Mobile Robot Short project support

Use this preliminary code as the basis to develop the comming Short Project

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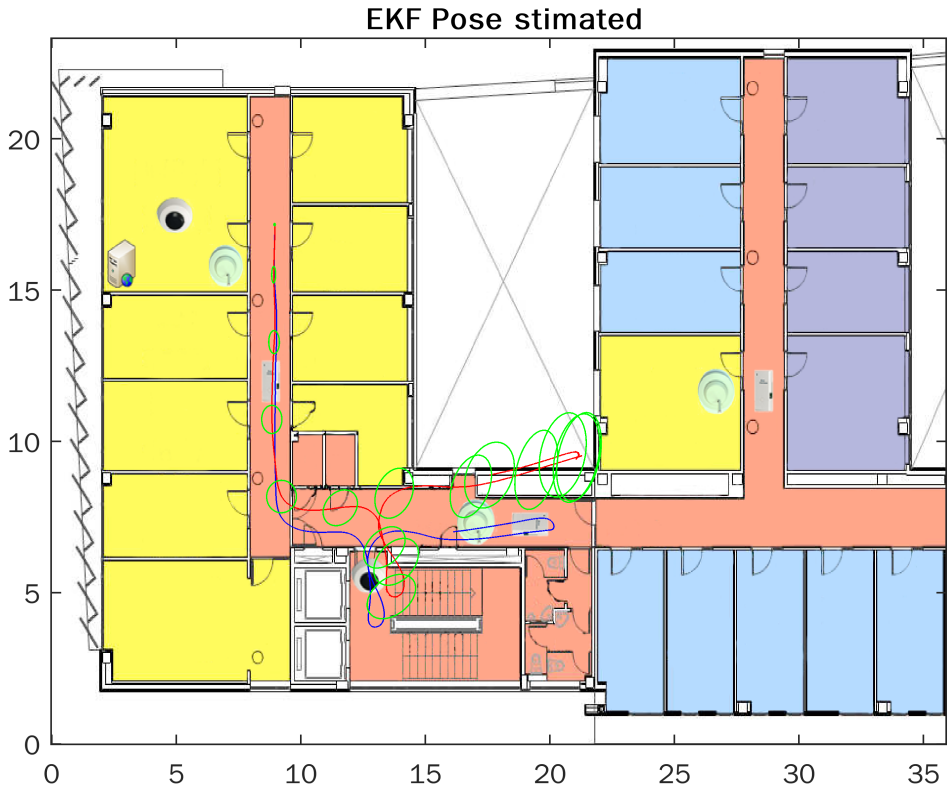
Pose stimation code

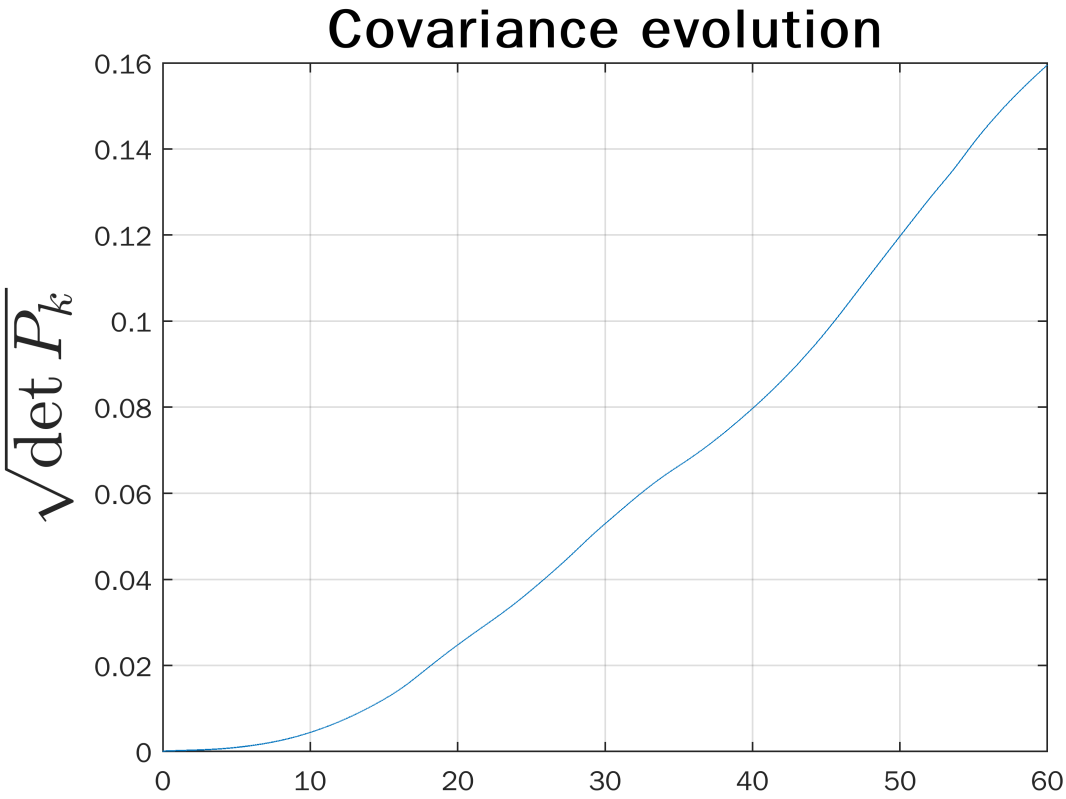
Open: EKF_Pose_estimation.slx model.

See: Where2Find_Code.pdf file to learn how to acces to Pose_ estimation code and plotting results.

```
clear
close all
clf
sim("EKF_Pose_estimation_1.slx" )
```

```
ProcNoiseTheta = 9.0000e-06
Ts = 0.0200
```





Plotting the enviroment and estimated trajectory

Attention "Do not change proces noise" in the Simulink model: EKF_Pose_estimation_1.slx.

Laser_Data_CV_d_b were computed with:

ProcNoiseD=0.019^2; and ProcNoiseTheta=0.003^2

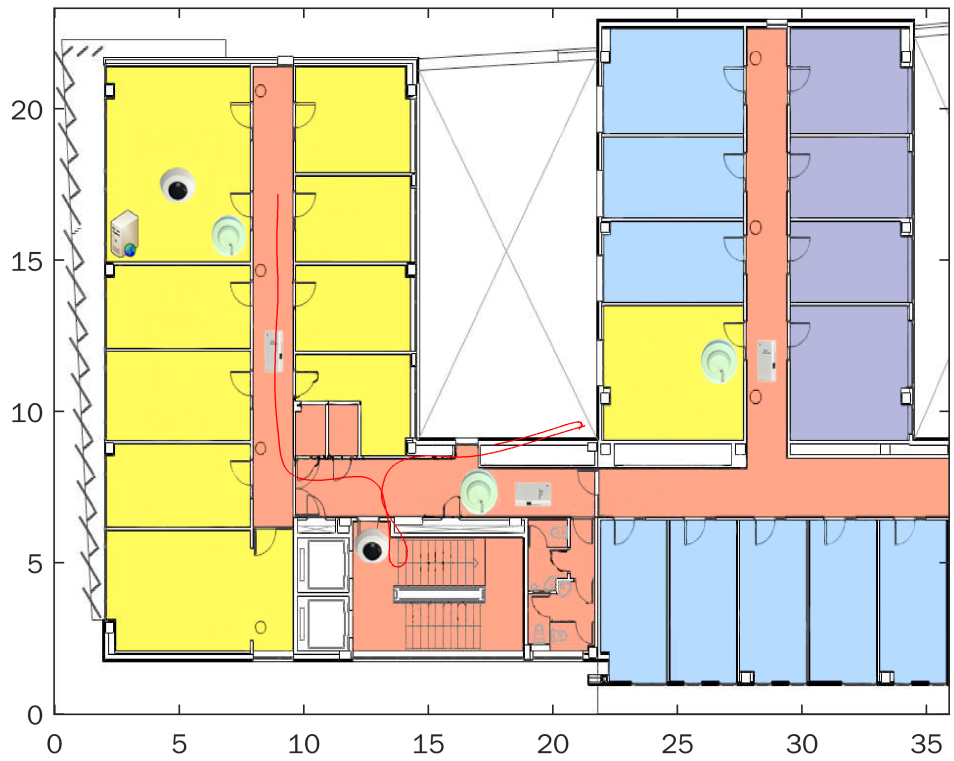
```
figure1=figure
```

```
figure1 =
  Figure (3) with properties:

      Number: 3
        Name: ''
       Color: [1 1 1]
    Position: [671 661 577 433]
       Units: 'pixels'

  Show all properties
```

```
I=imread('Enviroment.png');
x_ima=[0 35.9];
y_ima=[23.31 0];
image(I,'XData',x_ima,'YData',y_ima);
axis xy
hold on
plot(Pose_est.Data(:,1),Pose_est.Data(:,2),'r')
```



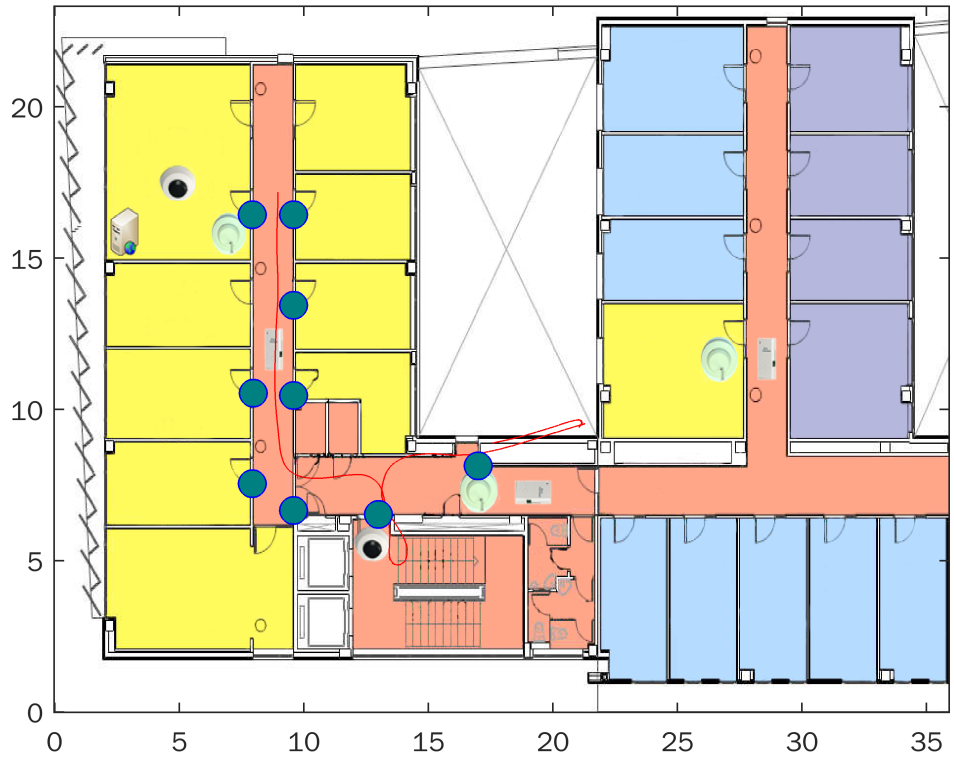
Land Marks

They are known. They can be extracter from laser data, there are easy algorithms for finding they, like corner detection, etc ...

```
Lmk= [7.934 16.431 0 1;...
      9.583 16.431 0 1;...
      9.584 13.444 0 1;...
      9.584 10.461 0 1;...
      7.973 10.534 0 1;...
      7.934  7.547 0 1;...
      9.584  6.654 0 1;...
     13.001  6.525 0 1;...
     17.007  8.136 0 1];
```

Plot Land Marks

```
hold on
sz = 100;
s=scatter(Lmk(:,1),Lmk(:,2),sz);
s.LineWidth = 0.6;
s.MarkerEdgeColor = 'b';
s.MarkerFaceColor = [0 0.5 0.5];
```



See an animation

In our system the computer is able to detect the landMark every 400ms

```
load('Laser_Data_CV__d_b.mat') % See the data
%%%%%%%%%%%Robot shape %%%%%%%%%%%
Robot= [0 -0.2 0 1;0.4 0 0 1;0 0.2 0 1]';% The Robot icon is a triangle
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%Laser foot print %%%%%%%%
Laser_Range=3.9% meters
```

```
Laser_Range = 3.9000
```

```
w=linspace(-30*pi/180,210*pi/180,20); %Laser foot print
s_x=Laser_Range*sin(w);s_y=Laser_Range*cos(w);
Lfp.v=[[s_x 0];[s_y 0]]';
Lfp.f= [1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 1];
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
hold on
axis([0 35.9 0 23.31]);
Robot_tr=eye(4)*Robot;
hr=patch(Robot_tr(1,1), Robot_tr(2,1),'b');
hlfp=patch('Faces',Lfp.f,'Vertices',Lfp.v,'FaceColor','blue','FaceAlpha',.2);
hll=line([0 0.01],[0 0.01],'Color','red','LineStyle','-');
hr=[]
```

```
hr =

     []
```

```
hlft=[]
```

```
hlft =

     []
```

```
hll=[]
```

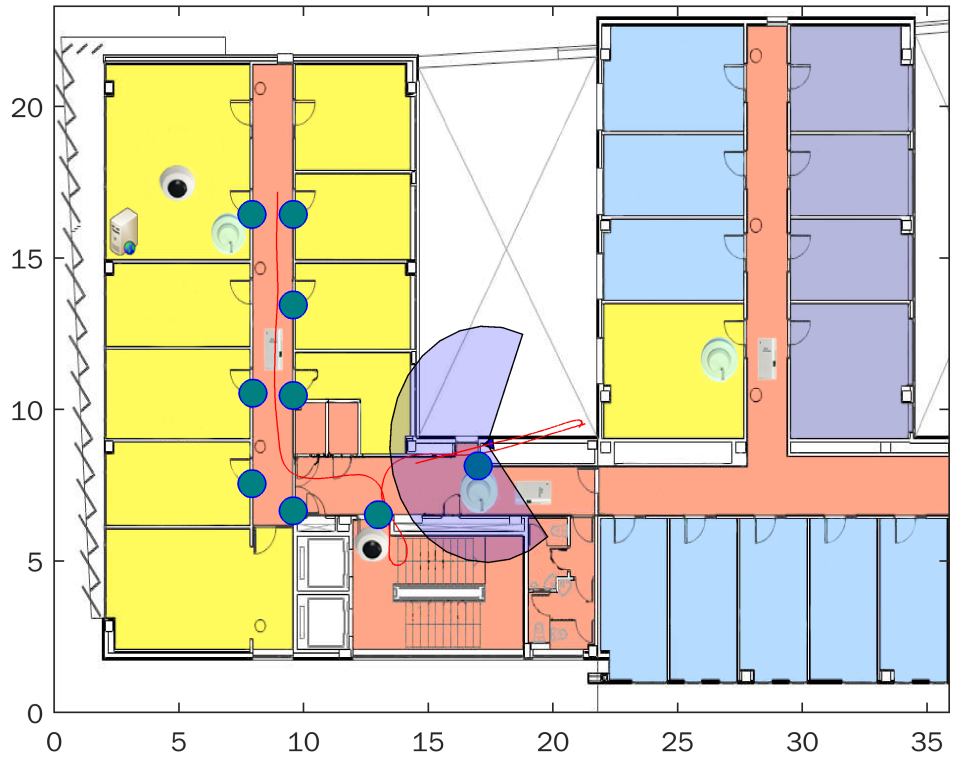
```
hll =

     []
```

```
sz = 100; % to see thing biger
speed=5; % to speed up the animation
for i=1:3000 % Use the for loop to see a movie
k_m=mod(i,speed);
if k_m==0
delete (hr); % Deleting figures and laser lines
delete (hlfp);
delete (hll)
s=scatter(Lmk(:,1),Lmk(:,2),sz);
s.LineWidth = 0.6;
s.MarkerEdgeColor = 'b';
s.MarkerFaceColor = [0 0.5 0.5];
Robot_pose=transl(Pose_est.Data(i,1),Pose_est.Data(i,2),0)*trotz(Pose_est.Data(i,3));
Robot_tr=Robot_pose*Robot;% moving the robot
Laser_fp=Robot_pose*transl(0.25,0,0)*[Lfp.v zeros(21,1) ones(21,1)]';
```

```
axis([0 35.9 0 23.31]);
hr=patch(Robot_tr(1,:), Robot_tr(2,:),'b');
hlfp=patch('Faces',Lfp.f,'Vertices',Laser_fp(1:2,:)','FaceColor','blue','FaceAlpha',.2)
Ls_lm_W=Robot_pose*[l_s_d(i,:).*cos(l_s_b(i,:));l_s_d(i,:).*sin(l_s_b(i,:)) ;zeros(1,9)
position=transl(Robot_pose);
hll=line([position(1) Ls_lm_W(1,1)...X's
          position(1) Ls_lm_W(1,2)...
          position(1) Ls_lm_W(1,3)...
          position(1) Ls_lm_W(1,4)...
          position(1) Ls_lm_W(1,5)...
          position(1) Ls_lm_W(1,6)...
          position(1) Ls_lm_W(1,7)...
          position(1) Ls_lm_W(1,8)...
          position(1) Ls_lm_W(1,9)],...
          [position(2) Ls_lm_W(2,1)...%Y's
          position(2) Ls_lm_W(2,2)...
          position(2) Ls_lm_W(2,3)...
          position(2) Ls_lm_W(2,4)...
          position(2) Ls_lm_W(2,5)...
          position(2) Ls_lm_W(2,6)...
          position(2) Ls_lm_W(2,7)...
          position(2) Ls_lm_W(2,8)...
          position(2) Ls_lm_W(2,9)],'Color','red','LineStyle','-');

pause(0.01);
end
end
```



Testing Similarity Transform

Show up again the Enriroment with both trajectories:

Theoric - Pose_t and estimate Pose_est

```
figure1=figure
```

```
figure1 =
  Figure (4) with properties:

      Number: 4
        Name: ''
       Color: [0.9400 0.9400 0.9400]
    Position: [1001 919 560 420]
       Units: 'pixels'

  Show all properties
```

```
I=imread('Enviroment.png');
x_ima=[0 35.9];
y_ima=[23.31 0];
image(I,'XData',x_ima,'YData',y_ima);
axis xy
hold on
plot(Pose_est.Data(:,1),Pose_est.Data(:,2),'r')
plot(Pose_t.Data(:,1),Pose_t.Data(:,2),'b')
```

Analize simulation

At time array index 860, i.e t=860*0.02=17.2 seg. and see the differences

```
m=860
```

```
m = 860
```

```
Robot_pose=transl(Pose_est.Data(m,1),Pose_est.Data(m,2),0)*trotz(Pose_est.Data(m,3))
```

```
Robot_pose = 4×4
    0.9281    0.3722         0    9.6984
   -0.3722    0.9281         0    7.8317
         0         0    1.0000         0
         0         0         0    1.0000
```

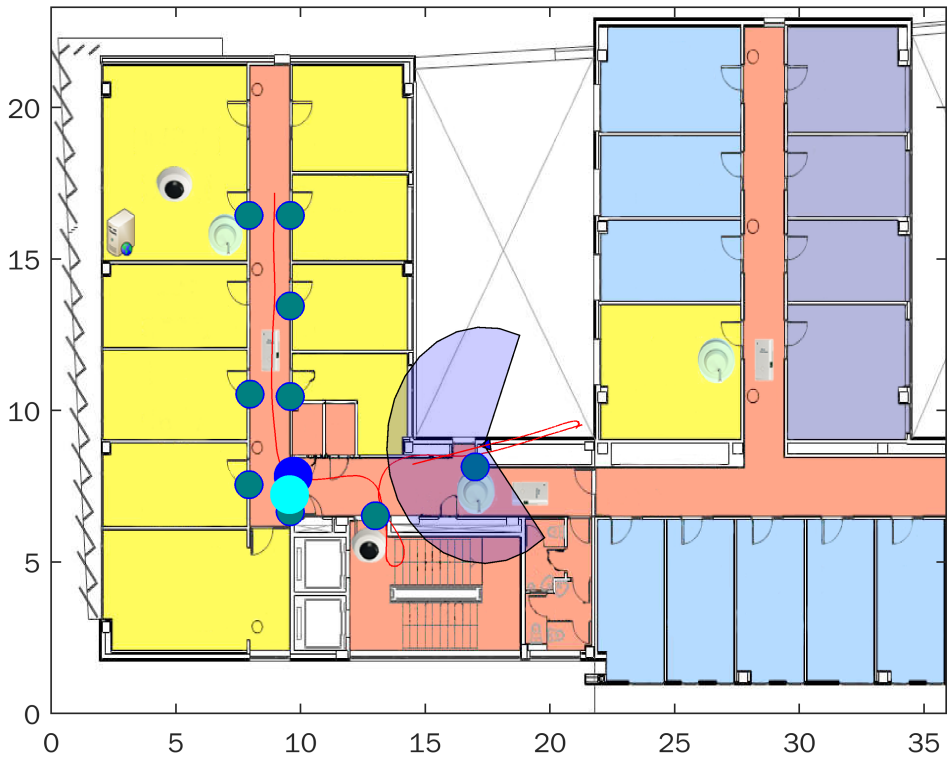
```
Robot_m=transl(Robot_pose)
```

```
Robot_m = 3×1
    9.6984
    7.8317
         0
```

```
Robot_pose_teo=transl(transl(Pose_t.Data(m,1),Pose_t.Data(m,2),0)*trotz(Pose_t.Data(m,3
```

```
Robot_pose_teo = 3×1
    9.5581
    7.2179
         0
```

```
scatter(Robot_m(1),Robot_m(2),200, 'b','filled');
scatter(Robot_pose_teo(1),Robot_pose_teo(2),200, 'c','filled');
```



Read the laser

```
d_4=l_s_d(m,4)
```

```
d_4 = 3.2481
```

```
b_4=l_s_b(m,4)
```

```
b_4 = 2.0338
```

```
d_78=l_s_d(m,7:8)
```

```
d_78 = 1×2
    0.5699    3.5156
```

```
b_78=l_s_b(m,7:8)
```

```
b_78 = 1×2
    5.2291    0.2723
```

Laser 2 Word

```
[x4,y4]=pol2cart(b_4(1,1),d_4(1,1))
```

```
x4 = -1.4507
y4 = 2.9061
```

```
[x7,y7]=pol2cart(b_78(1,1),d_78(1,1))
```

```
x7 = 0.2815
y7 = -0.4955
```

```
[x8,y8]=pol2cart(b_78(1,2),d_78(1,2))
```

```
x8 = 3.3860
y8 = 0.9455
```

```
L_m4_w=Robot_pose*[x4 y4 0 1]'
```

```
L_m4_w = 4×1
    9.4337
   11.0689
         0
    1.0000
```

```
L_m7_w=Robot_pose*[x7 y7 0 1]'
```

```
L_m7_w = 4×1
    9.7753
    7.2670
         0
    1.0000
```

```
L_m8_w=Robot_pose*[x8 y8 0 1]'
```

```
L_m8_w = 4×1
   13.1931
    7.4488
         0
    1.0000
```

```
%Innovation=[L_m4_w L_m7_w L_m8_w];
Innovation=[L_m7_w L_m8_w]
```

```
Innovation = 4×2
    9.7753   13.1931
    7.2670    7.4488
         0         0
    1.0000    1.0000
```

LandMark needed

```
LandMark= Lmk'
```

```
LandMark = 4×9
    7.9340    9.5830    9.5840    9.5840    7.9730    7.9340    9.5840   13.0010 ···
   16.4310   16.4310   13.4440   10.4610   10.5340    7.5470    6.6540    6.5250
         0         0         0         0         0         0         0         0
    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
```

```
%LandMark= [LandMark(1:2,4) % LandMark(1:2,7:8)]%% uncomment when three Landmark
LandMark= LandMark(1:2,7:8) % Only two LandMarks
```

```
LandMark = 2×2
    9.5840   13.0010
    6.6540    6.5250
```

Plot the scene

Legend for points:

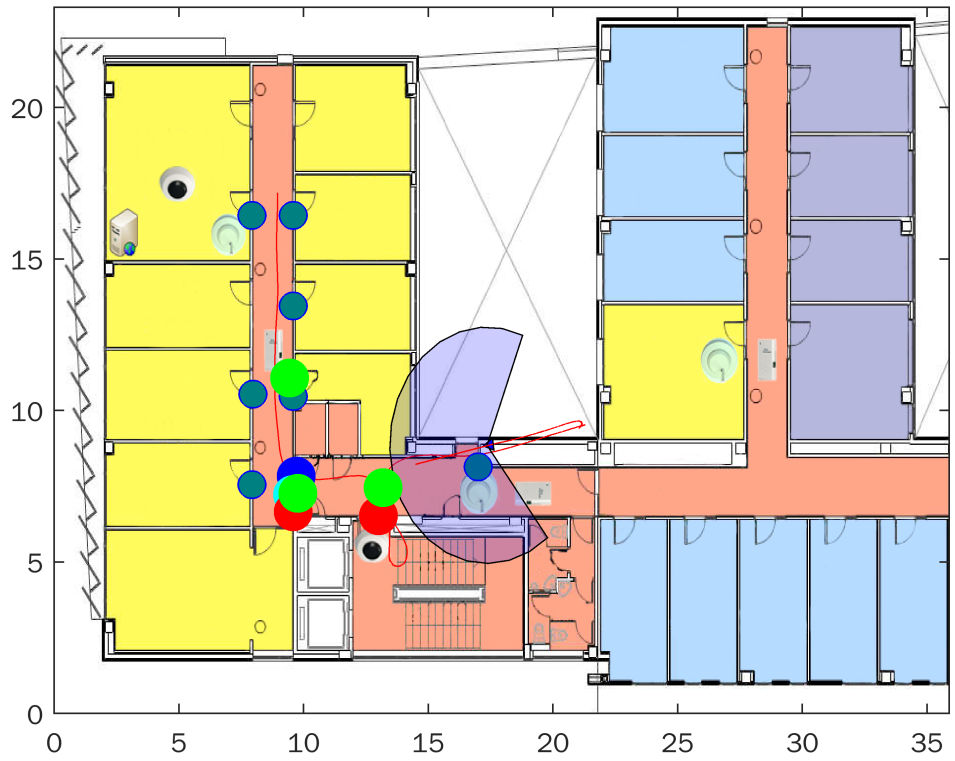
Blue: Estimated Pose

Cyan: True/theoric Pose

Red: known Land Marks

Green: Measured Land Marks. Innovation

```
scatter(LandMark(1,:),LandMark(2,:),200, 'r','filled');
scatter(L_m4_w(1),L_m4_w(2),200, 'g','filled');
scatter(L_m7_w(1),L_m7_w(2),200, 'g','filled');
scatter(L_m8_w(1),L_m8_w(2),200, 'g','filled');
```



Building the Matrices A & B

```
A = [];
for i=1:size(LandMark, 2)
    A = [A;[LandMark(1,i),LandMark(2,i),1,0]];
    A = [A;[LandMark(2,i),-LandMark(1,i),0,1]]
```

```
end
```

```
A = 2×4
    9.5840    6.6540    1.0000         0
    6.6540   -9.5840         0    1.0000
A = 4×4
    9.5840    6.6540    1.0000         0
    6.6540   -9.5840         0    1.0000
   13.0010    6.5250    1.0000         0
    6.5250  -13.0010         0    1.0000
```

```
B = [];
for i=1:size(Innovation, 2)
    B = [B; Innovation(1,i); Innovation(2,i)]
end
```

```
B = 2×1
    9.7753
    7.2670
B = 4×1
    9.7753
    7.2670
   13.1931
    7.4488
```

Finding the error in pose

```
X = inv((A'*A))*A'*B;
tx_ST = X(3)
```

```
tx_ST = 0.8265
```

```
ty_ST = X(4)
```

```
ty_ST = -0.2363
```

```
alpha_ST = atan2(X(2),X(1))
```

```
alpha_ST = -0.0909
```

Testing Least squared

```
A*[cos(alpha_ST) sin(alpha_ST) tx_ST ty_ST]'
```

```
ans = 4×1
    9.7670
    7.2601
   13.1816
    7.4417
```

```
B
```

```
B = 4×1
    9.7753
    7.2670
   13.1931
    7.4488
```

```
Innovation
```

```
Innovation = 4×2
    9.7753   13.1931
    7.2670    7.4488
         0         0
    1.0000    1.0000
```

Testing at origen

```
%Operation=trotz(-alpha_ST)*transl(tx_ST,ty_ST,0)*[LandMark; 0 0 0; 1 1 1]
%% uncomment when three Landmark

Operation=trotz(-alpha_ST)*transl(tx_ST,ty_ST,0)*[LandMark; 0 0 ; 1 1 ] % Only two Land
```

```
Operation = 4×2
    9.7850   13.1997
    7.3360    7.5177
         0         0
    1.0000    1.0000
```

```
Innovation
```

```
Innovation = 4×2
    9.7753   13.1931
    7.2670    7.4488
         0         0
    1.0000    1.0000
```

Going Back

```
Operation_back=transl(-tx_ST,-ty_ST,0)*trotz(alpha_ST)*Innovation
```

```
Operation_back = 4×2
    9.5680   12.9882
    6.5861    6.4570
         0         0
    1.0000    1.0000
```

```
LandMark
```

```
LandMark = 2×2
    9.5840   13.0010
    6.6540    6.5250
```

```

```

Cancel errors

```
Robot_error= transl(-tx_ST,-ty_ST,0)*trotz(alpha_ST)*[Robot_m;1]
```

```
Robot_error = 4×1
    9.5427
    7.1554
         0
    1.0000
```

```
scatter(Robot_error(1),Robot_error(2),70, 'cyan','filled');
```