Problem4

1. The Intrinsic Parameters of My Camera

In the first step, I calibrate my camera with 20 photos.

```
# Camera intrinsic parameter calibration
import cv2
import numpy as np
import glob

def calibrateCamera(calibrationImagesPath):
    # Set the size of the chessboard
    chessboardSize = (9, 6)
    # Prepare 3D points of the chessboard
    objP = np.zeros((chessboardSize[0] * chessboardSize[1], 3), np.float32)
    objP[:, :2] = np.mgrid[0:chessboardSize[0], 0:chessboardSize[1]].T.reshape(-1, 2)

    # Store 3D points and 2D points of all images
    objPoints = []  # 3D points
    imgPoints = []  # 2D points

    # Read all calibration images
    images = glob.glob(calibrationImagesPath + '/*.jpg')

    for fName in images:
        img = cv2.imread(fName)
        gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)

        # Find chessboard corners
        ret, corners = cv2.findChessboardCorners(gray, chessboardSize, None)

        if ret:
            objPoints.append(objP)
            imgPoints.append(corners)

            # Visualize corners
            cv2.drawChessboardCorners(img, chessboardSize, corners, ret)
            cv2.imshow('img', img)
            cv2.waitKey(100)

    cv2.destroyAllWindows()

    # Calibrate the camera
    ret, cameraMatrix, distCoeffs, rvecs, tvecs = cv2.calibrateCamera(objPoints, imgPoints,
gray.shape[::-1], None, None)
```

```
    return cameraMatrix, distCoeffs

# Use the function
calibrationImagesPath = 'calibration'
cameraMatrix, distCoeffs = calibrateCamera(calibrationImagesPath)

print("Camera intrinsic matrix:\n", cameraMatrix)
print("Distortion coefficients:\n", distCoeffs)
```

The output is:

```
Camera intrinsic matrix:
 [[3.21213568e+03 0.00000000e+00 2.04268063e+03]
 [0.00000000e+00 3.20530786e+03 1.51530661e+03]
 [0.00000000e+00 0.00000000e+00 1.00000000e+00]]
Distortion coefficients:
 [[ 8.96554632e-02 -5.57785523e-01  1.96391705e-03  1.07377332e-03  1.10837801e+00]]
```

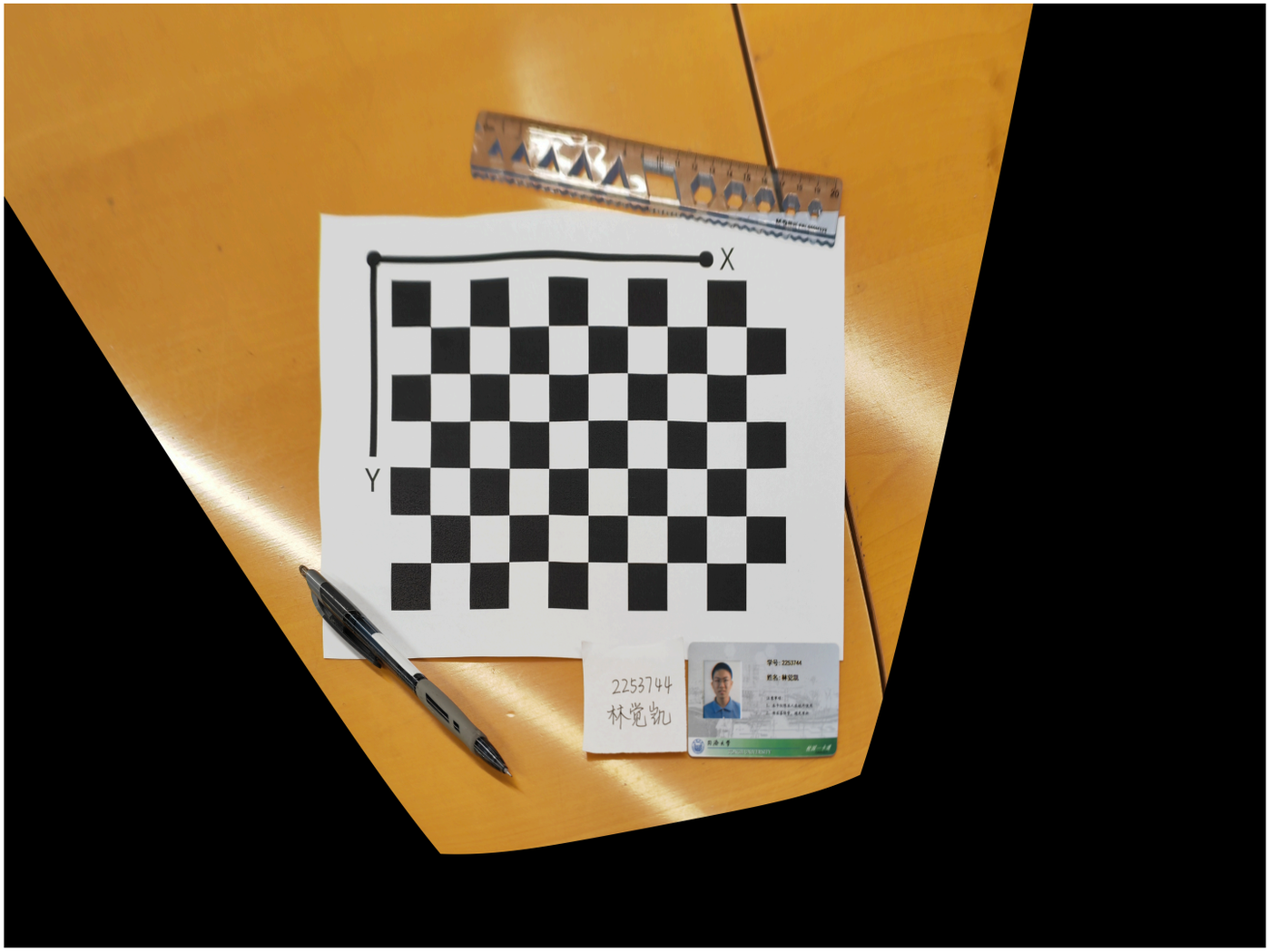
So the intrinsic parameters of my camera is:

$$K = \begin{bmatrix} 3212.13568 & 0 & 2042.68063 \\ 0 & 3205.30786 & 1515.30661 \\ 0 & 0 & 1 \end{bmatrix}$$

$$D = [k_1 \quad k_2 \quad \rho_1 \quad \rho_2 \quad k_3] = [0.0896554632 \quad -0.557785523 \quad 0.00196391705 \quad 0.00107377332 \quad 1.10837801]$$

2. The Original Image

3. The Generated bird's-eye-view Image




```
import cv2
import numpy as np
from matplotlib import pyplot as plt

def generateBirdseyeView(inputImagePath, outputImagePath, cameraMatrix, distCoeffs):
    # Read the input image
    image = cv2.imread(inputImagePath)
    if image is None:
        print("Unable to read the input image. Please check the path.")
        return

    # Undistort the image
    h, w = image.shape[:2]
    imageUndistorted = cv2.undistort(image, cameraMatrix, distCoeffs, None)

    # Chessboard size
    chessboardSize = (9, 6)

    # Find chessboard corners
    gray = cv2.cvtColor(imageUndistorted, cv2.COLOR_BGR2GRAY)
    ret, corners = cv2.findChessboardCorners(gray, chessboardSize, None)

    if not ret:
```

```
        print("Failed to find chessboard corners, please check the input image.")
        return

    # Use the four corners of the chessboard as source points
    srcPoints = np.float32([corners[0], corners[chessboardSize[0]-1],
                            corners[-chessboardSize[0]], corners[-1]])

    # Adjust destination points to keep the top-left corner in the original position
    leftTop = corners[0].ravel() * 4
    dstPoints = np.float32([leftTop,
                            [leftTop[0] + w, leftTop[1]],
                            [leftTop[0], leftTop[1] + h],
                            [leftTop[0] + w, leftTop[1] + h]])

    # Compute the homography matrix and apply perspective transformation
    H = cv2.getPerspectiveTransform(srcPoints, dstPoints)
    print("Homography matrix:\n", H)  # Output the homography matrix
    birdImage = cv2.warpPerspective(imageUndistorted, H, (w*4, h*4))

    # Save the bird's-eye view image
    cv2.imwrite(outputImagePath, birdImage)

    # Display the original and bird's-eye view images
    plt.figure(figsize=(10, 5))
    plt.subplot(1, 2, 1)
    plt.title('Original Image')
    plt.imshow(cv2.cvtColor(imageUndistorted, cv2.COLOR_BGR2RGB))
    plt.axis('off')

    plt.subplot(1, 2, 2)
    plt.title('Bird\'s-eye View')
    plt.imshow(cv2.cvtColor(birdImage, cv2.COLOR_BGR2RGB))
    plt.axis('off')

    plt.show()

# Use the function
inputImagePath = 'birdview/input.jpg'
outputImagePath = 'birdview/output.jpg'
generateBirdseyeView(inputImagePath, outputImagePath, cameraMatrix, distCoeffs)
```

```
Homography matrix:
 [[ 7.71717730e+00  1.17953429e+01 -9.65974598e+03]
 [-2.56002703e-01  2.13743306e+01 -1.19289641e+04]
 [ 9.83385048e-05  1.22567548e-03  1.00000000e+00]]
```