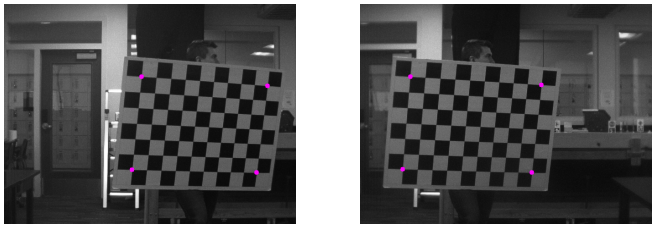
Stereo Calibration

Curtis Johnson
ECEn 631, Feb 2024

1. 3D Measurements



(a) (b)

Figure 1. Left and right stereo calibration images with the 4 corner points in purple.

The 3D point data w.r.t each camera is listed here in inches. The first row is the upper left, second row is upper right, third is lower left, and fourth is lower right:

$$\text{left points} = \begin{bmatrix} -13.899993 & -9.208256 & 188.98727 \\ 18.239597 & -7.6996655 & 203.03925 \\ -16.352592 & 13.661686 & 192.2307 \\ 15.7629 & 15.221519 & 206.37717 \end{bmatrix}$$

$$\text{right points} = \begin{bmatrix} -34.23877 & -9.207365 & 188.98727 \\ -2.0991762 & -7.7084355 & 203.03925 \\ -36.691364 & 13.714727 & 192.2307 \\ -4.575874 & 15.243156 & 206.37717 \end{bmatrix}$$

The calculations are correct as the discrepancy between the left and right points is small. I used the reprojection matrix Q after rectification.

$$P_l - \left(P_r + [||T||, 0, 0]^T\right) = \begin{bmatrix} -2.559e-06 & 8.907e-04 & 0.000e+00 \\ 5.403e-07 & -8.769e-03 & 0.000e+00 \\ 2.209e-06 & 5.304e-02 & 0.000e+00 \\ -1.749e-07 & 2.163e-02 & 0.000e+00 \end{bmatrix} \quad (1)$$

The actual distance between the top left and top right points is 34.92 inches, and my measurement estimates this as 35.11 inches.

2. Baseball Tracking

Figure 2 shows the stereo image pairs with the ball detected in each pair. Each row is a pair of images in time, The blue box is the region of interest where I search for the ball, and the orange dot is the estimated center of the ball.

3. Trajectory Estimation

The estimated intercept point is $(x, y) = (1.42, 32.01)$ inches relative to a frame parallel to the left camera frame and whose origin lies at the midpoint between the left and right cameras. Note that positive y points down. The entire trajectory is shown with the data in Figure 3.

In order to estimate this trajectory, I fit a parabola using least-squares to the data in the side view to calculate the y intercept. Since that is the plane where gravity acts projectile motion is parabolic in that plane.

In the top-down plane, we fit a line to the data to calculate the x intercept, since we are assuming no forces act on the ball in the x and z directions (e.g. drag, curveball effects from fluid dynamics, etc).

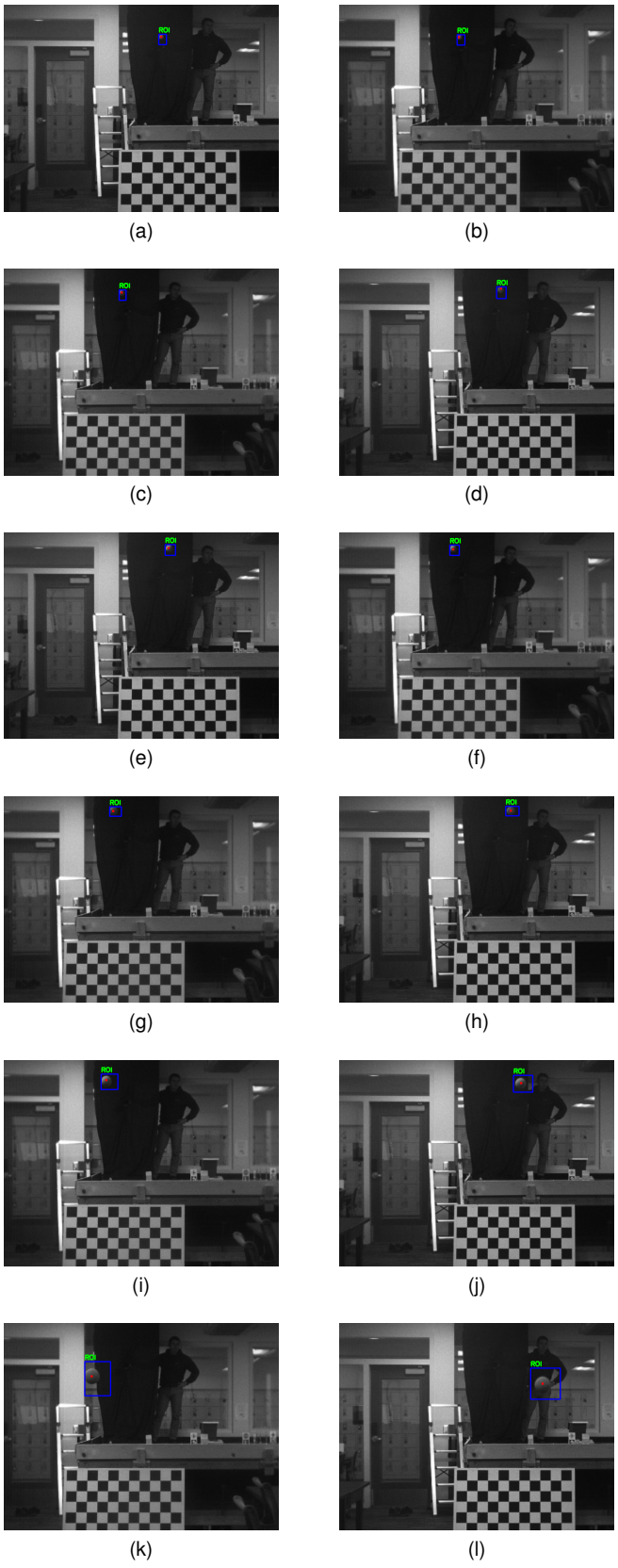


Figure 2. 5, 10, 15, 20, 25, 30th stereo image pairs over time. Left column is the left image, the right column is the right image.

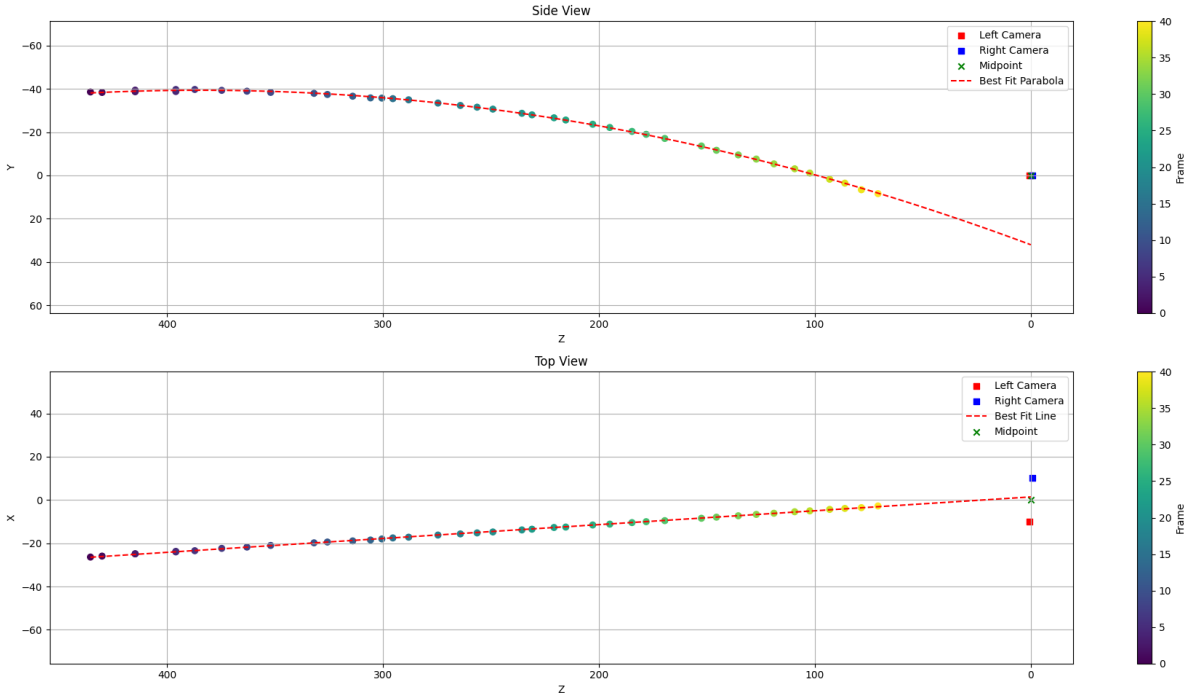


Figure 3. 3D Trajectory Estimation