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Devon Quaternik

```
%ELEN 644
%HW 7

clear;
close all;
```

Problem 2

```
% Part b
syms a b x1 x2 x3 y1 y2 y3 t1 t2 t3 tx ty

J1 = [1 0 -(sin(t1)*x1)-(cos(t1)*y1); 0 1 (cos(t1)*x1)-(sin(t1)*y1)];
J2 = [1 0 -(sin(t2)*x2)-(cos(t2)*y2); 0 1 (cos(t2)*x2)-(sin(t2)*y2)];
J3 = [1 0 -(sin(t3)*x3)-(cos(t3)*y3); 0 1 (cos(t3)*x3)-(sin(t3)*y3)];
dx1 = [a*x1 - b*y1 + tx; b*x1 + a*y1 + ty];
dx2 = [a*x2 - b*y2 + tx; b*x2 + a*y2 + ty];
dx3 = [a*x3 - b*y3 + tx; b*x3 + a*y3 + ty];


A = (J1'*J1)+(J2'*J2)+(J3'*J3);
rank(A)
b = J1'*dx1 + J2'*dx2 + J3'*dx3;

disp('Since A is a full rank matrix, we are able to find p here,
 although due to size it is not shown');
```

```
ans =

     3

Since A is a full rank matrix, we are able to find p here, although
 due to size it is not shown
```

Problem 3

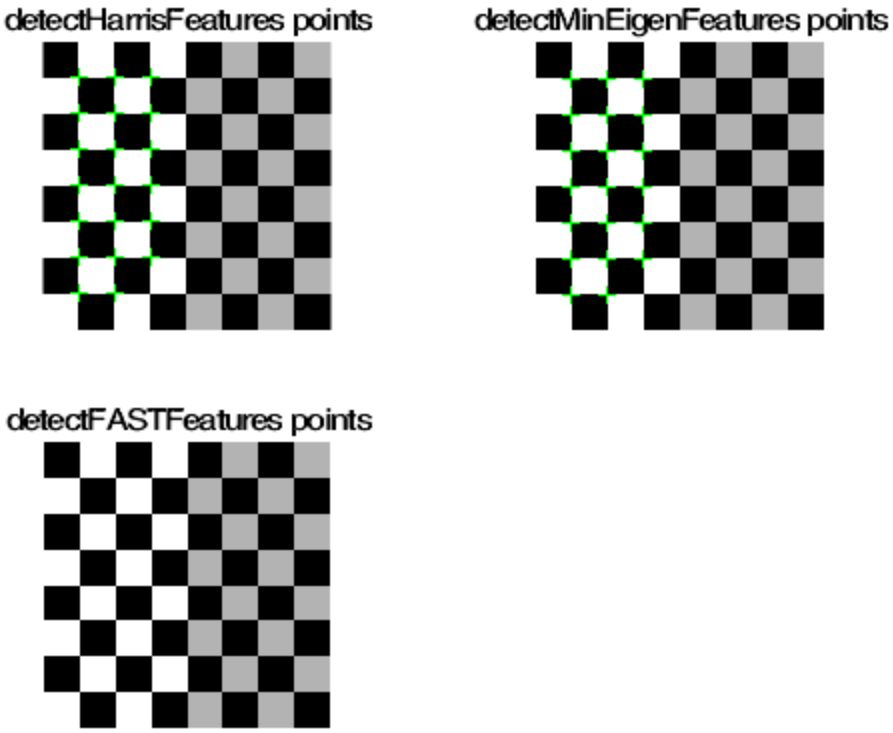
```
% From HW5 cleaned up to remove all displays and ;
im1 = checkerboard(20,4,4);
im2 = rgb2gray(imread('4.1.05.tiff'));

% Problem 1
```

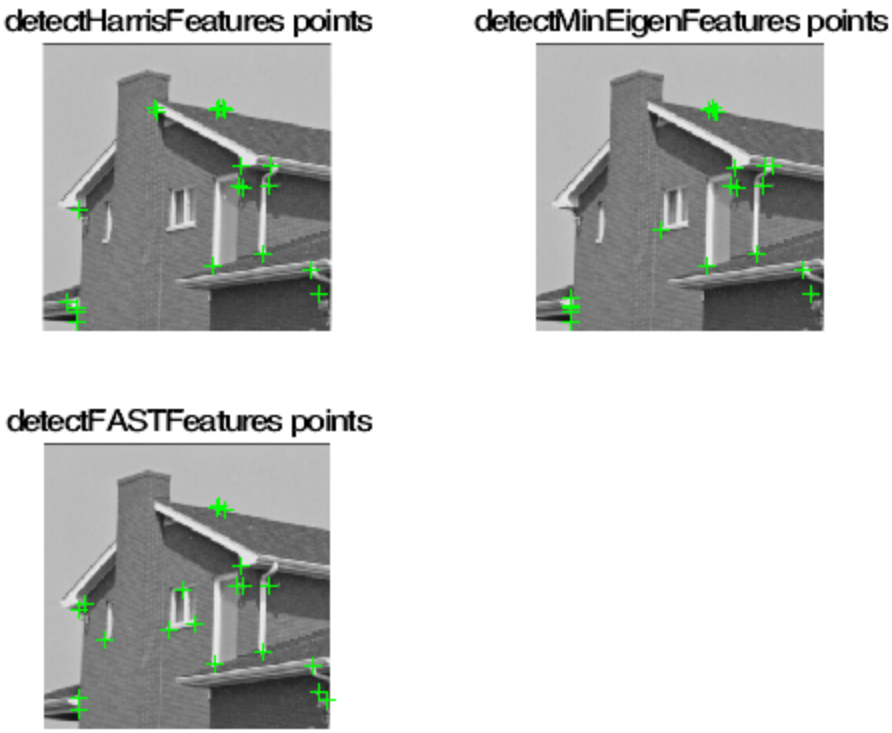
```
% Part a
ogpoints1 = detectHarrisFeatures(im1);

numpoints = length(ogpoints1);

% Part b
h1 = fspecial('Gaussian',5,1);
h2 = fspecial('Gaussian',15,3);
h3 = fspecial('Gaussian',25,5);
smim1 = filter2(h1,im1);
smim2 = filter2(h2,im1);
smim3 = filter2(h3,im1);

smpts1 = detectHarrisFeatures(smim1);
smptsl1 = length(smpts1);
smpts2 = detectHarrisFeatures(smim2);
smptsl2 = length(smpts2);
smpts3 = detectHarrisFeatures(smim3);
smptsl3 = length(smpts3);



% Part c
h = (1/16)*[1 4 6 4 1];
dim = dscale2(im1,h,3);
dpts1 = detectHarrisFeatures(dim(:,:,1));
dptsl1 = length(dpts1);
dpts2 = detectHarrisFeatures(dim(:,:,2));
dptsl2 = length(dpts2);
dpts3 = detectHarrisFeatures(dim(:,:,3));
dptsl3 = length(dpts3);


% Problem 2
% Part a
ogpoints2 = detectHarrisFeatures(im2);
numpoints = length(ogpoints2);

% Part b
h1 = fspecial('Gaussian',5,1);
h2 = fspecial('Gaussian',15,3);
h3 = fspecial('Gaussian',25,5);
smim1 = filter2(h1,im2);
smim2 = filter2(h2,im2);
smim3 = filter2(h3,im2);

smpts1 = detectHarrisFeatures(smim1);
smptsl1 = length(smpts1);
smpts2 = detectHarrisFeatures(smim2);
smptsl2 = length(smpts2);
smpts3 = detectHarrisFeatures(smim3);
smptsl3 = length(smpts3);
```

```
% Part c
h = (1/16)*[1 4 6 4 1];
dim = dscale2(im2,h,3);
dpts1 = detectHarrisFeatures(dim(:,:,1));
dptsl1 = length(dpts1);
dpts2 = detectHarrisFeatures(dim(:,:,2));
dptsl2 = length(dpts2);
dpts3 = detectHarrisFeatures(dim(:,:,3));
dptsl3 = length(dpts3);



% HW7 Work

eigpts1 = detectMinEigenFeatures(im1);
eigpts2 = detectMinEigenFeatures(im2);
fstpts1 = detectFASTFeatures(im1);
fstpts2 = detectFASTFeatures(im2);

figure;
subplot(2,2,1),imshow(im1); hold on;
plot(ogpoints1.selectStrongest(20));
title('detectHarrisFeatures points');
subplot(2,2,2),imshow(im1); hold on;
plot(eigpts1.selectStrongest(20));
title('detectMinEigenFeatures points');
subplot(2,2,3),imshow(im1); hold on;
plot(fstpts1.selectStrongest(20));
title('detectFASTFeatures points');

figure;
subplot(2,2,1),imshow(im2); hold on;
plot(ogpoints2.selectStrongest(20));
title('detectHarrisFeatures points');
subplot(2,2,2),imshow(im2); hold on;
plot(eigpts2.selectStrongest(20));
title('detectMinEigenFeatures points');
subplot(2,2,3),imshow(im2); hold on;
plot(fstpts2.selectStrongest(20));
title('detectFASTFeatures points');

disp('For the checkerboard, Eigen works identically to Harris. FAST,
 on the other hand, captures none of the points.');
disp('For the house image, the Eigen features detect points that are
 similar to Harris, but a few points are different. FAST features
 captures similar, but they tend to be actual corners of the building
 or its features, rather than near them.');
```

```
For the checkerboard, Eigen works identically to Harris. FAST, on the
 other hand, captures none of the points.
For the house image, the Eigen features detect points that are similar
 to Harris, but a few points are different. FAST features captures
```

similar, but they tend to be actual corners of the building or its features, rather than near them.





Problem 4

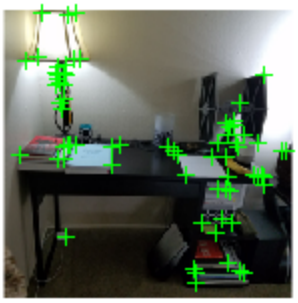
```
% Part a
% Using original and shifted images from both sets.
[cfar,farmap] = imread('Photos/centerfar.jpg');
cfar = imrotate(cfar,-90);
cfar = imresize(cfar,[256,256]);
[slim,slmap] = imread('Photos/shiftleft.jpg');
slim = imrotate(slim,-90);
slim = imresize(slim,[256,256]);
[srim,srmap] = imread('Photos/shiftright.jpg');
srim = imrotate(srim,-90);
srim = imresize(srim,[256,256]);

cfarg = rgb2gray(cfar);
slimg = rgb2gray(slim);
srimg = rgb2gray(srim);

[oc,ocmap] = imread('Outdoor/oc.jpg');
oc = imrotate(oc,-90);
oc = imresize(oc,[256,256]);
[osl,oslmap]=imread('Outdoor/osl.jpg');
osl = imrotate(osl,-90);
osl = imresize(osl,[256,256]);
[osr,osrmap]=imread('Outdoor/osr.jpg');
```

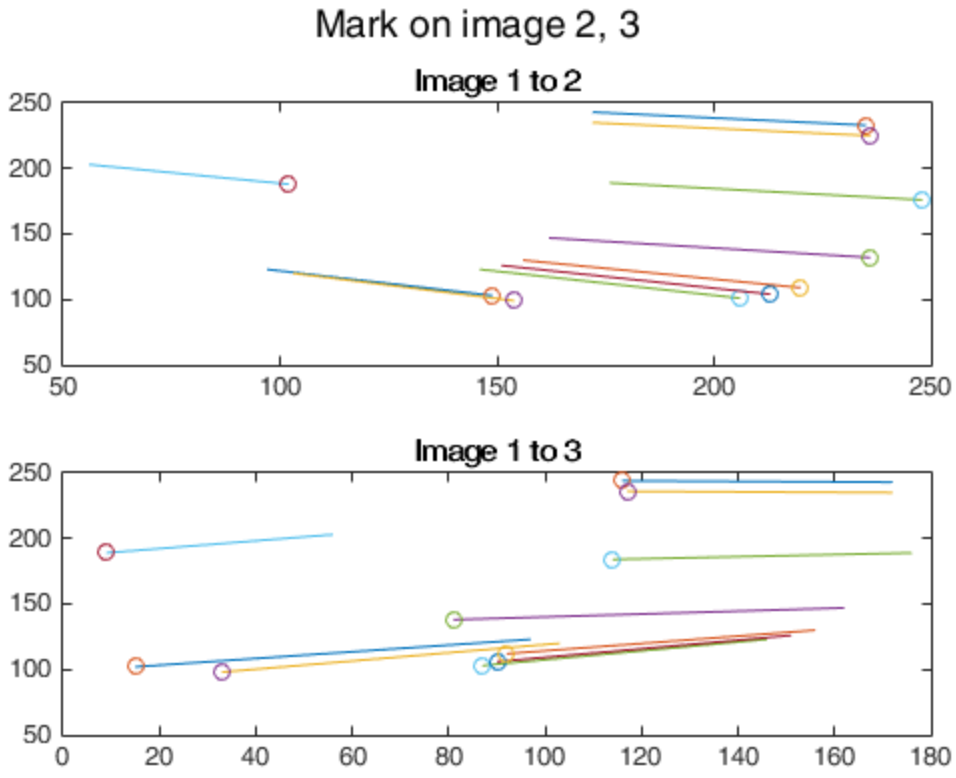
```
osr = imrotate(osr,-90);
osr = imresize(osr,[256,256]);

ocg = rgb2gray(oc);
oslg = rgb2gray(osl);
osrg = rgb2gray(osr);

clpts = detectFASTFeatures(cfarg);
slpts = detectFASTFeatures(slimg);
srpts = detectFASTFeatures(srimg);

ocpts = detectFASTFeatures(ocg);
oslpts = detectFASTFeatures(oslg);
osrpts = detectFASTFeatures(osrg);

figure;
subplot(2,2,1),imshow(cfar,farmap); hold on;
plot(clpts.selectStrongest(70));
subplot(2,2,2),imshow(slim,slmap); hold on;
plot(slpts.selectStrongest(70));
subplot(2,2,3),imshow(srim,srmap); hold on;
plot(srpts.selectStrongest(70));

figure;
subplot(2,2,1),imshow(oc,ocmap); hold on;
plot(ocpts.selectStrongest(60));
subplot(2,2,2),imshow(osl,oslmap); hold on;
plot(oslpts.selectStrongest(60));
subplot(2,2,3),imshow(osr,osrmap); hold on;
plot(osrpts.selectStrongest(60));

%indoor point pairs
xi1 = [97 123; 103 120; 146 123; 151 126; 156 130; 162 147; 56 203;
 172 243; 172 235; 176 189];
xi2 = [149 103; 154 99; 206 101; 213 104; 220 109; 236 132; 102 188;
 235 233; 236 225; 248 176];
xi3 = [15 102; 33 98; 87 103; 90 106; 92 112; 81 138; 9 189; 116 244;
 117 236; 114 184];

figure;
for i = 1:10
    subplot(2,1,1),plot([xi1(i,1) xi2(i,1)],[xi1(i,2) xi2(i,2)]);
 hold on;
    plot(xi2(i,1),xi2(i,2),'o');
    title('Image 1 to 2');
    subplot(2,1,2),plot([xi1(i,1) xi3(i,1)],[xi1(i,2) xi3(i,2)]);
 hold on;
    plot(xi3(i,1),xi3(i,2),'o');
    title('Image 1 to 3');
end
suptitle('Mark on image 2, 3');

%outdoor point pairs
```

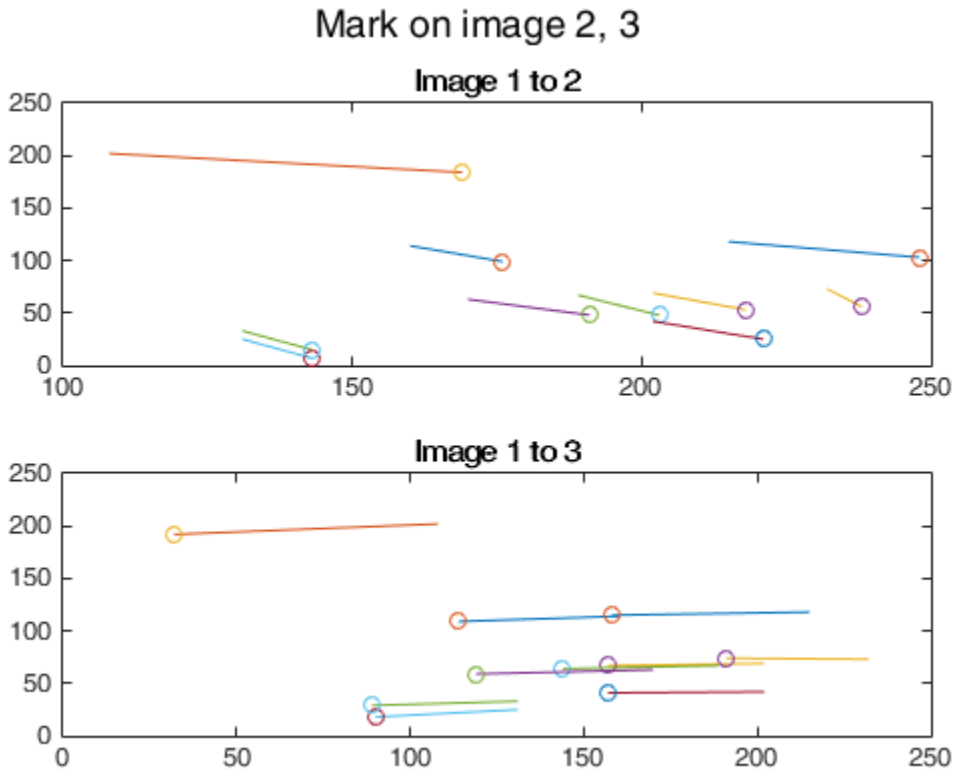
```
xo1 = [160 114; 202 69; 189 67; 202 42; 108 202; 170 63; 131 25; 215
 118; 232 73; 131 33];
xo2 = [176 99; 218 53; 203 48; 221 25; 169 184; 191 48; 143 7; 248
 103; 238 56; 143 15];
xo3 = [114 109; 157 67; 144 64; 157 41; 32 192; 119 59; 90 18; 158
 115; 191 74; 89 29];

figure;
for i = 1:10
    subplot(2,1,1),plot([xo1(i,1) xo2(i,1)],[xo1(i,2) xo2(i,2)]);
 hold on;
    plot(xo2(i,1),xo2(i,2),'o');
    title('Image 1 to 2');
    subplot(2,1,2),plot([xo1(i,1) xo3(i,1)],[xo1(i,2) xo3(i,2)]);
 hold on;
    plot(xo3(i,1),xo3(i,2),'o');
    title('Image 1 to 3');
end
suptitle('Mark on image 2, 3');

% Part B
% All have same jacobian and therefore A matrix.
Jx = [1 0; 0 1];
A = 10*Jx;

% only 2 sets of dx as we only have 2 sets of points
for i = 1: 10
    %indoors
    dxi1(i,1) = xi2(i,1) - xi1(i,1);
    dxi1(i,2) = xi2(i,2) - xi1(i,2);
    dxi2(i,1) = xi3(i,1) - xi1(i,1);
    dxi2(i,2) = xi3(i,2) - xi1(i,2);

    %outdoors
    dxo1(i,1) = xo2(i,1) - xo1(i,1);
    dxo1(i,2) = xo2(i,2) - xo1(i,2);
    dxo2(i,1) = xo3(i,1) - xo1(i,1);
    dxo2(i,2) = xo3(i,2) - xo1(i,2);
end


bi12 = Jx'*(sum(dxi1))'
bi13 = Jx'*(sum(dxi2))'

bo12 = Jx'*(sum(dxo1))'
bo13 = Jx'*(sum(dxo2))'

ip12 = inv(A)*bi12
ip13 = inv(A)*bi13

op12 = inv(A)*bo12
op13 = inv(A)*bo13

ti12 = [1 0 ip12(1); 0 1 ip12(2)];
```

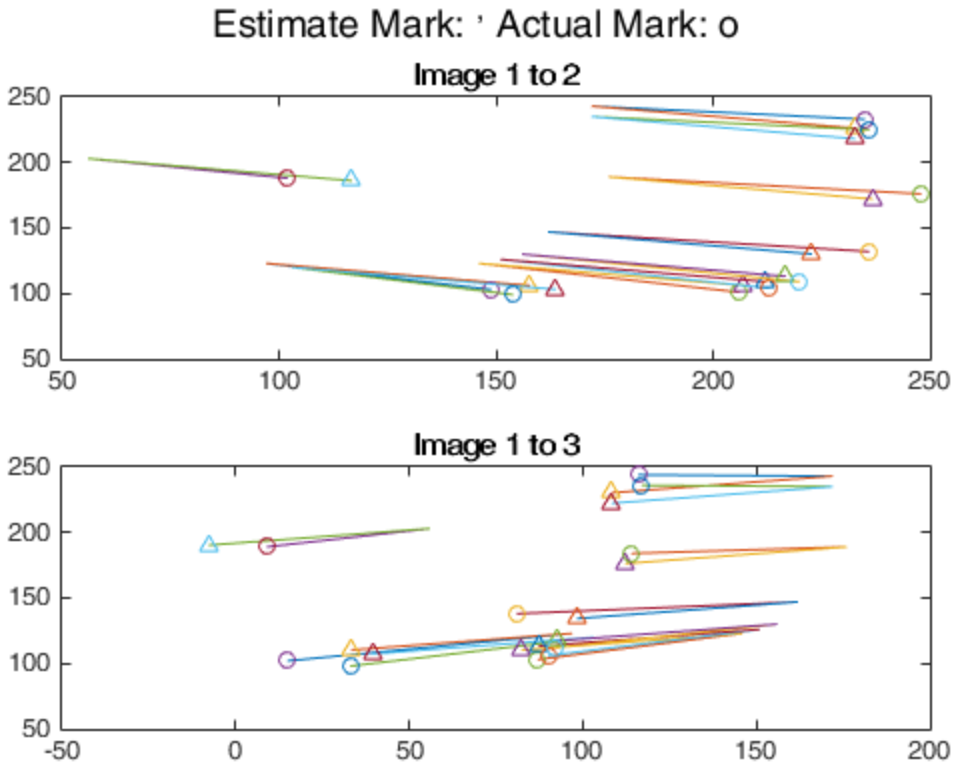
```
ti13 = [1 0 ip13(1); 0 1 ip13(2)];

to12 = [1 0 op12(1); 0 1 op12(2)];
to13 = [1 0 op13(1); 0 1 op13(2)];

figure;
for i = 1:10
    xi1(i,3) = 1;
    xei12(i,:) = ti12*xi1(i,:)';
    xei13(i,:) = ti13*xi1(i,:)';
    subplot(2,1,1),plot([xi1(i,1) xi2(i,1)],[xi1(i,2) xi2(i,2)]);
 hold on;
    plot([xi1(i,1) xei12(i,1)],[xi1(i,2) xei12(i,2)]);
    plot(xei12(i,1),xei12(i,2),'^');
    plot(xi2(i,1),xi2(i,2),'o');
    title('Image 1 to 2');
    subplot(2,1,2),plot([xi1(i,1) xi3(i,1)],[xi1(i,2) xi3(i,2)]);
 hold on;
    plot([xi1(i,1) xei13(i,1)],[xi1(i,2) xei13(i,2)]);
    plot(xei13(i,1),xei13(i,2),'^');
    plot(xi3(i,1),xi3(i,2),'o');
    title('Image 1 to 3');
end
suptitle('Estimate Mark: ^, Actual Mark: o');

figure;
for i = 1:10
    xo1(i,3) = 1;
    xeo12(i,:) = to12*xo1(i,:)';
    xeo13(i,:) = to13*xo1(i,:)';
    subplot(2,1,1),plot([xo1(i,1) xo2(i,1)],[xo1(i,2) xo2(i,2)]);
 hold on;
    plot([xo1(i,1) xeo12(i,1)],[xo1(i,2) xeo12(i,2)]);
    plot(xeo12(i,1),xeo12(i,2),'^');
    plot(xo2(i,1),xo2(i,2),'o');
    title('Image 1 to 2');
    subplot(2,1,2),plot([xo1(i,1) xo3(i,1)],[xo1(i,2) xo3(i,2)]);
 hold on;
    plot([xo1(i,1) xeo13(i,1)],[xo1(i,2) xeo13(i,2)]);
    plot(xeo13(i,1),xeo13(i,2),'^');
    plot(xo3(i,1),xo3(i,2),'o');
    title('Image 1 to 3');
end
suptitle('Estimate Mark: ^, Actual Mark: o');


bi12 =

   608
  -169


bi13 =
```

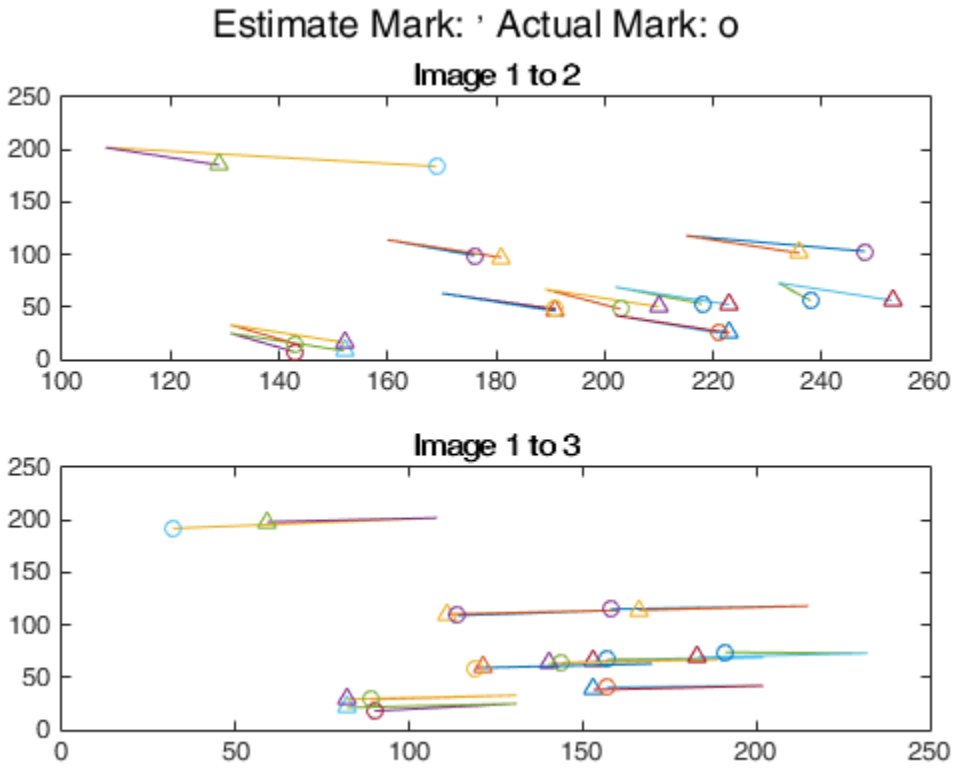
```
   -637
   -127


bo12 =

    210
   -168


bo13 =

   -489
    -38


ip12 =

    60.8000
   -16.9000


ip13 =

   -63.7000
   -12.7000


op12 =

    21.0000
   -16.8000


op13 =

   -48.9000
    -3.8000
```




Mark on image 2, 3
Image 1 to 2
250
200
150
100
50
50
100
150
200
250
Image 1 to 3
250
200
150
100
50
0
20
40
60
80
100
120
140
160
180


Mark on image 2, 3
Image 1 to 2
250
200
150
100
50
0
100
150
200
250
Image 1 to 3
250
200
150
100
50
0
0
50
100
150
200
250


Estimate Mark: ' Actual Mark: o
Image 1 to 2
250
200
150
100
50
50
100
150
200
250
Image 1 to 3
250
200
150
100
50
-50
0
50
100
150
200


Estimate Mark: ' Actual Mark: o
Image 1 to 2
250
200
150
100
50
0
100
120
140
160
180
200
220
240
260
Image 1 to 3
250
200
150
100
50
0
0
50
100
150
200
250

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