ECEn 631 Stereo Calibration and Rectification.

Objectives:

- Learn stereo camera geometry.
- Learn to calibrate stereo system using OpenCV functions.
- Learn to rectify stereo images.

Instructions:

- Use the **Baseball Catcher system in Room 408 EB** to complete this assignment.
- This assignment will help prepare you for your Baseball Catcher team project. Save your code and reuse it later.
- Learn to use the Baseball Catcher program to capture image sequences for this assignment.
- You should ask your team members to help you capture the image sequences (one holds the chessboard, and one clicks the buttons)
- Write your own code to read in the image frames you have captured to calibrate the stereo system.
- Team members can use the same image sequences for this assignment.
- You can download the practice sequences and data from Learning Suite to confirm that your code works before using your own.
- Generate a PDF file that includes (with proper headings) the intrinsic and distortion parameters for both left and right cameras (Task 1), extrinsic parameters and essential and fundamental matrices (Task 2), one pair of images with epipolar lines clearly marked (Task 3), the original, rectified, and their absolute difference for both cameras (Task 4), and your explanations.
- Submit your PDF file and source code file(s) in one zip file without the folder or directory.
- Use your first name and last name (e.g., justinsmith.zip) as the file name.
- Login to myBYU and submit your work through BYU Learning Suite online submission.

The chessboard size in the practice sequences is 2"×2". The size of the large chessboard made for this assignment and the baseball catcher project in 408EB is 3.88"×3.88". The x and y coordinates of the chessboard 3-D points entered to the calibration function should be multiplied by 2.0 and 3.88, respectively. The z coordinates stay the same (0).

Image Acquisition:

- Read the Baseball Catcher User Guide carefully before you operate the baseball catcher.
- Create a team folder for your team in the Baseball Catcher system in 408EB.
- Have one of your team members hold the chessboard in front of the camera(s) and move the chessboard around.
- Check "Display" and "Use Camera" boxes and set the maximum number of frames you want to acquire.
- Select "Single" to acquire one image pair every time you click the "Capture Frames" button. The frame number will be shown to the right of the "Capture Frames" button.
- Move the chessboard around in front of the left camera (ignore the right camera) and click the "Capture Frames" button once for each chessboard position. Replay the captured sequence to confirm its quality. Select "Left" and click the "Save Sequence" button to save the image sequence for calibrating the left camera. A folder (yyyymmddhhmmss) and a subfolder (/L) will be created to save the captured left image sequence.
- Move the chessboard around in front of the right camera (ignore the left camera) and click the "Capture Frames" button once for each chessboard position. Replay the captured sequence to confirm its quality. Select "Right" and click the "Save Sequence" button to save the image sequence for calibrating the right camera. A folder (yyyymmddhhmmss) and a subfolder (/R) will be created to save the captured right image sequence.
- Move the chessboard around in front of both cameras and click the "Capture Frames" button once for each chessboard position. Replay the captured sequence to confirm its quality. Make sure the entire chessboard is seen by BOTH cameras. Select "Stereo" and click the "Save Sequence" button to save both the left and right image sequences for calibrating the stereo system. A folder (yyyymmddhhmmss) and two subfolders (/L and /R) will be created to save the captured left and right image sequences.
- You will need total four image sequences for this assignment. The first sequence is for calibrating the left camera. The second sequence is for calibrating the right camera. The third (L) and fourth (R) sequences together are the stereo image sequence for calibrating the stereo system.
- You should calibrate two cameras separately in order to get accurate intrinsic and distortion parameters for each camera (Task 1).
- You can then use these two sets of intrinsic and distortion parameters (one set for each camera) and the stereo image sequence to calibrate the stereo system (Task 2).
- Copy these images to your thumb drive or cloud drive and remove them from the computer hard drive (**empty the recycle bin**).
- Tips to get good images:
  - Make sure you step back and forth until the images are in focus, especially around the edges.
  - Make sure the lighting in the room isn't too bright above the calibration board, if the squares get washed out, the calibration parameters will not be accurate. Tilting the board slightly forward helps remove the glares.
  - Focus on the area 15 to 30 feet from the catcher or 10 to 25 feet from the pitching machine.
  - You can capture and use as many images as you want. In general, using more images gives you better calibration result.

Task 1: Camera Calibration 25 points

- Use the captured left and right image sequences to calibrate the left and right cameras individually.
- Find chessboard corners (subpixel) and do cameraCalibrate() for each camera.
- This task is the same as Task 2 in Assignment 2. You can reuse the code and don't have to submit the code again.
- Include one set of the intrinsic (3×3) and distortion (1×5) parameters for each camera in your PDF File.
- You can and should download the practice images and the resulting calibration parameters from Learning Suit to confirm that your code works. Please note that the stereo system used to capture these images is different (lens focal length, baseline, and chessboard size) from the system for the baseball catcher. Read the instruction carefully.

Task 2: Stereo Calibration 25 points

- Use the stereo image sequences and the two sets of intrinsic and distortion parameters calculated in Task 1 and the OpenCV stereoCalibrate() function to obtain a unique set of extrinsic parameters between the two cameras, an essential matrix, and a fundamental matrix.
- Perform stereo calibration using the test image sequences and report your results.
- Include (one set for each image sequence) the extrinsic parameters (3×3 R and 3×1 T), essential matrix (3×3), and fundamental matrix (3×3) in your PDF file.
- Submit your code for this task.

Task 3: Epipolar Lines 25 points

- Select one pair of images from your stereo image sequences for this task.
- Use undistort () to undistort lens distortion for both images. Selected 3 points of interest from the left image and 3 **different** points from the right image and draw a circle around them on their respective image.
- Use the fundamental matrix from Task 2 and computeCorrespondEpilines() to find and draw 3 epipolar lines of the selected 3 points for each of the left and right images. The epipolar lines found for the three points in the left image should be drawn in the right image and vice versa. Confirm that the corresponding points lie on their epipolar lines in the other image.
- Include both images with the superimposed colored epipolar lines in your PDF file.
- Submit your code for this task.

Task 4: Rectification 25 points

Select one pair of images from your stereo image sequences for this task.

- Use stereoRectify( ), initUndistortRectifyMap( ), and remap( ) functions to rectify both left and right images.
- Confirm that the image rows are aligned by drawing a few horizontal lines in both rectified images.
- Include the two original images and the two rectified images in your PDF file.
- Include the two absolute difference images (between the rectified and original images) in your PDF File.
- Submit your code for this task.