

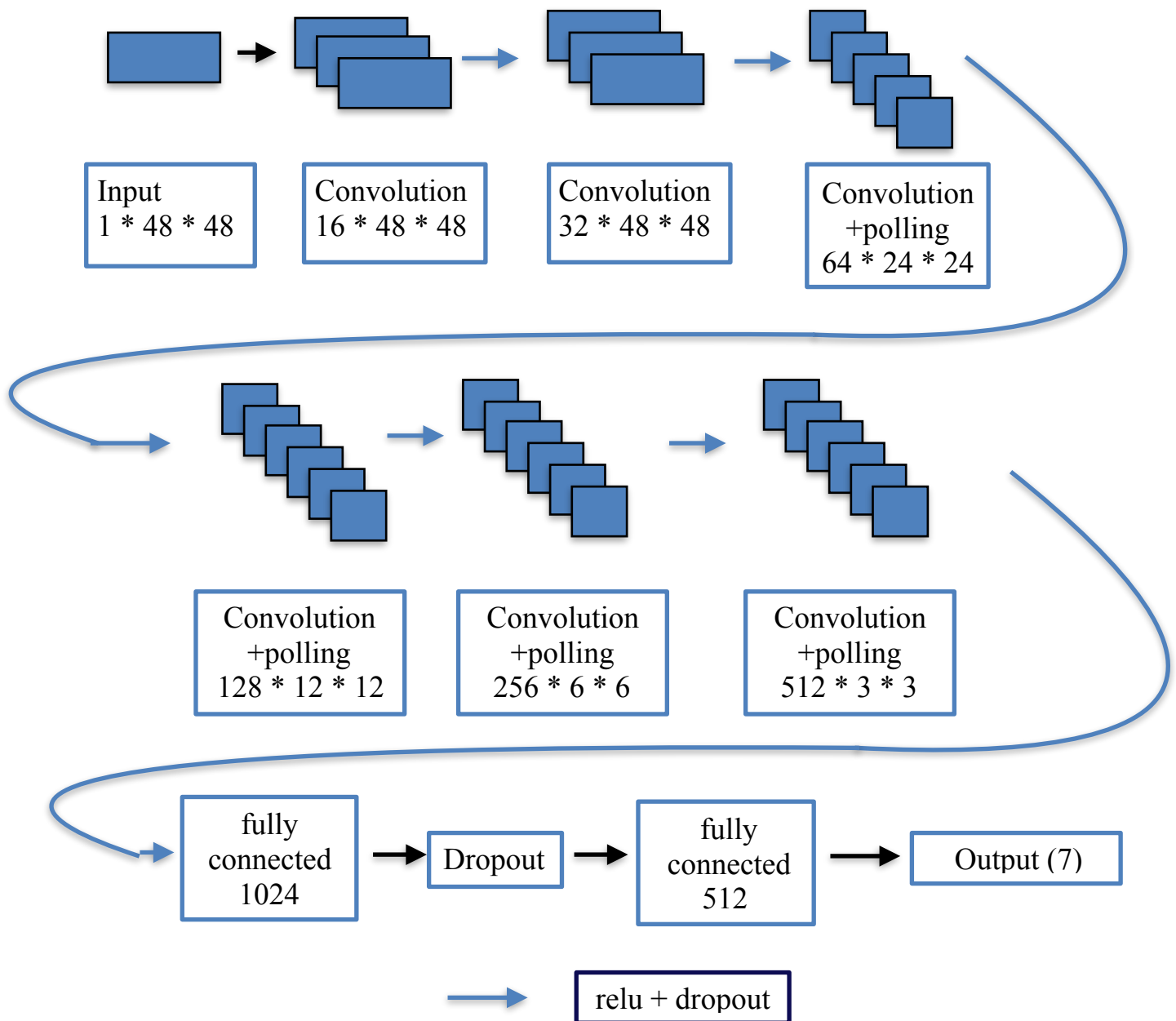
Homework3 Report

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EE5184 - Machine Learning

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1. (1%) 請說明你實作的 CNN model，其模型架構、訓練過程和準確率為何？



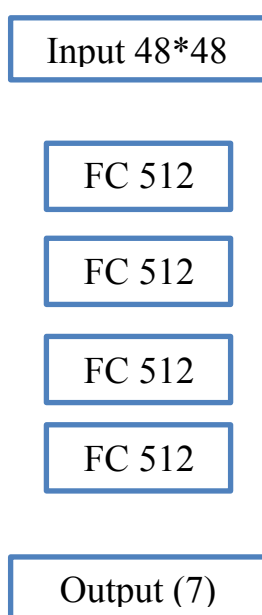
訓練過程：

Make batch \rightarrow forward \rightarrow loss backward \rightarrow (loop)

準確率：

Model	Public score	Private score
單一 model	0.69183	0.70075
Ensemble 2 models	0.69796	0.71858

2. (1%) 承上題，請用與上述 CNN 接近的參數量，實做簡單的 DNN model，其模型架構、訓練過程和準確率為何？試與上題結果做比較，並說明你觀察到了什麼？



訓練過程：

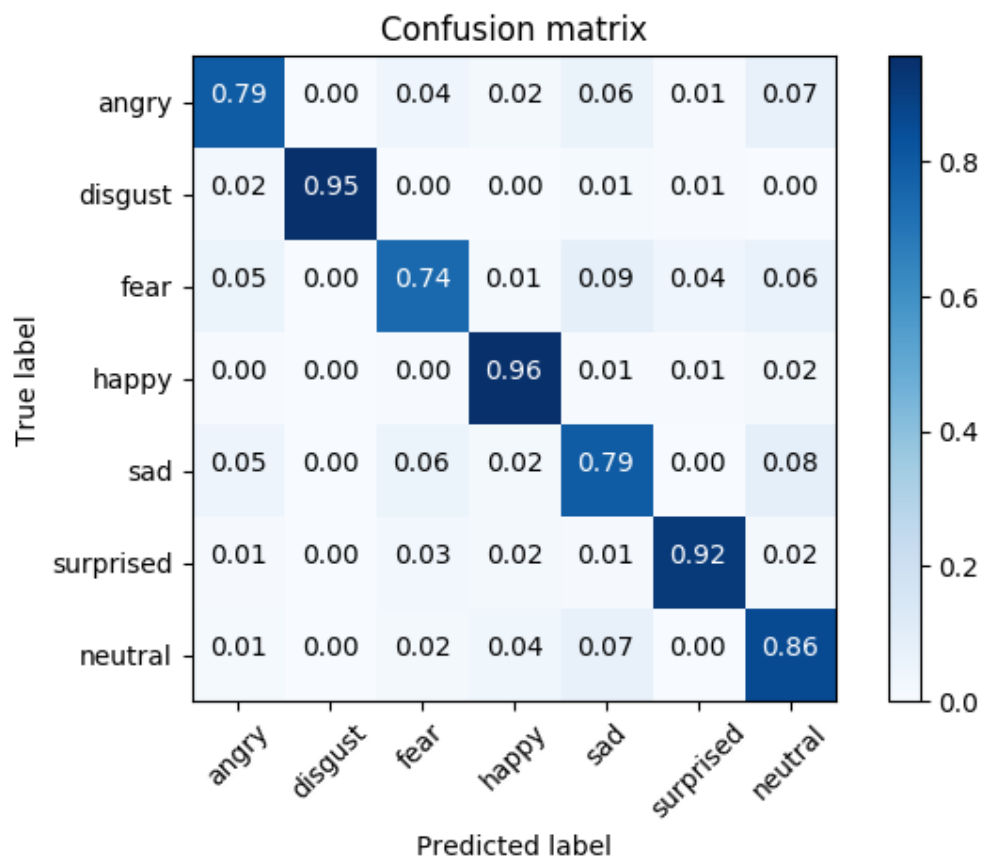
Make batch → forward → loss backward →(loop)

Model	Public score	Private score
CNN	0.36277	0.37977
DNN	0.69138	0.70075

觀察：

DNN 不像 CNN 有 Convolution layer，較難察覺各個 pixel 之間的關係，因此在同樣數量的參數下，DNN 的準確率低了許多。
(就算沒有仔細調整架構與 Hyperparameter, CNN 也可以輕鬆超過 50%)

3. (1%) 觀察答錯的圖片中，哪些 class 彼此間容易用混？並說明你觀察到了什麼？[繪出 confusion matrix 分析]



從上圖可看出，disgust、happy、surprised 三者比較不易搞混，angry、fear、sad 三者容易互相搞混。sad 也容易與 neutral 搞混。

-----Handwritten question-----

4. (1.5%, each 0.5%) CNN time/space complexity:

For a. b. Given a CNN model as

```
model = Sequential()
model.add(Conv2D(filters=6,
                  strides=(3, 3),
                  padding="valid",
                  kernel_size=(2,2),
                  input_shape=(8,8,5),
                  activation='relu'))
model.add(Conv2D(filters=4,
                  strides=(2, 2),
                  padding="valid",
                  kernel_size=(2,2),
                  activation='relu'))
```

And for the c. given the parameter as:

kernel size = (k,k);

channel size = c;

filter size = f;

input shape = (n,n);

padding = 1;

strides = (s,s);

a. How many parameters are there in each layer (Hint: you may consider whether the number of parameter is related with)

Layer A: $(5*2*2+1)*6 = 126$

Layer B: $(1*2*2+1)*4 = 20$

b. How many multiplications/additions are needed for a forward pass (each layer).

Layer A:

$5 * 6 * 2^3 * 3^2 = 2160$ multiplications

$5 * 6 * 2^2 * 1 * 3^2 = 1080$ additions

Layer B:

multiplications

addition

c. What is the time complexity of convolutional neural networks? (note: you must use big-O upper bound, and there are l layer, you can use C_l, C_{l-1} as lth and l-1th layer)

For each layer, it takes

$c * f * k^3 * \lceil \frac{n}{s} \rceil^2$ multiplications and

$$(c * f * k^2(k-1) * [\frac{n}{s}]^2) + (c-1) * k^2 \quad \text{additions}$$

And the time complexity of a CNN is $O(l * c * f * k^3 * [\frac{n}{s}]^2)$

5. (1.5%, each 0.5%) PCA practice: Problem statement: Given 10 samples in 3D space. $(1, 2, 3), (4, 8, 5), (3, 12, 9), (1, 8, 5), (5, 14, 2), (7, 4, 1), (9, 8, 9), (3, 8, 1), (11, 5, 6), (10, 11, 7)$

a. (1) What are the principal axes?

$$\mu = (5.4, 8, 4.8)$$

$$\text{covariance matrix} = \begin{bmatrix} 13.38 & 0.56 & 3.64 \\ 0.56 & 13.56 & 3.22 \\ 3.64 & 3.22 & 9.07 \end{bmatrix}$$

$$w^1 = (-0.85, -0.03, -0.52)$$

$$w^2 = (0.34, 0.73, -0.59)$$

$$w^3 = (0.4, -0.68, -0.62)$$

b. (2) Compute the principal components for each sample.

$$(1, 2, 3) \rightarrow (-2.47, 0.04, -2.81)$$

$$(4, 8, 5) \rightarrow (-6.24, 4.28, -6.91)$$

$$(3, 12, 9) \rightarrow (-7.59, 4.53, -12.49)$$

$$(1, 8, 5) \rightarrow (-3.68, 3.27, -8.11)$$

$$(5, 14, 2) \rightarrow (-5.69, 10.79, -8.73)$$

$$(7, 4, 1) \rightarrow (-6.60, 4.71, -0.53)$$

$$(9, 8, 9) \rightarrow (-12.59, 3.61, -7.38)$$

$$(3, 8, 1) \rightarrow (-3.30, 6.30, -4.84)$$

$$(11, 5, 6) \rightarrow (-12.65, 3.85, -2.69)$$

$$(10, 11, 7) \rightarrow (-12.48, 7.33, -7.78)$$

c. (3) Reconstruction error if reduced to 2D. (Calculate the L2-norm)

$$L = \sum \| (x - \bar{x}) - (\sum_{k=1}^K (x - \bar{x}) \cdot w^k \cdot w^k) \|_2$$

$$L = 10.57$$