _ = results[['gen_size','solved_value']].groupby('gen_size').sum().plot(st
```

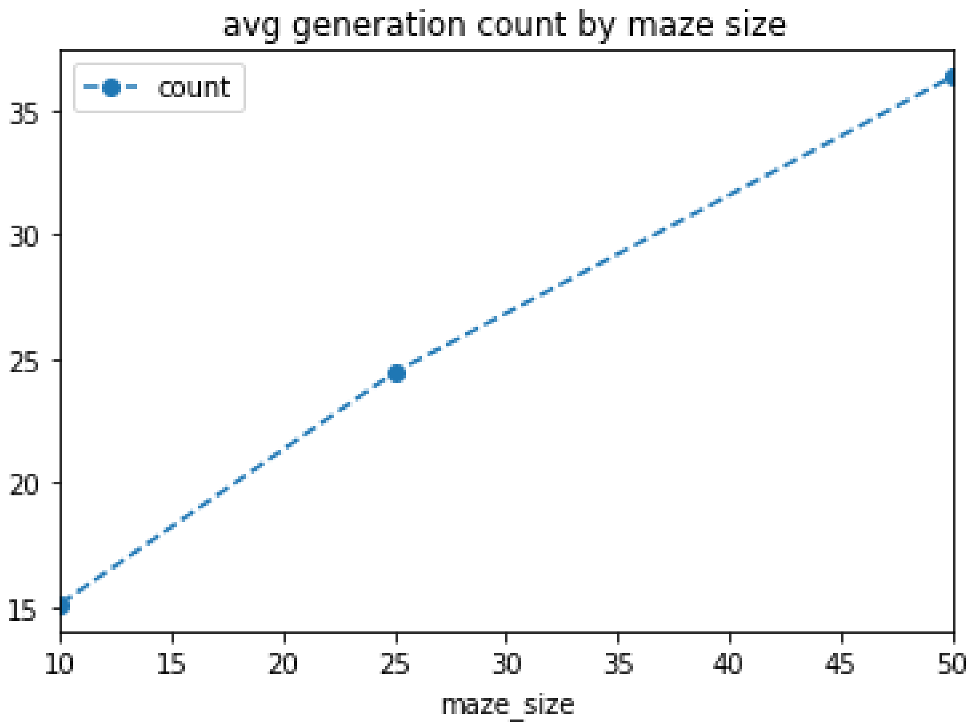


```
In [53]: _ = results[['obstacles','solved_value']].groupby('obstacles').sum().plot
```

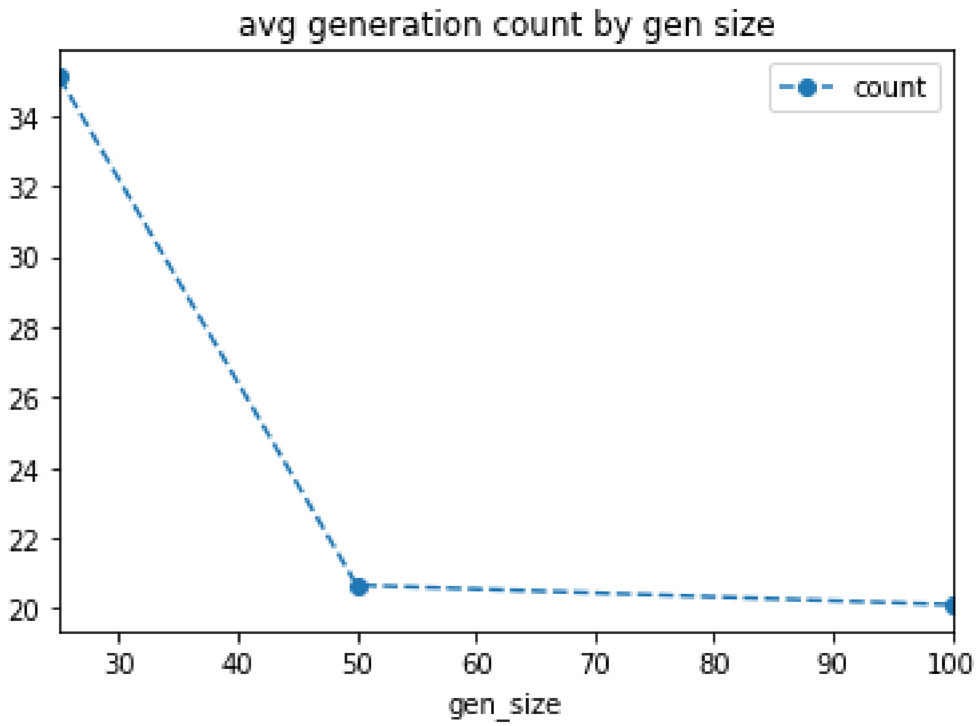


Generation Count (Max Generation == 50) Plots

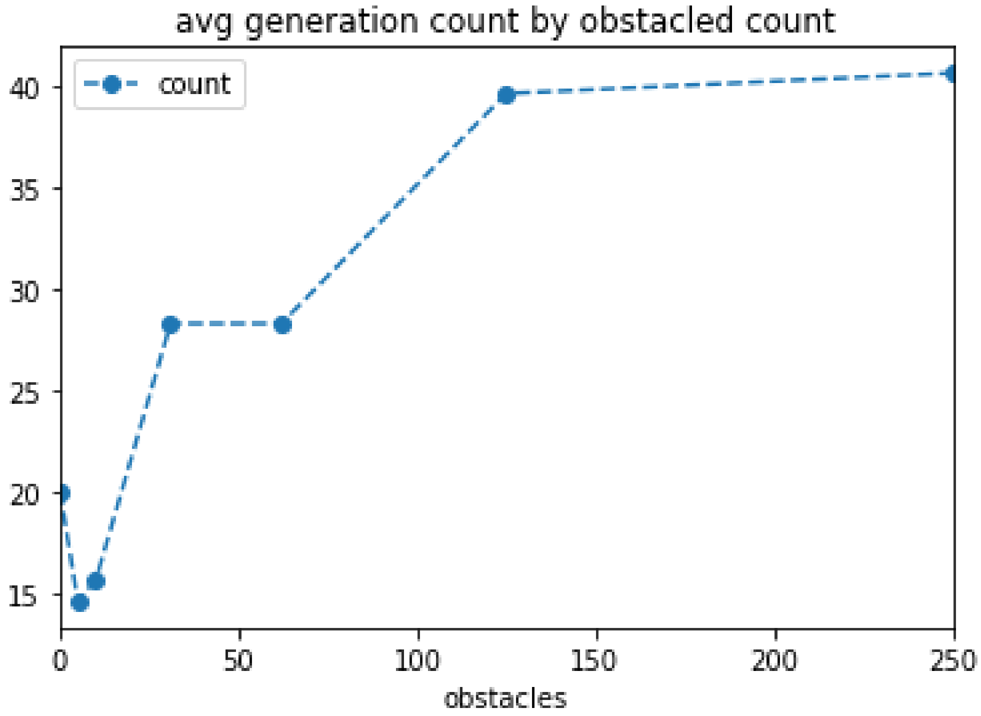
```
In [67]: _ = results[['count','maze_size']].groupby('maze_size').mean().plot(style=
```



```
In [68]: _ = results[['count','gen_size']].groupby('gen_size').mean().plot(style='o
```



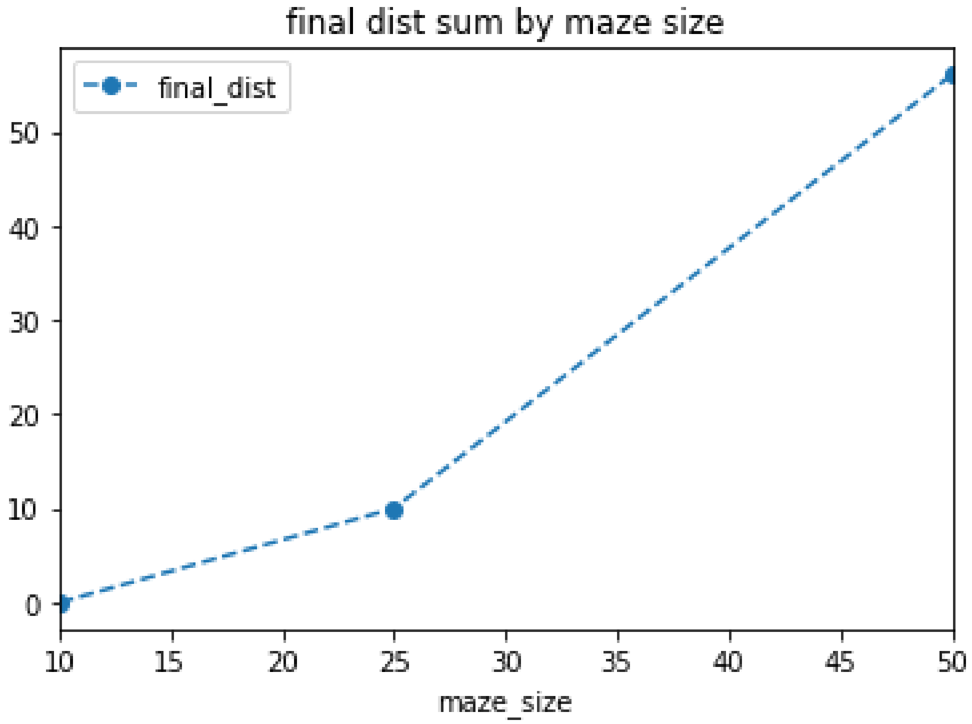
```
In [69]: _ = results[['count','obstacles']].groupby('obstacles').mean().plot(style=
```



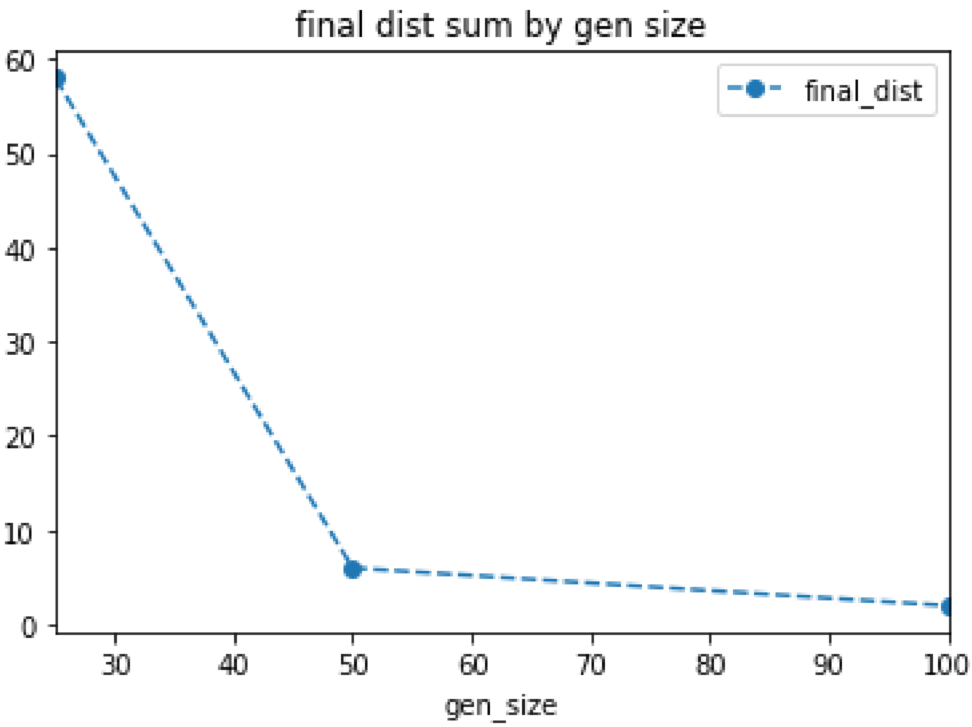
0 is higher and its ok since there are more 0 games than other options

Distance From Finish Points Plots

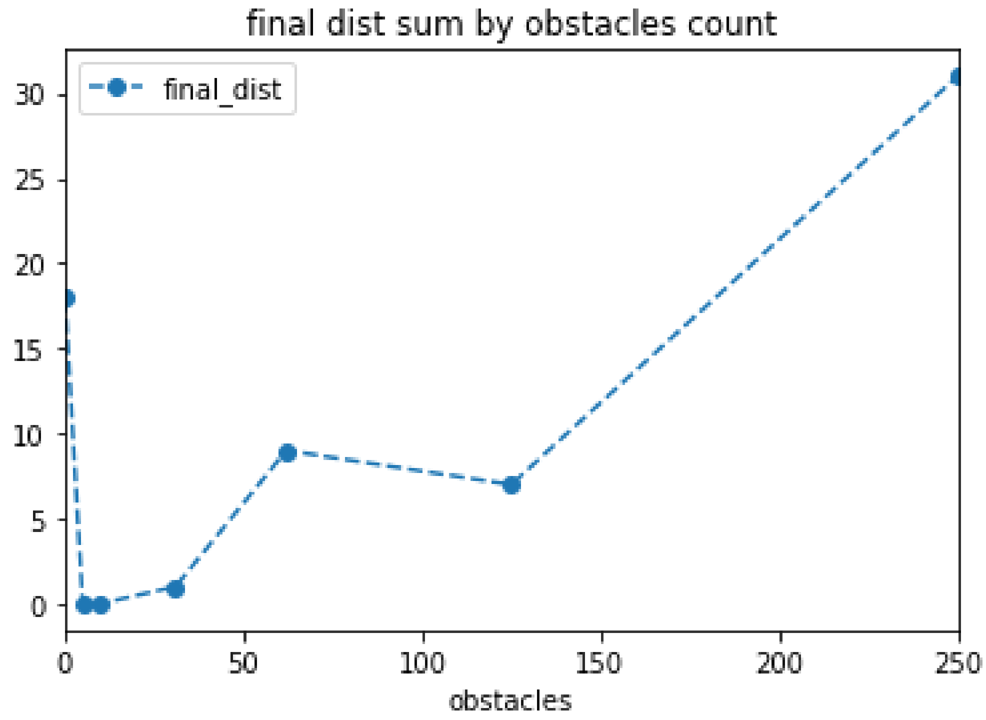
```
In [57]: _ = results[['maze_size','final_dist']].groupby('maze_size').sum().plot(st
```



```
In [59]: _ = results[['gen_size','final_dist']].groupby('gen_size').sum().plot(styl
```



```
In [60]: _ = results[['obstacles','final_dist']].groupby('obstacles').sum().plot(st
```



0 is higher and its ok since there are more 0 games than other options

All Results Printed

```
In [55]: results
```

```
Out[55]:     count  gen_size  maze_size  solved_value  solved  final_dist  obstacle
         0      16        25         10             1    True           0
         1      15        50         10             1    True           0
         2      14       100         10             1    True           0
         3      16        25         10             1    True           0
         4      15        50         10             1    True           0
         5      13       100         10             1    True           0
         6      17        25         10             1    True           0          1
         7      15        50         10             1    True           0          1
         8      15       100         10             1    True           0          1
         9      17        25         25             1    True           0
         10     17        50         25             1    True           0
         11     16       100         25             1    True           0
         12     50        25         25             0   False           1          3
```

```
13     17        50         25             1    True           0         3
14     18       100         25             1    True           0         3
15     50        25         25             0   False           9         6
16     17        50         25             1    True           0         6
17     18       100         25             1    True           0         6
18     50        25         50             0   False          18
19     18        50         50             1    True           0
20     18       100         50             1    True           0
21     50        25         50             0   False           1        12
22     50        50         50             0   False           6        12
23     19       100         50             1    True           0        12
24     50        25         50             0   False          29        25
25     22        50         50             1    True           0        25
26     50       100         50             0   False           2        25
```