

```

clear
clf
%Part 1

%step 1
au=557.0943; av=712.9824; u0=326.3819; v0=298.6679;
f=80;
Tx=100; Ty=0; Tz=1500;
Phix=0.8*pi/2; Phiy=-1.8*pi/2; Phix1=pi/5;
image=zeros(480,640);

%step 2
intrinsics=[au 0 u0 0; 0 av v0 0; 0 0 1 0];
rx=[1 0 0; 0 cos(Phix) -sin(Phix); 0 sin(Phix) cos(Phix)];
ry=[cos(Phiy) 0 sin(Phiy); 0 1 0; -sin(Phiy) 0 cos(Phiy)];
rx1=[1 0 0; 0 cos(Phix1) -sin(Phix1); 0 sin(Phix1) cos(Phix1)];
T=[Tx; Ty; Tz];
extrinsecs=[rx*ry*rx1 T;0 0 0 1];
A_Faugeras=intrinsics*extrinsecs;%Faugeras transformation matrix
A_Faugeras_scale=A_Faugeras/A_Faugeras(3,4);

%step 3
Pw1=[100;100;0;1];Pw2=[400;400;0;1];
Pw3=[100;0;100;1];Pw4=[400;0;400;1];
Pw5=[0;100;100;1];Pw6=[0;400;400;1];

%step 4
Pu1=intrinsics*extrinsecs*Pw1;
Pu2=intrinsics*extrinsecs*Pw2;
Pu3=intrinsics*extrinsecs*Pw3;
Pu4=intrinsics*extrinsecs*Pw4;
Pu5=intrinsics*extrinsecs*Pw5;
Pu6=intrinsics*extrinsecs*Pw6;
Pu1=Pu1/Pu1(3);
Pu2=Pu2/Pu2(3);
Pu3=Pu3/Pu3(3);
Pu4=Pu4/Pu4(3);
Pu5=Pu5/Pu5(3);
Pu6=Pu6/Pu6(3);
Pu1=[Pu1(1);Pu1(2)];
Pu2=[Pu2(1);Pu2(2)];
Pu3=[Pu3(1);Pu3(2)];
Pu4=[Pu4(1);Pu4(2)];
Pu5=[Pu5(1);Pu5(2)];
Pu6=[Pu6(1);Pu6(2)];

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%step 5
figure(1)
hold on
stem(Pu1(1), Pu1(2), 'LineStyle', 'none');
stem(Pu2(1), Pu2(2), 'LineStyle', 'none');
stem(Pu3(1), Pu3(2), 'LineStyle', 'none');
stem(Pu4(1), Pu4(2), 'LineStyle', 'none');
stem(Pu5(1), Pu5(2), 'LineStyle', 'none');
stem(Pu6(1), Pu6(2), 'LineStyle', 'none');
title('2D projection points');
hold off

%step 6
Q1=[Pw1(1) Pw1(2) Pw1(3) 1 0 0 0 0 -Pu1(1)*Pw1(1) -Pu1(1)*Pw1(2) -Pu1(1)*Pw1(3)];
Q2=[0 0 0 0 Pw1(1) Pw1(2) Pw1(3) 1 -Pu1(2)*Pw1(1) -Pu1(2)*Pw1(2) -Pu1(2)*Pw1(3)];
Q3=[Pw2(1) Pw2(2) Pw2(3) 1 0 0 0 0 -Pu2(1)*Pw2(1) -Pu2(1)*Pw2(2) -Pu2(1)*Pw2(3)];
Q4=[0 0 0 0 Pw2(1) Pw2(2) Pw2(3) 1 -Pu2(2)*Pw2(1) -Pu2(2)*Pw2(2) -Pu2(2)*Pw2(3)];
Q5=[Pw3(1) Pw3(2) Pw3(3) 1 0 0 0 0 -Pu3(1)*Pw3(1) -Pu3(1)*Pw3(2) -Pu3(1)*Pw3(3)];
Q6=[0 0 0 0 Pw3(1) Pw3(2) Pw3(3) 1 -Pu3(2)*Pw3(1) -Pu3(2)*Pw3(2) -Pu3(2)*Pw3(3)];
Q7=[Pw4(1) Pw4(2) Pw4(3) 1 0 0 0 0 -Pu4(1)*Pw4(1) -Pu4(1)*Pw4(2) -Pu4(1)*Pw4(3)];
Q8=[0 0 0 0 Pw4(1) Pw4(2) Pw4(3) 1 -Pu4(2)*Pw4(1) -Pu4(2)*Pw4(2) -Pu4(2)*Pw4(3)];
Q9=[Pw5(1) Pw5(2) Pw5(3) 1 0 0 0 0 -Pu5(1)*Pw5(1) -Pu5(1)*Pw5(2) -Pu5(1)*Pw5(3)];
Q10=[0 0 0 0 Pw5(1) Pw5(2) Pw5(3) 1 -Pu5(2)*Pw5(1) -Pu5(2)*Pw5(2) -Pu5(2)*Pw5(3)];
Q11=[Pw6(1) Pw6(2) Pw6(3) 1 0 0 0 0 -Pu6(1)*Pw6(1) -Pu6(1)*Pw6(2) -Pu6(1)*Pw6(3)];
Q12=[0 0 0 0 Pw6(1) Pw6(2) Pw6(3) 1 -Pu6(2)*Pw6(1) -Pu6(2)*Pw6(2) -Pu6(2)*Pw6(3)];
Q=[Q1;Q2;Q3;Q4;Q5;Q6;Q7;Q8;Q9;Q10;Q11;Q12];
B=[Pu1(1);Pu1(2);Pu2(1);Pu2(2);Pu3(1);Pu3(2);Pu4(1);Pu4(2);Pu5(1);Pu5(2);Pu6(1)
);Pu6(2)];
A_Hall=inv(Q'*Q)*Q'*B;
A_Hall_nonoise=[A_Hall(1) A_Hall(2) A_Hall(3) A_Hall(4);A_Hall(5) A_Hall(6)
A_Hall(7) A_Hall(8);A_Hall(9) A_Hall(10) A_Hall(11) 1];

%step 7

%step 8
mu=0;
sigma=0.5102;
Pu1_o=Pu1;
Pu2_o=Pu2;
Pu3_o=Pu3;
Pu4_o=Pu4;
Pu5_o=Pu5;
Pu6_o=Pu6;
Pu1=Pu1+[normrnd(mu, sigma);normrnd(mu, sigma)];

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Pu2=Pu2+[normrnd(mu, sigma);normrnd(mu, sigma)];
Pu3=Pu3+[normrnd(mu, sigma);normrnd(mu, sigma)];
Pu4=Pu4+[normrnd(mu, sigma);normrnd(mu, sigma)];
Pu5=Pu5+[normrnd(mu, sigma);normrnd(mu, sigma)];
Pu6=Pu6+[normrnd(mu, sigma);normrnd(mu, sigma)];
figure(2)
hold on
stem(Pu1(1), Pu1(2), 'LineStyle', 'none');
stem(Pu2(1), Pu2(2), 'LineStyle', 'none');
stem(Pu3(1), Pu3(2), 'LineStyle', 'none');
stem(Pu4(1), Pu4(2), 'LineStyle', 'none');
stem(Pu5(1), Pu5(2), 'LineStyle', 'none');
stem(Pu6(1), Pu6(2), 'LineStyle', 'none');
title('2D projection points with noise');
hold off
Q1=[Pw1(1) Pw1(2) Pw1(3) 1 0 0 0 0 -Pu1(1)*Pw1(1) -Pu1(1)*Pw1(2) -Pu1(1)*Pw1(3)];
Q2=[0 0 0 0 Pw1(1) Pw1(2) Pw1(3) 1 -Pu1(2)*Pw1(1) -Pu1(2)*Pw1(2) -Pu1(2)*Pw1(3)];
Q3=[Pw2(1) Pw2(2) Pw2(3) 1 0 0 0 0 -Pu2(1)*Pw2(1) -Pu2(1)*Pw2(2) -Pu2(1)*Pw2(3)];
Q4=[0 0 0 0 Pw2(1) Pw2(2) Pw2(3) 1 -Pu2(2)*Pw2(1) -Pu2(2)*Pw2(2) -Pu2(2)*Pw2(3)];
Q5=[Pw3(1) Pw3(2) Pw3(3) 1 0 0 0 0 -Pu3(1)*Pw3(1) -Pu3(1)*Pw3(2) -Pu3(1)*Pw3(3)];
Q6=[0 0 0 0 Pw3(1) Pw3(2) Pw3(3) 1 -Pu3(2)*Pw3(1) -Pu3(2)*Pw3(2) -Pu3(2)*Pw3(3)];
Q7=[Pw4(1) Pw4(2) Pw4(3) 1 0 0 0 0 -Pu4(1)*Pw4(1) -Pu4(1)*Pw4(2) -Pu4(1)*Pw4(3)];
Q8=[0 0 0 0 Pw4(1) Pw4(2) Pw4(3) 1 -Pu4(2)*Pw4(1) -Pu4(2)*Pw4(2) -Pu4(2)*Pw4(3)];
Q9=[Pw5(1) Pw5(2) Pw5(3) 1 0 0 0 0 -Pu5(1)*Pw5(1) -Pu5(1)*Pw5(2) -Pu5(1)*Pw5(3)];
Q10=[0 0 0 0 Pw5(1) Pw5(2) Pw5(3) 1 -Pu5(2)*Pw5(1) -Pu5(2)*Pw5(2) -Pu5(2)*Pw5(3)];
Q11=[Pw6(1) Pw6(2) Pw6(3) 1 0 0 0 0 -Pu6(1)*Pw6(1) -Pu6(1)*Pw6(2) -Pu6(1)*Pw6(3)];
Q12=[0 0 0 0 Pw6(1) Pw6(2) Pw6(3) 1 -Pu6(2)*Pw6(1) -Pu6(2)*Pw6(2) -Pu6(2)*Pw6(3)];
Q=[Q1;Q2;Q3;Q4;Q5;Q6;Q7;Q8;Q9;Q10;Q11;Q12];
B=[Pu1(1);Pu1(2);Pu2(1);Pu2(2);Pu3(1);Pu3(2);Pu4(1);Pu4(2);Pu5(1);Pu5(2);Pu6(1)
);Pu6(2)];
A_Hall=inv(Q'*Q)*Q'*B;
A_Hall_noise=[A_Hall(1) A_Hall(2) A_Hall(3) A_Hall(4);A_Hall(5) A_Hall(6)
A_Hall(7) A_Hall(8);A_Hall(9) A_Hall(10) A_Hall(11) 1];

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clear
clf
%Step 9
au=557.0943; av=712.9824; u0=326.3819; v0=298.6679;
f=80;
Tx=100; Ty=0; Tz=1500;
Phix=0.8*pi/2; Phiy=-1.8*pi/2; Phix1=pi/5;
image=zeros(640,480);

intrinsics=[au 0 u0 0; 0 av v0 0; 0 0 1 0];
rx=[1 0 0; 0 cos(Phix) -sin(Phix); 0 sin(Phix) cos(Phix)];
ry=[cos(Phiy) 0 sin(Phiy); 0 1 0; -sin(Phiy) 0 cos(Phiy)];
rx1=[1 0 0; 0 cos(Phix1) -sin(Phix1); 0 sin(Phix1) cos(Phix1)];
T=[Tx; Ty; Tz];
extrinsecs=[rx*ry*rx1 T;0 0 0 1];
A_Faugeras=intrinsics*extrinsecs;

N=100;
a=-480;
b=480;
Pw=a+(b-a)*rand(N,3);% define 3D points
I=ones(N,1);
Pw=[Pw, I];
B=zeros(N,1);
mu=0;
sigma=0.5102;
for i=1:N
    Pu_o(i,:)=(A_Faugeras*Pw(i,:))';%compute 2D projection points for 3D points
    Pu_o(i,:)=Pu_o(i,:)/Pu_o(i,3);%normalization

    figure(1)
    hold on
    stem(Pu_o(i,1),Pu_o(i,2),'LineStyle','none');
    title('2D projection points');
    hold off

    Pu(i,:)=Pu_o(i,:)+[normrnd(mu,sigma) normrnd(mu,sigma) 0];% add Gaussian
noise to the point
    figure(2)
    hold on
    stem(Pu(i,1),Pu(i,2),'LineStyle','none');
    title('2D projection points with noise');
    hold off

    Q(2*i-1,:)= [Pw(i,1) Pw(i,2) Pw(i,3) 1 0 0 0 0 -Pu(i,1)*Pw(i,1) -Pu(i,1)*Pw(i,2)

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-Pu(i, 1)*Pw(i, 3)];
    Q(2*i, :)= [0 0 0 0 Pw(i, 1) Pw(i, 2) Pw(i, 3) 1 -Pu(i, 2)*Pw(i, 1) -Pu(i, 2)*Pw(i, 2)
-Pu(i, 2)*Pw(i, 3)];
    B(2*i-1)=Pu(i, 1);
    B(2*i)=Pu(i, 2);
end
A_Hall=inv(Q'*Q)*Q'*B;
A_Hall_noise=[A_Hall(1) A_Hall(2) A_Hall(3) A_Hall(4);A_Hall(5) A_Hall(6)
A_Hall(7) A_Hall(8);A_Hall(9) A_Hall(10) A_Hall(11) 1];
A_Faugeras_scale=A_Faugeras/A_Faugeras(3, 4);

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clear
clf
%Part2
%Step10
au=557.0943; av=712.9824; u0=326.3819; v0=298.6679;
f=80;
Tx=100; Ty=0; Tz=1500;
Phix=0.8*pi/2; Phiy=-1.8*pi/2; Phix1=pi/5;
image=zeros(640,480);

intrinsics=[au 0 u0 0; 0 av v0 0; 0 0 1 0];
rx=[1 0 0; 0 cos(Phix) -sin(Phix); 0 sin(Phix) cos(Phix)];
ry=[cos(Phiy) 0 sin(Phiy); 0 1 0; -sin(Phiy) 0 cos(Phiy)];
rx1=[1 0 0; 0 cos(Phix1) -sin(Phix1); 0 sin(Phix1) cos(Phix1)];
T=[Tx; Ty; Tz];
extrinsecs=[rx*ry*rx1 T;0 0 0 1];
A_Faugeras_original=intrinsics*extrinsecs;
A_Faugeras_original_scale=A_Faugeras_original/A_Faugeras_original(3,4);

N=6;
a=-480;
b=480;
Pw=a+(b-a)*rand(N,3);
I=ones(N,1);
Pw=[Pw, I];
B=zeros(N,1);
mu=0;
sigma=0.5102;
for i=1:N
    Pu(i,:)=(A_Faugeras_original*Pw(i,:))';
    Pu(i,:)=Pu(i,:)/Pu(i,3);

    figure(1)
    hold on
    stem(Pu(i,1),Pu(i,2),'LineStyle','none');
    title('2D projection points');
    hold off

    Q(2*i-1,:)= [Pw(i,1:3) -Pu(i,1)*Pw(i,1:3) 0 0 0 1 0];
    Q(2*i,:)= [0 0 0 -Pu(i,2)*Pw(i,1:3) Pw(i,1:3) 0 1];
    B(2*i-1)=Pu(i,1);
    B(2*i)=Pu(i,2);
end

X_LS=inv(Q'*Q)*Q'*B;

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T1_LS=X_LS(1:3)';
T2_LS=X_LS(4:6)';
T3_LS=X_LS(7:9)';
C1_LS=X_LS(10);
C2_LS=X_LS(11);
tz_LS=1/sum(T2_LS.^2).^0.5;
u0_LS=T1_LS*T2_LS'/(sum(T2_LS.^2));
v0_LS=T2_LS*T3_LS'*tz_LS^2;
au_LS= sum(cross(T1_LS',T2_LS').^2).^0.5*tz_LS^2;
av_LS= sum(cross(T2_LS',T3_LS').^2).^0.5*tz_LS^2;
r1_LS=(T1_LS-T1_LS*T2_LS'*T2_LS*tz_LS^2)/(tz_LS*sum(cross(T1_LS',T2_LS').^2).^0.5);
r2_LS=(T3_LS-T2_LS*T3_LS'*T2_LS*tz_LS^2)/(tz_LS*sum(cross(T2_LS',T3_LS').^2).^0.5);
r3_LS=T2_LS*tz_LS;
tx_LS=(C1_LS-T1_LS*T2_LS'*tz_LS^2)/(tz_LS*sum(cross(T1_LS',T2_LS').^2).^0.5);
ty_LS=(C2_LS-T2_LS*T3_LS'*tz_LS^2)/(tz_LS*sum(cross(T2_LS',T3_LS').^2).^0.5);

intrinsic_LS=[au_LS 0 u0_LS 0; 0 av_LS v0_LS 0; 0 0 1 0];
T_LS=[tx_LS; ty_LS; tz_LS];
extrinsec_LS=[r1_LS;r2_LS;r3_LS];
extrinsec_LS=[extrinsec_LS T_LS];
extrinsec_LS=[extrinsec_LS;0 0 0 1];
A_Faugeras_LS=intrinsic_LS*extrinsec_LS;
A_Faugeras_LS_scale=A_Faugeras_LS/A_Faugeras_LS(3,4);

[U,S,V] = svd(Q,0);
X_SVD=V*inv(S)*U'*B;
T1_SVD=X_SVD(1:3)';
T2_SVD=X_SVD(4:6)';
T3_SVD=X_SVD(7:9)';
C1_SVD=X_SVD(10);
C2_SVD=X_SVD(11);
tz_SVD=1/sum(T2_SVD.^2).^0.5;
u0_SVD=T1_SVD*T2_SVD'/(sum(T2_SVD.^2));
v0_SVD=T2_SVD*T3_SVD'*tz_SVD^2;
au_SVD= sum(cross(T1_SVD',T2_SVD').^2).^0.5*tz_SVD^2;
av_SVD= sum(cross(T2_SVD',T3_SVD').^2).^0.5*tz_SVD^2;
r1_SVD=(T1_SVD-T1_SVD*T2_SVD'*T2_SVD*tz_SVD^2)/(tz_SVD*sum(cross(T1_SVD',T2_SVD').^2).^0.5);
r2_SVD=(T3_SVD-T2_SVD*T3_SVD'*T2_SVD*tz_SVD^2)/(tz_SVD*sum(cross(T2_SVD',T3_SVD').^2).^0.5);
r3_SVD=T2_SVD*tz_SVD;
tx_SVD=(C1_SVD-T1_SVD*T2_SVD'*tz_SVD^2)/(tz_SVD*sum(cross(T1_SVD',T2_SVD').^2).^0.5);

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ty_SVD=(C2_SVD-T2_SVD*T3_SVD'*tz_SVD^2)/(tz_SVD*sum(cross(T2_SVD', T3_SVD')).^2)
.^0.5);
```

```
intrinsic_SVD=[au_SVD 0 u0_SVD 0; 0 av_SVD v0_SVD 0; 0 0 1 0];
```

```
T_SVD=[tx_SVD; ty_SVD; tz_SVD];
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extrinsecs_SVD=[r1_SVD;r2_SVD;r3_SVD];
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extrinsecs_SVD=[extrinsecs_SVD T_SVD];
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extrinsecs_SVD=[extrinsecs_SVD;0 0 0 1];
```

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A_Faugeras_SVD=intrinsic_SVD*extrinsecs_SVD;
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A_Faugeras_SVD_scale=A_Faugeras_SVD/A_Faugeras_SVD(3,4);
```

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clear
clf
%Part2
%Step11
au=557.0943; av=712.9824; u0=326.3819; v0=298.6679;
f=80;
Tx=100; Ty=0; Tz=1500;
Phix=0.8*pi/2; Phiy=-1.8*pi/2; Phix1=pi/5;
image=zeros(640,480);

intrinsics=[au 0 u0 0; 0 av v0 0; 0 0 1 0];
rx=[1 0 0; 0 cos(Phix) -sin(Phix); 0 sin(Phix) cos(Phix)];
ry=[cos(Phiy) 0 sin(Phiy); 0 1 0; -sin(Phiy) 0 cos(Phiy)];
rx1=[1 0 0; 0 cos(Phix1) -sin(Phix1); 0 sin(Phix1) cos(Phix1)];
T=[Tx; Ty; Tz];
extrinsecs=[rx*ry*rx1 T;0 0 0 1];
A_Faugeras_original=intrinsics*extrinsecs;
A_Faugeras_original_scale=A_Faugeras_original/A_Faugeras_original(3,4);

N=6;
a=-480;
b=480;
Pw=a+(b-a)*rand(N,3);
I=ones(N,1);
Pw=[Pw, I];
B=zeros(N,1);

mu=0;
signal=0.5102;
sigma2=2*signal;
sigma3=3*signal;
sigma=signal;

for i=1:N
    Pu_o(i,:)=(A_Faugeras_original*Pw(i,:))';
    Pu_o(i,:)=Pu_o(i,:)/Pu_o(i,3);

    figure(1)
    hold on
    stem(Pu_o(i,1),Pu_o(i,2),'LineStyle','none');
    title('2D projection points');
    hold off

    Pu(i,:)=Pu_o(i,:)+[normrnd(mu,sigma) normrnd(mu,sigma) 0];
    figure(2)

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hold on
stem(Pu(i, 1), Pu(i, 2), 'LineStyle', 'none');
title('2D projection points with noise');
hold off

Q_Hall(2*i-1, :)= [Pw(i, 1:3) 1 0 0 0 0 -Pu_o(i, 1)*Pw(i, 1:3)];
Q_Hall(2*i, :)= [0 0 0 0 Pw(i, 1:3) 1 -Pu_o(i, 2)*Pw(i, 1:3)];
Q_Hall_noise(2*i-1, :)= [Pw(i, 1:3) 1 0 0 0 0 -Pu(i, 1)*Pw(i, 1:3)];
Q_Hall_noise(2*i, :)= [0 0 0 0 Pw(i, 1:3) 1 -Pu(i, 2)*Pw(i, 1:3)];

Q_Faugeras(2*i-1, :)= [Pw(i, 1:3) -Pu_o(i, 1)*Pw(i, 1:3) 0 0 0 1 0];
Q_Faugeras(2*i, :)= [0 0 0 -Pu_o(i, 2)*Pw(i, 1:3) Pw(i, 1:3) 0 1];
Q_Faugeras_noise(2*i-1, :)= [Pw(i, 1:3) -Pu(i, 1)*Pw(i, 1:3) 0 0 0 1 0];
Q_Faugeras_noise(2*i, :)= [0 0 0 -Pu(i, 2)*Pw(i, 1:3) Pw(i, 1:3) 0 1];

B(2*i-1)=Pu(i, 1);
B(2*i)=Pu(i, 2);
end

A_Hall=inv(Q_Hall'*Q_Hall)*Q_Hall'*B;
A_Hall=[A_Hall(1) A_Hall(2) A_Hall(3) A_Hall(4);A_Hall(5) A_Hall(6) A_Hall(7)
A_Hall(8);A_Hall(9) A_Hall(10) A_Hall(11) 1];
A_Hall_noise=inv(Q_Hall_noise'*Q_Hall_noise)*Q_Hall_noise'*B;
A_Hall_noise=[A_Hall_noise(1) A_Hall_noise(2) A_Hall_noise(3)
A_Hall_noise(4);A_Hall_noise(5) A_Hall_noise(6) A_Hall_noise(7)
A_Hall_noise(8);A_Hall_noise(9) A_Hall_noise(10) A_Hall_noise(11) 1];

X_Faugeras_noise_LS=inv(Q_Faugeras_noise'*Q_Faugeras_noise)*Q_Faugeras_noise'*
B;
T1_Faugeras_noise_LS=X_Faugeras_noise_LS(1:3)';
T2_Faugeras_noise_LS=X_Faugeras_noise_LS(4:6)';
T3_Faugeras_noise_LS=X_Faugeras_noise_LS(7:9)';
C1_Faugeras_noise_LS=X_Faugeras_noise_LS(10);
C2_Faugeras_noise_LS=X_Faugeras_noise_LS(11);
tz_Faugeras_noise_LS=1/sum(T2_Faugeras_noise_LS.^2).^0.5;
u0_Faugeras_noise_LS=T1_Faugeras_noise_LS*T2_Faugeras_noise_LS'/(sum(T2_Faugeras_noise_LS.^2));
v0_Faugeras_noise_LS=T2_Faugeras_noise_LS*T3_Faugeras_noise_LS'*tz_Faugeras_noise_LS^2;
au_Faugeras_noise_LS=
sum(cross(T1_Faugeras_noise_LS', T2_Faugeras_noise_LS').^2).^0.5*tz_Faugeras_noise_LS^2;
av_Faugeras_noise_LS=
sum(cross(T2_Faugeras_noise_LS', T3_Faugeras_noise_LS').^2).^0.5*tz_Faugeras_noise_LS^2;

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ise_LS^2;
r1_Faugeras_noise_LS=(T1_Faugeras_noise_LS-T1_Faugeras_noise_LS*T2_Faugeras_no
ise_LS'*T2_Faugeras_noise_LS*tz_Faugeras_noise_LS^2)/(tz_Faugeras_noise_LS*sum
(cross(T1_Faugeras_noise_LS',T2_Faugeras_noise_LS').^2).^0.5);
r2_Faugeras_noise_LS=(T3_Faugeras_noise_LS-T2_Faugeras_noise_LS*T3_Faugeras_no
ise_LS'*T2_Faugeras_noise_LS*tz_Faugeras_noise_LS^2)/(tz_Faugeras_noise_LS*sum
(cross(T2_Faugeras_noise_LS',T3_Faugeras_noise_LS').^2).^0.5);
r3_Faugeras_noise_LS=T2_Faugeras_noise_LS*tz_Faugeras_noise_LS;
tx_Faugeras_noise_LS=(C1_Faugeras_noise_LS-T1_Faugeras_noise_LS*T2_Faugeras_no
ise_LS'*tz_Faugeras_noise_LS^2)/(tz_Faugeras_noise_LS*sum(cross(T1_Faugeras_no
ise_LS',T2_Faugeras_noise_LS').^2).^0.5);
ty_Faugeras_noise_LS=(C2_Faugeras_noise_LS-T2_Faugeras_noise_LS*T3_Faugeras_no
ise_LS'*tz_Faugeras_noise_LS^2)/(tz_Faugeras_noise_LS*sum(cross(T2_Faugeras_no
ise_LS',T3_Faugeras_noise_LS').^2).^0.5);

```

```

intrinsic_Faugeras_noise_LS=[au_Faugeras_noise_LS 0 u0_Faugeras_noise_LS 0; 0
av_Faugeras_noise_LS v0_Faugeras_noise_LS 0; 0 0 1 0];
T_Faugeras_noise_LS=[tx_Faugeras_noise_LS; ty_Faugeras_noise_LS;
tz_Faugeras_noise_LS];
extrinsecs_Faugeras_noise_LS=[r1_Faugeras_noise_LS;r2_Faugeras_noise_LS;r3_Fau
geras_noise_LS];
extrinsecs_Faugeras_noise_LS=[extrinsecs_Faugeras_noise_LS
T_Faugeras_noise_LS];
extrinsecs_Faugeras_noise_LS=[extrinsecs_Faugeras_noise_LS;0 0 0 1];
A_Faugeras_noise_LS=intrinsic_Faugeras_noise_LS*extrinsecs_Faugeras_noise_LS;
A_Faugeras_noise_LS_scale=A_Faugeras_noise_LS/A_Faugeras_noise_LS(3,4);

```

```

X_Faugeras_LS=inv(Q_Faugeras'*Q_Faugeras)*Q_Faugeras'*B;
T1_Faugeras_LS=X_Faugeras_LS(1:3)';
T2_Faugeras_LS=X_Faugeras_LS(4:6)';
T3_Faugeras_LS=X_Faugeras_LS(7:9)';
C1_Faugeras_LS=X_Faugeras_LS(10);
C2_Faugeras_LS=X_Faugeras_LS(11);
tz_Faugeras_LS=1/sum(T2_Faugeras_LS.^2).^0.5;
u0_Faugeras_LS=T1_Faugeras_LS*T2_Faugeras_LS'/(sum(T2_Faugeras_LS.^2));
v0_Faugeras_LS=T2_Faugeras_LS*T3_Faugeras_LS'*tz_Faugeras_LS^2;
au_Faugeras_LS=
sum(cross(T1_Faugeras_LS',T2_Faugeras_LS').^2).^0.5*tz_Faugeras_LS^2;
av_Faugeras_LS=
sum(cross(T2_Faugeras_LS',T3_Faugeras_LS').^2).^0.5*tz_Faugeras_LS^2;
r1_Faugeras_LS=(T1_Faugeras_LS-T1_Faugeras_LS*T2_Faugeras_LS'*T2_Faugeras_LS*t
z_Faugeras_LS^2)/(tz_Faugeras_LS*sum(cross(T1_Faugeras_LS',T2_Faugeras_LS').^2
).^0.5);
r2_Faugeras_LS=(T3_Faugeras_LS-T2_Faugeras_LS*T3_Faugeras_LS'*T2_Faugeras_LS*t
z_Faugeras_LS^2)/(tz_Faugeras_LS*sum(cross(T2_Faugeras_LS',T3_Faugeras_LS').^2

```

```

). ^0.5);
r3_Faugeras_LS=T2_Faugeras_LS*tz_Faugeras_LS;
tx_Faugeras_LS=(C1_Faugeras_LS-T1_Faugeras_LS*T2_Faugeras_LS'*tz_Faugeras_LS^2
)/(tz_Faugeras_LS*sum(cross(T1_Faugeras_LS',T2_Faugeras_LS').^2).^0.5);
ty_Faugeras_LS=(C2_Faugeras_LS-T2_Faugeras_LS*T3_Faugeras_LS'*tz_Faugeras_LS^2
)/(tz_Faugeras_LS*sum(cross(T2_Faugeras_LS',T3_Faugeras_LS').^2).^0.5);

intrinsic_Faugeras_LS=[au_Faugeras_LS 0 u0_Faugeras_LS 0; 0 av_Faugeras_LS
v0_Faugeras_LS 0; 0 0 1 0];
T_Faugeras_LS=[tx_Faugeras_LS; ty_Faugeras_LS; tz_Faugeras_LS];
extrinsec_Faugeras_LS=[r1_Faugeras_LS;r2_Faugeras_LS;r3_Faugeras_LS];
extrinsec_Faugeras_LS=[extrinsec_Faugeras_LS T_Faugeras_LS];
extrinsec_Faugeras_LS=[extrinsec_Faugeras_LS;0 0 0 1];
A_Faugeras_LS=intrinsic_Faugeras_LS*extrinsec_Faugeras_LS;
A_Faugeras_LS_scale=A_Faugeras_LS/A_Faugeras_LS(3,4);

[U,S,V] = svd(Q_Faugeras,0);
X_Faugeras_SVD=V*inv(S)*U'*B;
T1_Faugeras_SVD=X_Faugeras_SVD(1:3)';
T2_Faugeras_SVD=X_Faugeras_SVD(4:6)';
T3_Faugeras_SVD=X_Faugeras_SVD(7:9)';
C1_Faugeras_SVD=X_Faugeras_SVD(10);
C2_Faugeras_SVD=X_Faugeras_SVD(11);
tz_Faugeras_SVD=1/sum(T2_Faugeras_SVD.^2).^0.5;
u0_Faugeras_SVD=T1_Faugeras_SVD*T2_Faugeras_SVD'/(sum(T2_Faugeras_SVD.^2));
v0_Faugeras_SVD=T2_Faugeras_SVD*T3_Faugeras_SVD'*tz_Faugeras_SVD^2;
au_Faugeras_SVD=
sum(cross(T1_Faugeras_SVD',T2_Faugeras_SVD').^2).^0.5*tz_Faugeras_SVD^2;
av_Faugeras_SVD=
sum(cross(T2_Faugeras_SVD',T3_Faugeras_SVD').^2).^0.5*tz_Faugeras_SVD^2;
r1_Faugeras_SVD=(T1_Faugeras_SVD-T1_Faugeras_SVD*T2_Faugeras_SVD'*T2_Faugeras_
SVD*tz_Faugeras_SVD^2)/(tz_Faugeras_SVD*sum(cross(T1_Faugeras_SVD',T2_Faugeras_
_SVD').^2).^0.5);
r2_Faugeras_SVD=(T3_Faugeras_SVD-T2_Faugeras_SVD*T3_Faugeras_SVD'*T2_Faugeras_
SVD*tz_Faugeras_SVD^2)/(tz_Faugeras_SVD*sum(cross(T2_Faugeras_SVD',T3_Faugeras_
_SVD').^2).^0.5);
r3_Faugeras_SVD=T2_Faugeras_SVD*tz_Faugeras_SVD;
tx_Faugeras_SVD=(C1_Faugeras_SVD-T1_Faugeras_SVD*T2_Faugeras_SVD'*tz_Faugeras_
SVD^2)/(tz_Faugeras_SVD*sum(cross(T1_Faugeras_SVD',T2_Faugeras_SVD').^2).^0.5)
;
ty_Faugeras_SVD=(C2_Faugeras_SVD-T2_Faugeras_SVD*T3_Faugeras_SVD'*tz_Faugeras_
SVD^2)/(tz_Faugeras_SVD*sum(cross(T2_Faugeras_SVD',T3_Faugeras_SVD').^2).^0.5)
;

intrinsic_Faugeras_SVD=[au_Faugeras_SVD 0 u0_Faugeras_SVD 0; 0 av_Faugeras_SVD

```

```

v0_Faugeras_SVD=[0; 0 0 1 0];
T_Faugeras_SVD=[tx_Faugeras_SVD; ty_Faugeras_SVD; tz_Faugeras_SVD];
extrinsecs_Faugeras_SVD=[r1_Faugeras_SVD;r2_Faugeras_SVD;r3_Faugeras_SVD];
extrinsecs_Faugeras_SVD=[extrinsecs_Faugeras_SVD T_Faugeras_SVD];
extrinsecs_Faugeras_SVD=[extrinsecs_Faugeras_SVD;0 0 0 1];
A_Faugeras_SVD=intrinsics_Faugeras_SVD*extrinsecs_Faugeras_SVD;
A_Faugeras_SVD_scale=A_Faugeras_SVD/A_Faugeras_SVD(3,4);

[U,S,V]=svd(Q_Faugeras_noise,0);
X_Faugeras_noise_SVD=V*inv(S)*U'*B;
T1_Faugeras_noise_SVD=X_Faugeras_noise_SVD(1:3)';
T2_Faugeras_noise_SVD=X_Faugeras_noise_SVD(4:6)';
T3_Faugeras_noise_SVD=X_Faugeras_noise_SVD(7:9)';
C1_Faugeras_noise_SVD=X_Faugeras_noise_SVD(10);
C2_Faugeras_noise_SVD=X_Faugeras_noise_SVD(11);
tz_Faugeras_noise_SVD=1/sum(T2_Faugeras_noise_SVD.^2).^0.5;
u0_Faugeras_noise_SVD=T1_Faugeras_noise_SVD*T2_Faugeras_noise_SVD'/(sum(T2_Faugeras_noise_SVD.^2));
v0_Faugeras_noise_SVD=T2_Faugeras_noise_SVD*T3_Faugeras_noise_SVD'*tz_Faugeras_noise_SVD^2;
au_Faugeras_noise_SVD=
sum(cross(T1_Faugeras_noise_SVD',T2_Faugeras_noise_SVD').^2).^0.5*tz_Faugeras_noise_SVD^2;
av_Faugeras_noise_SVD=
sum(cross(T2_Faugeras_noise_SVD',T3_Faugeras_noise_SVD').^2).^0.5*tz_Faugeras_noise_SVD^2;
r1_Faugeras_noise_SVD=(T1_Faugeras_noise_SVD-T1_Faugeras_noise_SVD*T2_Faugeras_noise_SVD'*T2_Faugeras_noise_SVD*tz_Faugeras_noise_SVD^2)/(tz_Faugeras_noise_SVD*sum(cross(T1_Faugeras_noise_SVD',T2_Faugeras_noise_SVD').^2).^0.5);
r2_Faugeras_noise_SVD=(T3_Faugeras_noise_SVD-T2_Faugeras_noise_SVD*T3_Faugeras_noise_SVD'*T2_Faugeras_noise_SVD*tz_Faugeras_noise_SVD^2)/(tz_Faugeras_noise_SVD*sum(cross(T2_Faugeras_noise_SVD',T3_Faugeras_noise_SVD').^2).^0.5);
r3_Faugeras_noise_SVD=T2_Faugeras_noise_SVD*tz_Faugeras_noise_SVD;
tx_Faugeras_noise_SVD=(C1_Faugeras_noise_SVD-T1_Faugeras_noise_SVD*T2_Faugeras_noise_SVD'*tz_Faugeras_noise_SVD^2)/(tz_Faugeras_noise_SVD*sum(cross(T1_Faugeras_noise_SVD',T2_Faugeras_noise_SVD').^2).^0.5);
ty_Faugeras_noise_SVD=(C2_Faugeras_noise_SVD-T2_Faugeras_noise_SVD*T3_Faugeras_noise_SVD'*tz_Faugeras_noise_SVD^2)/(tz_Faugeras_noise_SVD*sum(cross(T2_Faugeras_noise_SVD',T3_Faugeras_noise_SVD').^2).^0.5);

intrinsics_Faugeras_noise_SVD=[au_Faugeras_noise_SVD 0 u0_Faugeras_noise_SVD 0;
0 av_Faugeras_noise_SVD v0_Faugeras_noise_SVD 0; 0 0 1 0];
T_Faugeras_noise_SVD=[tx_Faugeras_noise_SVD; ty_Faugeras_noise_SVD;
tz_Faugeras_noise_SVD];
extrinsecs_Faugeras_noise_SVD=[r1_Faugeras_noise_SVD;r2_Faugeras_noise_SVD;r3_

```

```
Faugeras_noise_SVD];  
extrinsecs_Faugeras_noise_SVD=[extrinsecs_Faugeras_noise_SVD  
T_Faugeras_noise_SVD];  
extrinsecs_Faugeras_noise_SVD=[extrinsecs_Faugeras_noise_SVD;0 0 0 1];  
A_Faugeras_noise_SVD=intrinsics_Faugeras_noise_SVD*extrinsecs_Faugeras_noise_S  
VD;  
A_Faugeras_noise_SVD_scale=A_Faugeras_noise_SVD/A_Faugeras_noise_SVD(3,4);
```

```

clear
clf
cla
%Part 3
%step 12
au=557.0943; av=712.9824; u0=326.3819; v0=298.6679;
f=80;
Tx=100; Ty=0; Tz=1500;
Phix=0.8*pi/2; Phiy=-1.8*pi/2; Phix1=pi/5;
image=zeros(640,480);

intrinsics=[au 0 u0 0; 0 av v0 0; 0 0 1 0];
rx=[1 0 0; 0 cos(Phix) -sin(Phix); 0 sin(Phix) cos(Phix)];
ry=[cos(Phiy) 0 sin(Phiy); 0 1 0; -sin(Phiy) 0 cos(Phiy)];
rx1=[1 0 0; 0 cos(Phix1) -sin(Phix1); 0 sin(Phix1) cos(Phix1)];
T=[Tx; Ty; Tz];
extrinsecs=[rx*ry*rx1 T;0 0 0 1];
A_Faugeras_original=intrinsics*extrinsecs;
A_Faugeras_original_scale=A_Faugeras_original/A_Faugeras_original(3,4);

figure(1)
hold on
grid on

xlim([-500 500]);
ylim([-900 500]);
zlim([-500 1300]);
xlabel('x');
ylabel('y');
zlabel('z');
x_aix_w=[100 0 0]';
y_aix_w=[0 100 0]';
z_aix_w=[0 0 100]';
o_w=[0 0 0 1]';
quiver3(o_w(1),o_w(2),o_w(3),x_aix_w(1),x_aix_w(2),x_aix_w(3),'Color','r','LineWidth',2);
quiver3(o_w(1),o_w(2),o_w(3),y_aix_w(1),y_aix_w(2),y_aix_w(3),'Color','r','LineWidth',2);
quiver3(o_w(1),o_w(2),o_w(3),z_aix_w(1),z_aix_w(2),z_aix_w(3),'Color','r','LineWidth',2);
text(o_w(1),o_w(2),o_w(3),'World Coordinate System');
text(x_aix_w(1),x_aix_w(2),x_aix_w(3),'x');
text(y_aix_w(1),y_aix_w(2),y_aix_w(3),'y');

```

```
text(z_aix_w(1),z_aix_w(2),z_aix_w(3),'z');
```

```
o_c_ctow=inv(extrinsec)*[0 0 0 1]';  
x_aix_c=[100 0 0 1]';  
y_aix_c=[0 100 0 1]';  
z_aix_c=[0 0 100 1]';  
x_aix_ctow=inv(extrinsec)*x_aix_c;  
y_aix_ctow=inv(extrinsec)*y_aix_c;  
z_aix_ctow=inv(extrinsec)*z_aix_c;  
line([o_w(1) o_c_ctow(1)], [o_w(2) o_c_ctow(2)], [o_w(3)  
o_c_ctow(3)], 'Color', 'b', 'LineWidth', 1);  
line([o_c_ctow(1) x_aix_ctow(1)], [o_c_ctow(2) x_aix_ctow(2)], [o_c_ctow(3)  
x_aix_ctow(3)], 'Color', [0.98 0.42 0.08], 'LineWidth', 2);  
line([o_c_ctow(1) y_aix_ctow(1)], [o_c_ctow(2) y_aix_ctow(2)], [o_c_ctow(3)  
y_aix_ctow(3)], 'Color', [0.97 0.42 0.08], 'LineWidth', 2);  
line([o_c_ctow(1) z_aix_ctow(1)], [o_c_ctow(2) z_aix_ctow(2)], [o_c_ctow(3)  
z_aix_ctow(3)], 'Color', [0.97 0.42 0.08], 'LineWidth', 2);  
text(o_c_ctow(1),o_c_ctow(2),o_c_ctow(3),'Camera Coordinate System');  
text(x_aix_ctow(1),x_aix_ctow(2),x_aix_ctow(3),'x');  
text(y_aix_ctow(1),y_aix_ctow(2),y_aix_ctow(3),'y');  
text(z_aix_ctow(1),z_aix_ctow(2),z_aix_ctow(3),'z');
```

```
view([2 1 3])
```

```
o_i=[-640 -480 1]';  
o_i_itoc(1)=f*(o_i(1)-u0)/au;  
o_i_itoc(2)=f*(o_i(2)-v0)/av;  
o_i_itoc(3)=f;  
a_i=[-640 2*480 1]';  
a_i_itoc(1)=f*(a_i(1)-u0)/au;  
a_i_itoc(2)=f*(a_i(2)-v0)/av;  
a_i_itoc(3)=f;  
b_i=[640*2 480*2 1]';  
b_i_itoc(1)=f*(b_i(1)-u0)/au;  
b_i_itoc(2)=f*(b_i(2)-v0)/av;  
b_i_itoc(3)=f;  
c_i=[640*2 -480 1]';  
c_i_itoc(1)=f*(c_i(1)-u0)/au;  
c_i_itoc(2)=f*(c_i(2)-v0)/av;  
c_i_itoc(3)=f;  
o_i_itow=inv(extrinsec)*[o_i_itoc 1]';
```

```

a_i_itow=inv(extrinsecs)*[a_i_itoc 1]';
b_i_itow=inv(extrinsecs)*[b_i_itoc 1]';
c_i_itow=inv(extrinsecs)*[c_i_itoc 1]';
line([o_i_itow(1) a_i_itow(1)], [o_i_itow(2) a_i_itow(2)], [o_i_itow(3)
a_i_itow(3)], 'Color', 'b', 'LineWidth', 1);
line([o_i_itow(1) c_i_itow(1)], [o_i_itow(2) c_i_itow(2)], [o_i_itow(3)
c_i_itow(3)], 'Color', 'b', 'LineWidth', 1);
line([b_i_itow(1) c_i_itow(1)], [b_i_itow(2) c_i_itow(2)], [b_i_itow(3)
c_i_itow(3)], 'Color', 'b', 'LineWidth', 1);
line([b_i_itow(1) a_i_itow(1)], [b_i_itow(2) a_i_itow(2)], [b_i_itow(3)
a_i_itow(3)], 'Color', 'b', 'LineWidth', 1);
text(o_i_itow(1), o_i_itow(2), o_i_itow(3), 'Image Plane');

o_c_projection(1)=0;
o_c_projection(2)=0;
o_c_projection(3)=f;
o_c_projection_itow=inv(extrinsecs)*[o_c_projection 1]';
plot3(o_c_projection_itow(1), o_c_projection_itow(2), o_c_projection_itow(3), '.',
'color', [0.63 0.07 0.98], 'MarkerSize', 10);
line([o_c_ctow(1) o_c_projection_itow(1)], [o_c_ctow(2)
o_c_projection_itow(2)], [o_c_ctow(3) o_c_projection_itow(3)], 'Color', [0.63 0.07
0.98], 'LineWidth', 2);

N=10;
a=-480;
b=480;
Pw=a+(b-a)*rand(N, 3); % define 3D points
I=ones(N, 1);
Pw=[Pw, I];
B=zeros(N, 1);
mu=0;
sigma=0.5102;
for i=1:N
    Pu_o(i, :)=(A_Faugeras_original*Pw(i, :))'; %compute 2D projection points for
3D points
    Pu_o(i, :)=Pu_o(i, :)/Pu_o(i, 3); %normalization
    Pu_o_i_itoc(i, 1)=f*(Pu_o(i, 1)-u0)/au;
    Pu_o_i_itoc(i, 2)=f*(Pu_o(i, 2)-v0)/av;
    Pu_o_i_itoc(i, 3)=f;
    Pu_o_i_itoc(i, 4)=1;
    Pu_i_itow(i, :)=inv(extrinsecs)*Pu_o_i_itoc(i, :);
    plot3(Pu_i_itow(i, 1), Pu_i_itow(i, 2), Pu_i_itow(i, 3), '.', 'color', [0.674
0.164 0.2], 'MarkerSize', 5);
    line([o_c_ctow(1) Pw(i, 1)], [o_c_ctow(2) Pw(i, 2)], [o_c_ctow(3)
Pw(i, 3)], 'Color', [0.674 0.164 0.2], 'LineWidth', 1);

```

```
end
```

```
figure(2)
```

```
hold on
```

```
grid on
```

```
view([1 4 7])
```

```
xlim([-300 300]);
```

```
ylim([-1000 -600]);
```

```
zlim([700 1300]);
```

```
xlabel('x');
```

```
ylabel('y');
```

```
zlabel('z');
```

```
x_aix_w=[100 0 0]';
```

```
y_aix_w=[0 100 0]';
```

```
z_aix_w=[0 0 100]';
```

```
o_w=[0 0 0 1]';
```

```
quiver3(o_w(1),o_w(2),o_w(3),x_aix_w(1),x_aix_w(2),x_aix_w(3),'Color','r','LineWidth',2);
```

```
quiver3(o_w(1),o_w(2),o_w(3),y_aix_w(1),y_aix_w(2),y_aix_w(3),'Color','r','LineWidth',2);
```

```
quiver3(o_w(1),o_w(2),o_w(3),z_aix_w(1),z_aix_w(2),z_aix_w(3),'Color','r','LineWidth',2);
```

```
text(o_w(1),o_w(2),o_w(3),'World Coordinate System');
```

```
text(x_aix_w(1),x_aix_w(2),x_aix_w(3),'x');
```

```
text(y_aix_w(1),y_aix_w(2),y_aix_w(3),'y');
```

```
text(z_aix_w(1),z_aix_w(2),z_aix_w(3),'z');
```

```
o_c_ctow=inv(extrinsec)*[0 0 0 1]';
```

```
x_aix_c=[100 0 0 1]';
```

```
y_aix_c=[0 100 0 1]';
```

```
z_aix_c=[0 0 100 1]';
```

```
x_aix_ctow=inv(extrinsec)*x_aix_c;
```

```
y_aix_ctow=inv(extrinsec)*y_aix_c;
```

```
z_aix_ctow=inv(extrinsec)*z_aix_c;
```

```
line([o_w(1) o_c_ctow(1)], [o_w(2) o_c_ctow(2)], [o_w(3) o_c_ctow(3)], 'Color', 'b', 'LineWidth', 1);
```

```
line([o_c_ctow(1) x_aix_ctow(1)], [o_c_ctow(2) x_aix_ctow(2)], [o_c_ctow(3) x_aix_ctow(3)], 'Color', [0.98 0.42 0.08], 'LineWidth', 2);
```

```
line([o_c_ctow(1) y_aix_ctow(1)], [o_c_ctow(2) y_aix_ctow(2)], [o_c_ctow(3) y_aix_ctow(3)], 'Color', [0.97 0.42 0.08], 'LineWidth', 2);
```

```

line([o_c_ctow(1) z_aix_ctow(1)], [o_c_ctow(2) z_aix_ctow(2)], [o_c_ctow(3)
z_aix_ctow(3)], 'Color', [0.97 0.42 0.08], 'LineWidth', 2);
text(o_c_ctow(1), o_c_ctow(2), o_c_ctow(3), 'Camera Coordinate System');
text(x_aix_ctow(1), x_aix_ctow(2), x_aix_ctow(3), 'x');
text(y_aix_ctow(1), y_aix_ctow(2), y_aix_ctow(3), 'y');
text(z_aix_ctow(1), z_aix_ctow(2), z_aix_ctow(3), 'z');

```

```

o_i=[-640 -480 1]';
o_i_itoc(1)=f*(o_i(1)-u0)/au;
o_i_itoc(2)=f*(o_i(2)-v0)/av;
o_i_itoc(3)=f;
a_i=[-640 2*480 1]';
a_i_itoc(1)=f*(a_i(1)-u0)/au;
a_i_itoc(2)=f*(a_i(2)-v0)/av;
a_i_itoc(3)=f;
b_i=[640*2 480*2 1]';
b_i_itoc(1)=f*(b_i(1)-u0)/au;
b_i_itoc(2)=f*(b_i(2)-v0)/av;
b_i_itoc(3)=f;
c_i=[640*2 -480 1]';
c_i_itoc(1)=f*(c_i(1)-u0)/au;
c_i_itoc(2)=f*(c_i(2)-v0)/av;
c_i_itoc(3)=f;
o_i_itow=inv(extrinsecs)*[o_i_itoc 1]';
a_i_itow=inv(extrinsecs)*[a_i_itoc 1]';
b_i_itow=inv(extrinsecs)*[b_i_itoc 1]';
c_i_itow=inv(extrinsecs)*[c_i_itoc 1]';
line([o_i_itow(1) a_i_itow(1)], [o_i_itow(2) a_i_itow(2)], [o_i_itow(3)
a_i_itow(3)], 'Color', 'b', 'LineWidth', 1);
line([o_i_itow(1) c_i_itow(1)], [o_i_itow(2) c_i_itow(2)], [o_i_itow(3)
c_i_itow(3)], 'Color', 'b', 'LineWidth', 1);
line([b_i_itow(1) c_i_itow(1)], [b_i_itow(2) c_i_itow(2)], [b_i_itow(3)
c_i_itow(3)], 'Color', 'b', 'LineWidth', 1);
line([b_i_itow(1) a_i_itow(1)], [b_i_itow(2) a_i_itow(2)], [b_i_itow(3)
a_i_itow(3)], 'Color', 'b', 'LineWidth', 1);
text(o_i_itow(1), o_i_itow(2), o_i_itow(3), 'Image Plane');

o_c_projection(1)=0;
o_c_projection(2)=0;
o_c_projection(3)=f;
o_c_projection_itow=inv(extrinsecs)*[o_c_projection 1]';
plot3(o_c_projection_itow(1), o_c_projection_itow(2), o_c_projection_itow(3), '.',
'color', [0.63 0.07 0.98], 'MarkerSize', 10);

```

```

line([o_c_ctow(1) o_c_projection_itow(1)], [o_c_ctow(2)
o_c_projection_itow(2)], [o_c_ctow(3) o_c_projection_itow(3)], 'Color', [0.63 0.07
0.98], 'LineWidth', 2);

N=10;
a=-480;
b=480;
Pw=a+(b-a)*rand(N,3);% define 3D points
I=ones(N,1);
Pw=[Pw, I];
B=zeros(N,1);
mu=0;
sigma=0.5102;
for i=1:N
    Pu_o(i,:)=(A_Faugeras_original*Pw(i,:))';%compute 2D projection points for
3D points
    Pu_o(i,:)=Pu_o(i,:)/Pu_o(i,3);%normalization
    Pu_o_i_itoc(i,1)=f*(Pu_o(i,1)-u0)/au;
    Pu_o_i_itoc(i,2)=f*(Pu_o(i,2)-v0)/av;
    Pu_o_i_itoc(i,3)=f;
    Pu_o_i_itoc(i,4)=1;
    Pu_i_itow(i,:)=inv(extrinsecs)*Pu_o_i_itoc(i,:);
    plot3(Pu_i_itow(i,1),Pu_i_itow(i,2),Pu_i_itow(i,3),'.','color',[0.674
0.164 0.2], 'MarkerSize', 5);
    line([o_c_ctow(1) Pw(i,1)], [o_c_ctow(2) Pw(i,2)], [o_c_ctow(3)
Pw(i,3)], 'Color', [0.674 0.164 0.2], 'LineWidth', 1);
end

```