

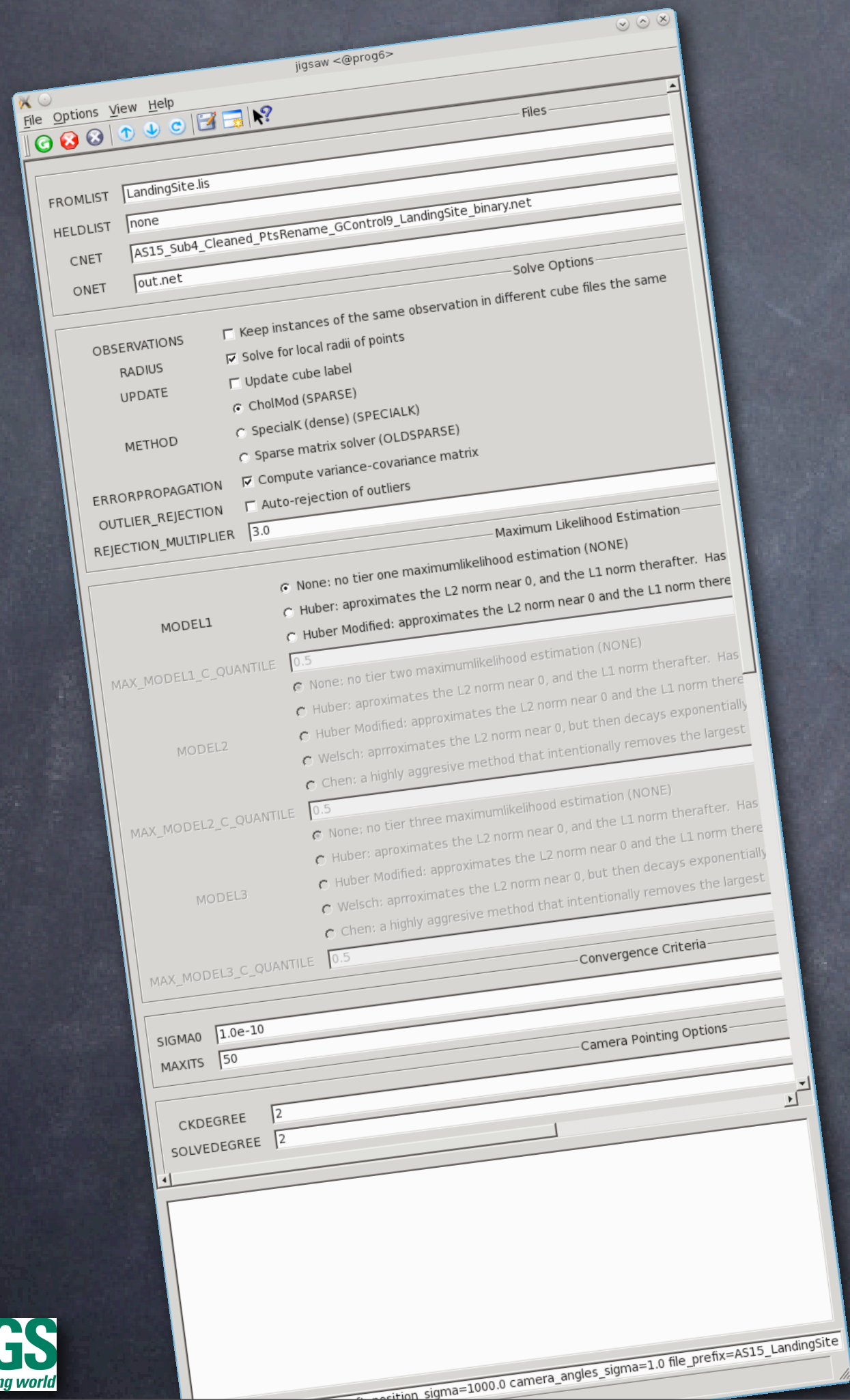
Jigsaw



The ISIS Bundle
Adjustment for
Extraterrestrial
Photogrammetry

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Least Squares Bundle Adjustment



Input

- Image Measurements.
- Initial values for image pointing/position and ground point coordinates.
- 'a priori' precisions for above parameters if available.

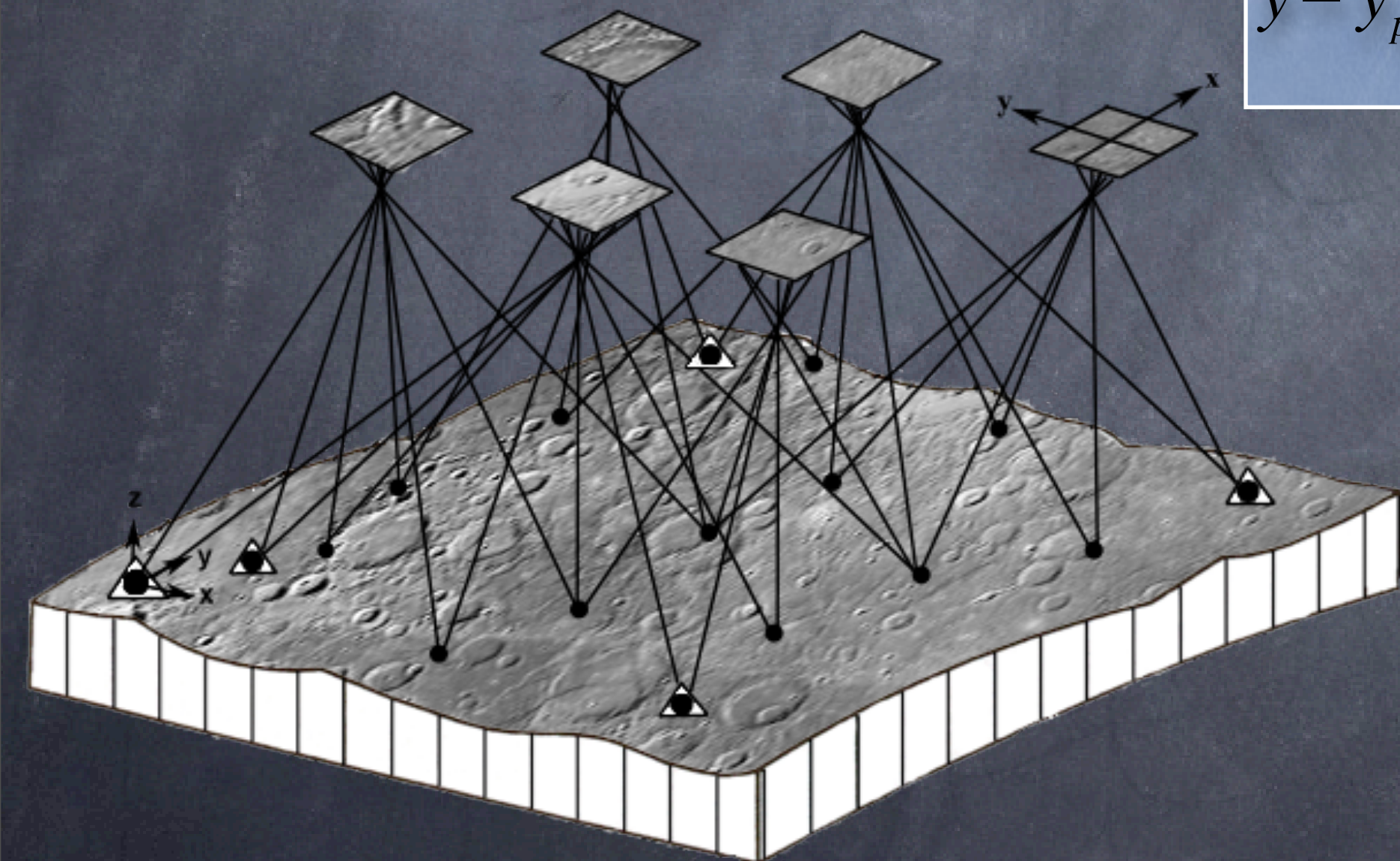
Output

- Refined image pointing/position and ground point coordinates.
- Their uncertainties.
- Solution statistics.

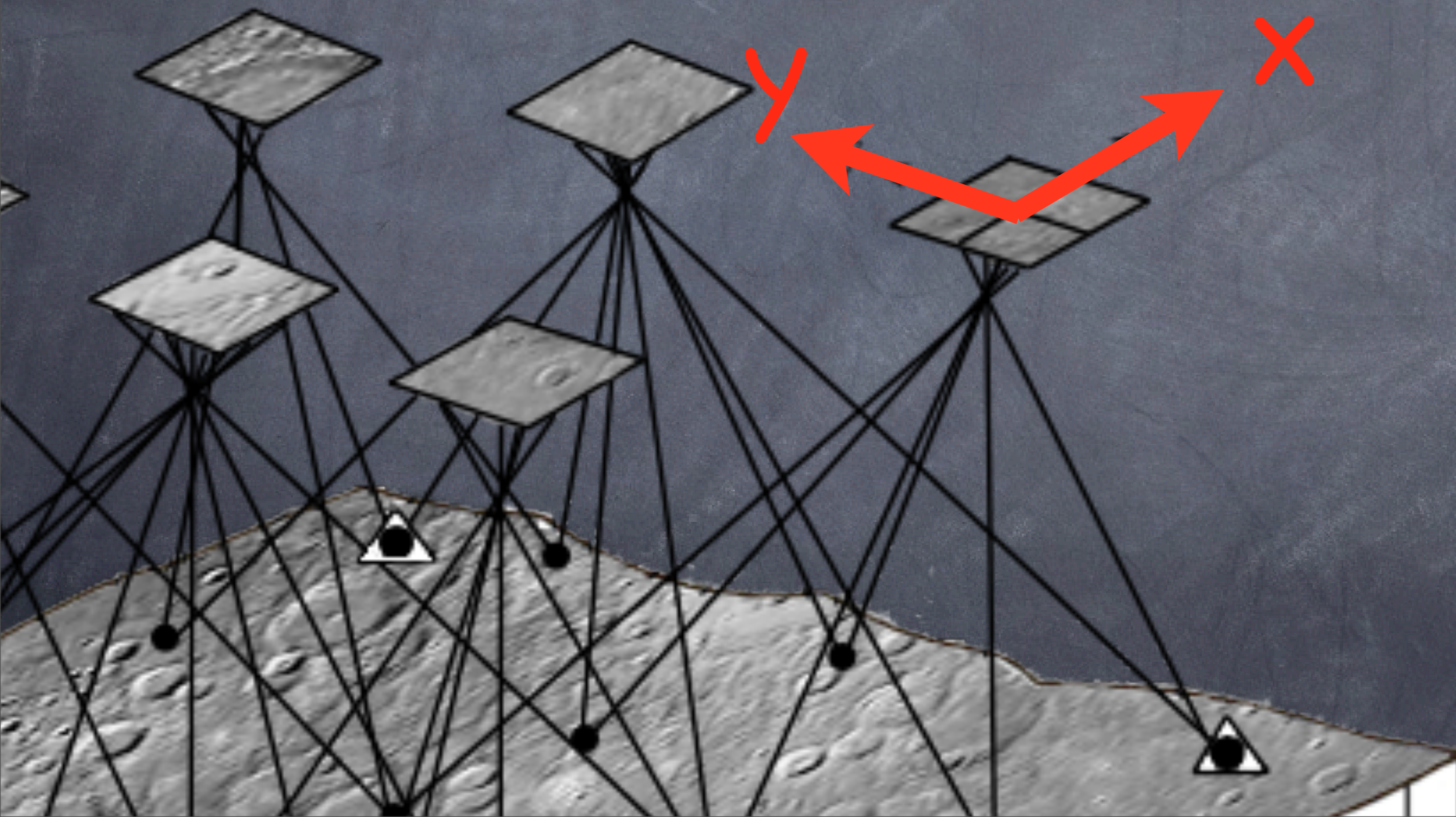
The Mathematical Model

$$x - x_p + \delta_x = -c \frac{m_{11}(X - X_c) + m_{12}(Y - Y_c) + m_{13}(Z - Z_c)}{m_{31}(X - X_c) + m_{32}(Y - Y_c) + m_{33}(Z - Z_c)}$$
$$y - y_p + \delta_y = -c \frac{m_{21}(X - X_c) + m_{22}(Y - Y_c) + m_{23}(Z - Z_c)}{m_{31}(X - X_c) + m_{32}(Y - Y_c) + m_{33}(Z - Z_c)}$$

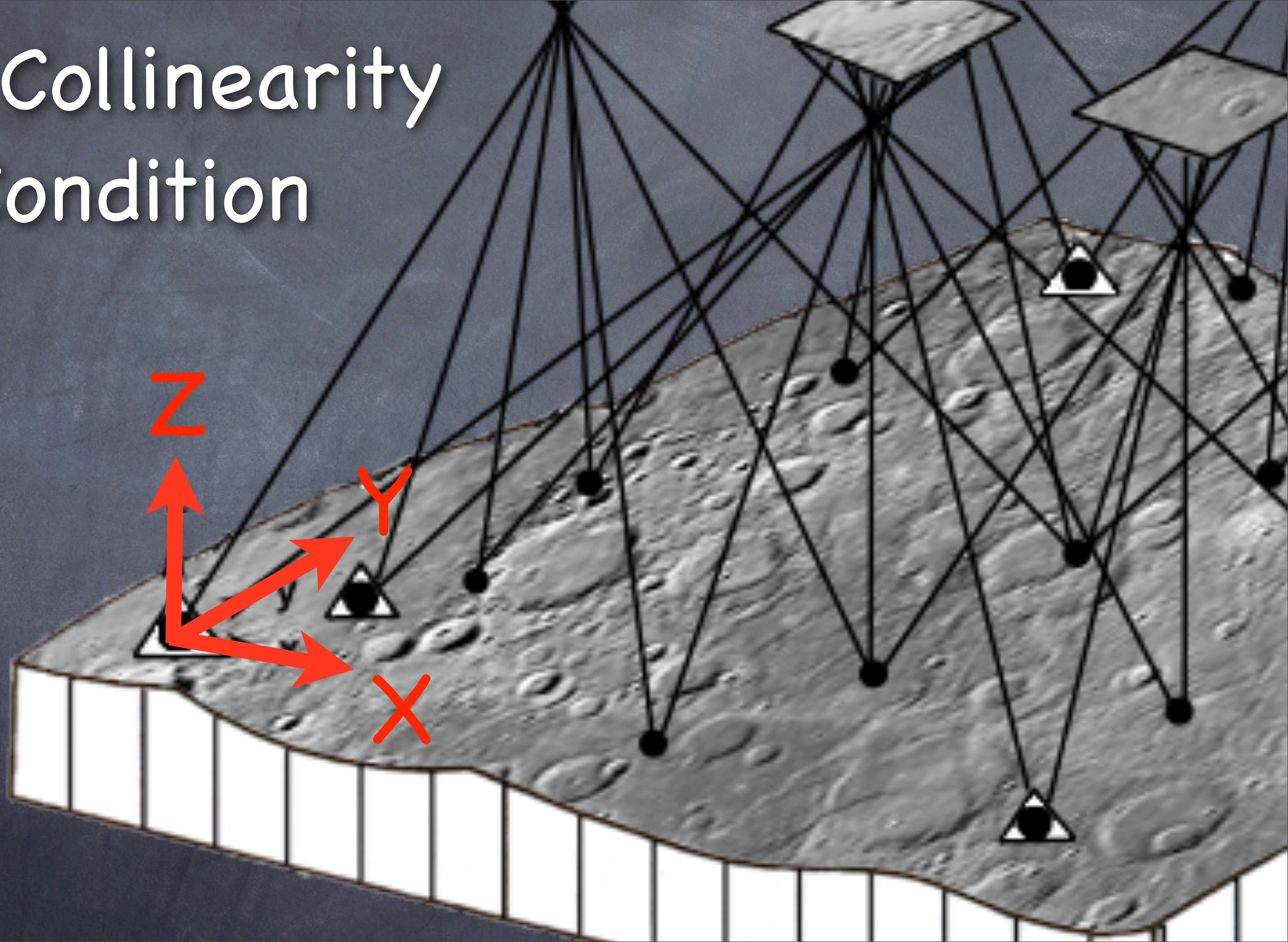
The Collinearity Condition



The Collinearity Condition



The Collinearity Condition



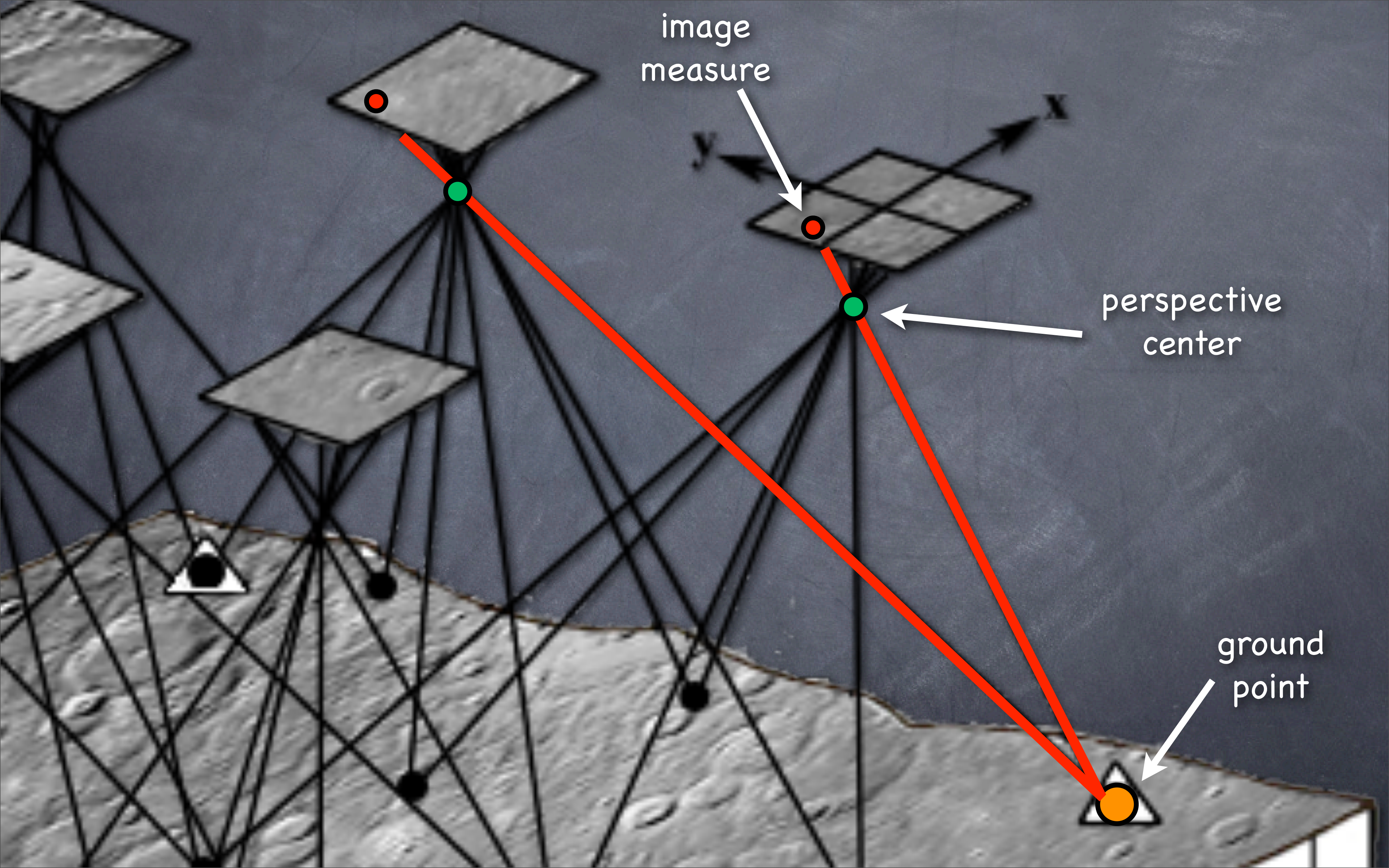


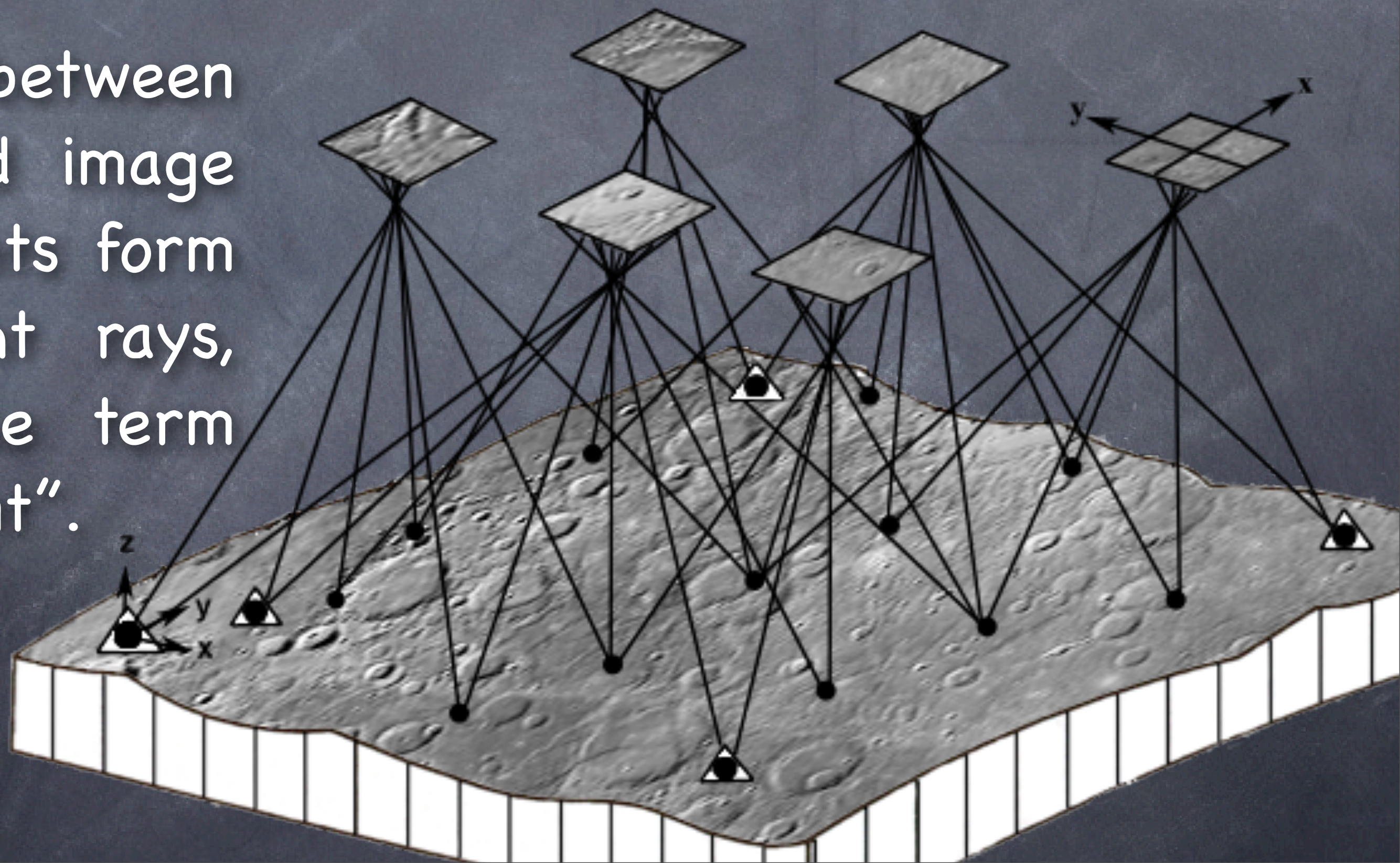
image
measure

perspective
center

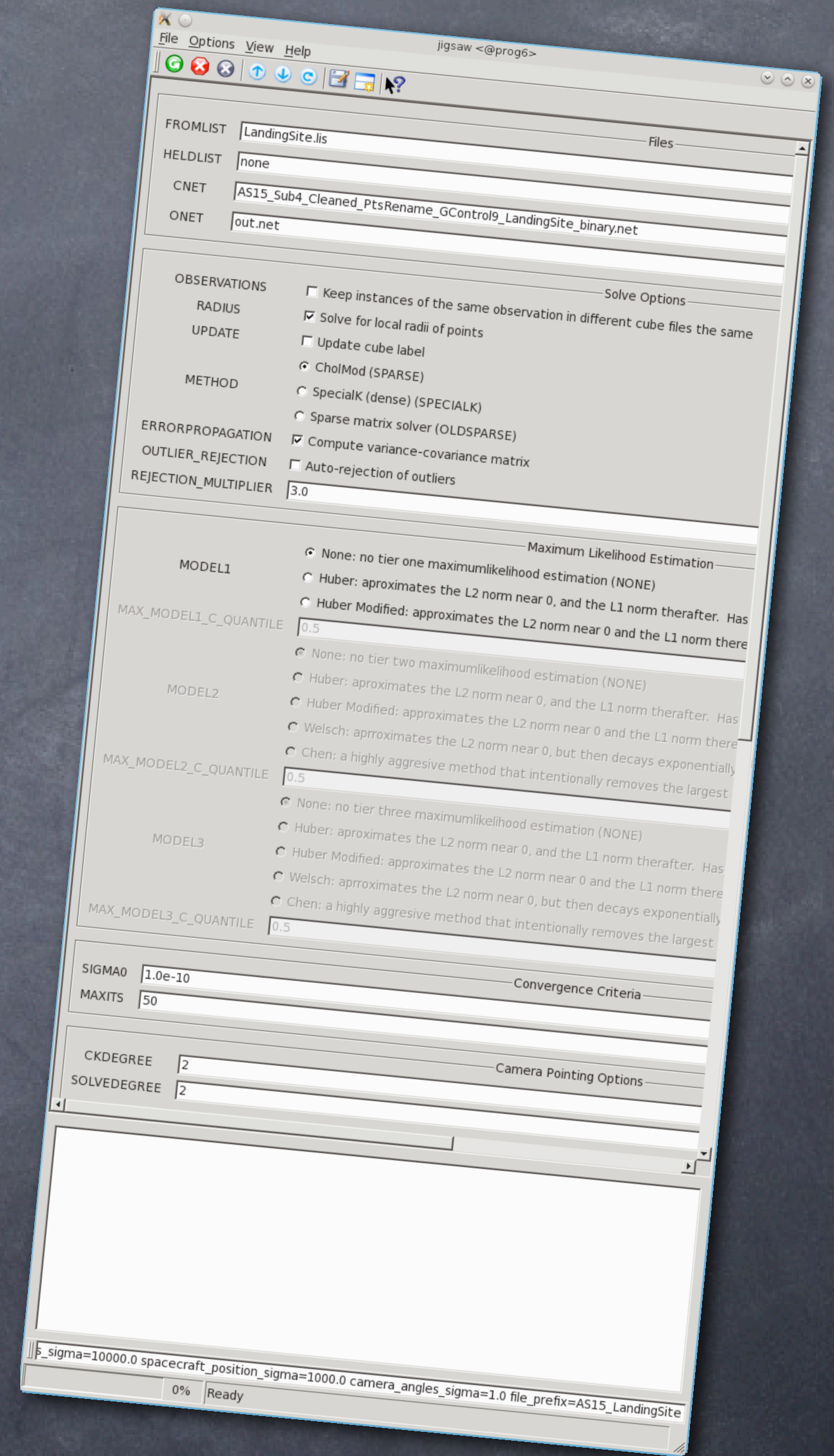
ground
point

The Bundle Adjustment

All connections between object points and image space measurements form a bundle of light rays, the origin of the term "Bundle Adjustment".



Jigsaw Interface



Files

- FROMLIST
 - ascii list of images in the control network.
- HELDLIST
 - ascii list of images for which position & pointing parameters are to be held fixed.
- CNET
 - Input control network.
- ONET
 - Output control network.

The screenshot shows the 'jigsaw' software interface with the following sections:

- Files:** FROMLIST, HELDLIST (none), CNET, ONET.
- Options:** OBSERVATIONS, RADIUS, UPDATE, METHOD, ERRORPROPAGATION, OUTLIER_REJECTION, REJECTION_MULTIPLIER (3.0).
- Maximum Likelihood Estimation:** MODEL1, MODEL2, MODEL3, each with MAX_MODEL*_C_QUANTILE (0.5) and radio button options for estimation methods (None, Huber, Huber Modified, Welsch, Chen).
- Convergence Criteria:** SIGMA0 (1.0e-10), MAXITS (50).

Solve Options

- OBSERVATIONS (Observation Mode)
 - All images within an “observation” have the same position & pointing.
 - Example: LRO NAC L/R
- RADIUS
- UPDATE
- METHOD
 - CholMod (default)
 - SpecialK
 - OLDSPARSE

The screenshot shows the 'jigsaw' software interface. The 'Solve Options' panel is highlighted with a black border. It contains the following settings:

- OBSERVATIONS: Keep instances of the same observation in different cube files the same
- RADIUS: Solve for local radii of points
- UPDATE: Update cube label
- METHOD: CholMod (SPARSE), SpecialK (dense) (SPECIALK), Sparse matrix solver (OLDSPARSE)
- ERRORPROPAGATION: Compute variance-covariance matrix
- OUTLIER_REJECTION: Auto-rejection of outliers
- REJECTION_MULTIPLIER: 3.0

The 'Maximum Likelihood Estimation' panel shows settings for three models:

- MODEL1: None: no tier one maximumlikelihood estimation (NONE), Huber: approximates the L2 norm near 0, and the L1 norm thereafter. Has, Huber Modified: approximates the L2 norm near 0 and the L1 norm there. MAX_MODEL1_C_QUANTILE: 0.5
- MODEL2: None: no tier two maximumlikelihood estimation (NONE), Huber: approximates the L2 norm near 0, and the L1 norm thereafter. Has, Huber Modified: approximates the L2 norm near 0 and the L1 norm there, Welsch: approximates the L2 norm near 0, but then decays exponentially, Chen: a highly aggressive method that intentionally removes the largest t. MAX_MODEL2_C_QUANTILE: 0.5
- MODEL3: None: no tier three maximumlikelihood estimation (NONE), Huber: approximates the L2 norm near 0, and the L1 norm thereafter. Has, Huber Modified: approximates the L2 norm near 0 and the L1 norm there, Welsch: approximates the L2 norm near 0, but then decays exponentially, Chen: a highly aggressive method that intentionally removes the largest t. MAX_MODEL3_C_QUANTILE: 0.5

The 'Convergence Criteria' panel shows:

- SIGMA0: 1.0e-10
- MAXITS: 50

Solve Options

- ERRORPROPAGATION
- Generation of parameter uncertainties.
- OUTLIER REJECTION
 - Automated rejection of outliers
- REJECTION_MULTIPLIER
- METHOD
 - CholMod (default)
 - SpecialK
 - OLDSPARSE

The screenshot shows the 'jigsaw <@prog6>' application window. The 'Solve Options' panel is highlighted with a black border. It contains the following settings:

- OBSERVATIONS: Keep instances of the same observation in different cube files the same
- RADIUS: Solve for local radii of points
- UPDATE: Update cube label
- METHOD: CholMod (SPARSE), SpecialK (dense) (SPECIALK), Sparse matrix solver (OLDSPARSE)
- ERRORPROPAGATION: Compute variance-covariance matrix
- OUTLIER_REJECTION: Auto-rejection of outliers
- REJECTION_MULTIPLIER: 3.0

The 'Maximum Likelihood Estimation' panel is also visible, showing settings for three models:

- MODEL1: None: no tier one maximumlikelihood estimation (NONE), Huber: approximates the L2 norm near 0, and the L1 norm thereafter. Has, Huber Modified: approximates the L2 norm near 0 and the L1 norm there
- MAX_MODEL1_C_QUANTILE: 0.5
- MODEL2: None: no tier two maximumlikelihood estimation (NONE), Huber: approximates the L2 norm near 0, and the L1 norm thereafter. Has, Huber Modified: approximates the L2 norm near 0 and the L1 norm there, Welsch: approximates the L2 norm near 0, but then decays exponentially, Chen: a highly aggressive method that intentionally removes the largest t
- MAX_MODEL2_C_QUANTILE: 0.5
- MODEL3: None: no tier three maximumlikelihood estimation (NONE), Huber: approximates the L2 norm near 0, and the L1 norm thereafter. Has, Huber Modified: approximates the L2 norm near 0 and the L1 norm there, Welsch: approximates the L2 norm near 0, but then decays exponentially, Chen: a highly aggressive method that intentionally removes the largest t
- MAX_MODEL3_C_QUANTILE: 0.5

The 'Convergence Criteria' panel at the bottom shows:

- SIGMA0: 1.0e-10
- MAXITS: 50

Maximum Likelihood Estimation

SEE NEXT PRESENTATION!

jigsaw <@prog6>

File Options View Help

Files

FROMLIST

HELDLIST

CNET

ONET

Solve Options

OBSERVATIONS Keep instances of the same observation in different cube files the same

RADIUS Solve for local radii of points

UPDATE Update cube label

METHOD CholMod (SPARSE)

ERRORPROPAGATION Compute variance-covariance matrix

OUTLIER_REJECTION Auto-rejection of outliers

REJECTION_MULTIPLIER

Maximum Likelihood Estimation

MODEL1 None: no tier one maximumlikelihood estimation (NONE)

Huber: aproximates the L2 norm near 0, and the L1 norm thereafter. Has

Huber Modified: aproximates the L2 norm near 0 and the L1 norm there

MAX_MODEL1_C_QUANTILE

MODEL2 None: no tier two maximumlikelihood estimation (NONE)

Huber: aproximates the L2 norm near 0, and the L1 norm thereafter. Has

Huber Modified: aproximates the L2 norm near 0 and the L1 norm there

Welsch: aproximates the L2 norm near 0, but then decays exponentially

Chen: a highly aggresive method that intentionally removes the largest 1

MAX_MODEL2_C_QUANTILE

MODEL3 None: no tier three maximumlikelihood estimation (NONE)

Huber: aproximates the L2 norm near 0, and the L1 norm thereafter. Has

Huber Modified: aproximates the L2 norm near 0 and the L1 norm there

Welsch: aproximates the L2 norm near 0, but then decays exponentially

Chen: a highly aggresive method that intentionally removes the largest 1

MAX_MODEL3_C_QUANTILE

SIGMA0

MAXITS

Convergence Criteria

- SIGMA0

- Convergence occurs when change in Sigma0 in successive iterations is less or equal to this value.

- Setting to a larger value results in fewer iterations.

- MAXITS

- Adjustment stops (regardless of convergence) upon reaching maximum iterations.

The screenshot shows the 'jigsaw <@prog6>' application window. The 'Convergence Criteria' section at the bottom is highlighted with a black brushstroke. It contains the following settings:

Parameter	Value
SIGMA0	1.0e-10
MAXITS	50

Other visible settings in the 'Solve Options' section include:

- OBSERVATIONS: Keep instances of the same observation in different cube files the same
- RADIUS: Solve for local radii of points
- UPDATE: Update cube label
- METHOD: CholMod (SPARSE)
- ERRORPROPAGATION: Compute variance-covariance matrix
- OUTLIER_REJECTION: Auto-rejection of outliers
- REJECTION_MULTIPLIER: 3.0

The 'Maximum Likelihood Estimation' section shows three models (MODEL1, MODEL2, MODEL3) with their respective quantile values set to 0.5 and various estimation methods selected.

Camera Pointing Options

- CKDEGREE
- Degree of polynomial for computation of initial values (time-dependent sensors, e.g. line scan).

Camera Pointing Options

CKDEGREE

SOLVEDEGREE

Don't solve for any camera pointing factors (NONE)

Solve for camera angles: right ascension, declination and optionally twist (ANGLES)

CAMSOLVE

Solve for camera angles AND their angular velocities (VELOCITIES)

Solve for camera angles, their angular velocities and accelerations (ACCELERATIONS)

Solve for all coefficients in the polynomials fit to the camera angles. (ALL)

TWIST Solve for twist

SPSOLVE

Don't solve for any spacecraft position parameters (NONE)

Solve for the spacecraft positions (POSITION)

Solve for the spacecraft positions and velocities (VELOCITIES)

Solve for the spacecraft positions, velocities, and accelerations (ACCELERATIONS)

Parameter Uncertainties

POINT_LATITUDE_SIGMA	<input type="text" value="none"/>
POINT_LONGITUDE_SIGMA	<input type="text" value="none"/>
POINT_RADIUS_SIGMA	<input type="text" value="none"/>
SPACECRAFT_POSITION_SIGMA	<input type="text" value="none"/>
SPACECRAFT_VELOCITY_SIGMA	<input type="text" value="none"/>
SPACECRAFT_ACCELERATION_SIGMA	<input type="text" value="none"/>
CAMERA_ANGLES_SIGMA	<input type="text" value="none"/>
CAMERA_ANGULAR_VELOCITY_SIGMA	<input type="text" value="none"/>
CAMERA_ANGULAR_ACCELERATION_SIGMA	<input type="text" value="none"/>

Output Options

FILE_PREFIX

BUNDLEOUT_TXT Standard bundle output file - bundleout.txt

OUTPUT_CSV Outputs point and image data (body-fixed) to csv file - bundleout_points.csv

RESIDUALS_CSV Outputs image coordinate residuals to csv file - residuals.csv

(RGE) jigsaw Konsole 4 Making_A_Mosaic.txt - KW BundleAdjust.c

Camera Pointing Options

- SOLVEDEGREE
 - Degree of polynomial in adjustment.
 - e.g., degree of 2 \Rightarrow solving for 3 polynomial coefficients.
 - $at^2 + bt + c$; where
 - t = time
 - a = angular acceleration
 - b = angular velocity
 - c = angle

Camera Pointing Options

CKDEGREE

SOLVEDEGREE

Don't solve for any camera pointing factors (NONE)

Solve for camera angles: right ascension, declination and optionally twist (ANGLES)

CAMSOLVE

Solve for camera angles AND their angular velocities (VELOCITIES)

Solve for camera angles, their angular velocities and accelerations (ACCELERATIONS)

Solve for all coefficients in the polynomials fit to the camera angles. (ALL)

TWIST Solve for twist

SPSOLVE

Don't solve for any spacecraft position parameters (NONE)

Solve for the spacecraft positions (POSITION)

Solve for the spacecraft positions and velocities (VELOCITIES)

Solve for the spacecraft positions, velocities, and accelerations (ACCELERATIONS)

Parameter Uncertainties

POINT_LATITUDE_SIGMA	<input type="text" value="none"/>
POINT_LONGITUDE_SIGMA	<input type="text" value="none"/>
POINT_RADIUS_SIGMA	<input type="text" value="none"/>
SPACECRAFT_POSITION_SIGMA	<input type="text" value="none"/>
SPACECRAFT_VELOCITY_SIGMA	<input type="text" value="none"/>
SPACECRAFT_ACCELERATION_SIGMA	<input type="text" value="none"/>
CAMERA_ANGLES_SIGMA	<input type="text" value="none"/>
CAMERA_ANGULAR_VELOCITY_SIGMA	<input type="text" value="none"/>
CAMERA_ANGULAR_ACCELERATION_SIGMA	<input type="text" value="none"/>

Output Options

FILE_PREFIX

BUNDLEOUT_TXT Standard bundle output file - bundleout.txt

OUTPUT_CSV Outputs point and image data (body-fixed) to csv file - bundleout_points.csv

RESIDUALS_CSV Outputs image coordinate residuals to csv file - residuals.csv

(RGE) jigsaw Konsole 4 Making_A_Mosaic.txt - KW BundleAdjust.c

Camera Pointing Options

- CAMSOLVE
 - Selection of angular parameters in the adjustment.
- TWIST

Camera Pointing Options

CKDEGREE

SOLVEDEGREE

Don't solve for any camera pointing factors (NONE)

Solve for camera angles: right ascension, declination and optionally twist (ANGLES)

CAMSOLVE

Solve for camera angles AND their angular velocities (VELOCITIES)

Solve for camera angles, their angular velocities and accelerations (ACCELERATIONS)

Solve for all coefficients in the polynomials fit to the camera angles. (ALL)

TWIST Solve for twist

SPSOLVE

Don't solve for any spacecraft position parameters (NONE)

Solve for the spacecraft positions (POSITION)

Solve for the spacecraft positions and velocities (VELOCITIES)

Solve for the spacecraft positions, velocities, and accelerations (ACCELERATIONS)

Parameter Uncertainties

POINT_LATITUDE_SIGMA	<input type="text" value="none"/>
POINT_LONGITUDE_SIGMA	<input type="text" value="none"/>
POINT_RADIUS_SIGMA	<input type="text" value="none"/>
SPACECRAFT_POSITION_SIGMA	<input type="text" value="none"/>
SPACECRAFT_VELOCITY_SIGMA	<input type="text" value="none"/>
SPACECRAFT_ACCELERATION_SIGMA	<input type="text" value="none"/>
CAMERA_ANGLES_SIGMA	<input type="text" value="none"/>
CAMERA_ANGULAR_VELOCITY_SIGMA	<input type="text" value="none"/>
CAMERA_ANGULAR_ACCELERATION_SIGMA	<input type="text" value="none"/>

Output Options

FILE_PREFIX

BUNDLEOUT_TXT Standard bundle output file - bundleout.txt

OUTPUT_CSV Outputs point and image data (body-fixed) to csv file - bundleout_points.csv

RESIDUALS_CSV Outputs image coordinate residuals to csv file - residuals.csv

(RGE) jigsaw Konsole 4 Making_A_Mosaic.txt - KW BundleAdjust.c

Spacecraft Options

- SPSOLVE
 - Selection of spacecraft position parameters in the adjustment.
- NOTE: capability to solve for coefficients of higher degree polynomials (as with pointing) is coming soon.

Camera Pointing Options

CKDEGREE

SOLVEDEGREE

Don't solve for any camera pointing factors (NONE)

Solve for camera angles: right ascension, declination and optionally twist (ANGLES)

CAMSOLVE

Solve for camera angles AND their angular velocities (VELOCITIES)

Solve for camera angles, their angular velocities and accelerations (ACCELERATIONS)

Solve for all coefficients in the polynomials fit to the camera angles. (ALL)

TWIST Solve for twist

Spacecraft Options

Don't solve for any spacecraft position parameters (NONE)

Solve for the spacecraft positions (POSITION)

SPSOLVE

Solve for the spacecraft positions and velocities (VELOCITIES)

Solve for the spacecraft positions, velocities, and accelerations (ACCELERATIONS)

POINT_LATITUDE_SIGMA

POINT_LONGITUDE_SIGMA

POINT_RADIUS_SIGMA

SPACECRAFT_POSITION_SIGMA

SPACECRAFT_VELOCITY_SIGMA

SPACECRAFT_ACCELERATION_SIGMA

CAMERA_ANGLES_SIGMA

CAMERA_ANGULAR_VELOCITY_SIGMA

CAMERA_ANGULAR_ACCELERATION_SIGMA

Output Options

FILE_PREFIX

BUNDLEOUT_TXT Standard bundle output file - bundleout.txt

OUTPUT_CSV Outputs point and image data (body-fixed) to csv file - bundleout_points.csv

RESIDUALS_CSV Outputs image coordinate residuals to csv file - residuals.csv

(RGE) jigsaw Konsole 4 Making_A_Mosaic.txt - KW BundleAdjust.c

Global Parameter Uncertainties

- Global 'a priori' uncertainties for ground point coordinates, position, & pointing parameters.
- Parameter weights in the adjustment are computed from uncertainties.
- Point sigmas in control network take precedence.

The screenshot shows the BundleAdjust software interface with several sections:

- Camera Pointing Options:**
 - CKDEGREE: 2
 - SOLVEDEGREE: 2
 - Don't solve for any camera pointing factors (NONE) []
 - Solve for camera angles: right ascension, declination and optionally twist (ANGLES) [x]
 - CAMSOLVE:
 - Solve for camera angles AND their angular velocities (VELOCITIES) []
 - Solve for camera angles, their angular velocities and accelerations (ACCELERATIONS) []
 - Solve for all coefficients in the polynomials fit to the camera angles. (ALL) []
 - TWIST: Solve for twist
- Spacecraft Options:**
 - Don't solve for any spacecraft position parameters (NONE) [x]
 - Solve for the spacecraft positions (POSITION) []
 - Solve for the spacecraft positions and velocities (VELOCITIES) []
 - Solve for the spacecraft positions, velocities, and accelerations (ACCELERATIONS) []
- Parameter Uncertainties:** (highlighted with a red box)

POINT_LATITUDE_SIGMA	none
POINT_LONGITUDE_SIGMA	none
POINT_RADIUS_SIGMA	none
SPACECRAFT_POSITION_SIGMA	none
SPACECRAFT_VELOCITY_SIGMA	none
SPACECRAFT_ACCELERATION_SIGMA	none
CAMERA_ANGLES_SIGMA	none
CAMERA_ANGULAR_VELOCITY_SIGMA	none
CAMERA_ANGULAR_ACCELERATION_SIGMA	none
- Output Options:**
 - FILE_PREFIX: none
 - BUNDLEOUT_TXT: Standard bundle output file - bundleout.txt
 - OUTPUT_CSV: Outputs point and image data (body-fixed) to csv file - bundleout_points.csv
 - RESIDUALS_CSV: Outputs image coordinate residuals to csv file - residuals.csv

The taskbar at the bottom shows open applications: (RGE), jigsaw, Konsole, Making_A_Mosaic.txt - KW, and BundleAdjust.c

Output Options

- FILE_PREFIX
- BUNDLEOUT_TXT
 - Standard report "bundleout.txt" contains...
 - adjusted parameters
 - adjusted parameter uncertainties (if error propagation is on)
 - Statistics
- OUTPUT_CSV
 - "bundleout_images.csv"
 - "bundleout_points.csv"

Camera Pointing Options

CKDEGREE 2

SOLVEDEGREE 2

Don't solve for any camera pointing factors (NONE)

Solve for camera angles: right ascension, declination and optionally twist (ANGLES)

CAMSOLVE

Solve for camera angles AND their angular velocities (VELOCITIES)

Solve for camera angles, their angular velocities and accelerations (ACCELERATIONS)

Solve for all coefficients in the polynomials fit to the camera angles. (ALL)

TWIST Solve for twist

Spacecraft Options

Don't solve for any spacecraft position parameters (NONE)

Solve for the spacecraft positions (POSITION)

Solve for the spacecraft positions and velocities (VELOCITIES)

Solve for the spacecraft positions, velocities, and accelerations (ACCELERATIONS)

SPSOLVE

Parameter Uncertainties

POINT_LATITUDE_SIGMA	none
POINT_LONGITUDE_SIGMA	none
POINT_RADIUS_SIGMA	none
SPACECRAFT_POSITION_SIGMA	none
SPACECRAFT_VELOCITY_SIGMA	none
SPACECRAFT_ACCELERATION_SIGMA	none
CAMERA_ANGLES_SIGMA	none
CAMERA_ANGULAR_VELOCITY_SIGMA	none
CAMERA_ANGULAR_ACCELERATION_SIGMA	none

Output Options

FILE_PREFIX none

BUNDLEOUT_TXT Standard bundle output file - bundleout.txt

OUTPUT_CSV Outputs point and image data (body-fixed) to csv file - bundleout_points.csv

RESIDUALS_CSV Outputs image coordinate residuals to csv file - residuals.csv

Output Options

- RESIDUALS_CSV
- "residuals_images.csv"

Camera Pointing Options

CKDEGREE

SOLVEDEGREE

Don't solve for any camera pointing factors (NONE)

Solve for camera angles: right ascension, declination and optionally twist (ANGLES)

CAMSOLVE

Solve for camera angles AND their angular velocities (VELOCITIES)

Solve for camera angles, their angular velocities and accelerations (ACCELERATIONS)

Solve for all coefficients in the polynomials fit to the camera angles. (ALL)

TWIST Solve for twist

Spacecraft Options

Don't solve for any spacecraft position parameters (NONE)

Solve for the spacecraft positions (POSITION)

Solve for the spacecraft positions and velocities (VELOCITIES)

Solve for the spacecraft positions, velocities, and accelerations (ACCELERATIONS)

SPSOLVE

Parameter Uncertainties

POINT_LATITUDE_SIGMA	<input type="text" value="none"/>
POINT_LONGITUDE_SIGMA	<input type="text" value="none"/>
POINT_RADIUS_SIGMA	<input type="text" value="none"/>
SPACECRAFT_POSITION_SIGMA	<input type="text" value="none"/>
SPACECRAFT_VELOCITY_SIGMA	<input type="text" value="none"/>
SPACECRAFT_ACCELERATION_SIGMA	<input type="text" value="none"/>
CAMERA_ANGLES_SIGMA	<input type="text" value="none"/>
CAMERA_ANGULAR_VELOCITY_SIGMA	<input type="text" value="none"/>
CAMERA_ANGULAR_ACCELERATION_SIGMA	<input type="text" value="none"/>

Output Options

FILE_PREFIX

BUNDLEOUT_TXT Standard bundle output file - bundleout.txt

OUTPUT_CSV Outputs point and image data (body-fixed) to csv file - bundleout_points.csv

RESIDUALS_CSV Outputs image coordinate residuals to csv file - residuals.csv

Output



Run Time: 2012-06-22T15:39:42
Network Filename: AS15_Sub4_Cleaned_PtsRename_GControl9_LandingSite_binary.net
Network Id: LandingSite
Network Description: cnetextracted
Target: Moon

Linear Units: kilometers
Angular Units: decimal degrees

INPUT: SOLVE OPTIONS

OBSERVATIONS: OFF
RADIUS: ON
SOLUTION TYPE: SPARSE
ERROR PROPAGATION: ON
OUTLIER REJECTION: ON
REJECTION MULTIPLIER: 3.000000

MAXIMUM LIKELIHOOD ESTIMATION

Tier 0 Enabled: FALSE
Tier 1 Enabled: FALSE
Tier 2 Enabled: FALSE

INPUT: CONVERGENCE CRITERIA

SIGMA0: 1.000000e-10
MAXIMUM ITERATIONS: 50

INPUT: CAMERA POINTING OPTIONS

CAMSOLVE: ANGLES
TWIST: ON

INPUT: SPACECRAFT OPTIONS

SPSOLVE: POSITION

INPUT: GLOBAL IMAGE PARAMETER UNCERTAINTIES

POINT LATITUDE SIGMA: N/A
POINT LONGITUDE SIGMA: N/A
POINT RADIUS SIGMA: N/A
SPACECRAFT POSITION SIGMA: 500.000000 (meters)
SPACECRAFT VELOCITY SIGMA: N/A
SPACECRAFT ACCELERATION SIGMA: N/A
CAMERA ANGLES SIGMA: 3.000000 (dd)
CAMERA ANGULAR VELOCITY SIGMA: N/A
CAMERA ANGULAR ACCELERATION SIGMA: N/A

JIGSAW: RESULTS

Images: 5
Points: 395
Total Measures: 950
Total Observations: 1900
Good Observations: 1844
Rejected Observations: 56
Constrained Point Parameters: 99
Constrained Image Parameters: 30
Unknowns: 1215
Degrees of Freedom: 758
Convergence Criteria: 1e-10(Sigma0)
Iterations: 6
Sigma0: 0.55322850893198283195
Error Propagation Elapsed Time: 0.0500 (seconds)
Total Elapsed Time: 0.4400 (seconds)

Residual Percentiles:

Percentile 1:	-1.486	Percentile 34:	-0.014
Percentile 2:	-1.118	Percentile 35:	-0.010
Percentile 3:	-0.868	Percentile 36:	-0.008
Percentile 4:	-0.756	Percentile 37:	-0.006
Percentile 5:	-0.658	Percentile 38:	-0.004
Percentile 6:	-0.602	Percentile 39:	-0.003
Percentile 7:	-0.545	Percentile 40:	-0.003
Percentile 8:	-0.498	Percentile 41:	-0.003
Percentile 9:	-0.468		

Examining the Results

Things to look for...

- Sigma0: ideally close to 1.0.
- Examine measure residuals for outliers.
- Unreasonably high adjusted parameter uncertainties.
- Magnitude of the corrections to weighted parameters.

Potential problems to consider...

- Poor a priori parameter values
 - Bad SPICE? Problem DEM?
- Measurement errors – Wrong feature? Wrong point label?
- Improperly weighted point coordinates?
- Weak image geometry?
- Number and geometry of image measurements for a ground point
- Camera model problem?