電腦視覺與深度學習
(Computer Vision and Deep Learning)
Homework 1

有問題請在moodle討論

Office Hour: 14:00~16:00, Mon.

10:00~12:00, Thu.

At CSIE 9F Robotics Lab.

Notice (1/2)

- Copying homework is strictly prohibited!! Penalty: Both individuals will receive a score of 0!!
- Due date => 09:00:00, 2024/11/08 (Fri.)

  Do not submit late, or the following points will be deducted:
  - Submit within seven days after the deadline, and your score will be reduced by half.
  - If you submit after this period, you will receive a score of 0.
- You must attend the demonstration, otherwise your score will be 0. The demonstration schedule will be announced on NCKU Moodle.
- You must create GUI, otherwise your point will be deducted.
- Upload to => 140.116.154.28 -> Upload/Homework/Hw1
  - User ID: cvdl2024 Password: RL2024cvdl
- Format
  - Filename: Hw1_Q1_StudentID_Name_Version.rar
    - Ex: Hw1_Q1_F71234567_林小明_V1.rar
    - If you want to update your file, you should update your version to be V2,
    - Ex: Hw1_Q1_F71234567_林小明_V2.rar
  - Content: Project folder *(Excluding the pictures)

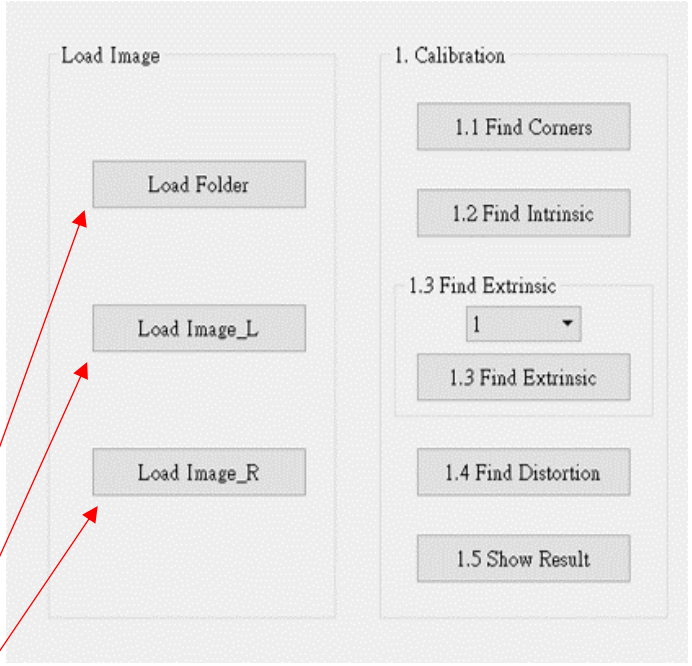
    *Note: Remove your “Debug” folder to reduce file size.

Notice (2/2)

- Python (recommended):
  - **Python 3.8**
  - **Opencv-contrib-python (4.10.0)**
  - **UI framework: pyqt5 (5.15.11)**

Assignment scoring (Total: 100%)

1. Camera Calibration (出題：Kerwin)
   - 1.1 Corner detection
   - 1.2 Find the intrinsic matrix
   - 1.3 Find the extrinsic matrix
   - 1.4 Find the distortion matrix
   - 1.5 Show the undistorted result
2. Augmented Reality (出題：Yiyu)
   - 2.1 Show words on board
   - 2.2 Show words vertically
3. Stereo Disparity Map (出題： Tien)
   - 3.1 Stereo Disparity Map
4. SIFT
   - 4.1 Keypoints (出題： Ian)
   - 4.2 Matched Keypoints

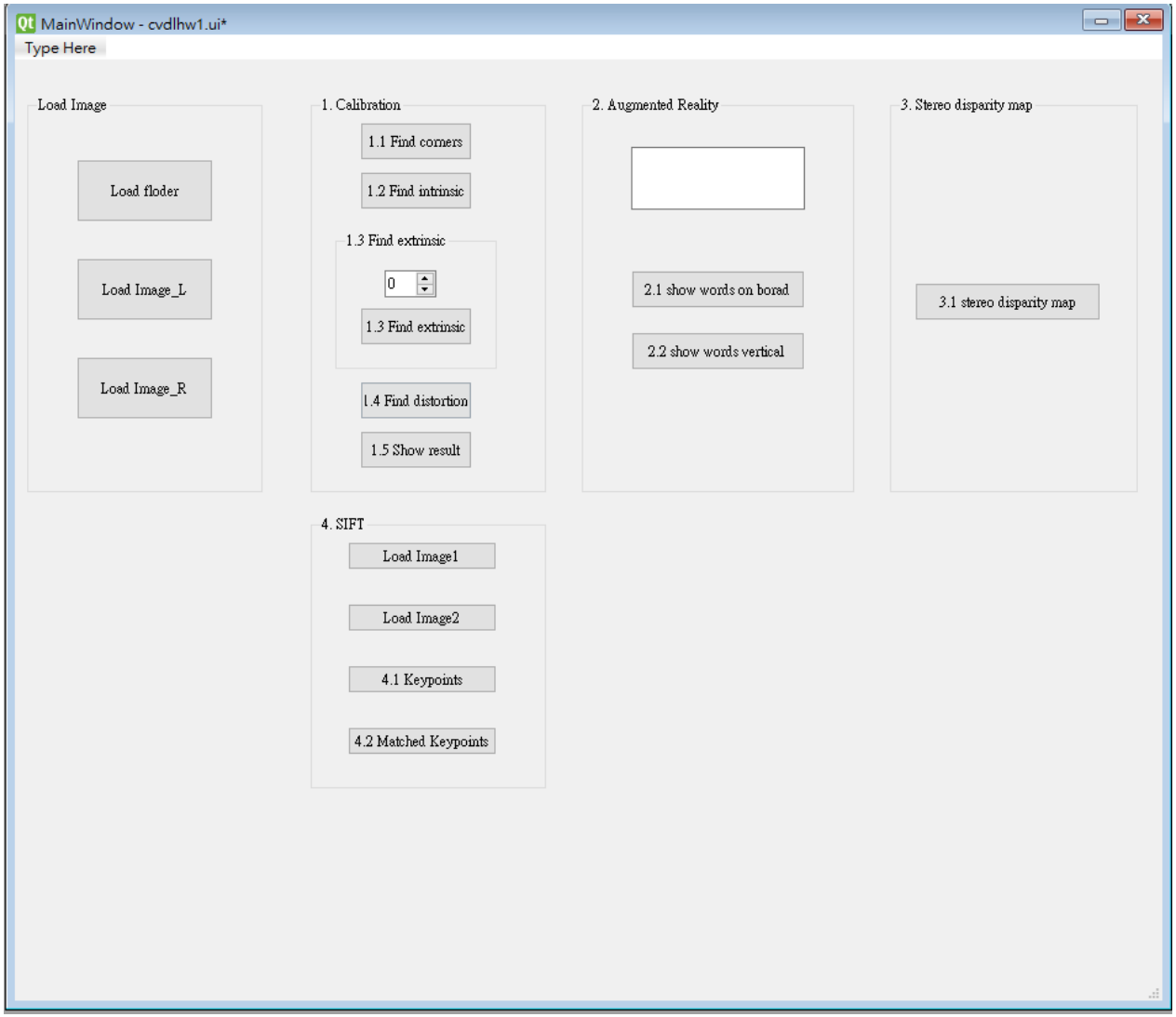


* Don’t fix your image path
  (There is another dataset for demonstration)

Load image please use the following function to read the path.
QFileDialog.getOpenFileName

Assignment scoring (Total: 100%)

- Use one UI to present 4 questions.



1. Camera Calibration

(出題： Kerwin)

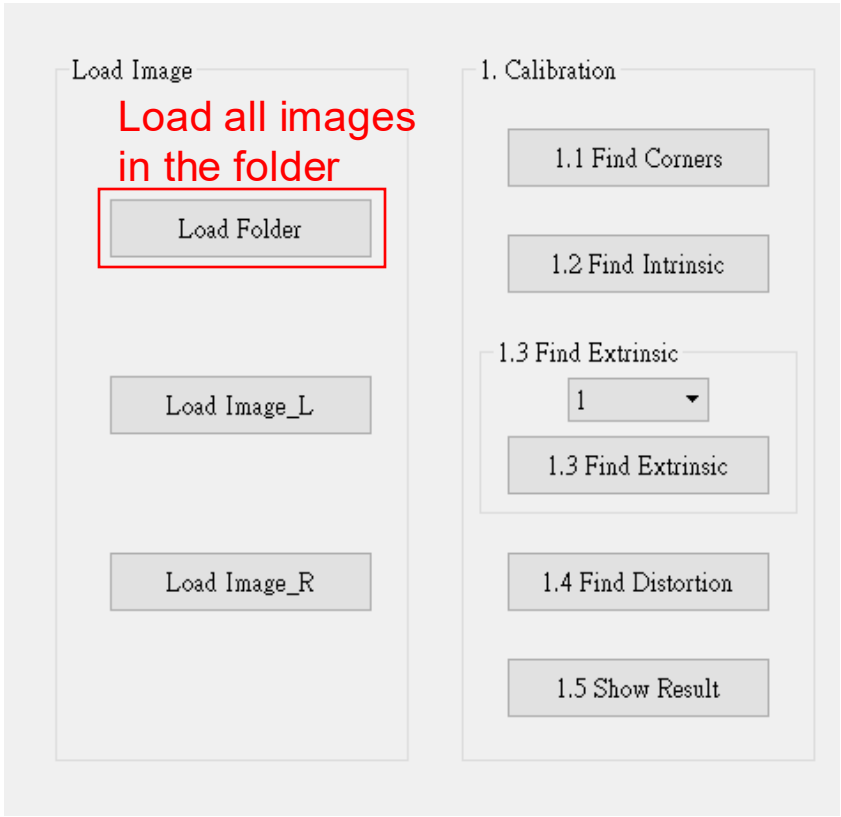
1.1 Corner detection

1.2 Find the intrinsic matrix K

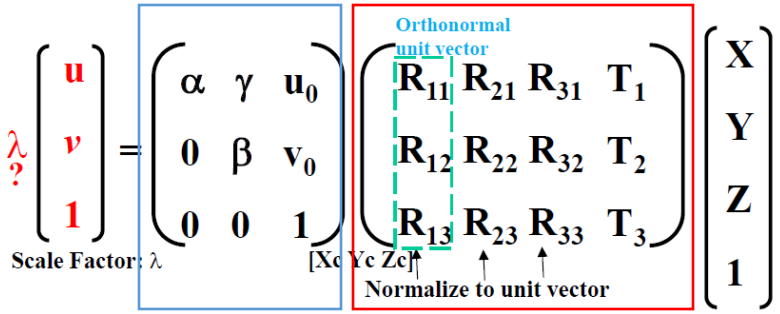
1.3 Find the extrinsic matrix $[R, T]$

1.4 Find the distortion matrix D

1.5 Show the undistorted result



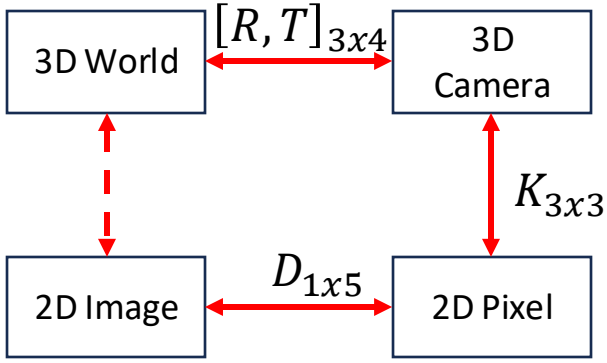
$[R, T]_{3x4}$:
Extrinsic Matrix



K_{3x3}: Intrinsic Matrix

$$D_{1x5} = [k_1, k_2, p_1, p_2, k_3]$$

D_{1x5}: Distortion Matrix



1.1 Corner Detection

(出題： Kerwin)

grayimg: input image. (2048x2048)
(width, high): width and high of corner in chessboard (11x8)
corners: corners points (1x2) on chessboard in image coord.

- Given: 15 images, 1.bmp ~ 15.bmp
- Q1:

1) Find and draw the corners on the chessboard for each image.

ret, corners (O/P) = cv2.findChessboardCorners(grayimg (I/P), (width, high) (I/P)) ➔ in order to detect the corner of chessboard.

corners (O/P) = cv2.cornerSubPix(grayimg (I/P), corners (I/P), winSize (I/P), zeroZone (I/P), criteria (I/P)) ➔ in order to increase accuracy.

winSize = (5, 5), the range of the search area near the corner point.
zeroZone = (-1, -1), window size prevent from focusing on edge of image, (-1, -1) means not to set a dead zone
criteria = (cv2.TERM_CRITERIA_MAX_ITER + cv2.TERM_CRITERIA_EPS, 30, 0.001), termination optimization criteria which is OpenCV recommend.

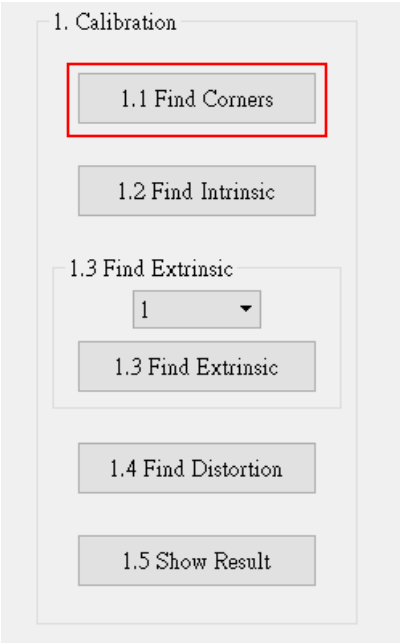
max iteration time

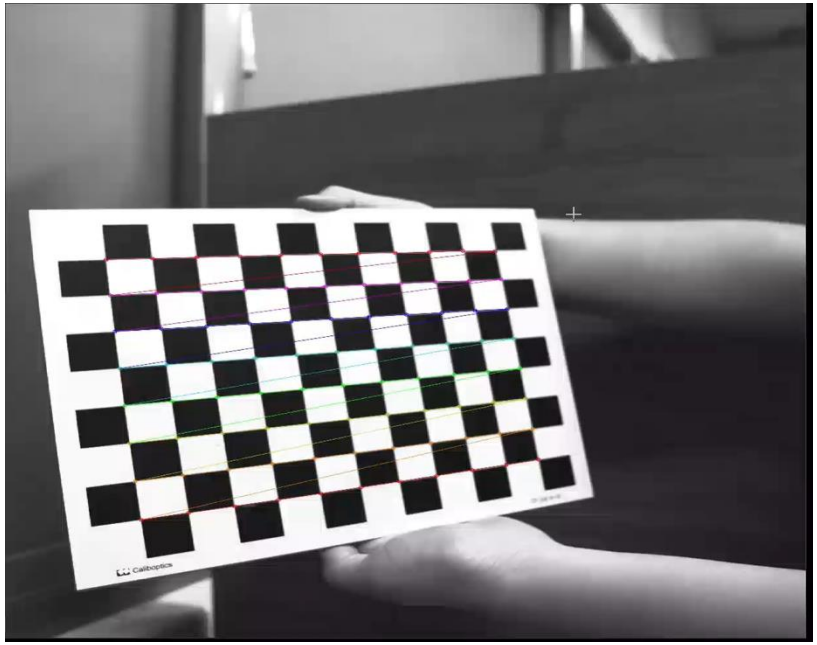
Precision of sliding window

2) Click button “1.1 Find Corners” to show each picture.

- Hint:

OpenCV Textbook Chapter 11 (p. 398 ~ p. 399)





1.2 Find the Intrinsic Matrix

(出題： Kerwin)

- Given: 15 images, 1.bmp ~ 15.bmp
- Q2:

  1) Find the intrinsic matrix:

$$\begin{bmatrix} \alpha & \gamma & u_0 \\ 0 & \beta & v_0 \\ 0 & 0 & 1 \end{bmatrix}$$

ins: intrinsic matrix(K: $3x3$)
dist: distortion matrix(D: $1x5$)
rvec: rotation vector(R: $1x3$)
tvec: translation vector(T: $1x3$)

O/P O/P O/P O/P I/P I/P I/P

ins, dist, rvec, tvec=cv2.calibrateCamera (objectPoints, imagePoints=corners, (w, h))

3x3 1x5 1x3 1x3

➔ in order to get R, T, K, D

objectPoints: corners points of chessboard in 3D coordinate.(unit: 0.02m), (11x8x1)

(w,h): image size(2048, 2048)

  2) Click button "1.2 Find Intrinsic" and then show the result on the console window.

Output format:

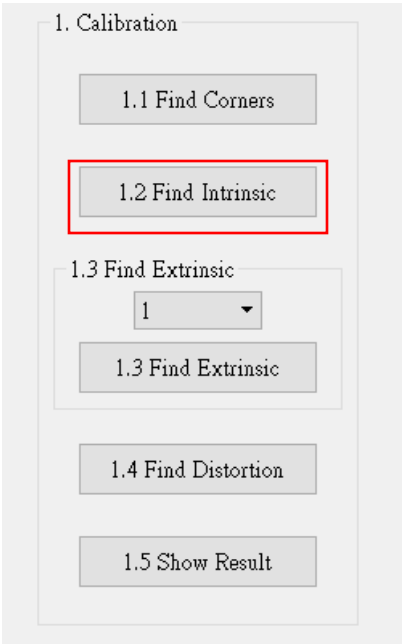
```
Intrinsic:
[[2.22370244e+03 0.00000000e+00 1.03021663e+03]
 [0.00000000e+00 2.22296836e+03 1.03752624e+03]
 [0.00000000e+00 0.00000000e+00 1.00000000e+00]]
```

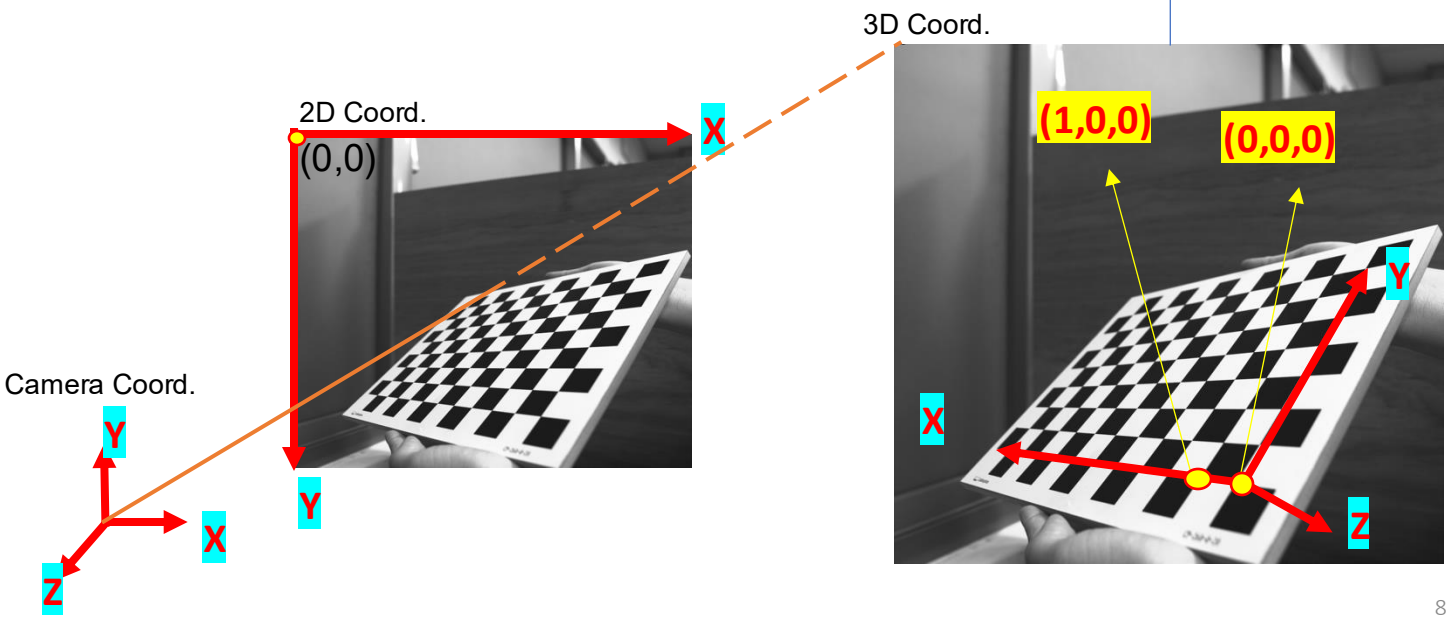
(Just an example)

- Hint:

  OpenCV Textbook Chapter 11 (p.398 ~ p.400)

Totoal points:
(0,0,0),…, (11,0,0)
⋮ ⋱ ⋮
(0,7,0),…, (11,7,0)





1.3 Find the Extrinsic Matrix

(出題： Kerwin)

extrinsic_matrix

$$\begin{bmatrix} r_{11} & r_{12} & r_{13} & T_X \\ r_{21} & r_{22} & r_{23} & T_Y \\ r_{31} & r_{32} & r_{33} & T_Z \end{bmatrix}$$

- Given: Intrinsic parameters, distortion coefficients, and the list of 15 images
- Q3:
  1) Find the extrinsic matrix of the chessboard for each of the 15 images, respectively:

     You can get rvec, tvec from (1.2) in cv2.calibrateCamera.

     rotation_matrix (O/P) = cv2.Rodrigues(rvec (I/P))[0] ➔ Rodrigues transformation: transform rotation vector into rotation matrix.

     extrinsic_matrix (O/P) = np.hstack(rotation_matrix (I/P), tvec (I/P)) ➔ Merge R and T in order to get extrinsic matrix.

  2) Click button "1.3 Find Extrinsic" and then show the result on the console window.

     Output format:

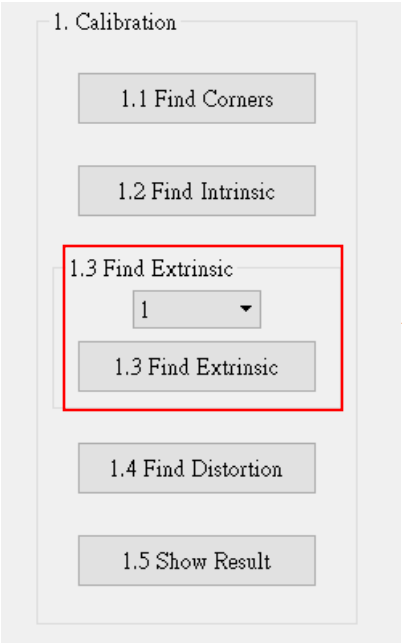
```
Extrinsic:
[[-0.8767247  -0.23001438  0.4224301   4.39838495]
 [ 0.19727469 -0.97293475 -0.12033563  0.68022105]
 [ 0.43867585 -0.02216645  0.89837194 16.22126   ]]
```

(Just an example)

- Hint:

  Extrinsic matrix can be obtained simultaneously with intrinsic.

  OpenCV Textbook Chapter 11, (p.370 ~ p.402)



(1) List of numbers: 1~15
(2) Select 1, then 1.bmp will be applied, and so on

rvec, tvec get from (1.2) in cv2.calibrateCamera

1.4 Find the Distortion Matrix

(出題： Kerwin)

- Given: 15 images
- Q4:

  1) Find the distortion matrix: $[k_1, k_2, p_1, p_2, k_3]$

  You can get distortion matrix from (1.2) in cv2.calibrateCamera.

  2) Click button "1.4 Find Distortion" to show the result on the console window.

  Output format:

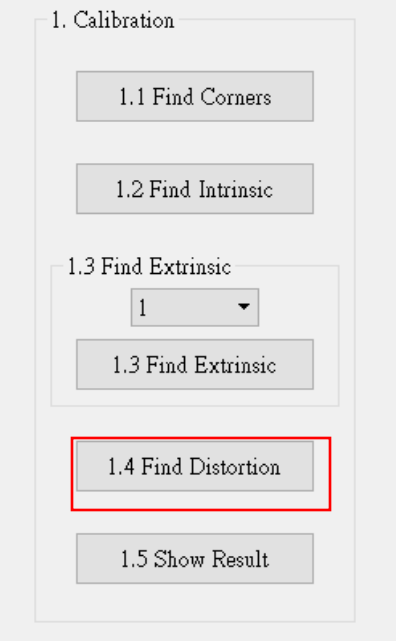
```
Distortion:
[[-0.11868112  0.02776881 -0.00092036  0.00047227  0.11793646]]
```

- Hint:

  (Just an example)

  Distortion coefficients can be obtained simultaneously with intrinsic.

  OpenCV Textbook Chapter 11 (p.398 ~ p.400)



1.5 Show the Undistorted Result

(出題： Kerwin)

- Given: 15 images
- Q5:

  1) Undistort the chessboard images.

  You can get intrinsic matrix and distortion matrix from (1.2) in cv2.calibrateCamera.

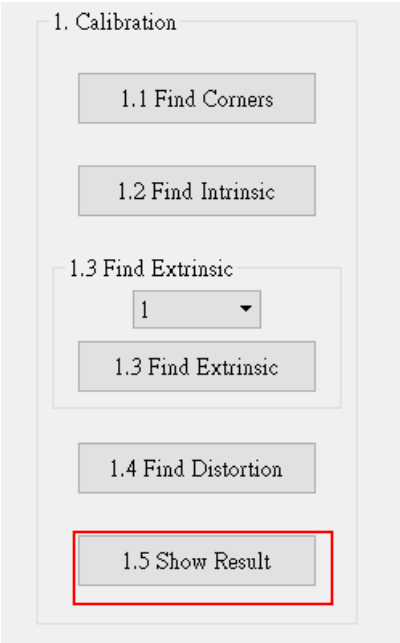
  result_img = cv2.undistort(grayimg, ins, dist) ➔ Undistort the image by intrinsic matrix and distortion matrix

  (Q/P: result_img; I/P: grayimg, ins, dist)

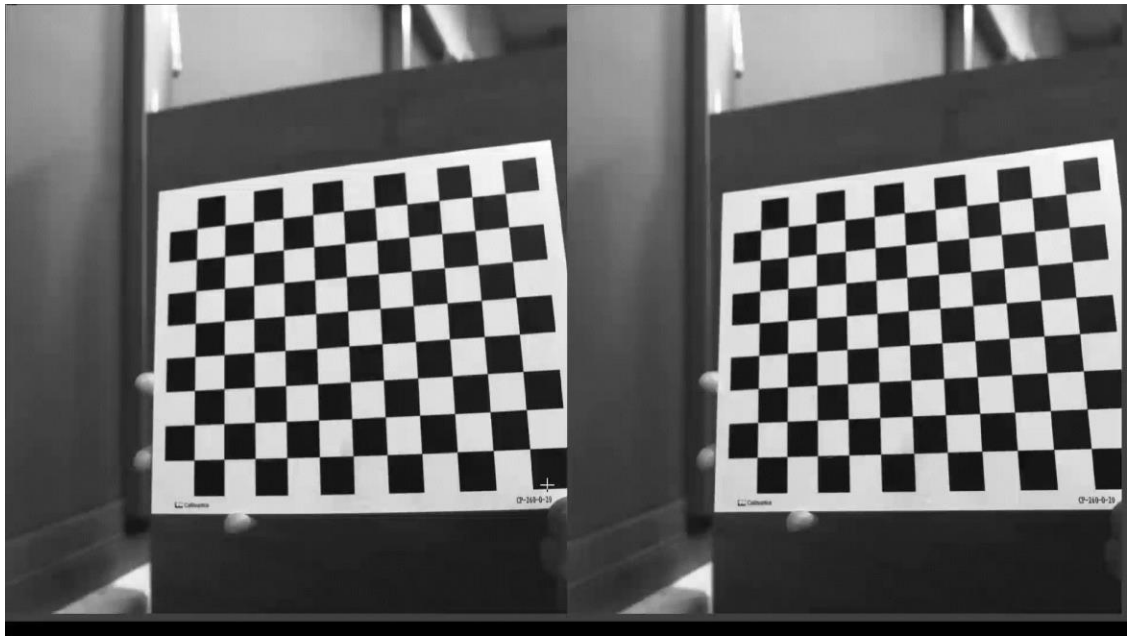
  2) Click button "1.5 Show Result" to show distorted and undistorted images

- Hint:

  OpenCV Textbook Chapter 11 (p.398 ~ p.400)

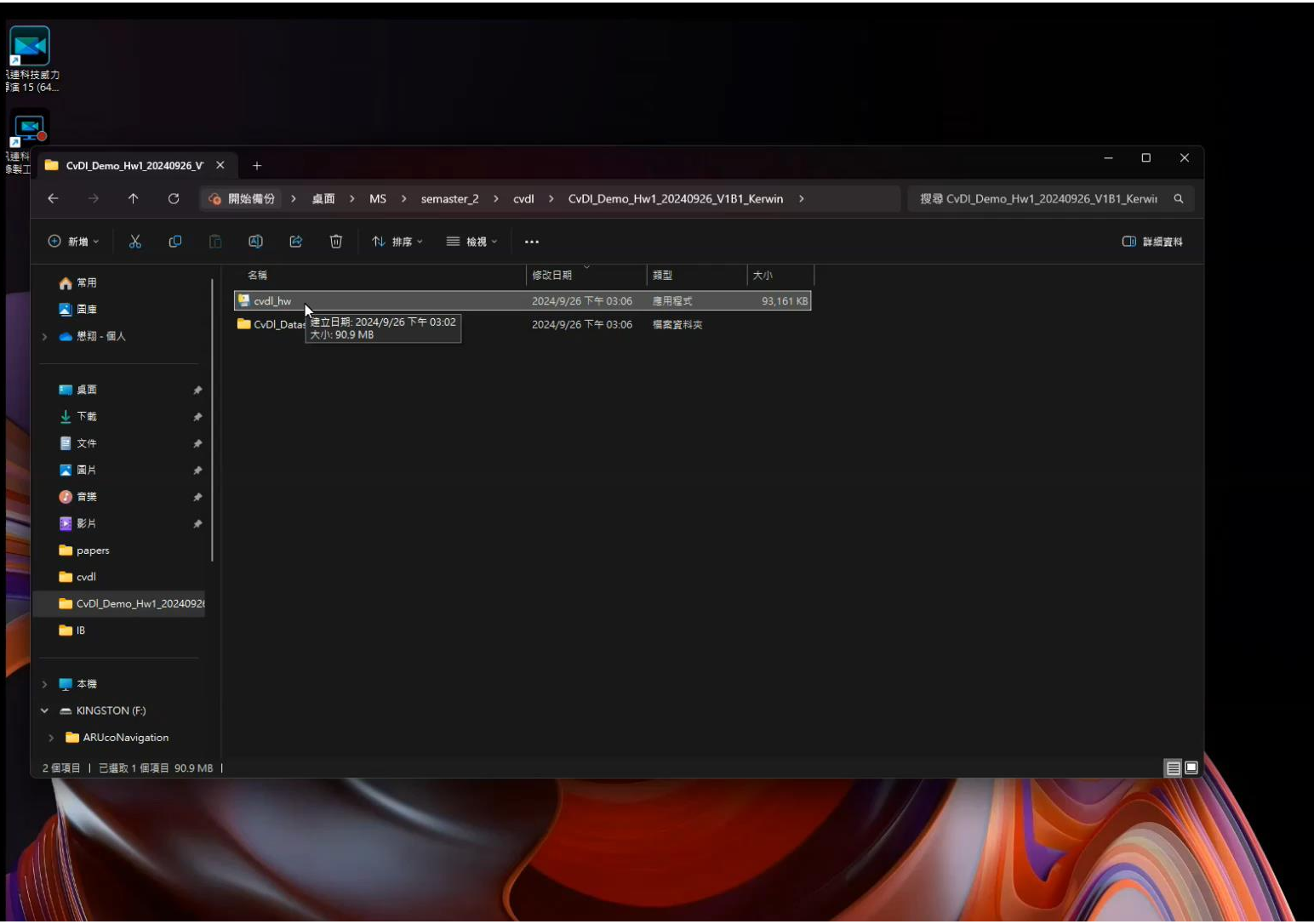


Distorted image | Undistorted image



1.6 Camera Calibration – Demo Video

(出題： Kerwin)

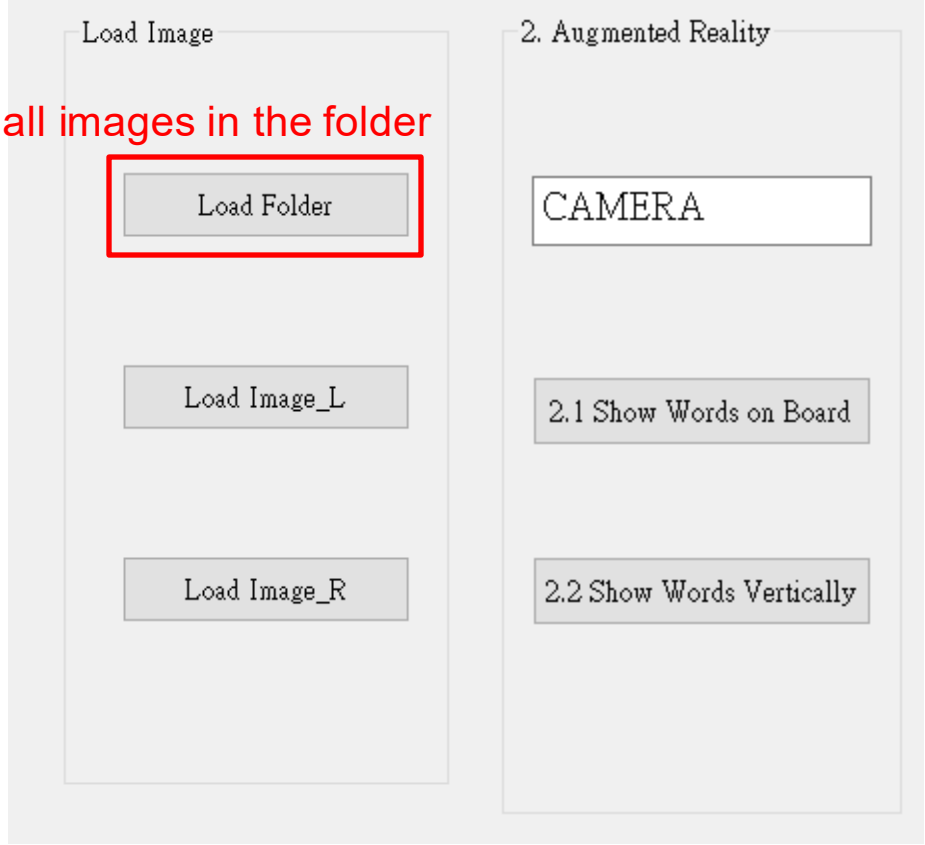


2. Augmented Reality

(出題： Yiyu)

2.1 Show words on board

2.2 Show words vertically



2. Augmented Reality

(出題： Yiyu)

➢ Guides and Requirements:

1) How to use the database: (alphabet_db_onboard.txt, alphabet_db_vertical.txt)

– Inside the database:
(1) It contains the 3D world coordinates of letter A to Z
(2) Each letter represents an object

– Use OpenCV function to read and derive the array or matrix of the char
Here take 'K' in 'alphabet_db_onboard.txt' for example
e.g. (Python):

O/P: created file reader I/P: file name I/P: specify mode

fs = cv2.FileStorage('alphabet_db_onboard.txt', cv2.FILE_STORAGE_READ) ➔ read data from database

charPoints = fs.getNode('K').mat() ➔ convert it into to a matrix; Node K: Six 3D points as below

O/P: Object coordinates (3x2x3) I/P: specify the letter

```
charPoints = [ [[2, 2, 0], [2, 0, 0]],
               [[0, 2, 0], [2, 1, 0]],
               [[2, 1, 0], [0, 0, 0]]] Unit: 0.02m (square size of the checkerboard)
```

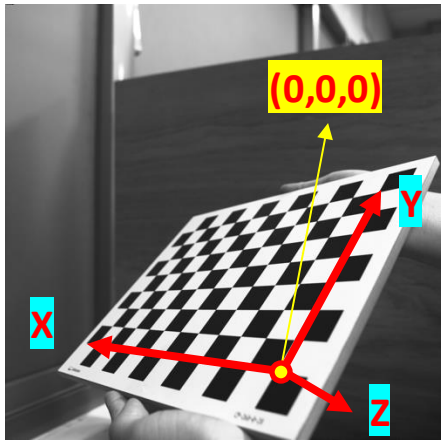
– Letter 'K' consist of 3 lines, so the 'charPoints' consists 3 pairs of 3D coordinates in World Coordinate representing two ends of the line shown in the upper right image.

2) Chessboard Coordinates

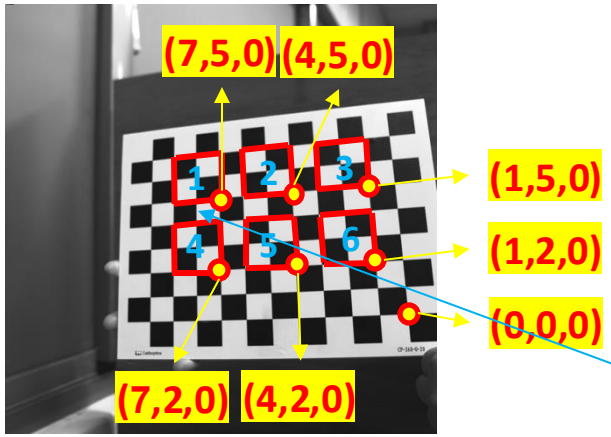
– The chessboard x, y, z axis and (0,0,0) coordinate are shown in the bottom left image

– Each char should be placed in the order and position shown in the bottom right image
- Apply translation to 3D object coordinates to move to the designated position (add value to coord.)

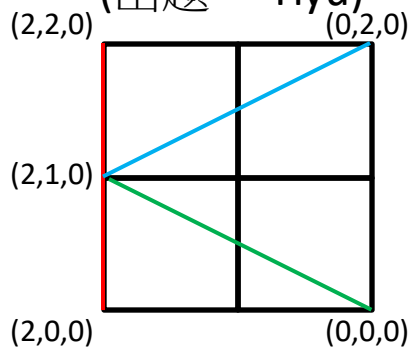
3D World Coordinate = 3D Chessboard Coordinate



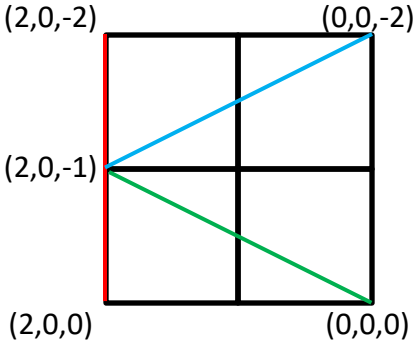
Chessboard Coordinate



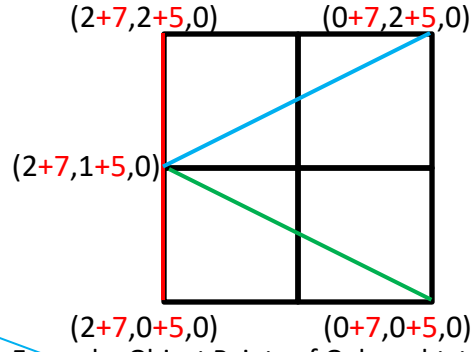
Position and Order



Object Points in Onboard.txt: The 3D world coordinates = 3D object coordinates (X, Y, Z=0)



Object Points in Vertical.txt: The 3D world coordinates = 3D object coordinates (X, Y=0, Z)



Example: Object Points of Onboard.txt in position 1 (3D world coordinates)

2.1 Show words on board

(出題： Yiyu)

ins: intrinsic matrix(K: $3x3$)
dist: distortion matrix(D: $1x5$)
rvec: rotation vector(R: $1x3$)
tvec: translation vector(T: $1x3$)
(w, h): image size

➢ Given: 5 images (1~5.bmp), alphabet_db_onboard.txt

Q1: **Show a Word (e.g. CAMERA) on chessboard**

1) Calibrate 5 images to get intrinsic, extrinsic, distortion, rotation vector, and translation vector parameters.

Link for camera calibration example

O/P O/P O/P O/P I/P: corner points of the chessboard in 3D world coordinate(11x8x1) for 5 images I/P

ins, dist, rvec, tvec=cv2.calibrateCamera (objectPoints, imagePoints=corners, (w, h))

3x3 1x5 1x3x5 1x3x5 I/P: corner points of the chessboard in 2D image coordinate for 5 images

2) Input a word less than 6 char in English in textEdit box.

3) Derive the shape of the word by using the provided database (alphabet_db_onboard.txt) and project it on image.

O/P: created file reader I/P: file name I/P: specify mode

fs = cv2.FileStorage('alphabet_db_onboard.txt', cv2.FILE_STORAGE_READ) ➔ read data from database

charPoints = fs.getNode('K').mat() ➔ convert it into a matrix

O/P: Object 3D world coordinates (3x2x3 for 'K') I/P: input the letter from UI text box

charPoints = [[[2, 2, 0], [2, 0, 0]],
[[0, 2, 0], [2, 1, 0]],
[[2, 1, 0], [0, 0, 0]]] Unit: 0.02m (square size of the checkerboard)

4) Project points on chessboard for each image

O/P: new object 2D coordinates I/P: object 3D world coordinates

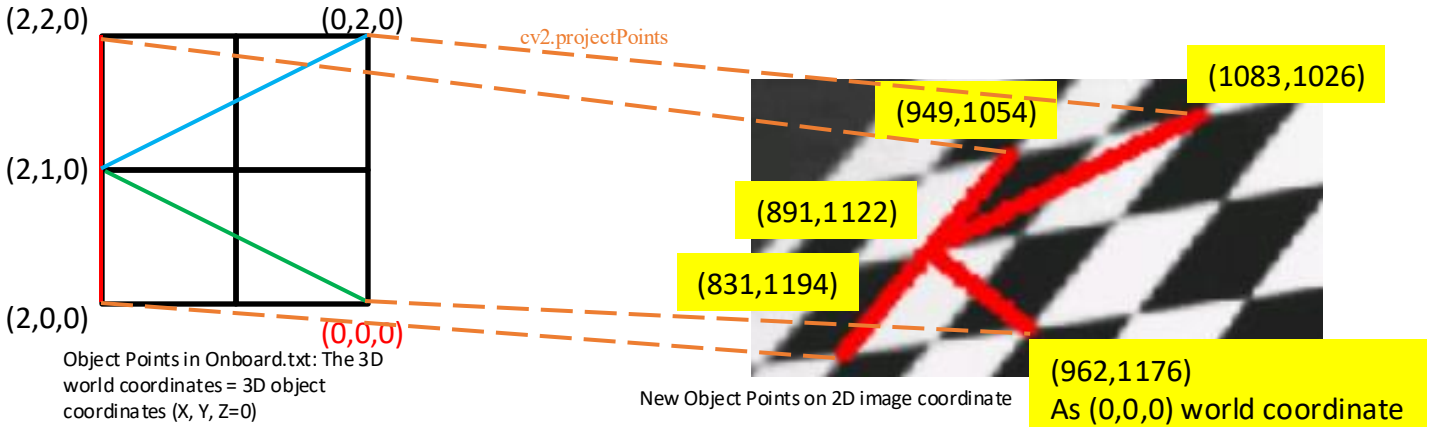
newCharPoints = cv2.projectPoints(charPoints, ins, dist, rvec, tvec) ➔ Get transformed object points

I/P I/P I/P I/P

5) Click button "2.1 Show Words on Board" to show the result of each image for 1 second (5 images in total).

cv2.line(image, pointA, pointB) ➔ Draw a line on image from point A to B (points aquired from newCharPoints)

I/P I/P I/P



Object Points in Onboard.txt: The 3D world coordinates = 3D object coordinates (X, Y, Z=0)

New Object Points on 2D image coordinate

2.2 Show words vertically

(出題： Yiyu)

ins: intrinsic matrix(K: $3x3$)
dist: distortion matrix(D: $1x5$)
rvec: rotation vector(R: $1x3$)
tvec: translation vector(T: $1x3$)
(w, h): image size

➢ Given: 5 images (1~5.bmp), alphabet_db_vertical.txt

Q2: **Show a Word (e.g. CAMERA) vertically on chessboard**

1) Calibrate 5 images to get intrinsic, extrinsic, distortion, rotation vector, and translation vector parameters.

Link for camera calibration example

O/P O/P O/P O/P I/P: corner points of the chessboard in 3D world coordinate(11x8x1) for 5 images I/P

ins, dist, rvec, tvec=cv2.calibrateCamera (objectPoints, imagePoints=corners, (w, h))

3x3 1x5 1x3x5 1x3x5 I/P: corner points of the chessboard in 2D image coordinate for 5 images

2) Input a word less than 6 char in English in textEdit box.

3) Derive the shape of the word by using the provided database (alphabet_db_vertical.txt) and project it on image.

O/P: created file reader I/P: file name I/P: specify mode

fs = cv2.FileStorage('alphabet_db_vertical.txt', cv2.FILE_STORAGE_READ) ➔ read data from database

charPoints = fs.getNode('K').mat() ➔ convert it into a matrix

O/P: Object 3D world coordinates (3x2x3 for 'K') I/P: input the letter from UI text box

charPoints = [[[2, 0, -2], [2, 0, 0]],
[[0, 0, -2], [2, 0, -1]],
[[2, 0, -1], [0, 0, 0]]] Unit: 0.02m (square size of the checkerboard)

4) Project points on chessboard for each image

O/P: new object 2D coordinates I/P: object 3D world coordinates

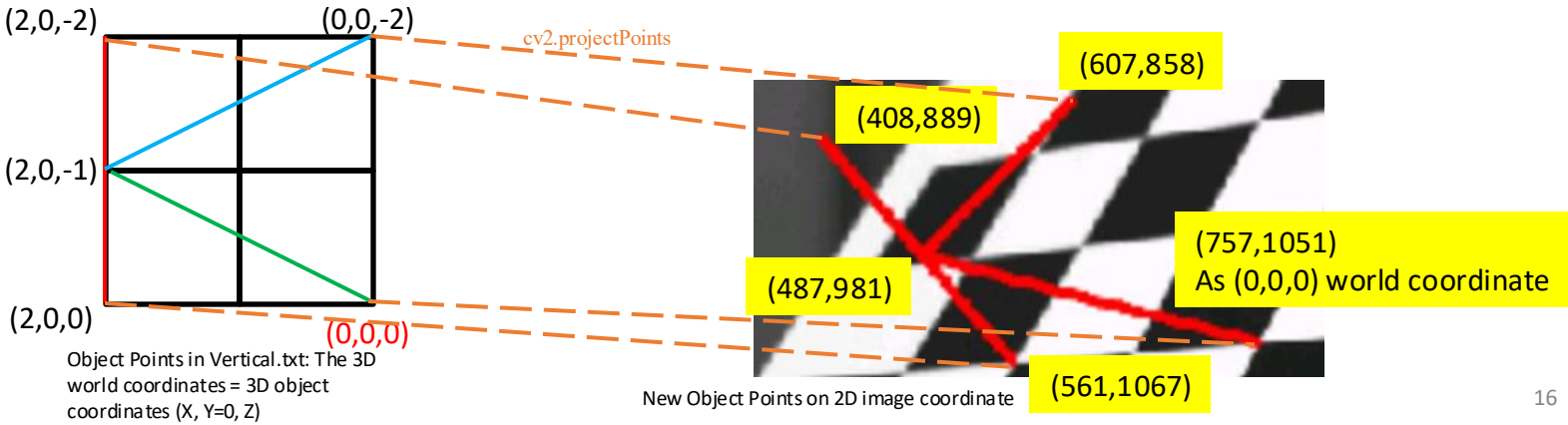
newCharPoints = cv2.projectPoints(charPoints, ins, dist, rvec, tvec) ➔ Get transformed object points

I/P I/P I/P I/P

5) Click button "2.2 Show Words vertically" to show result, each picture for 1 second (total 5 images).

cv2.line(image, pointA, pointB) ➔ Draw a line on image from point A to B (points aquired from newCharPoints)

I/P I/P I/P

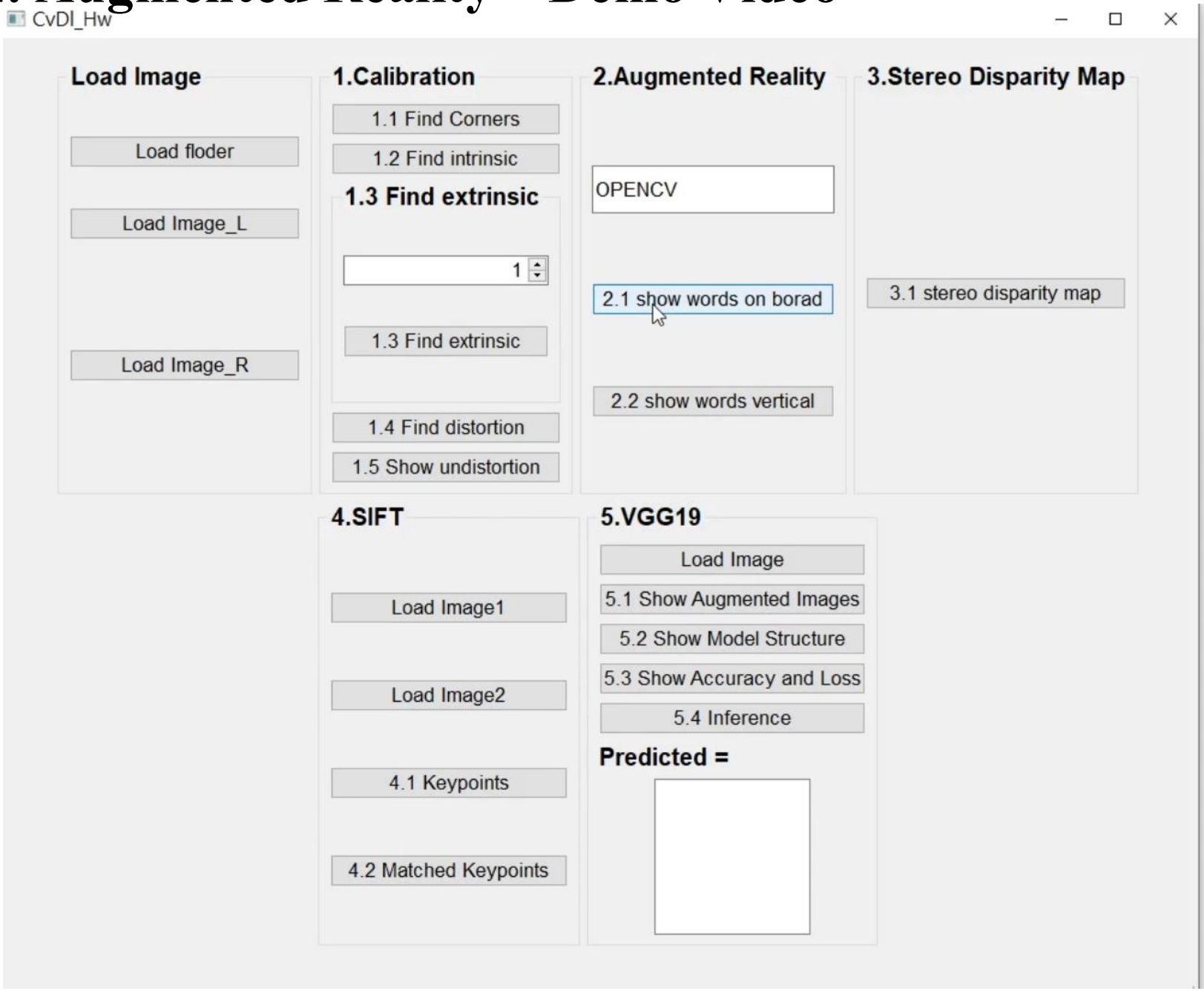


Object Points in Vertical.txt: The 3D world coordinates = 3D object coordinates (X, Y=0, Z)

New Object Points on 2D image coordinate

2. Augmented Reality – Demo Video

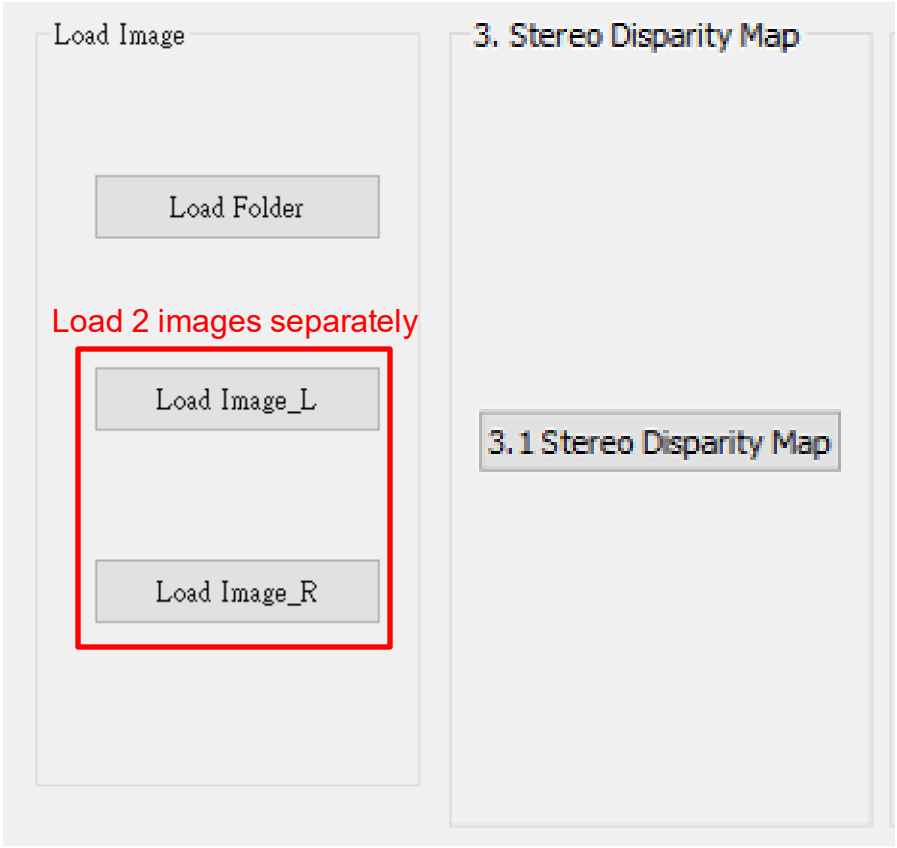
(出題： Yiyu)



3. Stereo Disparity Map

(出題：Tien)

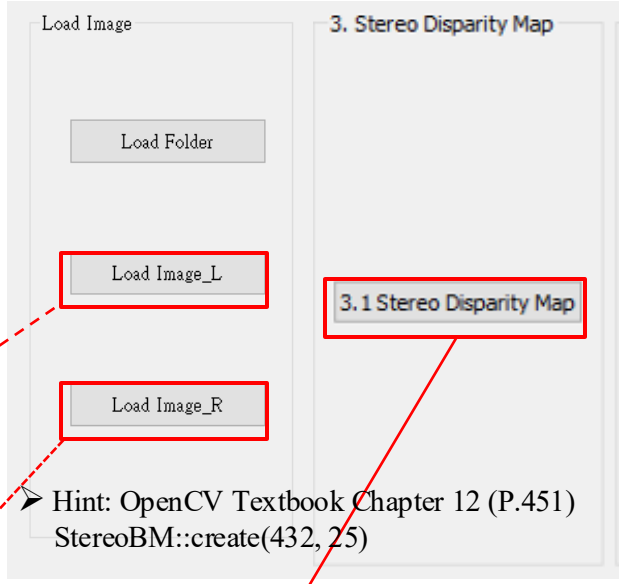
3.1 Stereo Disparity Map



3.1 Stereo Disparity Map

(出題：Tien)

1. Given: a pair of images, imL.png and imR.png (have been rectified).
   Q: **Find the disparity map/image based on Left and Right stereo images**
   1) Load imL.png (click "Load Image_L"). (Input)
   2) Load imR.png (click "Load Image_R"). (Input)
   3) Click button "3.1 Stereo Disparity Map" (Output) to show result.

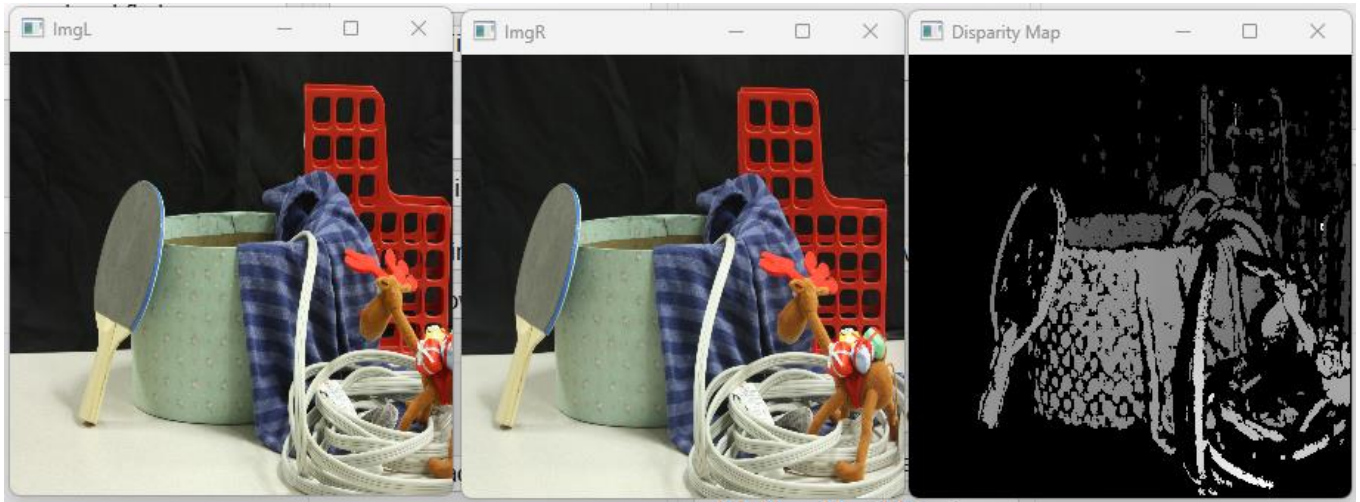


Hint:

Usually max disparity is less than 64 pixels

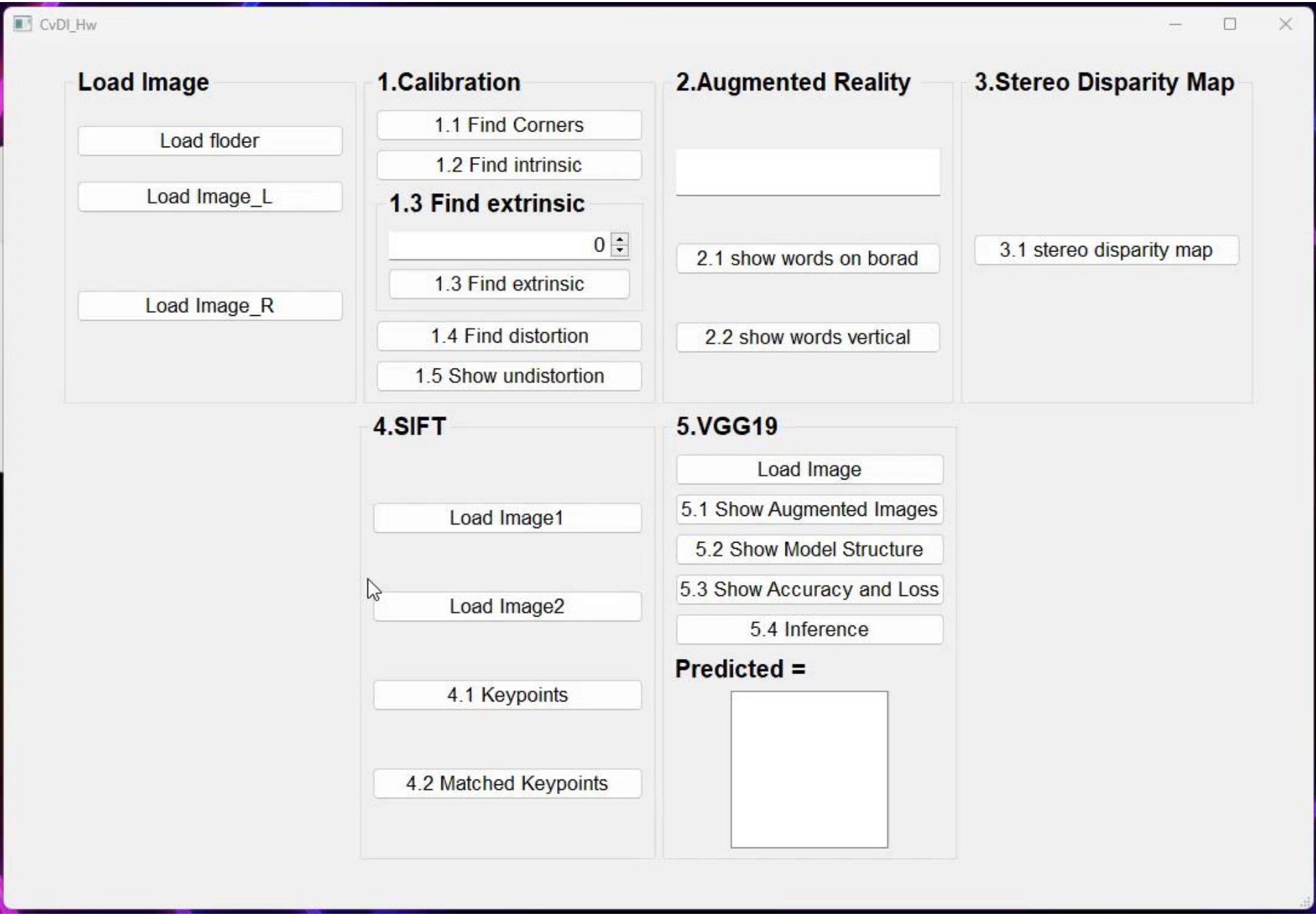
1. Use OpenCV StereoBM class to build StereoBM objects.
2. stereo = cv2.StereoBM.create(**numDisparities**=432, **blockSize**=25)
3. disparity (Output) = stereo.compute(**imgL**,**imgR**) (Input)
4. Show the Disparity Map (the value must be normalized to [0, 255])
   - The above parameters can be freely changed according to the following rules.
     - **numDisparities (int)**: The disparity search range must be positive and divisible by 16.
     - **blockSize (int)**: The size of blocks compared by the algorithm, must be odd and within the range [5, 51].
       - Larger block size implies smoother but less accurate disparity map.
       - Smaller block size gives finer disparity details, yet increase the likelihood of algorithmic misalignment.

Both input image are W: 2816, H: 1916



3. Stereo Disparity Map - Demo Video

(出題：Tien)

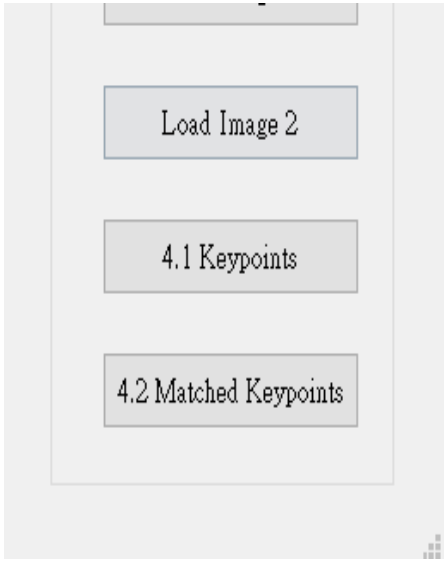


4. SIFT

(出題：Ian)

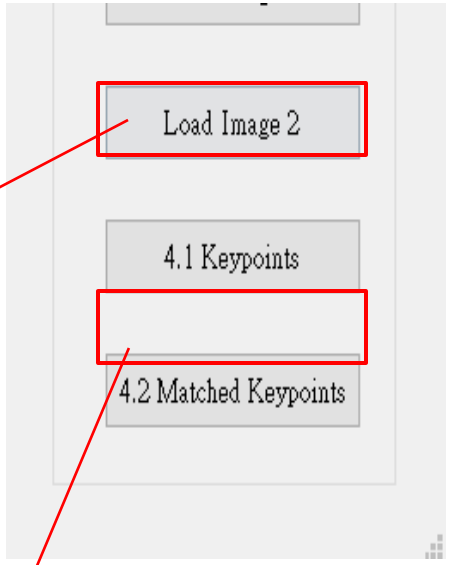
4.1 SIFT Keypoints

4.2 Matched Keypoints



4.1 SIFT Keypoints

(出題： Ian)



1 - Click button “Load Image 1” to load Left.jpg.

- Click button “4.1 Keypoints” to show:

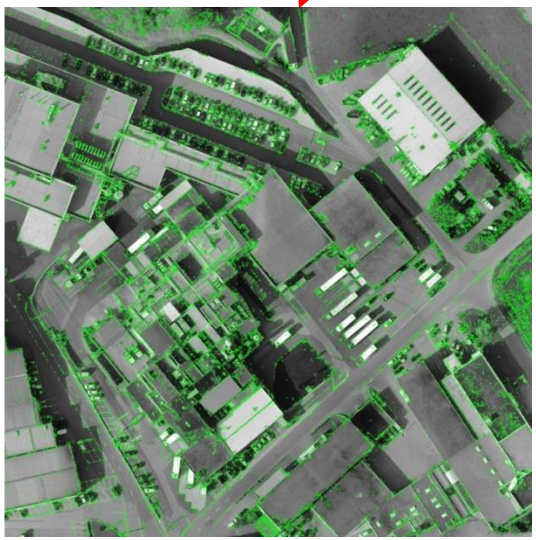
1) Convert image to grayscale image.
   - gray (O/P) = cv2.cvtColor(img (I/P), cv2.COLOR_BGR2GRAY)
2) Based on SIFT algorithm, find keypoints on Left.jpg.
   - Use OpenCV SIFT detector to detect keypoints and descriptors.
   - sift = cv2.SIFT_create() # Create a SIFT detector
   - keypoints (O/P), descriptors (O/P) = sift.detectAndCompute(gray (I/P), None)

     # Many SIFT keypoints, each keypoint has its descriptor
3) Then draw the keypoints of Left.jpg as I_1.
   - img = cv2.drawKeypoints(gray (I/P), keypoints (I/P), None, color=(0,255,0)) (keypoints color; r g b)
4) Please show image I_1

Input:

Left.jpg

Output:



I_1

Reference : OpenCV Textbook SIFT, p321, 464, 524

4.2 Matched Keypoints

(出題： Ian)

1 - Click button “Load Image 1” to load Left.jpg.

- Click button “Load Image 2” to load Right.jpg.

- Click button “4.2 Matched Keypoints”,

1) Based on SIFT algorithm, find the keypoints and descriptors at Image 1 and Image 2 (same as question 4.1)

2) Find match keypoints of two images

matches[m,n]: two nearest matched keypoints for each keypoint

- matches (O/P) = cv2.BFMatcher().knnMatch(descriptors1 (I/P), descriptors2 (I/P), k=2)

3) Extract Good Matches from 2) result:

- Hint:

```
for m, n in matches:
    if m.distance < 0.75*n.distance:
        good_matches.append(m)
```

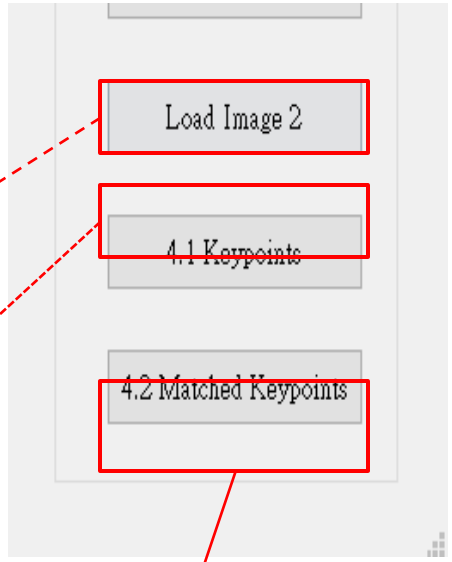
Ratio Test: If the distance to the closest match is much smaller than the distance to the second closest, the match is considered good.

4) Draw the matched feature points between two image

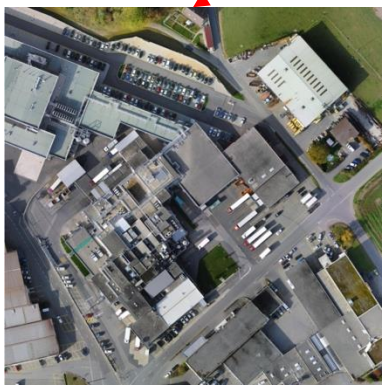
- Hint: Use “cv2.drawMatchesKnn()” to draw the matches.

```
cv2.drawMatchesKnn(gray1 (I/P), keypoints1 (I/P), gray2 (I/P), keypoints2 (I/P), good_matches (I/P),
    None, flags=cv2.DrawMatchesFlags_NOT_DRAW_SINGLE_POINTS)
```

5) Please show image I_2



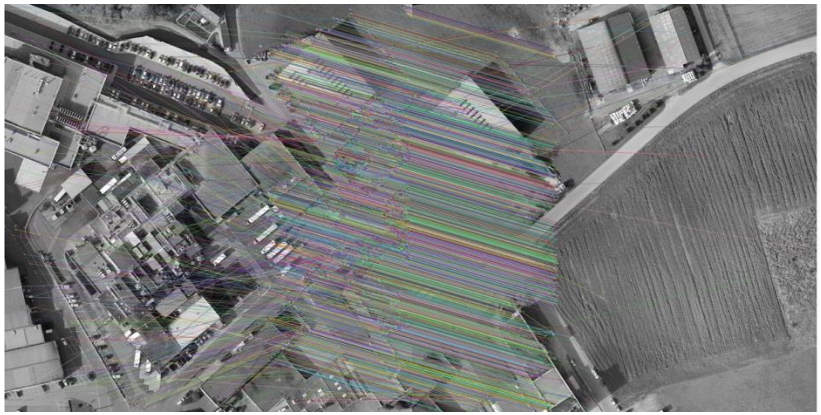
Input:



Left.jpg

Right.jpg

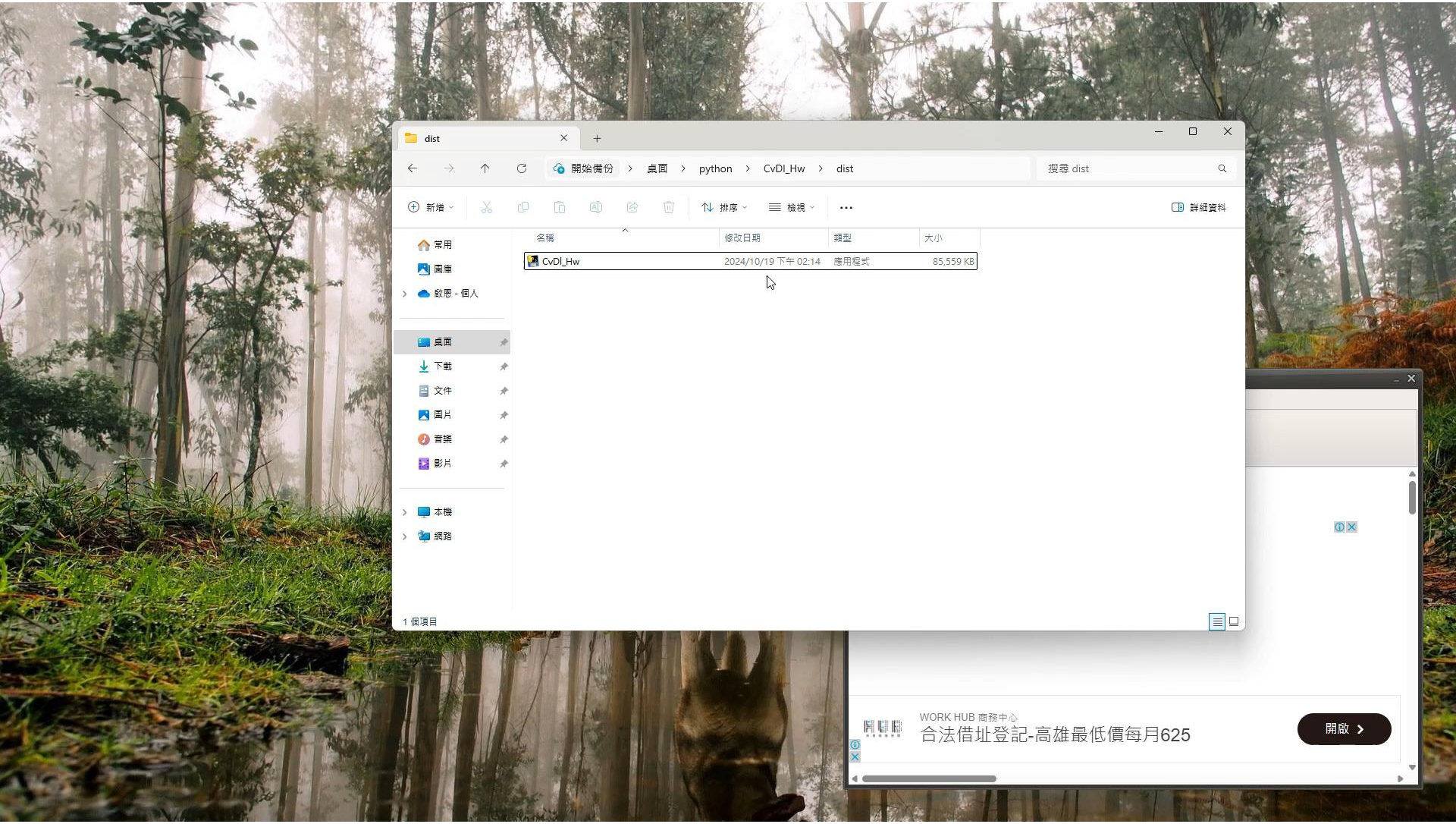
Output:



I_2

Reference: OpenCV Textbook SIFT, p321, 464, 524

4. SIFT - DEMO


dist
開始備份
桌面
python
CvDl_Hw
dist
搜尋 dist
新增
排序
檢視
詳細資料
常用
圖庫
啟恩 - 個人
桌面
下載
文件
圖片
音樂
影片
本機
網路
名稱
修改日期
類型
大小
CvDl_Hw
2024/10/19 下午 02:14
應用程式
85,559 KB
1 個項目
WORK HUB 商務中心
合法借址登記-高雄最低價每月625
開啟