# Short Project 2 (Robot Móvil)

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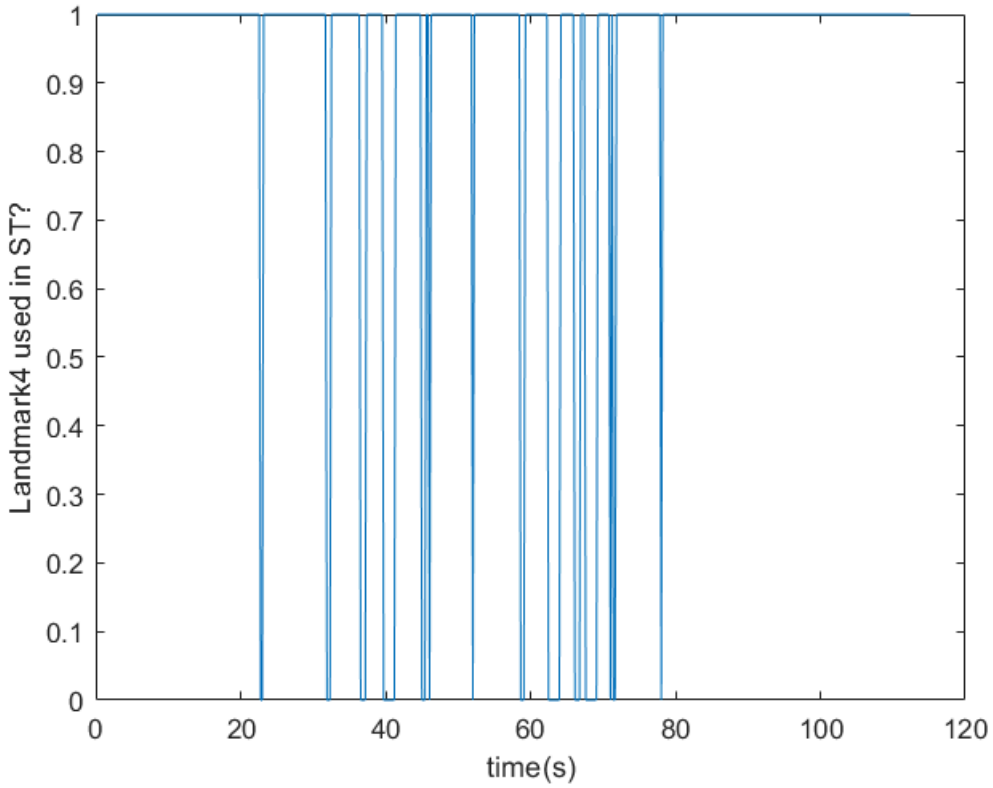
```
clear;
clc;
clear poseIntegration % clear persistent variables
clear poseIntegration2
load('Work_Space_Localization_Short_project.mat');

Robot= [0 -0.2 0 1;0.4 0 0 1;0 0.2 0 1]';% The Robot icon is a triangle
Lsum = data_enc(:,6)/1000;
Rsum = data_enc(:,7)/1000;
IC = [0 0 pi/2]; %[xo,yo,th0]
V = diag([0.01^2 0.01^2]); % noise
Pk0 = pk.signals.values(:,:,1);
S = width/2/1000; % mm to m
error = [0 0 0];
errors(1,:) = error;
number_landmarks = zeros(1,523);
landmark1 = zeros(1,523);
landmark2 = zeros(1,523);
landmark3 = zeros(1,523);
landmark4 = zeros(1,523);
detPK = zeros(1,523);
```

```
for index=1:523

    % The given script
    t = 0: 2*pi/359 : 2*pi;
    P = polar(t, 4.5 * ones(size(t)));% to fix the limits
    set(P, 'Visible', 'off')
    subplot(2,2,1)
    polar(t, lds_dis (index,2:361), '--g'); % Ploting the laser data wrt Robot frame
    title ('Laser data at Robot Reference Frame','FontWeight','bold','FontSize',8)
    subplot(2,2,2)
    title ('Data on Wordl Reference Frame', 'FontWeight','bold','FontSize',8)
    axis([-3 3 -2 4])
    grid on
    hold on
    for i=1:4 % plotting the 4 Land Marks
        circle (LandMark(i,:)',0.15)
    end
    scatter(ldx(index,:), ldy(index,:)) % plotting the land mark seen by the Robot wrt  wordl r
    plot (trajec(:,1), trajec(:,2), 'r.','LineWidth',1.5) % Plotting the trajectory
    Robot_tr=transl(trajec(index,1),trajec(index,2),0)*trotz(mod(trajec(index,3)+pi/2,2*pi))*Ro
    patch(Robot_tr(1,:), Robot_tr(2,:),'b');
    plot_ellipse(pk.signals.values(1:2,1:2,index),[trajec(index,1), trajec(index,2)],'g'); % Pl


    % ---------------------------------------------------------------
```

```
% Plot pose integration without error feedback
subplot(2,2,4)
title ('Robot Pose Integration without error', 'FontWeight','bold','FontSize',8)
axis([-3 3 -2 4])
grid on
hold on
plot(trajec(:,1), trajec(:,2), 'r.','LineWidth',1.5)
% calculate pose with noise
if index == 1
    [poseT, poseEst, Pk] = poseIntegration(V, Pk0, IC, Lsum(1), Rsum(1), S);
else
     L = Lsum(index)-Lsum(index-1);
     R = Rsum(index)-Rsum(index-1);
    [poseT, poseEst, Pk] = poseIntegration(V, Pk0, IC, L, R, S);
end
% Move robot to that pose
x = poseEst(1); y = poseEst(2); theta = poseEst(3);
detPK(index) = sqrt(det(Pk));
Robot_T = transl(x, y, 0)*trotz(theta)*Robot;
patch(Robot_T(1,:), Robot_T(2,:),'b');
plot_ellipse(Pk(1:2, 1:2),[x, y],'g');

% Landmark in Robot Reference Frame (pink colour)
posV = polar2Cart(lds_dis(index,:));
scatter(posV(:,1), posV(:,2), [], [255,192,203]/255);

scatter(LandMark(:,1), LandMark(:,2), [], [0,0,0]/255);  % True Landmark (black)

laserW = rob2W(posV, poseEst);
%scatter(laserW(:,1), laserW(:,2), 'cyan') % no need to plot twice

% we plot the landmark in world reference frame each one associated to
% the nearest true landmark by colour
asLandM = assoLndMrk(LandMark, laserW);
aux = unique(asLandM);
number_landmarks(index) = size(aux,2);
landmark1(index) = ismember(1,aux);
landmark2(index) = ismember(2,aux);
landmark3(index) = ismember(3,aux);
landmark4(index) = ismember(4,aux);
scatter(laserW(:,1), laserW(:,2), [] ,asLandM); % Landmark in World Reference Frame

% -------------------------------------------------------------
% bacically the same

% pose integration calculating the error and correcting the pose in the
% next iteration
subplot(2,2,3);
title ('Robot Pose Integration with error feedback', 'FontWeight','bold','FontSize',8)
axis([-3 3 -2 4])
grid on
hold on
plot(trajec(:,1), trajec(:,2), 'r.','LineWidth',1.5)
```

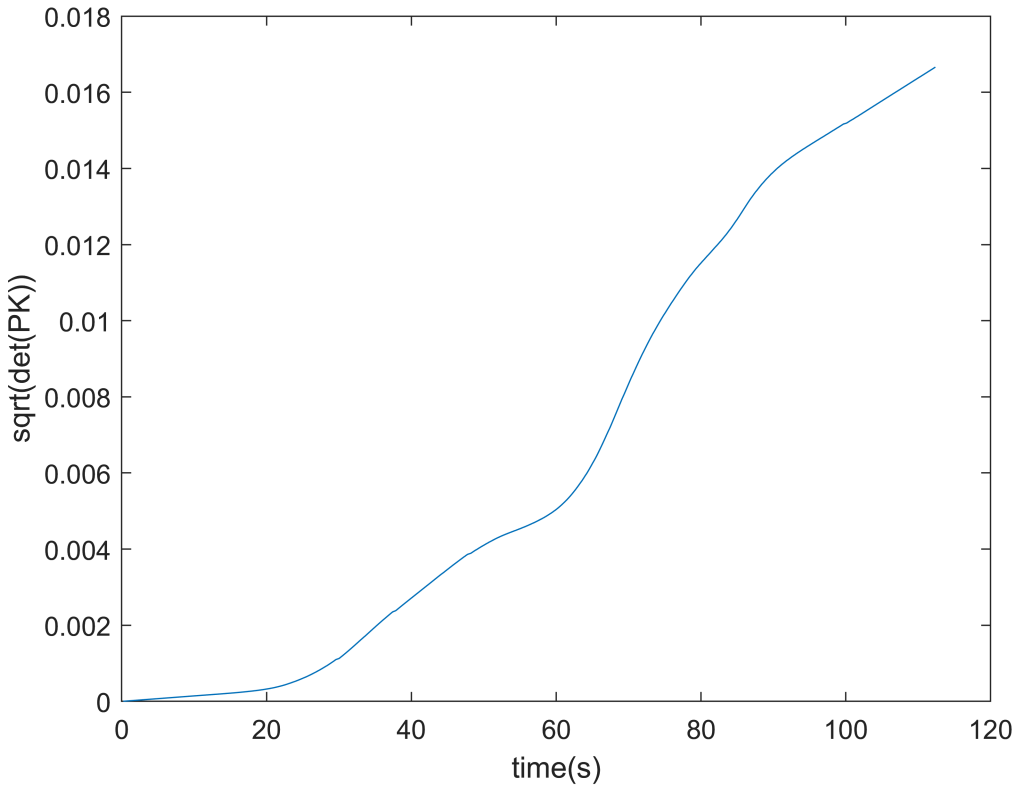
```
    if index == 1
        [poseT, poseEst, Pk] = poseIntegration2(V, Pk0, IC, Lsum(1), Rsum(1), S, error);
    else
        [poseT, poseEst, Pk] = poseIntegration2(V, Pk0, IC, L, R, S, error);
    end
    x = poseEst(1); y = poseEst(2); theta = poseEst(3);
    Robot_T = transl(x, y, 0)*trotz(theta)*Robot;
    patch(Robot_T(1,:), Robot_T(2,:),'b');
    if (~isnan(Pk(1,1)))
        plot_ellipse(Pk(1:2, 1:2),[x, y],'g');
    end
    posV = polar2Cart(lds_dis(index,:));
    scatter(posV(:,1), posV(:,2), [], [255,192,203]/255);  % Landmark in Robot Reference Frame
    scatter(LandMark(:,1), LandMark(:,2), [], [0,0,0]/255);  % True Landmark
    laserW = rob2W(posV, poseEst);
    asLandM = assoLndMrk(LandMark, laserW);
    scatter(laserW(:,1), laserW(:,2), [] ,asLandM); % Landmark in World Reference Frame
    error = ST(LandMark, asLandM, laserW);
    if index < 523
        errors(index+1,:) = error;
    end

    pause(0.01);
    clf
end
```

```
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  9.601929e-18.
Warning: Matrix is close to singular or badly scaled. Results may be inaccurate. RCOND =  9.473903e-18.
```



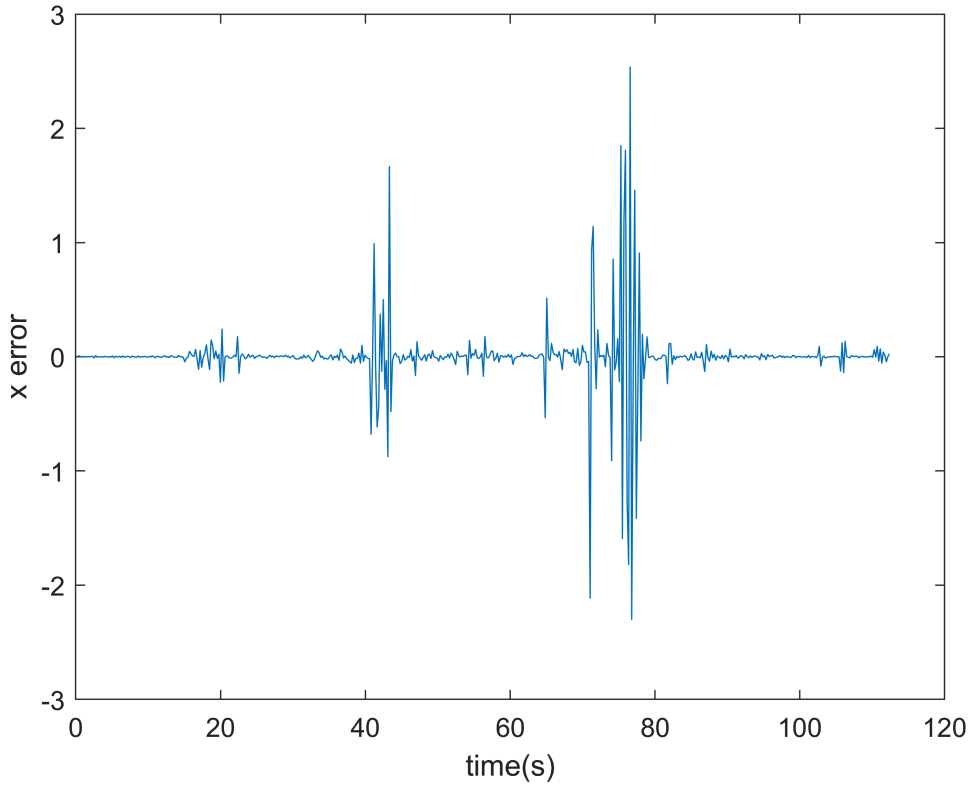
### Plot square root determinant of Pk

```
plot(data_enc(:,1), detPK);
xlabel("time(s)");
ylabel("sqrt(det(PK))");
```



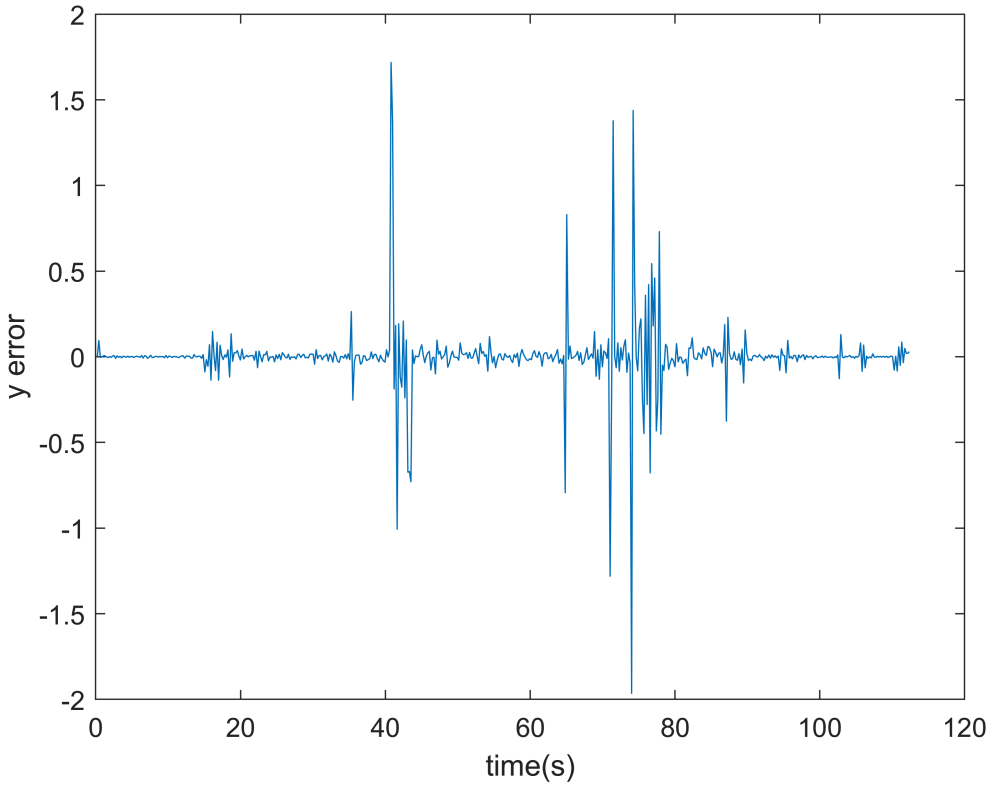

### X error over time

```
plot(data_enc(:,1)', errors(:,1));
xlabel("time(s)");
ylabel("x error");
```



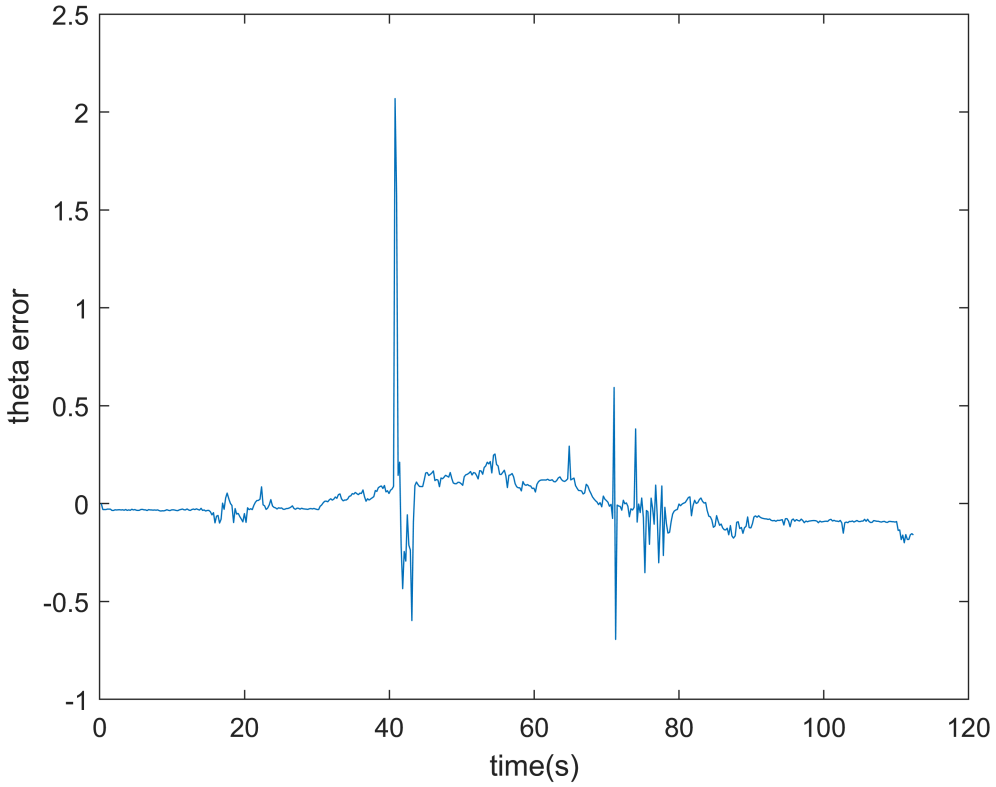

**Y error over time**

```
plot(data_enc(:,1)', errors(:,2));
xlabel("time(s)");
ylabel("y error");
```



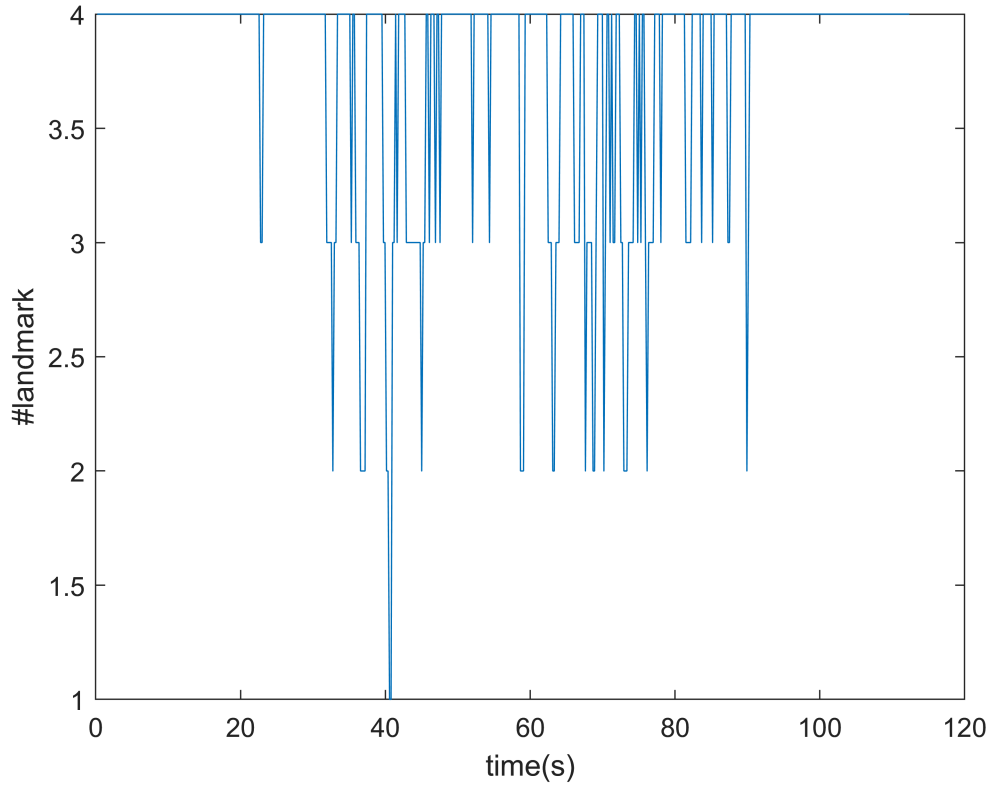

**Theta error over time**

```
plot(data_enc(:,1)', errors(:,3));
xlabel("time(s)");
ylabel("theta error");
```



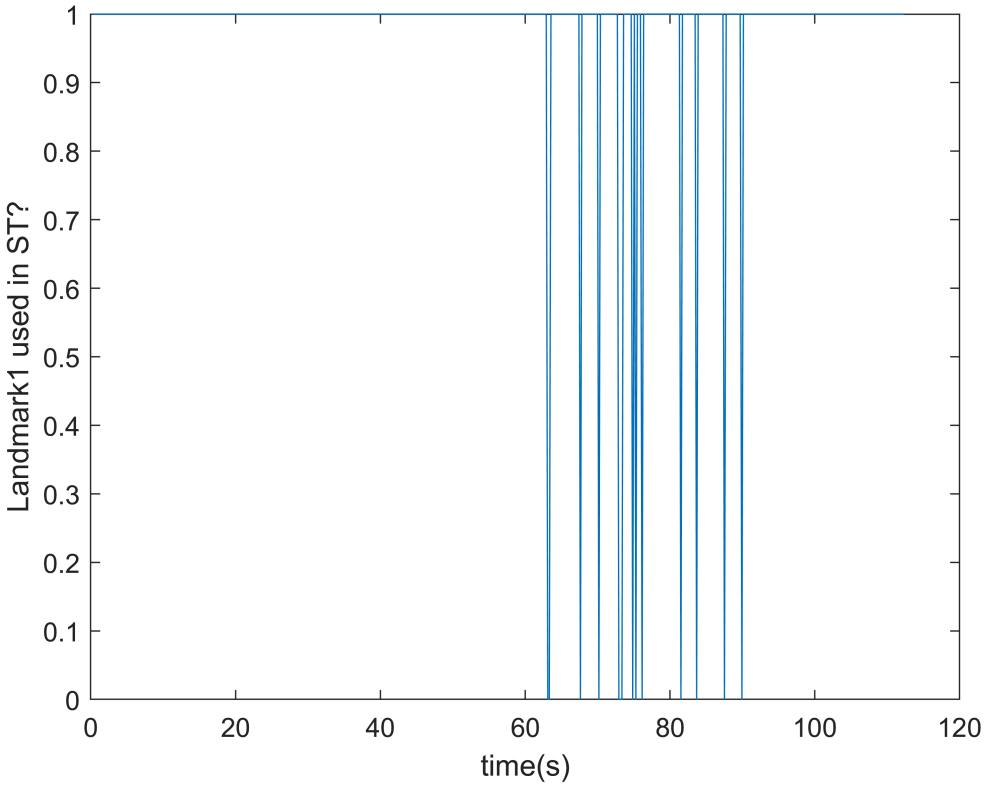

**Number of landmarks used over time**

```
plot(data_enc(:,1)',number_landmarks);
xlabel("time(s)");
ylabel("#landmark");
```



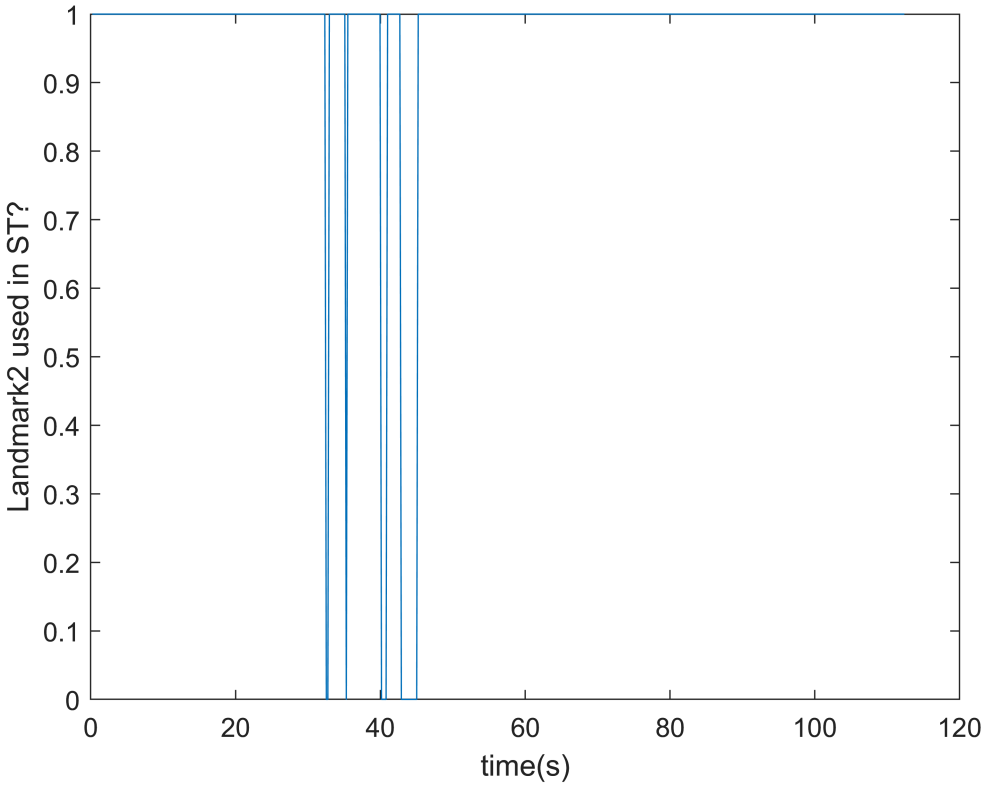

**Landmark 1 usage over time**

```
plot(data_enc(:,1)',landmark1);
xlabel("time(s)");
ylabel("Landmark1 used in ST?");
```



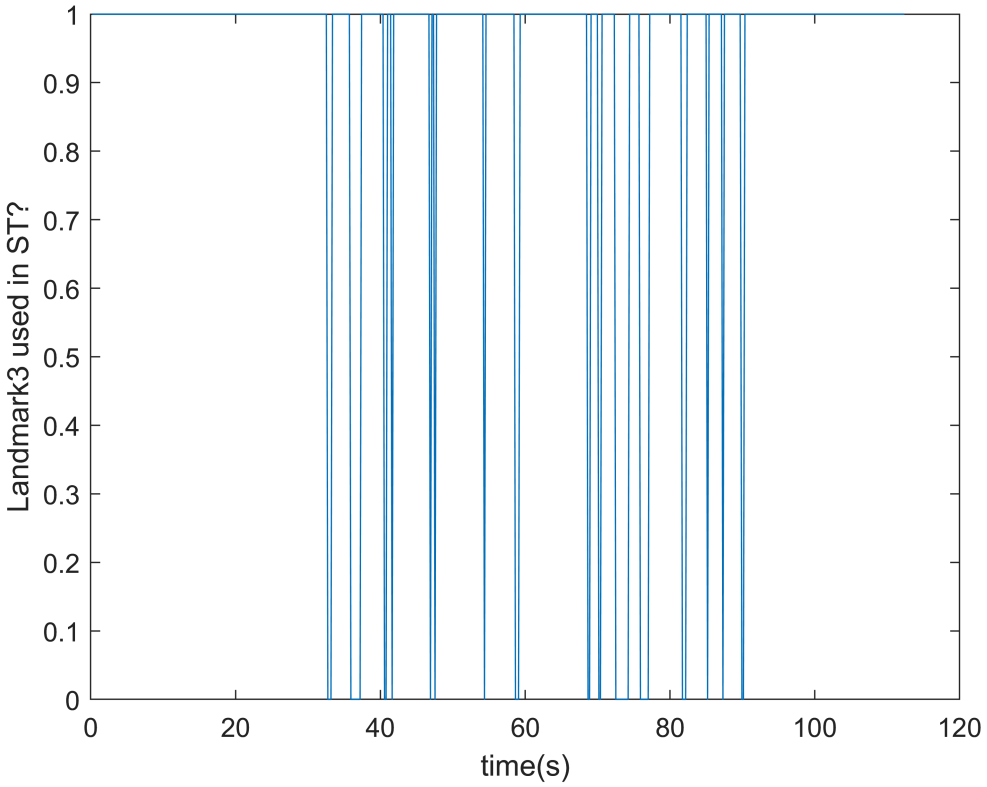

**Landmark 2 usage over time**

```
plot(data_enc(:,1)',landmark2);
xlabel("time(s)");
ylabel("Landmark2 used in ST?");
```



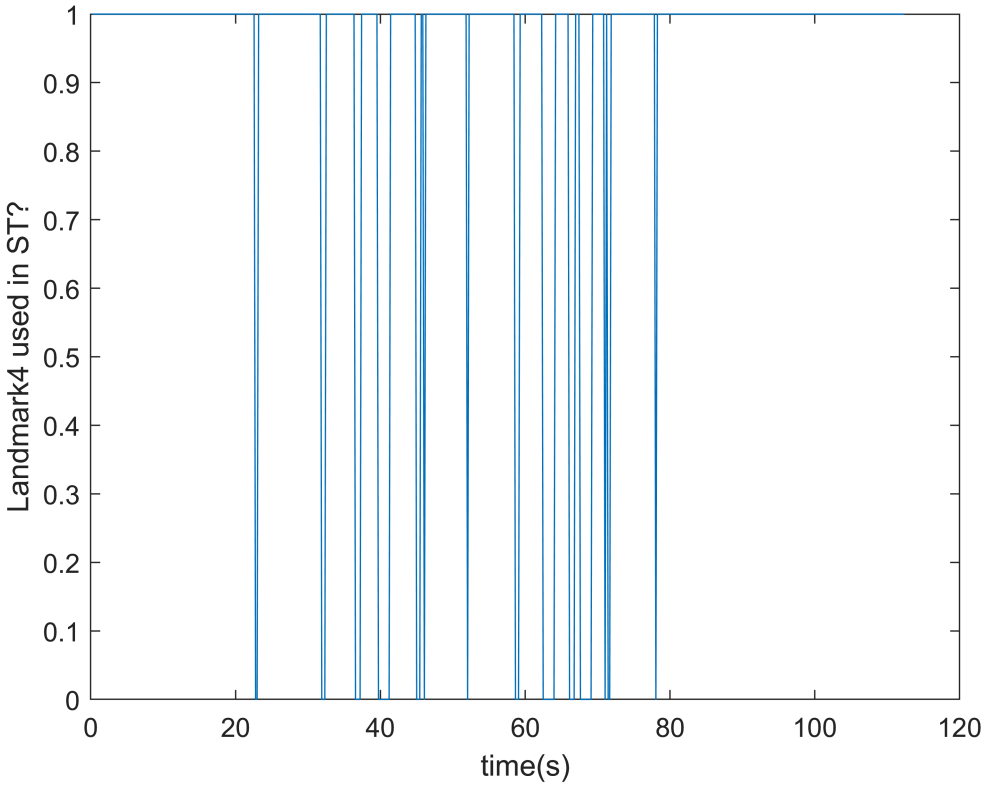

**Landmark 3 usage over time**

```
plot(data_enc(:,1)',landmark3);
xlabel("time(s)");
ylabel("Landmark3 used in ST?");
```




**Landmark 4 usage over time**

```
plot(data_enc(:,1)',landmark4);
xlabel("time(s)");
ylabel("Landmark4 used in ST?");
```


Landmark4 used in ST?
time(s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
20
40
60
80
100
120