**Final Exam**

Question 1

1. If the control points are treated as known (constants), then define the total number of observations (n), the number of unknowns (u), and the redundancy (r) of the adjustment.

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| --- | --- | --- | --- | --- | --- |
| **Observations** | | | **Unknowns** | | |
| 3D GCP | 1 x 3 x 2 | 6 | Images | 6 x 8 | 48 |
| HCP | 2 x 2 x 3 | 12 | Tie points | 27 x 3 | 81 |
| VCP | 2 x 2 x 2 | 8 | HCP | 2 x 1 | 2 |
| Tie Points | 15 x 2 x 2 | 60 | VCP | 2 x 2 | 4 |
| Tie Points | 10 x 3 x 2 | 60 | **Total Unknowns (u)** | | **135** |
| Tie Points | 2 x 4 x 2 | 16 | **Redundancy (r = n-u)** | | **27** |
| **Total Observations (n)** | | **162** |  |  |  |

1. Recompute n, u, and r if we have GPS estimates of the perspective centers at image exposure, and both the GPS PC coordinates and the control points are treated as weighted coordinate parameter observations.

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| --- | --- | --- | --- | --- | --- |
| **Observations** | |  | **Unknowns** |  |  |
| 3D GCP | 1 x 3 x 2 | 6 | Images | 6 x 8 | 48 |
| HCP | 2 x 3 x 2 | 12 | Tie points | 27 x 3 | 81 |
| VCP | 2 x 2 x 2 | 8 | HCP | 2 x 3 | 6 |
| Tie Points | 15 x 2 x 2 | 60 | VCP | 2 x 3 | 6 |
| Tie Points | 10 x 3 x 2 | 60 | 3D GCP | 1 x 3 | 3 |
| Tie Points | 2 x 4 x 2 | 16 | **Total Unknowns (u)** | | **144** |
| 3D GCP | 1 x 3 | 3 | **Redundancy (r = n-u)** | | **51** |
| HCP | 2 x 2 | 4 |  |  |  |
| VCP | 1 x 2 | 2 |  |  |  |
| GPS PCs | 3 x 8 | 24 |  |  |  |
| **Total Observations (n)** |  | **195** |  |  |  |

Question 2

|  |  |
| --- | --- |
| 1. **R = R3\*R2\*R1** | |
| ω (°) | -38.6244 |
| ϕ (°) | 35.003 |
| κ (°) | -152.6317 |

|  |  |
| --- | --- |
| 1. **R = R1\*R2\*R3** | |
| ω (°) | 28.5601 |
| ϕ (°) | -43.2307 |
| κ (°) | -176.761 |

|  |  |
| --- | --- |
| 1. **R = R3\*R1\*R2** | |
| ω (°) | -30.7509 |
| ϕ (°) | 41.8718 |
| κ (°) | -177.2544 |

Question 3

1. Determine the most appropriate calibration model for the camera from the options

available in MATLAB (do NOT use the skew correction). The most appropriate model

should be the minimum amount of parameters without sacrificing accuracy. Justify your

selection of the final distortion model. Provide the distortion parameters AND their

estimated errors. Transform the principal point solution from a digital image to a fiducial

coordinate system.

1. Are there any calibration images that appear to be outliers? If so, why do you think those image(s) are causing larger measurement errors? Do the camera calibration parameters estimated change significantly if you remove the outlier image(s)? Justify why you would characterize the change in parameters as significant/not significant (Hint: the significance level may be different for different distortion parameters).
2. The Matlab calibration model returns two values for the focal length. Briefly discuss why two values are returned, and how these would be used in the collinearity equations (this may require some literature review).

Question 4

Using a bundle adjustment, derive exterior orientation parameters for each of the cameras and estimate ground coordinates for the pass points. Compute estimated accuracy for both EOPs and pass point coordinates.

Additional Questions:

1. Are any of the image measurements outliers? If yes, rerun the adjustment with those image observation(s) removed. Does it make a difference in the final solution?
2. Is the estimated accuracy given for the image measurements correct? Based on the adjustment results, is the actual image measurement accuracy lower or higher? Justify your answer.
3. The estimated standard deviation for the final coordinates of one of the pass points is significantly higher than the others. Which point is it? Why do you think the estimated accuracy of this point is worse than the others?