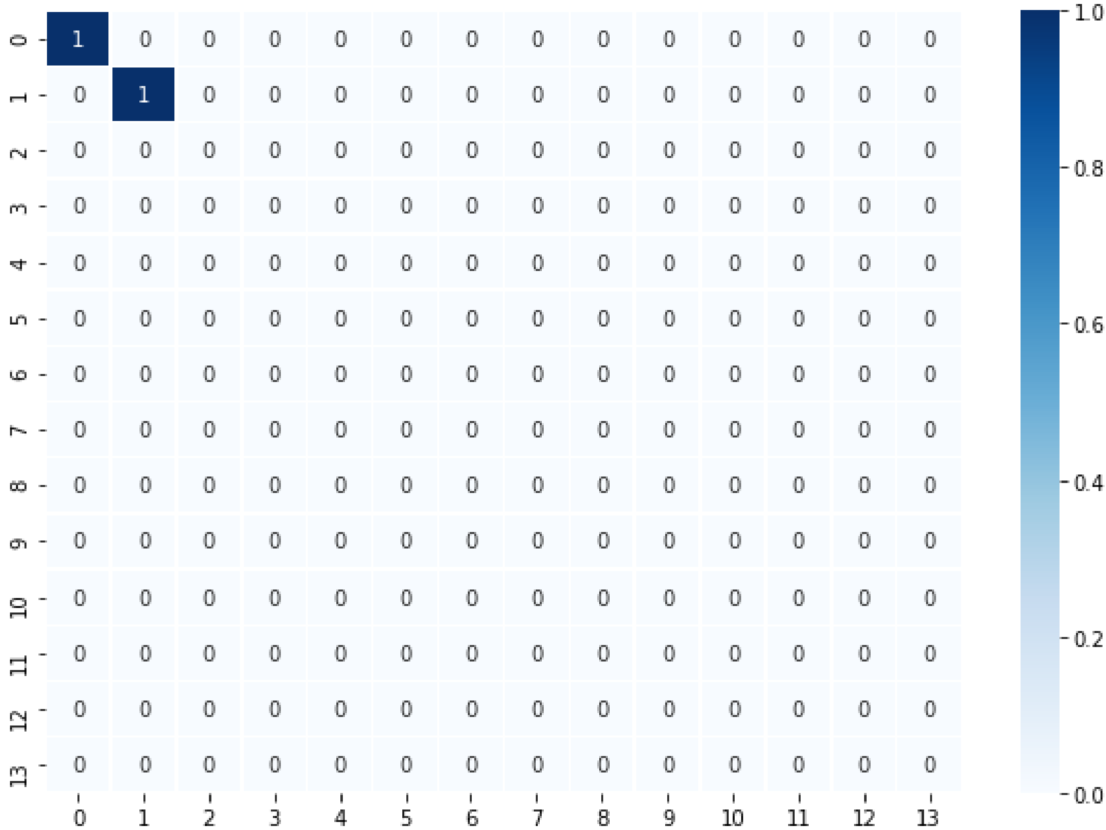
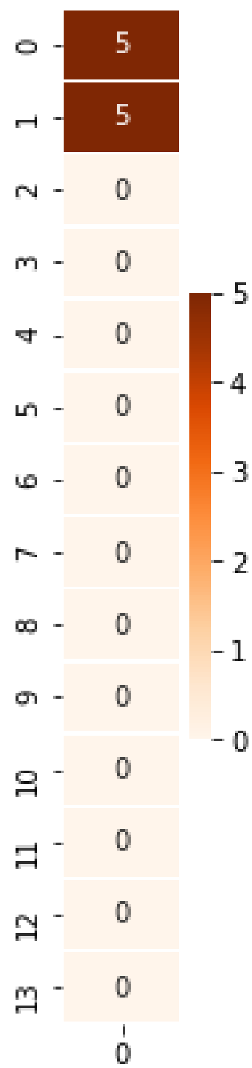
slam

April 16, 2019

```
In [60]: import numpy as np
         from helpers import make_data
         import matplotlib.pyplot as plt
         from pandas import DataFrame
         import seaborn as sns
         from helpers import display_world

         %matplotlib inline

In [61]: def initialize_constraints(N, num_landmarks, world_size):
             ''' This function takes in a number of time steps N, number of landmarks, and a w
                 and returns initialized constraint matrices, omega and xi.'''

             rows = 2*N + 2*num_landmarks
             cols = rows

             omega = np.zeros((rows, cols))
             omega[:2, :2] += np.array([[1, 0],
                                        [0, 1]])

             xi = np.zeros((rows,))
             xi[:2] += world_size/2

             return omega, xi


In [62]: N_test = 5
         num_landmarks_test = 2
         small_world = 10

         # initialize the constraints
         initial_omega, initial_xi = initialize_constraints(N_test, num_landmarks_test, small_w

         plt.rcParams["figure.figsize"] = (10,7)
         sns.heatmap(DataFrame(initial_omega), cmap='Blues', annot=True, linewidths=.5)

Out[62]: <matplotlib.axes._subplots.AxesSubplot at 0x7fa6106dacc0>
```




```
In [63]: plt.rcParams["figure.figsize"] = (1,7)
         sns.heatmap(DataFrame(initial_xi), cmap='Oranges', annot=True, linewidths=.5)

Out[63]: <matplotlib.axes._subplots.AxesSubplot at 0x7fa6103d8080>
```




```
In [5]: def slam(data, N, num_landmarks, world_size, motion_noise, measurement_noise):

            omega, xi = initialize_constraints(N, num_landmarks, world_size)

            for i in range(len(data)):
                measurements = data[i][0]
                motion = data[i][1]

                for ms in measurements:
                    landmark_idx = ms[0]
                    x = ms[1]
                    y = ms[2]
```

```
        # add/substract noise for all X_Pos and X_Landmark values

        # X-L = +?
        # X_pos is found at each 2 cells
        omega[2*i, 2*i] += 1 / measurement_noise
        # X_LandMarks can ben found at 2*Nstep idx, then each 2 cells
        omega[2*i, 2*N + 2*landmark_idx] += -1 / measurement_noise

        # L-X = -?
        # Landmark according to the
        omega[2*N + 2*landmark_idx, 2*i] += -1 / measurement_noise
        # Landmark according to itself
        omega[2*N + 2*landmark_idx, 2*N + 2*landmark_idx] += 1 / measurement_noise

        # update the xi value for the X_Pos & Lx
        xi[2*i] += -x / measurement_noise
        xi[2*N + 2*landmark_idx] += x / measurement_noise


        # SAME THINGS FOR Y_Pos and Ly (just add +1 on indices)

        omega[2*i + 1, 2*i + 1] += 1 / measurement_noise
        omega[2*i + 1, 2*N + 2*landmark_idx + 1] += -1 / measurement_noise
        omega[2*N + 2*landmark_idx + 1, 2*i + 1] += -1 / measurement_noise
        omega[2*N + 2*landmark_idx + 1, 2*N + 2*landmark_idx + 1] += 1 / measuremen

        xi[2*i + 1] += -y / measurement_noise
        xi[2*N + 2*landmark_idx + 1] += y / measurement_noise


    # EXACTE SAME THINGS FOR MOTION : BUT between X and X+2 ; Y and Y+2 which is t
    dx, dy = motion[0], motion[1]
    omega[2*i, 2*i] += 1 / motion_noise
    omega[2*i, 2*i + 2] += -1 / motion_noise
    omega[2*i + 2, 2*i] += -1 / motion_noise
    omega[2*i + 2, 2*i + 2] += 1 / motion_noise

    omega[2*i + 1, 2*i + 1] += 1 / motion_noise
    omega[2*i + 1, 2*i + 3] += -1 / motion_noise
    omega[2*i + 3, 2*i + 1] += -1 / motion_noise
    omega[2*i + 3, 2*i + 3] += 1 / motion_noise

    xi[2*i] += -dx / motion_noise
    xi[2*i + 2] += dx / motion_noise
    xi[2*i + 1] += -dy / motion_noise
    xi[2*i + 3] += dy / motion_noise

mu = np.dot(np.linalg.inv(omega), xi)
```

```
        return mu # return `mu`
```

```
In [34]: def get_poses_landmarks(mu, N):
             """
             This function iterate over the mu matrix N times
             to get the x and y position of the robot.
             Then iterate over the rest of the list to get
             all the Landmarks positions.

             Example:
             For N=20 steps time
             We iterate from 0-19 to get all the positions
             of the robot

             Then From 20 to the rest to get the Landmark positions
             """
             poses = []
             for i in range(N):
                 # get all the (x, y) poses
                 poses.append((mu[2*i].item(), mu[2*i+1].item()))

             landmarks = []
             for i in range(num_landmarks):
                 landmarks.append((mu[2*(N+i)].item(), mu[2*(N+i)+1].item()))

             return poses, landmarks
```

```
In [7]: def print_all(poses, landmarks):
            print('\n')
            print('Estimated Poses:')
            for i in range(len(poses)):
                print('['+', '.join('%.3f'%p for p in poses[i])+']')
            print('\n')
            print('Estimated Landmarks:')
            for i in range(len(landmarks)):
                print('['+', '.join('%.3f'%l for l in landmarks[i])+']')
```

```
In [8]: # World Params
        num_landmarks      = 5        # number of landmarks
        N                  = 20       # time steps
        world_size         = 100.0    # size of world (square)

        # robot parameters
        measurement_range  = 50.0     # range at which we can sense landmarks
        motion_noise       = 2.0      # noise in robot motion
        measurement_noise  = 2.0      # noise in the measurements
        distance           = 20.0     # distance by which robot (intends to) move each iterata
```

```
        data = make_data(N, num_landmarks, world_size, measurement_range, motion_noise, measure
```

```
Landmarks:  [[2, 96], [93, 75], [95, 76], [64, 73], [91, 70]]
Robot: [x=72.60208 y=79.85855]
```

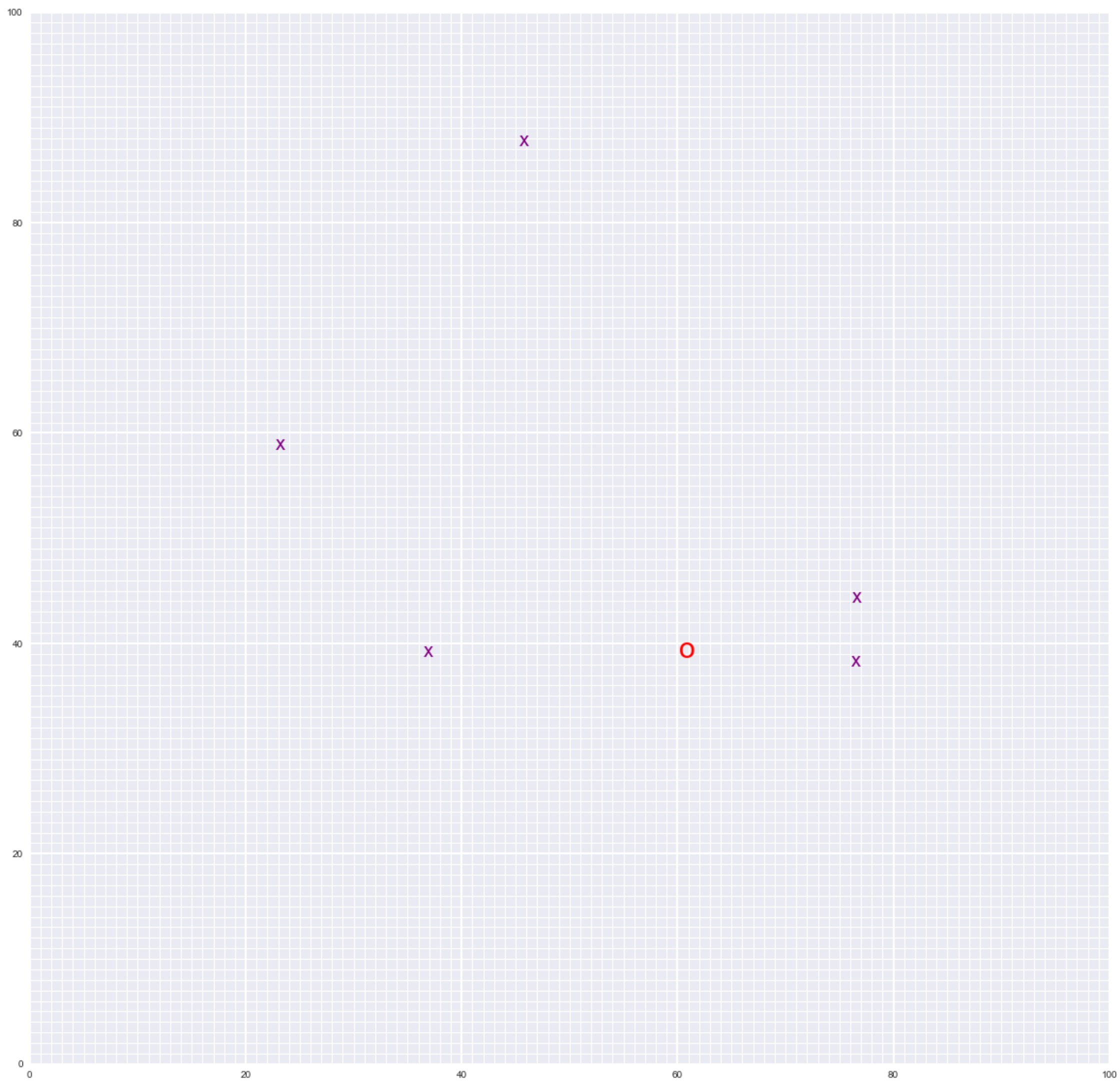
```
In [9]: mu = slam(data, N, num_landmarks, world_size, motion_noise, measurement_noise)

        if(mu is not None):
            poses, landmarks = get_poses_landmarks(mu, N)
            print_all(poses, landmarks)
```

```
Estimated Poses:
[50.000, 50.000]
[62.856, 63.875]
[76.730, 76.953]
[92.421, 90.632]
[73.529, 93.619]
[54.079, 94.239]
[33.393, 95.659]
[11.502, 98.547]
[24.490, 83.945]
[36.807, 67.983]
[50.189, 51.808]
[64.051, 38.349]
[77.329, 24.977]
[90.872, 11.280]
[73.320, 2.089]
[78.671, 22.099]
[84.023, 42.109]
[88.347, 61.041]
[93.908, 81.413]
[73.922, 80.656]


Estimated Landmarks:
[2.269, 96.903]
[93.235, 75.123]
[94.793, 76.790]
[63.883, 73.388]
[90.500, 70.147]
```

```
In [11]: plt.rcParams["figure.figsize"] = (20,20)
```

```
# check if poses has been created
if 'poses' in locals():
    # print out the last pose
    print('Last pose: ', poses[-1])
    # display the last position of the robot *and* the landmark positions
    display_world(int(world_size), poses[-1], landmarks)
```

```
Last pose:  (60.86100011526081, 39.355578252838484)
```



Once We have our matrices, we have to fill both OMEGA AND XI by doing:
`robot_positions = [[x0, y0]]`

MOVE

Say we have a mvt from (xy0) to (xy1) by after 5 rotation wheels   We know xy1 is 5 rotation wheels far from xy0
So We populate OMEGA and Xi
We compute the Mu matrix to get the position xy1
We append the position xy1 in our array
`robot_positions = [ [x0, y0], [x1, y1] ]`

THEN WE SENSE FROM x1y1 Position
We detect a landmark 8m away
We populate OMEGA and Xi

THEN WE MOVE
And so one