TCL 创意感动生活 The Creative Life

Topics on Face Detection and Recognition

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1. Introduction to the project background

2. About the face detection

3. About the face recognition and BPNN

4. Demo and Interesting video sharing

5. Q&A

Background

- Application of face detection and recognition

✓ customs port

✓ crime investigation

✓ Camera assistant auto-focus

- What shall we do for our consumer

✓ Recommendation

✓ Authentication based application

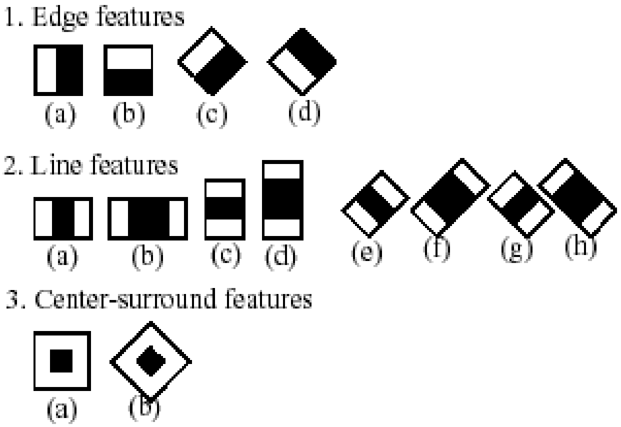
- Machine learning itself is a flexible tool for value add application

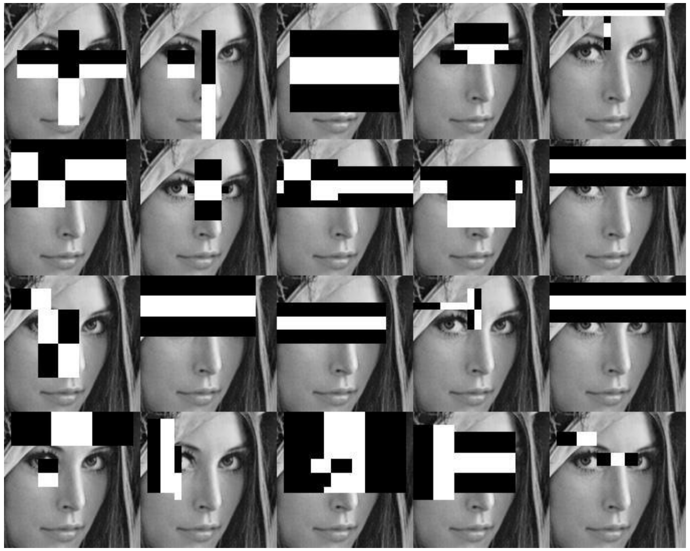
✓ Health related application

✓ Artificial intelligent

Face Detection

- A little bit more detail
  - The Haar-like feature vs. Local Binary Pattern feature



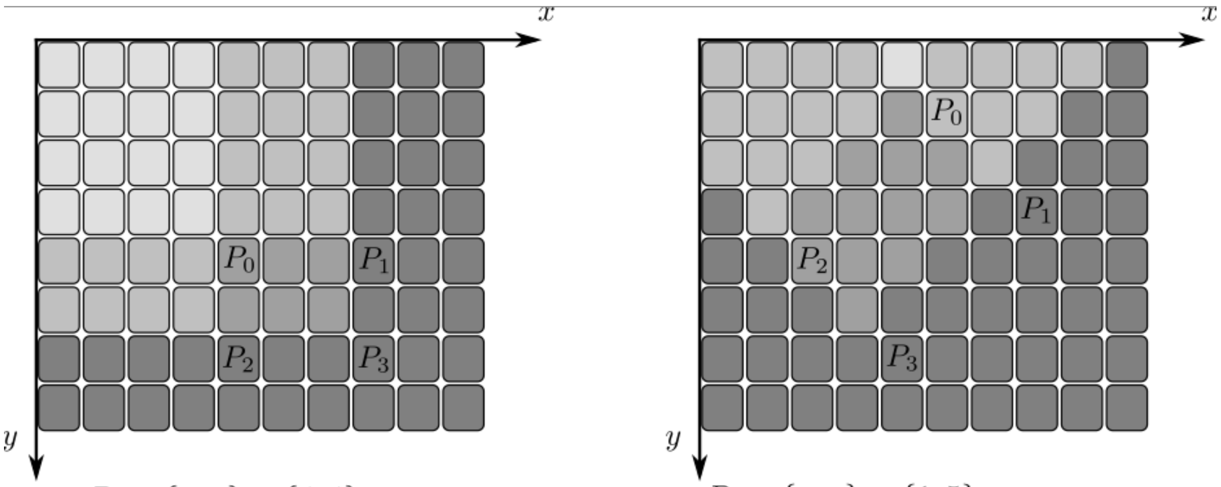


In our solution

- Minimum sliding window size: 30*30 changeable
- Haar feature window size: 20*20 fixed

Face Detection

- A little bit more detail
  - Integral image for acceleration

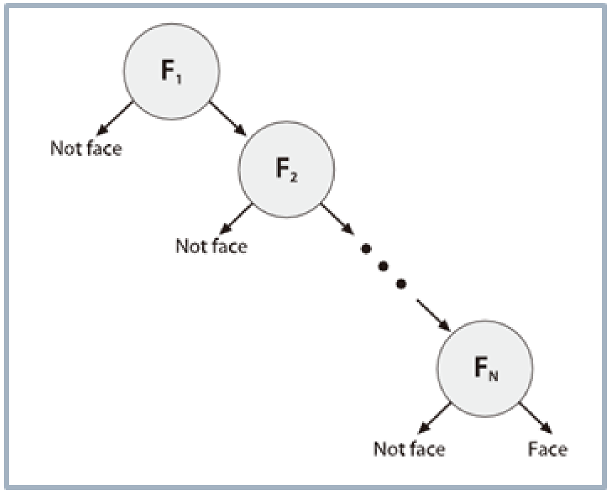


$$P_0 = \{y, x\} = \{4, 4\}$$
$$P_1 = \{y, x + w\} = \{4, 7\}$$
$$P_2 = \{y + h, x\} = \{6, 4\}$$
$$P_3 = \{y + h, x + w\} = \{6, 7\}$$

$$P_0 = \{y, x\} = \{1, 5\}$$
$$P_1 = \{y + w, x + w\} = \{3, 7\}$$
$$P_2 = \{y + h, x - h\} = \{4, 2\}$$
$$P_3 = \{y + w + h, x + w - h\} = \{6, 4\}$$

Face Detection

- A little bit more detail
  - ➢ Adaptive boost cascade classifier



Simplified explanation:

Reject rate = [1 - (1-P)^n]
P: probability of being reject
n: number of stage

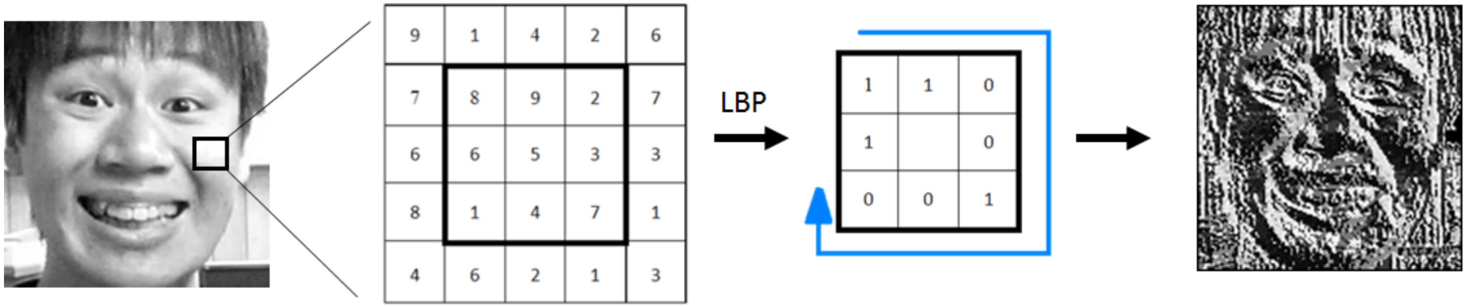
If P = 0.1, n = 20
Reject rate = 0.8784
Cascade of a series of weak classifiers can be a strong classifier

In our solution

➢ Number of stage: around 22 stages varies from model to model

Face Detection

- A little bit more detail
  - ➢ Haar-like feature vs. Local Binary Pattern feature



9	1	4	2	6
7	8	9	2	7
6	6	5	3	3
8	1	4	7	1
4	6	2	1	3

1	1	0
1		0
0	0	1

In our solution

➢ LBP window size: 24*24 bits, fixed
➢ LBP feature length: 3 pixels radius

➢ Haar feature model 22 stages, 661 KB
➢ LBP feature model 20 stages, 51 KB

Face Detection

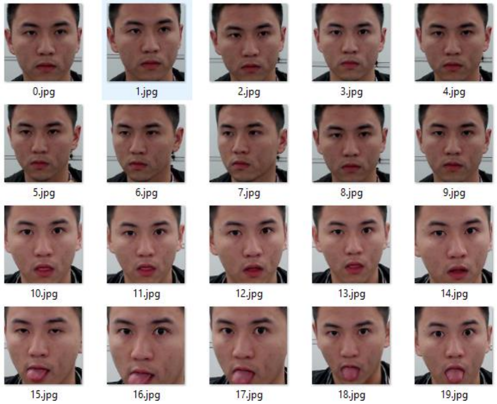
Image1: October 1927 Fifth Solvay International Conference
Source:http://zhblog.engic.org/20140308-212830/

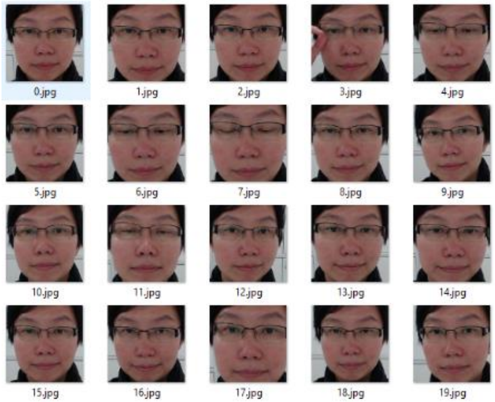
Face Recognition

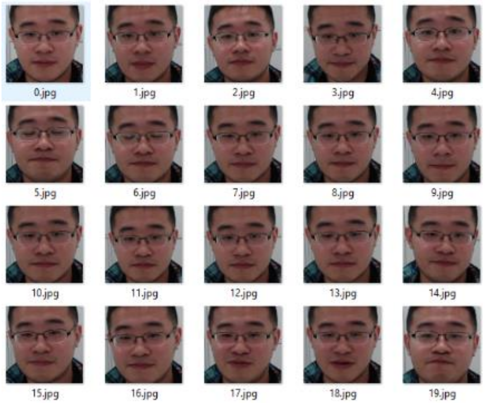
- How to recognize
  - ➢ Methodology key word: template
  - ➢ Extract most representative feature
  - ➢ Pre-process

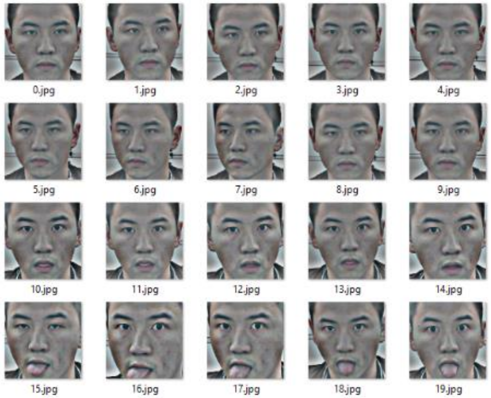
Face Recognition

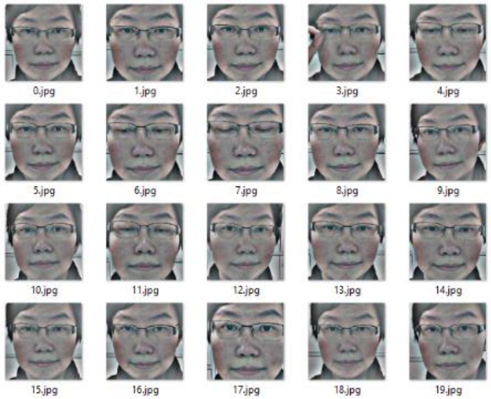
- How to recognize
  - ➢ Pre-process for eye detection and face alignment

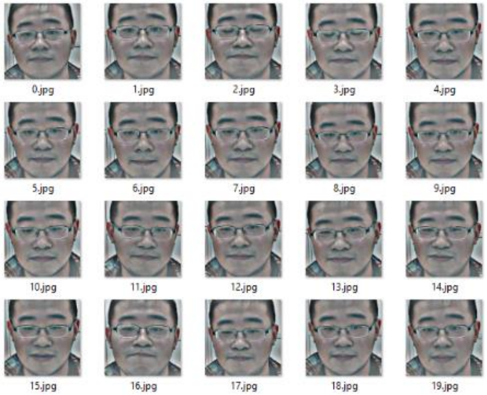






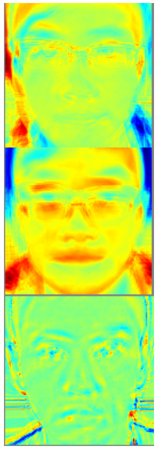




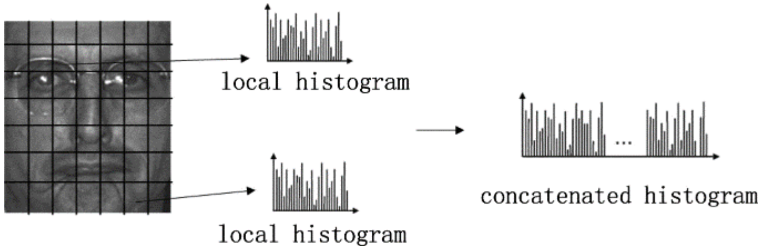


Face Recognition

- How to extract feature
  - Principal Component Analysis
    - Use a set of mathematical completeness orthogonal unified basis to represent the image
    - Calculate the covariance matrix
    - Calculate the eigenvalue and eigenvector of the covariance matrix
    - The vector of eigenvalues represent the subjects and the eigenvectors are basis

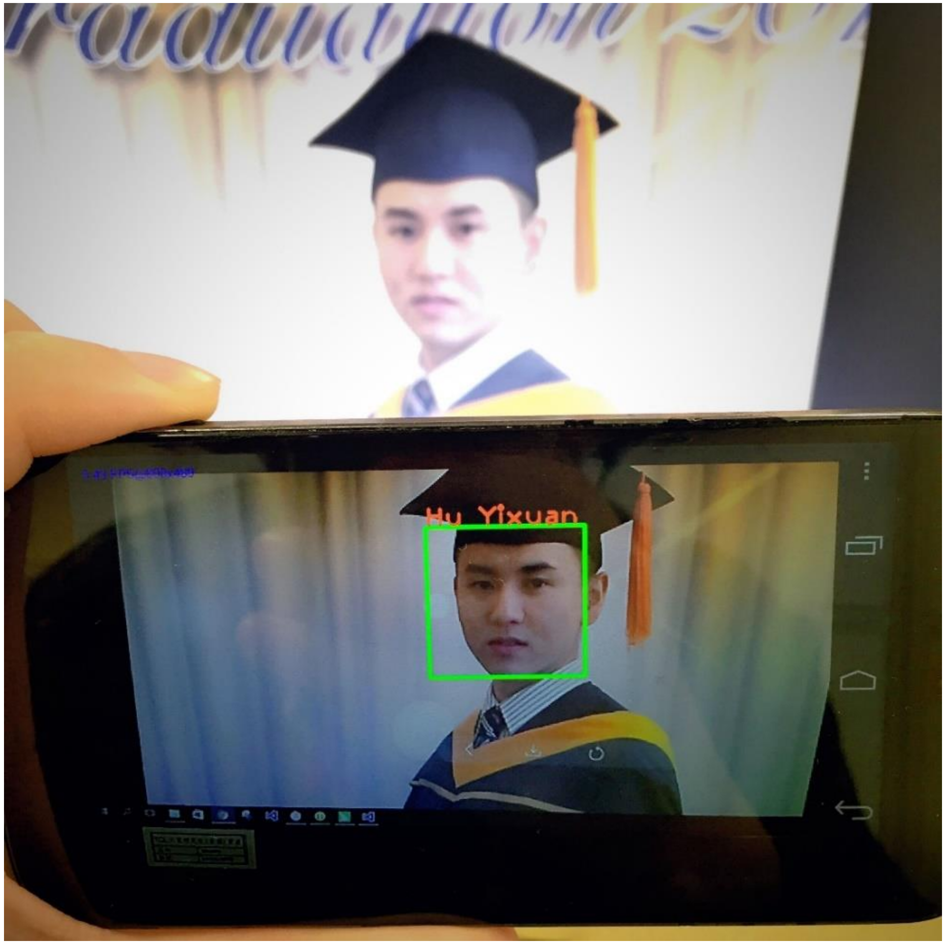


  - Linear Discrimination Analysis
    - Follow a same methodology with the PCA, but the basis of the space is not orthogonal
    - Performance is relatively better than PCA
  - Local Binary Pattern Histogram
    - Calculate the LBP feature in different region of the image
    - Compare the statistics feature with the pre-trained template



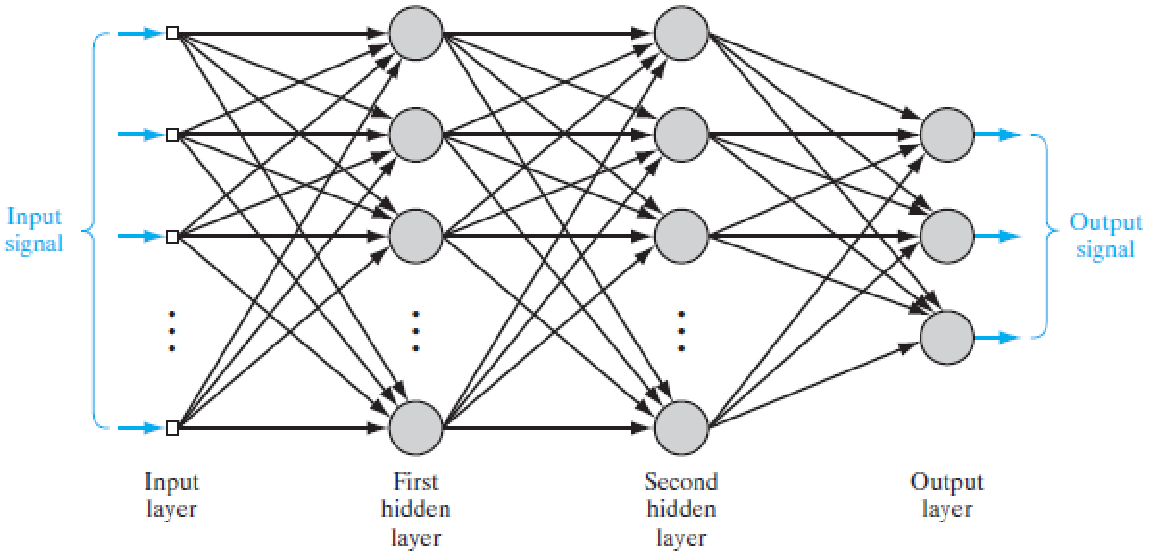
Face Recognition

Performance	LDA	LBPH
Model size	600KB	6.3MB
Frame per second	15-30	6-15
Accuracy	plain	better



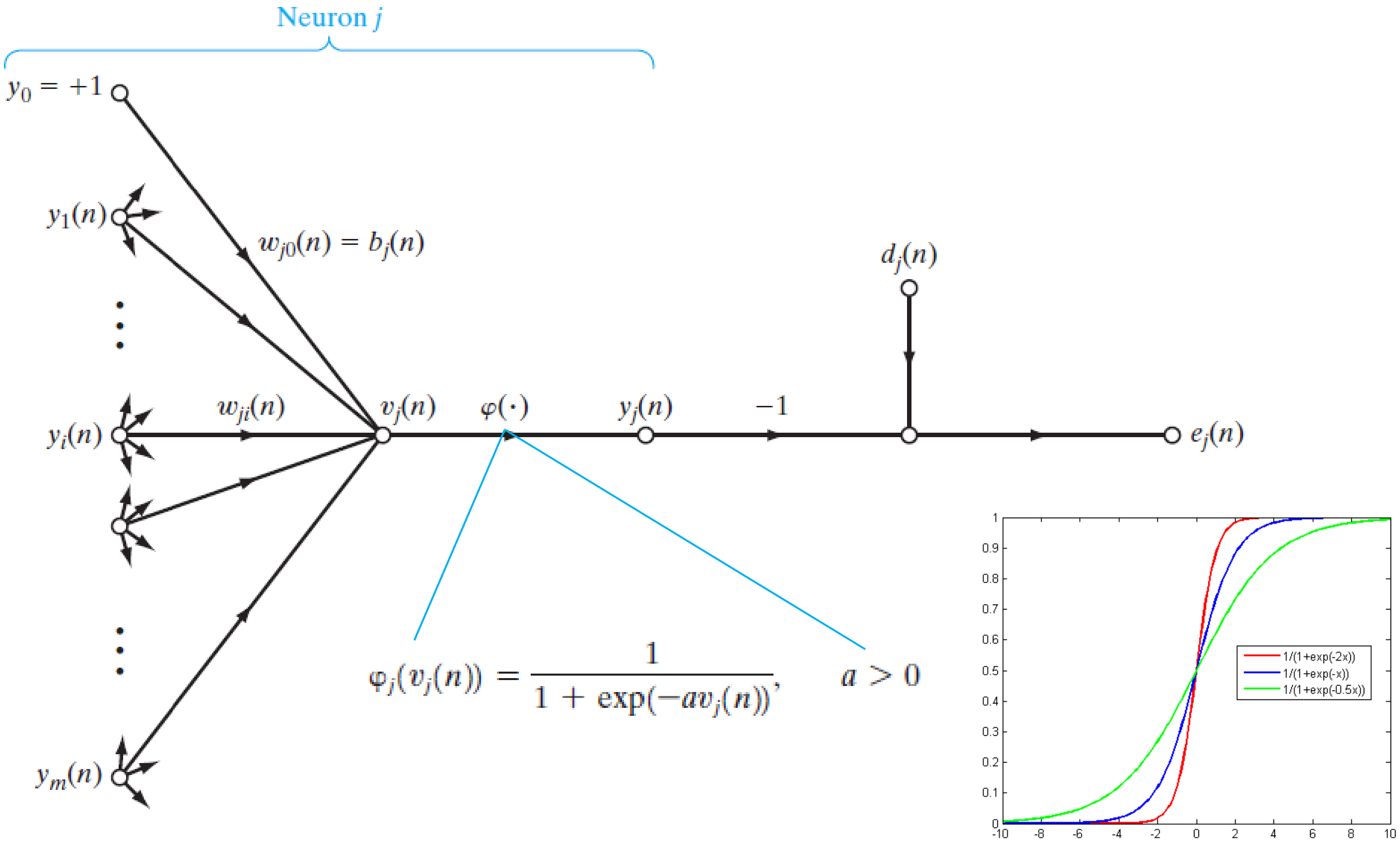
Neutral network

- Still, template, the difference is that the “template” of the neutral network is “learned” from the data through the “network”.



Back Propagation Neutral Network

- A single neuron



$$\varphi_j(v_j(n)) = \frac{1}{1 + \exp(-av_j(n))}, \quad a > 0$$

Back Propagation Neutral Network

- Weight correction

$$\begin{pmatrix} \textit{Weight} \\ \textit{correction} \\ \Delta w_{ji}(n) \end{pmatrix} = \begin{pmatrix} \textit{learning-} \\ \textit{rate parameter} \\ \eta \end{pmatrix} \times \begin{pmatrix} \textit{local} \\ \textit{gradient} \\ \delta_j(n) \end{pmatrix} \times \begin{pmatrix} \textit{input signal} \\ \textit{of neuron } j, \\ y_i(n) \end{pmatrix}$$

$$\begin{aligned} \delta_j(n) &= \frac{\partial \mathscr{E}(n)}{\partial v_j(n)} \\ &= \frac{\partial \mathscr{E}(n)}{\partial e_j(n)} \frac{\partial e_j(n)}{\partial y_j(n)} \frac{\partial y_j(n)}{\partial v_j(n)} \\ &= e_j(n)\varphi_j'(v_j(n)) \end{aligned}$$

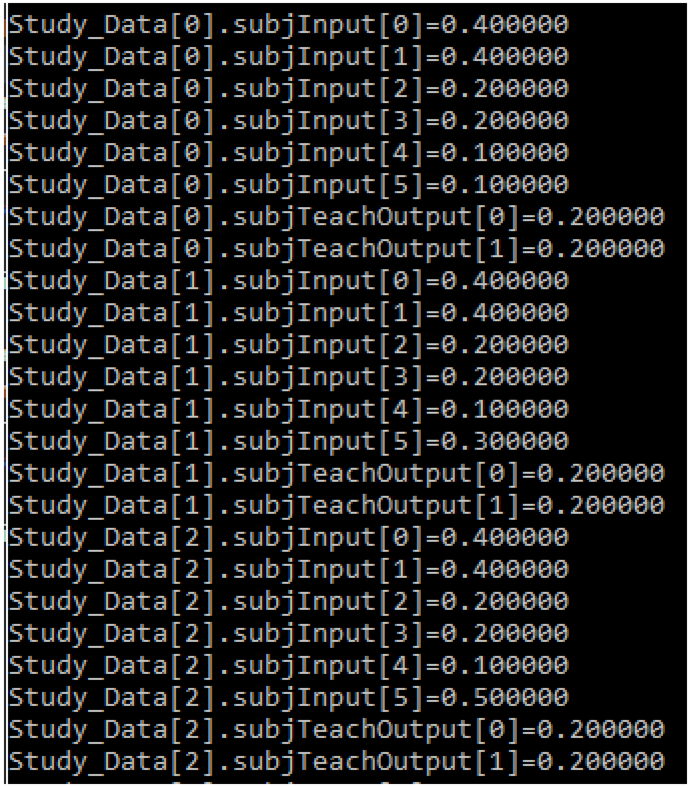
Back Propagation Neutral Network

- About the data

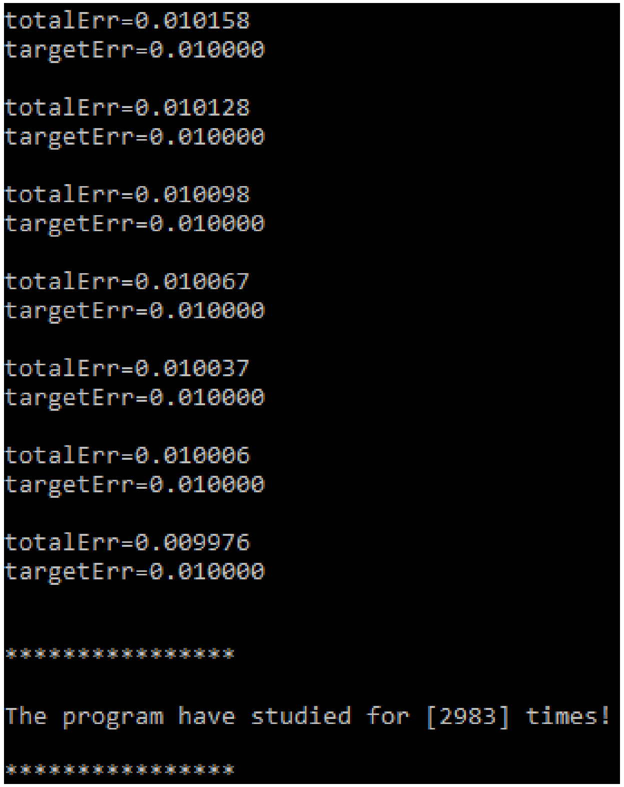
	Unacceptable	Accpetable	Good	Very good
CLASS	(F, F)	(F, T)	(T, F)	(T, T)
Price	4	4	2	2
Maint	4	2	1	1
Doors	2	2	3	4
Persons	2	4	4	4
Luggage	1	3	5	5
Safety	1	5	3	5

Data and output

```
0.4 0.4 0.2 0.2 0.1 0.1
0.4 0.4 0.2 0.2 0.1 0.3
0.4 0.4 0.2 0.2 0.1 0.5
0.4 0.2 0.2 0.4 0.3 0.5
0.4 0.2 0.2 0.4 0.5 0.5
0.4 0.2 0.2 0.5 0.5 0.5
0.2 0.1 0.3 0.4 0.1 0.5
0.2 0.1 0.3 0.4 0.3 0.5
0.2 0.1 0.3 0.4 0.5 0.3
0.2 0.1 0.3 0.5 0.3 0.5
0.2 0.1 0.4 0.4 0.3 0.5
0.2 0.1 0.4 0.4 0.5 0.5
0.2 0.2
0.2 0.2
0.2 0.2
0.2 0.8
0.2 0.8
0.2 0.8
0.8 0.2
0.8 0.2
0.8 0.2
0.8 0.8
0.8 0.8
0.8 0.8
```

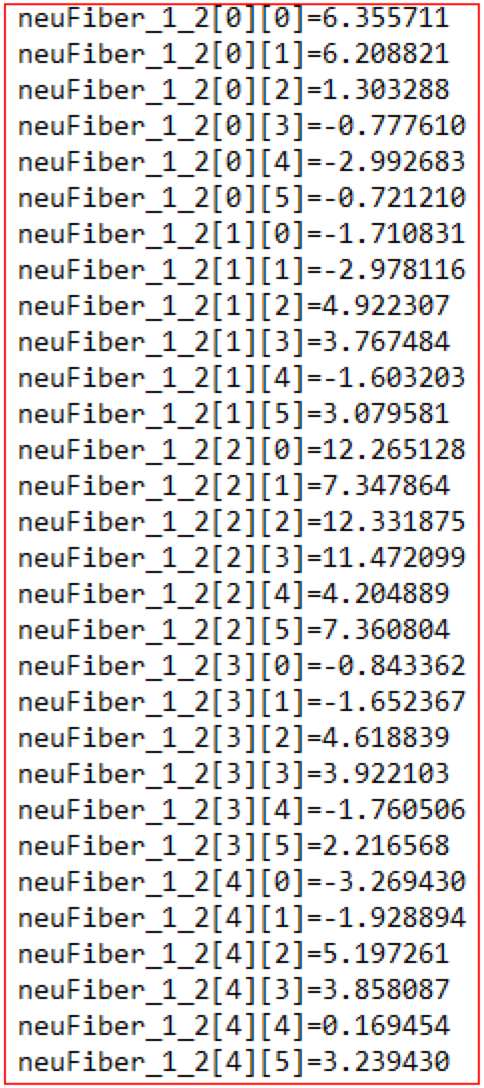


```
Study_Data[0].subjInput[0]=0.400000
Study_Data[0].subjInput[1]=0.400000
Study_Data[0].subjInput[2]=0.200000
Study_Data[0].subjInput[3]=0.200000
Study_Data[0].subjInput[4]=0.100000
Study_Data[0].subjInput[5]=0.100000
Study_Data[0].subjTeachOutput[0]=0.200000
Study_Data[0].subjTeachOutput[1]=0.200000
Study_Data[1].subjInput[0]=0.400000
Study_Data[1].subjInput[1]=0.400000
Study_Data[1].subjInput[2]=0.200000
Study_Data[1].subjInput[3]=0.200000
Study_Data[1].subjInput[4]=0.100000
Study_Data[1].subjInput[5]=0.300000
Study_Data[1].subjTeachOutput[0]=0.200000
Study_Data[1].subjTeachOutput[1]=0.200000
Study_Data[2].subjInput[0]=0.400000
Study_Data[2].subjInput[1]=0.400000
Study_Data[2].subjInput[2]=0.200000
Study_Data[2].subjInput[3]=0.200000
Study_Data[2].subjInput[4]=0.100000
Study_Data[2].subjInput[5]=0.500000
Study_Data[2].subjTeachOutput[0]=0.200000
Study_Data[2].subjTeachOutput[1]=0.200000
```

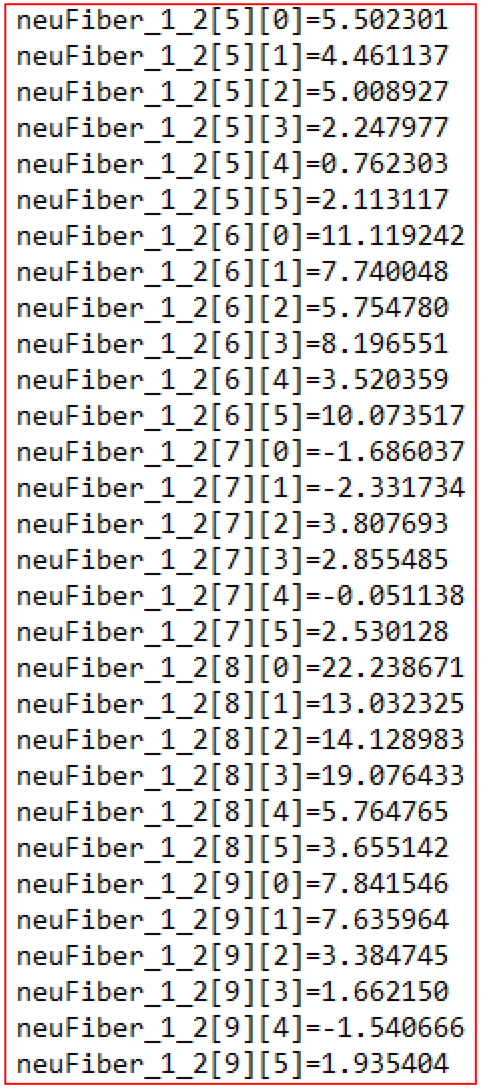


```
totalErr=0.010158
targetErr=0.010000

totalErr=0.010128
targetErr=0.010000

totalErr=0.010098
targetErr=0.010000

totalErr=0.010067
targetErr=0.010000

totalErr=0.010037
targetErr=0.010000

totalErr=0.010006
targetErr=0.010000

totalErr=0.009976
targetErr=0.010000


****************

The program have studied for [2983] times!

****************
```

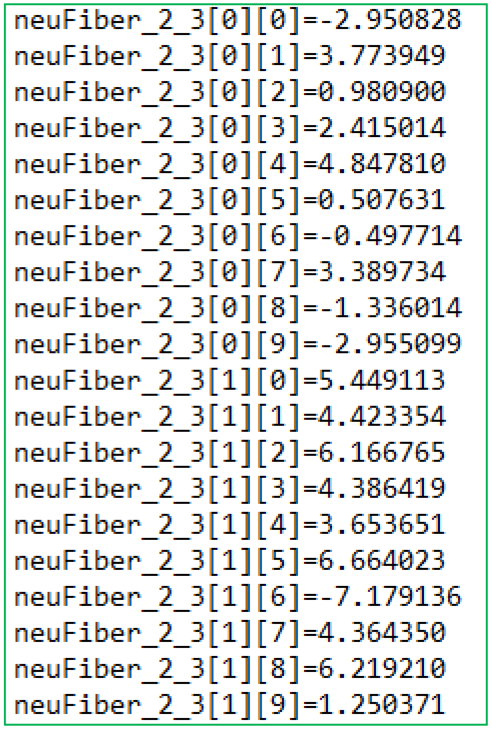
Weights



```
neuFiber_1_2[0][0]=6.355711
neuFiber_1_2[0][1]=6.208821
neuFiber_1_2[0][2]=1.303288
neuFiber_1_2[0][3]=-0.777610
neuFiber_1_2[0][4]=-2.992683
neuFiber_1_2[0][5]=-0.721210
neuFiber_1_2[1][0]=-1.710831
neuFiber_1_2[1][1]=-2.978116
neuFiber_1_2[1][2]=4.922307
neuFiber_1_2[1][3]=3.767484
neuFiber_1_2[1][4]=-1.603203
neuFiber_1_2[1][5]=3.079581
neuFiber_1_2[2][0]=12.265128
neuFiber_1_2[2][1]=7.347864
neuFiber_1_2[2][2]=12.331875
neuFiber_1_2[2][3]=11.472099
neuFiber_1_2[2][4]=4.204889
neuFiber_1_2[2][5]=7.360804
neuFiber_1_2[3][0]=-0.843362
neuFiber_1_2[3][1]=-1.652367
neuFiber_1_2[3][2]=4.618839
neuFiber_1_2[3][3]=3.922103
neuFiber_1_2[3][4]=-1.760506
neuFiber_1_2[3][5]=2.216568
neuFiber_1_2[4][0]=-3.269430
neuFiber_1_2[4][1]=-1.928894
neuFiber_1_2[4][2]=5.197261
neuFiber_1_2[4][3]=3.858087
neuFiber_1_2[4][4]=0.169454
neuFiber_1_2[4][5]=3.239430
```



```
neuFiber_1_2[5][0]=5.502301
neuFiber_1_2[5][1]=4.461137
neuFiber_1_2[5][2]=5.008927
neuFiber_1_2[5][3]=2.247977
neuFiber_1_2[5][4]=0.762303
neuFiber_1_2[5][5]=2.113117
neuFiber_1_2[6][0]=11.119242
neuFiber_1_2[6][1]=7.740048
neuFiber_1_2[6][2]=5.754780
neuFiber_1_2[6][3]=8.196551
neuFiber_1_2[6][4]=3.520359
neuFiber_1_2[6][5]=10.073517
neuFiber_1_2[7][0]=-1.686037
neuFiber_1_2[7][1]=-2.331734
neuFiber_1_2[7][2]=3.807693
neuFiber_1_2[7][3]=2.855485
neuFiber_1_2[7][4]=-0.051138
neuFiber_1_2[7][5]=2.530128
neuFiber_1_2[8][0]=22.238671
neuFiber_1_2[8][1]=13.032325
neuFiber_1_2[8][2]=14.128983
neuFiber_1_2[8][3]=19.076433
neuFiber_1_2[8][4]=5.764765
neuFiber_1_2[8][5]=3.655142
neuFiber_1_2[9][0]=7.841546
neuFiber_1_2[9][1]=7.635964
neuFiber_1_2[9][2]=3.384745
neuFiber_1_2[9][3]=1.662150
neuFiber_1_2[9][4]=-1.540666
neuFiber_1_2[9][5]=1.935404
```



```
neuFiber_2_3[0][0]=-2.950828
neuFiber_2_3[0][1]=3.773949
neuFiber_2_3[0][2]=0.980900
neuFiber_2_3[0][3]=2.415014
neuFiber_2_3[0][4]=4.847810
neuFiber_2_3[0][5]=0.507631
neuFiber_2_3[0][6]=-0.497714
neuFiber_2_3[0][7]=3.389734
neuFiber_2_3[0][8]=-1.336014
neuFiber_2_3[0][9]=-2.955099
neuFiber_2_3[1][0]=5.449113
neuFiber_2_3[1][1]=4.423354
neuFiber_2_3[1][2]=6.166765
neuFiber_2_3[1][3]=4.386419
neuFiber_2_3[1][4]=3.653651
neuFiber_2_3[1][5]=6.664023
neuFiber_2_3[1][6]=-7.179136
neuFiber_2_3[1][7]=4.364350
neuFiber_2_3[1][8]=6.219210
neuFiber_2_3[1][9]=1.250371
```

Q&A

Interesting Video Sharing

- Google soli (2015):
  https://www.google.com/atap/project-soli/
- University of Minnesota-mind control (2013):
  https://www.youtube.com/watch?v=baEYCberLUA
- MIT-eavesdrop through vibration (2014)：
  https://www.youtube.com/watch?v=FKXOucXB4a8
- Auviz-AuvizDNN (2015)：
  https://www.youtube.com/watch?v=hQVbqmuMZoM
- Facebook-“Aquila” (2015) :
  http://www.stuff.co.nz/technology/social-networking/70710497/facebooks-airforce-giant-solarpowered-aquila-drone-to-bring-internet-to-rural-areas
- Light field camera:
  https://illum.lytro.com/illum

Thanks！

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