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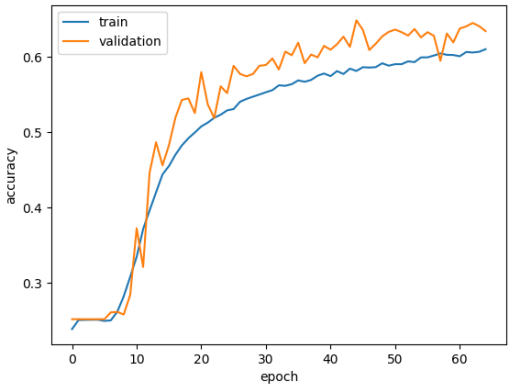
1. (1%) 請說明你實作的 CNN model，其模型架構、訓練過程和準確率為何？

Layer (type)	Output Shape	Param #
conv2d_1 (Conv2D)	(None, 46, 46, 32)	320
zero_padding2d_1 (ZeroPaddin	(None, 48, 48, 32)	0
batch_normalization_1 (Batch	(None, 48, 48, 32)	128
activation_1 (Activation)	(None, 48, 48, 32)	0
dropout_1 (Dropout)	(None, 48, 48, 32)	0
conv2d_2 (Conv2D)	(None, 46, 46, 64)	18496
zero_padding2d_2 (ZeroPaddin	(None, 48, 48, 64)	0
batch_normalization_2 (Batch	(None, 48, 48, 64)	256
activation_2 (Activation)	(None, 48, 48, 64)	0
dropout_2 (Dropout)	(None, 48, 48, 64)	0
average_pooling2d_1 (Average	(None, 24, 24, 64)	0
conv2d_3 (Conv2D)	(None, 22, 22, 64)	36928
zero_padding2d_3 (ZeroPaddin	(None, 24, 24, 64)	0
batch_normalization_3 (Batch	(None, 24, 24, 64)	256
activation_3 (Activation)	(None, 24, 24, 64)	0
dropout_3 (Dropout)	(None, 24, 24, 64)	0
conv2d_4 (Conv2D)	(None, 22, 22, 64)	36928
zero_padding2d_4 (ZeroPaddin	(None, 24, 24, 64)	0
batch_normalization_4 (Batch	(None, 24, 24, 64)	256
activation_4 (Activation)	(None, 24, 24, 64)	0
dropout_4 (Dropout)	(None, 24, 24, 64)	0
dropout_4 (Dropout)	(None, 24, 24, 64)	0
average_pooling2d_2 (Average	(None, 12, 12, 64)	0
conv2d_5 (Conv2D)	(None, 10, 10, 128)	73856
zero_padding2d_5 (ZeroPaddin	(None, 12, 12, 128)	0
batch_normalization_5 (Batch	(None, 12, 12, 128)	512
activation_5 (Activation)	(None, 12, 12, 128)	0
dropout_5 (Dropout)	(None, 12, 12, 128)	0
conv2d_6 (Conv2D)	(None, 10, 10, 128)	147584
zero_padding2d_6 (ZeroPaddin	(None, 12, 12, 128)	0
batch_normalization_6 (Batch	(None, 12, 12, 128)	512
activation_6 (Activation)	(None, 12, 12, 128)	0
dropout_6 (Dropout)	(None, 12, 12, 128)	0
average_pooling2d_3 (Average	(None, 6, 6, 128)	0
conv2d_7 (Conv2D)	(None, 4, 4, 256)	295168
zero_padding2d_7 (ZeroPaddin	(None, 6, 6, 256)	0
batch_normalization_7 (Batch	(None, 6, 6, 256)	1024
activation_7 (Activation)	(None, 6, 6, 256)	0
dropout_7 (Dropout)	(None, 6, 6, 256)	0
conv2d_8 (Conv2D)	(None, 4, 4, 256)	590080
zero_padding2d_8 (ZeroPaddin	(None, 6, 6, 256)	0
batch_normalization_8 (Batch	(None, 6, 6, 256)	1024
activation_8 (Activation)	(None, 6, 6, 256)	0
activation_8 (Activation)	(None, 6, 6, 256)	0
dropout_8 (Dropout)	(None, 6, 6, 256)	0
average_pooling2d_4 (Average	(None, 3, 3, 256)	0
flatten_1 (Flatten)	(None, 2304)	0
dense_1 (Dense)	(None, 1024)	2360320
activation_9 (Activation)	(None, 1024)	0
dropout_9 (Dropout)	(None, 1024)	0
dense_2 (Dense)	(None, 1024)	1049600
activation_10 (Activation)	(None, 1024)	0
dropout_10 (Dropout)	(None, 1024)	0
dense_3 (Dense)	(None, 7)	7175
activation_11 (Activation)	(None, 7)	0

Total params: 4,620,423
Trainable params: 4,618,439
Non-trainable params: 1,984

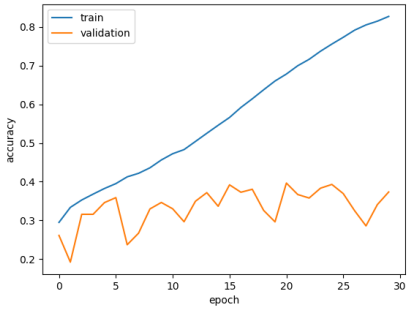


大致上是 ccpccpccpccpff 的架構（參考 vgg 架構），其中 pooling 使用 average pooling，activation funcation 使用 relu，有加上 batch normalization。訓練時有使用 keras image generator 來翻轉、旋轉、位移圖片。訓練過程的圖如上，validation 取原始資料的 10%，可能是因為 validation 資料數量較小，因此有較大的波動。Kaggle 上的最高分數是取多次 epoch ensemble 後的結果，分別是第 62, 63, 71, 74 次 epoch，選取的方式為在 validation 上表現最好的。Kaggle 上的 accuracy 為：0.6883

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？

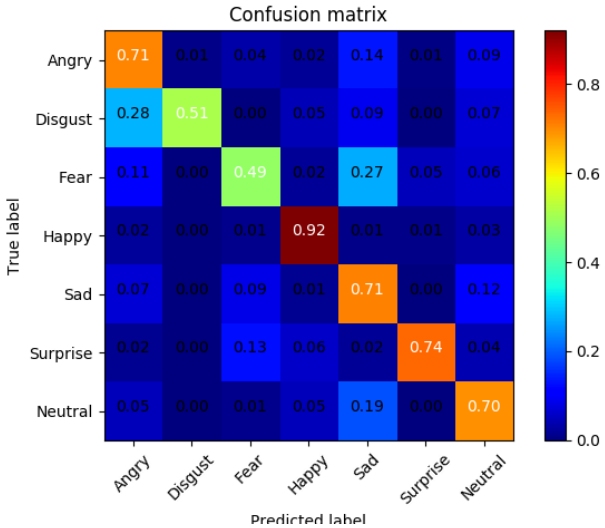
Layer (type)	Output Shape	Param #
max_pooling2d_1 (MaxPooling2	(None, 24, 24, 1)	0
flatten_1 (Flatten)	(None, 576)	0
dense_1 (Dense)	(None, 1024)	590848
batch_normalization_1 (Batch	(None, 1024)	4096
activation_1 (Activation)	(None, 1024)	0
dense_2 (Dense)	(None, 1024)	1049600
batch_normalization_2 (Batch	(None, 1024)	4096
activation_2 (Activation)	(None, 1024)	0
dense_3 (Dense)	(None, 1024)	1049600
batch_normalization_3 (Batch	(None, 1024)	4096
activation_3 (Activation)	(None, 1024)	0
dense_4 (Dense)	(None, 1024)	1049600
batch_normalization_4 (Batch	(None, 1024)	4096
activation_4 (Activation)	(None, 1024)	0
dense_5 (Dense)	(None, 512)	524800
batch_normalization_5 (Batch	(None, 512)	2048
activation_5 (Activation)	(None, 512)	0
dense_6 (Dense)	(None, 512)	262656
batch_normalization_6 (Batch	(None, 512)	2048
activation_6 (Activation)	(None, 512)	0
dense_7 (Dense)	(None, 256)	131328
batch_normalization_7 (Batch	(None, 256)	1024
activation_7 (Activation)	(None, 256)	0
dense_8 (Dense)	(None, 7)	1799
activation_8 (Activation)	(None, 7)	0

Total params: 4,681,735
Trainable params: 4,670,983
Non-trainable params: 10,752



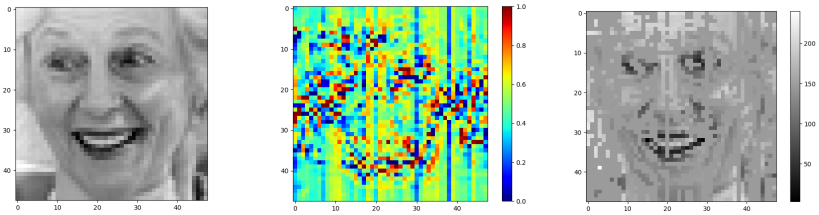
雖然參數差不多多，但結果準確率卻差非常多。模型架構大概就是用了 6 層 fully connected network，最後參數 4,670,983 和 cnn 的 4,618,439 差不多。Kaggle 上的準確率：0.365975，相較 cnn 差了非常多。

3. (1%) 觀察答錯的圖片中，哪些 class 彼此間容易用混？[繪出 confusion matrix 分析]



其中，可發現錯誤其實算是平均的，之間差距沒有非常大。其中較大的部分有兩個：1. 把 disgust 判斷成 angry 2. 把 fear 判斷成 sad。可以想像容易混淆的 class 之間確實是有一定相似度，也造成辨識上的困難。

4. (1%) 從(1)(2)可以發現，使用 CNN 的確有些好處，試繪出其 saliency maps，觀察模型在做 classification 時，是 focus 在圖片的哪些部份



大致上是 focus 在眼睛和嘴巴的部分，對於表情來說的確是重要的，看來 cnn 有抓到重點。

5. (1%) 承(1)(2)，利用上課所提到的 gradient ascent 方法，觀察特定層的 filter 最容易被哪種圖片 activate。
(Collaborators:)
答：