

Calibration Procedure

Calibration of all 6 cameras was performed as described in the lab specifications using a 4x6 grid. The generated calibration images are shown below in Figures 1-6. Camera 5 was particularly hard to calibrate due to the large amount of noise that can be seen above and below the grid in Figure 6, and would give a lot of false point identifications on the grid or background if the noise overlapped the calibration area. Restarting the camera did not fix this issue, so calibration simply had to be performed when the noise moved to an area not obstructing the calibration mat. The X and Y axes for calibration were referenced as shown in Figure 7.

The tracking area for the calibration was also created by bounding every camera's area with a polygon. The results of this can be clearly seen in Figure 8 by the rectangular area being tracked by the cameras. In figure 8, two regions can clearly be seen in the tracked rectangle, with these two regions representing myself and my lab partner (Connor O'Sullivan). Also, the default thresholds for each camera were used as the calibration software tended to catch the grids correctly on the normal threshold value, though it could have been tweaked if needed.

The X, Y, and Z coordinates were not explicitly captured during calibration as the lab manual stated they would be included in the data in the calibration folder. This data can be viewed in Figure 9 from the Calib_0.txt – Calib_5.txt data files. Calibration point data is shown in Figures 10-15 from CalPoints_0.txt – CalPoints_5.txt.

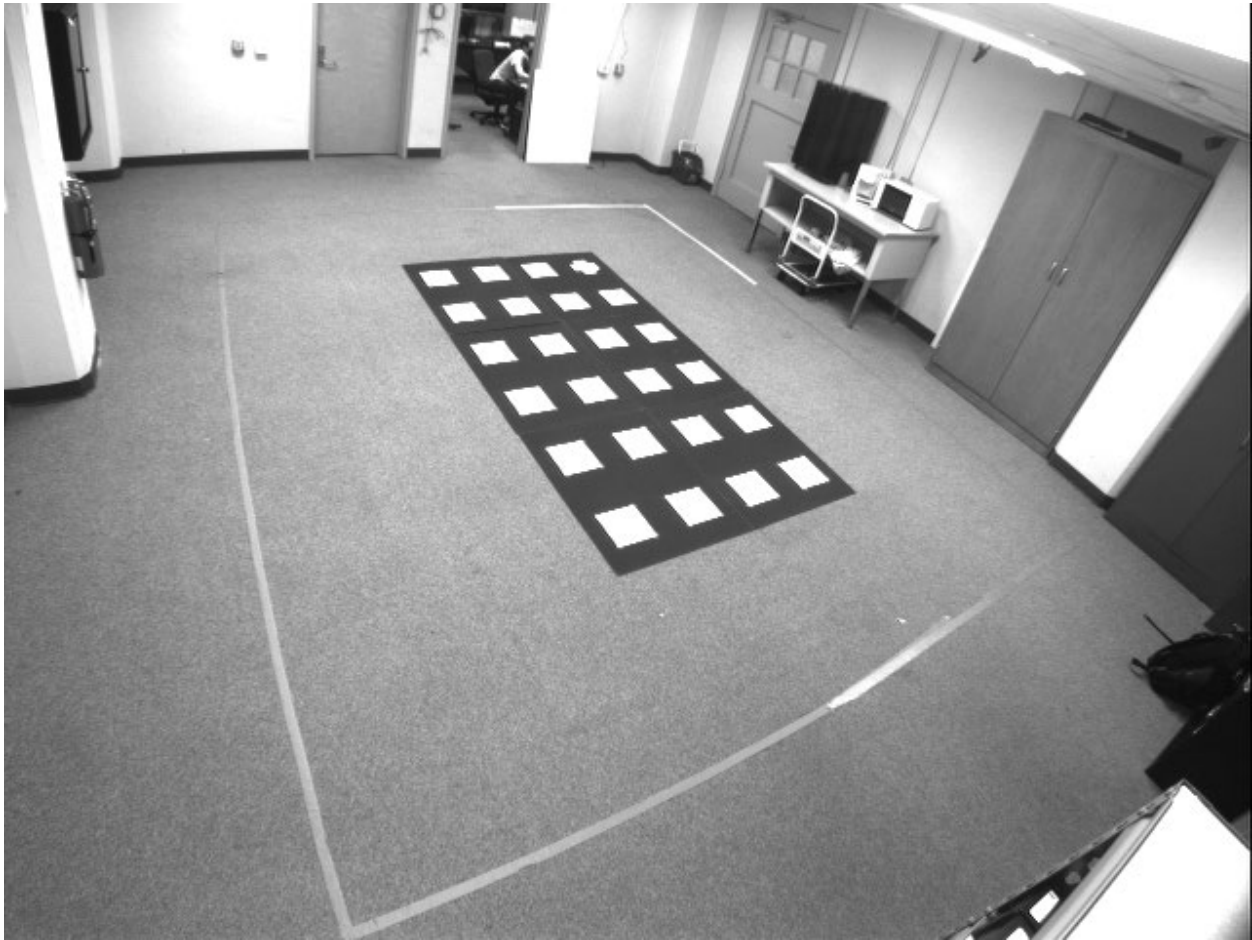


Figure 1: Camera 0 calibration image

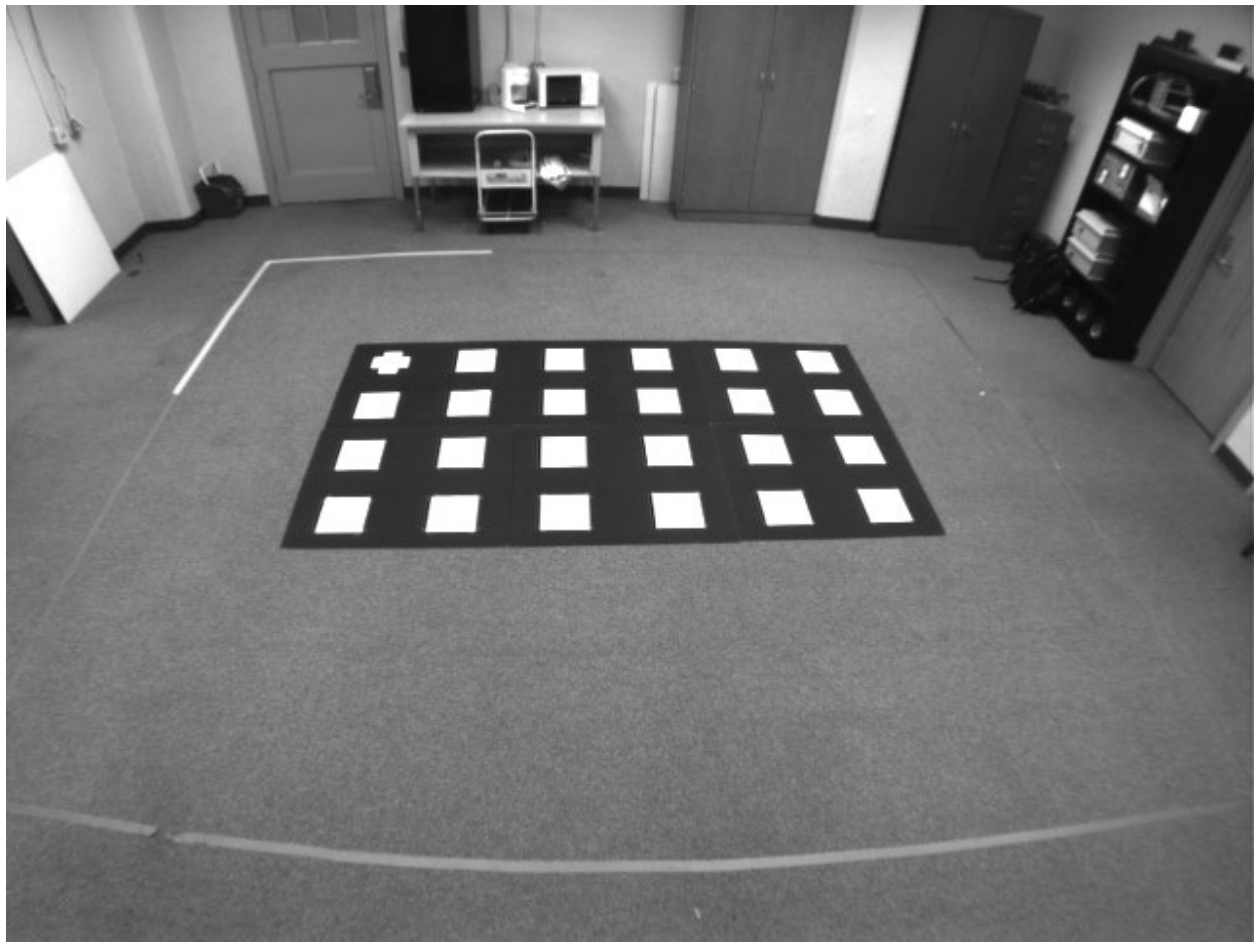


Figure 2: Camera 1 calibration image

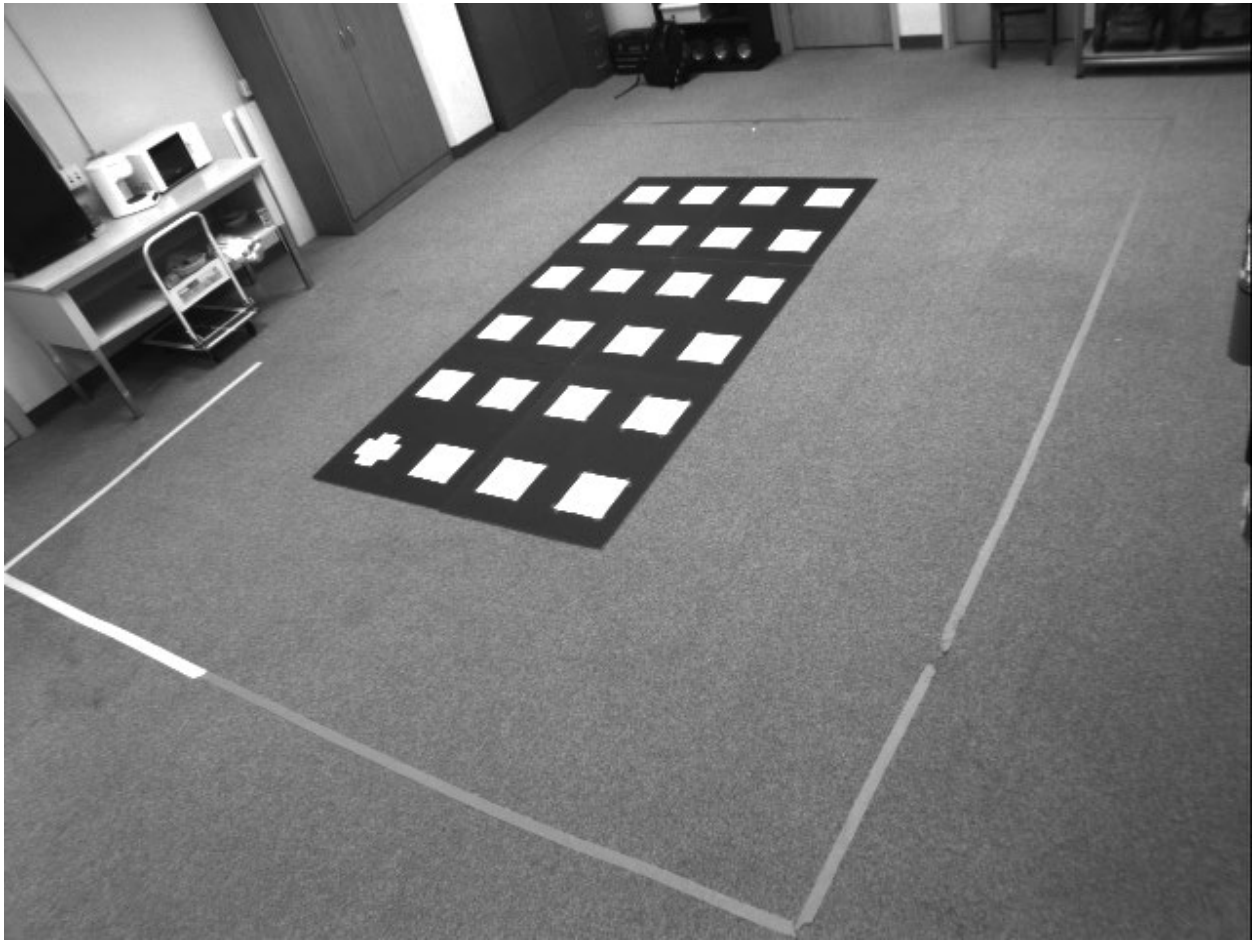


Figure 3: Camera 2 calibration image

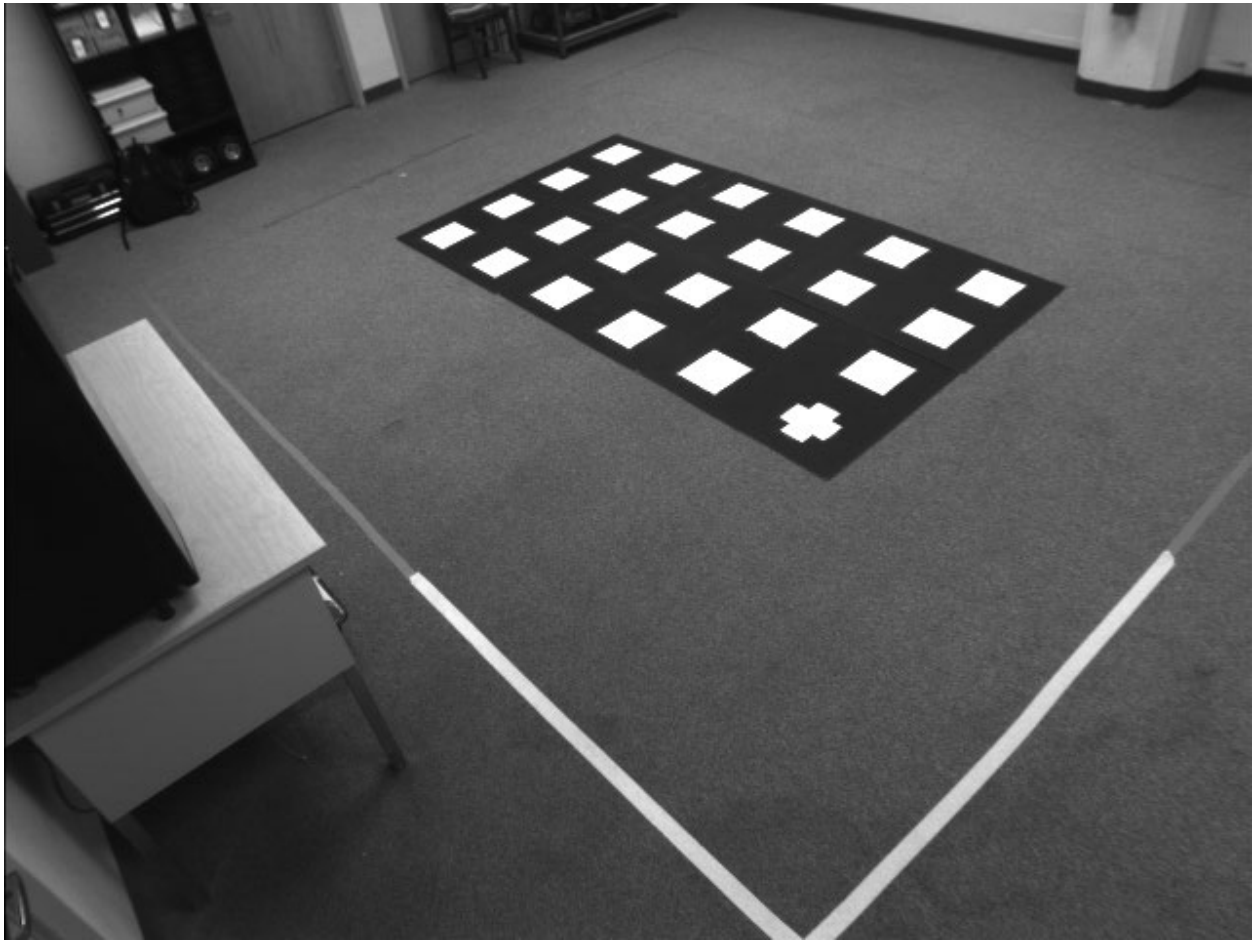


Figure 4: Camera 3 calibration image

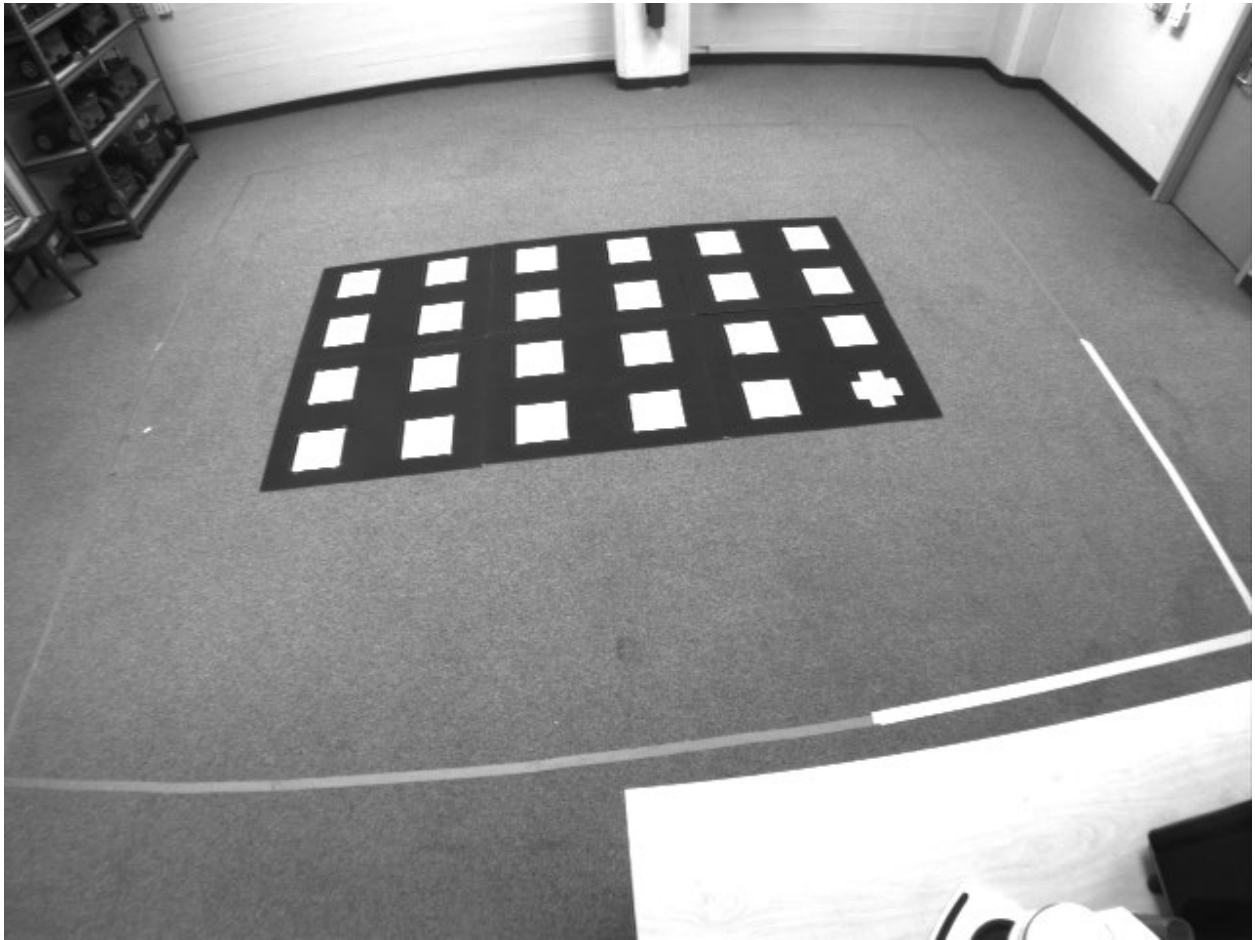


Figure 5: Camera 4 calibration image

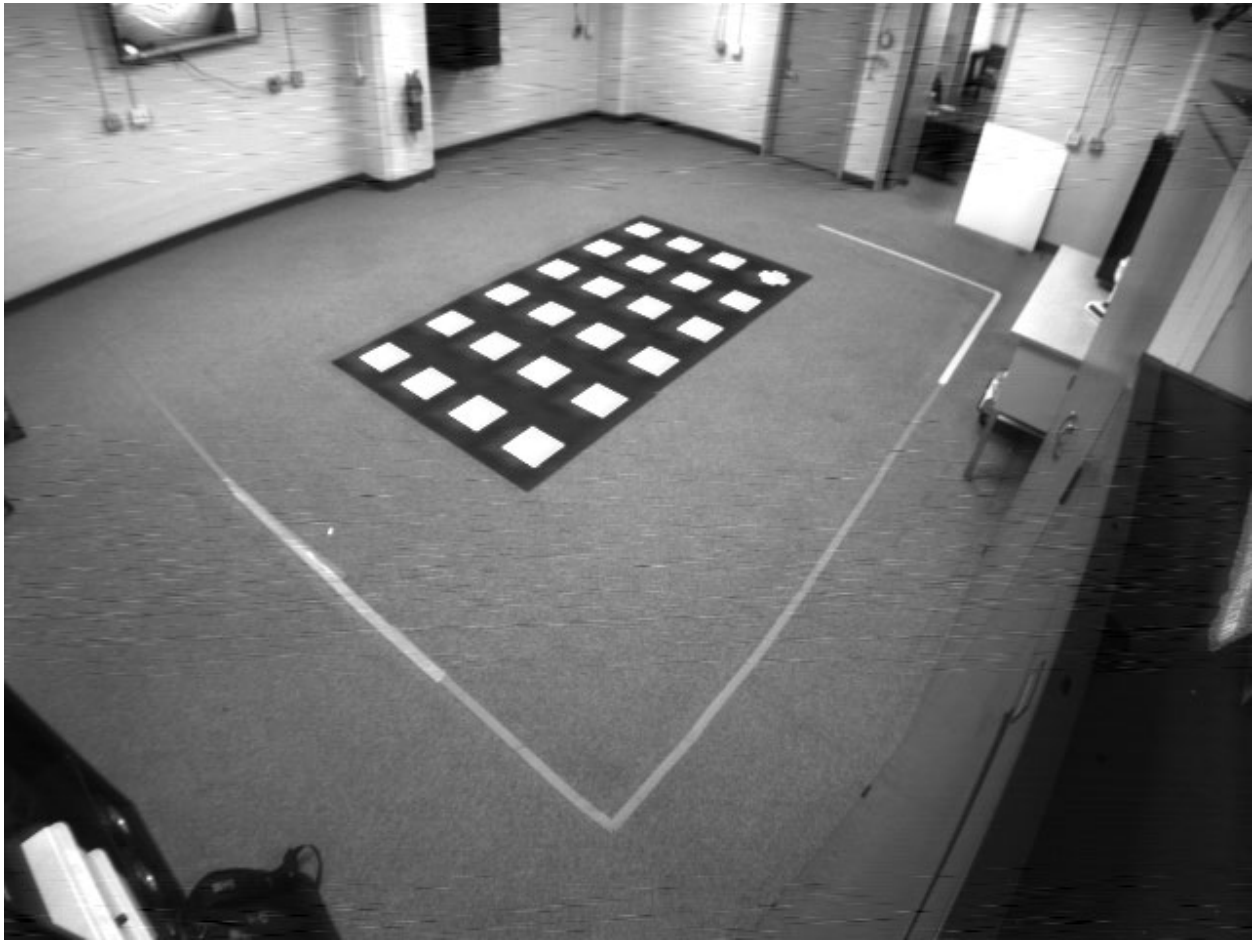


Figure 6: Camera 5 calibration image

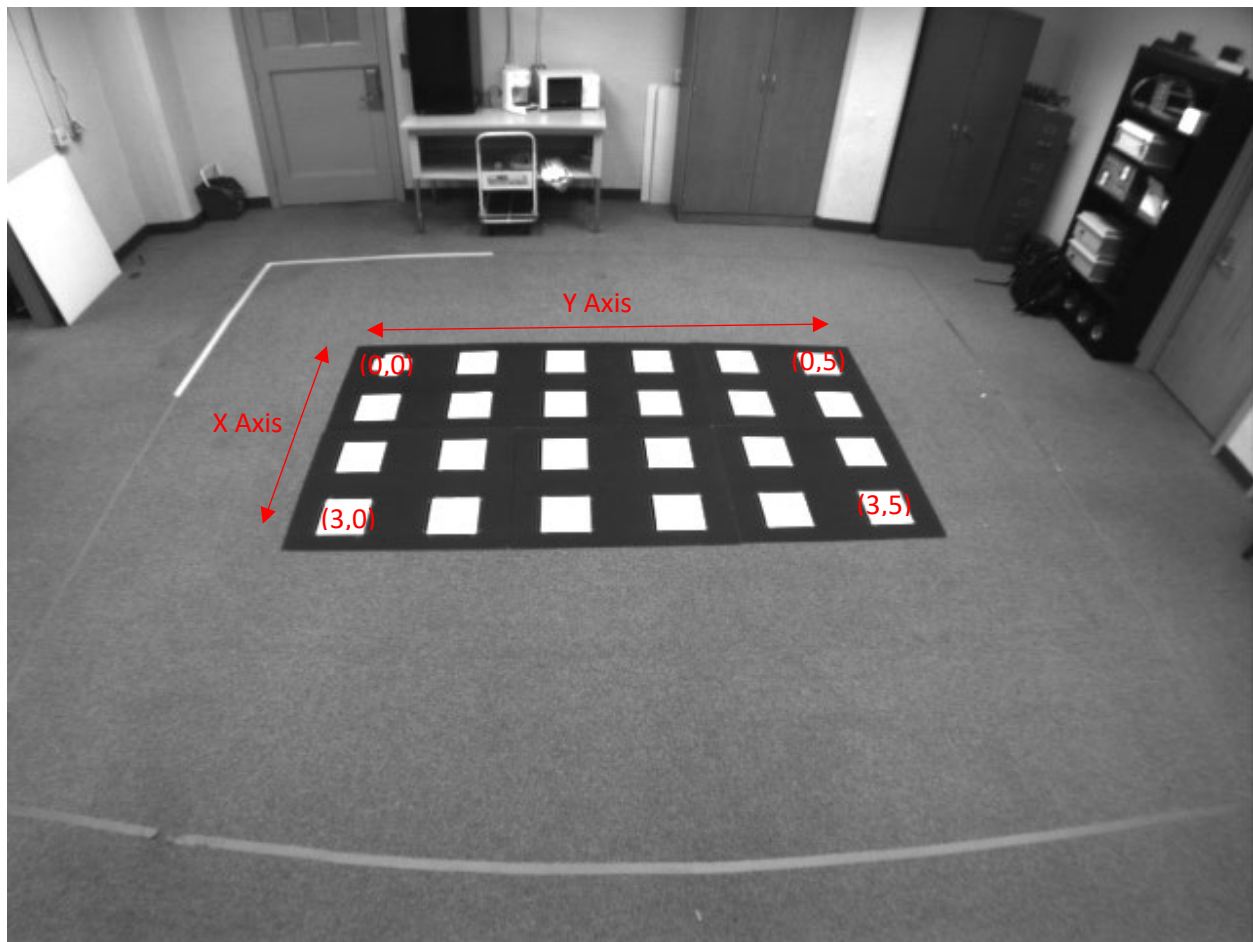


Figure 7: X and Y axis shown on camera 1 calibration image

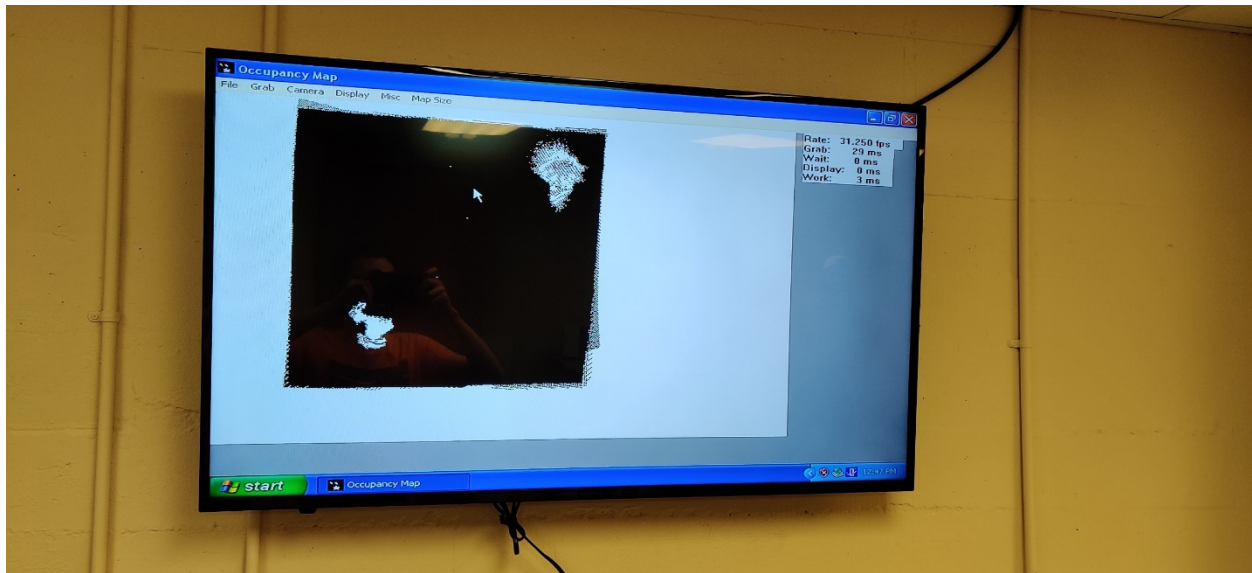


Figure 8: Example of the properly calibrated cameras tracking two objects on the calibrated area

Calib Data						
Camera	0	1	2	3	4	5
	640	640	640	640	640	640
	640	640	640	640	640	640
	0.023	0.023	0.023	0.023	0.023	0.023
	0.023	0.023	0.023	0.023	0.023	0.023
	0.023	0.023	0.023	0.023	0.023	0.023
	0.023	0.023	0.023	0.023	0.023	0.023
	299.181	312.9972	331.9766	317.1021	330.7508	339.2652
	227.3813	246.8293	260.6472	242.8648	249.0958	219.084
	1	1	1	1	1	1
	7.950057	8.120431	10.61236	11.33419	8.194826	8.188748
	0.0034	0.003592	0.001381	0.001519	0.003799	0.003999
	-29.9179	-1320.46	-1261.8	696.1701	1041.279	799.1984
	-1432.48	-728.011	-289.059	-206.497	-462.459	-1143.76
	5275.98	3880.945	4072.412	3545.47	3083.353	5080.771
	-2.35797	3.040784	2.424567	2.384281	-3.07006	-2.33011
	0.511908	0.79238	0.52529	-0.43302	-0.62255	-0.41131
	2.926481	1.484183	0.212658	-0.60004	-1.72497	-2.66639
	0	0	0	0	0	0
	0	0	0	0	0	0

Figure 9: Calibration data from Calib_0.txt to Calib_5.txt

```
1218.000000 0.000000 0.000000 222.301587 140.539683
812.000000 0.000000 0.000000 249.268908 138.159664
406.000000 0.000000 0.000000 274.027778 136.388889
0.000000 0.000000 0.000000 297.389610 134.844156
1218.000000 508.000000 0.000000 235.298137 157.981366
812.000000 508.000000 0.000000 264.050725 154.891304
406.000000 508.000000 0.000000 289.860465 152.410853
0.000000 508.000000 0.000000 314.147826 150.200000
1218.000000 1016.000000 0.000000 250.707921 178.648515
812.000000 1016.000000 0.000000 280.906077 174.430939
406.000000 1016.000000 0.000000 308.555556 171.339869
0.000000 1016.000000 0.000000 333.709220 168.290780
1218.000000 1524.000000 0.000000 269.360465 203.236434
812.000000 1524.000000 0.000000 301.224670 197.753304
406.000000 1524.000000 0.000000 329.390625 192.828125
0.000000 1524.000000 0.000000 355.617647 188.676471
1218.000000 2032.000000 0.000000 291.749235 232.489297
812.000000 2032.000000 0.000000 325.150538 224.906810
406.000000 2032.000000 0.000000 354.766667 218.337500
0.000000 2032.000000 0.000000 380.912621 212.451456
1218.000000 2540.000000 0.000000 318.652278 267.443645
812.000000 2540.000000 0.000000 353.302326 257.305233
406.000000 2540.000000 0.000000 383.140893 248.134021
0.000000 2540.000000 0.000000 409.670833 240.000000
```

Figure 10: Data from CalPoints_0.txt

```
1218.000000 0.000000 0.000000 172.334076 260.877506  
812.000000 0.000000 0.000000 181.195846 230.124629  
406.000000 0.000000 0.000000 189.860215 204.724014  
0.000000 0.000000 0.000000 196.745562 182.656805  
1218.000000 508.000000 0.000000 228.714885 260.132075  
812.000000 508.000000 0.000000 233.497191 228.890449  
406.000000 508.000000 0.000000 237.232394 203.693662  
0.000000 508.000000 0.000000 240.842795 181.777293  
1218.000000 1016.000000 0.000000 286.278261 259.567391  
812.000000 1016.000000 0.000000 285.469816 228.519685  
406.000000 1016.000000 0.000000 285.960145 203.050725  
0.000000 1016.000000 0.000000 285.817352 181.118721  
1218.000000 1524.000000 0.000000 344.200883 258.538631  
812.000000 1524.000000 0.000000 339.000000 228.000000  
406.000000 1524.000000 0.000000 334.196226 202.226415  
0.000000 1524.000000 0.000000 330.553488 181.051163  
1218.000000 2032.000000 0.000000 398.845036 257.220339  
812.000000 2032.000000 0.000000 389.243902 227.033537  
406.000000 2032.000000 0.000000 381.200787 202.673228  
0.000000 2032.000000 0.000000 374.074074 181.268519  
1218.000000 2540.000000 0.000000 450.349462 256.059140  
812.000000 2540.000000 0.000000 437.347368 227.557895  
406.000000 2540.000000 0.000000 425.650602 203.072289  
0.000000 2540.000000 0.000000 415.725490 182.205882
```

Figure 11: Data from CalPoints_1.txt

```
0.000000 0.000000 0.000000 190.952191 228.314741
0.000000 508.000000 0.000000 225.478571 195.110714
0.000000 1016.000000 0.000000 256.263830 165.736170
0.000000 1524.000000 0.000000 283.376884 140.065327
0.000000 2032.000000 0.000000 307.157895 117.596491
0.000000 2540.000000 0.000000 328.580420 97.972028
406.000000 0.000000 0.000000 223.877604 235.205729
406.000000 508.000000 0.000000 257.805643 199.664577
406.000000 1016.000000 0.000000 287.800000 168.776471
406.000000 1524.000000 0.000000 314.032407 141.805556
406.000000 2032.000000 0.000000 337.251366 118.502732
406.000000 2540.000000 0.000000 357.922078 98.019481
812.000000 0.000000 0.000000 259.474501 243.246120
812.000000 508.000000 0.000000 293.500000 204.462366
812.000000 1016.000000 0.000000 322.319079 172.476974
812.000000 1524.000000 0.000000 348.235772 143.646341
812.000000 2032.000000 0.000000 369.744898 119.647959
812.000000 2540.000000 0.000000 389.506024 98.168675
1218.000000 0.000000 0.000000 301.047794 251.700368
1218.000000 508.000000 0.000000 333.765517 210.629885
1218.000000 1016.000000 0.000000 361.156805 176.340237
1218.000000 1524.000000 0.000000 385.141304 146.358696
1218.000000 2032.000000 0.000000 404.811659 121.264574
1218.000000 2540.000000 0.000000 422.838889 99.088889
```

Figure 12: Data from CalPoints_2.txt

```
0.000000 2540.000000 0.000000 227.539683 118.560847  
406.000000 2540.000000 0.000000 258.192090 103.655367  
812.000000 2540.000000 0.000000 286.756410 89.750000  
1218.000000 2540.000000 0.000000 314.000000 77.000000  
0.000000 2032.000000 0.000000 254.144105 132.454148  
406.000000 2032.000000 0.000000 286.098592 115.967136  
812.000000 2032.000000 0.000000 315.816754 100.863874  
1218.000000 2032.000000 0.000000 343.488235 87.188235  
0.000000 1524.000000 0.000000 285.520690 147.800000  
406.000000 1524.000000 0.000000 318.447876 129.683398  
812.000000 1524.000000 0.000000 348.799107 113.098214  
1218.000000 1524.000000 0.000000 377.014925 98.203980  
0.000000 1016.000000 0.000000 321.375691 166.544199  
406.000000 1016.000000 0.000000 355.408805 146.591195  
812.000000 1016.000000 0.000000 386.761733 128.451264  
1218.000000 1016.000000 0.000000 415.110204 111.767347  
0.000000 508.000000 0.000000 363.888646 188.519651  
406.000000 508.000000 0.000000 398.496144 165.861183  
812.000000 508.000000 0.000000 429.149560 145.319648  
1218.000000 508.000000 0.000000 457.254237 127.081356  
0.000000 0.000000 0.000000 413.050228 214.287671  
406.000000 0.000000 0.000000 447.561077 188.759834  
812.000000 0.000000 0.000000 478.455422 166.200000  
1218.000000 0.000000 0.000000 505.759777 145.441341
```

Figure 13: Data from CalPoints_3.txt

```
0.000000 2540.000000 0.000000 161.169197 228.531453
406.000000 2540.000000 0.000000 168.501362 195.585831
812.000000 2540.000000 0.000000 175.273649 167.398649
1218.000000 2540.000000 0.000000 181.523013 143.251046
0.000000 2032.000000 0.000000 216.881048 221.983871
406.000000 2032.000000 0.000000 220.380711 188.835025
812.000000 2032.000000 0.000000 223.542587 160.832808
1218.000000 2032.000000 0.000000 226.482213 136.960474
0.000000 1524.000000 0.000000 275.196117 214.413592
406.000000 1524.000000 0.000000 274.340000 181.827500
812.000000 1524.000000 0.000000 273.071207 154.201238
1218.000000 1524.000000 0.000000 272.820313 130.976563
0.000000 1016.000000 0.000000 334.456693 208.297244
406.000000 1016.000000 0.000000 328.812500 176.360000
812.000000 1016.000000 0.000000 324.476038 149.303514
1218.000000 1016.000000 0.000000 319.683398 126.235521
0.000000 508.000000 0.000000 392.745798 202.334034
406.000000 508.000000 0.000000 382.739362 171.188830
812.000000 508.000000 0.000000 373.485050 144.817276
1218.000000 508.000000 0.000000 365.670732 122.394309
0.000000 0.000000 0.000000 447.148036 197.135952
406.000000 0.000000 0.000000 433.465116 167.401163
812.000000 0.000000 0.000000 421.654804 141.967972
1218.000000 0.000000 0.000000 410.621739 119.965217
```

Figure 14: Data from CalPoints_4.txt

```
1218.000000 2540.000000 0.000000 194.789238 180.775785
1218.000000 2032.000000 0.000000 228.312169 163.582011
1218.000000 1524.000000 0.000000 257.590909 148.461039
1218.000000 1016.000000 0.000000 283.764706 135.926471
1218.000000 508.000000 0.000000 306.779817 125.073394
1218.000000 0.000000 0.000000 327.250000 115.793478
812.000000 2540.000000 0.000000 217.124514 194.412451
812.000000 2032.000000 0.000000 251.322727 175.122727
812.000000 1524.000000 0.000000 280.291429 158.697143
812.000000 1016.000000 0.000000 306.624113 145.056738
812.000000 508.000000 0.000000 328.547009 133.213675
812.000000 0.000000 0.000000 348.418367 123.316327
406.000000 2540.000000 0.000000 242.338762 209.592834
406.000000 2032.000000 0.000000 276.436508 188.373016
406.000000 1524.000000 0.000000 305.519802 170.128713
406.000000 1016.000000 0.000000 330.441718 155.331288
406.000000 508.000000 0.000000 351.921875 142.281250
406.000000 0.000000 0.000000 370.431373 131.539216
0.000000 2540.000000 0.000000 270.907609 226.891304
0.000000 2032.000000 0.000000 304.844291 203.114187
0.000000 1524.000000 0.000000 332.606195 182.946903
0.000000 1016.000000 0.000000 356.469274 166.491620
0.000000 508.000000 0.000000 376.913669 152.230216
0.000000 0.000000 0.000000 394.377778 140.355556
```

Figure 15: Data from CalPoints_5.txt