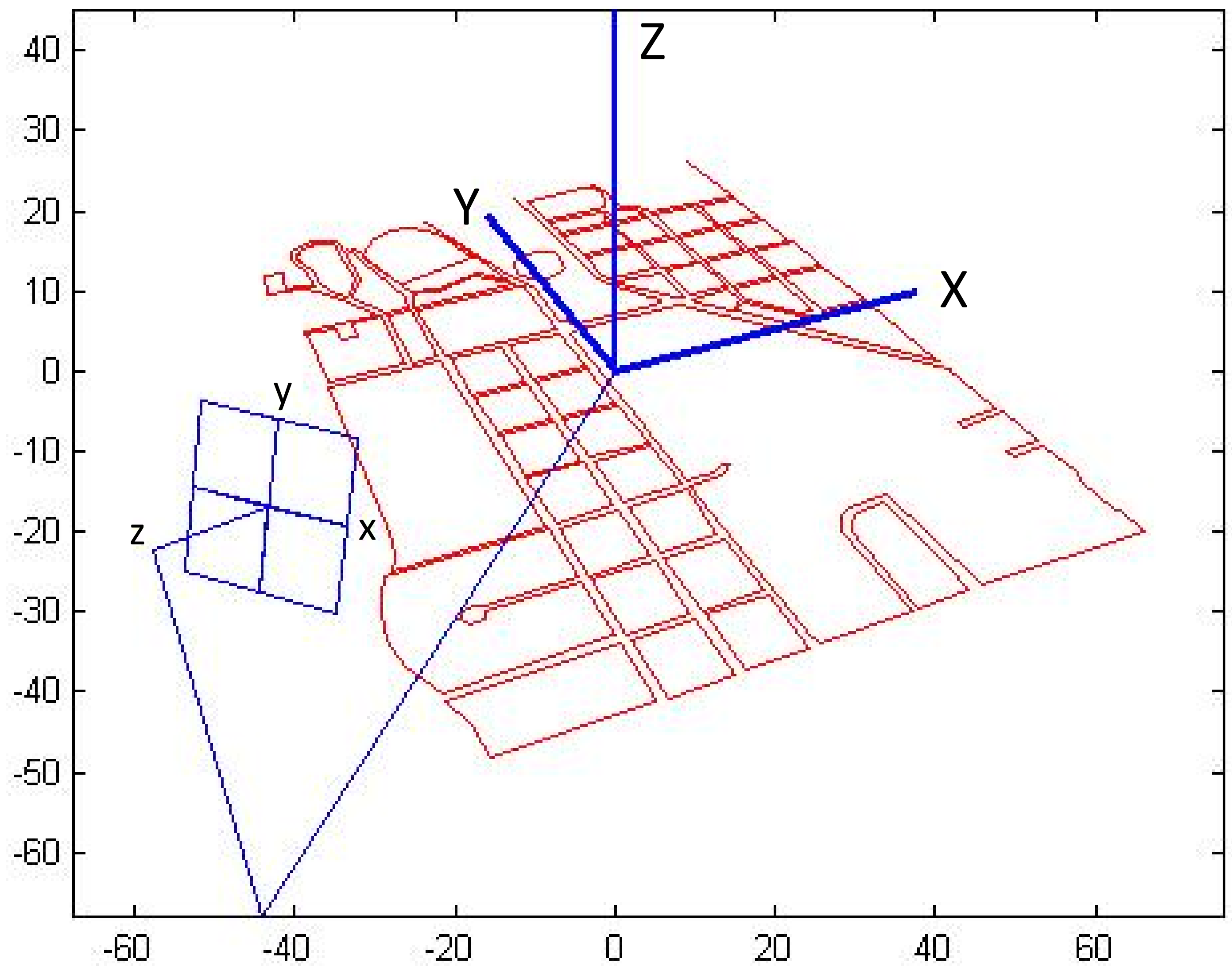
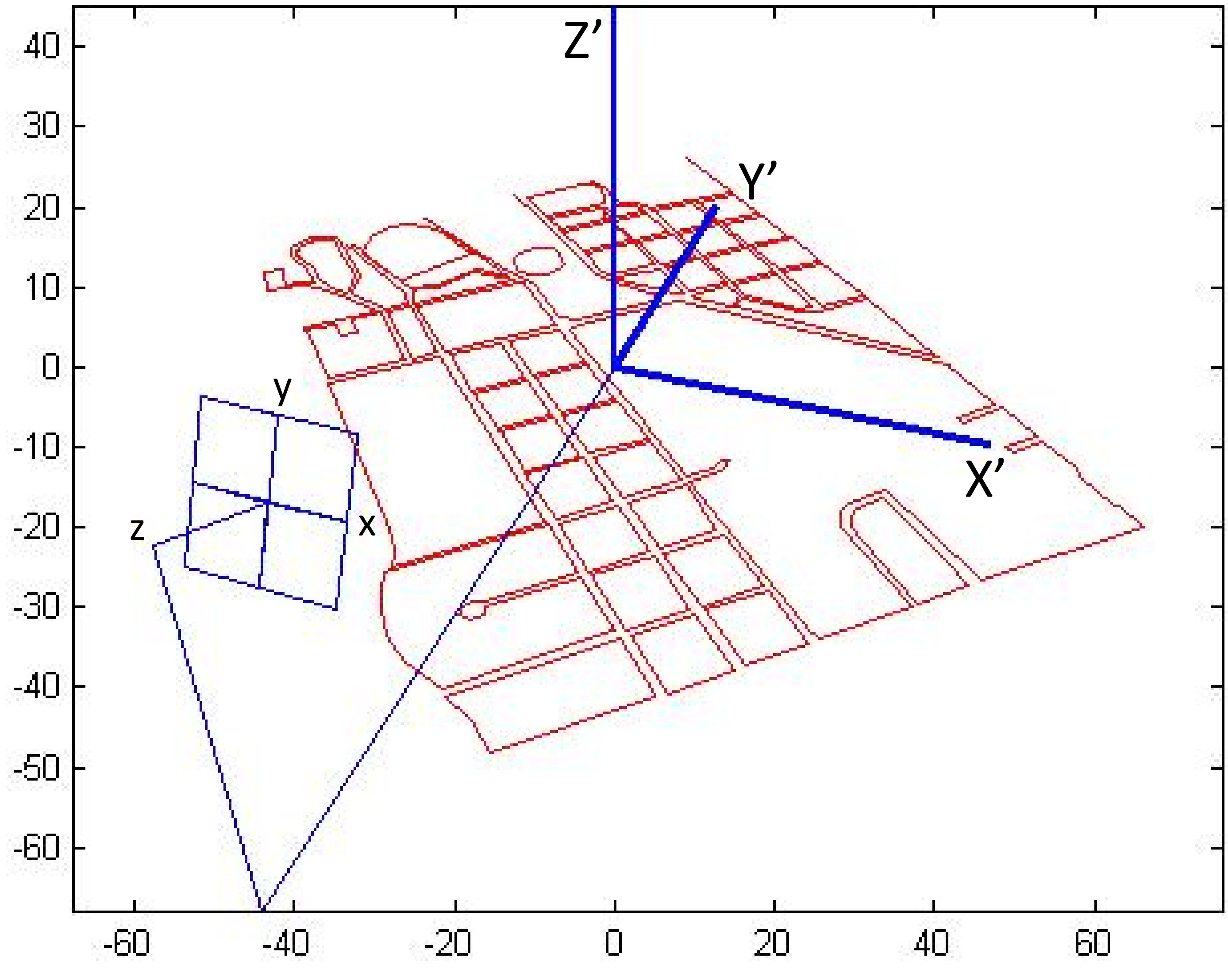
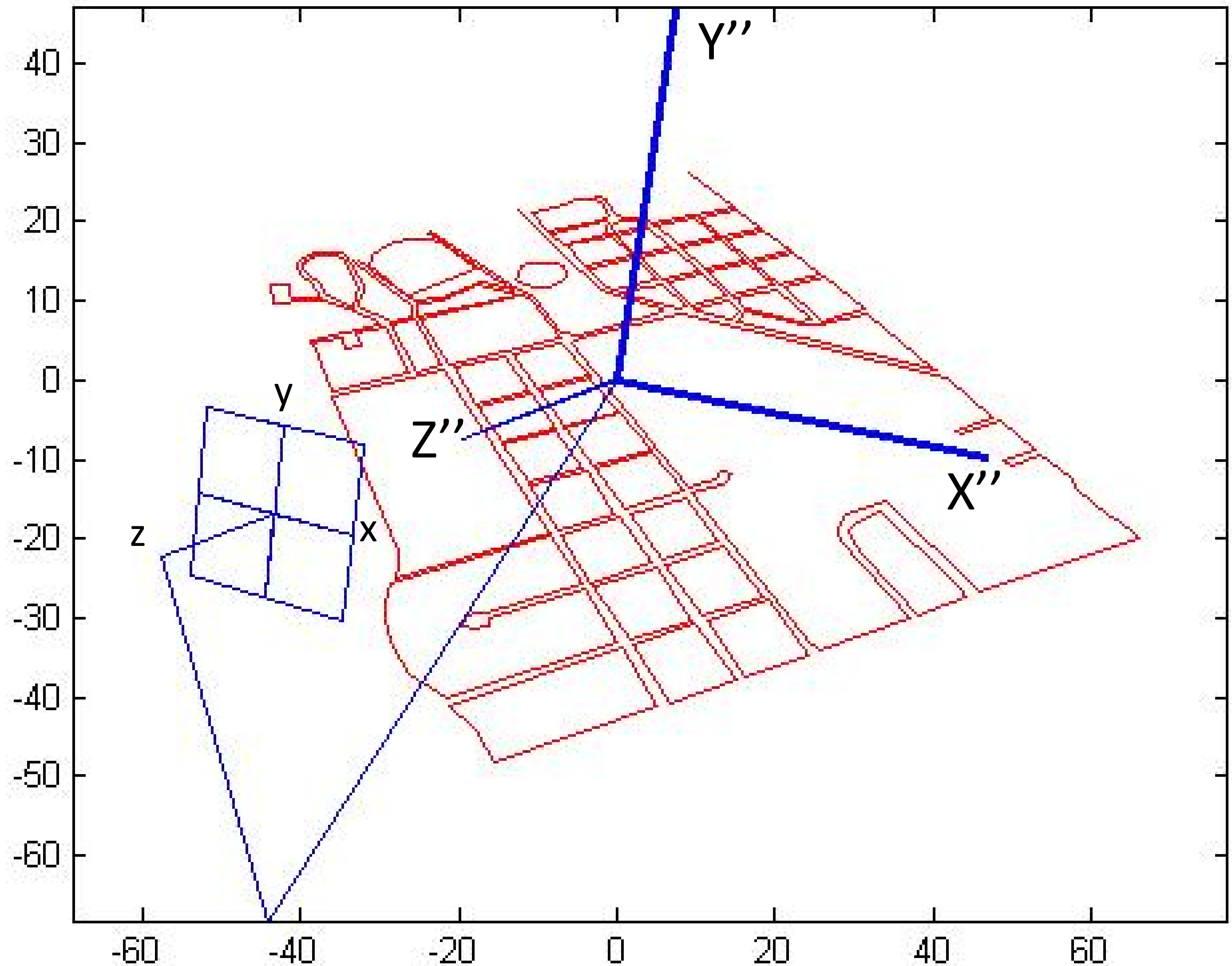
Initial Position



After Mz Rotation



After Mx Rotation



Construct rotation matrix by first multiplying by Mz(-45 deg), then by Mx(90-26.5) = Mx(63.5 deg):

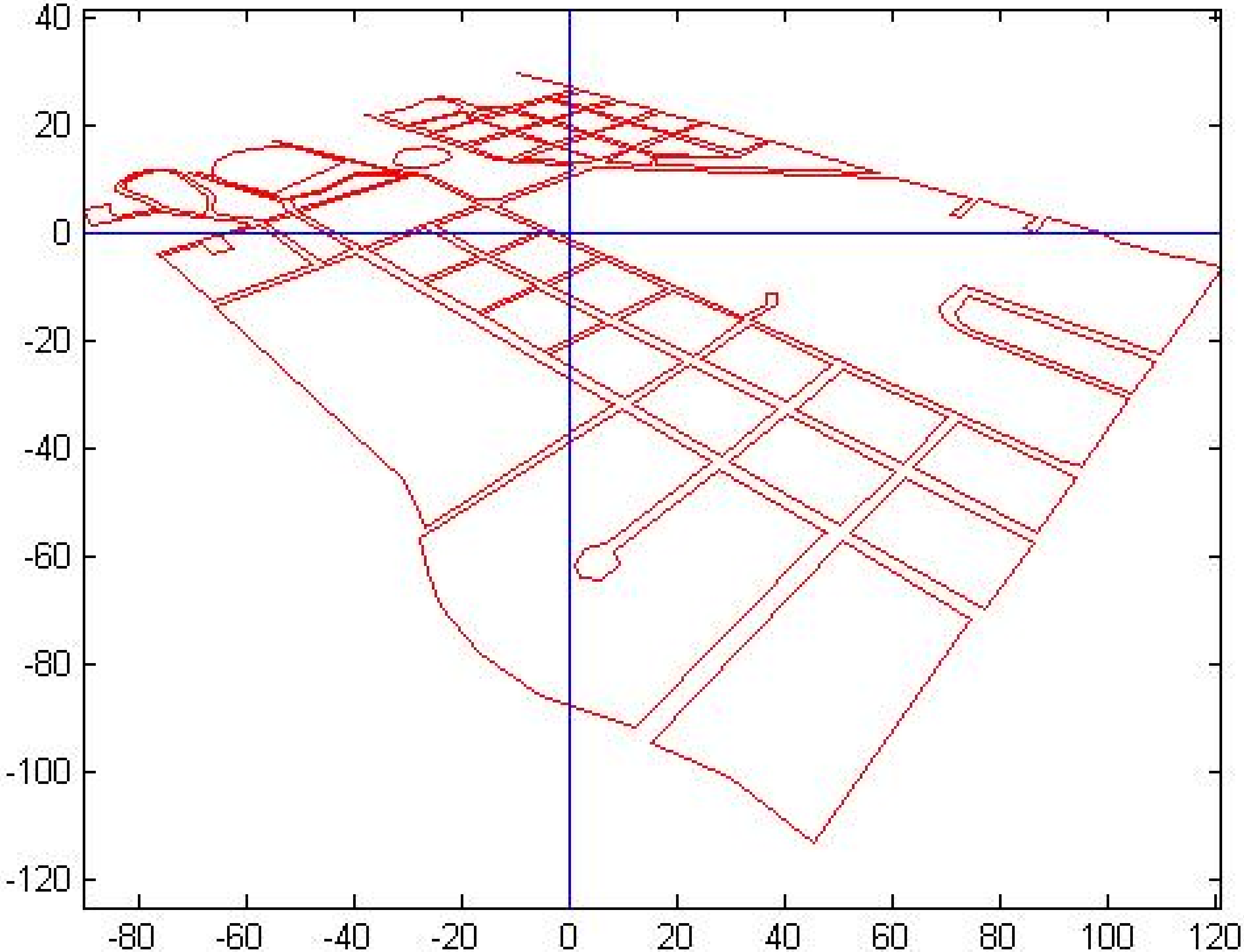
$$\mathbf{M} = \mathbf{M}_{\mathbf{x}}(90-26.5) * \mathbf{M}_{\mathbf{z}}(-45)$$

$$\begin{bmatrix} .7071 & -.7071 & 0 \\ .3155 & .3155 & .8549 \\ -.6328 & -.6328 & .4462 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & .4462 & .8949 \\ 0 & -.8949 & .4462 \end{bmatrix} * \begin{bmatrix} .7071 & -.7071 & 0 \\ .7071 & .7071 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Project object points into the image by:

$$x = x_0 - f * \frac{m_{11}(X - X_L) + m_{12}(Y - Y_L) + m_{13}(Z - Z_L)}{m_{31}(X - X_L) + m_{32}(Y - Y_L) + m_{33}(Z - Z_L)}$$

$$y = y_0 - f * \frac{m_{21}(X - X_L) + m_{22}(Y - Y_L) + m_{23}(Z - Z_L)}{m_{31}(X - X_L) + m_{32}(Y - Y_L) + m_{33}(Z - Z_L)}$$


40
20
0
-20
-40
-60
-80
-100
-120
-80
-60
-40
-20
0
20
40
60
80
100
120

```
% simp2b.m  17-sep-09
% simulate photo
% like simp2a.m but use 90-26.5 = 63.5 deg for mx rotation
% and use size to get polyline length instead of testing for NaN

load pdat;
px=zeros(100,1);
py=zeros(100,1);
gx=zeros(100,1);
gy=zeros(100,1);
n=0;
degrad=180/pi;
r45=45/degrad;
r63=63.5/degrad;

mx=[1 0 0;0 cos(r63) sin(r63);0 -sin(r63) cos(r63)];
mz=[cos(-r45) sin(-r45) 0;-sin(-r45) cos(-r45) 0;0 0 1];
m=mx*mz;
m
zg=200;
xl=913448;
yl=574562;
zl=700;
f=152.4;
% can use size to get number of features
% here it is hard-wired to 51
for i=1:51
  [nr,nc]=size(c(i).X);
  nv=nc-1;
  for j=1:nv
    gx(j)=c(i).X(j);
    gy(j)=c(i).Y(j);
    j=j+1;
    end
  px=zeros(nv,1);
  py=zeros(nv,1);
  for j=1:nv
    XYZ=[gx(j);gy(j);zg];
    XL=[xl;yl;zl];
    DX=XYZ-XL;
    UVW=m*DX;
    px(j)=-f*UVW(1)/UVW(3);
    py(j)=-f*UVW(2)/UVW(3);
    end
  plot(px,py,'r-');
  hold on
  end
axis equal

% draw image coordinate axes

v=axis;
px=[0 0];
py=[v(3) v(4)];
plot(px,py,'b-');
px=[v(1) v(2)];
py=[0 0];
plot(px,py,'b-');
```

2. Extract angles ω, φ, κ from given $M = M_\kappa M_\varphi M_\omega$:

$$\begin{bmatrix} .951251 & .272453 & -.144535 \\ -.254887 & .958333 & .128958 \\ .173648 & -.085832 & .981060 \end{bmatrix}$$

$$\phi = \sin^{-1}(.173648) = 10°$$

$$\omega = \tan^{-1}\left(\frac{.085832}{.981060}\right) = 5°$$

$$\kappa = \tan^{-1}\left(\frac{.254887}{.951251}\right) = 15°$$

3. $(X_L, Y_L, Z_L) = 913448, 574562, 700$

$(x_0, y_0, f) = 0, 0, 152.4$

M = matrix from problem 2, interpreted as being applied to object space coordinates:

$$\begin{pmatrix} x - x_0 \\ y - y_0 \\ -f \end{pmatrix} = \lambda M \begin{pmatrix} X - X_L \\ Y - Y_L \\ Z - Z_L \end{pmatrix}$$

for $Z = 200$, and $(x, y) = (90, -20)$ find ground XY

intersect ray with plane : $Z = 200$.

$$\begin{pmatrix} u \\ v \\ w \end{pmatrix} = M^T \begin{pmatrix} 90 \\ -20 \\ -152.4 \end{pmatrix}$$

$$X = X_L + (Z - Z_L)\, u/w = 913642.6$$

$$Y = Y_L + (Z - Z_L)\, v/w = 574617.8$$