電腦視覺與深度學習
(Computer Vision and Deep Learning)
Homework 2

TA:

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Office Hour: 17:00~19:00, Mon.

10:00~12:00, Wed.

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 => Midnight 23:59:59 on 2020/12/30 (Wed.)
  - No delay. If you submit homework after deadline, you will get 0.
- Upload to => 140.116.154.1 -> Upload/Homework/Hw2
  - User ID: cvdl2020 Password: cvdl2020
- Format
  - Filename: Hw2_StudentID_Name_Version.rar
    - Ex: Hw2_F71234567_ 林小明 _V1.rar
    - If you want to update your file, you should update your version to be V2, ex: Hw2_F71234567_ 林小明 _V2.rar
  - Content: project folder*(including the pictures)
    *note: remove your "Debug" folder to reduce file size

Notices (2/2)

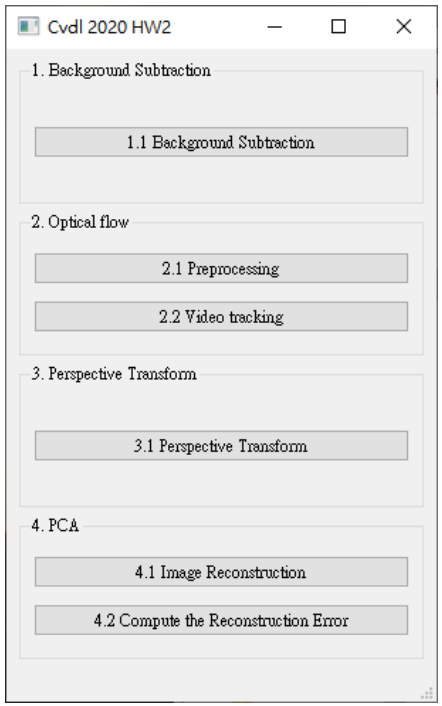
- Python
  - Python 3.7 (https://www.python.org/downloads/)
  - opencv-contrib-python (3.4.2.17)
  - Matplotlib 3.1.1
  - UI framework: pyqt5 (5.15.1)

- 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

Grading

1. (20%) Background Subtraction (出題： Brian)
2. (20%) Optical Flow (出題： Kevin)
   2.1 Preprocessing (10%)
   2.2 Video tracking (10%)
3. (20%) Perspective Transform (出題： Max)
4. (20%) PCA (出題： Mark)
   4.1 Image Reconstruction (10%)
   4.2 Compute the reconstruction error (10%)
5. (20%) Dogs and Cats classification Using ResNet50 (出題： Bill)

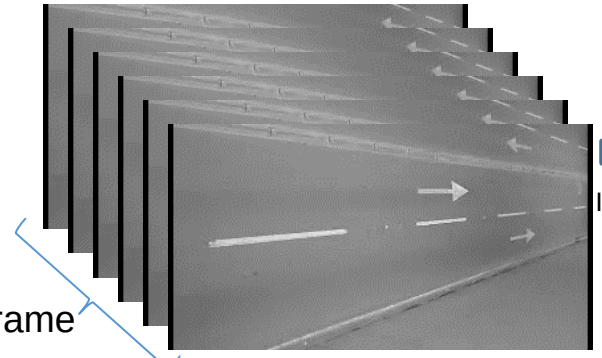
UI example



1. (20%) Background Subtraction: Simple Gaussian Model (1/2) （出題： Brian)

- Given a video: bgSub.mp4
- Q: 1) Click the button “1.1 Background Subtraction” to open two windows:
  - One shows the original video: bgSub.mp4
  - The other is the **foreground video**.
  - Use first 50 frames to build the background model
  - DO NOT use OpenCV function `cv2.createbackgroundSubstractor()`

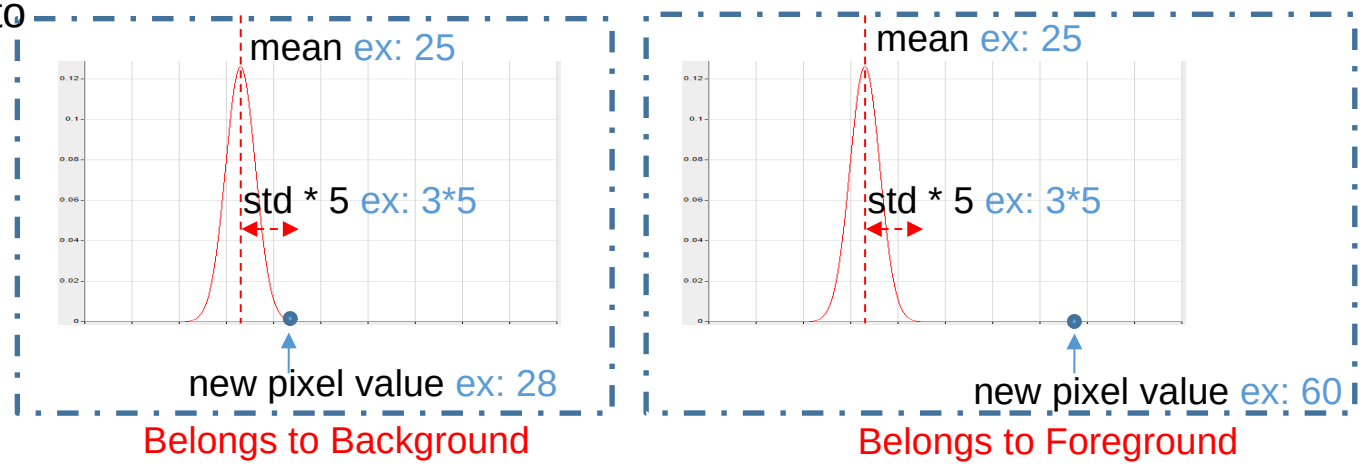
1. Build background model



Output: w x h gaussian models (mean and std)

2. Test new pixel belongs to background or foreground

Ex:
Mean = 25
Std (standard deviation) = 3



1. (20%) Background Subtraction: Simple Gaussian Model (2/2)　（出題： Brian)

- Hint : (1) Convert video frames to gray
  (2) For every pixels in video from 0~50 frames, build a gaussian model with mean and standard deviation (if standard deviation is less then 5, set to 5)
  (3) For frame > 50, test every frame pixels with respective gaussian model. If gray value difference between testing pixel and gaussian mean is larger than 5 times standard deviation, set testing pixel to 255 (foreground, white), 0 (background, black) otherwise.
- Demo video:

2. (20%) Optical Flow

(出題： Kevin)

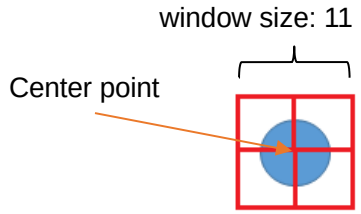
2.1 Preprocessing (10%)

2.2 Video tracking (10%)

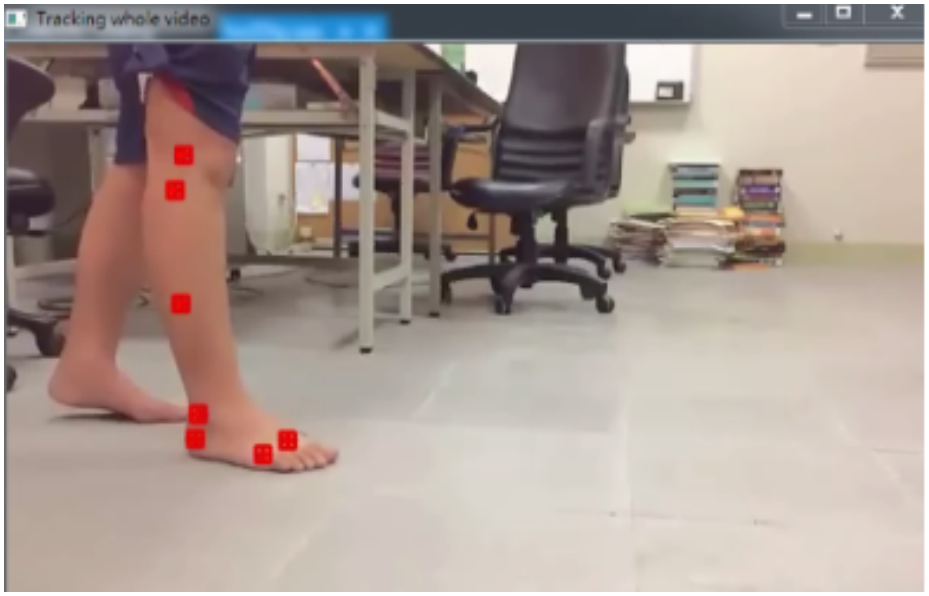
2.1 Preprocessing (10%)

(出題： Kevin)

- Given a video: opticalFlow.mp4
- Q: Click the button to show the square boundary with red cross mark (not red filled like the ex. image).

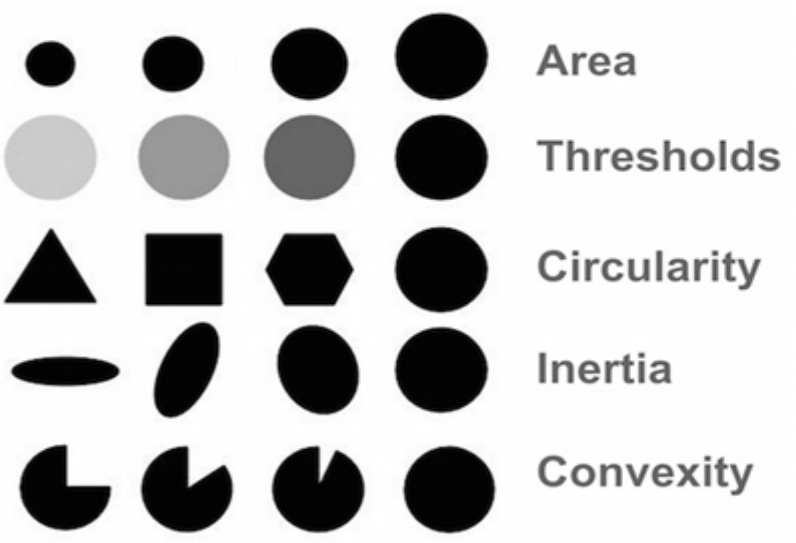


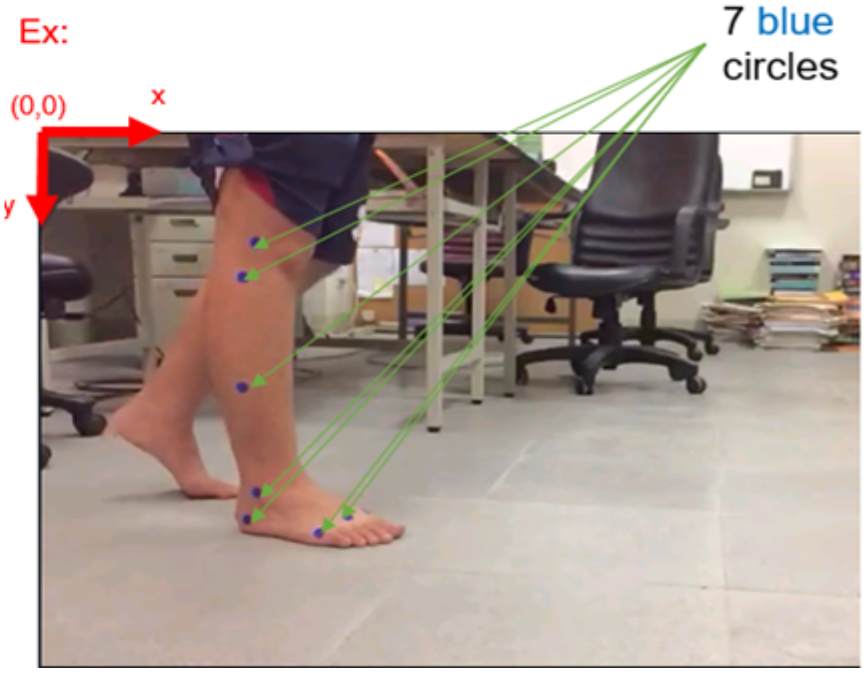
Ex:



How to detect 7 center points of 7 blue circles

- You can use `cv2.SimpleBlobDetector()` to detect blobs (binary large object), it can filter out blobs by examining their:
  1) Area (size)
  2) Thresholds (gray level)
  3) Circularity (if perfect circle, then it is 1.0)
  4) Inertia (**ratio of the minor and major axes)**
  5) Convexity (if no gap, then it is 1.0)





2.2 Video tracking (10%)

(出題： Kevin)

- Q: Click button to:
  1) (5%) Track the 7 center points on the whole video using OpenCv function `cv2.calcOpticalFlowPyrLK`.

     Ex: https://github.com/opencv/opencv/blob/master/samples/cpp/lkdemo.cpp
  2) (5%) Connect 7 corresponding tracking points of all frames (the whole video) to get 7 trajectories (flow). Ex: the demo video.

Demo video:

- Tool site:
  1. Load video
  2. Circle detect
  3. Optical flow

※ Tracking process may be fail, you should make the result as good as possible (at least 4~5 points success)

3. (20%) Perspective Transform: (出題： Max)

- Given a video: test4perspective.mp4
- Q: 1) Click the button “ 3.1 Perspective Transform” to show and save result video:
- Hint : (1) Read the test video and process frame by frame
  (2) Detect the ArUco maker inside the frames
  (3) Get the pixel position (x,y) of four makers in the frame
  (4) Do perspective transform
  (5) Show result video and save it

Next page will show you how to detect ArUco Maker

Please do perspective transform by you own with opencv

- Demo video:

❑ Hints: How to use ArUco Makers (1/2)

(出題： Max)

Step 1: You need to dectect the aruco makers inside each frame as below

```
while cv.waitKey(1) < 0:
    try:
        # get frame from the video
        hasFrame, frame = cap.read()

        # Load the dictionary that was used to generate the markers.
        dictionary = cv.aruco.Dictionary_get(cv.aruco.DICT_6X6_250)

        # Initialize the detector parameters using default values
        parameters = cv.aruco.DetectorParameters_create()

        # Detect the markers in the image
        markerCorners, markerIds, rejectedCandidates = cv.aruco.detectMarkers(
            frame, dictionary, parameters=parameters)
```

Step 2: Then you can get the pixel value of each makers, for example you can get pixel value of makers which's ID is 25

```
index = np.squeeze(np.where(markerIds == 25))
refPt1 = np.squeeze(markerCorners[index[0]])[1]
```

❑ Hints: How to use ArUco Makers (2/2)

(出題： Max)

Step 3: Then calculate the four edges of the region you want to perspective,

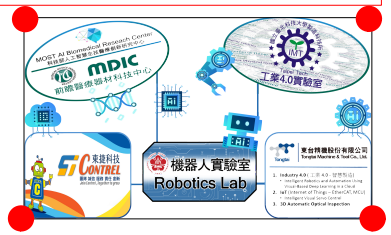
pts_dst are four points


```
index = np.squeeze(np.where(markerIds == 25))
refPt1 = np.squeeze(markerCorners[index[0]])[1]

index = np.squeeze(np.where(markerIds == 33))
refPt2 = np.squeeze(markerCorners[index[0]])[2]

distance = np.linalg.norm(refPt1-refPt2)

scalingFac = 0.02
pts_dst = [
    [refPt1[0] - round(scalingFac*distance), refPt1[1] - round(scalingFac*distance)]]
pts_dst = pts_dst + \
    [[refPt2[0] + round(scalingFac*distance),
      refPt2[1] - round(scalingFac*distance)]]

index = np.squeeze(np.where(markerIds == 30))
refPt3 = np.squeeze(markerCorners[index[0]])[0]
pts_dst = pts_dst + \
    [[refPt3[0] + round(scalingFac*distance),
      refPt3[1] + round(scalingFac*distance)]]

index = np.squeeze(np.where(markerIds == 23))
refPt4 = np.squeeze(markerCorners[index[0]])[0]
pts_dst = pts_dst + \
    [[refPt4[0] - round(scalingFac*distance),
      refPt4[1] + round(scalingFac*distance)]]

pts_src = [[0, 0], [im_src.shape[1], 0], [
    im_src.shape[1], im_src.shape[0]], [0, im_src.shape[0]]]
```

Find makers 25,33

Calculate the edge points for perspective

pts_src are also four points

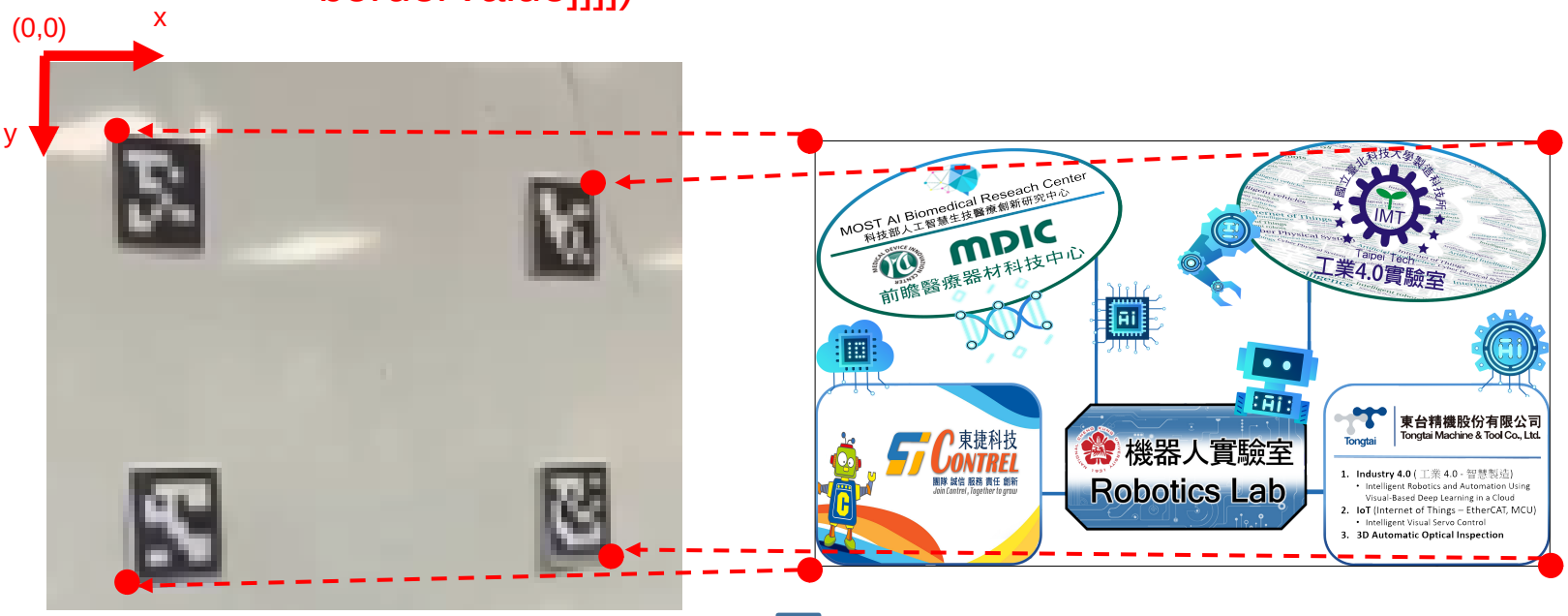


3. (20%) Perspective Transform: (出題： Max)

- ❑ Do the perspective transform
  - The function you will use for perspective transform

retval, mask=cv2.findHomography(srcPoints, dstPoints[, method[, ransacReprojThreshold[, mask[, maxIters[, confidence]]]]])

dst = cv2.warpPerspective(src, M, dsize[, dst[, flags[, borderMode[, borderValue]]]])



Result:

4. (20%) PCA

(出題： Mark)

4.1 Image Reconstruction (10%)

4.2 Compute the reconstruction error (10%)

4.1 (10%) PCA - Image Reconstruction (1/2) (出題：Mark)

- Given: Images of school badge
- Q1: Using PCA to do dimension reduction then reconstruct, click button "4.1 Image Reconstruction" and show original and reconstructed images.
- Hint: Use PCA from python library `sklearn.decomposition`

4.2 (10%) PCA - Compute the Reconstruction Error (2/2)

(出題： Mark)

- Given: Images of school badge
- Q2: Computing the reconstruction error (RE) for each school badge, and click button “4.2 Compute the reconstruction error” and print out on the console.
- EX:

```
[493174, 482253, 524416, 487007, 502523, 942532, 521524, 433513, 758603, 620116, 652831, 574274, 592094, 878298, 537152, 558690, 490437, 828428, 910308, 666765, 66006
```

Using the reference formula as shown below:

- Hint:

 is the modified result after the reconstruction

(which is)

You should do post processing such as normalization to make the gray value fall in the range [0, 255]

3.0 (20%)Dogs and Cats classification Using ResNet50 (出題： Bill)

1) Dataset introduction:

(1) ASIRRA (Animal Species Image Recognition for Restricting Access) is a HIP(Human Interactive Proof) that works by asking users to identify photographs of cats and dogs, that's supposed to be easy for people to solve, but difficult for computers. Now we can use artificial intelligence technology to achieve this goal.

(2) The dataset includes 12501 photos of cats and 12501 photos of dogs. You need to download them in Reference below(R2), and split the training set, validation set and test set by yourself.

2) Objective:

- You need to use python to write the ResNet network and complete the questions on the next few pages.

3) Environment Requirement

(1) Python 3.6
(2) Tensorflow 1.14
(3) Opencv-contrib-python 4.1.1 (for image show and write)

layer name	output size	18-layer	34-layer	50-layer	101-layer	152-layer
conv1	112×112	7×7, 64, stride 2				
		3×3 max pool, stride 2				
conv2_x	56×56	$\begin{bmatrix} 3\times3, 64 \\ 3\times3, 64 \end{bmatrix}\times2$	$\begin{bmatrix} 3\times3, 64 \\ 3\times3, 64 \end{bmatrix}\times3$	$\begin{bmatrix} 1\times1, 64 \\ 3\times3, 64 \\ 1\times1, 256 \end{bmatrix}\times3$	$\begin{bmatrix} 1\times1, 64 \\ 3\times3, 64 \\ 1\times1, 256 \end{bmatrix}\times3$	$\begin{bmatrix} 1\times1, 64 \\ 3\times3, 64 \\ 1\times1, 256 \end{bmatrix}\times3$
conv3_x	28×28	$\begin{bmatrix} 3\times3, 128 \\ 3\times3, 128 \end{bmatrix}\times2$	$\begin{bmatrix} 3\times3, 128 \\ 3\times3, 128 \end{bmatrix}\times4$	$\begin{bmatrix} 1\times1, 128 \\ 3\times3, 128 \\ 1\times1, 512 \end{bmatrix}\times4$	$\begin{bmatrix} 1\times1, 128 \\ 3\times3, 128 \\ 1\times1, 512 \end{bmatrix}\times4$	$\begin{bmatrix} 1\times1, 128 \\ 3\times3, 128 \\ 1\times1, 512 \end{bmatrix}\times8$
conv4_x	14×14	$\begin{bmatrix} 3\times3, 256 \\ 3\times3, 256 \end{bmatrix}\times2$	$\begin{bmatrix} 3\times3, 256 \\ 3\times3, 256 \end{bmatrix}\times6$	$\begin{bmatrix} 1\times1, 256 \\ 3\times3, 256 \\ 1\times1, 1024 \end{bmatrix}\times6$	$\begin{bmatrix} 1\times1, 256 \\ 3\times3, 256 \\ 1\times1, 1024 \end{bmatrix}\times23$	$\begin{bmatrix} 1\times1, 256 \\ 3\times3, 256 \\ 1\times1, 1024 \end{bmatrix}\times36$
conv5_x	7×7	$\begin{bmatrix} 3\times3, 512 \\ 3\times3, 512 \end{bmatrix}\times2$	$\begin{bmatrix} 3\times3, 512 \\ 3\times3, 512 \end{bmatrix}\times3$	$\begin{bmatrix} 1\times1, 512 \\ 3\times3, 512 \\ 1\times1, 2048 \end{bmatrix}\times3$	$\begin{bmatrix} 1\times1, 512 \\ 3\times3, 512 \\ 1\times1, 2048 \end{bmatrix}\times3$	$\begin{bmatrix} 1\times1, 512 \\ 3\times3, 512 \\ 1\times1, 2048 \end{bmatrix}\times3$
	1×1	average pool, 1000-d fc, softmax				
FLOPs		1.8×10^9	3.6×10^9	3.8×10^9	7.6×10^9	11.3×10^9

Fig. *ResNet's Network Architecture*

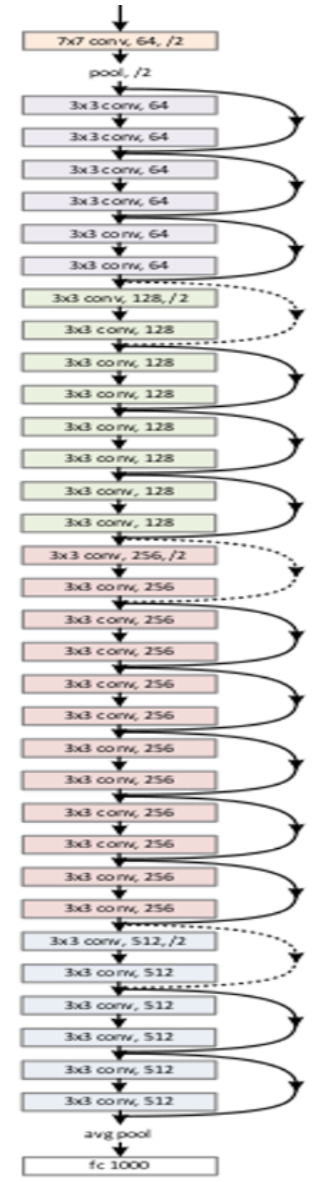


Fig. *ResNet50's Schematic Diagram*

R. Reference

R1) Deep Residual Learning for Image Recognition

R2) https://www.microsoft.com/en-us/download/details.aspx?id=54765 (ASIRRA)

5.1 Training by your computer **at least 5 epochs** and show(or upload) your source code of ResNet. **(5%)**

```
train loss = 0.67, train accuracy = 62.50%
train loss = 0.67, train accuracy = 62.50%
train loss = 0.70, train accuracy = 50.00%
train loss = 0.62, train accuracy = 87.50%
```

Fig. *Accuracy display during training*

5.2 Training at home and use TensorBoard to monitor, Save the final **screenshot of TensorBoard** (**5%**, Use other tools can get 3%).

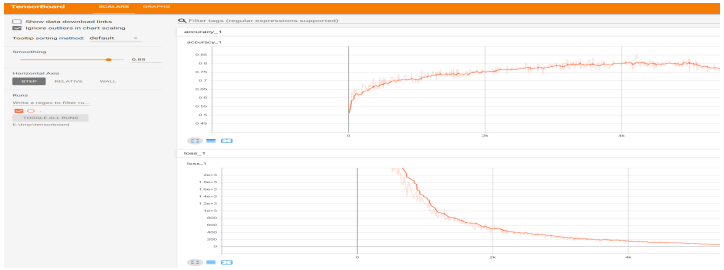


Fig. *Example of training with TensorBoard*

5.3 **Randomly select** a picture from the test set and mark its category. (**5%**)

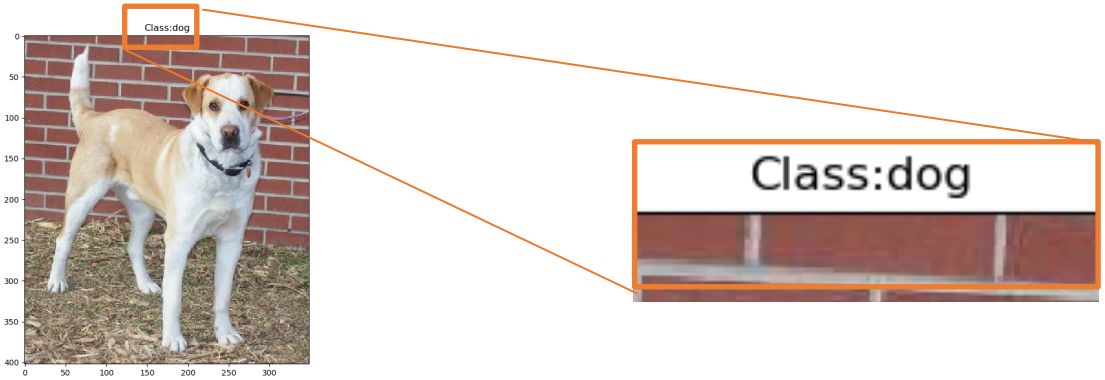


Fig. *Classification display example*

5.4 Improve ResNet50 with the method in yolov4:

Due to the early appearance of ResNet50, many augmentation methods have not implemented. In the latest ResNet50, Random-Erasing have been used to greatly improve the accuracy, so why don‘t we use this method on ResNet50? **Write the code of Random-Erasing (3%)** and **draw the comparison table of accuracy**, save it as a picture.**(2%)**

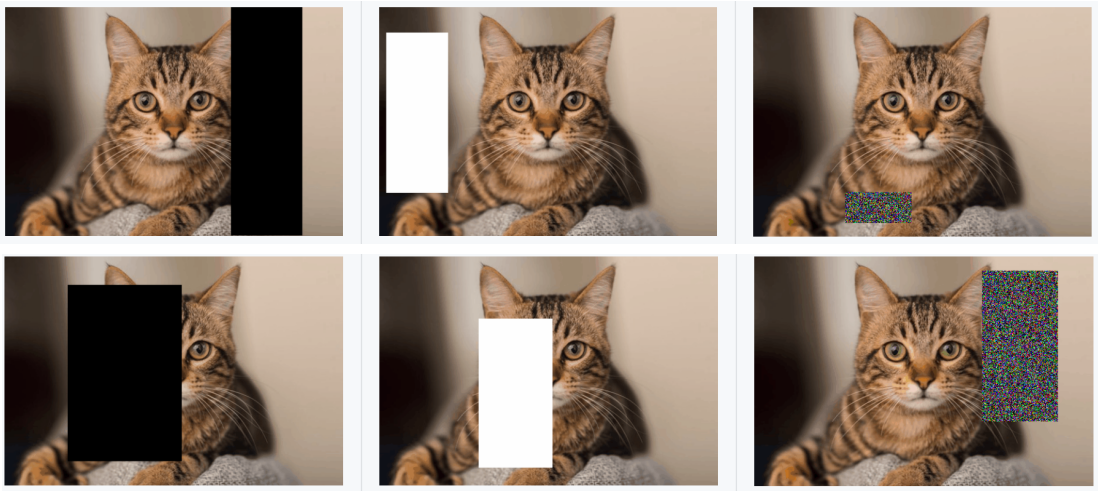


Fig. *Examples of the use of Random-Erasing*

Algorithm 1: Random Erasing Procedure

Input : Input image I;
Image size W and H;
Area of image S;
Erasing probability p;
Erasing area ratio range s_l and s_h;
Erasing aspect ratio range r_1 and r_2.
Output: Erased image I^*.
Initialization: $p_1 \leftarrow$ Rand (0, 1).

if $p_1 \geq p$ **then**
  $I^* \leftarrow I$;
  return I^*.
else
  while *True* **do**
    $S_e \leftarrow$ Rand $(s_l, s_h) \times S$;
    $r_e \leftarrow$ Rand (r_1, r_2);
    $H_e \leftarrow \sqrt{S_e \times r_e}$, $W_e \leftarrow \sqrt{\frac{S_e}{r_e}}$;
    $x_e \leftarrow$ Rand $(0, W)$, $y_e \leftarrow$ Rand $(0, H)$;
    if $x_e + W_e \leq W$ *and* $y_e + H_e \leq H$ **then**
      $I_e \leftarrow (x_e, y_e, x_e + W_e, y_e + H_e)$;
      $I(I_e) \leftarrow$ Rand (0, 255);
      $I^* \leftarrow I$;
      return I^*.
    end
  end
end

Fig. *Random-Erasing algorithm*

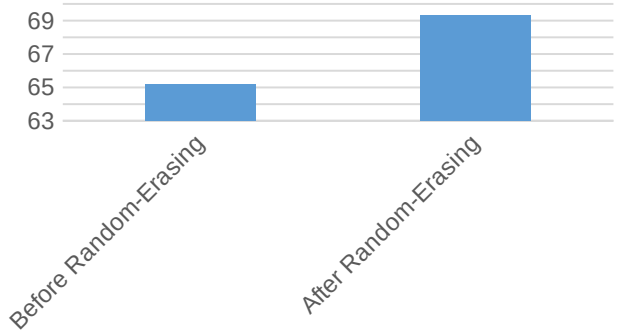


Fig. *Random-Erasing effect comparison example*

R. Reference

[Random Erasing Data Augmentation]