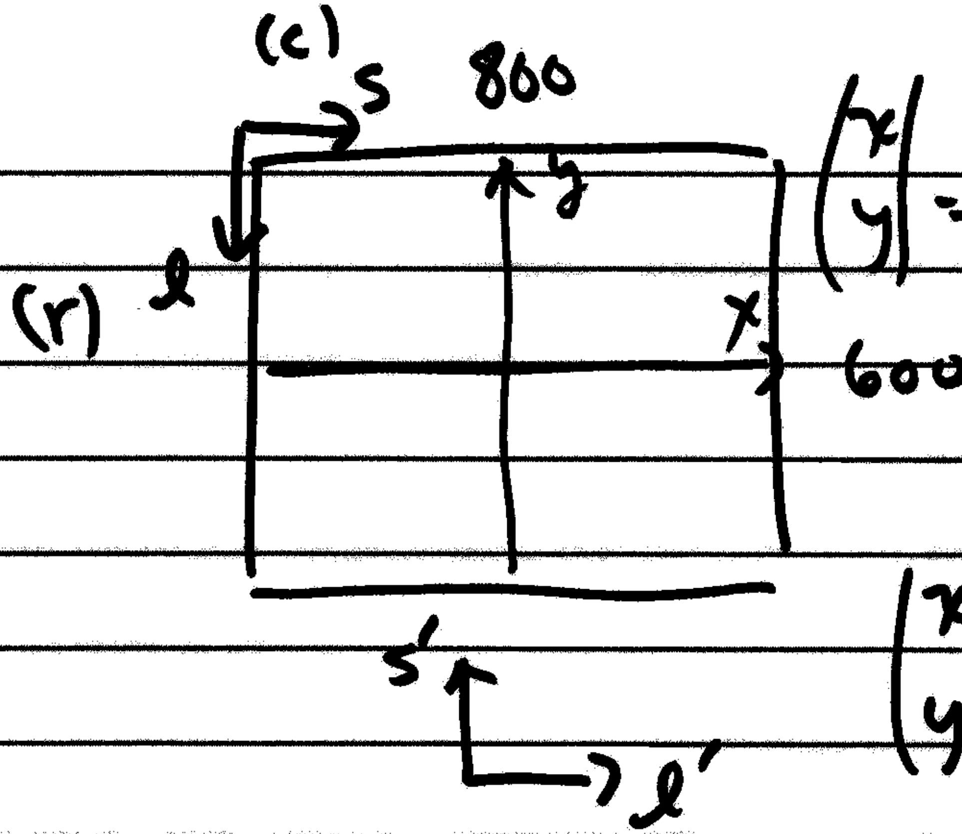
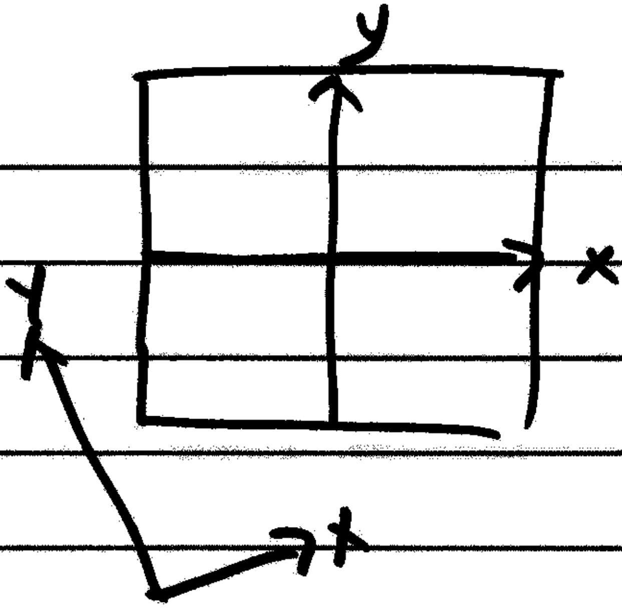


$$\begin{pmatrix}x\\y\end{pmatrix} = \begin{pmatrix}-400.5\\+300.5\end{pmatrix} + \begin{pmatrix}\cos 90 & \sin 90\\ -\sin 90 & \cos 90\end{pmatrix}\begin{pmatrix}l\\s\end{pmatrix}$$

$$\begin{pmatrix}x\\y\end{pmatrix} = \begin{pmatrix}-400.5\\300.5\end{pmatrix} + \begin{pmatrix}0 & 1\\ -1 & 0\end{pmatrix}\begin{pmatrix}l\\s\end{pmatrix}$$

Nominal Principal Point System $\longleftarrow$ Pixel Coordinates



$$\begin{pmatrix} X \\ Y \end{pmatrix} = \begin{pmatrix} a_0 \\ b_0 \end{pmatrix} + \begin{pmatrix} a_1 & a_2 \\ b_1 & b_2 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$ estimation

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} \quad \end{pmatrix} + \begin{pmatrix} \quad & \quad \end{pmatrix} \begin{pmatrix} X \\ Y \end{pmatrix}$$ application

$$x = t + mX$$

$$x - t = mX$$

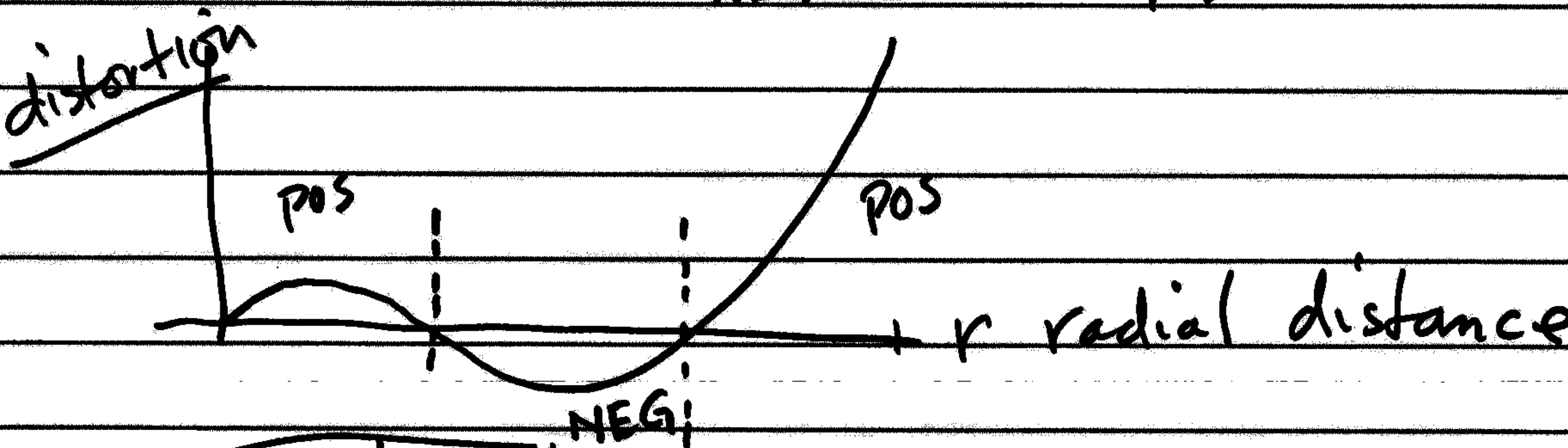
$$m^{-1}(x - t) = X$$

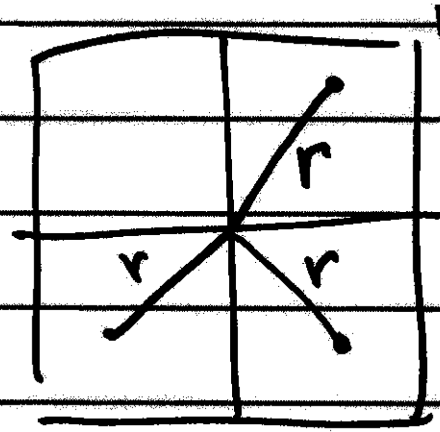
Meas. ← Cal.
(estimation)

Cal. ← Meas.
(application)

$$X = \boxed{-m^{-1}t} + \boxed{m^{-1}}\, x$$

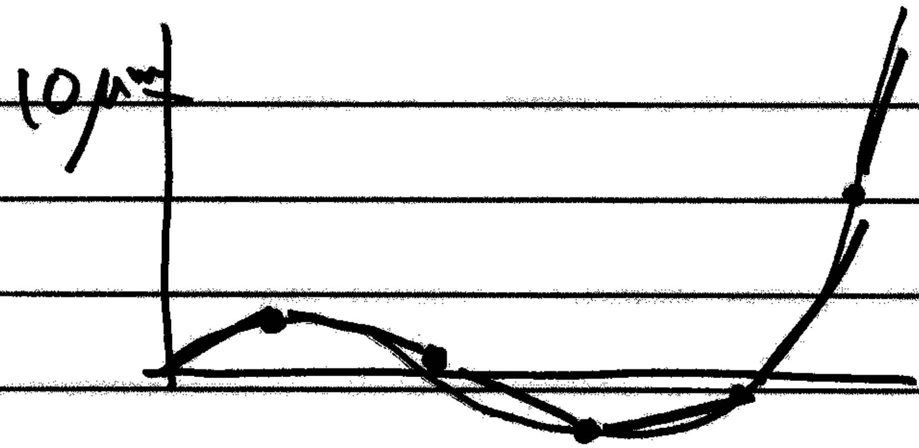

NEG
POS


distortion
POS
POS
NEG
r radial distance

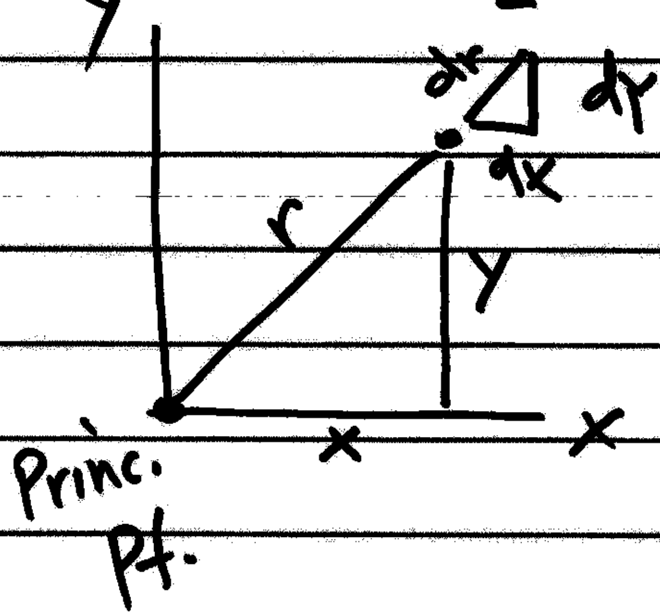

r
r
r

to get dr:

1. compute r
   evaluate $k_1 r^3 + k_2 r^5 \dots$
2. linear interpolation



$$dr = \underline{\underline{k_1}}\, r^3 + \underline{\underline{k_2}}\, r^5 + \underline{\underline{k_3}}\, r^7 \dots$$



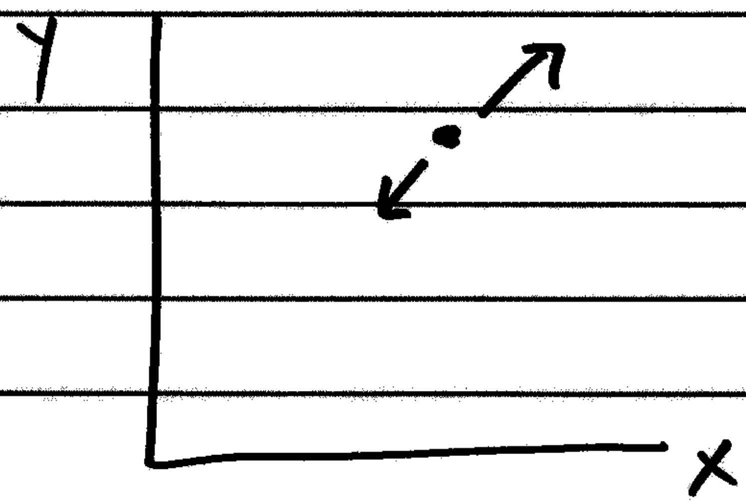
$$\frac{dr}{r} = \frac{dx}{x} = \frac{dy}{y}$$

$$dx = x\frac{dr}{r}, \quad dy = y \cdot \frac{dr}{r}$$

$$dx = \frac{x(k_1 r^3 + k_2 r^5 + k_3 r^7)}{r}$$

$$dx = x(k_1 r^2 + k_2 r^4 + k_3 r^6)$$

$$dy = y(\quad " \quad)$$



$$x_c = x - dx_{dist} \qquad \text{OR} \qquad x_c = x + dx_{corr}$$

$$y_c = y - dy_{dist} \qquad\qquad y_c = y + dy_{corr}$$

atmospheric refraction

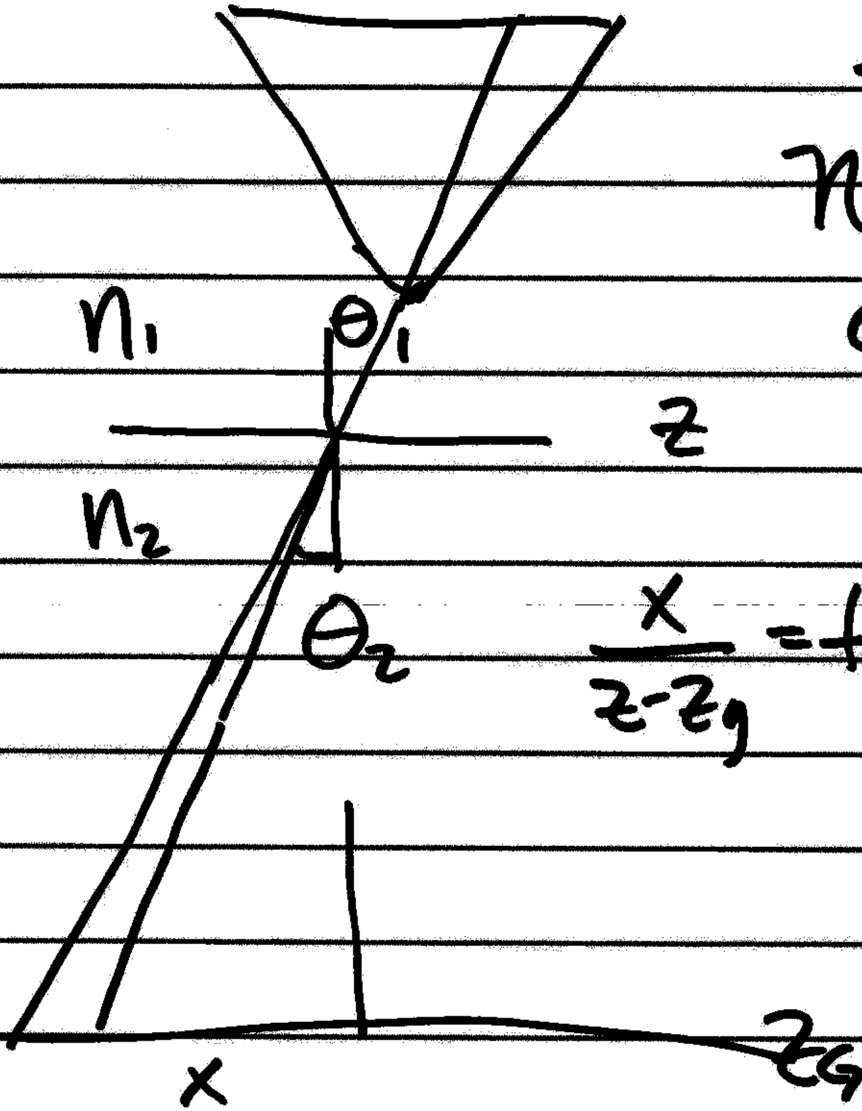
ρ density

Schut

PERS

$n^2 = 1 + 2c\rho$

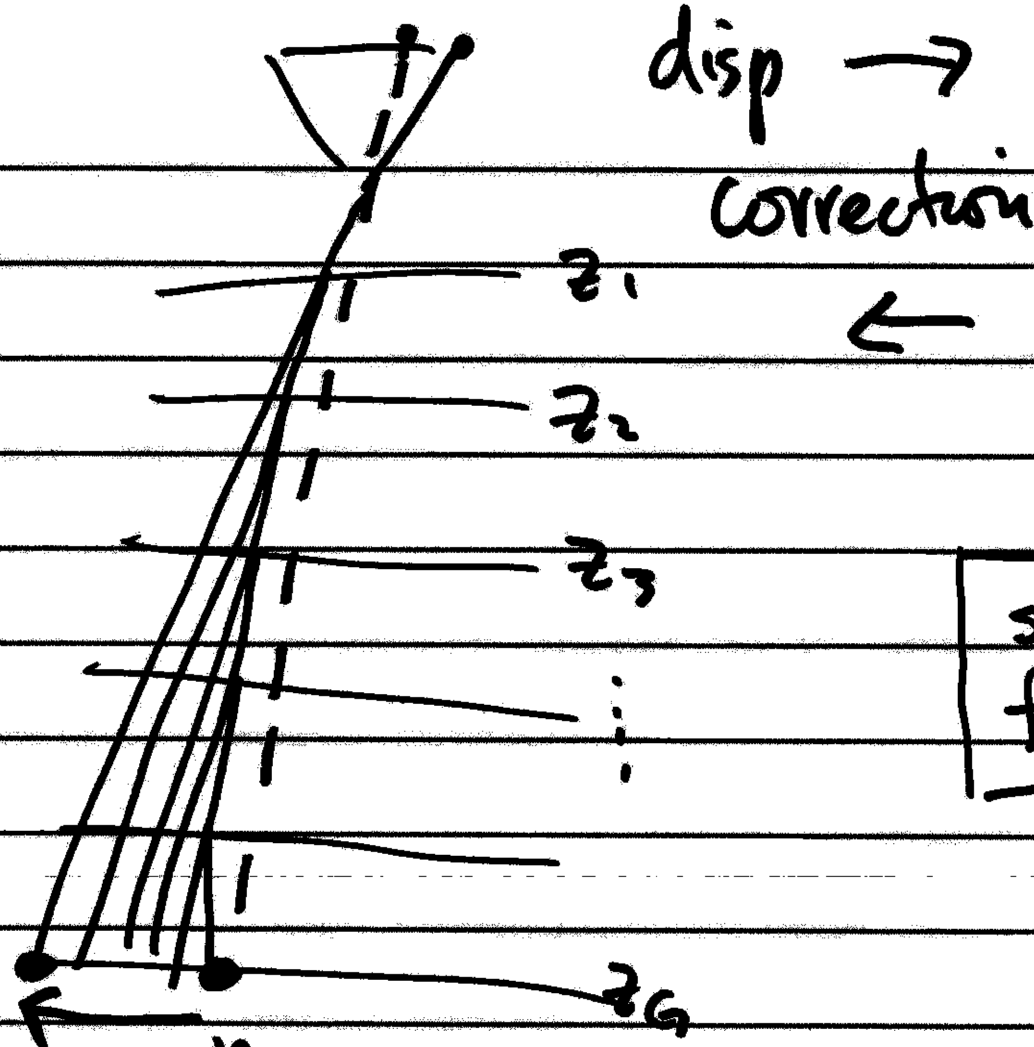
$c = .0002261$



$\frac{x}{z - z_g} = \tan\theta_1$

$dx_1 = (z - z_g)\tan\theta_1$

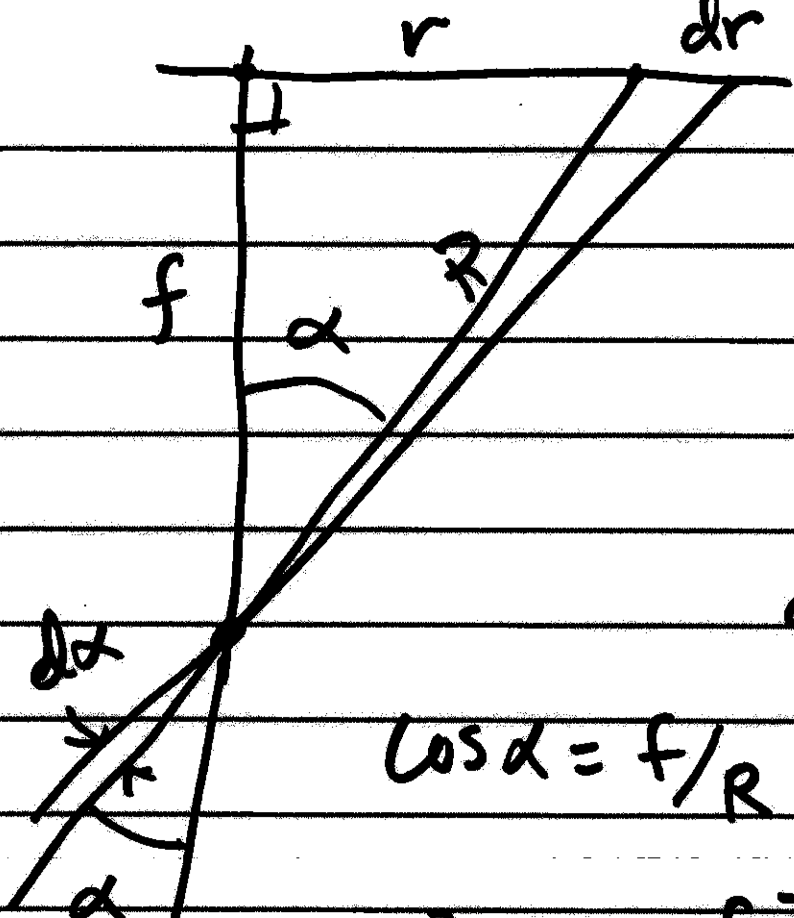
$\quad - (z - z_g)\tan\theta_2$



see slightly revised formula below

$$dx = \sum_{i=1}^{n} (z_i - z)\left[\tan\theta_i - \tan\theta_{i+1}\right]$$

$$\boxed{dX = \sum_{i=1}^{n} (z_i - z_G)\left[\tan\theta_i - \tan\theta_{i+1}\right]}$$



$$\frac{r}{f} = \tan\alpha$$

$$r = f \cdot \tan\alpha$$

$$\frac{dr}{d\alpha} = f \cdot \frac{1}{\cos^2\alpha}$$

$$dr = d\alpha \cdot f \cdot \frac{1}{\cos^2\alpha}$$

$$\cos\alpha = f/R = \frac{f}{\sqrt{f^2+r^2}}$$

$$\cos^2\alpha = \frac{f^2}{f^2+r^2}$$

$$\frac{1}{\cos^2\alpha} = \frac{f^2+r^2}{f^2} = \boxed{1 + \frac{r^2}{f^2}}$$

$$dr = \underbrace{d\alpha}_{} \cdot f \cdot \left(1 + \frac{r^2}{f^2}\right)$$

$$d\alpha = \underline{\underline{K}} \cdot \tan\alpha \qquad \tan\alpha = r/f, \quad K \cdot \frac{r}{f}$$

$$K = \left(\frac{2410\,H}{H^2 - 6H + 250} - \frac{2410\,h}{h^2 - 6h + 250}\left(\frac{h}{H}\right)\right) \times 10^{-6}$$

H flying height platform

h elevation of point

(Km)

$$dr = K\left(r + \frac{r^3}{f^2}\right)$$

$$\frac{dx}{x} = \frac{dr}{r}$$

$$dx = x \cdot \frac{dr}{r}$$ make sure it's negative

$$x_c = x - dx_{dist} + dx_{AR}$$

$$y_c = y - dy_{dist} + dy_{AR}$$

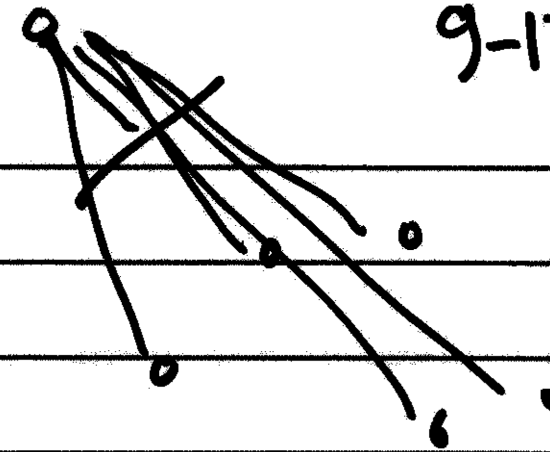
$$x = -f \frac{m_{11}(X - X_L) + m_{12}(Y - Y_L) + m_{13}(Z - Z_L)}{m_{31}(X - X_L) + m_{32}(Y - Y_L) + m_{33}(Z - Z_L)} + x_0$$

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

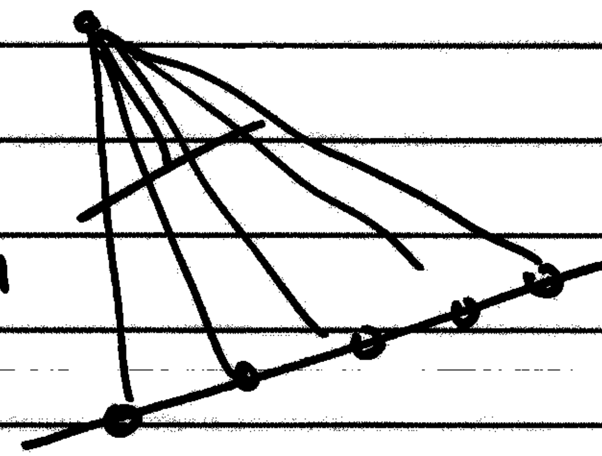
$$\underbrace{(m_{31}X + m_{32}Y + m_{33}Z)}_{\text{ground point}} - \underbrace{(m_{31}X_L + m_{32}Y_L + m_{33}Z_L)}_{\text{exp. sta}}$$

$$Z = e_0 + e_1 X + e_2 Y$$

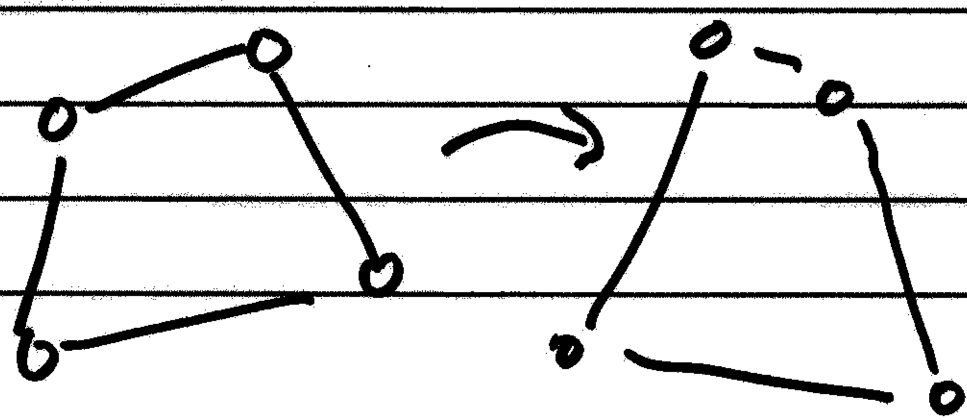
$$x = \frac{a_0 + a_1 X + a_2 Y}{c_1 X + c_2 Y + 1}$$



$$y = \frac{b_0 + b_1 X + b_2 Y}{c_1 X + c_2 Y + 1}$$



8 parameter transformation
projectivity equations



$$x c_1 X + x c_2 Y + x = a_0 + a_1 X + a_2 Y$$

$$y c_1 X + y c_2 Y + y = b_0 + b_1 X + b_2 Y$$

$$x = a_0 + a_1 X + a_2 Y - x c_1 X - x c_2 Y$$

$$y = b_0 + b_1 X + b_2 Y - y c_1 X - y c_2 Y$$

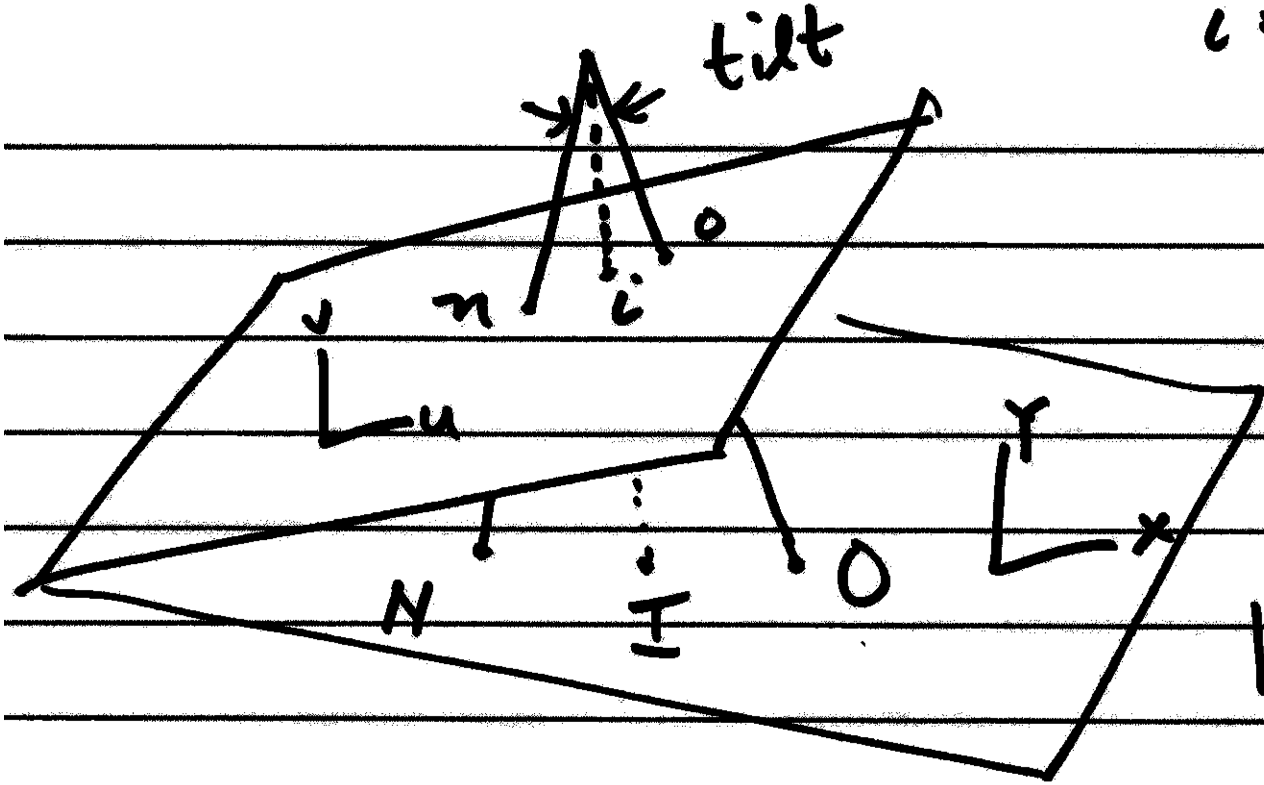
$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{bmatrix} 1 & X & Y & 0 & 0 & 0 & -xX & -xY \\ 0 & 0 & 0 & 1 & X & Y & -yX & -yY \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ b_0 \\ b_1 \\ b_2 \\ c_1 \\ c_2 \end{bmatrix}$$

each point : 2 equations
8 unknowns
4pts $\Rightarrow$ unique solution

simple rectification
(tilt only)

ortho rectification
(tilt + terrain)

i: isocenter



α', d', e'

α, d, e

$f', h' \leftarrow (f, h, t)$

Exterior Orientation $X_L Y_L Z_L \ \omega \phi \kappa$

Interior Orientation x_0, y_0, f

DLT: do not enforce

$$Z = e_0 + e_1 X + e_2 Y$$

$$x = \frac{L_1 X + L_2 Y + L_3 Z + L_4}{L_9 X + L_{10} Y + L_{11} Z + 1}$$

$$y = \frac{L_5 X + L_6 Y + L_7 Z + L_8}{L_9 X + L_{10} Y + L_{11} Z + 1}$$

(x_0, y_0)