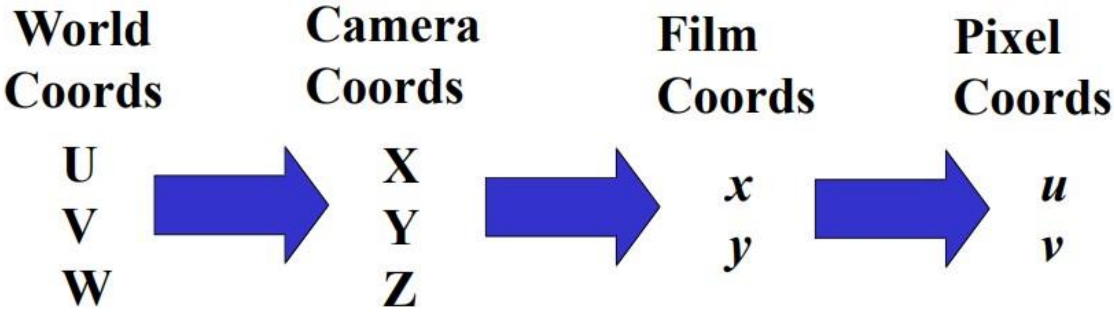
FORWARD PROJECTİON MATLAB CODE



We want a mathematical model to describe how 3D World points get projected into 2D pixel coordinates.Our goal is describe this sequence of transformation by a big matrix equation.

1. For this transformation first of all we need to conver worlds coordinates to camera coordinates. For this transformation we need rotation and translation matrix multiplied them than multiplied focal matrix and finally multiplied with our world coordinates.

$$\begin{pmatrix} x' \\ y' \\ z' \end{pmatrix} = \begin{pmatrix} f & 0 & 0 & 0 \\ 0 & f & 0 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} r_{11} & r_{12} & r_{13} & 0 \\ r_{21} & r_{22} & r_{23} & 0 \\ r_{31} & r_{32} & r_{33} & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 & -c_x \\ 0 & 1 & 0 & -c_y \\ 0 & 0 & 1 & -c_z \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} U \\ V \\ W \\ 1 \end{pmatrix}$$

Focal matr | Rotation matrix | Translation matrix

2. Now we need to translate from camera coordinates to film coordinates (3D to 2D). From our homogeneous coordinates to euclidian coordinates.

$$\begin{bmatrix} u \\ v \\ w \end{bmatrix} = \begin{bmatrix} u/w \\ v/w \\ 1 \end{bmatrix} \rightarrow \begin{bmatrix} u/w \\ v/w \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix}$$

3. Finally we need to translate film coordinates to pixel coordinates. For this transformation we multiplied our film coordinates with pixel size (0.012). Than finally we have pixel coordinates.

```
imshow(img,[]); hold on;
for i=1:7
    plot(v(i,:),u(i,:), 'r.', 'LineWidth', 3, 'MarkerSize', 10);
end
```

and with this code we show coordinates on the photo.

4. For finding to approximate height of building I used relief displacement.

```
du = 160;
dv = 5;

%with dx and dy find the bottom coordinates of building
K(1,:) = (u + du);
K(2,:) = (v + dv);
K(3,:) = coor(3,:);

imshow(img,[]); hold on;
plot(K(2,:),K(1,:), 'b.', 'LineWidth', 3, 'MarkerSize', 10);
```

- With this code I found the bottom coordinates of building.

```
dxmm = (du * 0.012);
dymm = (dv * 0.012);

%distance between top corner and bottom corner
%length of building object on the photo
d = sqrt((dxmm)^2 + (dymm)^2);
```

- From distance between up and bottom coordinates of building I found the height of building on the photo

```
%radial distance
%focal length coordinates in pixel
row_pp = 6912;
col_pp = 3840;

%we mutiplied 0.012 because we need to convert pixel to m
radial_dis = sqrt((row_pp-K(1,2))^2 + (col_pp-K(2,2))^2)*0.012 ;

%flying height 900m
building_height = (900*d)/radial_dis
```

- Finally I found the radial distance (principal point to top of building point). I found building height with this formula

  (Flying height * Height of building on the photo)/ Radial distance

Output

Bottom Point

Top Point

```
building_height =

   25.6841
```

Referances

- **HUMBOLDT STATE UNIVERSITY GPS216INTRODUCTİON TO REMOTE SENSING LECTURE NOTES**

- **OFFİCİAL MATWORK WEBSİTE**