Satellite Photogrammetry Homework 3

due Wed. 25th

GCP's

#	ϕ (DMS)	λ (DMS)	h (m)
1	39° 59' 11".68564	−105° 09' 50".27009	1694.043
2	39 58 43.93295	−105 16 27.65485	1839.814
3	39 58 47.78080	−105 19 50.89720	2344.236
4	40 00 52.11110	−105 10 39.02860	1576.331
5	40 02 26.29406	−105 15 04.93832	1608.981
6	40 00 13.11510	−105 22 01.31170	1882.383
7	40 04 02.40483	−105 12 15.03513	1554.534
8	40 03 59.66220	−105 17 17.66990	1702.424
9	40 05 09.29380	−105 20 22.15010	2170.606

1. Make a 2-image BBA using 9 GCP's and 2 pass points.

(a) select and measure 2 new pass points in both images, 1 near top and 1 near bottom of <u>overlap area</u>.

(b) consider the GCP's as fixed constants.

(c) carry as unknowns $\underbrace{q_{i_1}, q_{j_1}, q_{k_1}}_{\text{image 1 attitude}}, \underbrace{q_{i_2}, q_{j_2}, q_{k_2}}_{\text{image 2 attitude}}, \underbrace{\phi_1, \lambda_1, h_1}_{\text{pass pt. 1}}, \underbrace{\phi_2, \lambda_2, h_2}_{\text{pass pt. 2}}$

it will be 12×1 parameter vector.

(d) number of equations will be #points × #images × 2

$(9+2) \times 2 \times 2 = 44$

(e) this will be a non linear LS problem solved by indirect observations

(f) estimate initial approximations for pass point object coordinates : $\Phi_1, \lambda_1, h_1, \Phi_2, \lambda_2, h_2$

(g) recall structure of <u>condition</u> <u>equations</u> from lecture :
(example had 3 GCP's, 2 images, 2 pass points)

2 equations per point per image

$$
-\begin{bmatrix} F7_{1,1,\ell} \\ F7_{1,1,s} \\ F7_{1,2,\ell} \\ F7_{1,2,s} \\ \vdots \\ F7_{2,5,\ell} \\ F7_{2,5,s} \end{bmatrix}
=
\begin{array}{c}
\begin{array}{cccc} \overbrace{\qquad\quad}^{im1} & \overbrace{\qquad\quad}^{im2} & \overbrace{\qquad\quad}^{P4} & \overbrace{\qquad\quad}^{P5} \end{array} \\
\begin{bmatrix}
\times & \times & \times & o & o & o & o & o & o & o & o & o \\
\times & \times & \times & o & o & o & o & o & o & o & o & o \\
\times & \times & \times & o & o & o & o & o & o & o & o & o \\
\times & \times & \times & o & o & o & o & o & o & o & o & o \\
 & & & & & \vdots & & & & & & \\
o & o & o & \times & \times & \times & o & o & o & \times & \times & \times \\
o & o & o & \times & \times & \times & o & o & o & \times & \times & \times
\end{bmatrix}
\end{array}
\begin{bmatrix} \Delta q_{i_1} \\ \Delta q_{j_1} \\ \Delta q_{k_1} \\ \Delta q_{i_2} \\ \Delta q_{j_2} \\ \Delta q_{k_2} \\ \Delta\Phi_1 \\ \Delta\lambda_1 \\ \Delta h_1 \\ \Delta\Phi_2 \\ \Delta\lambda_2 \\ \Delta h_2 \end{bmatrix}
+
\begin{bmatrix} V_{1,1,\ell} \\ V_{1,1,s} \\ V_{1,2,\ell} \\ V_{1,2,s} \\ \vdots \\ V_{2,5,\ell} \\ V_{2,5,s} \end{bmatrix}
$$

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residuals

get elements of misclosure vector from F7 :

$FG2I\_\ell s\_0(im, \underbrace{\phi, \lambda, h}_{\text{ground point}}, \underbrace{\ell, s}_{\text{observation}}, \underbrace{\Delta p}_{\text{zeros}})$

get elements of B matrix (partial derivatives) from F8 :

$[\,\vdots\vdots\vdots\vdots\vdots\vdots\vdots\vdots\vdots\,] = FG2I\_\ell s\_0\_partials(im, \phi, \lambda, h, \ell, s, \Delta p)$

unknown vector update Δp_1 with Δq_1
update Δp_2 with Δq_2
update ϕ, λ, h with Δ's

$$\boxed{\vec{f} = B\vec{\Delta} + \vec{v}}$$

(h) before you solve anything check

(i) magnitude of f

(ii) structure of B (spy(B))

(i) If solving by normal equations,

$$\Delta = (B^T W B)^{-1} B^T W f$$

gives warning about singularity or poor condition number then solve by

$$\Delta = B \backslash f$$

OR, for weighted solution:

$B^T W B \Delta = B^T W f$; $\underbrace{B^T W^{1/2}}_{D^T} \underbrace{W^{1/2} B}_{D} \Delta = \underbrace{B^T W^{1/2}}_{D^T} \underbrace{W^{1/2} f}_{e}$

$D^T D \Delta = D^T e$

$$\Delta = D \backslash e$$

if W not diagonal, get $W^{1/2}$ by cholesky decomposition

(matlab LS solver without normal equations)

(j) construct weight matrix by

$$W = \begin{bmatrix} w_1 & & & \\ & w_2 & & \\ & & \ddots & \\ & & & w_n \end{bmatrix} \qquad w_i = \frac{\sigma_0^2}{\sigma_i^2}$$

σ_0^2 ← constant you choose

σ_i^2 ← variance of i^{th} observation

(k)
- show convergence $\Delta_1, \Delta_2, \Delta_3, \ldots$
- show residuals after convergence $V = f - B\Delta$ (should be ~ 1-2 pixels)
- show estimated parameters q's & ϕ, λ, h

(l) use your own functions (preferably) or ones that I provide. watch email for tips.