

In [2]:

In [4]: `from IPython.display import Image`Type *Markdown* and LaTeX: α^2

In [11]:

```
print('TASK 1 A')
Image("C:/Users/daria\Desktop\perseption\Problem_Set_3\PS3\photos\Task_1_A_res.png", width=320, height=240)
```

TASK 1 A

Out[11]:

```
(base) PS C:\Users\daria\Desktop\perseption\Problem_Set_3\PS3> python run.py -s -f sam -n 1
Task 1A
Status of graph: Nodes = 1, Factors = 1, Eigen Factors = 0
Printing NodePose2d: 0, state =
180
50
0
Printing Factor: 0, obs=
180
50
0
Residuals=
1.37962e-306
8.01898e-307
1.24612e-306
and Information matrix
1e+12    0    -0
    0 1e+12    -0
    0    0 1e+12
Calculated Jacobian =
0 0 0
0 0 0
0 0 0
Chi2 error = 0 and neighbour Nodes 1
```

In [24]:

```
print('Code 1A')
Image("C:/Users/daria\Desktop\perseption\Problem_Set_3\PS3\photos\code_1A.png", width=320, height=240)
```

Code 1A

Out[24]:

```
self.graph = mrob.F6graph()
#added part
print('Task 1A')

self.mu = initial_state.mu
self.sigma = initial_state.Sigma
self.sigma = inv(self.sigma)
self.pose = self.graph.add_node_pose_2d(self.mu)
self.graph.add_factor_1pose_2d(self.mu, *args: self.pose, self.sigma)
self.chi2 = []
self.graph.print(True)

self.landmarks = {}
self.landmarks_node = []
self.skip = []
self.estimate = {}
```

Type *Markdown* and LaTeX: α^2

In [12]:

```
print('TASK 1 B')
Image("C:/Users/daria/Desktop/perseption/Problem_Set_3/PS3/photos/Task_1_B_res.png", width=320, height=240)
```

TASK 1 B

Out[12]:

```
Task1B
estimated-state_1 [array([[180.],
 [ 50.],
 [ 0.]])]
estimated-state_2 [array([[180.],
 [ 50.],
 [ 0.]])], array([[190.],
 [ 50.],
 [ 0.]])]
```

In [23]:

```
print('Code 1 B')
Image("C:/Users/daria/Desktop/perseption/Problem_Set_3/PS3/photos/code_1B.png", width=320, height=240)
```

Code 1 B

Out[23]:

```
def predict(self, u):
    print('Task1B')
    print('estimated-state_1', self.graph.get_estimated_state())
    self.pose_for_jac = self.graph.get_estimated_state()[self.pose].T[0]
    J = state_jacobian(self.pose_for_jac, u)[1]

    new_node = self.graph.add_node_pose_2d(np.zeros(3))

    W_u = J @ get_motion_noise_covariance(u, self.alphas) @ J.T

    self.graph.add_factor_2poses_2d_odom(u, *args: self.pose, new_node, inv(W_u))
    self.pose = new_node
    print('estimated-state_2', self.graph.get_estimated_state())
```

TASK 1 C

```
In [13]: Image("C:/Users\doria\Desktop\perseption\Problem_Set_3\PS3\photos/task1_c_1.png", width=320, height=240)
```

```
Out[13]: Node: 0,Pos: [[180.]
[ 50.]
[ 0.]]
Node: 1,Pos: [[190.]
[ 50.]
[ 0.]]
Node: 4,Pos: [[200.]
[ 50.]
[ 0.]]
Node: 5,Pos: [[210.]
[ 50.]
[ 0.]]
Node: 6,Pos: [[220.]
[ 50.]
[ 0.]]
Node: 7,Pos: [[230.]
[ 50.]
[ 0.]]
Node: 8,Pos: [[240.]
[ 50.]
[ 0.]]
Node: 9,Pos: [[250.]
[ 50.]
[ 0.]]
Node: 11,Pos: [[260.]
[ 50.]
[ 0.]]
Node: 12,Pos: [[270.]
[ 50.]
[ 0.]]
Node: 13,Pos: [[280.]
[ 50.]
[ 0.]]
Node: 14,Pos: [[290.]
[ 50.]
[ 0.]]
Node: 15,Pos: [[300.]
[ 50.]
[ 0.]]
```

```
In [14]: Image("C:/Users\doria\Desktop\perseption\Problem_Set_3\PS3\photos/task_1_c_2.png", width=320, height=240)
```

```
Out[14]:
[ 0.]
Node: 21,Pos: [[360.]
[ 50.]
[ 0.]
Node: 22,Pos: [[370.]
[ 50.]
[ 0.]
Node: 23,Pos: [[377.07106781]
[ 57.07106781]
[ 1.57079633]]
landmark: 2,estimate state: [451.38980879 53.17247622]
landmark: 3,estimate state: [313.85269195 -1.30058974]
landmark: 10,estimate state: [503.33671309 239.9212871 ]
landmark: 24,estimate state: [341.16221714 273.26841633]
landmark: 25,estimate state: [286.21695984 332.61824792]
inform martix [[ 1.00000000e-02 -0.00000000e+00]
[ 0.00000000e+00 3.28280635e+01]]
```

```
In [22]: print('code 1C')
Image("C:/Users\doria\Desktop\perseption\Problem_Set_3\PS3\photos/code_1C.png", width=320, height=240)
```

code 1C

```
Out[22]:
def update(self, z, Q):
    print('basic')
    print('estimated state:', self.graph.get_estimated_state())
    W_z = Q
    for z_i in z:
        if z_i[-1] in self.landmarks.keys():
            initializeLandmark = False
            self.graph.add_factor_pose_landmark_2d(z_i[-1], 'pose' self.pose, self.landmarks[z_i[-1]],
            inv(W_z), initializeLandmark=initializeLandmark)
            # print(self.graph.get_estimated_state())

        else:
            initializeLandmark = True
            land_mark = self.graph.add_node_landmark_2d(np.zeros(2))
            self.landmarks[z_i[-1]] = land_mark
            self.graph.add_factor_pose_landmark_2d(z_i[-1], 'pose' self.pose, self.landmarks[z_i[-1]],
            inv(W_z), initializeLandmark=initializeLandmark)

        self.landmarks.node.append(
            f'landmarks: {self.landmarks[z_i[-1]]}, estimate state: {self.graph.get_estimated_state()[self.landmarks[z_i[-1]]][0:]})'
        self.state.append(self.landmarks[z_i[-1]])
        # print(
            # f'Node: {self.landmarks.get(z_i[-1])}, Pos: {self.graph.get_estimated_state()[self.landmarks.get(z_i[-1])][0:]})'
        )
        # print(self.landmarks.get(z_i[-1]), self.graph.get_estimated_state())

    for i in range(len(self.graph.get_estimated_state())):
        if i not in (self.state):
            print(f'Node: {i} Pos: {self.graph.get_estimated_state()[i]}')
            #
    print('\n'.join(self.landmarks_node))
    #
    print('inform martix', inv(W_z))
```

New function gives to us more information. Gauss-Newton add more details about estimation and poses of our robot

TASK 1 D-

```
In [20]: Image("C:/Users\daria\Desktop\perseption\Problem_Set_3\PS3\photos/Task_1_D.png", width=320, height=240)
```

```
Out[20]: TaskD
Node: 0, Pos: [[1.80000000e+02]
 [5.00000000e+01]
 [1.18460566e-13]]
Node: 1, Pos: [[1.90000000e+02]
 [5.00001185e+01]
 [2.36921134e-05]]
Node: 2, Pos: [[467.20476224]
 [ 0.88213239]]
Node: 3, Pos: [[317.49146288]
 [ 7.73966435]]
Node: 4, Pos: [[2.00045301e+02]
 [5.00186572e+01]
 [3.62517477e-03]]
Node: 5, Pos: [[2.10054954e+02]
 [5.00671383e+01]
 [5.97725355e-03]]
Node: 6, Pos: [[2.20033540e+02]
 [5.01331359e+01]
 [7.16992733e-03]]
Node: 7, Pos: [[2.30048079e+02]
 [5.02048981e+01]
 [7.16144571e-03]]
Node: 8, Pos: [[2.40049923e+02]
 [5.02713796e+01]
 [6.11955049e-03]]
Node: 9, Pos: [[2.50064066e+02]
 [5.03258702e+01]
 [4.78200064e-03]]
Node: 10, Pos: [[2.60165377e+02]
 [5.03802453e+01]
 [6.06344313e-03]]
Node: 11, Pos: [[2.70208281e+02]
```

```
In [21]: print('Code 1D')
Image("C:/Users/daria\Desktop\perseption\Problem_Set_3\PS3\photos/code_1D.png", width=320, height=240)
```

Code 1D

```
Out[21]:
92         #
93         sam.solve(mrob.GN)
94         #
95         #manual
96         sam.undoofx(n)
97         main() > with movie_writer.saving(fig, a... for t in tqdm(range(data.num_st...
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```
In [18]: print('Code task 1E-F')
Image("C:/Users\daria\Desktop\perseption\Problem_Set_3\PS3\photos/code_1_EF.png", width=320, height=240)
```

Code task 1E-F

```
Out[18]: #manual
sam.update(z, Q)

state_1 = []
state_2 = []
st = sam.graph.get_estimated_state()

for s in st:
    flat = list(s.flatten())
    state_1 = state_1 + flat
state_1 = np.array(state_1)

sam.solve(mrob.GN)

st = sam.graph.get_estimated_state()

for s in st:
    flat = list(s.flatten())
    state_2 = state_2 + flat
state_2 = np.array(state_2)

A = sam.graph.get_adjacency_matrix()
W = sam.graph.get_W_matrix()
I = sam.graph.get_information_matrix()

inf_matrix = A.todense().T @ W.todense() @ A.todense()
norm_inf_m = norm(I - inf_matrix)

b = sam.graph.get_vector_b()

d_x = inv(inf_matrix) @ b
norm_d_x = norm(d_x - (state_1 - state_2))

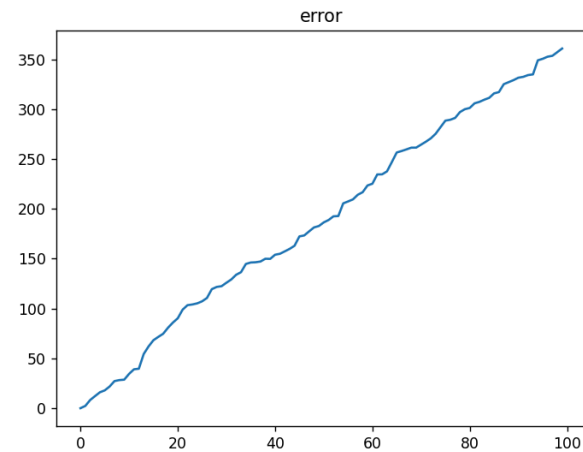
print('manual information matrix', norm_inf_m)
print('diff between manual and auto', norm_d_x)
```

TASK2


```
In [26]: print('TASK 2A')  
Image("C:/Users/daria\Desktop\perseption\Problem_Set_3\PS3\photos/error.png", width=320, height=240)
```

TASK 2A

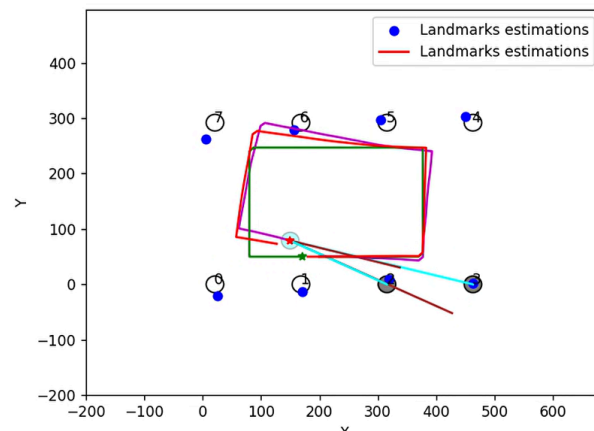
Out[26]:



```
In [28]: print('TASK 2B')  
Image("C:/Users/daria\Desktop\perseption\Problem_Set_3\PS3\photos/task2b.png", width=320, height=240)
```

TASK 2B

Out[28]:



```
In [27]: print('Code 2B')
Image("C:/Users/daria\Desktop\perseption\Problem_Set_3\PS3\photos/code2b.png", width=320, height=240)
```

Code 2B

Out[27]:

```
# TODO plot SLAM solution

pos_rob = []
pos_mark = []
new_pose = sam.graph.get_estimated_state()
for im in sam.landmarks.values():
    pos_rob.append(sam.graph.get_estimated_state()[im].T[0])
    new_pose[im] = '0'
pos_rob = np.array(pos_rob)

for i in range(len(sam.graph.get_estimated_state())):
    if new_pose[i] != '0':
        pos_mark.append(new_pose[i])
pos_mark = np.array(pos_mark)

plt.scatter(pos_rob[:, 0], pos_rob[:, 1], c='b', label='Landmarks estimations')

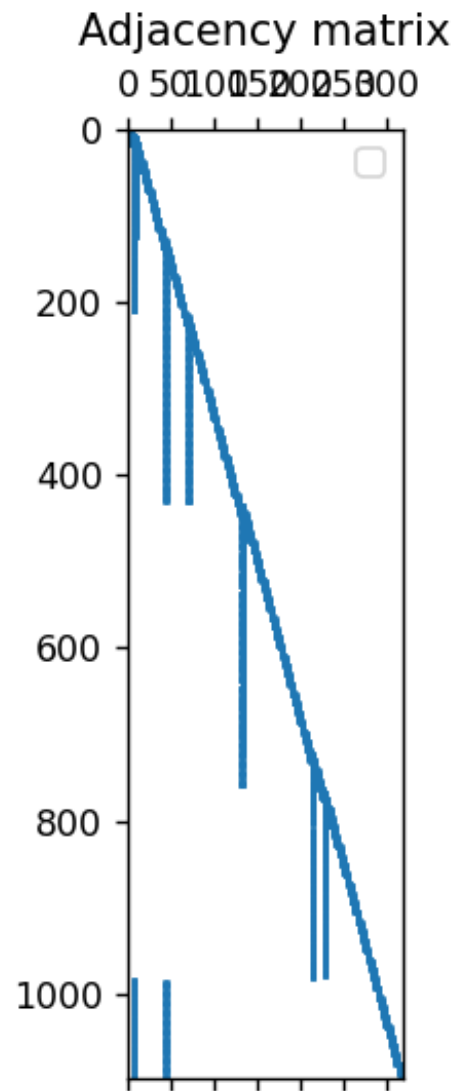
plt.plot(*args, pos_mark[:, 0], pos_mark[:, 1], c = 'r', label='Landmarks estimations')

if should_show_plots:
    Draw all the plots and pause to create an animation effect.
    plt.plot(*args, pos_rob_x, pos_rob_y, 'r', label='Robot Estimated States')
    plt.plot(*args, pos_mark_x, pos_mark_y, 'bo', label='Landmarks estimations')
    plt.legend(loc='upper right')
    plt.draw()
    plt.pause(args.plot_pause_len)
```

```
In [30]: print('TASK 2C')  
Image("C:/Users/daria/Desktop/perseption/Problem_Set_3/PS3/photos/matrix_1.png", width=320, height=240)
```

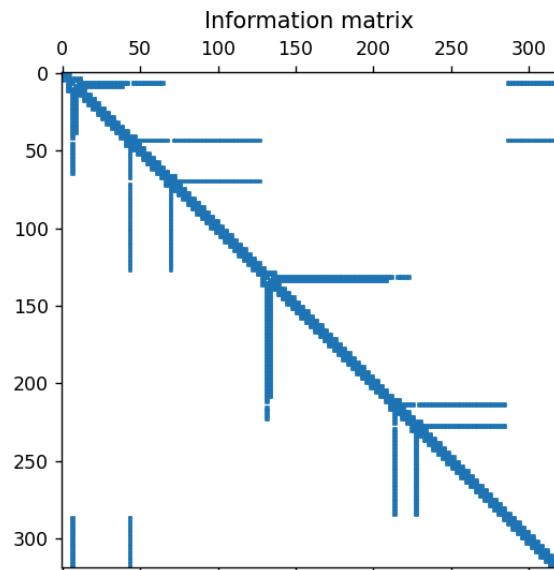
TASK 2C

Out[30]:



In [31]: `Image("C:/Users\doria\Desktop\perseption\Problem_Set_3\PS3\photos/matrix_2.png", width=320, height=240)`

Out[31]:



In [32]: `print('Code 2C')`
`Image("C:/Users\doria\Desktop\perseption\Problem_Set_3\PS3\photos/code2c.png", width=320, height=240)`

Code 2C

Out[32]:

```
plt.title("Adjacency matrix")
plt.spy(sam.graph.get_adjacency_matrix())
plt.show(True)

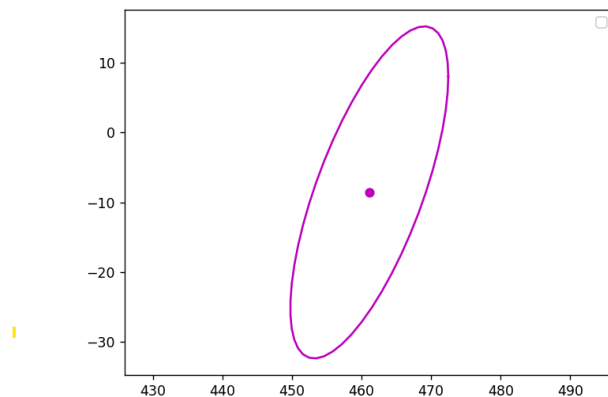
plt.title("Information matrix")
plt.spy(sam.graph.get_information_matrix())
plt.show(True)
```

We can see relationships between states and factors. We can see that information matrix has more relations

```
In [33]: print('TASK 2D')
Image("C:/Users/daria\Desktop\perseption\Problem_Set_3\PS3\photos/iso.png", width=320, height=240)
```

TASK 2D

Out[33]:



```
In [35]: print('Code 2D')
Image("C:/Users/daria\Desktop\perseption\Problem_Set_3\PS3\photos/code2d.png", width=320, height=240)
```

Code 2D

Out[35]:

```
200
plot2cov(csm_graph.get_estimated_state(0-1),T(0, -1), scipy.sparse.linalg.csr_matrix(csm_graph.get_information_matrix(0-1, -1, -1).todense(), 'e', 3))
plt.axis('equal')
plt.show(block=True)
```

```
In [37]: print('TASK 2E')
Image("C:/Users/daria\Desktop\perseption\Problem_Set_3\PS3\photos/task2e.png", width=320, height=240)
```

TASK 2E

Out[37]:

```
Graph Solution: GN: i:3, chi2: 19.651626371764653
```

```
In [36]: print('Code 2E')
Image("C:/Users\daria\Desktop\perseption\Problem_Set_3\PS3\photos/code2e.png", width=320, height=240)
```

Code 2E

```
Out[36]:
for i in range(10):
    n = i + 1
    sam.solve(mrob.LM)
    print(f"Graph Solution: GN: i:{n}, chi2: {sam.graph.chi2()}")
    sam.solve(mrob.LM)
__name__ == '__main__':
    main()
```

In []: