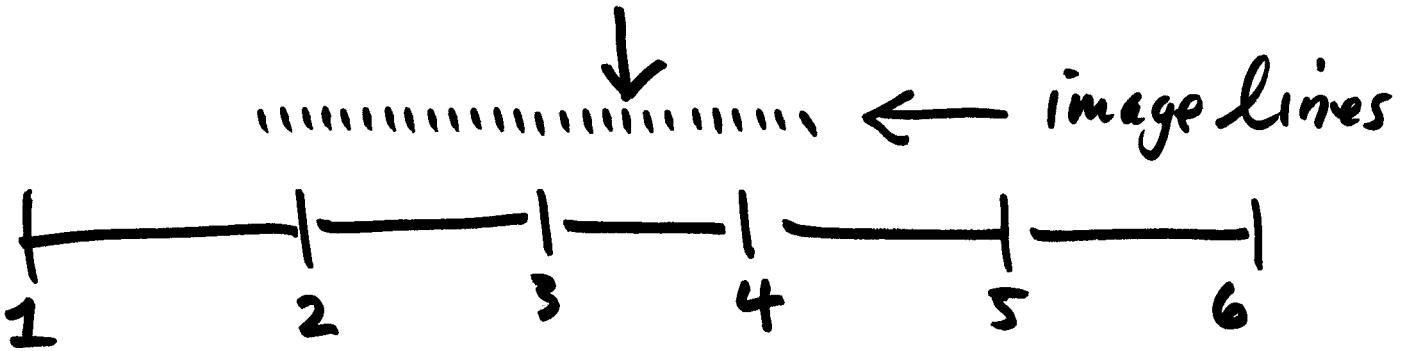
eph_att_cdf.zip

comma delimited format

M = CSVread('filename')

t_{es} : ephemeris start time

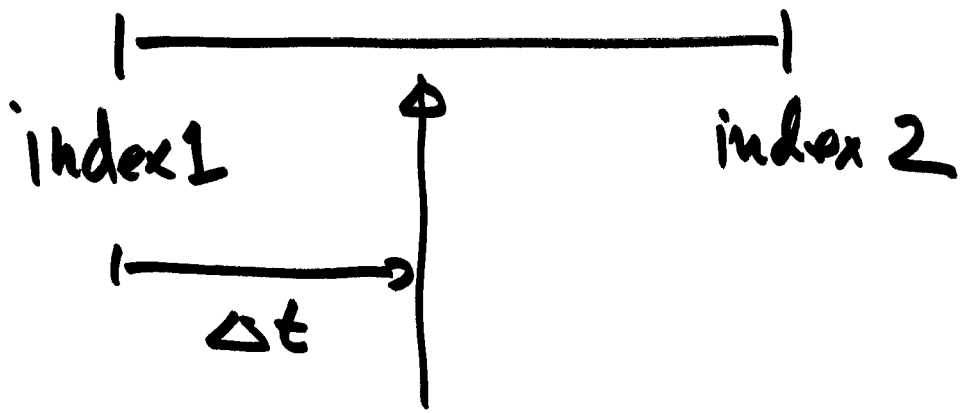
dte : 0.02 s



$$index1 = fix\left(\frac{t_{line} - t_{es}}{dte}\right) + 1$$

$$index2 = index1 + 1$$

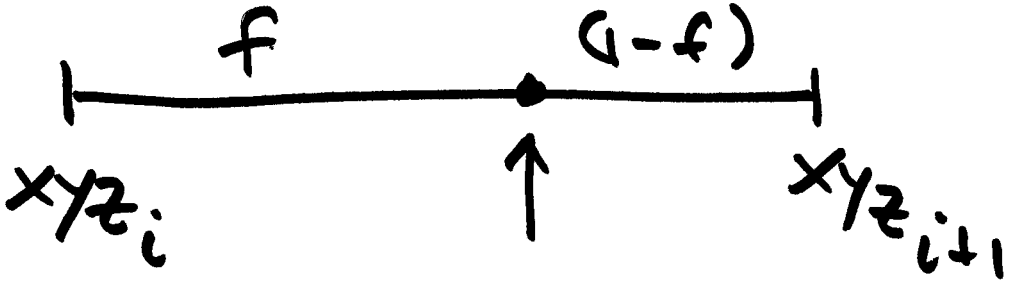
$$t_{index1} = t_{es} + (index1 - 1) \times dte$$



$$\Delta t = t - t_{,index1}$$

$$frac = \frac{\Delta t}{dte}$$

$$0 \leq frac \leq 1$$

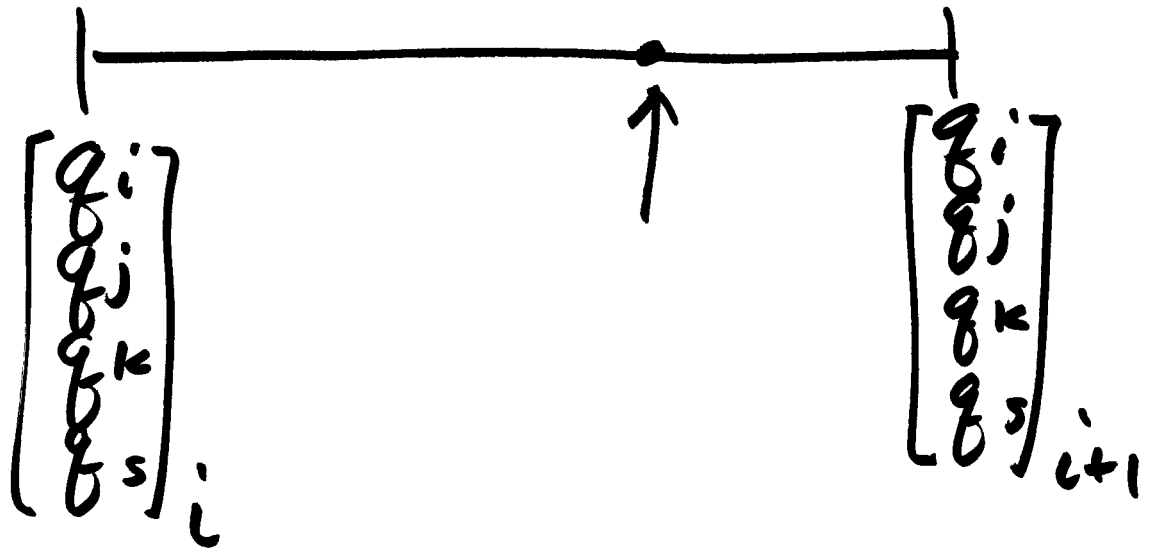


linear interpolation

$$x_L = f \cdot x_{L\,i+1} + (1-f)\, x_{L\,i}$$

$$Y_L = f \cdot Y_{L\,i+1} + (1-f)\, Y_{L\,i}$$

$$Z_L = f \cdot Z_{L\,i+1} + (1-f)\, Z_{L\,i}$$



$$q_i = f \cdot (q_i)_{i+1} + (1-f)(q_i)_i$$

$$q_j = f \cdot (q_j)_{i+1} + (1-f)(q_j)_i$$

$$q_k = f \cdot (q_k)_{i+1} + (1-f)(q_k)_i$$

$$q_s = f \cdot (q_s)_{i+1} + (1-f)(q_s)_i$$

$$\text{length} = \sqrt{q_i^2 + q_j^2 + q_k^2 + q_s^2}$$

$$q_i = q_i / \text{length}$$

$$\vdots$$

$$q_s = q_s / \text{length}$$

x_i, y_i, z_i, q

$q \rightarrow \alpha\beta\gamma\theta \rightarrow M$

$q \rightarrow M$

use $\underline{\underline{M}}^T$ for our condition equation

M_c : $q_c \rightarrow \alpha\beta\gamma\theta \rightarrow M_c$

$q_c \rightarrow M_c$

actually use M_c^T

fixed

$$\begin{pmatrix} 0 - x_0 \\ -s - y_0 \\ +f \end{pmatrix} = \lambda M_c M \left(\begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{ECF} - \begin{pmatrix} X_L \\ Y_L \\ Z_L \end{pmatrix}_{ECF} \right) = \begin{pmatrix} u \\ v \\ w \end{pmatrix}$$

Note: if we move matrices to left side of equation: they are transposed

$$\begin{pmatrix} 0-x_0 \\ -s-y_0 \\ +f \end{pmatrix} = \lambda \begin{pmatrix} u \\ v \\ w \end{pmatrix} \Rightarrow \begin{matrix} \frac{-x_0}{f} = \frac{u}{w} \\ \frac{-s-y_0}{f} = \frac{v}{w} \end{matrix}$$

$$-x_0 = f\frac{u}{w}$$

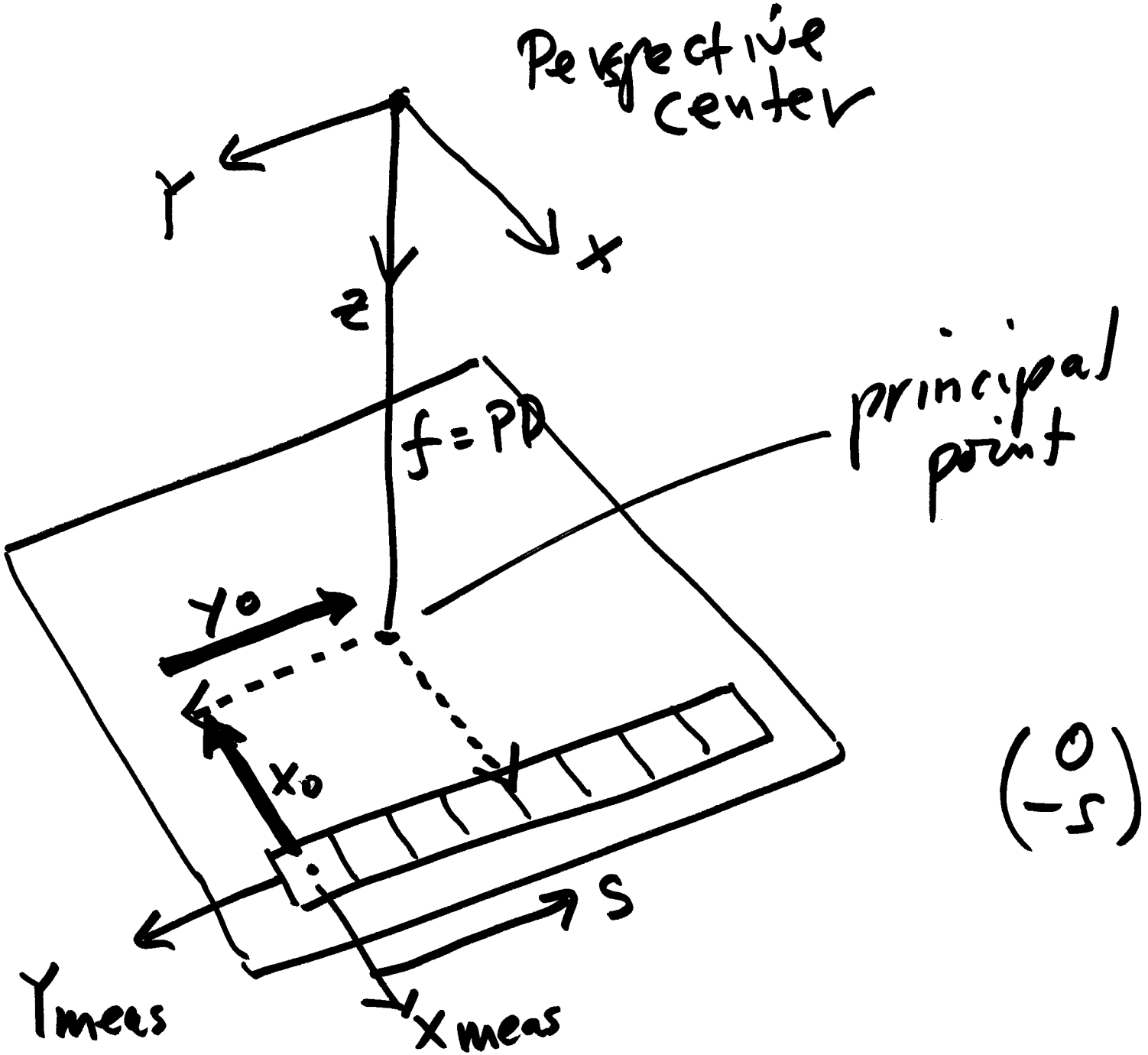
$$-s-y_0 = f\frac{v}{w}$$

0,0119.... mm/pix

$$F_x = -x_0 - f\frac{u}{w} \quad (\approx 0\,!)$$

$$F_y = -s-y_0 - f\frac{v}{w} \quad (\approx 0\,!)$$

<u>units</u> image space : <u>mm</u> or <u>pixels</u>



$\begin{pmatrix} 0 \\ -s \end{pmatrix}$

GCP: A7 ϕ 40° - 25' - 02.22420 N
λ 86 - 52' - 31.92162 W (neg)
h 178.92 m

h: ellipsoid height

ℓ: 13342 — $dt = \frac{1}{6900}$ sec.
S: 14461

interpolation for ephemeris data

index1 : 399
index2 : 400

$t_{\text{first line}}$ 27.463116 s
t_{line} 29.396594 s

x_L 370 856.251 m
Y_L -5214 148.908 interpolated value
z_L 4381 594.413
(may be off by 1 line)

q_i -.672 247 652
q_j .585 860 993
q_k .380 200 972
q_s .254 554 901

$\Rightarrow M$

$$\begin{pmatrix} u \\ v \\ w \end{pmatrix} = M_c M \left(\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} - \begin{pmatrix} X_c \\ Y_c \\ Z_c \end{pmatrix} \right) = \begin{pmatrix} 483 \\ -420 \\ 459955 \end{pmatrix} m$$

$$F_x = -x_0 - f\, u/w \qquad \text{(pixels)}$$

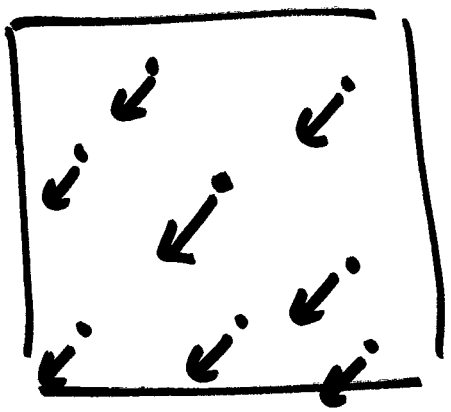
$$F_y = -s - y_0 - f\, v/w$$

$$x_0 \approx -801 \text{ pixels}$$

$$y_0 \approx -13767 \text{ pixels}$$

F_x: 22 pixels

F_y: -16 pixels



F_x: 22

F_y: −15

resulting misclosure ↘

A4: 40°-25'-15."09051 φ

86-55-39.63017 λ

155.42 h

ℓ: 12798

s: 7473

another GCP: you try!

$$\begin{pmatrix} x-x_0 \\ y-y_0 \\ +f \end{pmatrix} = \lambda M_a M_c M \left(\begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{ECF} - \left[\begin{pmatrix} X_L \\ Y_L \\ Z_L \end{pmatrix}_{ECF} + \begin{pmatrix} dx \\ dy \\ dz \end{pmatrix} \right] \right)$$

attitude correction

position correction vector

$$M_a = M_\kappa(d\underline{\kappa})\, M_\varphi(d\underline{\varphi})\, M_\omega(d\underline{\omega})$$

$$dx = dx_0 + dx_1 t + dx_2 t^2 + dx_3 t^3$$

dx_0, dx_1: constant terms

dx_2, dx_3: actual unknowns in adjustment

t, line number: surrogate for time

$$dy = dy_0 + dy_1 t + dy_2 t^2 + dy_3 t^3$$

$$dz = dz_0 + dz_1 t + dz_2 t^2 + dz_3 t^3$$

$$d\omega = \underline{d\omega_0} + \underline{d\omega_1} t + \underline{d\omega_2} t^2 + \underline{d\omega_3} t^3$$

$$d\varphi = \underline{d\varphi_0} + \underline{d\varphi_1} t + \underline{d\varphi_2} t^2 + \underline{d\varphi_3} t^3$$

$$dk = \underline{dk_0} + \underline{dk_1} t + \underline{dk_2} t^2 + \underline{dk_3} t^3$$

total of 24 unknowns

5 GCP : 10 equations

carry max of 10 unknowns

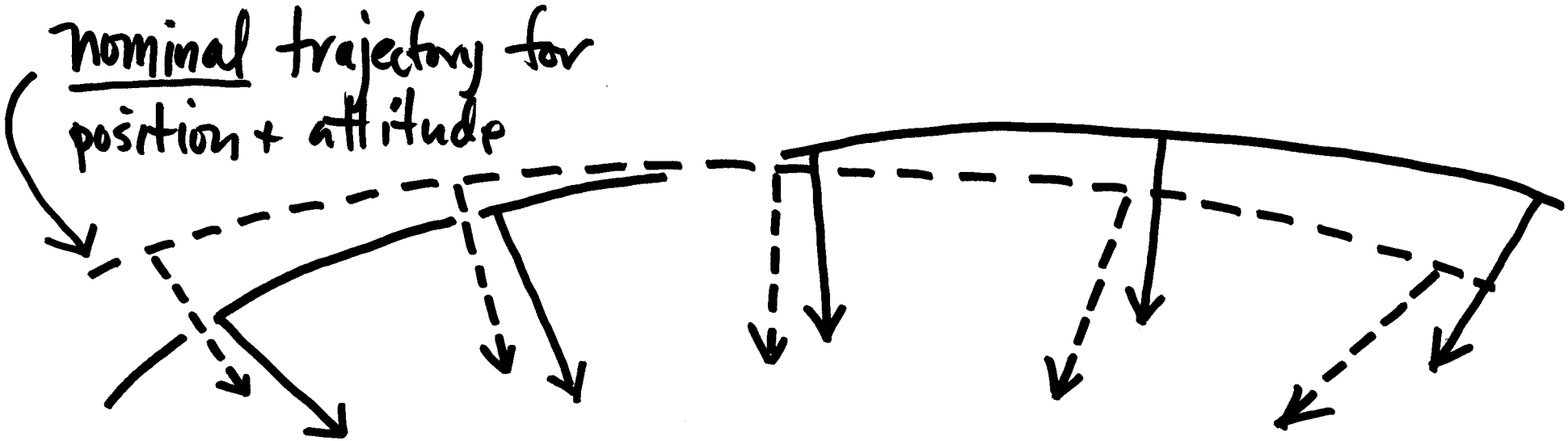
5-6 unknowns more practical

f, x_0, y_0, lens distortion: additional unknowns

$$\begin{pmatrix} x-x_0 \\ y-y_0 \\ +f \end{pmatrix} = \lambda M_c M \left[\begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{ECF} - \begin{pmatrix} X_L \\ Y_L \\ Z_L \end{pmatrix}_{ECF} \right]$$

$$M^T M_c^T \begin{pmatrix} x-x_0 \\ y-y_0 \\ +f \end{pmatrix} = \lambda \left[\begin{pmatrix} X \\ Y \\ Z \end{pmatrix}_{ECF} - \begin{pmatrix} X_L \\ Y_L \\ Z_L \end{pmatrix}_{ECF} \right]$$

} can move the matrices left & right



refined trajectory for
position + attitude
(after estimating polynomial coefficients)