Homework3 Report

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EE5184 - Machine Learning

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Note:1~3 題建議不要超過三頁

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？

Layer (type)	Output Shape	Param #
conv2d_1 (Conv2D)	(None, 48, 48, 64)	640
conv2d_2 (Conv2D)	(None, 48, 48, 64)	36928
max_pooling2d_1 (MaxPooling2	(None, 24, 24, 64)	0
dropout_1 (Dropout)	(None, 24, 24, 64)	0
conv2d_3 (Conv2D)	(None, 24, 24, 128)	73856
conv2d_4 (Conv2D)	(None, 24, 24, 128)	147584
max_pooling2d_2 (MaxPooling2	(None, 12, 12, 128)	0
dropout_2 (Dropout)	(None, 12, 12, 128)	0
conv2d_5 (Conv2D)	(None, 12, 12, 256)	295168
conv2d_6 (Conv2D)	(None, 12, 12, 256)	590080
conv2d_7 (Conv2D)	(None, 12, 12, 256)	590080
max_pooling2d_3 (MaxPooling2	(None, 6, 6, 256)	0
dropout_3 (Dropout)	(None, 6, 6, 256)	0
flatten_1 (Flatten)	(None, 9216)	0
dense_1 (Dense)	(None, 512)	4719104
dropout_4 (Dropout)	(None, 512)	0
dense_2 (Dense)	(None, 512)	262656
dropout_5 (Dropout)	(None, 512)	0
dense_3 (Dense)	(None, 7)	3591
activation_1 (Activation)	(None, 7)	0

Total params: 6,719,687
Trainable params: 6,719,687

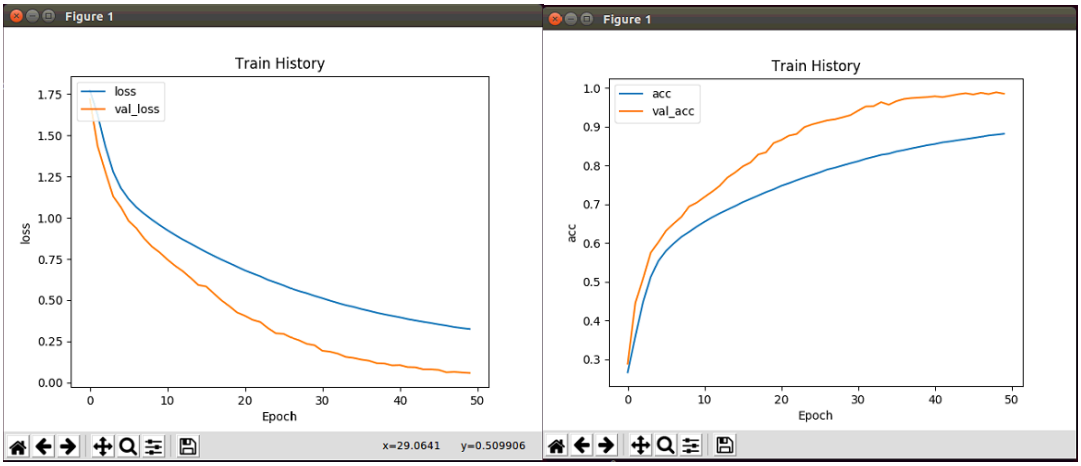
Figure 1 CNN model

模型架構 :

參考 VGG-16 架構，先兩層深度 64 的 convolution 層(使用 relu 激活)搭配 1 層 max pooling 層與 dropout 層避免 overfitting，接下來用類似的架構，架了兩層深度 128 的 convolution 層(使用 relu 激活)搭配 1 層 max pooling 層與 dropout 層，與層深度 128 的 convolution 層(使用 relu 激活)搭配 1 層 max pooling 層與 dropout 層，再來架 flatten 層讓資料扁平化，進入 Neural Network，架了 2 層 512 的全連接層與 dropout 層，最後 output layer 輸出 7 個分類，總參數:6719687 個。

訓練過程 :

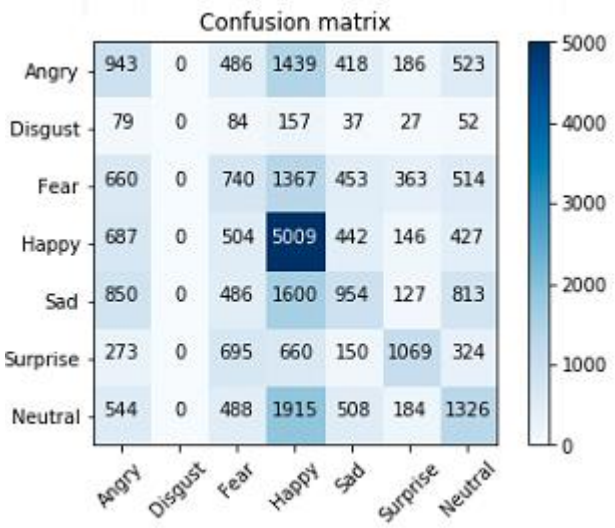
首先切 training data 前 4000 筆資料為 validation data，訓練過程採用 stochastic gradient descent (learning rate=0.005, decay=0.00001, momentum=0.9)，loss 採用 cross entropy，衡量標準為 accuracy，並加上 callback，隨時儲存訓練過程中表現好的 model，下圖為訓練過程的 loss 與 accuracy 變化。



準確率 : 0.68347 (public leader board)

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？

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]



Disgust 資料少因此無法正確識別，Happy 數量最多且和 Angry, Fear, Sad, Neutral 常常混淆，每個種類的資料數量差很多，需要特別處理。

4.

a. how many parameters are there in each layer?

$$\#\ of\ parameters\ =\ filters\ *\ (kernelsize * channels + 1)$$

Layer A:
filters = 6
kernel size = (2,2)
channels = 5, because input shape = (8,8,5)
parameters = 6*(2*2*5+1) = 126

Layer B:
filters = 4
kernel size = (2,2)
channels = 6 because output shape of layer A = (3,3,6)
parameters = 4*(2*2*6+1) = 100

b. How many multiplications/additions are needed for a forward pass?

number of multiplications = 111 filters * steps * (kernel size*channels)
number of additions = filters * steps * (kernel size*channels-1)

Layer A:
filters = 6
steps = (3,3) because ((input size-kernel size)/strides)+1=3.0
kernelsize = (2,2)
channels = 5
multiplications = 6*(3*3)*(2*2*5) = 1080
additions = 6*(3*3)*(2*2*5-1) = 1026

Layer B:
filters = 4
steps = (1,1) because ((input size-kernel size)/strides)+1=1.5,

by padding=valid, we drop incomplete stride and get steps=1
kernelsize = (2,2)
channels = 5
multiplications = 4*(1*1)*(2*2*6) = 96
additions = 4*(1*1)*(2*2*6-1) = 92

c. What is the time complexity of convolutional neural networks?

time complexity = number of multiplications + number of additions

Layer i:
given
kernel size = (k_i, k_i)
channelsize = c_i
input shape = $(n_i, n_i) \ = \ (n, n)$
Then
steps = (n,n) since steps of layer i = input shape of layer i+1
filters = c_{i+1} **since filters of layer i = channelsize of layer i+1**
Then
multiplications = $c_{i+1} * (n * n) * (k_i * k_i * c_i)$
additions = $c_{i+1} * (n * n) * (k_i * k_i * c_i - 1)$
time complexity = $c_{i+1} * (n * n) * (2 * k_i * k_i * c_i - 1) \ = \ O(c_i c_{i+1} k_i^2 n^2)$
Finally,
CNN:
$number\ of\ layers \ = \ l$
time complexity = $\sum_{i=1}^{l} O(c_i c_{i+1} k_i^2 n^2)$ **, where** c_{l+1} **is the desired output channelsize.**

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
,(3,8,1),(11,5,6),(10,11,7)
(1) What are the principal axes?
(2) Compute the principal components for each sample.
(3) Reconstruction error if reduced to 2D.
(Calculate the L2-norm)

(1)

$$\begin{bmatrix} & & \\ u1 & u2 & u3 \\ & & \end{bmatrix} = \begin{bmatrix} 0.5035 & 0.7791 & 0.3735 \\ 0.7370 & -0.6129 & 0.2849 \\ 0.4509 & 0.1318 & -0.8828 \end{bmatrix}$$

(2)

$$\begin{bmatrix} \lambda_1 & 0 & 0 \\ 0 & \lambda_2 & 0 \\ 0 & 0 & \lambda_3 \end{bmatrix} = \begin{bmatrix} 131.32 & 0 & 0 \\ 0 & 11.76 & 0 \\ 0 & 0 & 5.52 \end{bmatrix}$$

(3)

$$\text{投影誤差(project error)}=\frac{1}{m}\sum_{i=1}^{m}\|x^{(i)}-x_{approx}^{(i)}\|^2 = 5.5173$$

$$\text{總變差(total variation)} =\frac{1}{m}\sum_{i=1}^{m}\|x^{(i)}\|^2 = 148.6000$$

$$\text{誤差率(error ratio)} =\frac{\frac{1}{m}\sum_{i=1}^{m}\|x^{(i)}-x_{approx}^{(i)}\|^2}{\frac{1}{m}\sum_{i=1}^{m}\|x^{(i)}\|^2} = 0.0371$$

Reference : https://zhuanlan.zhihu.com/p/32953274?fbclid=IwAR0R86kHjM66-UaUWLvarBUAuS3MXDLqnHtS4OoK-BatRB-FWLYEdvaQS6Q