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

TA:
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Office Hour: 09:00~11:00, Wed.
19:00~21:00, Mon.
At CSIE 9F Robotics Lab.

Notices (1/2)

- Copying homework is strictly prohibited!! Penalty: Grade will be zero for both persons!!
- If the code can't run, you can come to our Lab within one week and show that your programming can work. Otherwise you will get zero!!
- Due date => 2019/11/06 (Wed.) 23:59:59
  - No delay. If you submit homework after deadline, you will get 0.
- Upload to => 140.116.154.1 -> Upload/Homework/HW1
  - User ID: cvdl2019 Password: cvdl2019
- Format
  - Filename: Hw1_StudentID_Name_Version.rar
    - Ex: Hw1_F71234567_林小明_v1.rar
    - If you want to update your file, you should update your version to be v2, ex: Hw1_F71234567_林小明_v2.rar
  - Content: project folder*(including the pictures)
    *note: remove your "Debug" folder to reduce file size

Notices (2/2)

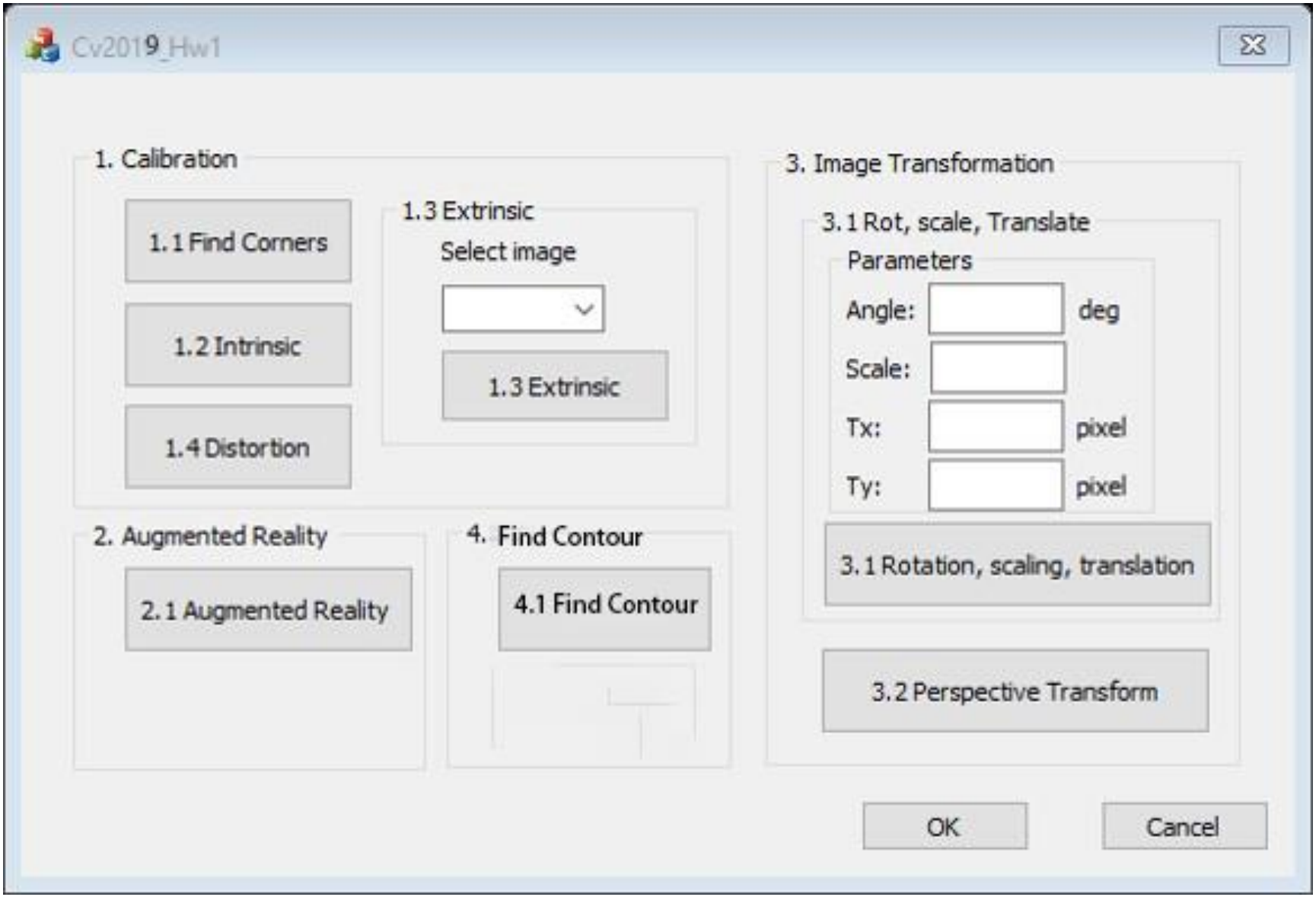
- C++ (check MFC guide in ftp)
  - OpenCV 3.3.1 (https://opencv.org/release.html)
  - Visual Studio 2015 (download from http://www.cc.ncku.edu.tw/download/)
  - UI framework: MFC
- Python
  - Python 3.7 (https://www.python.org/downloads/)
  - Tensorflow 2.0 / PyTorch 1.3.0
  - opencv-contrib-python (3.4.2.17)
  - Matplotlib 3.1.1
  - UI framework: pyqt5 (5.11.3)

Grading

0. Homework Format
1. (10%, reference) Camera Calibration (出題：Jang)
   - 1.1 Corner detection (0%)
   - 1.2 Find the intrinsic matrix (0%)
   - 1.3 Find the extrinsic matrix (0%)
   - 1.4 Find the distortion matrix (0%)
2. (20%) Augmented Reality (出題：Jang)
3. (10%, reference) Image Transformation (出題：YiYuan)
   - 3.1 Rotation, scaling, translation (0%)
   - 3.2 Perspective transform (0%)
4. (10%, reference) Find Contour (出題：Rex)
5. (50%) Training Cifar-10 classifier using LeNet (出題：Michael)

0. Homework Format

- Use MFC to create GUI like following picture



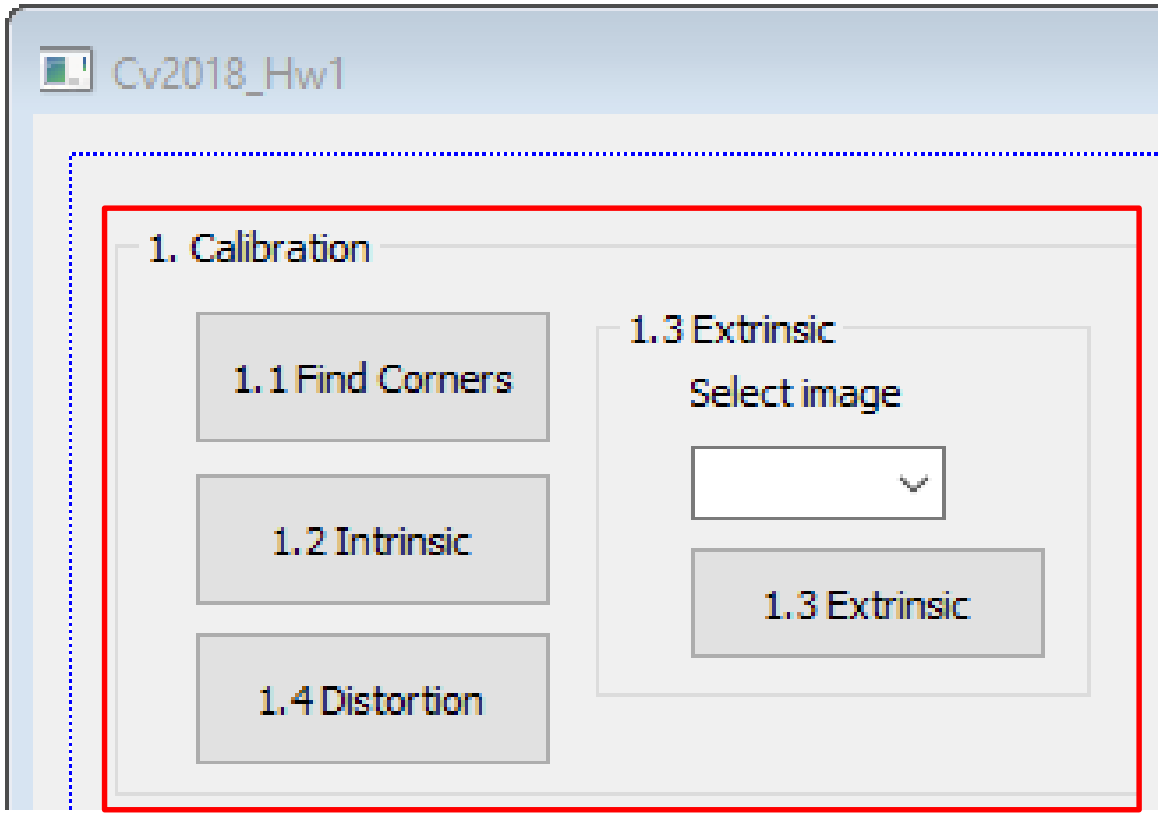
1. Camera Calibration (出題：Jang)

1.1 Corner detection

1.2 Find the intrinsic matrix

1.3 Find the extrinsic matrix

1.4 Find the distortion matrix

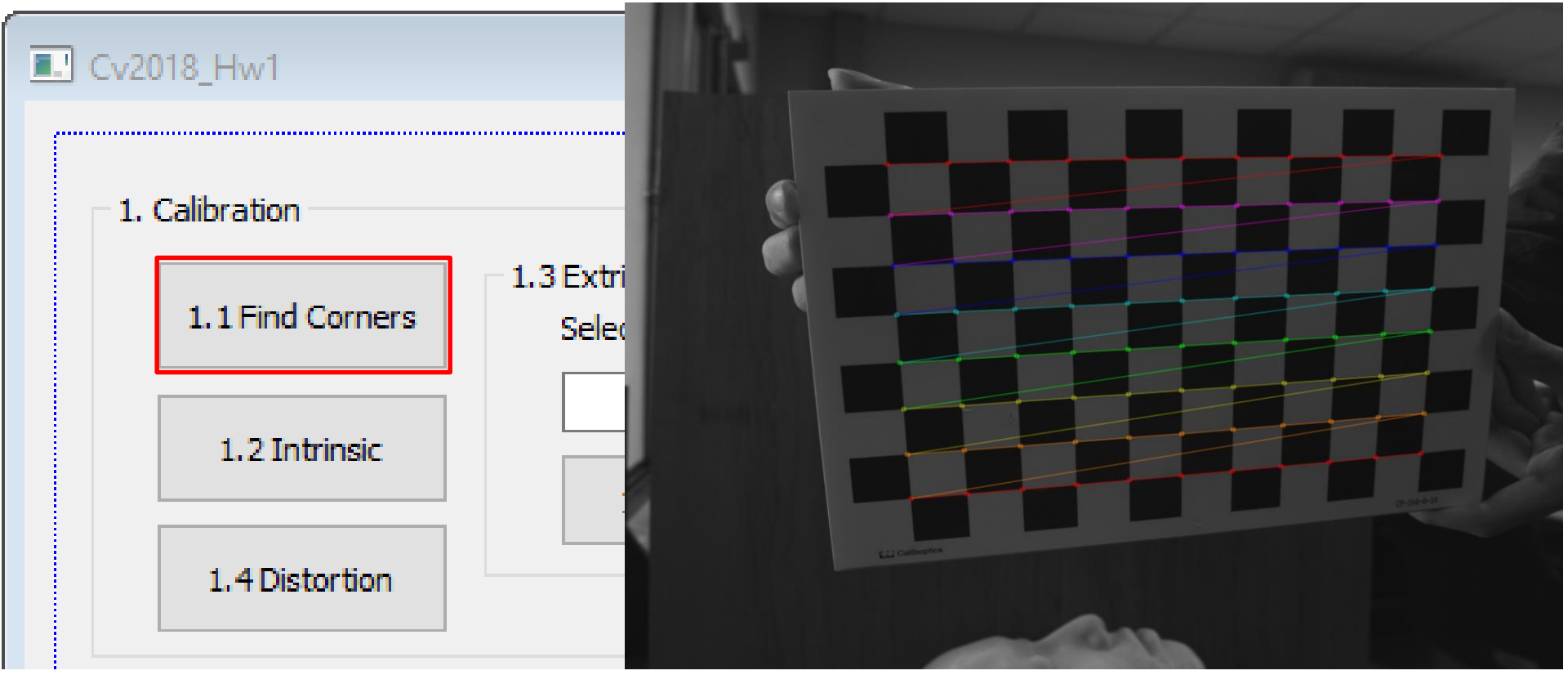


1.1 Corner Detection

- Given: 15 images, 1.bmp ~ 15.bmp
- Q: 1) Find and draw the corners on the chessboard for each image.
  2) Click button “1.1” to show the result.
- Hint :

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

  cvShowImage(…);
- Ex:



1.2 Find the Intrinsic Matrix

- Given: 15 images, 1.bmp ~ 15.bmp
- Q: 1) Find the intrinsic matrix ():

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

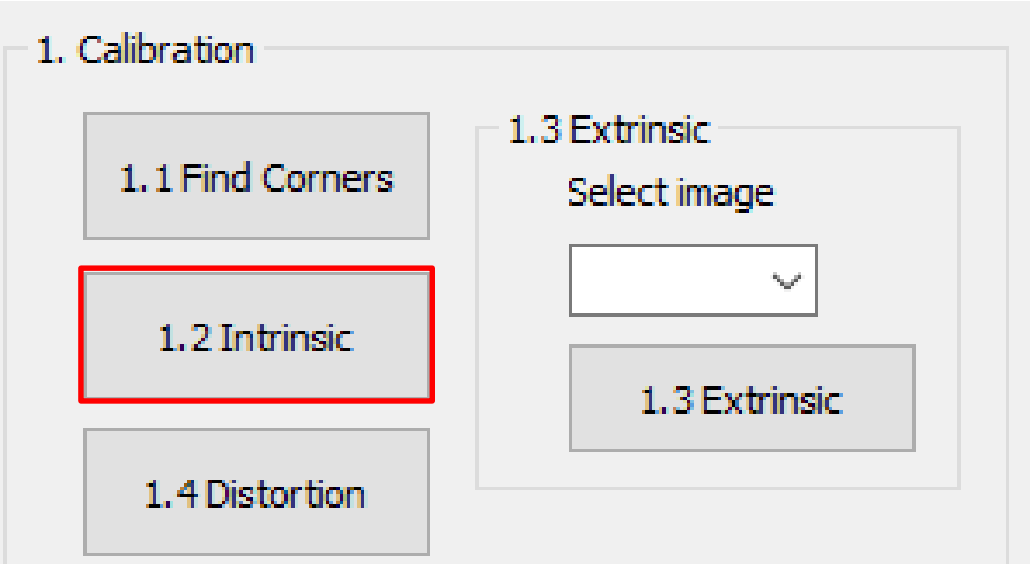
2) Click button “1.2” and then show the result on the console window.

- Output format:

```
[2227.333008, 0.000000, 384.186066;
0.000000, 2226.654541, 299.351746;
0.000000, 0.000000, 1.000000]
```

(Just an example)

- Hint: OpenCV Textbook Chapter 11 (P.398 ~ p.400)



1.3 Find the Extrinsic Matrix

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

$$\begin{bmatrix} R_{11} & R_{12} & R_{13} & T_1 \\ R_{21} & R_{22} & R_{23} & T_2 \\ R_{31} & R_{32} & R_{33} & T_3 \end{bmatrix}$$

2) Click button “1.3” and then show the result on the console window.

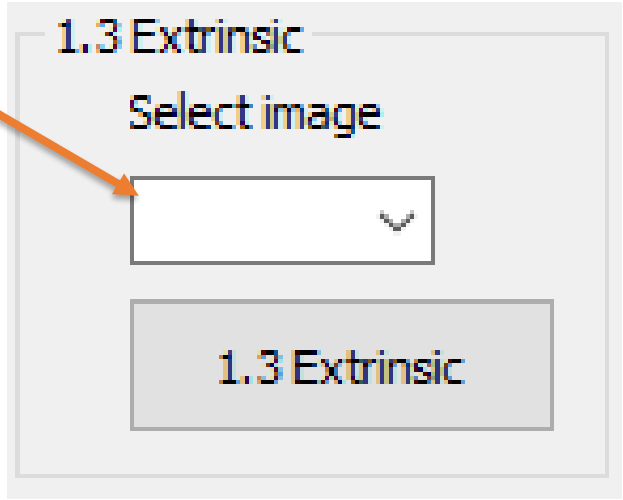
- Output format:

```
[-0.128827  ,0.991169  ,-0.031426  ,-1.969988 ;
0.983549  ,0.131755  ,0.123583  ,-1.105037 ;
0.126632  ,-0.014988  ,-0.991836  ,49.121323 ;  ]
```

(Just an example)

- Hint: OpenCV Textbook Chapter 11, p.370~402

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



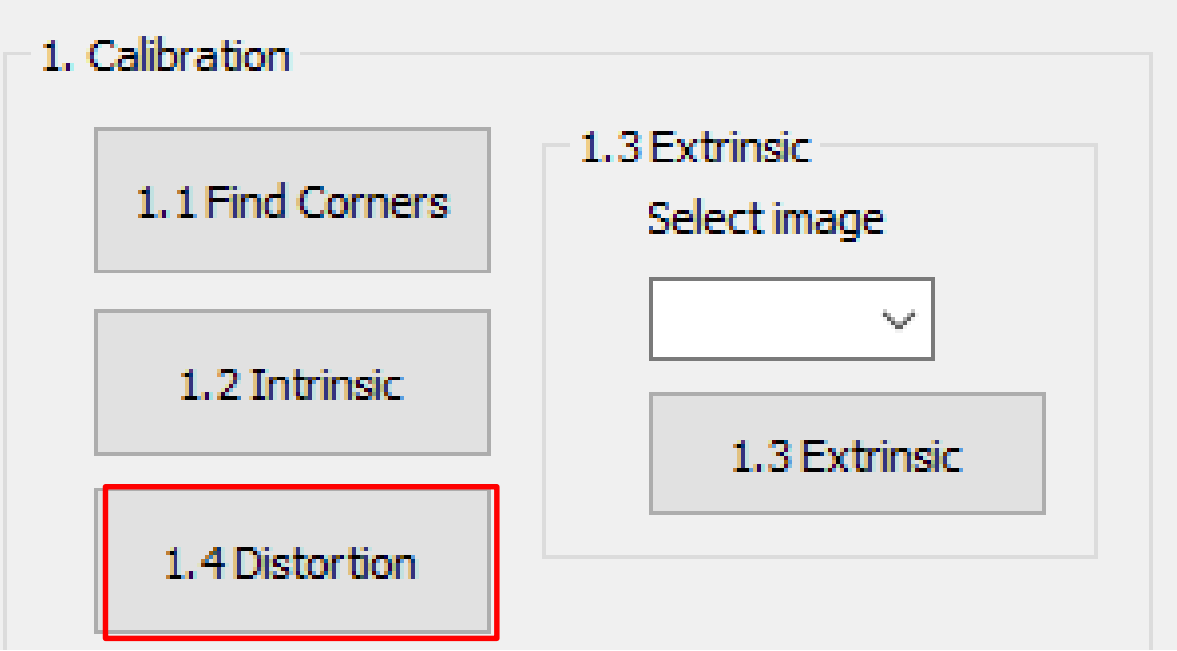
1.4 Find the Distortion Matrix

- Given: 15 images
- Q: 1) Find the distortion matrix: $[k_1, k_2, p_1, p_2, k_3]$
  2) Click button “1.4” to show the result on the console window.
- Output format:

```
[-0.072230, -0.261944, -0.000024, -0.003354, 4.228090]
```

(Just an example)

- Hint:
  - Distortion coefficients can be obtained simultaneously with intrinsic parameters
  - OpenCV Textbook Chapter 11 (P.398 ~ p.400)

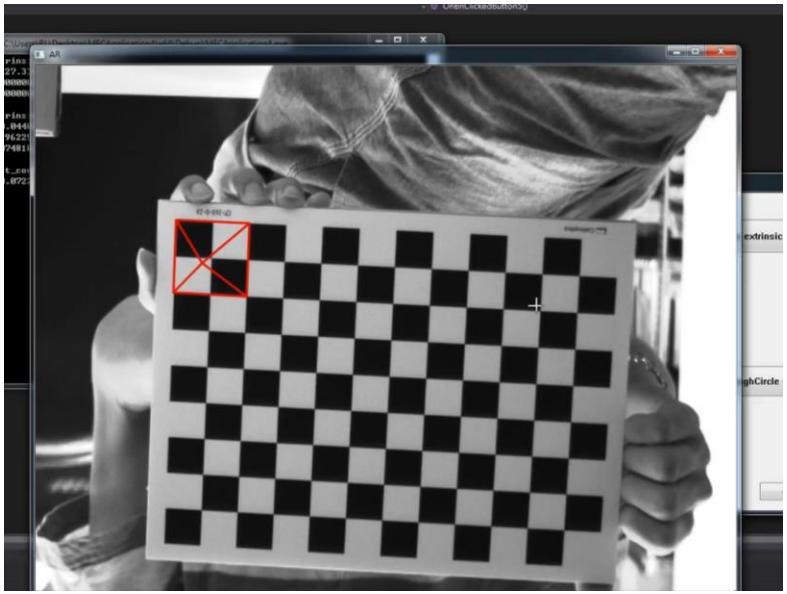


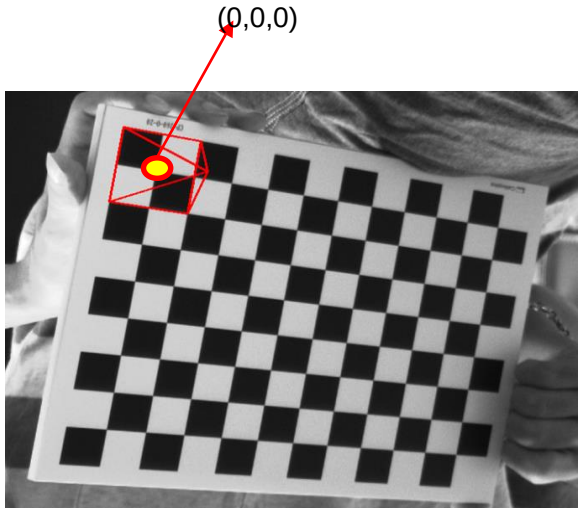
2. Augmented Reality (出題：Jang)

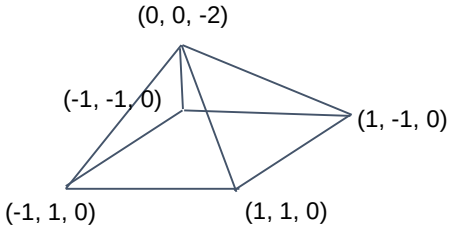
- Given: Intrinsic and extrinsic parameters, distortion coefficients, and 5 images: 1~5.bmp
- Q: 1) Draw a “pyramid” on the chessboard images (1.bmp to 5.bmp), then
  2) Click the button ”2” to show the pyramid on the picture. Show each picture for 0.5 seconds (total 5 images)
- Hint : Textbook Chapter 11, p.370~402

- 3D Object coordinates:
  Vertex (0, 0, -2)
  Corners(1, 1, 0)(1, -1, 0)(-1, -1, 0)(-1, 1, 0)

Demo video:







11

3.1 Transforms: Rotation, Scaling, Translation

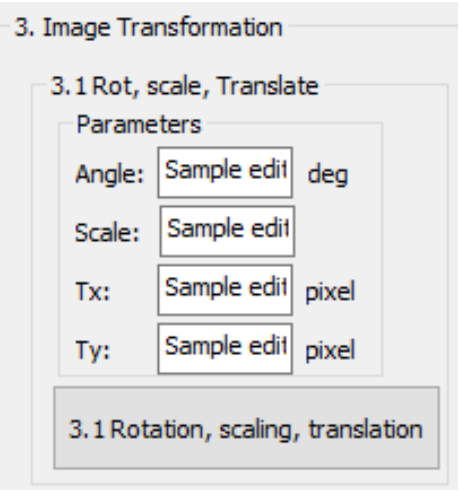
(出題：YiYuan) ??

- Given: ***OriginalTransform.png*** *image*
- Q: 1) Click button "**3.1**", ***OriginalTransform.png*** should be showed.
  2) Please rotate, scale and translate the small squared image (as Figure 3.1) with following parameters (should be entered in the GUI):
  (1) Angle = 45^0 (*counter-clockwise*)
  (2) Scale = 0.8,
  (3) Translation with:
  - $x_{new} = x_{old} + 150$ pixels = 130 + 150 = 280
  - $y_{new} = y_{old} + 50$ pixels = 125 + 50 = 175

  Point C (130,125) is center of small square image
- Hint :

  OpenCV Textbook Chapter 12 (p. 407 ~ p. 412)

  warpAffine(…);
- EX:



Small square image

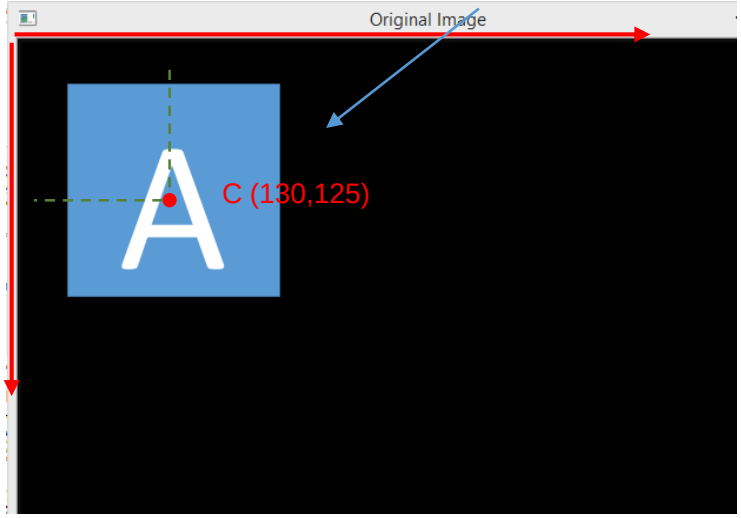


Figure 3.1 Original Image

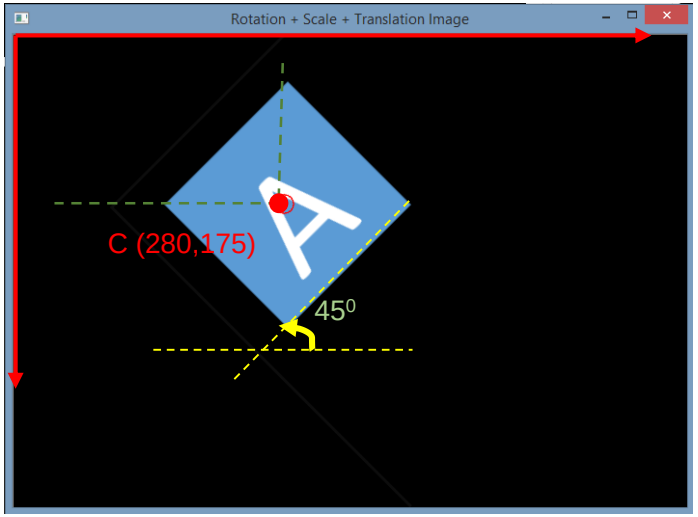
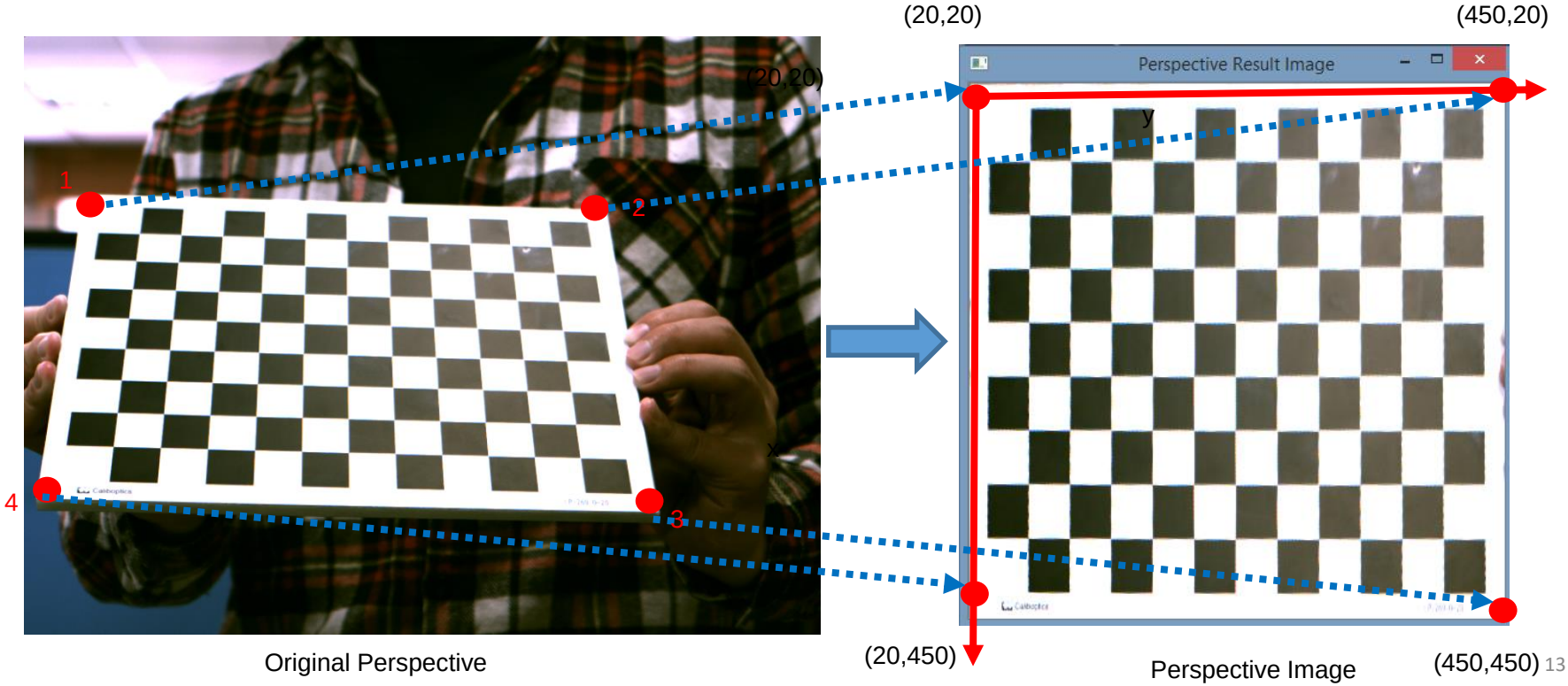


Figure 3.2 Rotation, Scale and Translation Image

3.2 Perspective Transformation (出題：YiYuan)

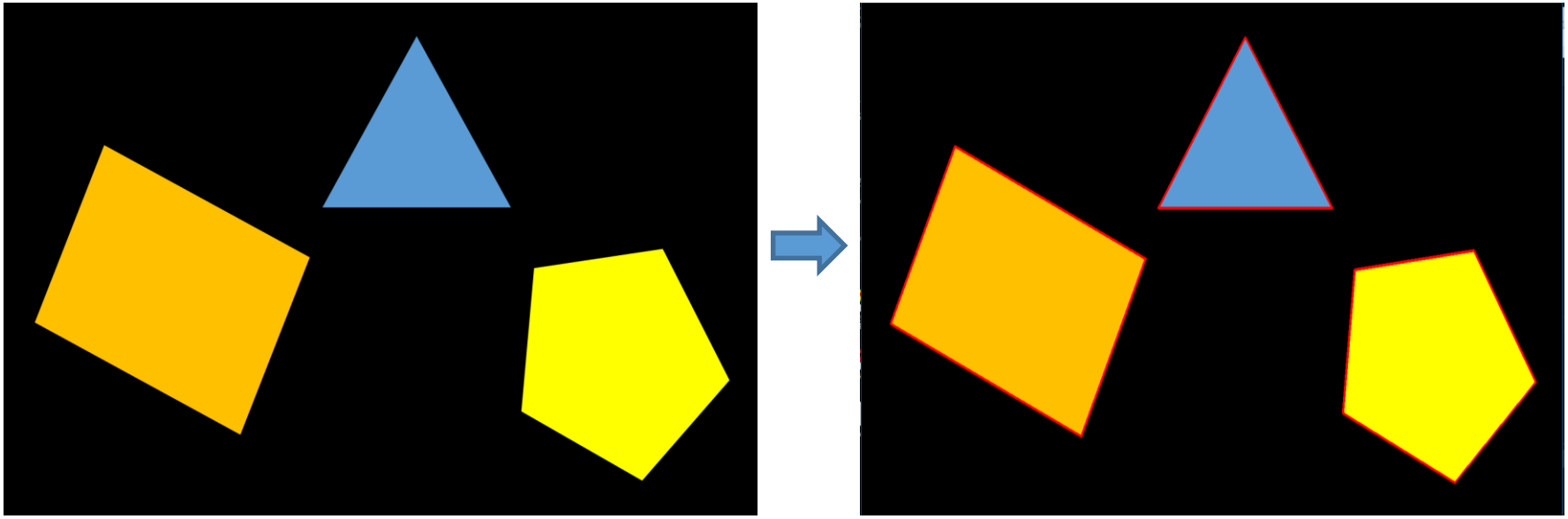
- Given: ***OriginalPerspective.png*** *image*
- Q: Use OpenCV functions to project the image
  1) Click button “3.2” to show image in the new window. Then do:
     a) Click 4 points showed in console window. (start from top-left corner of the original image, and then click clock-wise)
     b) Warp the original image to the location (20,20), (20,450), (450,450), (450,20). Open second window to show the result.
- Hint:
  - Textbook Chapter 6, p. 170~171
  - mouse callback function (p.96)



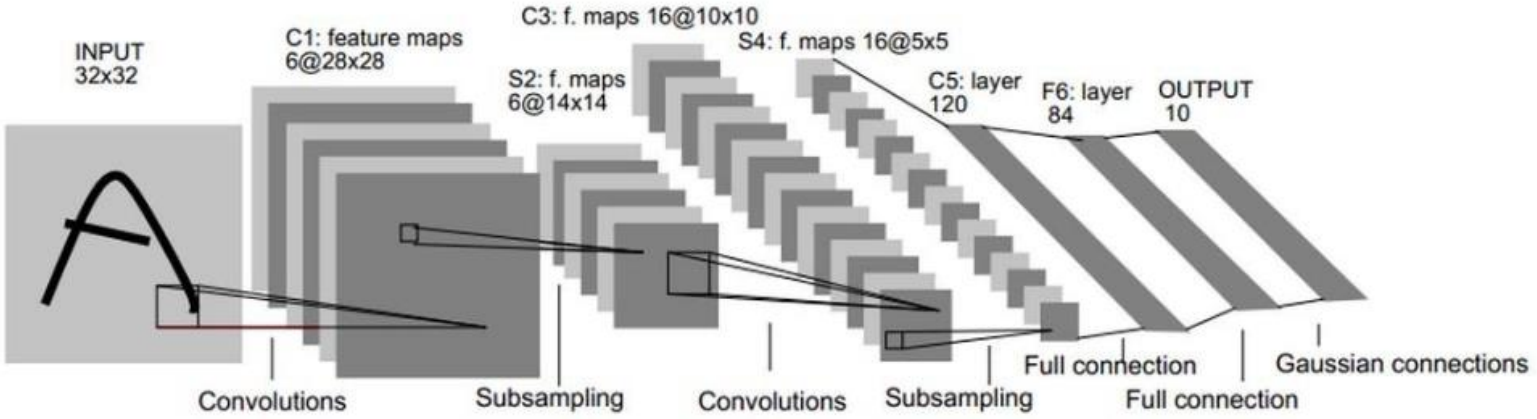
4.0 Find Contour (出題：Rex)

- Given: ***Contour.png*** *image*
- Q: Use OpenCV functions to find all the contours in the image
  1) Click button “4.1” to show image in the new window. Then draw the edges by red.

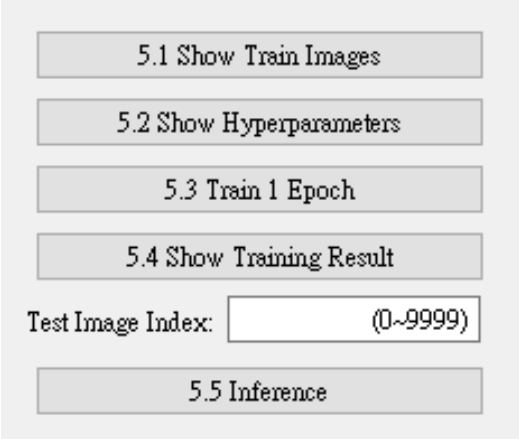
- Hint:
  - Textbook Chapter 8, p. 234~241



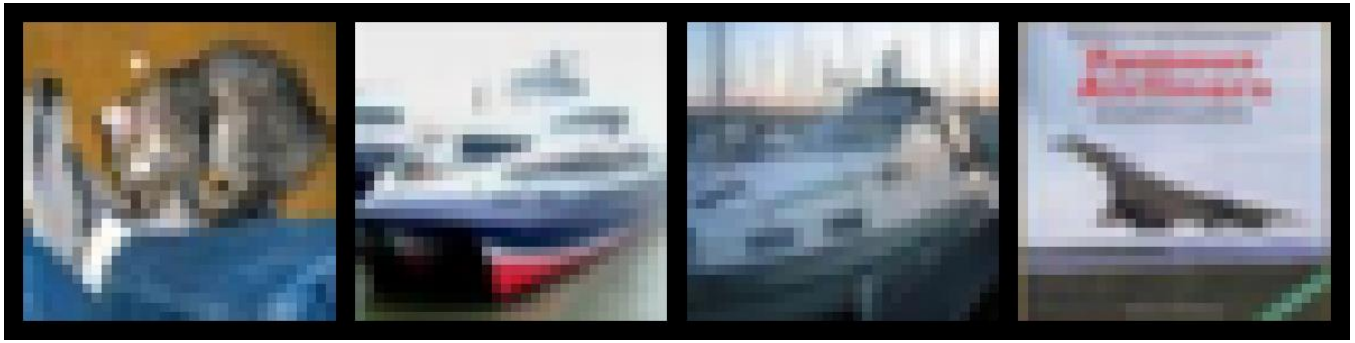
5.0 Train Cifar-10 Classifier Using LeNet-5 (出題：Michael)



1. Learn to construct LeNet-5 and train it by using data Cifar-10.
2. Environment Requirement
   1) Python 3.7
   2) Tensorflow 2.0 / PyTorch 1.3.0
   3) opencv-contrib-python 3.4.2.17
   4) Matplotlib 3.1.1
3. Reference
   1) Gradient-Based Learning Applied to Document Recognition (http://yann.lecun.com/exdb/publis/pdf/lecun-01a.pdf) (LeNet)
   2) Cifar-10 (https://www.cs.toronto.edu/~kriz/cifar.html)



5.1 Load Cifar-10 training dataset and randomly show 10 images and labels respectively. (10%)



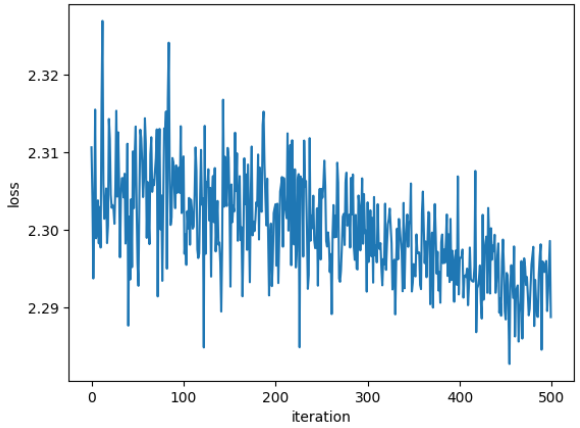
…

Label: cat ship ship airplane …

5.2 Print out training hyperparameters (batch size, learning rate, optimizer). (10%)

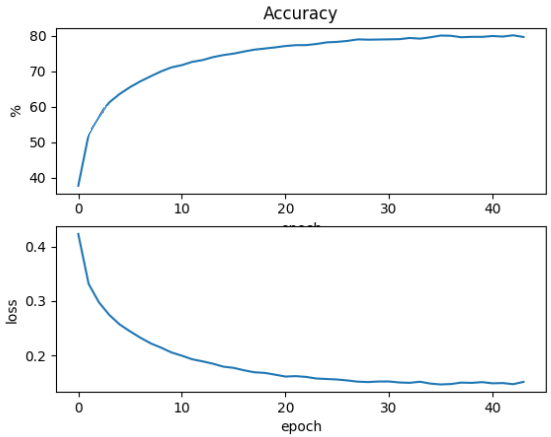
```
hyperparameters:
batch size: 32
learning rate: 0.001
optimizer: SGD
```

5.3 Train 1 epoch from initial status and show training loss at the end of the epoch. (10%)



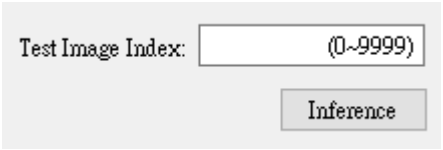
(Record loss per iteration)

5.4 Train your model at least 50 epochs by your own computer, save your model and take a screenshot of your training loss and accuracy. (10%)

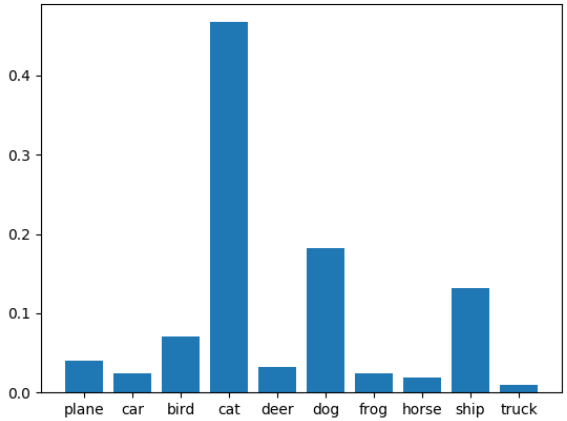


(Record accuracy/loss per epoch)

5.5 Load your model trained at 5.4. Let us choose one test image from Cifar-10 test images. Then inference the image, show image and estimate this test image. (10%)



Show image



Estimation result