**Lab #5**

Tasks 1:

A.) Points 100, 104, 105, 200.

Image 27

|  |  |
| --- | --- |
| XC (m) | 99.1813 |
| YC (m) | -628.2502 |
| ZC (m) | 1842.2475 |
| ω (°) | -0.2151 |
| ϕ (°) | 1.4566 |
| κ (°) | 90.1951 |

Image 28

|  |  |
| --- | --- |
| XC (m) | 105.1158 |
| YC (m) | -170.3082 |
| ZC (m) | 1833.9863 |
| ω (°) | -0.4713 |
| ϕ (°) | 0.5106 |
| κ (°) | 88.461 |

B.) Points 100, 104, 105, 200, 201.

Image 27

|  |  |
| --- | --- |
| XC (m) | 99.2689 |
| YC (m) | -628.2943 |
| ZC (m) | 1842.2306 |
| ω (°) | -0.2124 |
| ϕ (°) | 1.4612 |
| κ (°) | 90.1958 |

Image 28

|  |  |
| --- | --- |
| XC (m) | 105.1261 |
| YC (m) | -170.2981 |
| ZC (m) | 1833.9808 |
| ω (°) | -0.472 |
| ϕ (°) | 0.511 |
| κ (°) | 88.4608 |

C.) Points 100, 104, 105, 200, 201, 202.

Image 27

|  |  |
| --- | --- |
| XC (m) | 99.2712 |
| YC (m) | -628.3206 |
| ZC (m) | 1842.22 |
| ω (°) | -0.2102 |
| ϕ (°) | 1.4616 |
| κ (°) | 90.1957 |

Image 28

|  |  |
| --- | --- |
| XC (m) | 105.222 |
| YC (m) | -170.4222 |
| ZC (m) | 1834.0193 |
| ω (°) | -0.4619 |
| ϕ (°) | 0.5171 |
| κ (°) | 88.4607 |

D.) All

Image 27

|  |  |
| --- | --- |
| XC (m) | 99.2627 |
| YC (m) | -628.3256 |
| ZC (m) | 1842.2276 |
| ω (°) | -0.2102 |
| ϕ (°) | 1.4609 |
| κ (°) | 90.195 |

Image 28

|  |  |
| --- | --- |
| XC (m) | 105.1891 |
| YC (m) | -170.4356 |
| ZC (m) | 1834.0609 |
| ω (°) | -0.4598 |
| ϕ (°) | 0.5149 |
| κ (°) | 88.4618 |

Task 2:

S = 5000, σobs = 6 µm

c = 153.358 mm

xmax = 161.645 mm

All experiments converged after **3 iterations.** We used 6 µm from the RMSE of the Affine Transformation from Lab 1. A safety factor of 10 is included in each formula to be more conservative about the tolerances. xmax is obtained from the given image size, finding the distance to the corner.

Task 3:

A.A.) Points 100, 104, 105, 200.

*Standard Deviation*

Image 27

|  |  |
| --- | --- |
| XC (m) | 0.2024 |
| YC (m) | 0.1506 |
| ZC (m) | 0.0509 |
| ω (°) | 0.0117 |
| ϕ (°) | 0.0115 |
| κ (°) | 0.0024 |

Image 28

|  |  |
| --- | --- |
| XC (m) | 0.1708 |
| YC (m) | 0.1496 |
| ZC (m) | 0.0806 |
| ω (°) | 0.0111 |
| ϕ (°) | 0.0083 |
| κ (°) | 0.0036 |

A.B.) Points 100, 104, 105, 200, 201.

*Standard Deviation*

Image 27

|  |  |
| --- | --- |
| XC (m) | 0.1163 |
| YC (m) | 0.1416 |
| ZC (m) | 0.0443 |
| ω (°) | 0.0107 |
| ϕ (°) | 0.007 |
| κ (°) | 0.002 |

Image 28

|  |  |
| --- | --- |
| XC (m) | 0.0898 |
| YC (m) | 0.1264 |
| ZC (m) | 0.0596 |
| ω (°) | 0.0095 |
| ϕ (°) | 0.0049 |
| κ (°) | 0.0023 |

A.C.) Points 100, 104, 105, 200, 201, 202.

*Standard Deviation*

Image 27

|  |  |
| --- | --- |
| XC (m) | 0.1068 |
| YC (m) | 0.1345 |
| ZC (m) | 0.0406 |
| ω (°) | 0.0101 |
| ϕ (°) | 0.0066 |
| κ (°) | 0.0018 |

Image 28

|  |  |
| --- | --- |
| XC (m) | 0.0817 |
| YC (m) | 0.1025 |
| ZC (m) | 0.0547 |
| ω (°) | 0.0076 |
| ϕ (°) | 0.0043 |
| κ (°) | 0.0023 |

A.D.) All

*Standard Deviation*

Image 27

|  |  |
| --- | --- |
| XC (m) | 0.1014 |
| YC (m) | 0.1296 |
| ZC (m) | 0.037 |
| ω (°) | 0.0098 |
| ϕ (°) | 0.0061 |
| κ (°) | 0.0017 |

Image 28

|  |  |
| --- | --- |
| XC (m) | 0.0807 |
| YC (m) | 0.0997 |
| ZC (m) | 0.0516 |
| ω (°) | 0.0074 |
| ϕ (°) | 0.0042 |
| κ (°) | 0.0022 |

B.A.) Points 100, 104, 105, 200

Image 27

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Correlation Coefficient Matrix** | | | | | | | |
|  | XC | YC | ZC | ω | ϕ | κ |
| XC | 1.0000 | -0.5819 | -0.7132 | 0.6492 | 0.9952 | 0.7198 |
| YC | -0.5819 | 1.0000 | 0.8441 | -0.9914 | -0.6328 | -0.2941 |
| ZC | -0.7132 | 0.8441 | 1.0000 | -0.8798 | -0.7502 | -0.4335 |
| ω | 0.6492 | -0.9914 | -0.8798 | 1.0000 | 0.6974 | 0.3531 |
| ϕ | 0.9952 | -0.6328 | -0.7502 | 0.6974 | 1.0000 | 0.6968 |
| κ | 0.7198 | -0.2941 | -0.4335 | 0.3531 | 0.6968 | 1.0000 |

Image 28

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Correlation Coefficient Matrix** | | | | | | | |
|  | XC | YC | ZC | ω | ϕ | κ |
| XC | 1.0000 | 0.3347 | -0.6037 | -0.3313 | 0.9886 | -0.8906 |
| YC | 0.3347 | 1.0000 | -0.8851 | -0.9932 | 0.2292 | -0.4376 |
| ZC | -0.6037 | -0.8851 | 1.0000 | 0.9058 | -0.5219 | 0.6514 |
| ω | -0.3313 | -0.9932 | 0.9058 | 1.0000 | -0.2249 | 0.4416 |
| ϕ | 0.9886 | 0.2292 | -0.5219 | -0.2249 | 1.0000 | -0.8467 |
| κ | -0.8906 | -0.4376 | 0.6514 | 0.4416 | -0.8467 | 1.0000 |

B.B.) Points 100, 104, 105, 200, 201

Image 27

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Correlation Coefficient Matrix** | | | | | | | |
|  | XC | YC | ZC | ω | ϕ | κ |
| XC | 1.0000 | -0.5682 | -0.6227 | 0.6071 | 0.9891 | 0.5427 |
| YC | -0.5682 | 1.0000 | 0.8275 | -0.9941 | -0.6396 | -0.1355 |
| ZC | -0.6227 | 0.8275 | 1.0000 | -0.8555 | -0.6804 | -0.2180 |
| ω | 0.6071 | -0.9941 | -0.8555 | 1.0000 | 0.6768 | 0.1660 |
| ϕ | 0.9891 | -0.6396 | -0.6804 | 0.6768 | 1.0000 | 0.4946 |
| κ | 0.5427 | -0.1355 | -0.2180 | 0.1660 | 0.4946 | 1.0000 |

Image 28

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Correlation Coefficient Matrix** | | | | | | | |
|  | XC | YC | ZC | ω | ϕ | κ |
| XC | 1.0000 | -0.1455 | -0.1193 | 0.1424 | 0.9738 | -0.6996 |
| YC | -0.1455 | 1.0000 | -0.8606 | -0.9921 | -0.2904 | -0.1227 |
| ZC | -0.1193 | -0.8606 | 1.0000 | 0.8940 | 0.0085 | 0.2976 |
| ω | 0.1424 | -0.9921 | 0.8940 | 1.0000 | 0.2884 | 0.1370 |
| ϕ | 0.9738 | -0.2904 | 0.0085 | 0.2884 | 1.0000 | -0.5983 |
| κ | -0.6996 | -0.1227 | 0.2976 | 0.1370 | -0.5983 | 1.0000 |

B.C.) Points 100, 104, 105, 200, 201, 202

Image 27

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Correlation Coefficient Matrix** | | | | | | | |
|  | XC | YC | ZC | ω | ϕ | κ |
| XC | 1.0000 | -0.6714 | -0.6915 | 0.6956 | 0.9918 | 0.4440 |
| YC | -0.6714 | 1.0000 | 0.8179 | -0.9952 | -0.7124 | -0.2099 |
| ZC | -0.6915 | 0.8179 | 1.0000 | -0.8403 | -0.7201 | -0.2434 |
| ω | 0.6956 | -0.9952 | -0.8403 | 1.0000 | 0.7360 | 0.2197 |
| ϕ | 0.9918 | -0.7124 | -0.7201 | 0.7360 | 1.0000 | 0.4107 |
| κ | 0.4440 | -0.2099 | -0.2434 | 0.2197 | 0.4107 | 1.0000 |

Image 28

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Correlation Coefficient Matrix** | | | | | | | |
|  | XC | YC | ZC | ω | ϕ | κ |
| XC | 1.0000 | 0.0179 | -0.2684 | -0.0407 | 0.9775 | -0.7619 |
| YC | 0.0179 | 1.0000 | -0.8442 | -0.9888 | -0.0858 | -0.1686 |
| ZC | -0.2684 | -0.8442 | 1.0000 | 0.8939 | -0.1806 | 0.3347 |
| ω | -0.0407 | -0.9888 | 0.8939 | 1.0000 | 0.0637 | 0.1892 |
| ϕ | 0.9775 | -0.0858 | -0.1806 | 0.0637 | 1.0000 | -0.6749 |
| κ | -0.7619 | -0.1686 | 0.3347 | 0.1892 | -0.6749 | 1.0000 |

B.D.) All

Image 27

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Correlation Coefficient Matrix** | | | | | | | |
|  | XC | YC | ZC | ω | ϕ | κ |
| XC | 1.0000 | -0.6460 | -0.6515 | 0.6717 | 0.9916 | 0.4949 |
| YC | -0.6460 | 1.0000 | 0.8183 | -0.9953 | -0.6910 | -0.2575 |
| ZC | -0.6515 | 0.8183 | 1.0000 | -0.8411 | -0.6758 | -0.2620 |
| ω | 0.6717 | -0.9953 | -0.8411 | 1.0000 | 0.7161 | 0.2576 |
| ϕ | 0.9916 | -0.6910 | -0.6758 | 0.7161 | 1.0000 | 0.4598 |
| κ | 0.4949 | -0.2575 | -0.2620 | 0.2576 | 0.4598 | 1.0000 |

Image 28

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Correlation Coefficient Matrix** | | | | | | | |
|  | XC | YC | ZC | ω | ϕ | κ |
| XC | 1.0000 | 0.0217 | -0.2533 | -0.0356 | 0.9783 | -0.7660 |
| YC | 0.0217 | 1.0000 | -0.8600 | -0.9903 | -0.0979 | -0.2249 |
| ZC | -0.2533 | -0.8600 | 1.0000 | 0.9018 | -0.1410 | 0.3610 |
| ω | -0.0356 | -0.9903 | 0.9018 | 1.0000 | 0.0850 | 0.2281 |
| ϕ | 0.9783 | -0.0979 | -0.1410 | 0.0850 | 1.0000 | -0.6799 |
| κ | -0.7660 | -0.2249 | 0.3610 | 0.2281 | -0.6799 | 1.0000 |

C.A.) Points 100, 104, 105, 200.

Residuals and RMS **(mm)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Image 27** | | **Image 28** | |
| **ID** | **vX** | **vY** | **vX** | **vY** |
| **100** | -0.0008 | 0.0046 | -0.0013 | 0.0033 |
| **104** | 0.0061 | 0.0043 | 0.0002 | 0.0026 |
| **105** | -0.0032 | -0.0054 | 0.0011 | -0.0022 |
| **200** | -0.0021 | -0.0035 | 0 | -0.0037 |
|  |  |  |  |  |
| **RMS** | 0.0036 | 0.0045 | 0.0008 | 0.003 |

C.B.) Points 100, 104, 105, 200, 201.

Residuals and RMS **(mm)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Image 27** | | **Image 28** | |
| **ID** | **vX** | **vY** | **vX** | **vY** |
| **100** | 0.0021 | 0.0072 | -0.0013 | 0.0031 |
| **104** | 0.0079 | 0.0051 | -0.0001 | 0.0028 |
| **105** | 0.0010 | -0.0043 | 0.0011 | -0.0023 |
| **200** | -0.0001 | -0.0033 | -0.0004 | -0.0037 |
| **201** | -0.0109 | -0.0046 | 0.0007 | 0.0000 |
|  |  |  |  |  |
| **RMS** | 0.0061 | 0.0051 | 0.00083 | 0.002694 |

C.C.) Points 100, 104, 105, 200, 201, 202.

Residuals and RMS **(mm)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Image 27** | | **Image 28** | |
| **ID** | **vX** | **vY** | **vX** | **vY** |
| **100** | 0.0016 | 0.0077 | -0.0028 | 0.0061 |
| **104** | 0.0078 | 0.0034 | -0.008 | -0.0007 |
| **105** | 0.0004 | -0.0047 | -0.0003 | 0.0003 |
| **200** | -0.0005 | -0.0035 | 0.0013 | -0.0054 |
| **201** | -0.0111 | -0.0052 | -0.0007 | 0.0034 |
| **202** | 0.0017 | 0.0024 | 0.0105 | -0.0037 |
|  |  |  |  |  |
| **RMS** | 0.0056 | 0.0048 | 0.0055 | 0.0039 |

C.D.) All

Residuals and RMS **(mm)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Image 27** | | **Image 28** | |
| **ID** | **vX** | **vY** | **vX** | **vY** |
| **100** | 0.0013 | 0.0075 | -0.0032 | 0.0067 |
| **104** | 0.0096 | 0.005 | -0.0082 | 0.0041 |
| **105** | 0.0011 | -0.0019 | -0.0047 | 0.0058 |
| **200** | -0.0009 | -0.0033 | 0.0013 | -0.0059 |
| **201** | -0.0106 | -0.0046 | -0.0013 | 0.0028 |
| **202** | 0.0035 | 0.0031 | 0.0108 | -0.0008 |
| **203** | -0.0042 | -0.0057 | 0.0054 | -0.0127 |
|  |  |  |  |  |
| **RMS** | 0.0058 | 0.0047 | 0.006 | 0.0065 |

Task 4:

Image 27 Standard Deviation Changes:

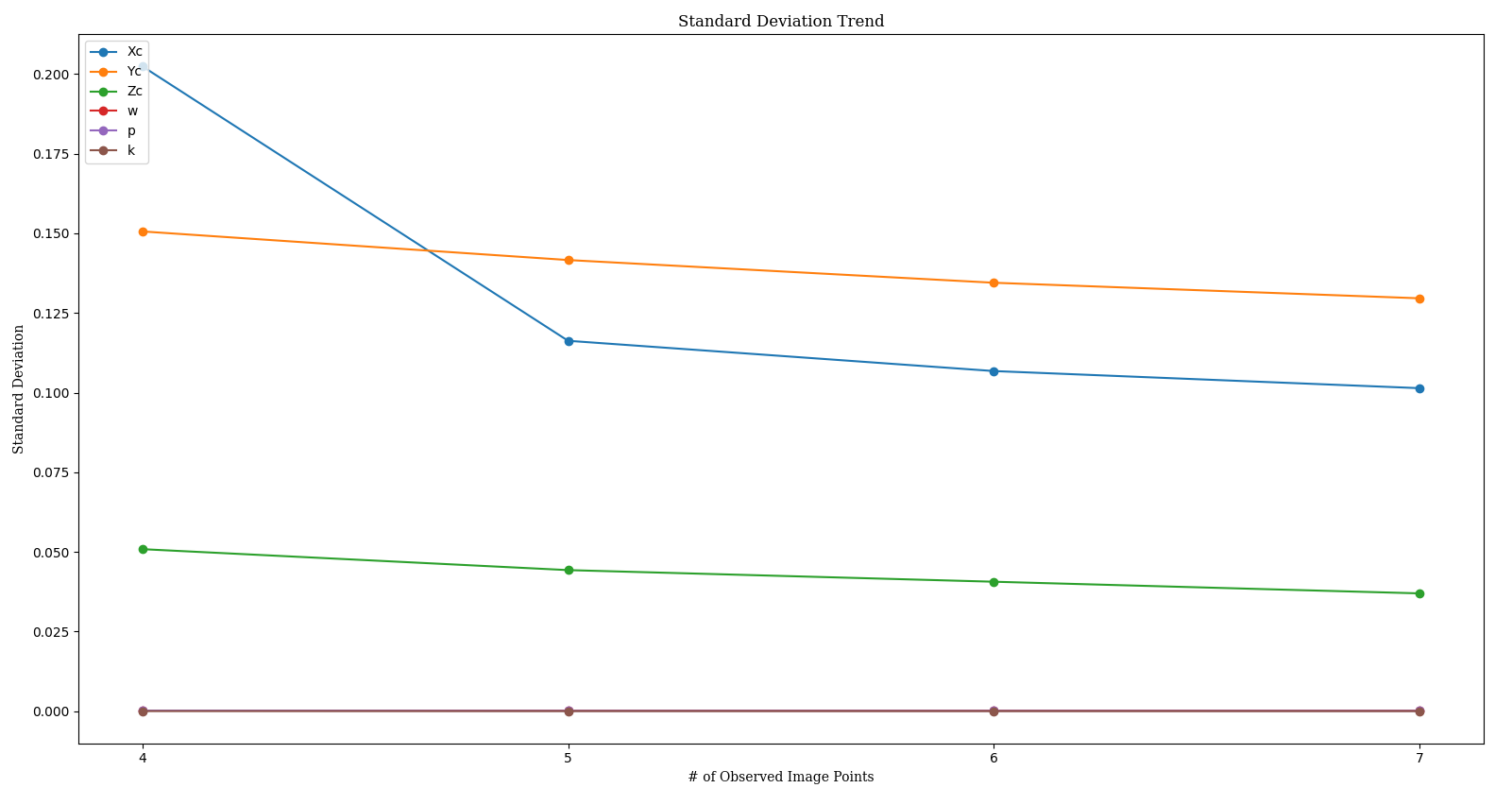
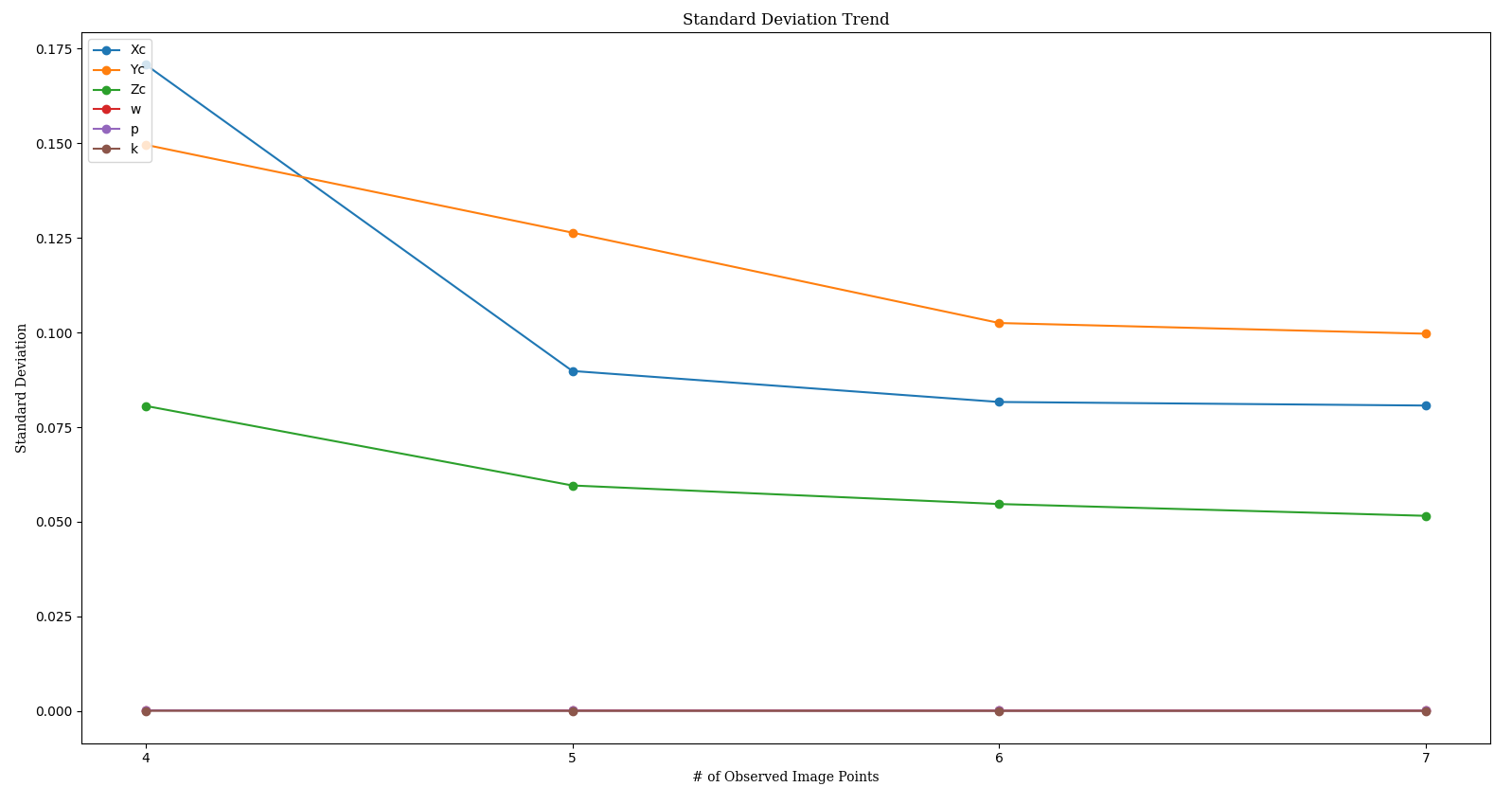


Image 28 Standard Deviation Changes:



For both images, the standard deviations of the coordinates decreased as we added more observed points. This is expected since we the larger number of observe points provided better representation. The angular parameters showed no change as they are already 0.

Image 27 Correlation Coefficient Changes:

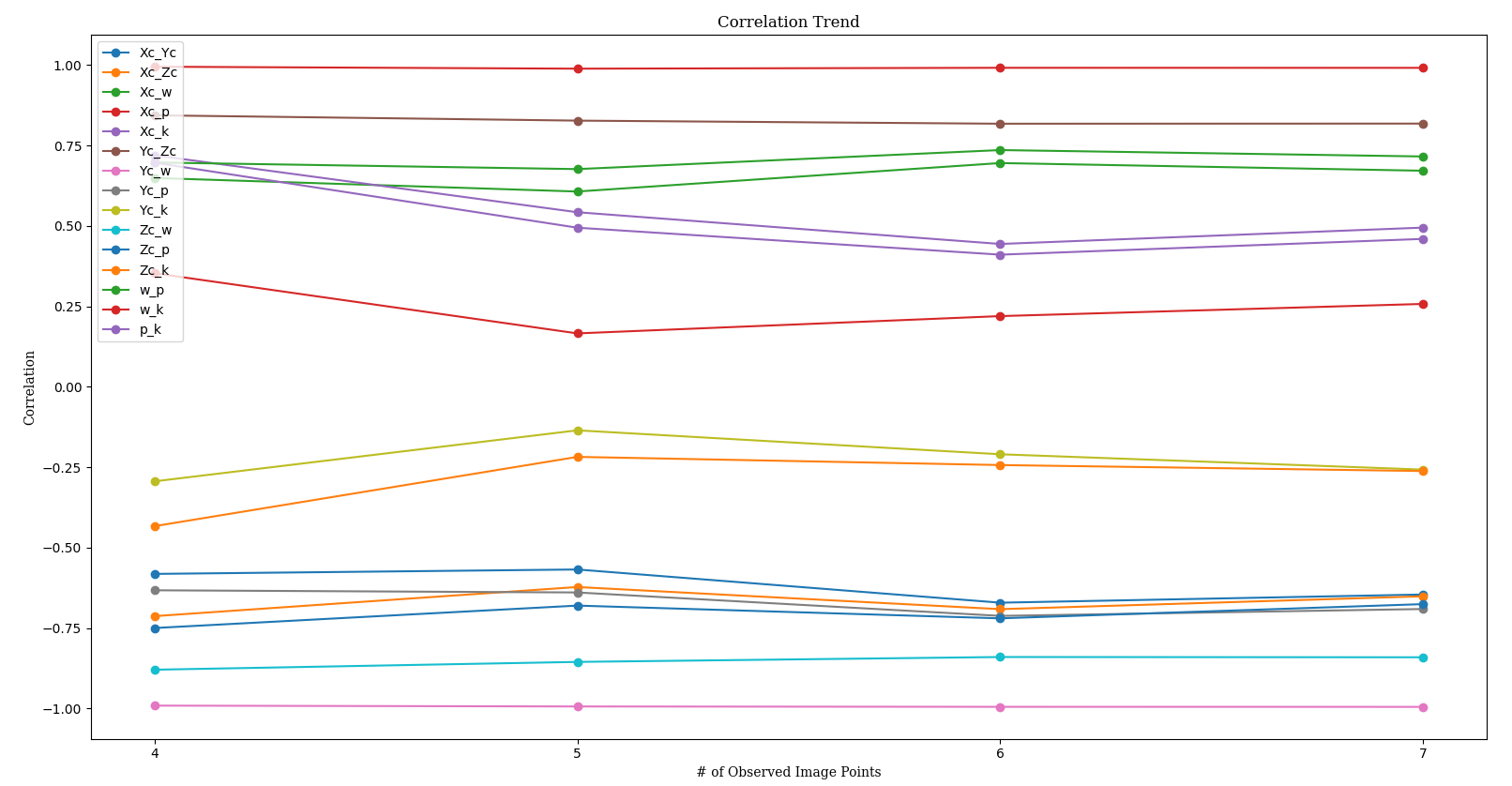
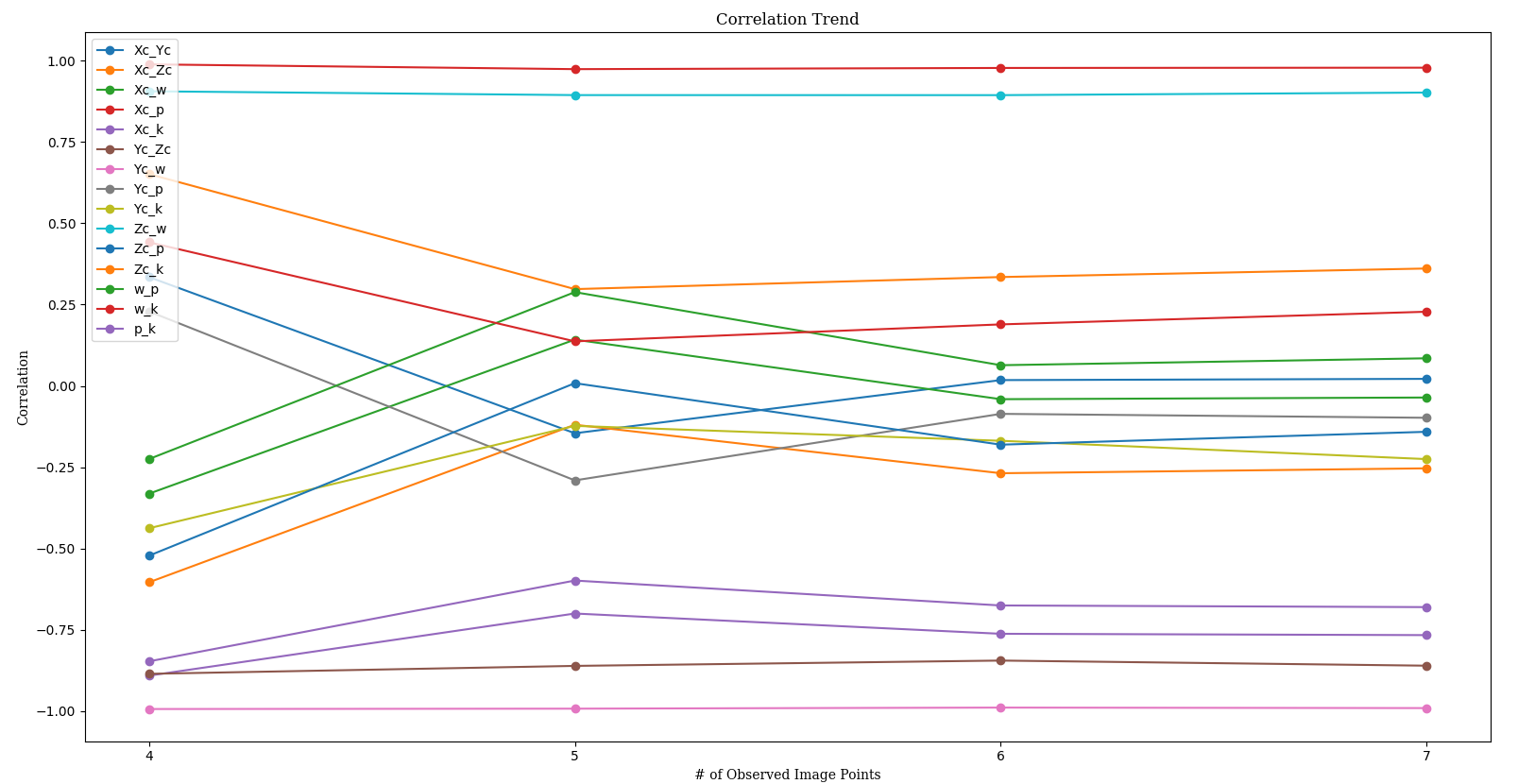


Image 28 Correlation Coefficient Changes:



We expect the correlation for each element to approach 0 as we increase the number of observed points. Correlation closer to 0 means that parameters are less correlated. This can be seen by some of the parameters in Image 28. However, Image 27 did not show this trend as we increased the number of observed points. A different approach is needed to decrease correlation, such as obtaining a more distributed set of image points.

Task 5:

|  |  |  |
| --- | --- | --- |
|  | **Lab 4** | **Lab 5** |
| **XC (m)** | 99.4938 | 99.2627 |
| **YC (m)** | -628.5518 | -628.3256 |
| **ZC (m)** | 1842.1882 | 1842.2276 |
| **ω (°)** | -1.4761 | -0.2102 |
| **ϕ (°)** | -0.1841 | 1.4609 |
| **κ (°)** | -90.1956 | 90.195 |

Resection uses the collinearity equations to orient a single image via least squares, while absolute orientation requires relative orientation to transform from model space to object space. Relative orientation requires two or more images. Therefore, one of the differences is the required number of images between Resection and Absolute Orientation (Relative Orientation included). Absolute orientation creates more room for error from relative orientation, which can propagate in absolute orientation. As a result, resection is more accurate.