

Part A

Camera : ASUS X00TDB

Intrinsic parameter : focal length(f_x, f_y), optical centers(c_x, c_y), distortion coefficient(k_1, k_2, p_1, p_2, k_3)

Use cv2.calibrateCamera() to get these parameters

```
# Calibration
ret, mtx, dist, rvecs, tvecs = cv2.calibrateCamera(obj_points_total, img_points_total, img_gray.shape[::-1], None, None)
print('Intrinsic matrix:\n', mtx)
```

```
Intrinsic matrix:
[[1.55504330e+03 0.00000000e+00 1.06166090e+03]
[0.00000000e+00 1.55897052e+03 7.56749441e+02]
[0.00000000e+00 0.00000000e+00 1.00000000e+00]]
```

```
# Calibration
ret, mtx, dist, rvecs, tvecs = cv2.calibrateCamera(obj_points_total, img_points_total, img_gray.shape[::-1], None, None)
print('distortion coefficient:\n', dist)
```

```
distortion coefficient:
[[ 0.03267881  0.72780747 -0.00692991  0.01315581 -0.13182098]]
```

The second output mtx camera matrix which contain parameter f_x, f_y, c_x, c_y

$f_x : \text{mtx}[0][0]$

$f_y : \text{mtx}[1][1]$

$c_x : \text{mtx}[0][2]$

$c_y : \text{mtx}[1][2]$

The third output is distortion coefficient which contain parameter k_1, k_2, p_1, p_2, k_3

The coefficient is the parameter of radial distortion and tangential distortion

radial distortion : this distortion is caused by the symmetry len shape, so the point farther from center point may have large distortion

$$x_{\text{distorted}} = x(1 + k_1r^2 + k_2r^4 + k_3r^6)$$

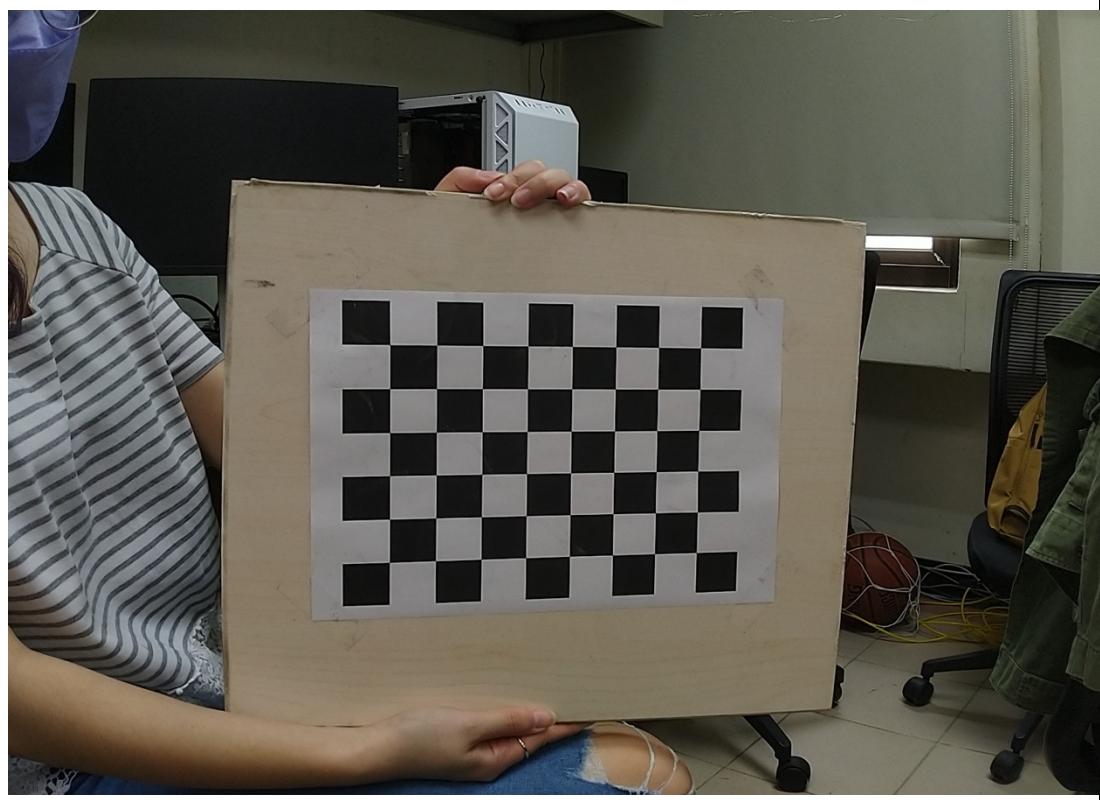
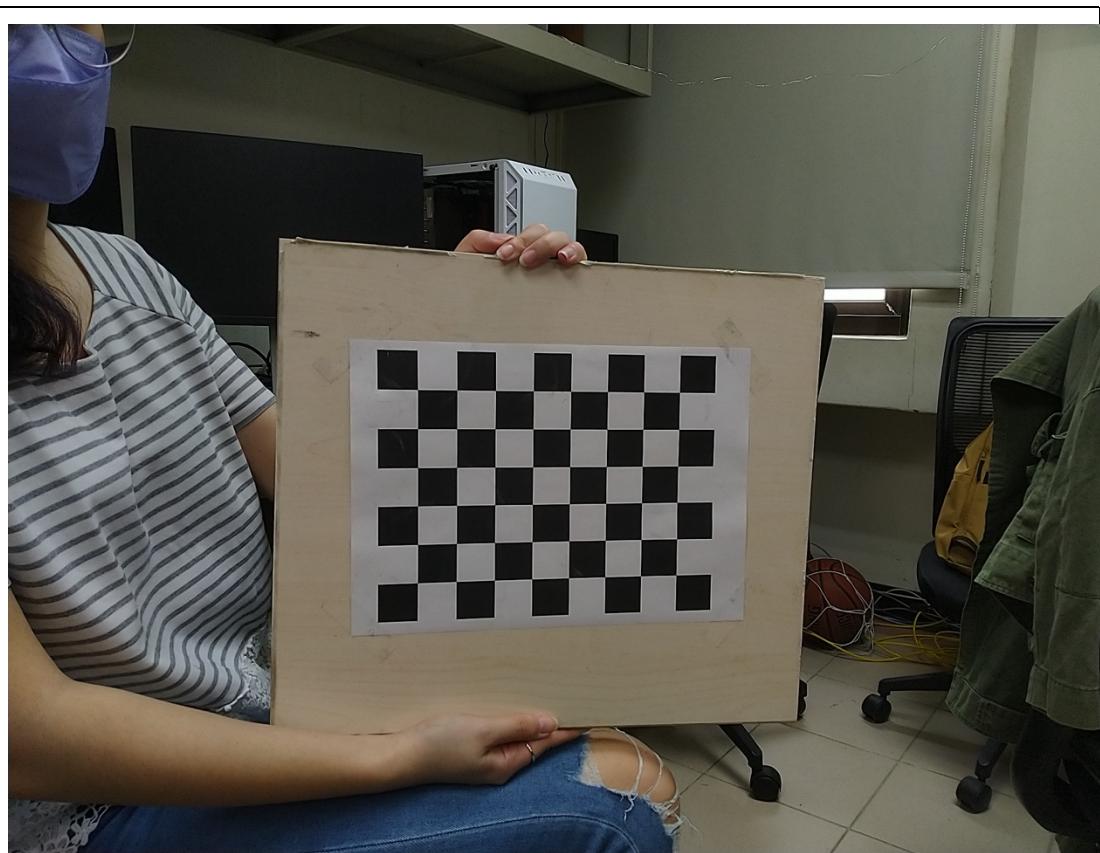
$$y_{\text{distorted}} = y(1 + k_1r^2 + k_2r^4 + k_3r^6)$$

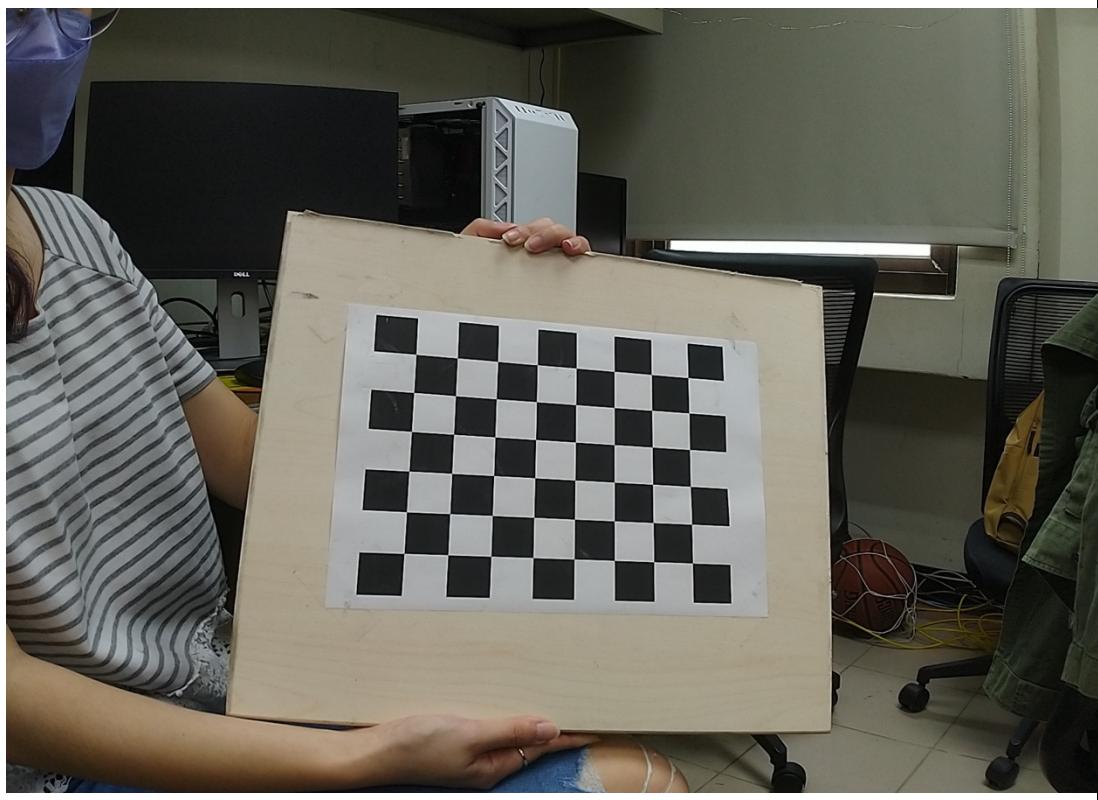
tangential distortion : this distortion is caused by non-parallel between len and real object, so some location in picture may look nearer in contrast with physical location.

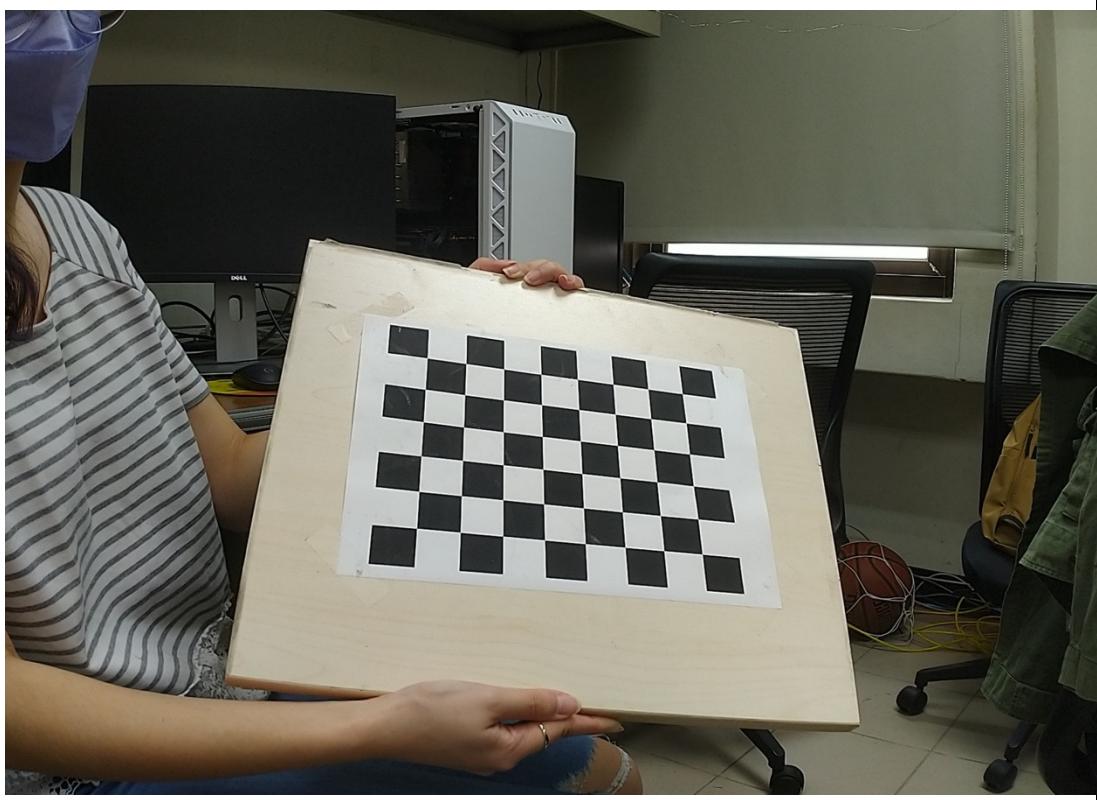
$$x_{\text{distorted}} = x + [2p_1xy + p_2(r^2 + 2x^2)]$$

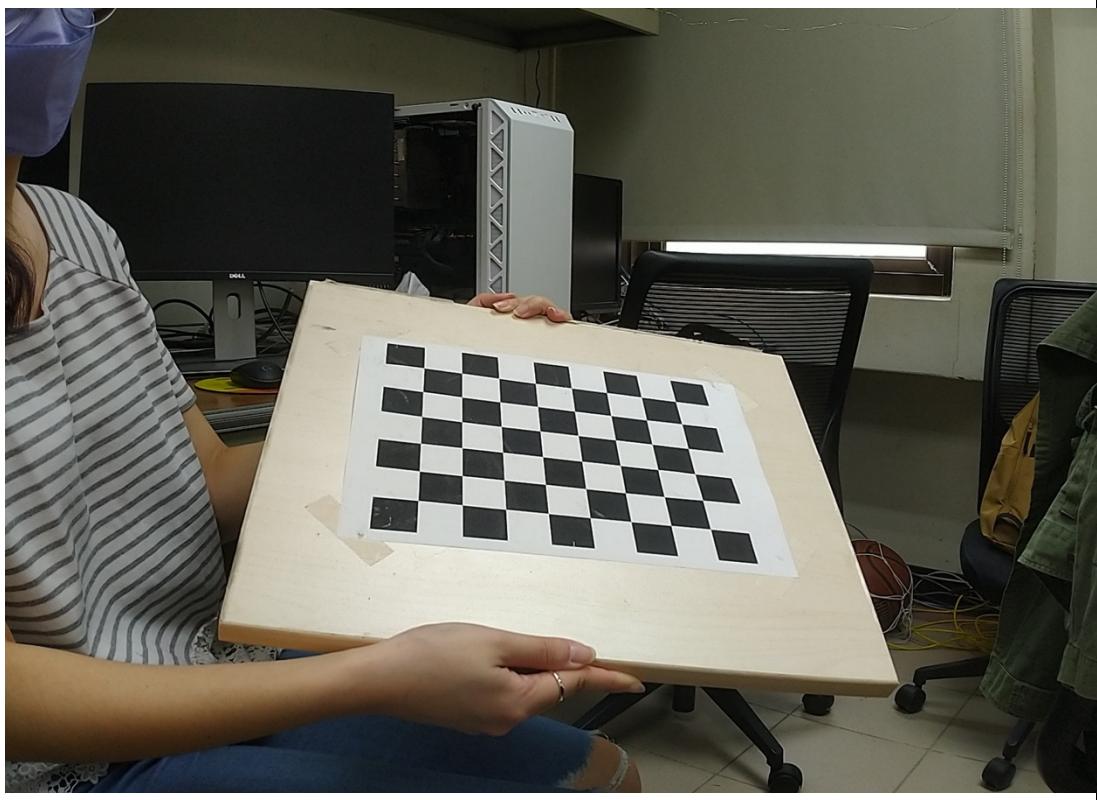
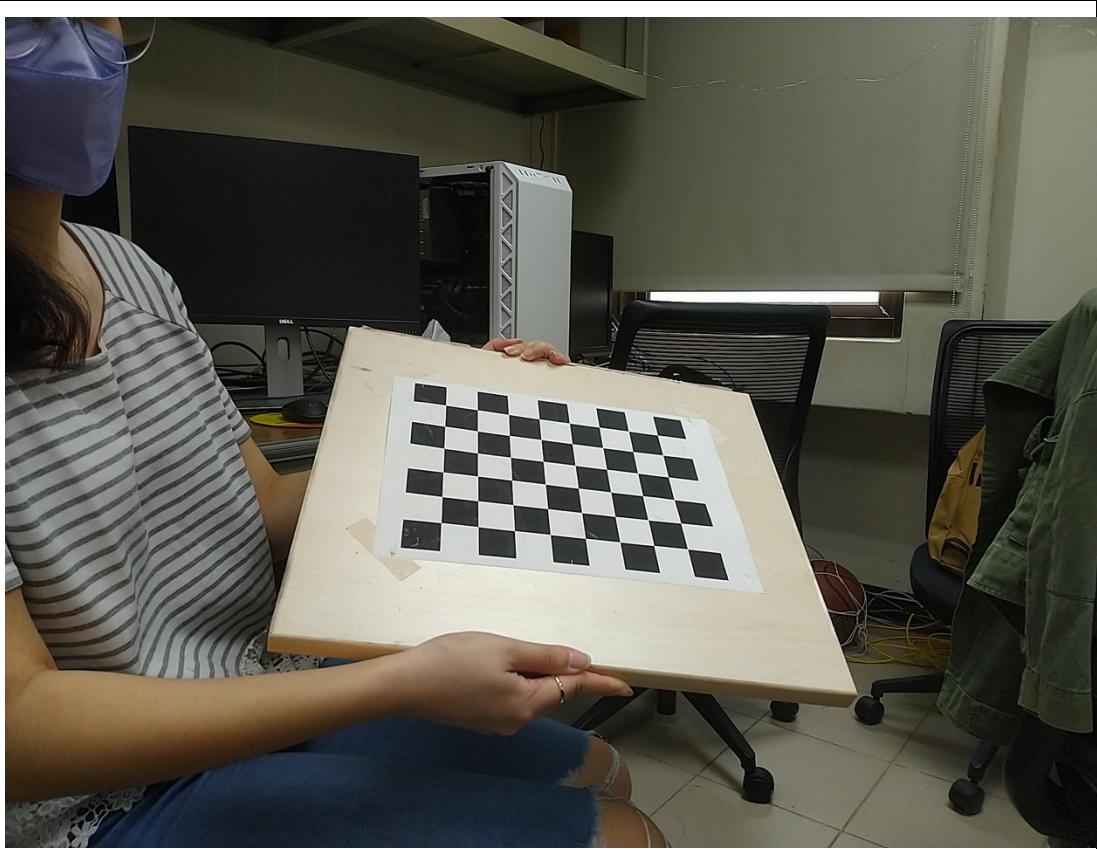
$$y_{\text{distorted}} = y + [p_1(r^2 + 2y^2) + 2p_2xy]$$

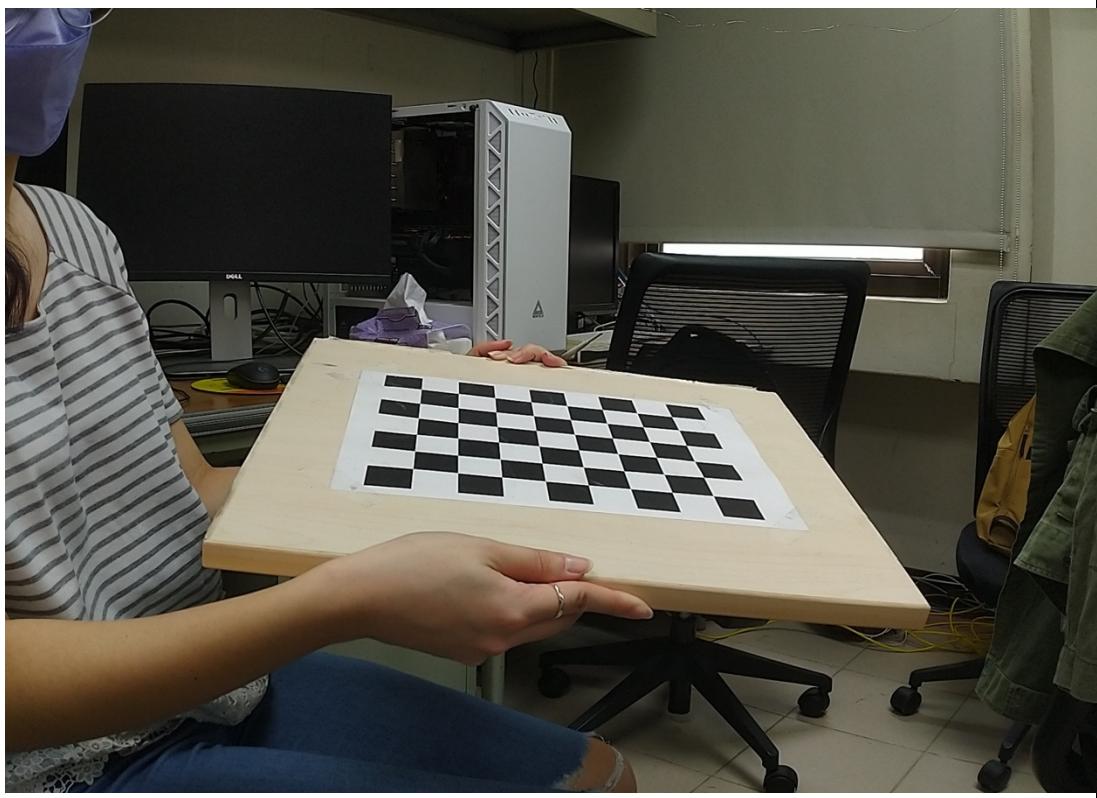
Distort(upside) vs undistort(downside)

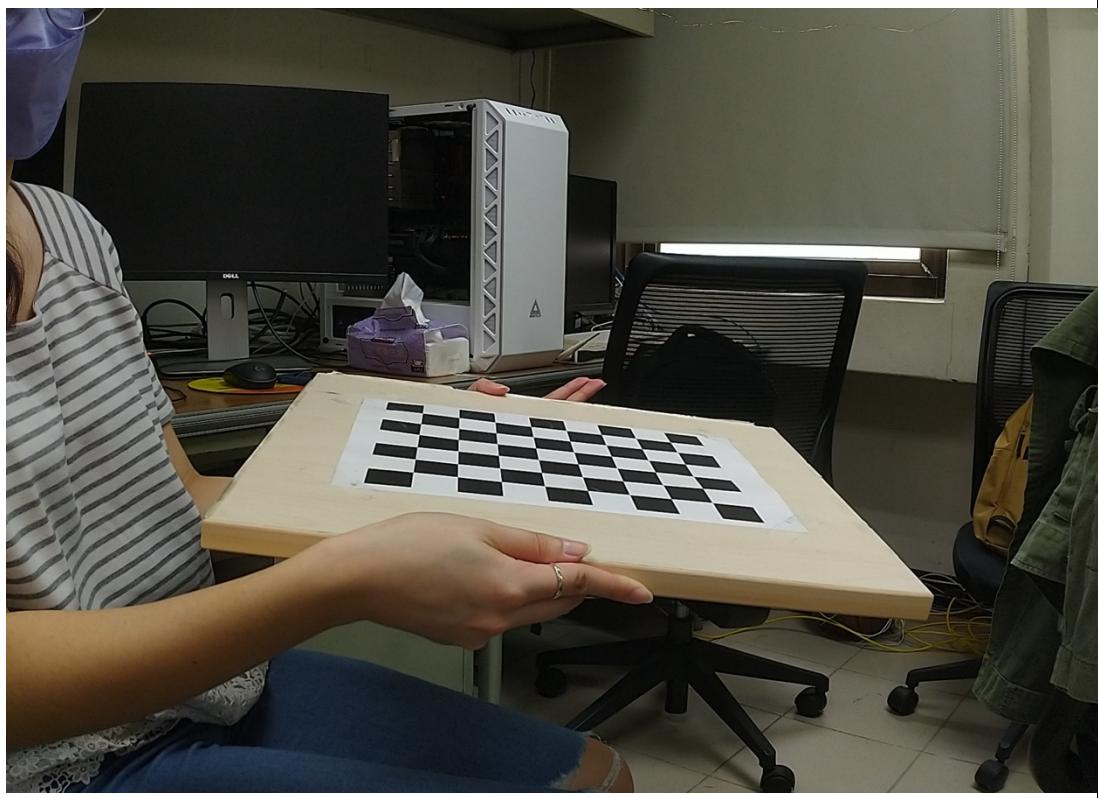


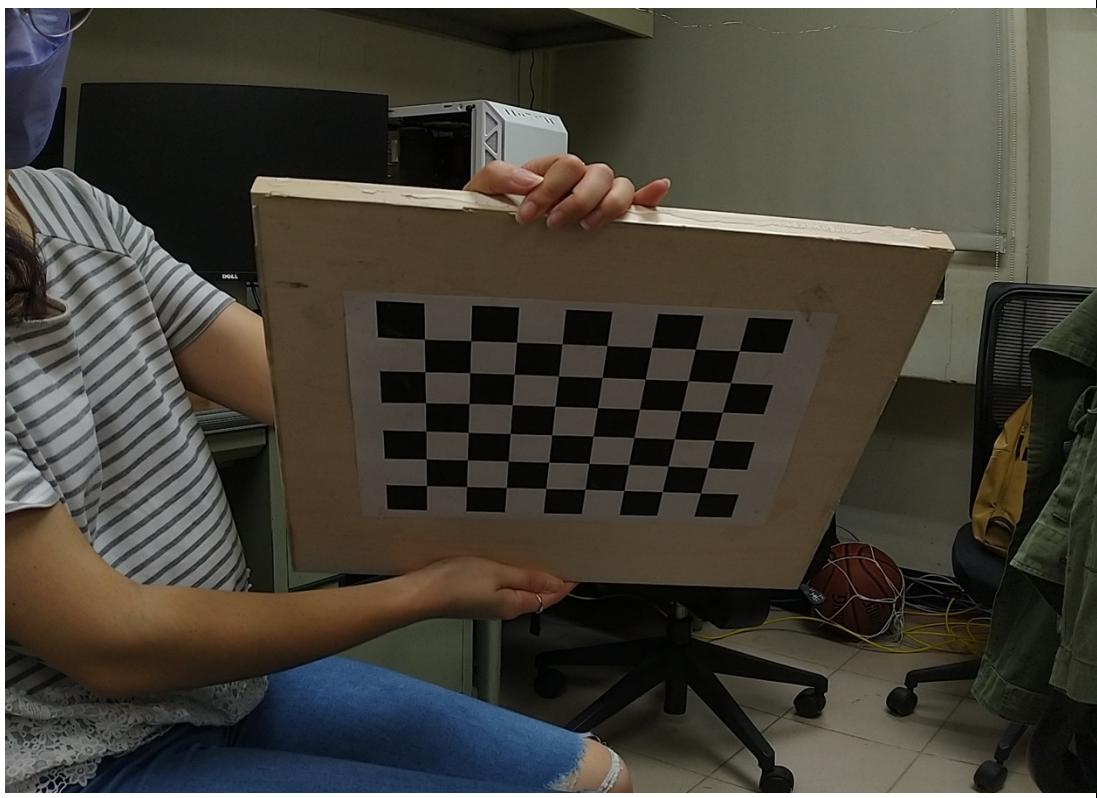
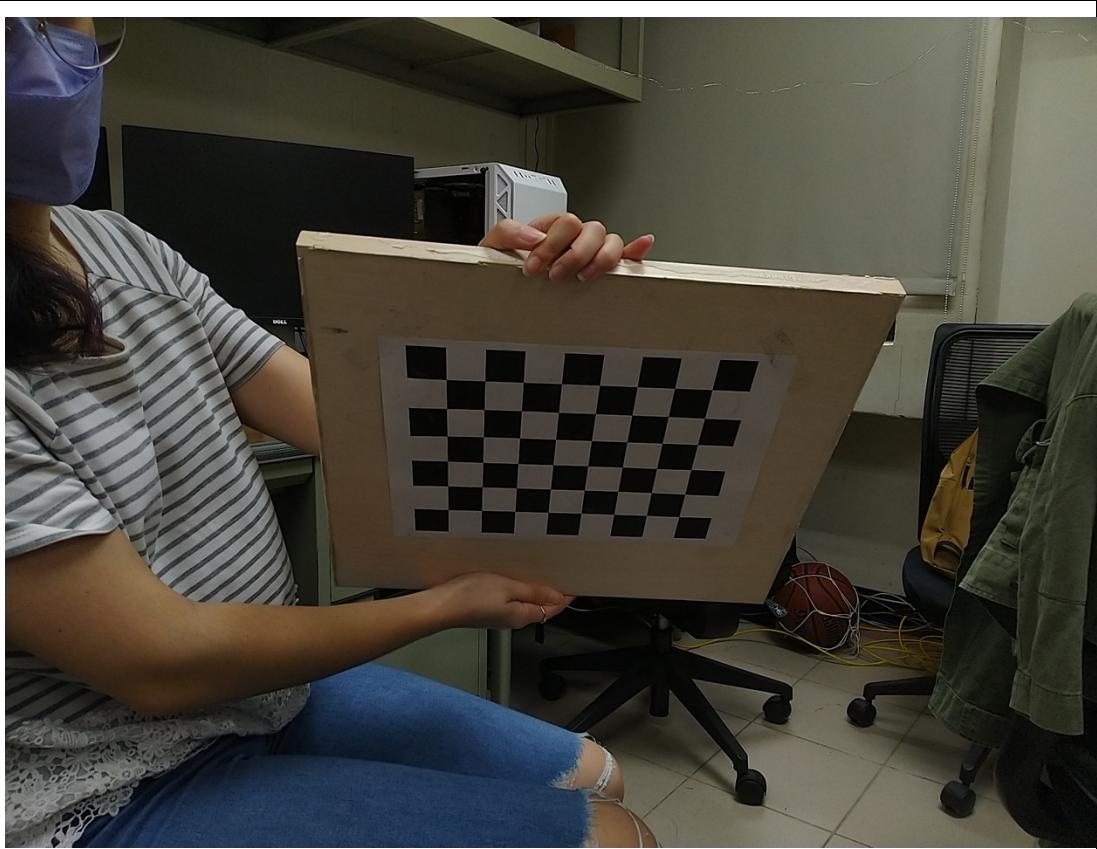


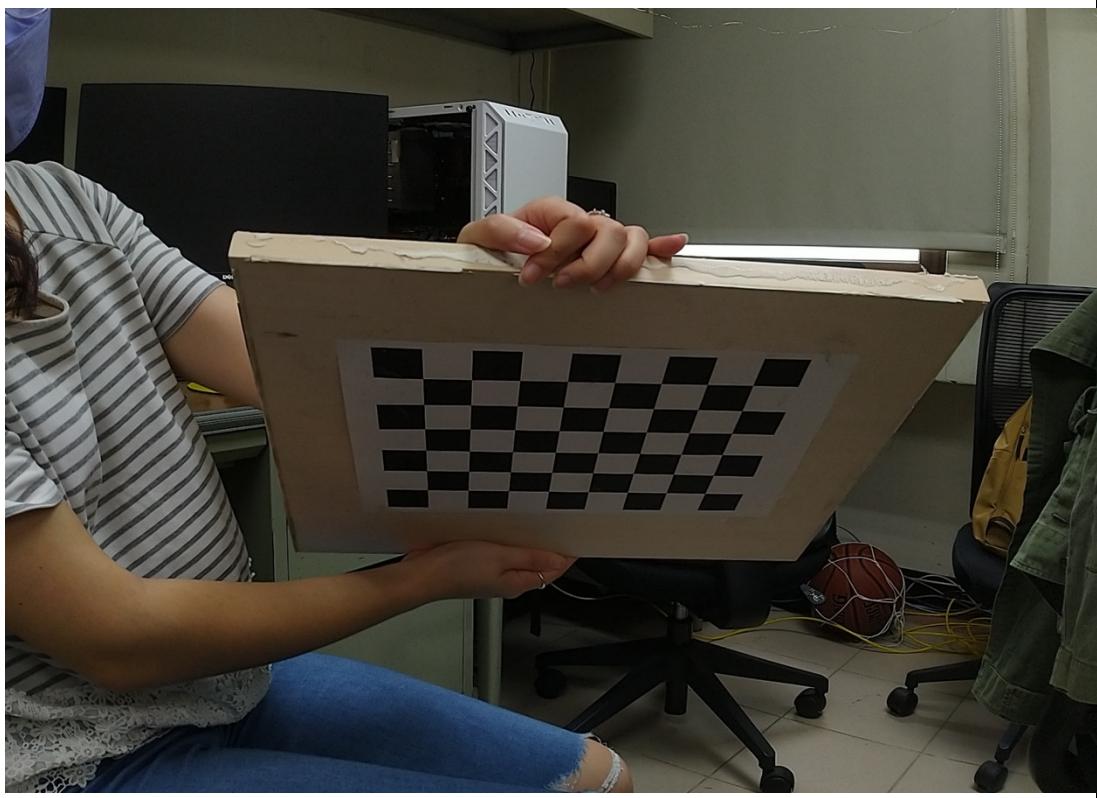
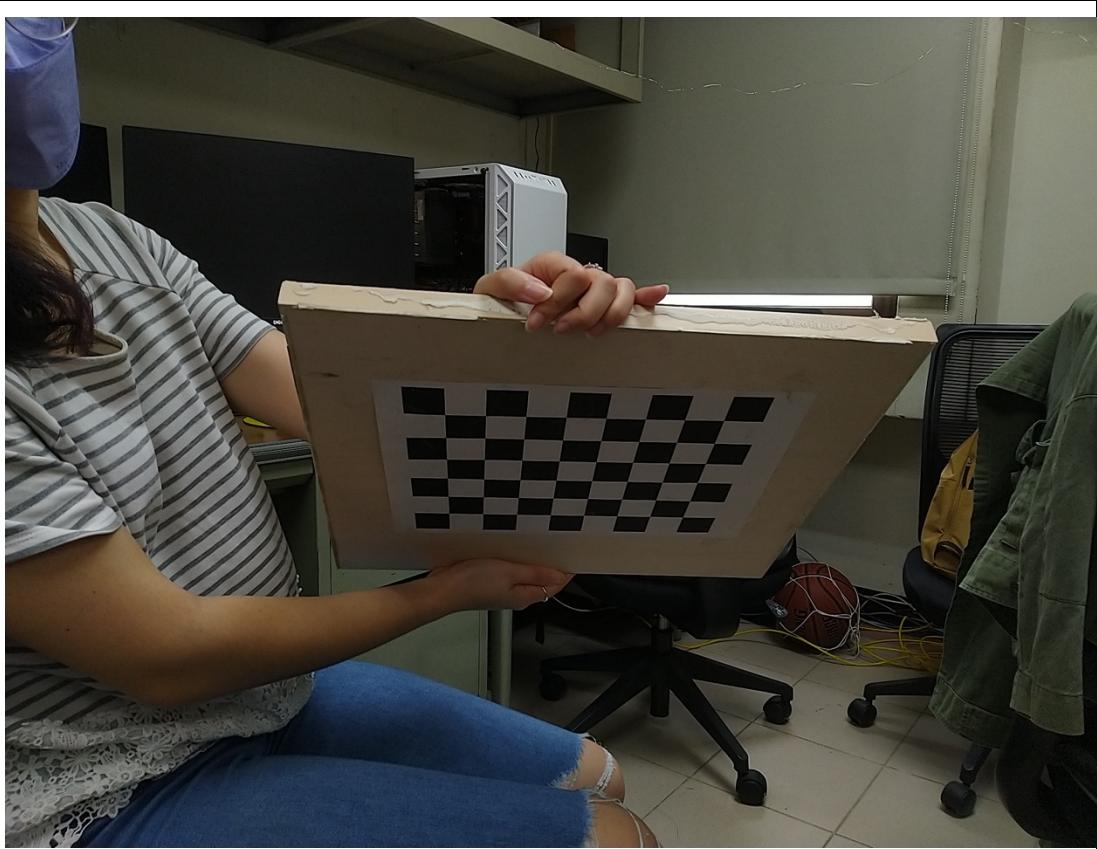


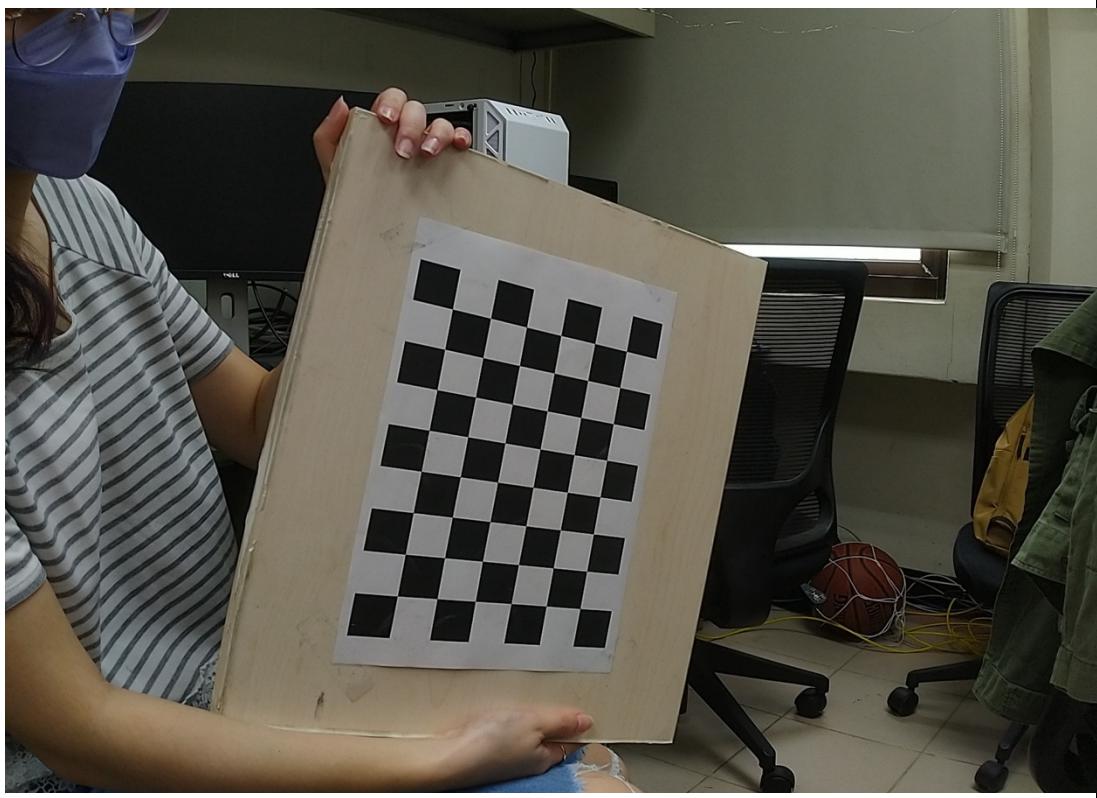
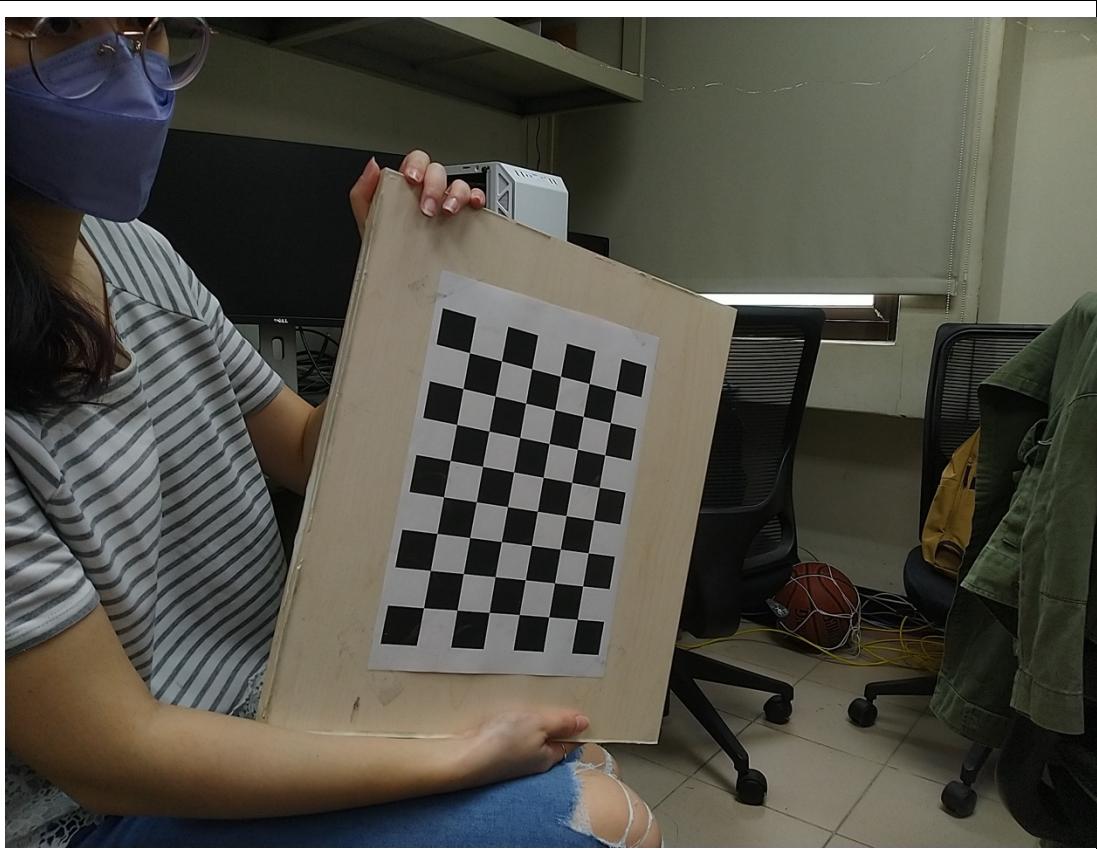


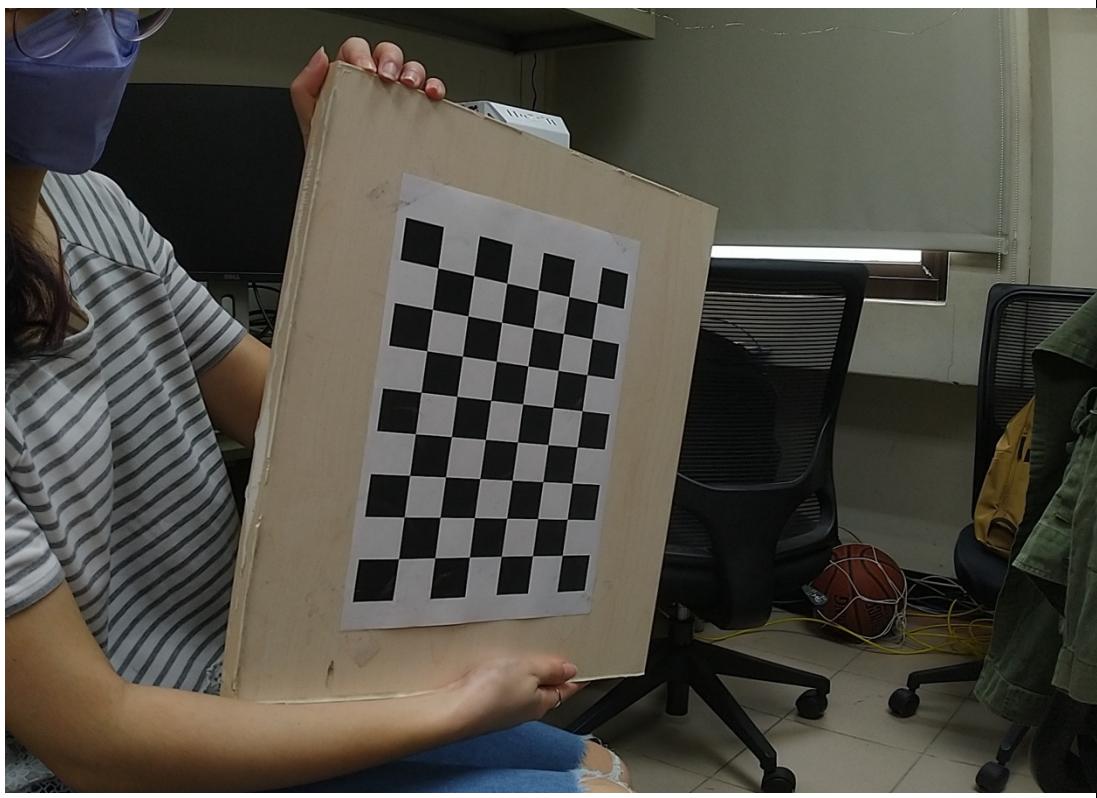


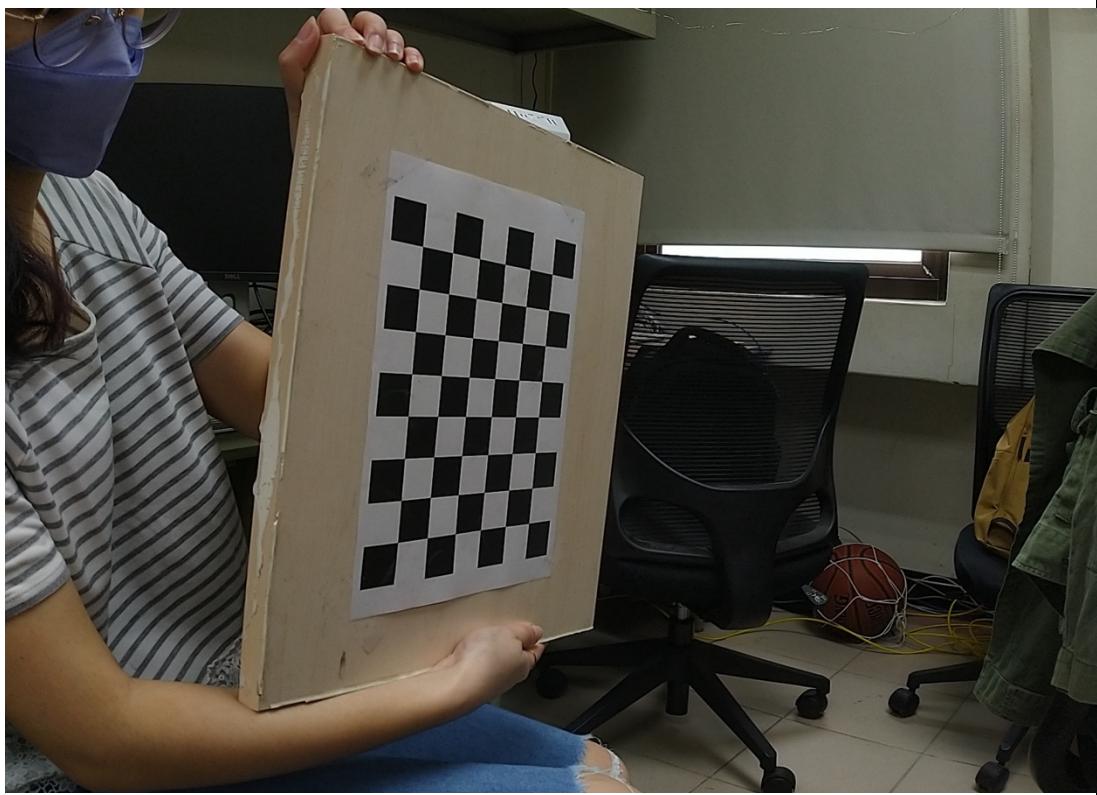


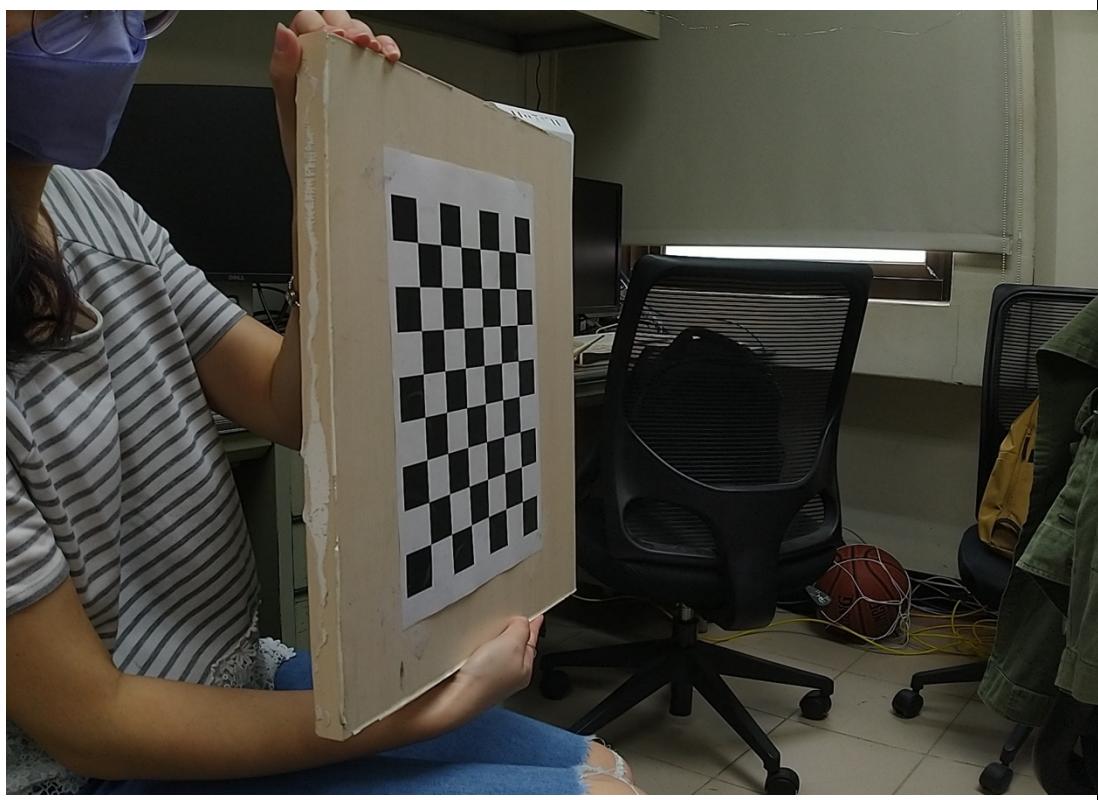
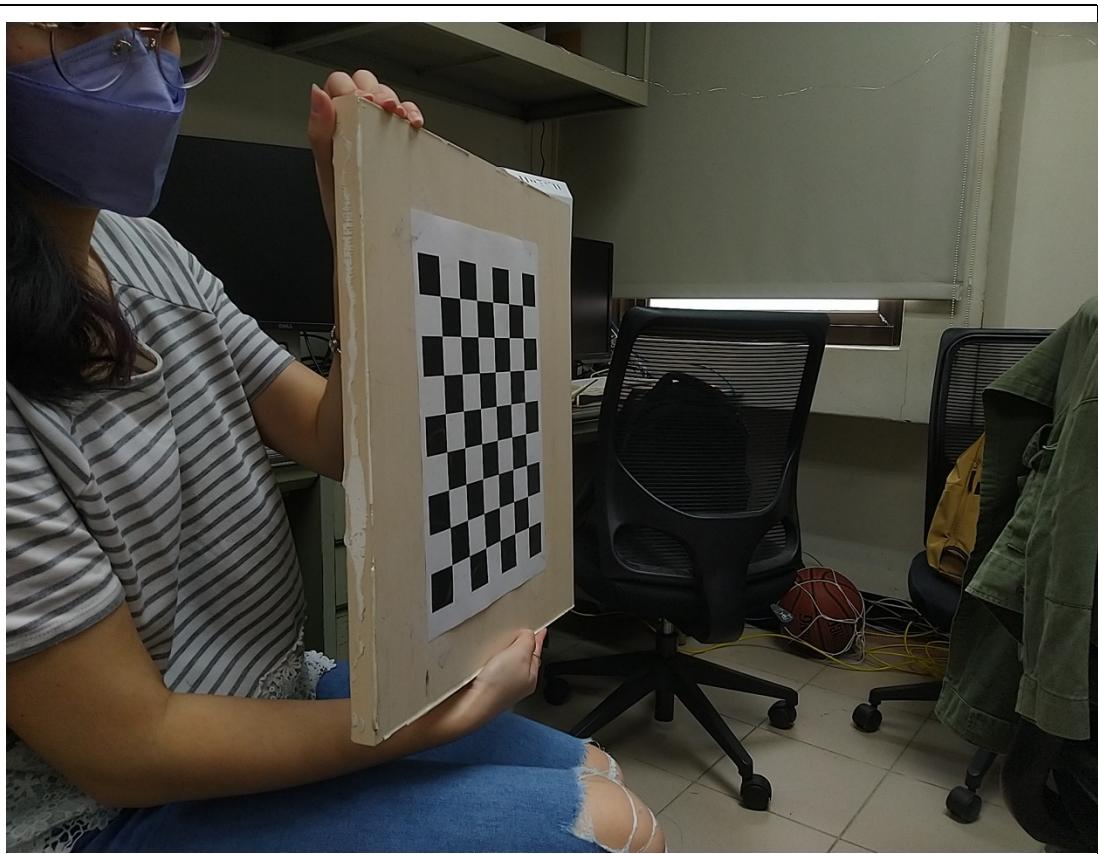


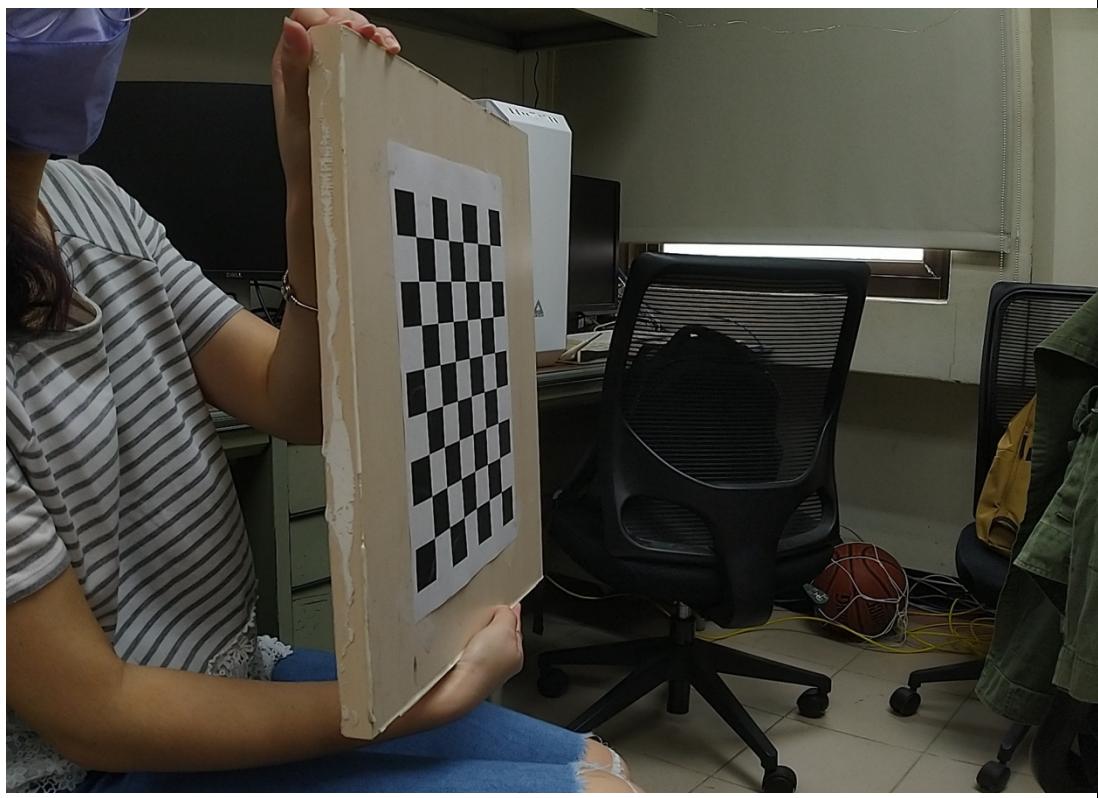


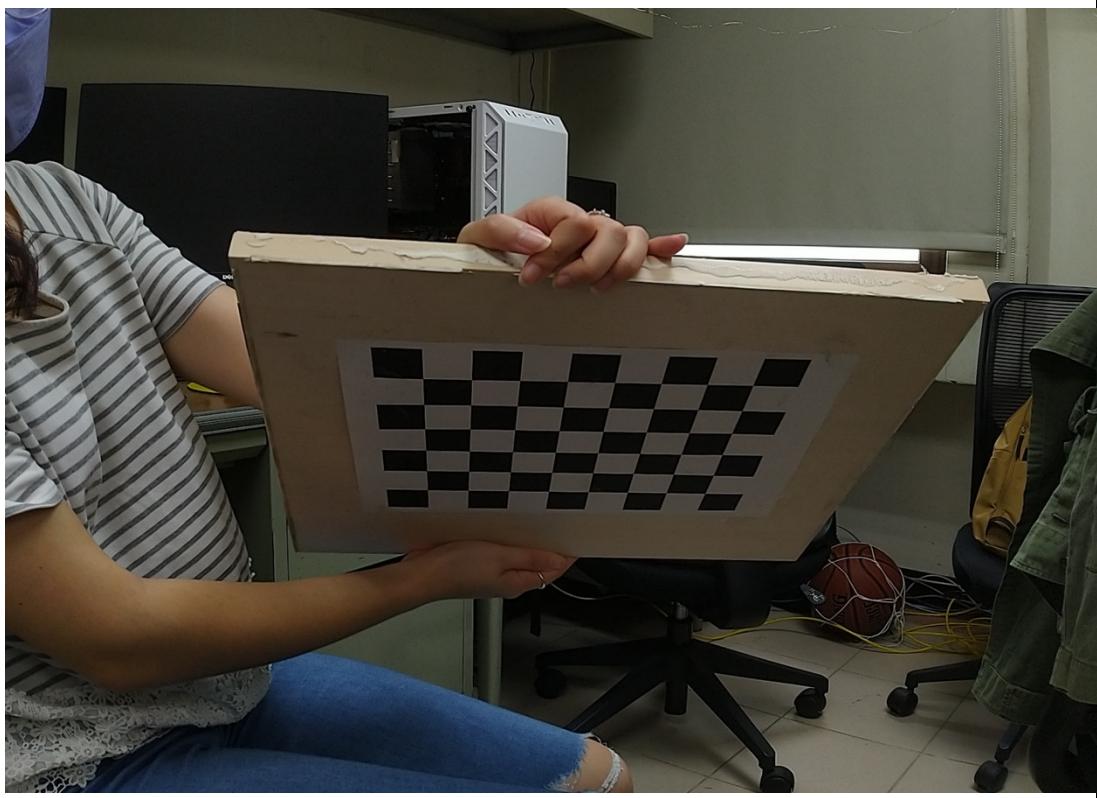
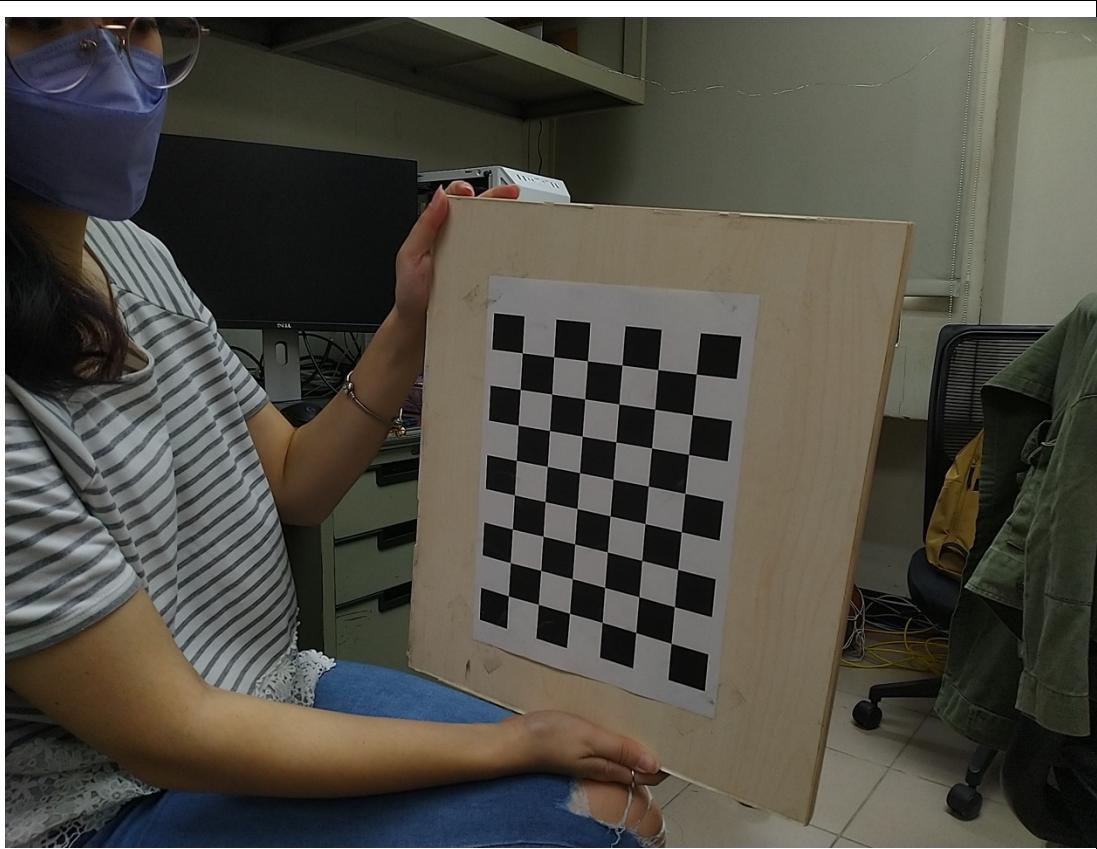


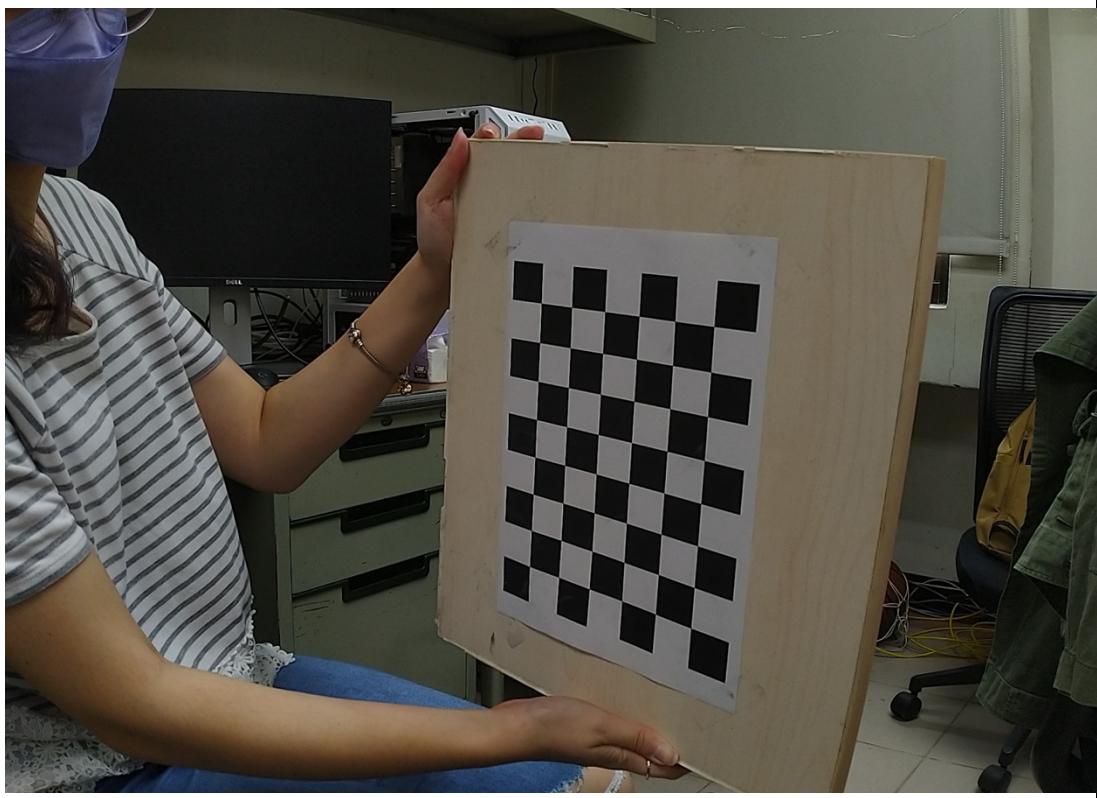
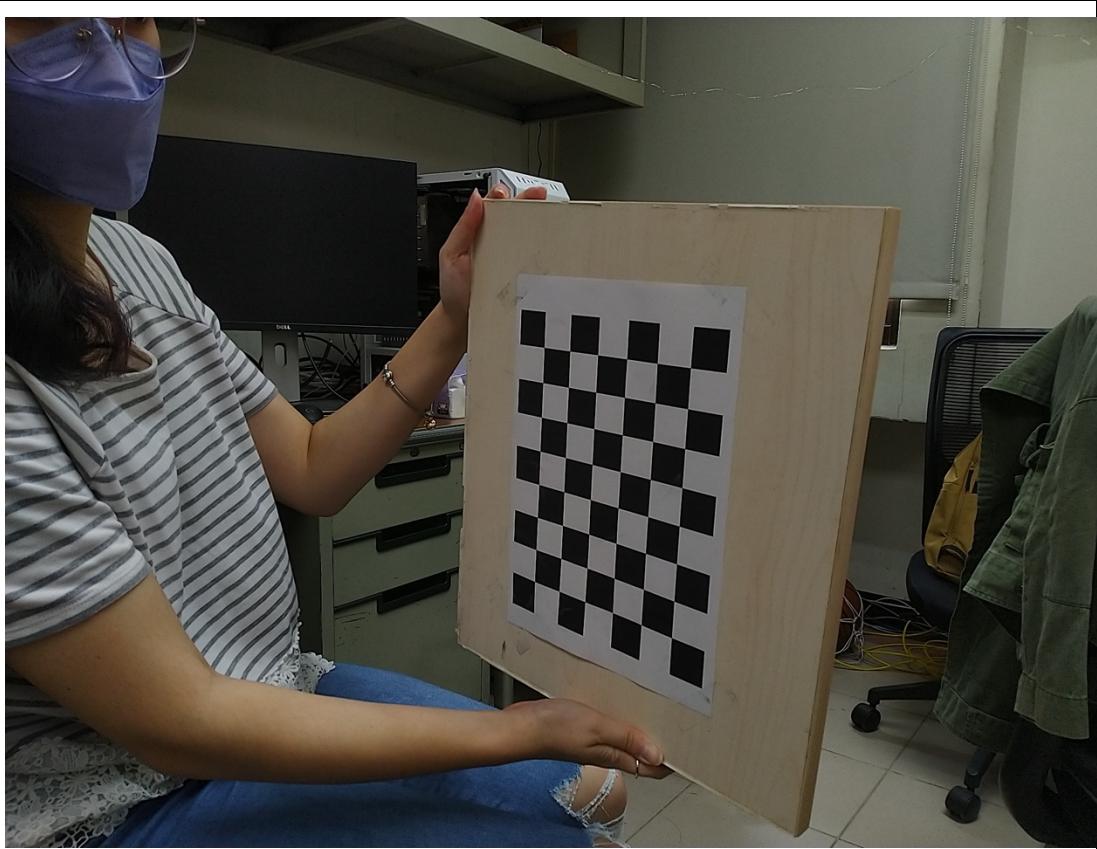


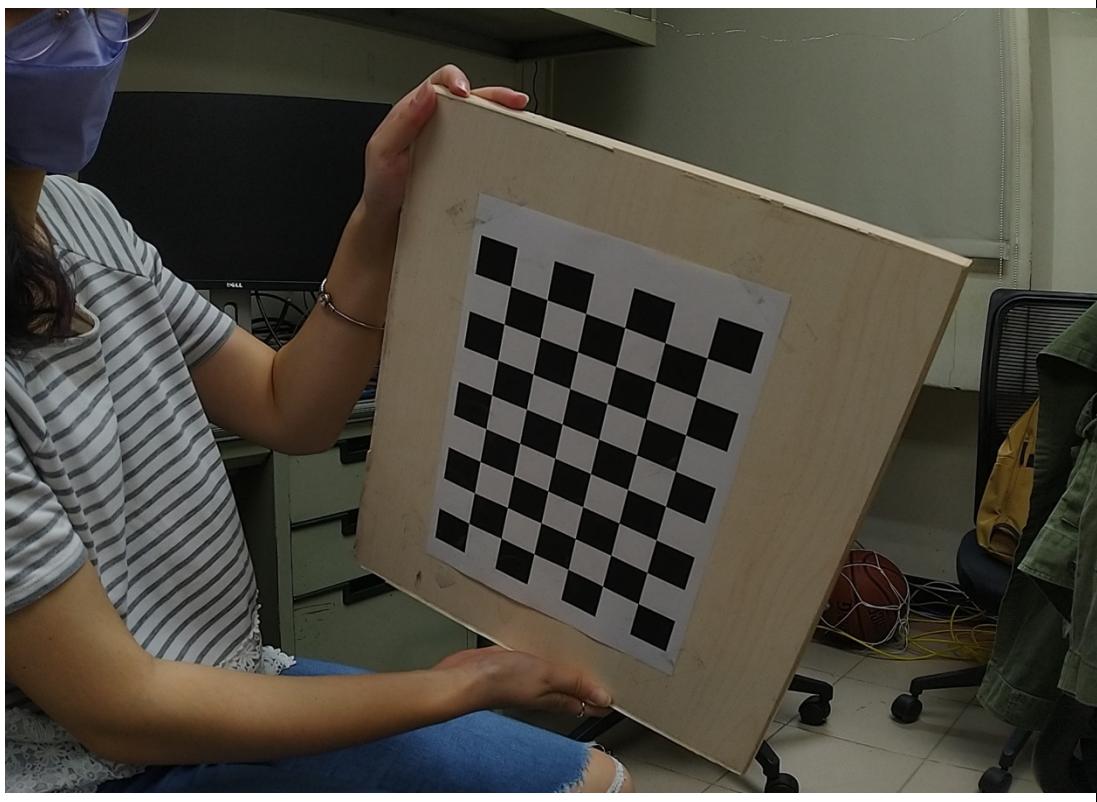
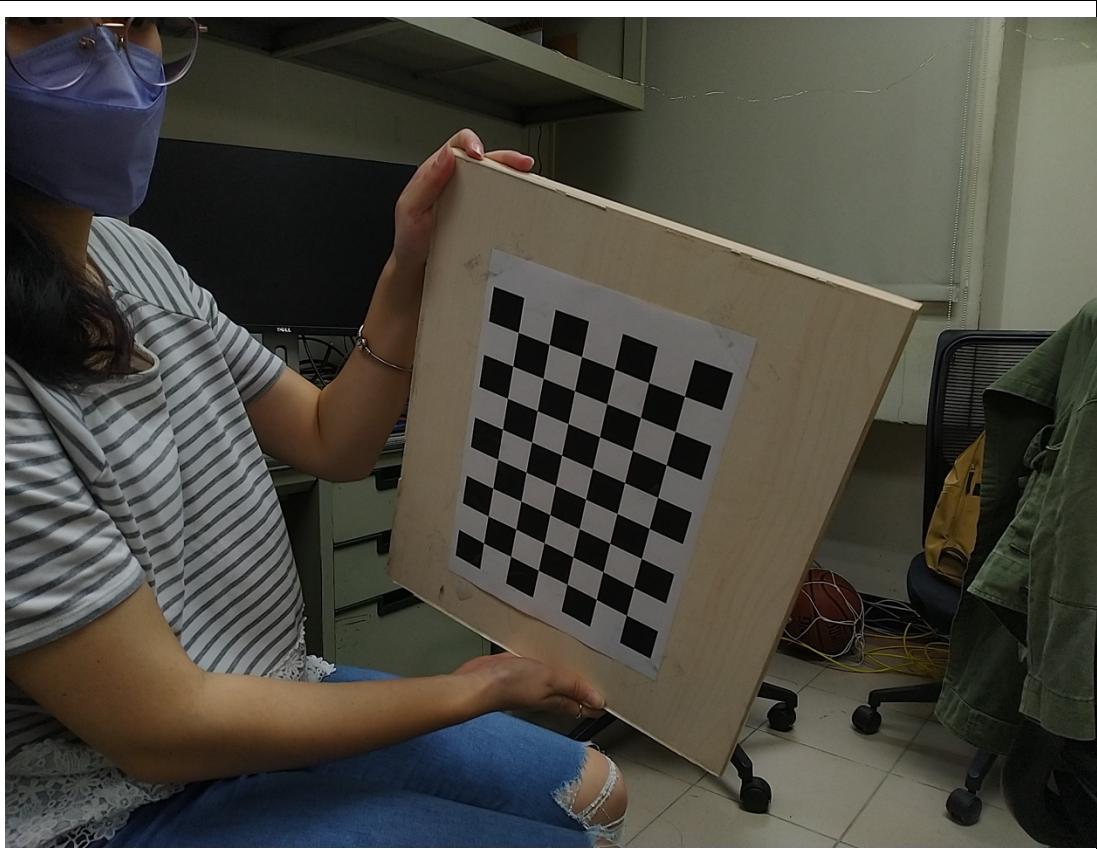


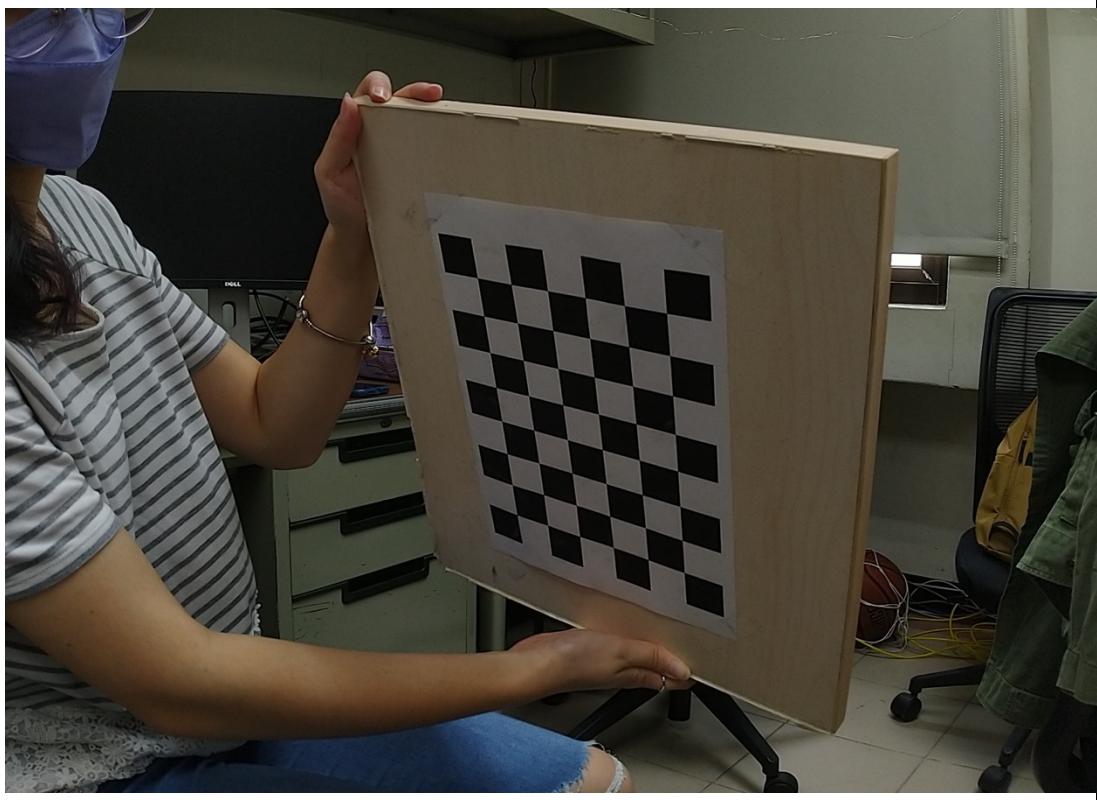
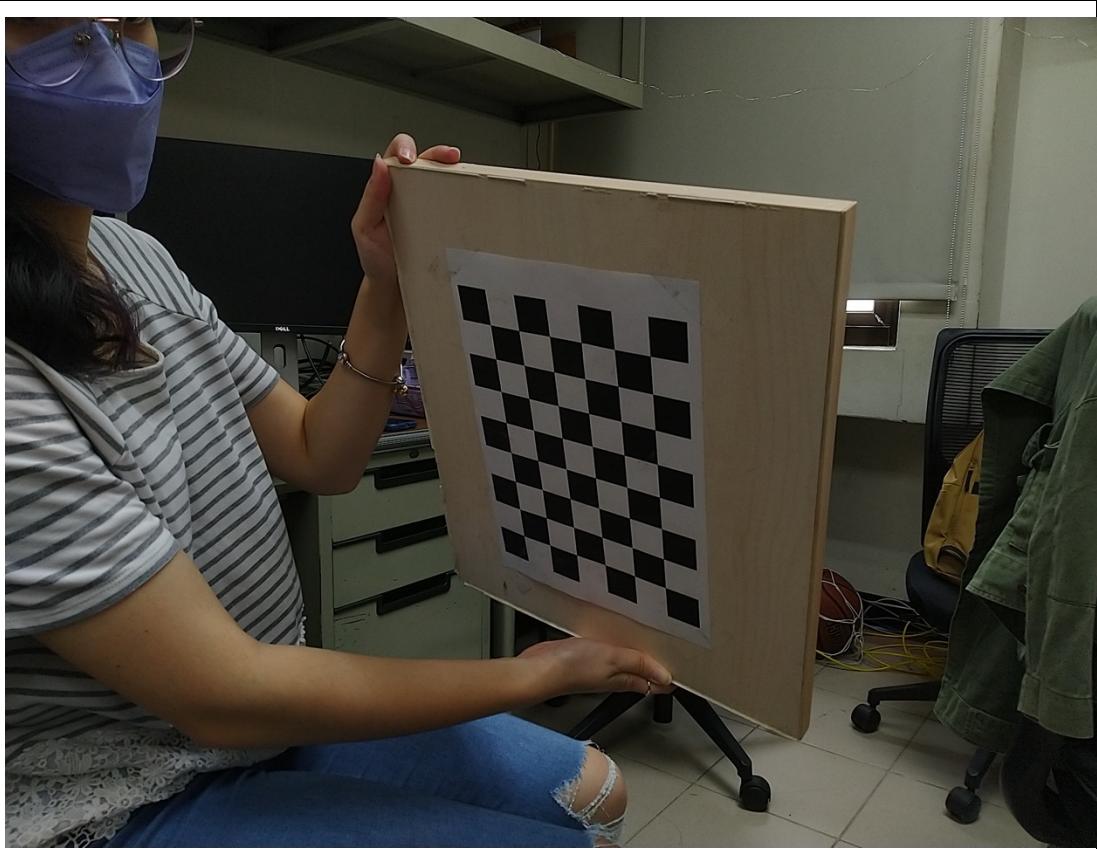


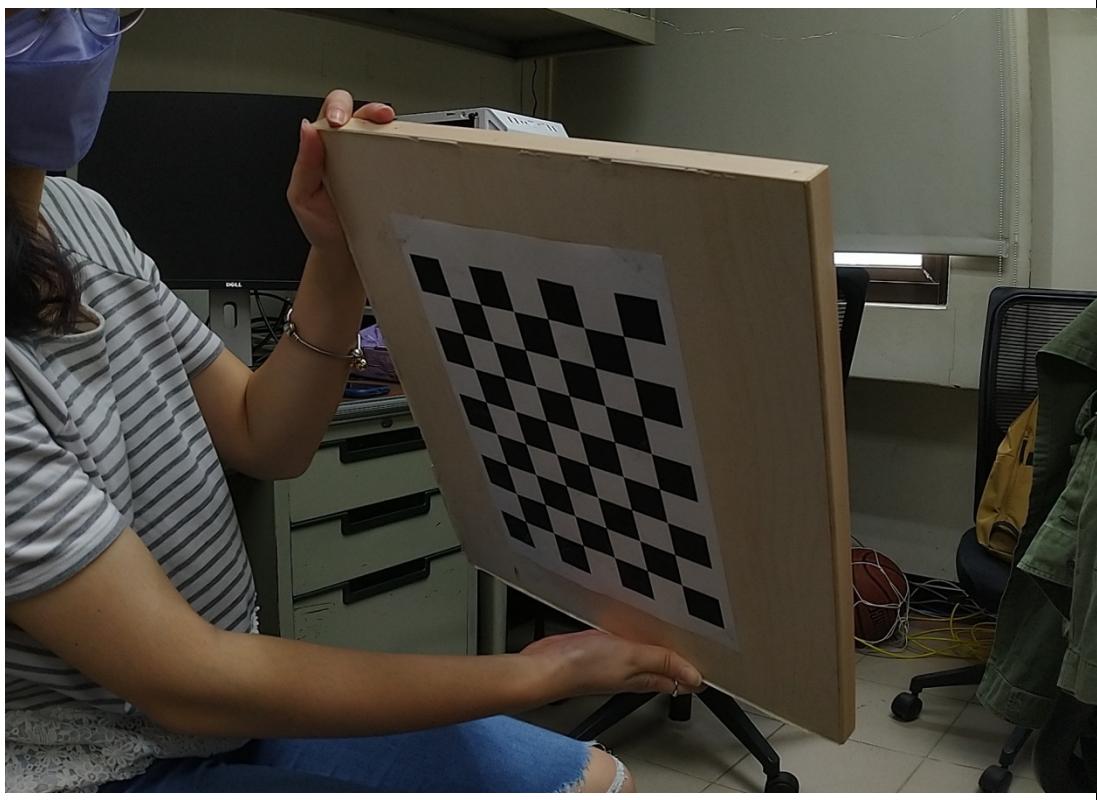
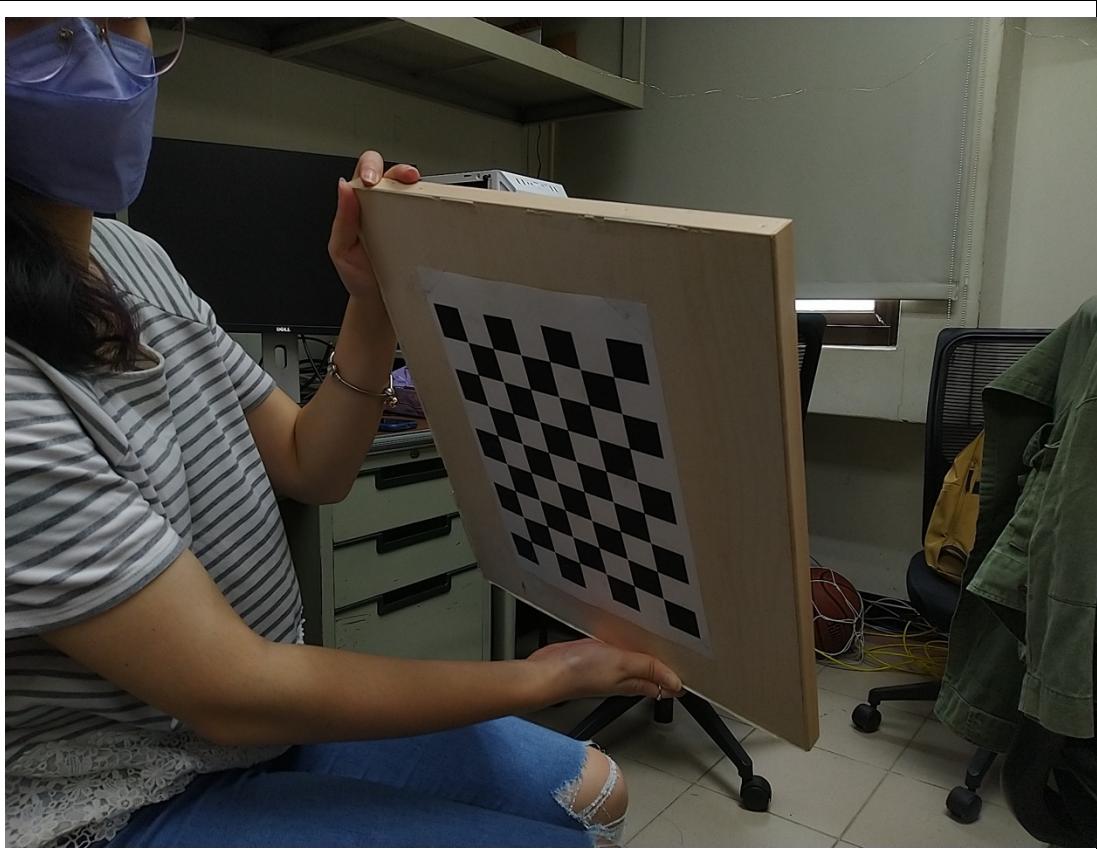


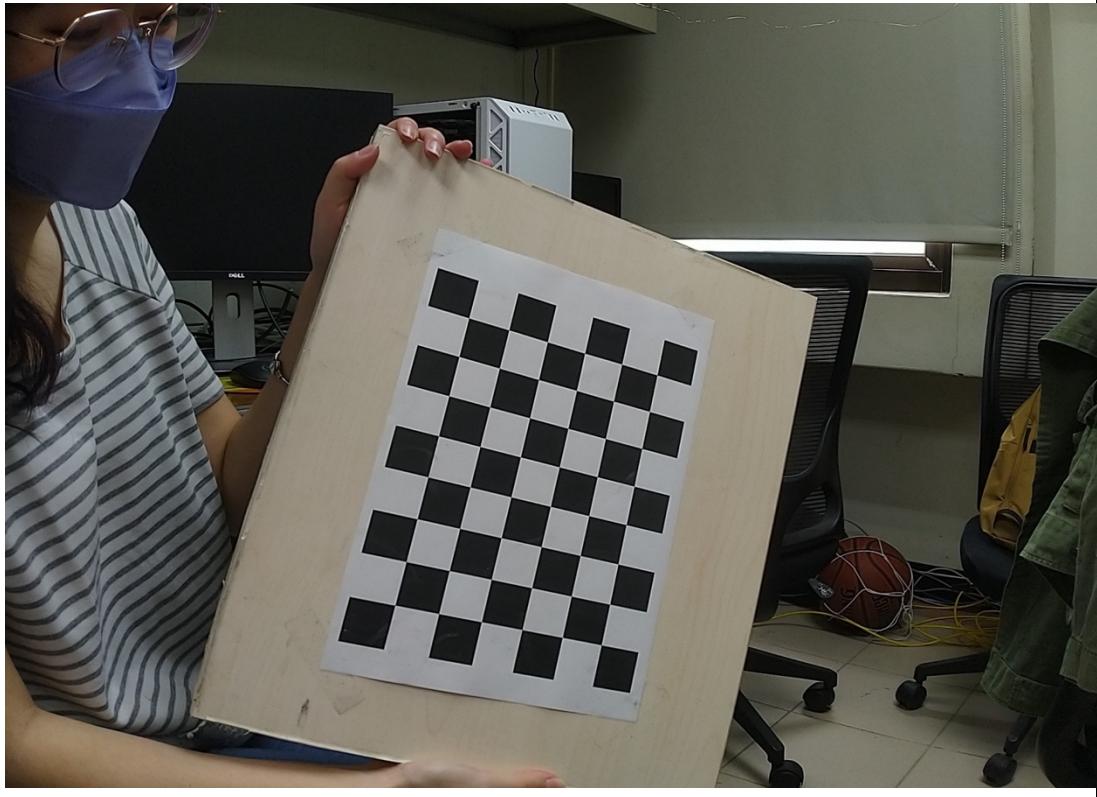
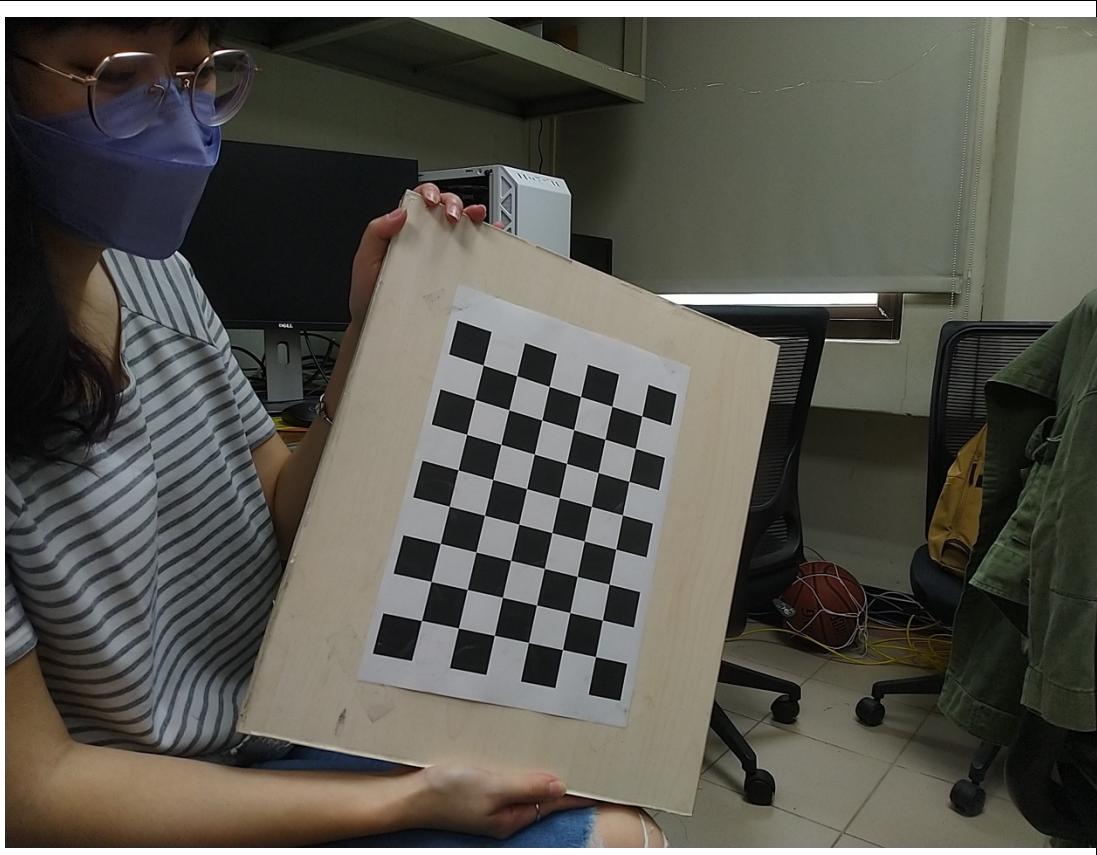


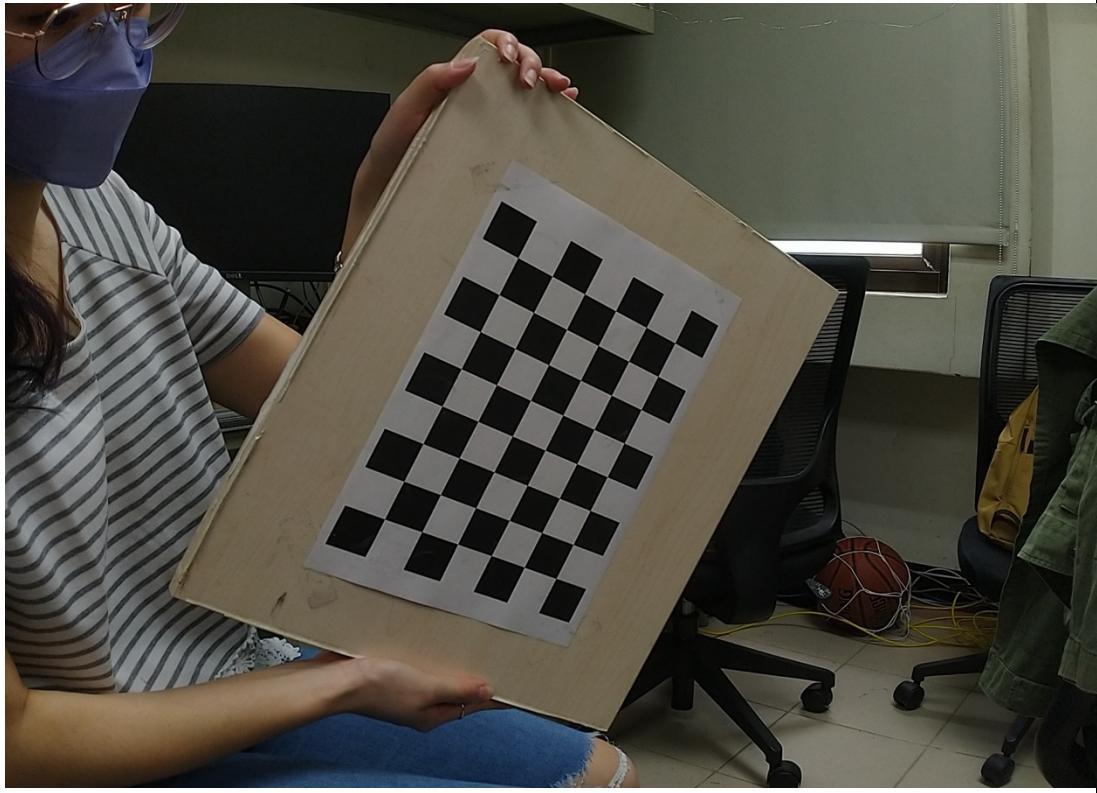
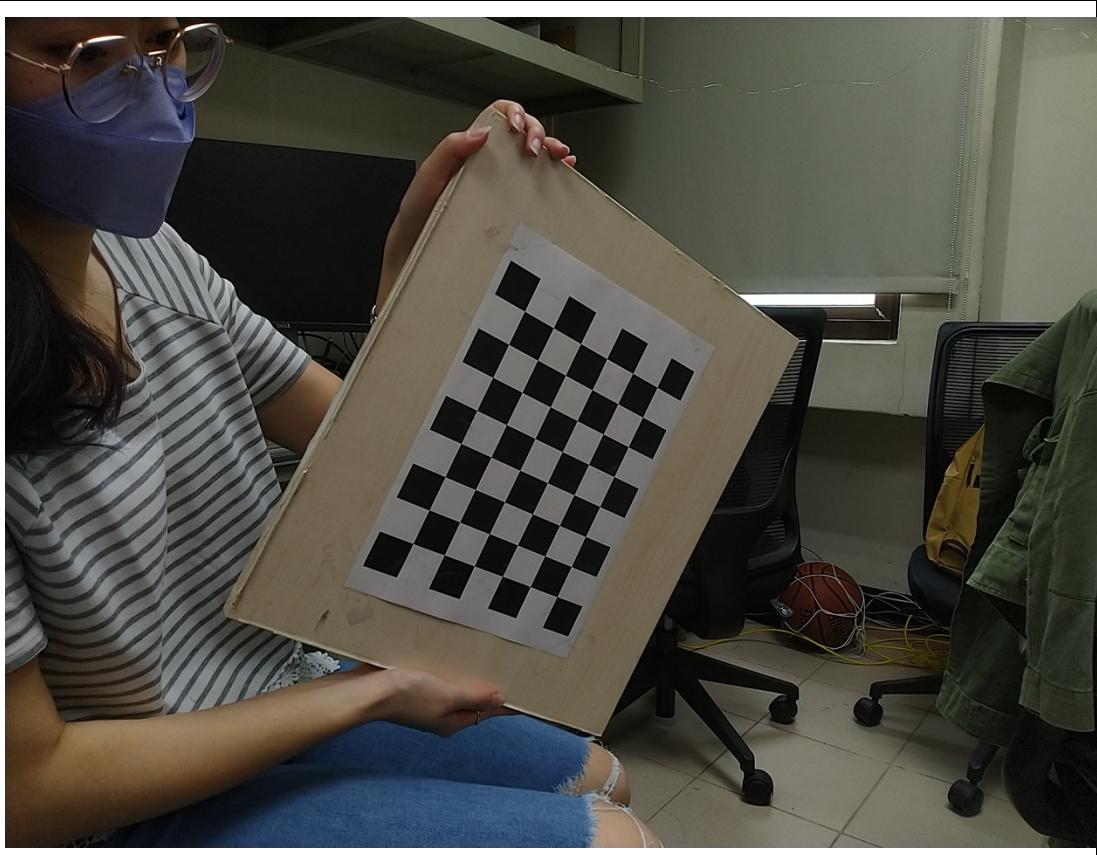














Effect:

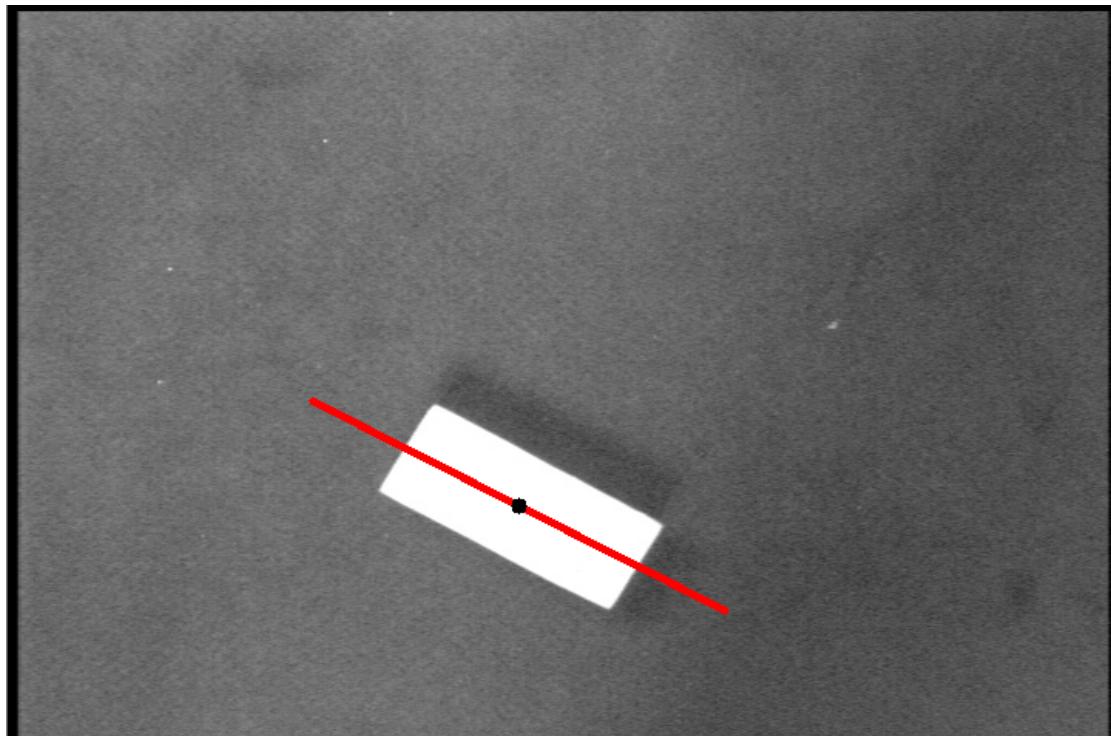
The straight line in physic may be not a straight line(curve line) in original picture.

After undistorting, however, the straight in physic will be straight line in picture

Part B

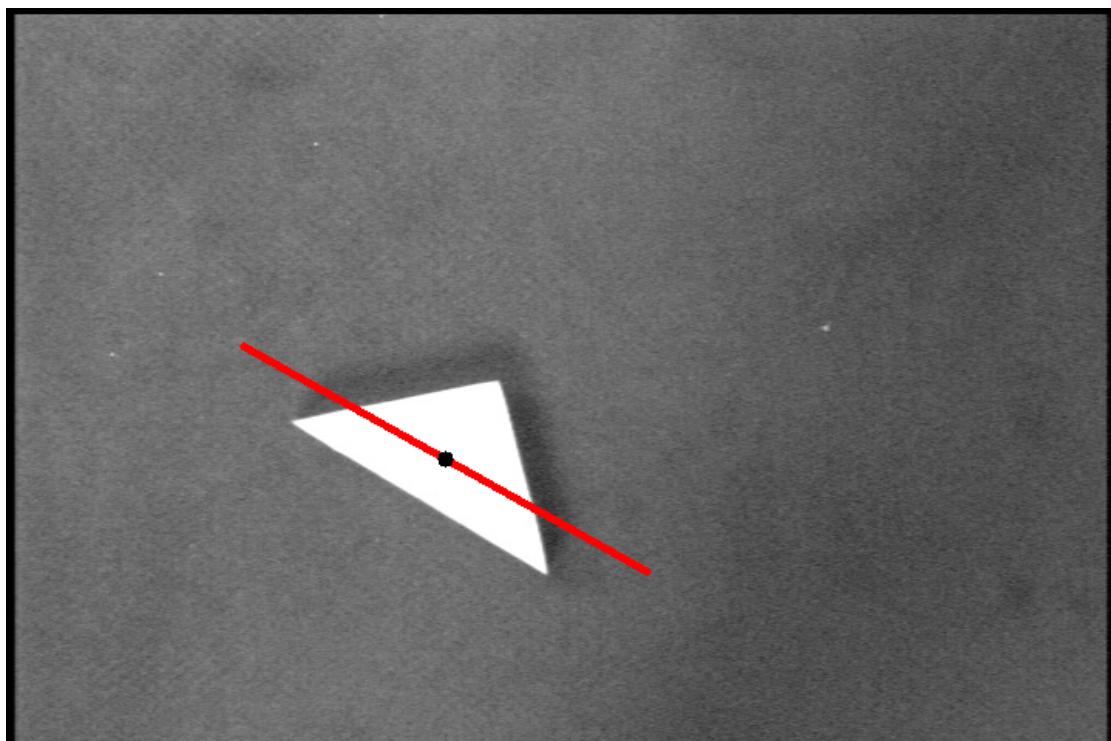
img/er7-1.jpg

centroid_x: 324.709, centroid_y: 331.772, principle_angle: 63.2087



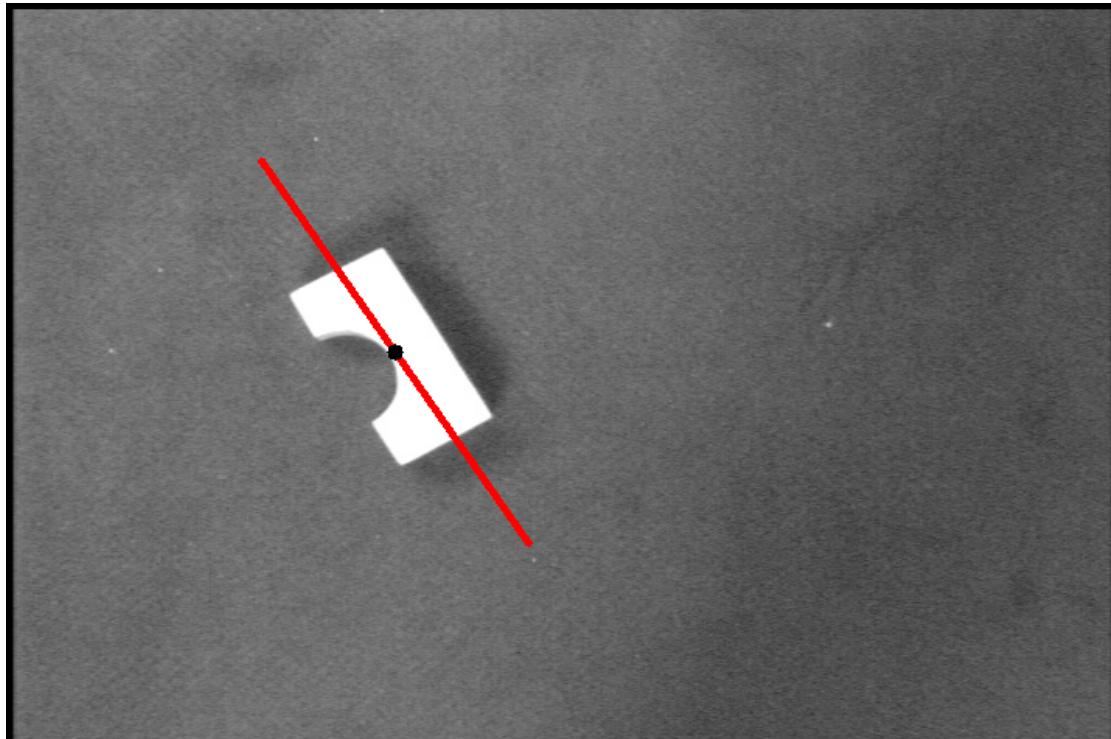
img/er7-2.jpg

centroid_x: 291.14, centroid_y: 285.138, principle_angle: 60.8036



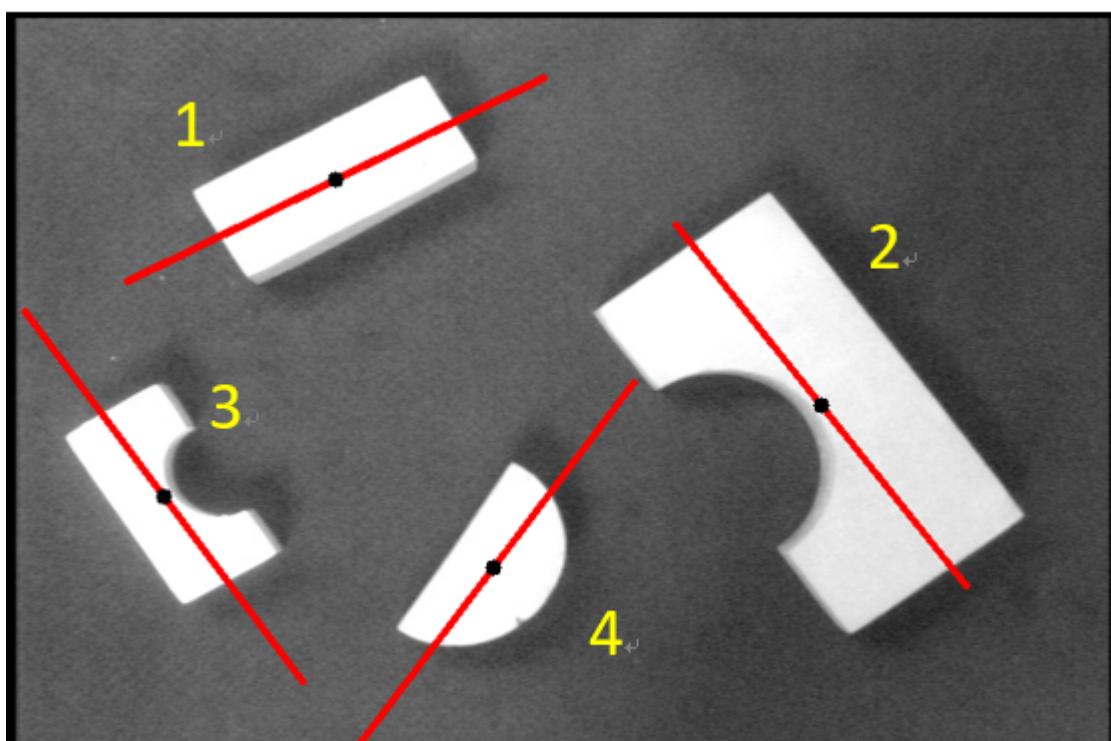
img/er7-3.jpg

centroid_x: 224.377, centroid_y: 252.898, principle_angle: 34.7456



img/er7-4.jpg

1. centroid_x: 108.126, centroid_y: 213.289, principle_angle: 116.034
2. centroid_x: 254.258, centroid_y: 527.219, principle_angle: 39.0362
3. centroid_x: 313.214, centroid_y: 102.766, principle_angle: 36.6835
4. centroid_x: 359.122, centroid_y: 315.382, principle_angle: 142.861



The division of work

	Part A	Part B
吳峻銘	✓	
謝賀淇	✓	
鄧遠祥		✓
張禾姈		✓