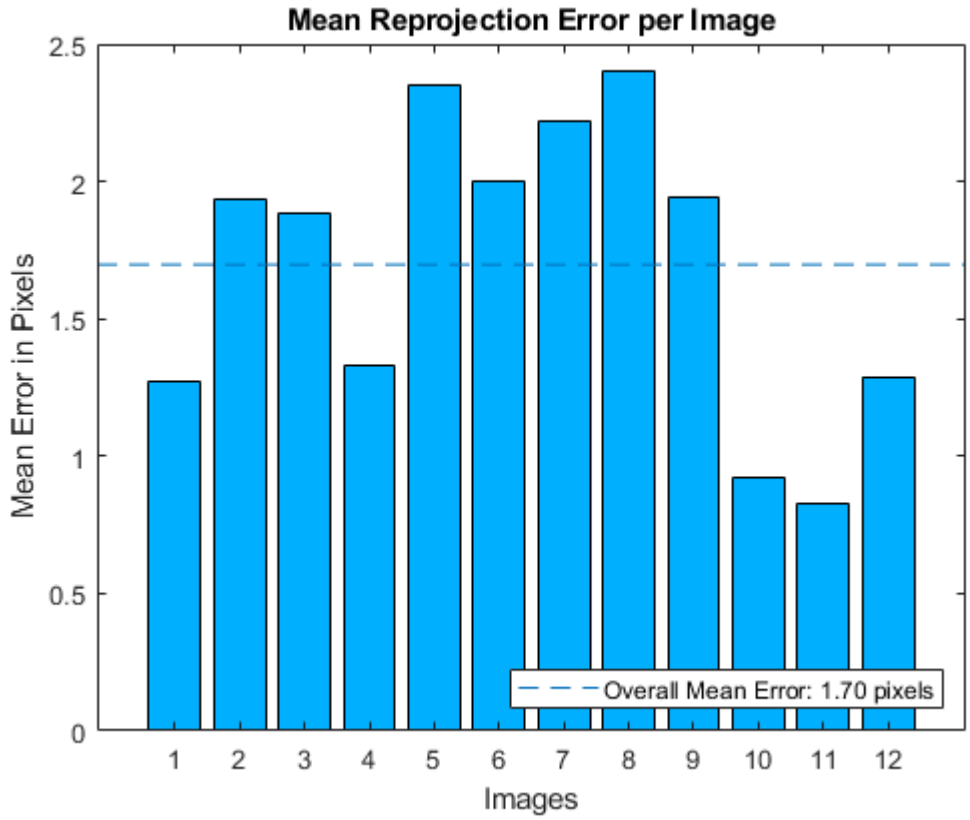
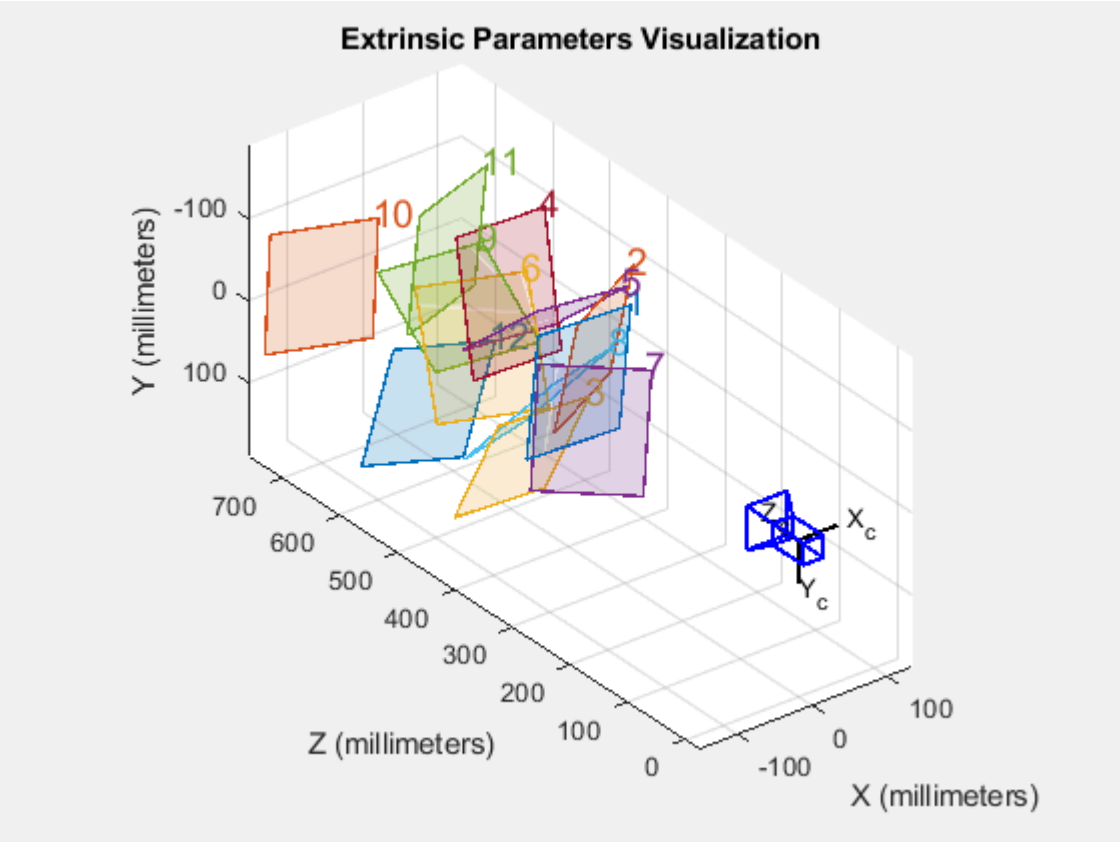
```
% Auto-generated by cameraCalibrator app on 07-Mar-2019
%--------------------------------------------------------


% Define images to process
imageFileNames = {'C:\Users\bengo\Downloads\Photos\IMG_20190307_144835.jpg',...
    'C:\Users\bengo\Downloads\Photos\IMG_20190307_144839.jpg',...
    'C:\Users\bengo\Downloads\Photos\IMG_20190307_144845.jpg',...
    'C:\Users\bengo\Downloads\Photos\IMG_20190307_144849.jpg',...
    'C:\Users\bengo\Downloads\Photos\IMG_20190307_144902.jpg',...
    'C:\Users\bengo\Downloads\Photos\IMG_20190307_144907.jpg',...
    'C:\Users\bengo\Downloads\Photos\IMG_20190307_144912.jpg',...
    'C:\Users\bengo\Downloads\Photos\IMG_20190307_144916.jpg',...
    'C:\Users\bengo\Downloads\Photos\IMG_20190307_144925.jpg',...
    'C:\Users\bengo\Downloads\Photos\IMG_20190307_145956.jpg',...
    'C:\Users\bengo\Downloads\Photos\IMG_20190307_150000.jpg',...
    'C:\Users\bengo\Downloads\Photos\IMG_20190307_150007.jpg',...
    };
% Detect checkerboards in images
[imagePoints, boardSize, imagesUsed] = detectCheckerboardPoints(imageFileNames);
```

```
Warning: The checkerboard must be asymmetric: one side should be even, and the other should be odd.
Otherwise, the orientation of the board may be detected incorrectly.
```

```
imageFileNames = imageFileNames(imagesUsed);

% Read the first image to obtain image size
originalImage = imread(imageFileNames{1});
[mrows, ncols, ~] = size(originalImage);

% Generate world coordinates of the corners of the squares
squareSize = 20;  % in units of 'millimeters'
worldPoints = generateCheckerboardPoints(boardSize, squareSize);

% Calibrate the camera
[cameraParams, imagesUsed, estimationErrors] = estimateCameraParameters(imagePoints, worldPoint
    'EstimateSkew', false, 'EstimateTangentialDistortion', false, ...
    'NumRadialDistortionCoefficients', 2, 'WorldUnits', 'millimeters', ...
    'InitialIntrinsicMatrix', [], 'InitialRadialDistortion', [], ...
    'ImageSize', [mrows, ncols]);

% View reprojection errors
h1=figure; showReprojectionErrors(cameraParams);
```




```
% Visualize pattern locations
h2=figure; showExtrinsics(cameraParams, 'CameraCentric');
```




```
% Display parameter estimation errors
displayErrors(estimationErrors, cameraParams);
```

```
   Standard Errors of Estimated Camera Parameters
   ----------------------------------------------

Intrinsics
----------
Focal length (pixels):   [ 3070.0706 +/- 10.4694    3078.4402 +/- 10.4414 ]
Principal point (pixels):[ 1542.1939 +/- 6.5626     2051.4664 +/- 6.1459  ]
Radial distortion:       [    0.0890 +/- 0.0102       -0.3901 +/- 0.0461  ]

Extrinsics
----------
Rotation vectors:
                         [    0.1223 +/- 0.0035       -0.0559 +/- 0.0036        1.5805 +/- 0.0004  ]
                         [   -0.1031 +/- 0.0023       -0.5263 +/- 0.0025        1.4621 +/- 0.0008  ]
                         [    0.3839 +/- 0.0023       -0.3428 +/- 0.0021        1.5736 +/- 0.0009  ]
                         [   -0.2134 +/- 0.0024        0.1700 +/- 0.0030        1.6076 +/- 0.0006  ]
                         [    0.7373 +/- 0.0029       -0.6411 +/- 0.0029        1.5172 +/- 0.0010  ]
                         [    0.3568 +/- 0.0023        0.5964 +/- 0.0021        1.4123 +/- 0.0009  ]
                         [    0.5739 +/- 0.0026        0.4655 +/- 0.0021        1.5404 +/- 0.0008  ]
                         [    0.3224 +/- 0.0023       -0.8006 +/- 0.0023        1.6956 +/- 0.0012  ]
                         [    0.5941 +/- 0.0023        0.4308 +/- 0.0021        1.0476 +/- 0.0009  ]
                         [    0.3788 +/- 0.0038        0.1748 +/- 0.0036        1.5237 +/- 0.0009  ]
                         [   -0.1063 +/- 0.0041       -0.3346 +/- 0.0041        1.5225 +/- 0.0010  ]
                         [    0.3691 +/- 0.0031        0.0126 +/- 0.0030        1.6714 +/- 0.0007  ]

Translation vectors (millimeters):
                         [   54.6931 +/- 0.7848     -102.9147 +/- 0.7519      362.4996 +/- 1.2961  ]
                         [   99.9625 +/- 0.8877     -111.3620 +/- 0.8424      416.8312 +/- 1.4067  ]
```

```
[   60.7808 +/- 0.9422       47.3451 +/- 0.8744      442.2324 +/- 1.5790  ]
[   22.2713 +/- 1.0001     -184.6262 +/- 0.9412      470.8002 +/- 1.5258  ]
[   46.7145 +/- 0.7533     -130.5458 +/- 0.7671      358.0768 +/- 1.3536  ]
[  -15.6585 +/- 0.9679     -128.0829 +/- 0.8936      451.4166 +/- 1.5584  ]
[   42.5193 +/- 0.6724      -51.4224 +/- 0.6161      310.4381 +/- 1.0961  ]
[   91.1710 +/- 0.9273       -4.7251 +/- 0.8819      438.9834 +/- 1.5224  ]
[  -72.3319 +/- 0.9680     -182.1332 +/- 0.9503      455.3882 +/- 1.6992  ]
[  -26.3646 +/- 1.4956      -84.9004 +/- 1.4005      696.6874 +/- 2.5083  ]
[  130.9712 +/- 1.5274      -86.6425 +/- 1.4263      712.7435 +/- 2.4590  ]
[   14.6484 +/- 1.1767       10.4370 +/- 1.0988      546.2735 +/- 1.9444  ]
```

```
% For example, you can use the calibration data to remove effects of lens distortion.
undistortedImage = undistortImage(originalImage, cameraParams);

% See additional examples of how to use the calibration data.  At the prompt type:
% showdemo('MeasuringPlanarObjectsExample')
% showdemo('StructureFromMotionExample')

%Intrinsic parameters
cameraParams.IntrinsicMatrix
```

```
ans = 3×3
          3070.0706430238                        0                        0
                        0          3078.44016537562                        0
         1542.19387510416          2051.46635260177                        1
```

```
%Extrinsic parameters
cameraParams.RotationVectors .* cameraParams.TranslationVectors
```

```
ans = 12×3
           6.6912742591676          5.7552602533178          572.935784781867
          -10.3039717135682          58.6141256641418          609.442186141381
           23.3344475143903         -16.2294675685102          695.878669496867
          -4.75164998150373         -31.3773224739326          756.835113550979
            34.443576158058          83.6915060910615          543.271457099125
           -5.5867682949675         -76.3917407238256          637.519339099098
           24.4039172698305          -23.936351073964          478.195226238324
           29.3908684715517          3.78273015153966          744.353334520456
          -42.9740657691582         -78.4664563805625          477.043621208733
          -9.98804933656441         -14.8427725910851          1061.54503980268
      ⋮
```

```
%World Points
cameraParams.WorldPoints
```

```
ans = 63×2
     0     0
     0    20
     0    40
     0    60
     0    80
     0   100
     0   120
    20     0
    20    20
```

```
    20    40
     ⋮
     ⋮
```

```
%Pixel coordinates = intrinsic * extrinsic * world points
```