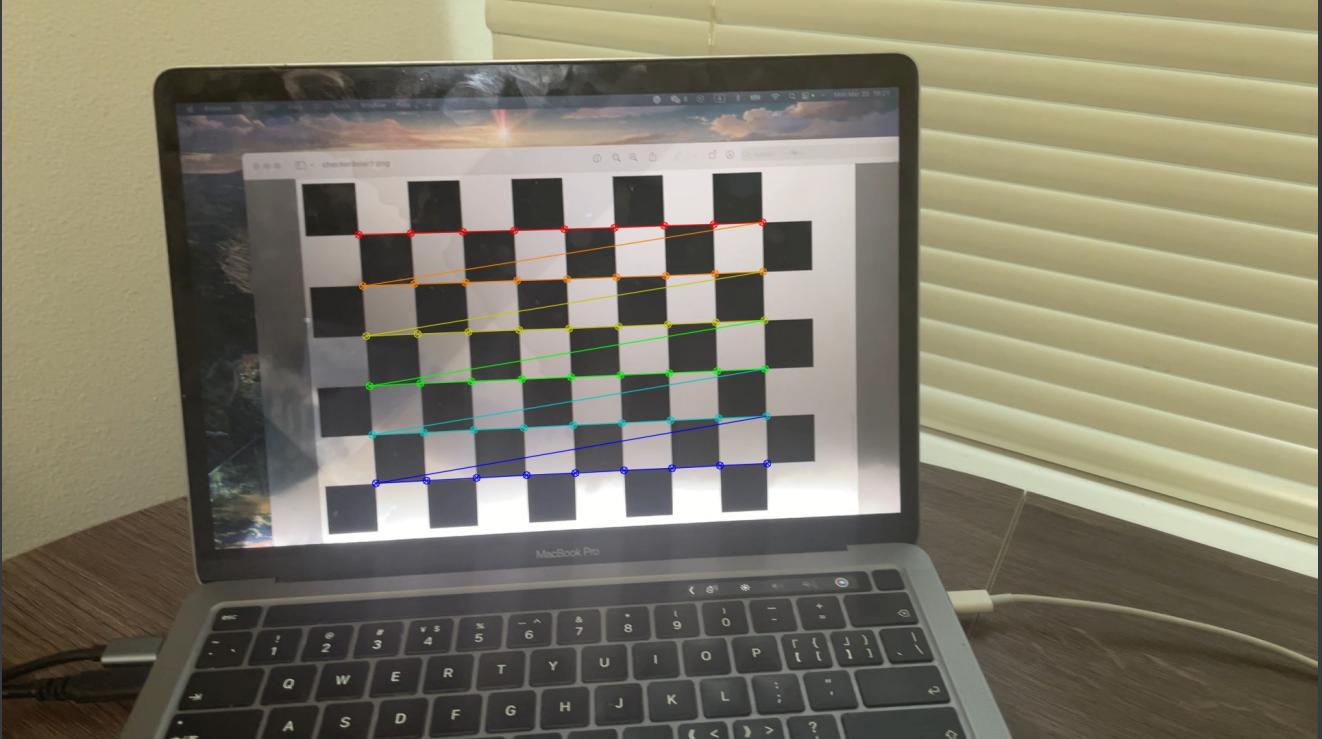


# Report

1. In this project, we implemented 4 programs. The first three accomplished the tasks as required. The last program implemented a new calibration method by using charuco board.
2. Required images:

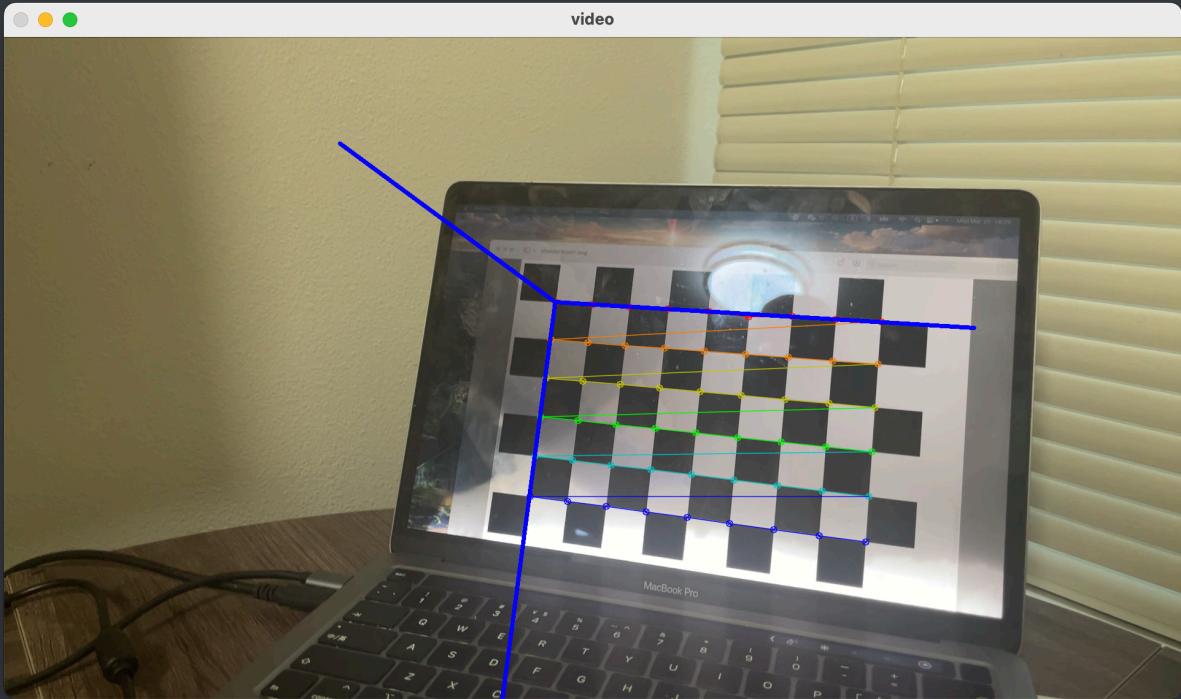
1. calibration image with chessboard corners highlighted:



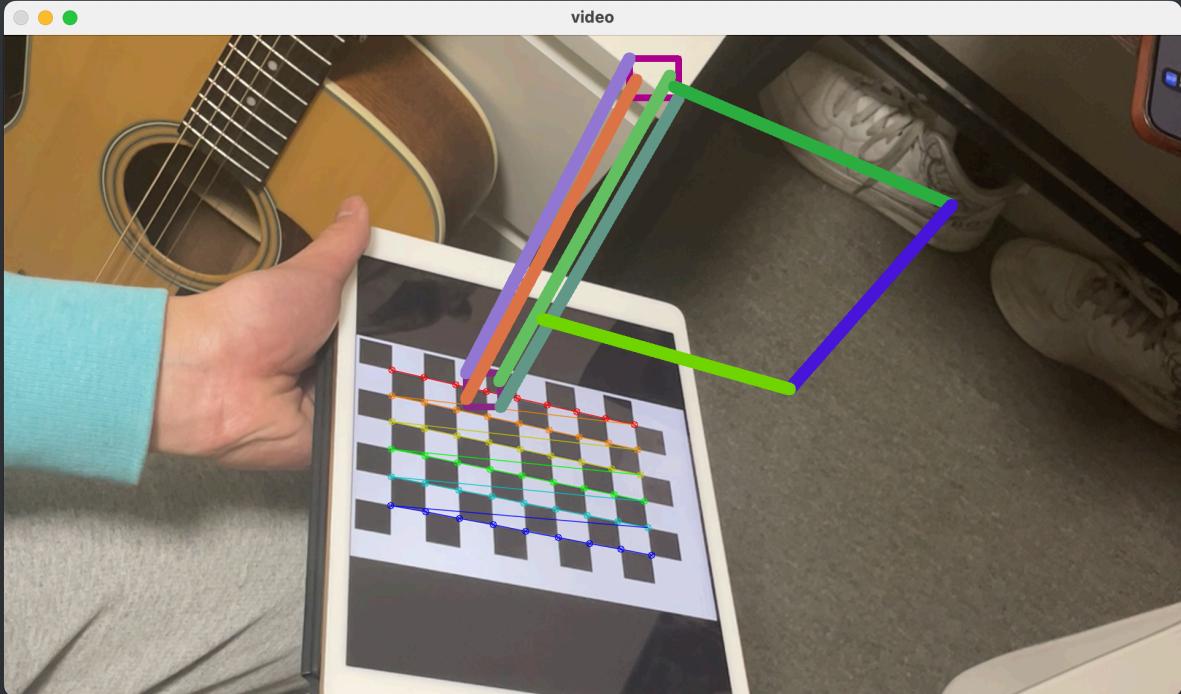
2. the error estimate:

```
Caliberated camera matrix is:  
[1382.767445929119, 0, 959.5724178611611;  
 0, 1382.767445929119, 538.5361628626779;  
 0, 0, 1]  
Caliberated distortion coefficients is:  
[0.1303860407790406, -0.1324127535834819, 0.01011963809147966,  
 -0.000989586652721378, -1.257477999276711]  
the reprojection error is: 0.608214
```

3. 3-D axes screenshot:



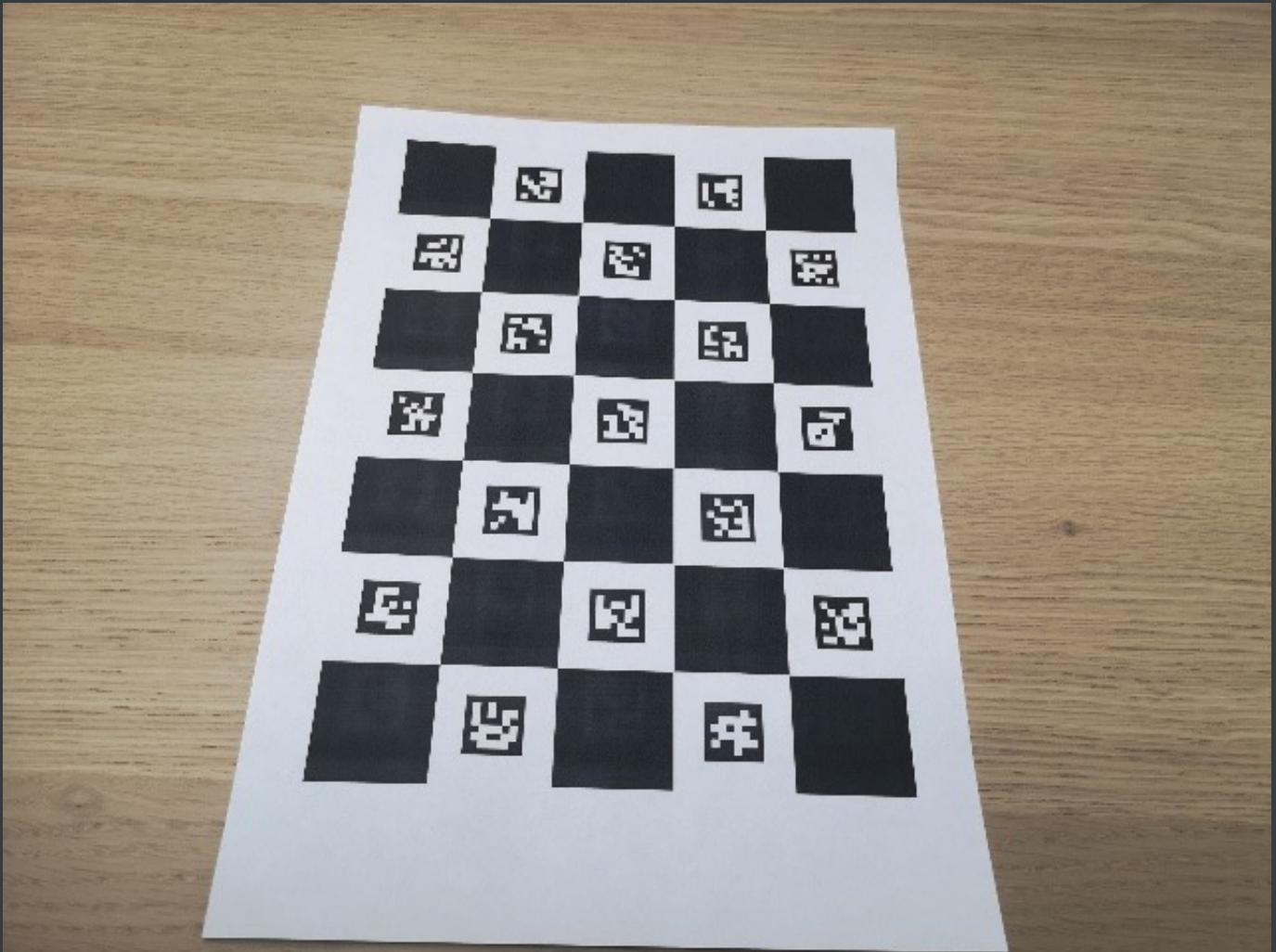
4. *phantom battle axe* screenshot:



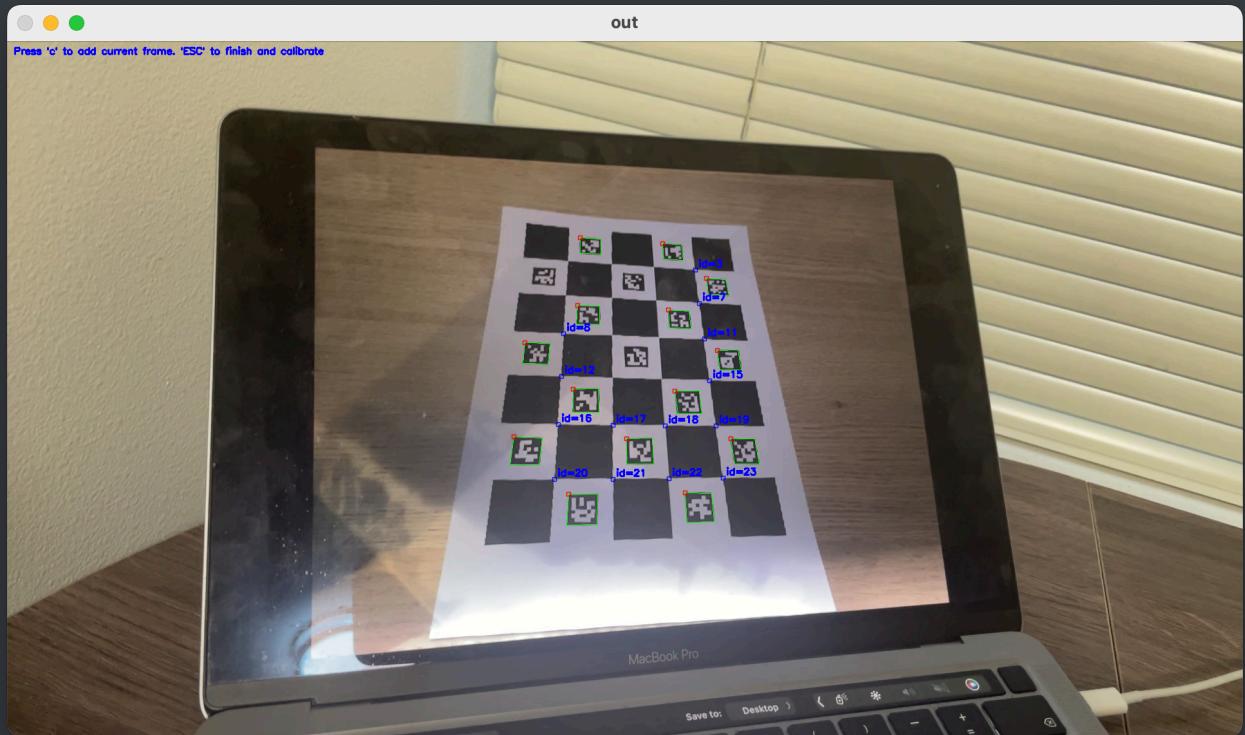
5. About task 7 details, please refer to video <https://youtu.be/TeACMVQ1rtg>. About Harris corners' function in AR, we can use the detected Harris corners of chessboard

as reference points to track the movement of objects in the image.

3. instead of using chessboard, we use charuco board to calibrate the camera, which can still work with minor block of the board.



Here is a example image about the calibration on the charuco board:



4. In this project, we learned to implement AR for the first time. Specifically in finding corner, calibration, and coordination system conversion, and making 3D object and project it into video.

5. Acknowledgement:

[https://docs.opencv.org/3.4/d9/d0c/group\\_\\_calib3d.html#ga93efa9b0aa890de240ca32b11253dd4a](https://docs.opencv.org/3.4/d9/d0c/group__calib3d.html#ga93efa9b0aa890de240ca32b11253dd4a)

[https://docs.opencv.org/4.x/dd/d1a/group\\_\\_imgproc\\_\\_feature.html#ga354e0d7c86d0d9da75de9b9701a9a87e](https://docs.opencv.org/4.x/dd/d1a/group__imgproc__feature.html#ga354e0d7c86d0d9da75de9b9701a9a87e)

[https://docs.opencv.org/3.4/d9/d0c/group\\_\\_calib3d.html#ga6a10b0bb120c4907e5eabbc d22319022](https://docs.opencv.org/3.4/d9/d0c/group__calib3d.html#ga6a10b0bb120c4907e5eabbc d22319022)