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, Wed.

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, 2025/10/31 (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: cvdl2025   Password: RL2025cvdl
- 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%)

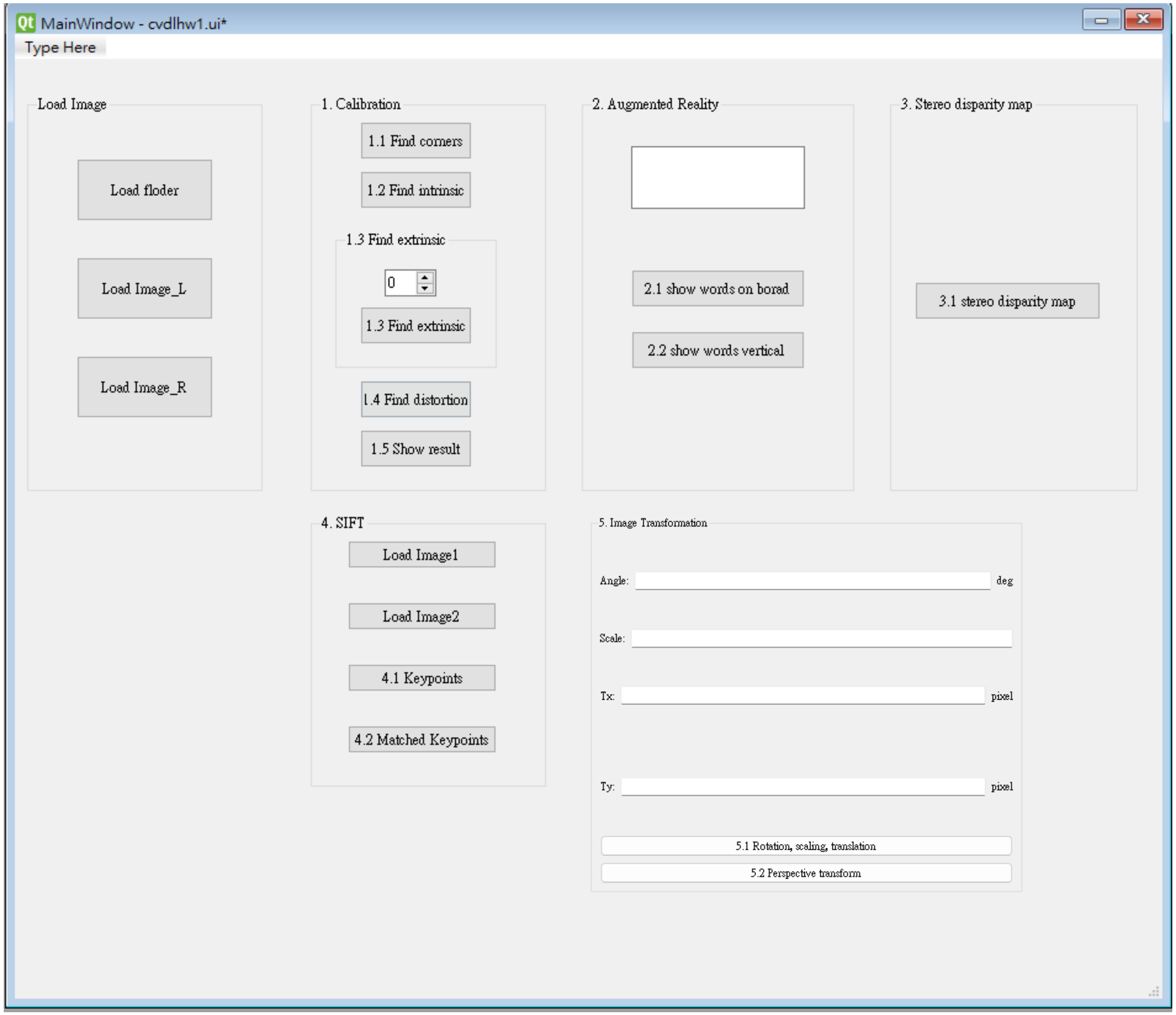
1. Camera Calibration (出題：Kerwin)
    1.1 Corner detection
    1.2 Find the intrinsic matrix
    1.3 Find the extrinsic matrix
    1.4 Find the distortion matrix
    1.5 Show the undistorted result
2. Augmented Reality (出題：Yiyu)
    2.1 Show words on board
    2.2 Show words vertically
3. Stereo Disparity Map (出題： Tien)
    3.1 Stereo Disparity Map
4. SIFT (出題： Ian)
    4.1 Keypoints
    4.2 Matched Keypoints
5. ~~Image Transformation~~ (出題： Yiyu)
    ~~5.1 Rotation, scaling, translation~~
    ~~5.2 Perspective transform~~

* 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)

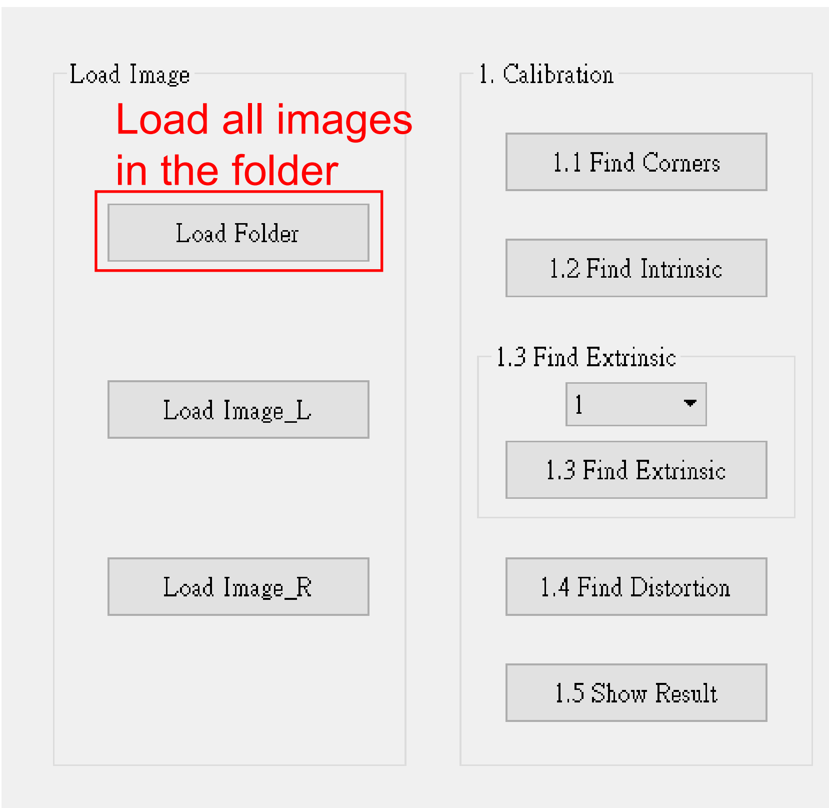
1.1 Corner detection

1.2 Find the intrinsic matrix K

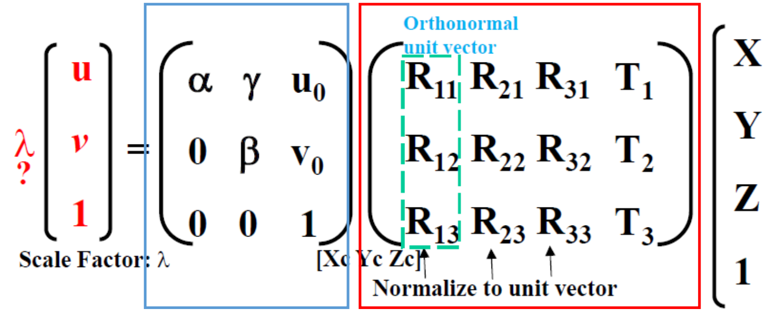
1.3 Find the extrinsic matrix $[R, T]$

1.4 Find the distortion matrix D

1.5 Show the undistorted result



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

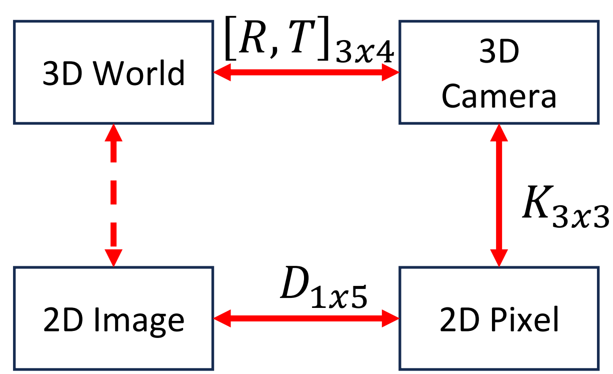


$$\lambda \begin{pmatrix} u \\ v \\ 1 \end{pmatrix} = \begin{pmatrix} \alpha & \gamma & u_0 \\ 0 & \beta & v_0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} R_{11} & R_{21} & R_{31} & T_1 \\ R_{12} & R_{22} & R_{32} & T_2 \\ R_{13} & R_{23} & R_{33} & T_3 \end{pmatrix} \begin{pmatrix} X \\ Y \\ Z \\ 1 \end{pmatrix}$$

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, height): 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.

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

O/P I/P I/P I/P I/P I/P
corners = cv2.cornerSubPix(grayimg, corners, winSize, zeroZone, criteria) ➔ 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.

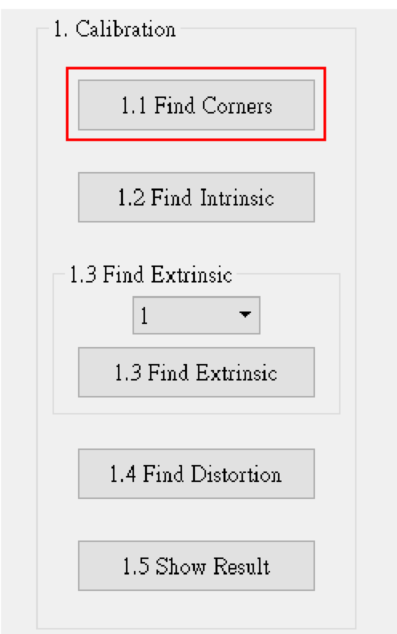
max iteration time

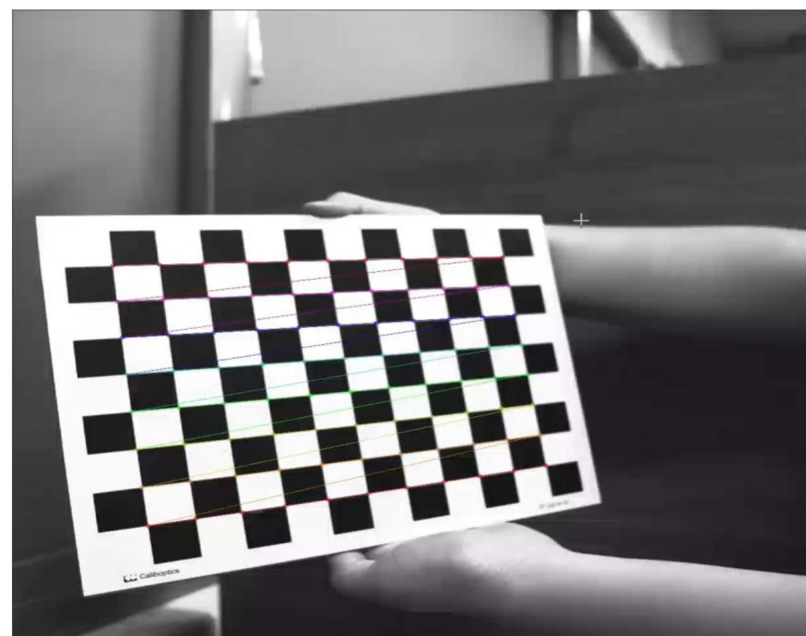
Precision of sliding window

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 (3DObjectPoints, 2DImagePoints=corners, (w, h))

3x3 1x5 1x3 1x3

➔ in order to get R, T, K, D

3DobjectPoints: 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:

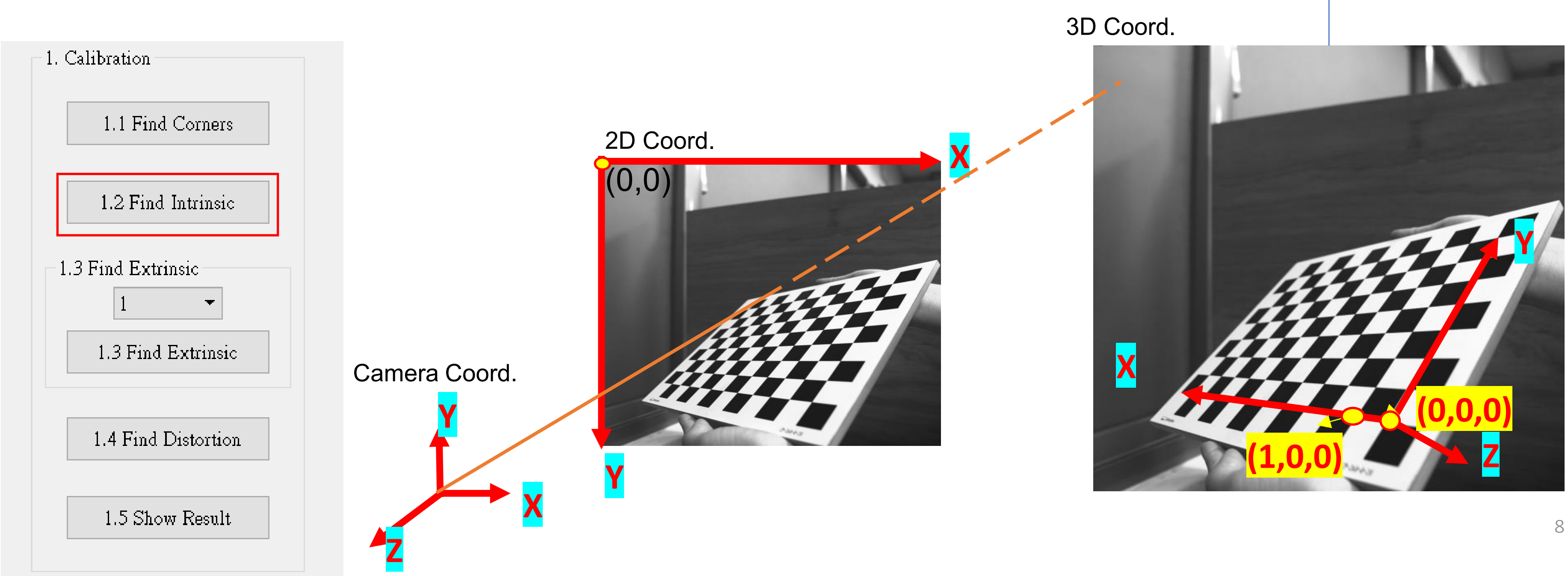
```
Intrinsic:
[[2.22370244e+03 0.00000000e+00 1.03021663e+03]
 [0.00000000e+00 2.22296836e+03 1.03752624e+03]
 [0.00000000e+00 0.00000000e+00 1.00000000e+00]]
```

(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.

     O/P I/P
     rotation_matrix = cv2.Rodrigues(rvec)[0] ➔ Rodrigues transformation: transform rotation vector into rotation matrix(3x3).

     extrinsic_matrix = np.hstack(rotation_matrix , tvec) ➔ Merge R and T in order to get extrinsic matrix(3x4).
     O/P I/P I/P

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

     Output format:

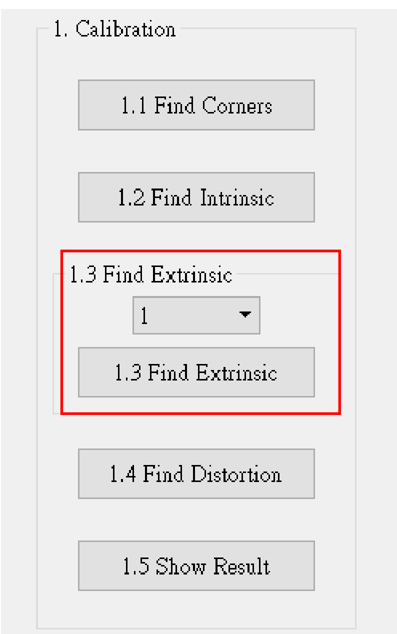
```
Extrinsic:
[[-0.8767247  -0.23001438  0.4224301   4.39838495]
 [ 0.19727469 -0.97293475 -0.12033563  0.68022105]
 [ 0.43867585 -0.02216645  0.89837194 16.22126   ]]
```

(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:

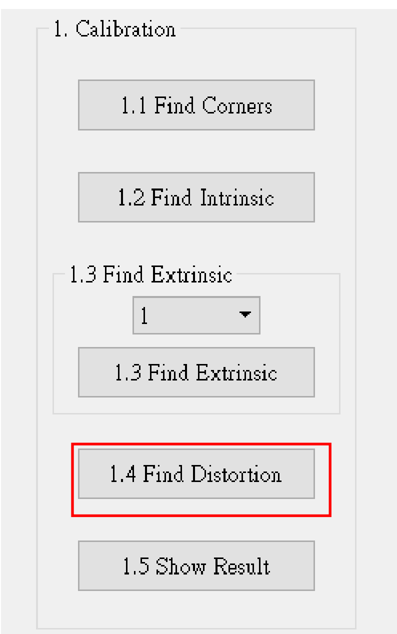
```
Distortion:
[[-0.11868112  0.02776881 -0.00092036  0.00047227  0.11793646]]
```

(Just an example)

- Hint:

  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.

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

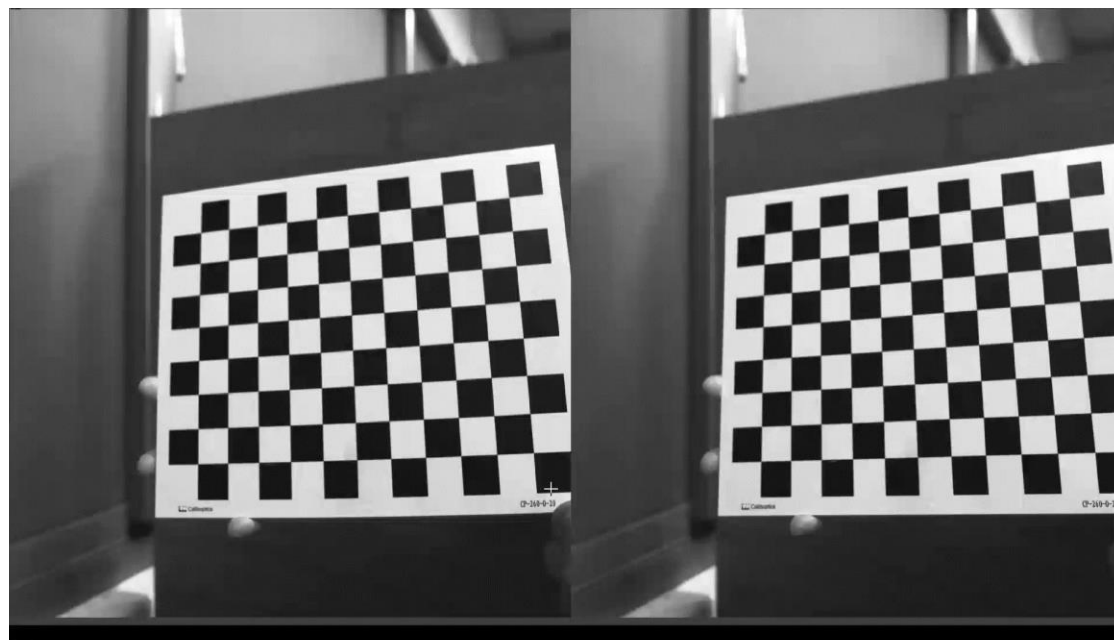
     result_img = cv2.undistort(grayimg, ins, dist) ➔ Undistort the image by intrinsic matrix and distortion matrix

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

- Hint:

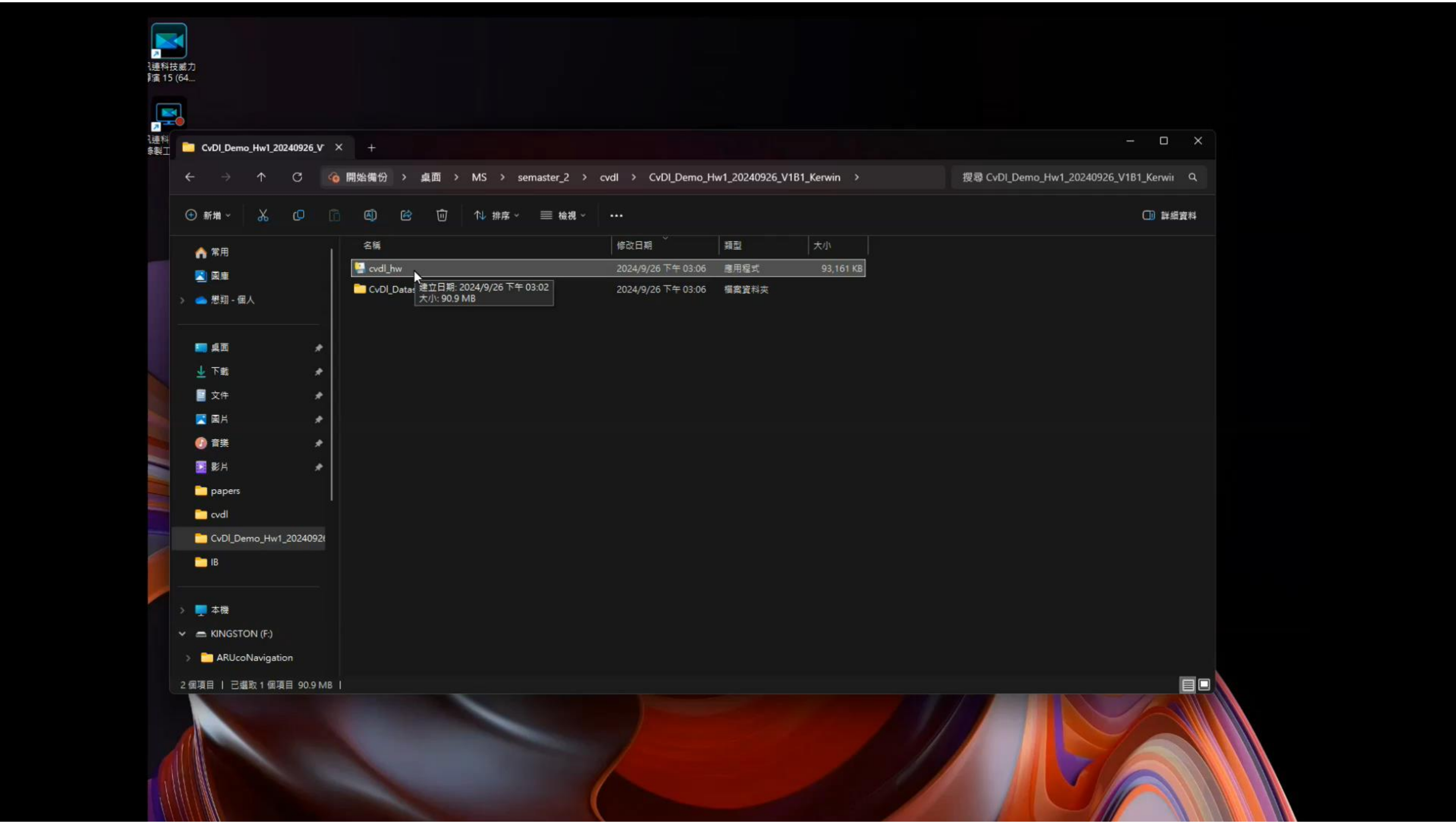
  OpenCV Textbook Chapter 11 (p.398 ~ p.400)

Distorted image　　Undistorted image



1.6 Camera Calibration – Demo Video

(出題： Kerwin)



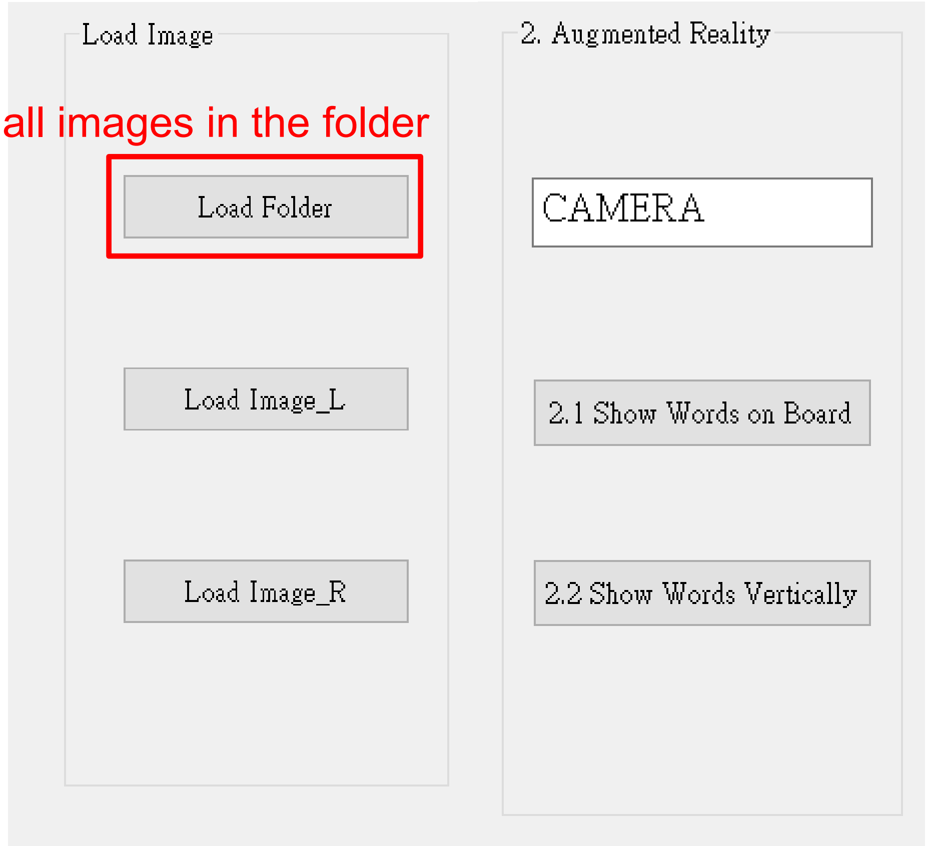
2. Augmented Reality

(出題： Yiyu)

2.1 Show words on board

2.2 Show words vertically

Load all images in the folder



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

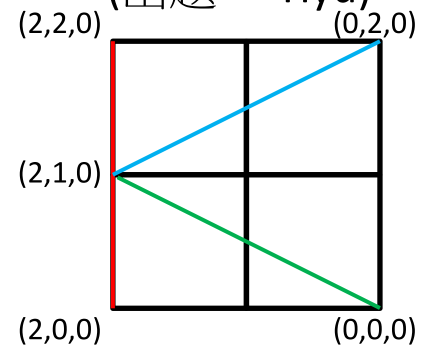
fs = cv2.FileStorage('alphabet_db_onboard.txt', cv2.FILE_STORAGE_READ)→ read data from database

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

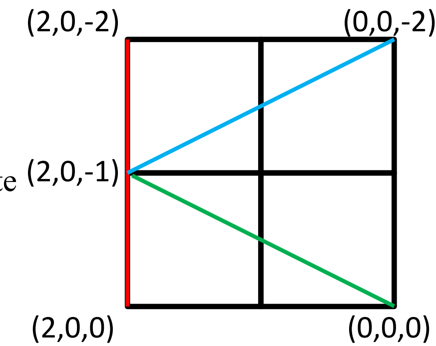
O/P: Object coordinates (3x2x3) I/P: specify the letter

```
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) origin coordinate are shown in the bottom left image
     - Each character 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.)

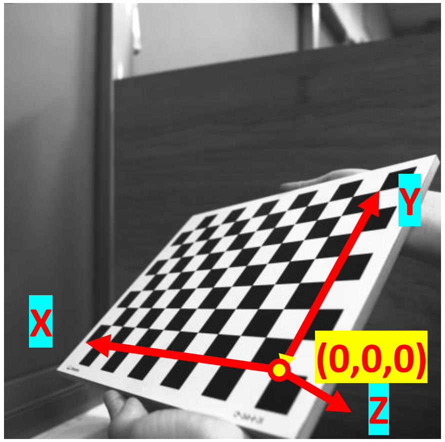


Object Points in Onboard.txt: The 3D world coordinates = 3D object coordinates (X, Y, Z=0)

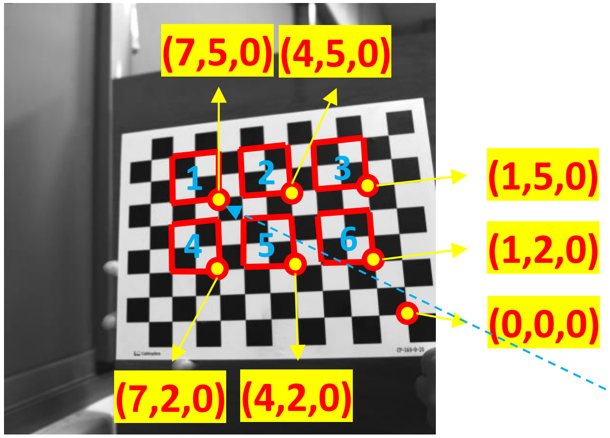


Object Points in Vertical.txt: The 3D world coordinates = 3D object coordinates (X, Y=0, Z)

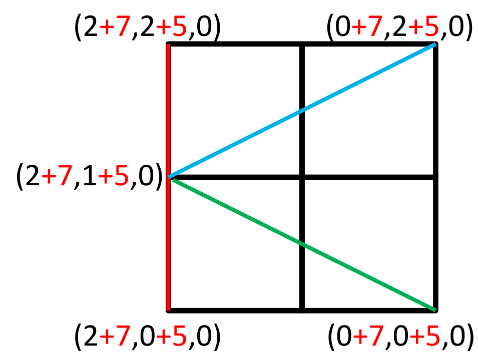
3D World Coordinate = 3D Chessboard Coordinate



Chessboard Coordinate



Position and Order



Example: Object points of Onboard.txt at position 1 (x-y plane of 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 $I_{i=1\sim5}$ I/P

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

3x3 1x5 (1x3) X5 images (1x3) X5 images I/P: corner points of the chessboard in 2D image coordinate for 5 images

2) Input a word less than 6 character 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+7, 2+5, 0], [2+7, 0+5, 0]],
[[0+7, 2+5, 0], [2+7, 1+5, 0]],
[[2+7, 1+5, 0], [0+7, 0+5, 0]]]

pointA pointB

newCharPoints = [[[949, 1054], [831, 1194]],
[[1083, 1026], [891, 1122]],
[[891, 1122], [962, 1176]]] 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 I/P I/P I/P I/P

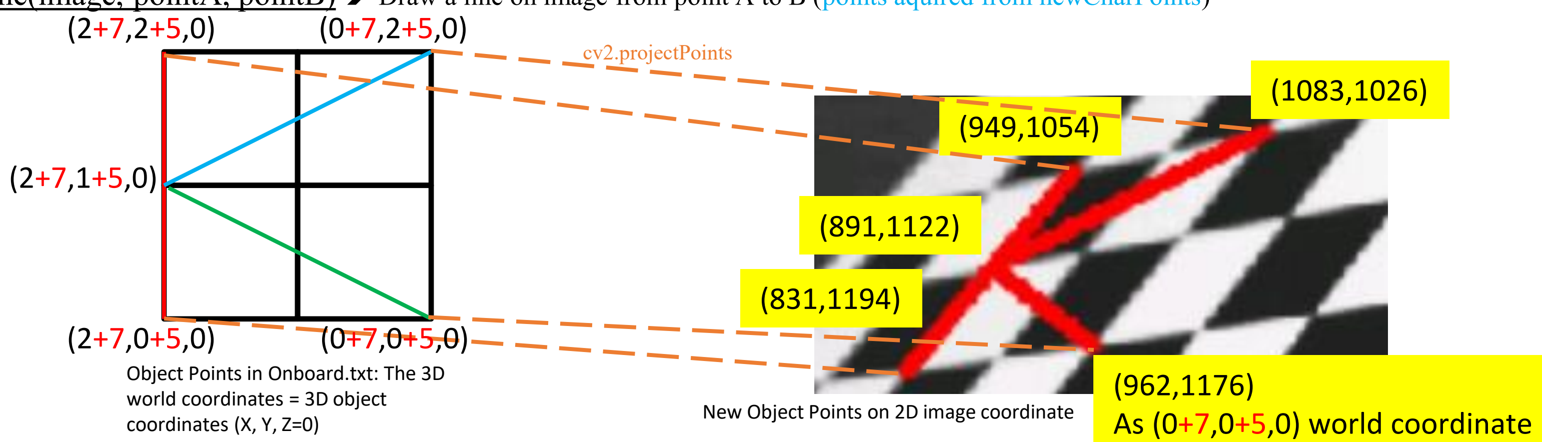
newCharPoints = cv2.projectPoints(charPoints, ins, dist, rvec, tvec)

➔ Get transformed 2D corner points of each charater. Total 6 characters. The position of each character is in order over 6 positions.

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

I/P I/P I/P

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



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_onboard.txt

Q1: **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 $I_{i=1\sim5}$ — I/P

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

3x3 1x5 (1x3) X5 images (1x3) X5 images — I/P: corner points of the chessboard in 2D image coordinate for 5 images

2) Input a word less than 6 character 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+7, 0+5, -2], [2+7, 0+5, 0]],
[[0+7, 0+5, -2], [2+7, 0+5, -1]],
[[2+7, 0+5, -1], [0+7, 0+5, 0]]]

pointA pointB

newCharPoints = [[[949, 1054], [831, 1194]],
[[1083, 1026], [891, 1122]],
[[891, 1122], [962, 1176]]] 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 — I/P I/P I/P I/P

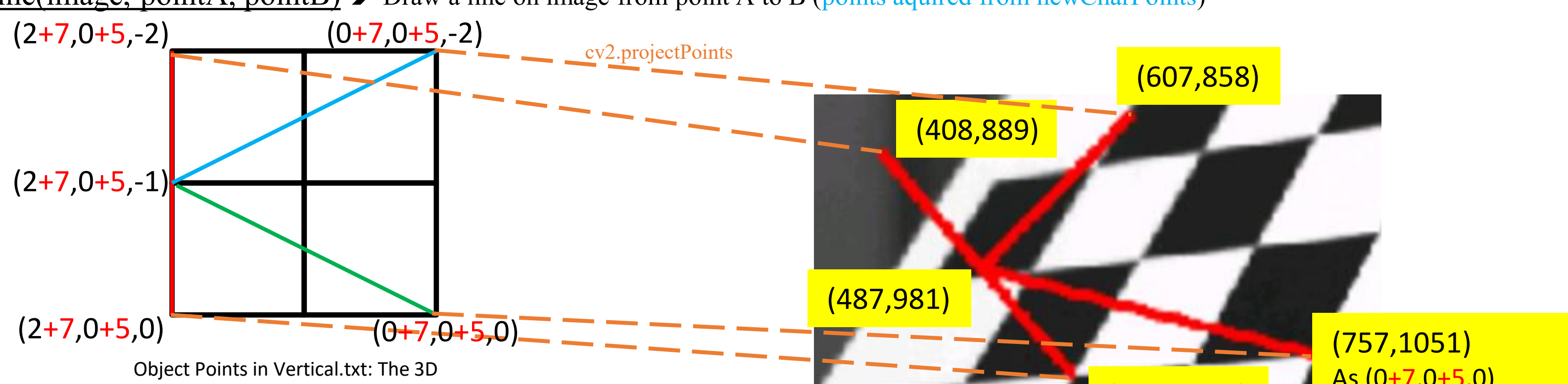
newCharPoints = cv2.projectPoints(charPoints, ins, dist, rvec, tvec)

➔ Get transformed 2D corner points of each charater. Total 6 characters. The position of each character is in order over 6 positions.

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

I/P I/P I/P

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

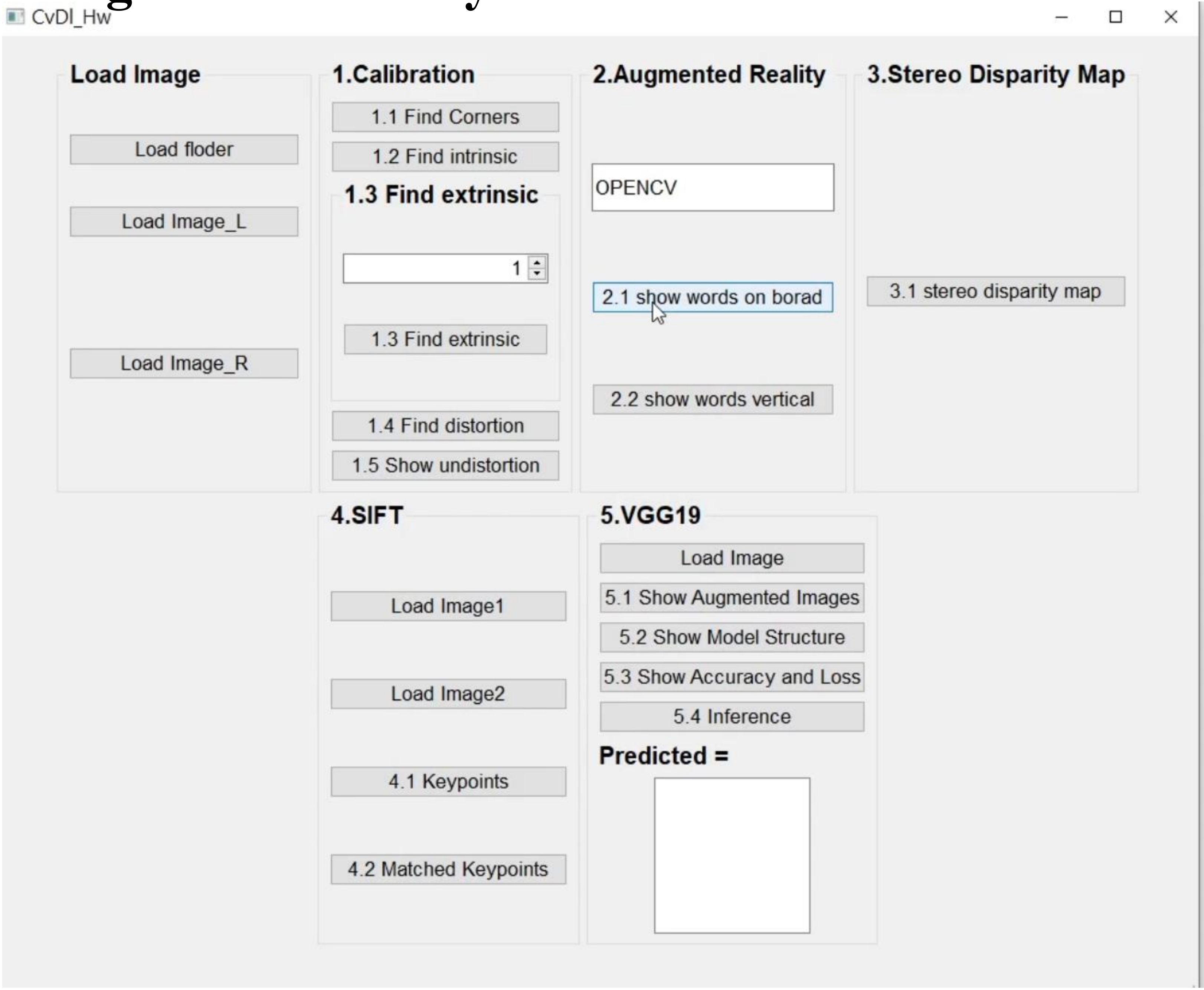


Object Points in Vertical.txt: The 3D world coordinates = 3D object coordinates (X, Y=0, Z)

New Object Points on 2D image coordinate

2. Augmented Reality – Demo Video

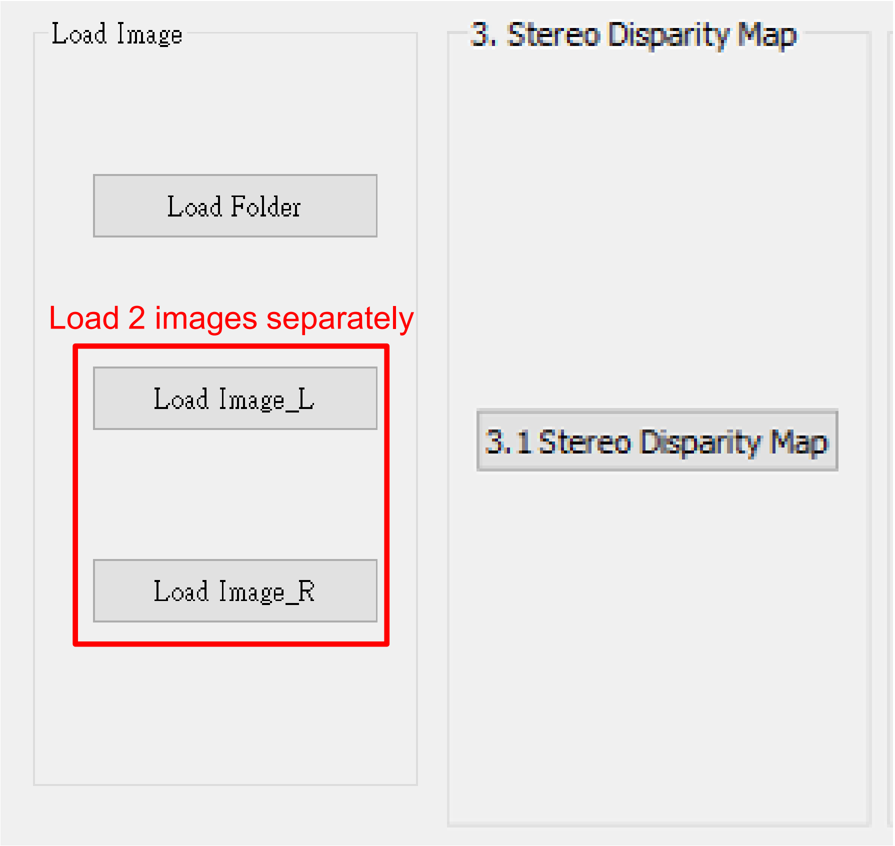
(出題： Yiyu)



3. Stereo Disparity Map

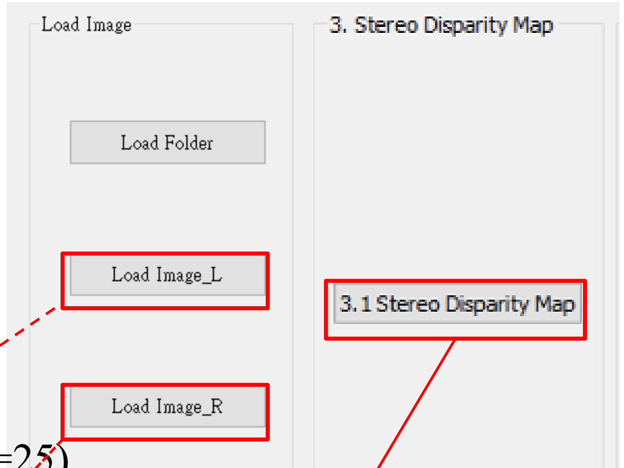
(出題：Tien)

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 imgL.png (click "Load Image_L"). (Input)
   2) Load imgR.png (click "Load Image_R"). (Input)
   3) Click button "3.1 Stereo Disparity Map" (Output) to show result.

Hint:

(BM: Block Matching)

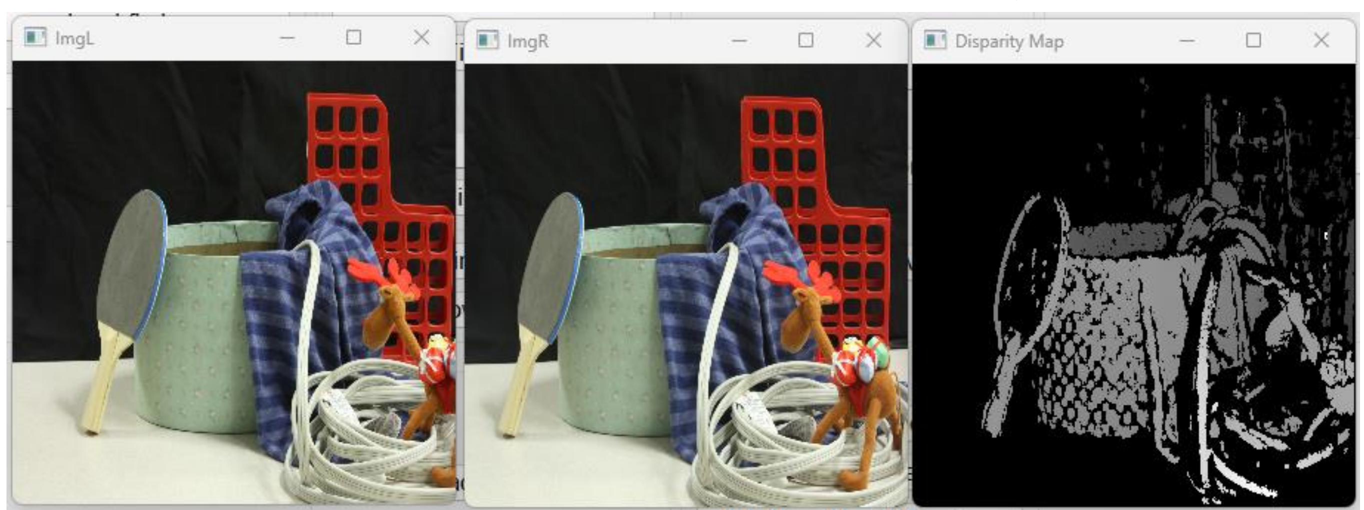
Usually max disparity is less than 64 pixels

1. Use OpenCV StereoBM class to build StereoBM objects.
2. class stereo = cv2.StereoBM.create(**numDisparities**=432, **blockSize**=25)
3. disparity (Output) = stereo.compute(**imgL,imgR**) (Input)
4. Show the Disparity Map (Normalize [Min, Max] of disparity value 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 window (block) size compared by the algorithm, must be odd and within the range [3, 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.

➢ Hint: OpenCV Textbook Chapter 12 (P.451)
StereoBM::create(432, 25)

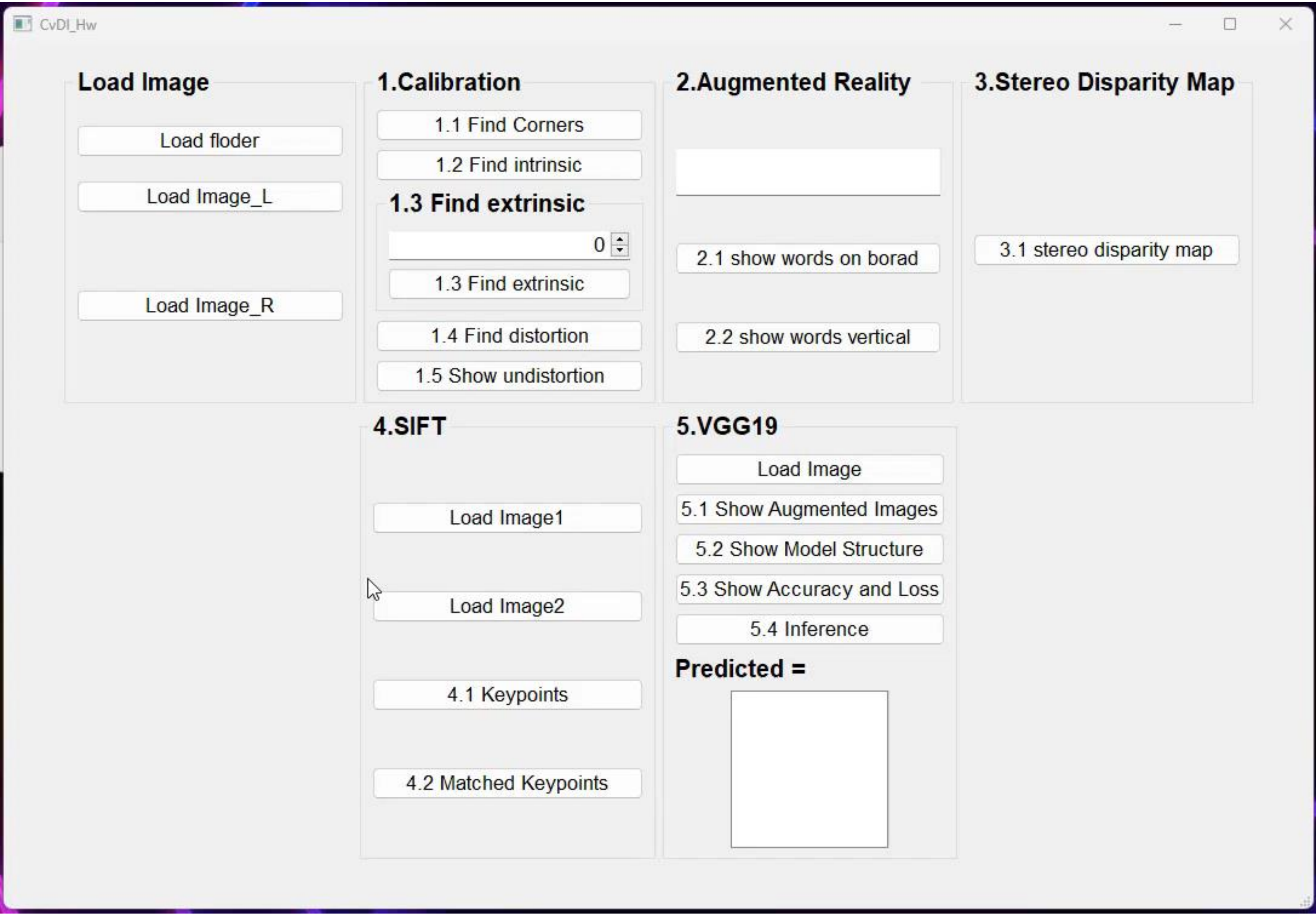
BlockSize = Window size

Both input image are W: 2816 pixel, H: 1916 pixel



3. Stereo Disparity Map - Demo Video

(出題：Tien)

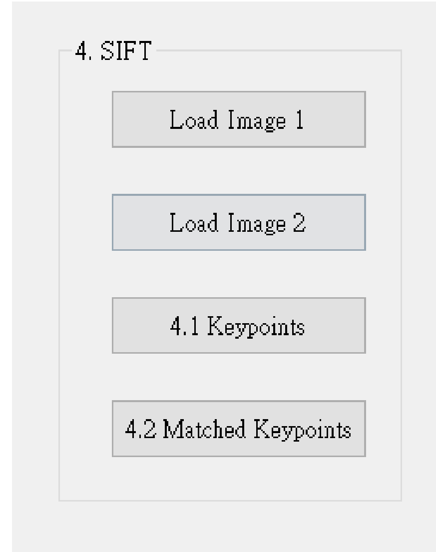


4. SIFT

(出題：Ian)

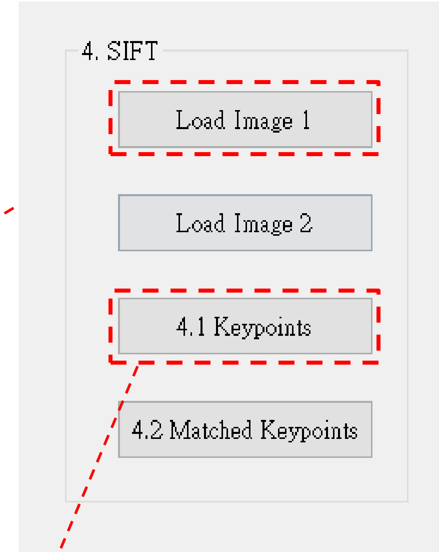
4.1 SIFT Keypoints

4.2 Matched Keypoints



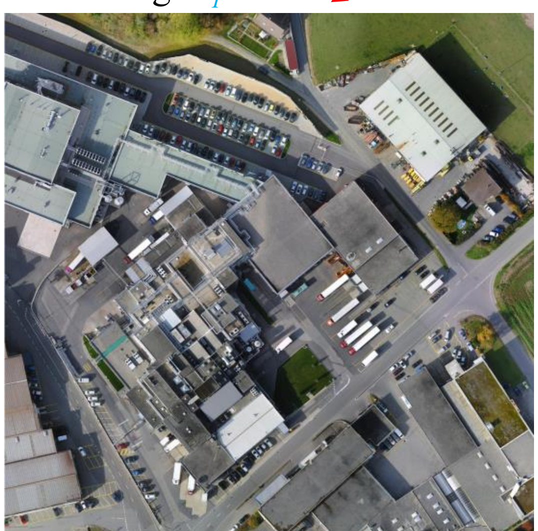
4.1 SIFT Keypoints

(出題： Ian)



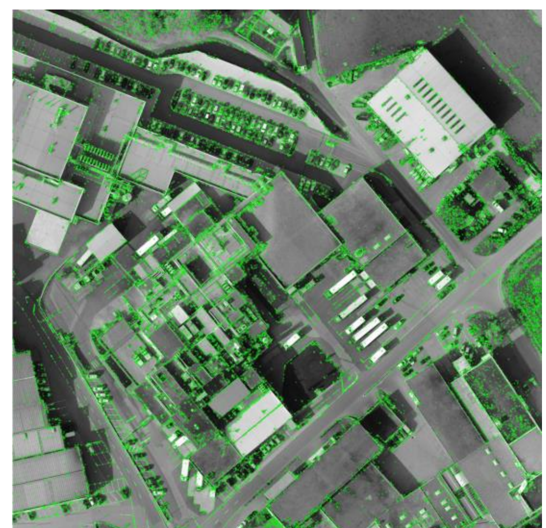
1. - Click button “Load Image 1” to load Left.jpg.
   - Click button “4.1 Keypoints” to show:
   1) Convert image to grayscale image.
      - O/P I/P
        gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
   2) Based on SIFT algorithm, find keypoints on Left.jpg.
      - Use OpenCV SIFT detector to detect keypoints and descriptors.
      - sift = cv2.SIFT_create()   # Create a SIFT detector
      - O/P O/P I/P
        keypoints, descriptors = sift.detectAndCompute(gray, None)
        # Many SIFT keypoints (contain coordinate, size, angle, etc.),
        each keypoint has its descriptor(1x128)
   3) Then draw the keypoints of Left.jpg as I_1.
      - keypoints color
        I/P I/P b g r
        img = cv2.drawKeypoints(gray, keypoints, None, color=(0,255,0))
   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 (O/P) = cv2.BFMatcher().knnMatch(descriptors1 (I/P), descriptors2 (I/P), k=2)

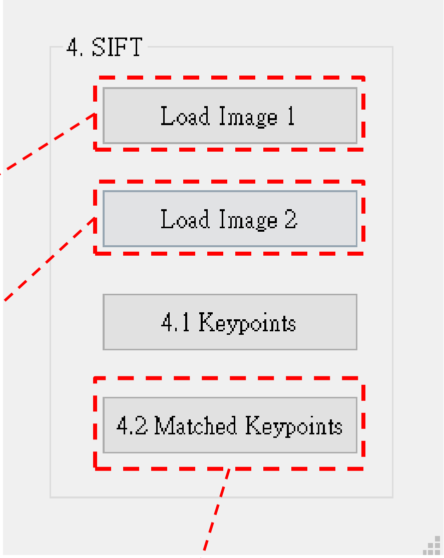
      matches[m,n]: two (k=2) closest matched keypoints for each keypoint of Left.jpg. m is the closest, n is the second closest.
   3) Extract Good Matches from 2) result:
      - Hint:

```
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 m is much smaller than the distance to the second closest n, 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, keypoints1, gray2, keypoints2, good_matches,
    None, flags=cv2.DrawMatchesFlags_NOT_DRAW_SINGLE_POINTS)
```

      (I/P: gray1, keypoints1, gray2, keypoints2, good_matches)
   5) Please show image I_2

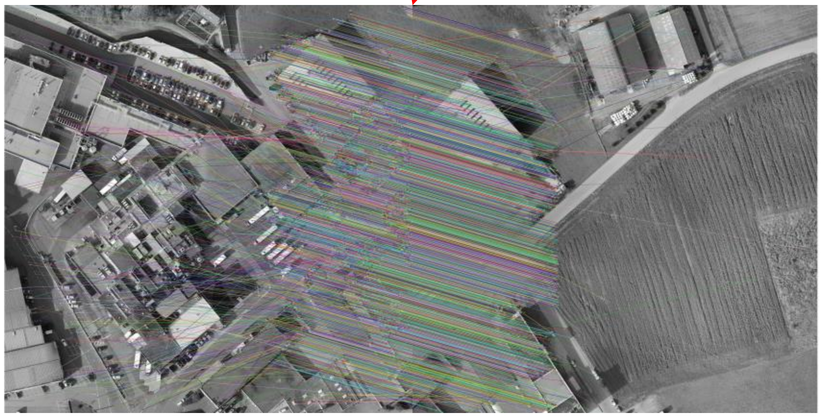


Input:

Left.jpg

Right.jpg

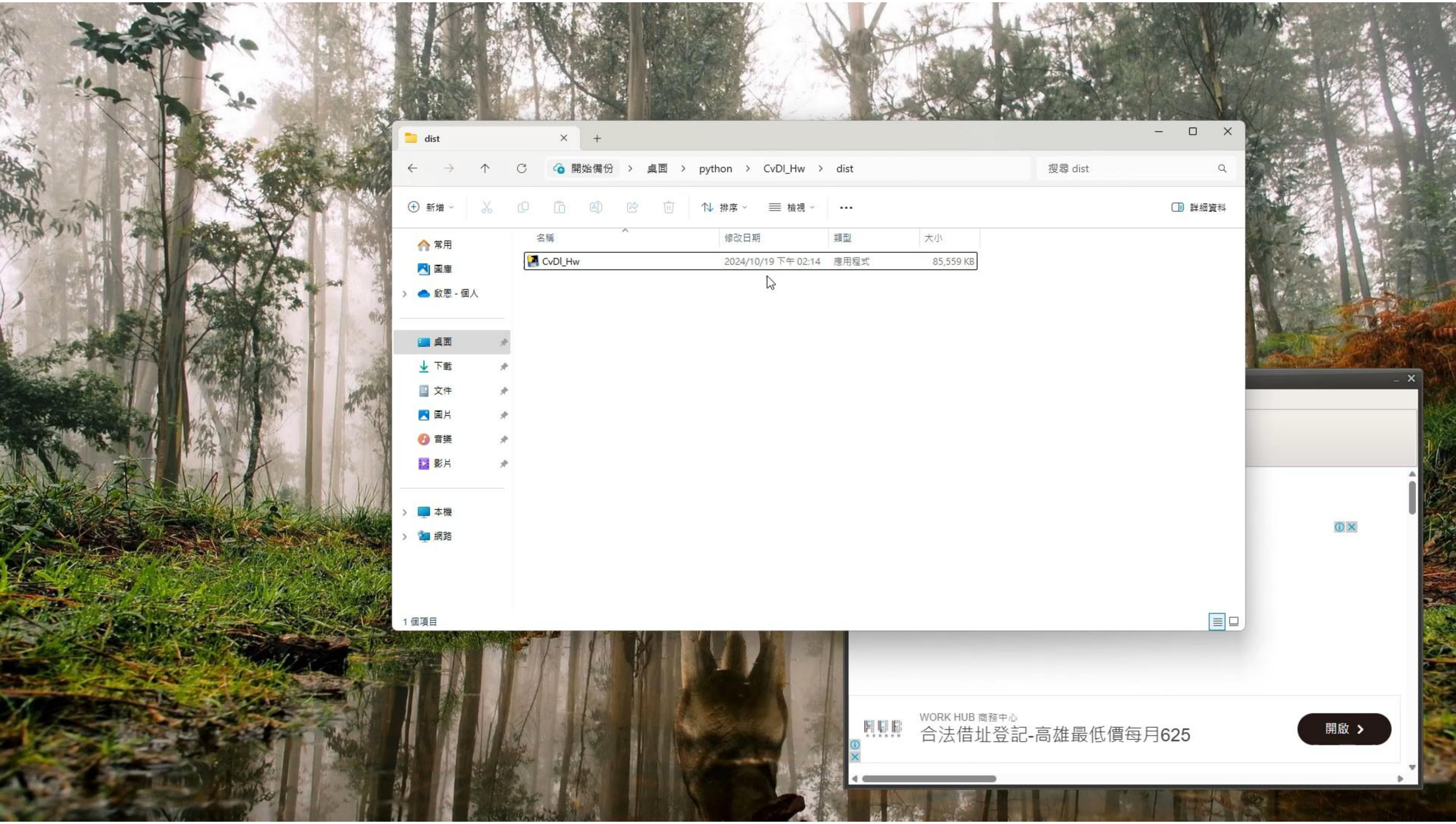
Output:



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
歐恩 - 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