Project 6

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2 Introduction

Yolo is a very powerful deep learning tool. This project is to use yolov2 to detect randomly generated digits and letters.

3 Dataset Exploration

There are training dataset and testing dataset. Both of them generated from EMNIST, downloaded from Kaggle. The training dataset has 10000 images, the testing one has 1000 images.
And here, we choose the Will's method to generate data.
There are 62 classes. 10 digits, 26 upper case letters and 26 lower case letters.

4 Model

To train the model, we install tensorflow-gpu, opencv, darkflow. The selected cfg is tiny-yolo-voc.cfg, the chosen weight is tiny-yolo-voc.weight. The class number is 62, the filter number is 335. The epoch is 200.

We will use the trained weight to recognize images from testing set. We will show the bounding box, confidence and recognizing result on image. Finally we compress the images as video.

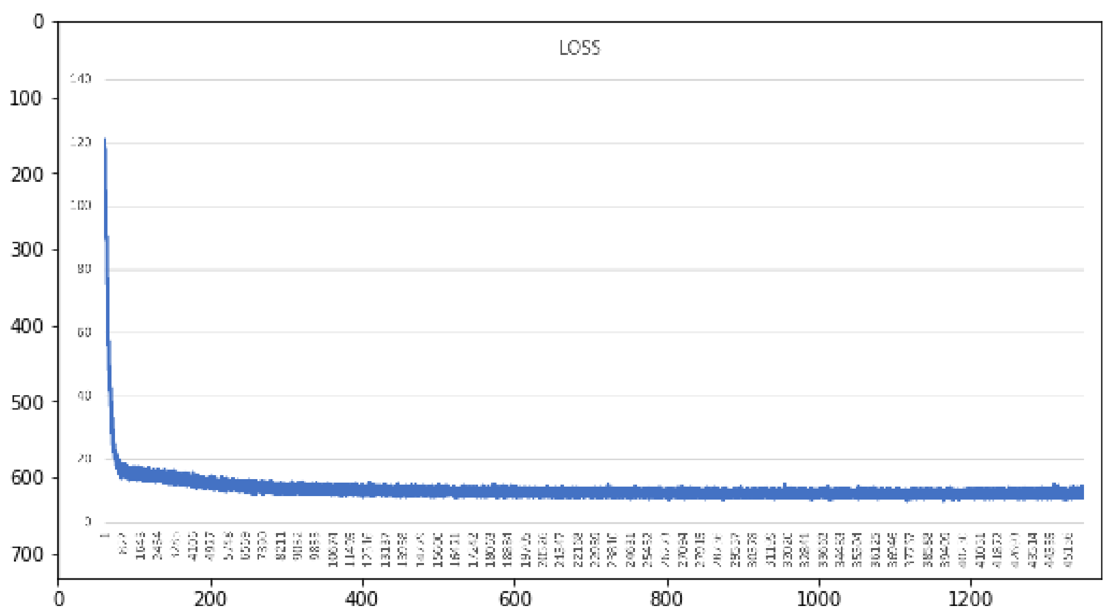
5 Conclusion

After long time training, we get the final results. The loss curve, the accuracy, the smaple output. Given that YOLO recognizes the image following randomly order instead of the order from the annotation_simples. What's more, it will recognize the same letters twice. Therefore, it's hard to use sklearn.metrics.confusion_matrix() to generate confusion matrix and use sklearn.metrics.classification_report() to display average accuracy and recall and f1-score as usual. On this condition, we start to count and match by ourself. To save the time, we only count the first 50 images.

5.1 Plot for Training Loss and Accuracy

```
In [9]: import numpy as np
        import cv2
        from matplotlib import pyplot as plt
        def BGR2RGB(Input):
            output = np.zeros(np.shape(Input));
            output[:,:,0] = Input[:,:,2]
            output[:,:,1] = Input[:,:,1]
            output[:,:,2] = Input[:,:,0]
            output = output.astype('uint8')
            return output
        plot1 = cv2.imread('./loss.png')
        plt.figure(figsize=(22,11))
        plt.subplot(121),plt.imshow(BGR2RGB(plot1))
```

```
Out[9]: (<matplotlib.axes._subplots.AxesSubplot at 0x1c35a42ba8>,
         <matplotlib.image.AxesImage at 0x1c36dbfe80>)
```



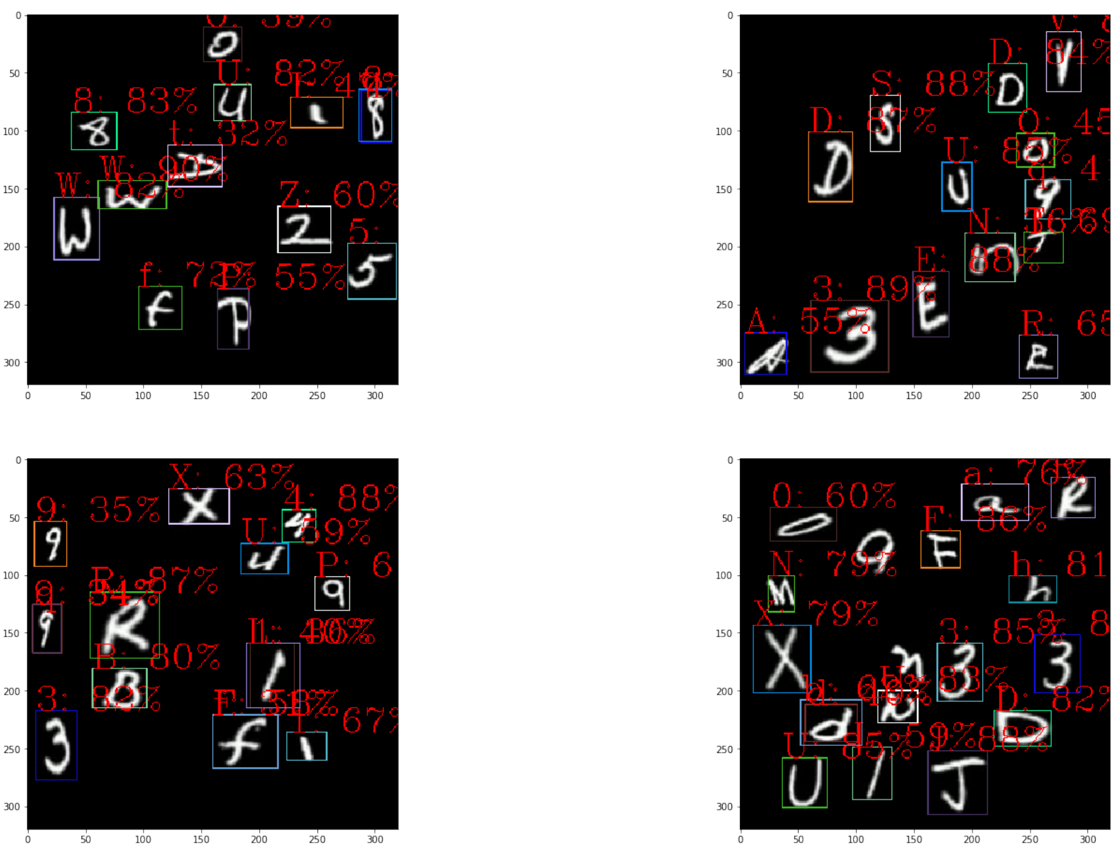
5.2 Recognition Video and Images

Please click here to play the video for recognizing.

Here is some sample images.

In [12]:
```
plot2 = cv2.imread('./tp/img_886.png')
plot3 = cv2.imread('./tp/img_887.png')
plot4 = cv2.imread('./tp/img_888.png')
plot5 = cv2.imread('./tp/img_889.png')
plt.figure(figsize=(25,16))
plt.subplot(221),plt.imshow(BGR2RGB(plot2))
plt.subplot(222),plt.imshow(BGR2RGB(plot3))
plt.subplot(223),plt.imshow(BGR2RGB(plot4))
plt.subplot(224),plt.imshow(BGR2RGB(plot5))
```

Out[12]:
```
(<matplotlib.axes._subplots.AxesSubplot at 0x1c367eb2b0>,
 <matplotlib.image.AxesImage at 0x1c38d87080>)
```



5.3 Confusion Matrix and Accuracy

In [13]:
```
### display confusion matrix
print(conf_matrix)
```

```
[[18  0  0 ...  0  0  0]
 [ 0 11  0 ...  0  0  0]
```

```
 [ 0  0 15 ...  0  0  0]
 ...
 [ 0  0  0 ...  5  0  0]
 [ 0  0  0 ...  0  3  0]
 [ 0  0  0 ...  0  0  1]]
```

```
In [19]: ### display accuracy for each digit or letter and average accuracy
         print('letters', 'Precision', 'Recall', 'F1-Score')
         for i in range(len(l)):
             print(l[i],'     ',np.round(each_pre[i],3),'      ',np.round(each_rec[i],3),'
         print('Averge:',np.round(ave_precision,3),'    ',np.round(ave_rec,3),'  ',np.round(ave
```

```
letters Precision Recall F1-Score
0       0.9       0.621       0.735
1       0.611       0.917       0.733
2       0.833       0.938       0.882
3       0.895       1.0       0.944
4       0.941       1.0       0.97
5       1.0       0.867       0.929
6       0.938       1.0       0.968
7       0.8       0.857       0.828
8       0.889       0.889       0.889
9       0.897       0.929       0.912
A       1.0       0.867       0.929
B       0.682       0.938       0.789
C       1.0       1.0       1.0
D       0.933       0.875       0.903
E       1.0       1.0       1.0
F       0.889       0.444       0.593
G       1.0       0.929       0.963
H       0.909       0.833       0.87
I       0.667       0.833       0.741
J       1.0       0.611       0.759
K       0.889       0.889       0.889
L       0.7       0.438       0.538
M       0.75       0.375       0.5
N       0.96       0.828       0.889
O       0.857       0.923       0.889
P       0.714       0.769       0.741
Q       0.812       0.812       0.812
R       1.0       1.0       1.0
S       0.789       1.0       0.882
T       0.867       0.867       0.867
U       1.0       0.846       0.917
V       0.889       0.889       0.889
W       1.0       0.938       0.968
X       0.923       0.923       0.923
```

Y	0.875	0.5	0.636
Z	1.0	0.786	0.88
a	0.636	0.875	0.737
b	0.833	0.714	0.769
c	1.0	1.0	1.0
d	0.722	0.812	0.765
e	0.947	1.0	0.973
f	0.75	0.9	0.818
g	0.667	0.714	0.69
h	0.8	0.857	0.828
i	1.0	1.0	1.0
j	0.0	nan	nan
k	0.5	1.0	0.667
l	0.0	nan	nan
m	0.6	1.0	0.75
n	1.0	1.0	1.0
o	0.875	0.875	0.875
p	0.333	0.333	0.333
q	0.5	0.5	0.5
r	0.875	1.0	0.933
s	1.0	1.0	1.0
t	0.923	1.0	0.96
u	0.4	1.0	0.571
v	0.333	1.0	0.5
w	0.667	1.0	0.8
x	1.0	1.0	1.0
y	0.5	1.0	0.667
z	1.0	1.0	1.0
Averge:	0.847	0.862	0.414

In general, YOLO is an awesome deep learning algorithm, it has fast speed. In our model, after 46000 steps, the loss becomes stable, the value is around 6 to 8. The loss curve can prove this. But we trust that if we keep training for more epoachs, the loss will be reduced to 1 someday.
In meanwhile, we also notice that the loss will increase a little bit after 55000 steps and back to 12. This is a point for future optimization work and a chance to go depth in YOLO.
Then, the prediction accuracy is 84.7%, no so bad. For detailed prediction result, please check the smaple images and uploaded video.
This is a very meaningful and interesting project. We really enjoy this experience!

6 Appendix

6.1 Testing

6.1.1 Convert the Testing Image to Video

```
In [6]: import cv2
        from darkflow.net.build import TFNet
```

```
import matplotlib.pyplot as plt
import time
```

```
In [3]: import os
        import numpy as np
        from os.path import isfile, join

        def convert_frames_to_video12(pathOut,fps):
            frame_array = []
            for i in range(1000):
                ID = str(i+1)
                while len(ID)<6:
                    ID='0'+ID
                filename = ('./Images/%s.jpg' % (ID))
                #reading each files
                img = cv2.imread(filename)
                #print(np.shape(img))
                height, width, layers = np.shape(img)
                size = (width,height)
                #inserting the frames into an image array
                frame_array.append(img)

            out = cv2.VideoWriter(pathOut,cv2.VideoWriter_fourcc(*'DIVX'), fps, size)

            for i in range(len(frame_array)):
                # writing to a image array
                out.write(frame_array[i])
            out.release()
```

```
In [4]: pathOut='reco_yolo.mp4'
        #pathIn='/Users/sunjian/Public/Document/4620/Project6/randyhand-will_dev/Images/'
        convert_frames_to_video12(pathOut,3)
```

6.1.2 Start Prediction

```
In [5]: options={
            'model': 'cfg/tiny-yolo-voc-3c.cfg',
            'load': 48250,
            'threshold': 0.3
            #'gpu':1.0
        }

        tfnet = TFNet(options)
```

```
Parsing cfg/tiny-yolo-voc-3c.cfg
Loading None ...
Finished in 7.390975952148438e-05s

Building net ...
```

```
Source | Train? | Layer description                | Output size
-------+--------+----------------------------------+---------------
       |        | input                            | (?, 416, 416, 3)
 Init  |  Yep!  | conv 3x3p1_1  +bnorm  leaky      | (?, 416, 416, 16)
 Load  |  Yep!  | maxp 2x2p0_2                     | (?, 208, 208, 16)
 Init  |  Yep!  | conv 3x3p1_1  +bnorm  leaky      | (?, 208, 208, 32)
 Load  |  Yep!  | maxp 2x2p0_2                     | (?, 104, 104, 32)
 Init  |  Yep!  | conv 3x3p1_1  +bnorm  leaky      | (?, 104, 104, 64)
 Load  |  Yep!  | maxp 2x2p0_2                     | (?, 52, 52, 64)
 Init  |  Yep!  | conv 3x3p1_1  +bnorm  leaky      | (?, 52, 52, 128)
 Load  |  Yep!  | maxp 2x2p0_2                     | (?, 26, 26, 128)
 Init  |  Yep!  | conv 3x3p1_1  +bnorm  leaky      | (?, 26, 26, 256)
 Load  |  Yep!  | maxp 2x2p0_2                     | (?, 13, 13, 256)
 Init  |  Yep!  | conv 3x3p1_1  +bnorm  leaky      | (?, 13, 13, 512)
 Load  |  Yep!  | maxp 2x2p0_1                     | (?, 13, 13, 512)
 Init  |  Yep!  | conv 3x3p1_1  +bnorm  leaky      | (?, 13, 13, 1024)
 Init  |  Yep!  | conv 3x3p1_1  +bnorm  leaky      | (?, 13, 13, 1024)
 Init  |  Yep!  | conv 1x1p0_1    linear           | (?, 13, 13, 335)
-------+--------+----------------------------------+---------------
Running entirely on CPU
Loading from ./ckpt/tiny-yolo-voc-3c-48250
INFO:tensorflow:Restoring parameters from ./ckpt/tiny-yolo-voc-3c-48250
Finished in 4.211627960205078s
```

In [134]:
```
## do it in video
capture = cv2.VideoCapture('reco_yolo.mp4')
colors = [tuple(255 * np.random.rand(3)) for i in range(16)]
count=0
pred=[]
while (capture.isOpened()):
    stime = time.time()
    ret, frame = capture.read()
    if ret:
        results = tfnet.return_predict(frame)
        for i in range(np.shape(results)[0]):
            label = results[i]['label']
            pred.append(label)
        for color, result in zip(colors, results):
            tl = (result['topleft']['x'], result['topleft']['y'])
            br = (result['bottomright']['x'], result['bottomright']['y'])
            label = result['label']
            confidence = result['confidence']
            text = '{}: {:.0f}%'.format(label, confidence * 100)
            frame = cv2.rectangle(frame, tl, br, color, 1)
            frame = cv2.putText(frame, text, tl, cv2.FONT_HERSHEY_COMPLEX, 1, (0, 0,
        count+=1
```

```
                MZ = ('./tp/img_%d.png' % (count))
                cv2.imwrite(MZ,frame)
                cv2.imshow('frame', frame)
                #print('FPS {:.1f}'.format(1 / (time.time() - stime)))
                if cv2.waitKey(1) & 0xFF == ord('q'):
                    break
            else:
                capture.release()
                cv2.destroyAllWindows()
                break
```

6.1.3 Convert the Predicted Result to Video

```
In [28]: def convert_frames_to_video(pathOut,fps):
             frame_array = []
             for i in range(1000):
                 filename = ('./tp/img_%d.png' % (i+1))
                 #reading each files
                 img = cv2.imread(filename)
                 #print(np.shape(img))
                 height, width, layers = np.shape(img)
                 size = (width,height)
                 #inserting the frames into an image array
                 frame_array.append(img)

             out = cv2.VideoWriter(pathOut,cv2.VideoWriter_fourcc(*'DIVX'), fps, size)

             for i in range(len(frame_array)):
                 # writing to a image array
                 out.write(frame_array[i])
             out.release()
```

```
In [29]: pathOut='reco.mp4'
         #pathIn='/Users/sunjian/Public/Document/4620/Project6/randyhand-will_dev/Images/'
         convert_frames_to_video(pathOut,3)
```

6.2 Confusion Matrix

```
In [7]: conf_matrix=np.array([[18,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0
        [0,11,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,6,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
        [0,0,15,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0
        [0,0,0,17,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
        [0,0,0,0,16,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0
        [0,0,0,0,0,13,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
        [0,0,0,0,0,0,15,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
        [1,0,0,0,0,0,0,12,0,0,0,0,0,0,0,1,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
        [0,0,0,0,0,0,0,0,16,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0
        [0,0,0,0,0,0,0,0,0,26,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1
```

[0,0,0,0,0,0,0,0,0,0,13,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[5,0,0,0,0,0,0,0,0,0,1,15,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,13,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[1,0,0,0,0,0,0,0,0,0,0,0,0,14,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,19,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,8,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,13,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,10,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,10,0,0,2,0,0,0,0,0,0,0,2,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,11,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,16,0,0,0,0,0,0,0,0,0,0,0,0,1,1,0,0,0,0,0,0,0,0
[0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,7,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,3,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,24,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[2,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,12,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,10,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,13,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,1
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,15,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,1,0,0,2,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,15,0,0,0,0,0,0,1,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,13,0,0,0,0,1,1,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,11,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,2,0,0,0,0,0,0,0,0,0,0,0,16,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,15,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,12,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,7,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,11,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,0,0,0,0,0,0,0,0,0,7,0,0,1,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,10,0,2,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,2,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,4,0,13,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,18,0,1
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,6,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,18,0
[0,0,0,0,0,0,0,0,2,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,10
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,2,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
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[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,4,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
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[0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,2,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,2,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,2,0,0,0,0,0,0,0,0,0,0,0

```
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,2,0,0,0,0,0,0,0,0
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
```

6.3 Calculate Precision, Recall and F1-score

In [8]:
```
row_sum=np.sum(conf_matrix,axis=1)
col_sum=np.sum(conf_matrix,axis=0)
total=sum(row_sum)
diagonal=0
each_pre=[]
each_rec=[]
F1_score=[]
for i in range(np.shape(row_sum)[0]):
    precis=conf_matrix[i,i]/row_sum[i]
    recall=conf_matrix[i,i]/col_sum[i]
    f1_sco=2*precis*recall/(precis+recall)
    each_pre.append(precis)
    each_rec.append(recall)
    F1_score.append(f1_sco)
    diagonal=diagonal+conf_matrix[i,i]
ave_precision=diagonal/total
l='0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz'
ave_rec=0
ave_f1=0
count=0
for i in range(len(l)):
    if (i==45 or i==47): continue
    else:
        ave_rec=ave_rec+each_rec[i]
        count=count+1
ave_rec=ave_rec/count
for i in range(len(l)):
    if (i==45 or i==47):continue
    else:
        ave_f1=ave_f1+F1_score[i]
        count=count+1
ave_f1=ave_f1/count
```

```
/Users/sunjian/anaconda3/envs/tfw/lib/python3.6/site-packages/ipykernel_launcher.py:10: Runtim
  # Remove the CWD from sys.path while we load stuff.
```