3

The University of Calgary
Department of Geomatics Engineering
ENGO 634: Principles of Photogrammetry

Relative Orientation

Lab Teaching Assistant:
Armin Ghayur Sadigh

Assignment date:
18/02/2025

Submission date:
11/03/2025

Fre Ashal 30231900
(fre.ashal@ucalgary.ca)
Okoye Akachukwu 30198304
(akachukwu.okoye1@ucalgary.ca)
Chrisantus Innocent 30240521
(chrisantus.innocent@ucalgary.ca)
Quinn Ledingham 30092066
(quinn.ledingham@ucalgary.ca)

Winter 2025

ENGO 634: Principles of Photogrammetry
Lab–3: Relative Orientation

Objectives

The scope of this lab is to carry out the relative orientation of a stereo pair using six tie points and calculate the 3D model coordinates. We intend to achieve that within the context of a multi-step assignment (2-5) focusing on photogrammetric restitution approximations. The specific tasks include:

1. Calculate the relative orientation parameters for the stereo pair using a base distance of 92 mm.
2. Check the validity of the solution regarding its residuals (Y-parallax values) and RO parameters.
3. Conduct a space intersection to find the model space coordinates of all object points.
4. Ensure the software works with the test data available in the lecture notes.

Relative orientation and space intersection:

Use the six tie points to estimate the relative orientation parameters for your stereo pair assuming a 92 mm base distance.

Relative Orientation

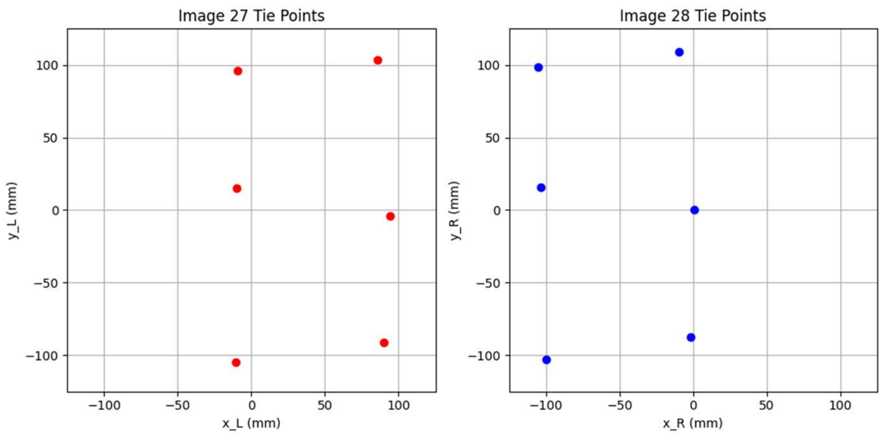
Relative orientation was completed using the six available tie points from lab assignment 2. The estimation of relative orientation parameters was done using the coplanarity condition.

Input Data: The tie point coordinates for Image 27 and Image 28 were used as given in Table 1.
Base Distance: The stereo pair was assumed to have a base distance of 92 mm.
Coplanarity Condition: The coplanarity condition was used for estimating the relative orientation parameters (bY, bZ, ω, φ, κ).
Residuals: The residuals were computed and so the Y-parallax values were calculated to evaluate the solution quality.

Table 1: *Initial tie point coordinates*

ID	Image 27		Image 28	
	x	y	x	y
T1	-10.105	15.011	-103.83	16.042
T2	94.369	-4.092	0.868	-0.022
T3	-10.762	-104.71	-100.17	-103.14
T4	90.075	-91.378	-1.607	-87.253
T5	-9.489	96.26	-105.4	98.706
T6	85.42	103.371	-9.738	109.306

Image 1: *Tie point plots*



Looking at these plots of the tie points it can be seen that image 27 is the left image and image 28 is the right image.

Table 2: *Y-Parallax values for tie points*

Point	Y-Parallax (mm)	Y-Parallax (pixels)
T1	0.0153	1.287
T2	-0.0159	-1.335
T3	-0.0066	-0.557
T4	0.0092	0.771
T5	-0.0099	-0.828
T6	0.0078	0.657

Residuals (Y-Parallax Values): The analysis of the residuals was done to determine the quality of the fit of the relative orientation solution. Larger residuals suggest that there are errors in the tie point measurements or that the relative orientation may not have been done correctly, while smaller residuals suggest that there is a good fit. If we take the pixel spacing from last lab of 0.0119mm/px then we can see that most parallaxes are smaller than a pixel and all of them are smaller than two pixels.

Table 3: *Estimated relative orientation parameters*

Orientation Parameter	Value
b_Y (mm)	-1.3008
b_Z (mm)	-1.3003
ω (dd)	-1.0032
ϕ (dd)	0.2585
κ (dd)	-1.7538

Table 4: *Correlation coefficient matrix of the estimated parameters*

	b_Y	b_Z	ω	ϕ	κ
b_Y	1.0	0.2544	-0.9766	-0.279	0.0336
b_Z	0.2544	1.0	-0.2463	-0.7616	-0.0229
ω	-0.9766	-0.2463	1.0	0.2653	0.1253
ϕ	-0.279	-0.7616	0.2653	1.0	0.0409
κ	0.0336	-0.0229	0.1253	0.0409	1.0

Relative Orientation Parameters:
The estimated parameters were analyzed for any large correlations that might exist. There is a high correlation between by and omega with a value of -0.9766, this makes sense since omega is the roll of the camera, a rotation around the x-axis, which when changed will move the y coordinate significantly. The high correlation between bz and phi (-0.7616) is for the same reason, changing the rotation around the y-axis will move the z coordinate. Kappa does not have the same type of high correlation with a parameter because bx is constant.

Gross Error Detection:
The coplanarity condition is not a true observation equation, however, the tie points have associated x and y coordinates. Major errors can be determined in these observations by looking at the residuals/y-parallax. For example, gross errors in the tie point measurements will cause large residuals. This is because the error forces the computed epipolar plane to be inconsistent.

Space Intersection

Space intersection was done to get the coordinates of the object points as part of the 3D model after relative orientation.

Table 5: *Model space coordinates for tie points*

Point	x (mm)	y (mm)	z (mm)
T1	-9.9688	14.8164	-156.2243
T2	92.0658	-4.0001	-154.4931
T3	-10.5394	-102.5484	-155.0824
T4	87.0929	-88.3482	-153.1153
T5	-9.4881	96.2460	-158.3431
T6	84.9816	102.8444	-157.5453

Table 6: Initial control/check point coordinates

ID	Image 27		Image 28	
	x	y	x	y
100	-9.59	96.218	-105.47	98.736
102	-2.413	-5.995	-95.081	-4.848
104	18.943	-81.815	-72.547	-79.764
105	90.379	-91.092	-1.357	-86.95
200	18.149	109.575	-77.826	113.405
201	44.598	7.473	-48.846	10.131
202	-7.657	-49.112	-98.855	-48.068
203	52.691	-93.178	-38.936	-90.079

Table 7: Model space coordinates for control/check points

Point	x (mm)	y (mm)	z (mm)
100	-9.5921	96.2715	-158.3930
102	-2.3846	-5.9159	-156.4915
104	18.3668	-79.3166	-153.5411
105	87.3462	-88.0244	-153.0441
200	18.1668	109.7020	-158.5132
201	43.8732	7.3538	-155.7842
202	-7.5412	-48.3543	-155.9639
203	50.8805	-89.9778	-152.9167

Software validation with test data from lecture notes

The software was validated using test data from the lecture notes. The software outcome was checked against the expected values and the differences were analyzed. It was verified that the software was working correctly as the outcome matched the given values.

Image 2: Test data tie point plots

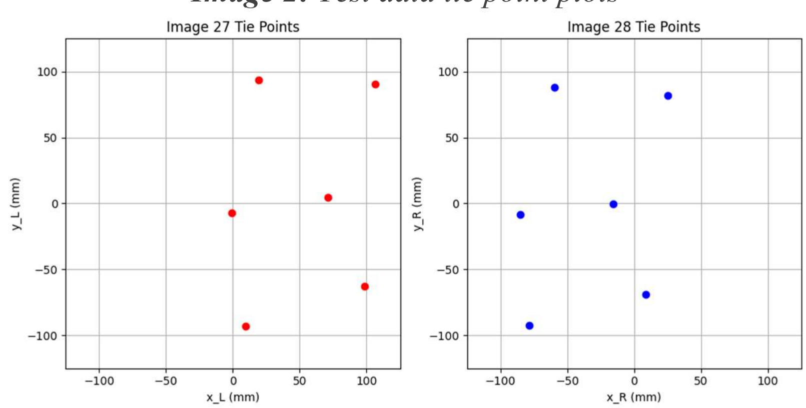


Table 8: *Estimated relative orientation parameters for test data*

Orientation Parameter	Value
b_Y (mm)	5.0455
b_Z (mm)	2.1725
ω (dd)	0.5218
ϕ (dd)	1.4815
κ (dd)	3.1700

The parameters bz, by are the same while the rotation angles are different but close.

Table 9: *Y-Parallax values for test data points*

ID	Y-Parallax
30	0.0030
40	-0.0020
72	-0.0087
127	0.0067
112	-0.0027
50	0.0036

Same y-parallaxes from the lecture notes.

Table 10: *Correlation coefficient matrix of the estimated parameters for test data*

	b_Y	b_Z	ω	ϕ	κ
b_Y	1.0	0.2486	-0.9848	-0.252	0.0167
b_Z	0.2486	1.0	-0.2953	-0.7065	-0.2117
ω	-0.9848	-0.2953	1.0	0.2886	0.0978
ϕ	-0.252	-0.7065	0.2886	1.0	0.055
κ	0.0167	-0.2117	0.0978	0.055	1.0

Similar correlation coefficient matrix, values are similar and parameters with high correlation in the notes have high correlation here.

Table 11: *Model space coordinates for test data points*

Point	x (mm)	y (mm)	z (mm)
T1	108.9302	92.5786	-155.7695
T2	19.5304	96.0258	-156.4878
T3	71.8751	4.9657	-154.1035
T4	-0.9473	-7.4078	-154.8060
T5	9.6380	-96.5329	-158.0535
T6	100.4898	-63.9177	-154.9389

Same model coordinates of points after intersection as are in the lecture notes.

Task Summary:

Name	Summary	Amount of Time
Quinn Ledingham	Code development and results compilation.	7 hours
Okoye Akachukwu	Report writing, and analysis	6 hours
Fre Ashal	Report editing, initial draft code	6 hours
Innocent Chrisantus	Report review, and analysis	6 hours 15mins

Appendix A: Code

Python code included in submission called lab3_calc.py