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1. (2%) 請說明你實作的 CNN model，其模型架構、訓練參數和準確率為何？並請用與上述 CNN 接近的參數量，實做簡單的 DNN model，同時也說明其模型架構、訓練參數和準確率為何？並說明你觀察到了什麼？

Layer (type)	Output Shape	Param #
input_1 (InputLayer)	(None, 48, 48, 1)	0
conv2d_1 (Conv2D)	(None, 48, 48, 64)	1664
leaky_re_lu_1 (LeakyReLU)	(None, 48, 48, 64)	0
batch_normalization_1 (Batch	(None, 48, 48, 64)	256
max_pooling2d_1 (MaxPooling2	(None, 24, 24, 64)	0
dropout_1 (Dropout)	(None, 24, 24, 64)	0
conv2d_2 (Conv2D)	(None, 24, 24, 128)	73856
leaky_re_lu_2 (LeakyReLU)	(None, 24, 24, 128)	0
batch_normalization_2 (Batch	(None, 24, 24, 128)	512
max_pooling2d_2 (MaxPooling2	(None, 12, 12, 128)	0
dropout_2 (Dropout)	(None, 12, 12, 128)	0
conv2d_3 (Conv2D)	(None, 12, 12, 512)	590336
leaky_re_lu_3 (LeakyReLU)	(None, 12, 12, 512)	0
batch_normalization_3 (Batch	(None, 12, 12, 512)	2048
max_pooling2d_3 (MaxPooling2	(None, 6, 6, 512)	0
dropout_3 (Dropout)	(None, 6, 6, 512)	0
conv2d_4 (Conv2D)	(None, 6, 6, 512)	2359808
leaky_re_lu_4 (LeakyReLU)	(None, 6, 6, 512)	0
batch_normalization_4 (Batch	(None, 6, 6, 512)	2048
max_pooling2d_4 (MaxPooling2	(None, 3, 3, 512)	0
dropout_4 (Dropout)	(None, 3, 3, 512)	0
flatten_1 (Flatten)	(None, 4608)	0
dense_1 (Dense)	(None, 512)	2359808
batch_normalization_5 (Batch	(None, 512)	2048
dropout_5 (Dropout)	(None, 512)	0
dense_2 (Dense)	(None, 512)	262656
batch_normalization_6 (Batch	(None, 512)	2048
dropout_6 (Dropout)	(None, 512)	0
dense_3 (Dense)	(None, 7)	3591

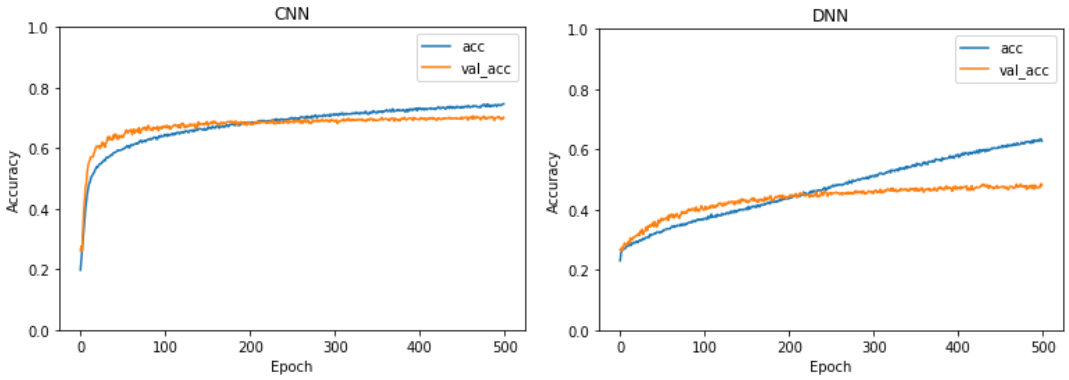
Total params: 5,660,679
Trainable params: 5,656,199
Non-trainable params: 4,480

Layer (type)	Output Shape	Param #
input_1 (InputLayer)	(None, 48, 48, 1)	0
flatten_1 (Flatten)	(None, 2304)	0
dense_1 (Dense)	(None, 1024)	2360320
batch_normalization_1 (Batch	(None, 1024)	4096
dense_2 (Dense)	(None, 1024)	1049600
batch_normalization_2 (Batch	(None, 1024)	4096
dense_3 (Dense)	(None, 1024)	1049600
batch_normalization_3 (Batch	(None, 1024)	4096
dense_4 (Dense)	(None, 512)	524800
batch_normalization_4 (Batch	(None, 512)	2048
dense_5 (Dense)	(None, 256)	131328
batch_normalization_5 (Batch	(None, 256)	1024
dense_6 (Dense)	(None, 128)	32896
batch_normalization_6 (Batch	(None, 128)	512
dense_7 (Dense)	(None, 64)	8256
batch_normalization_7 (Batch	(None, 64)	256
dense_8 (Dense)	(None, 7)	455

Total params: 5,173,383
Trainable params: 5,165,319
Non-trainable params: 8,064

上圖左右分別為 CNN 和 DNN 的架構，CNN 的 Dropout 分別為 0.2、0.3、0.4、0.4，LeakyReLU 的 alpha 設為 0.05，兩者皆使用 Adam 和 ImageDataGenerator，若未特別提到則是用 Keras 的預設參數，CNN 的準確度為 0.694，DNN 為 0.477，可以看出雖然兩者參數接近，但是 CNN 在圖片辨識的效果遠比一般 DNN 來的好。

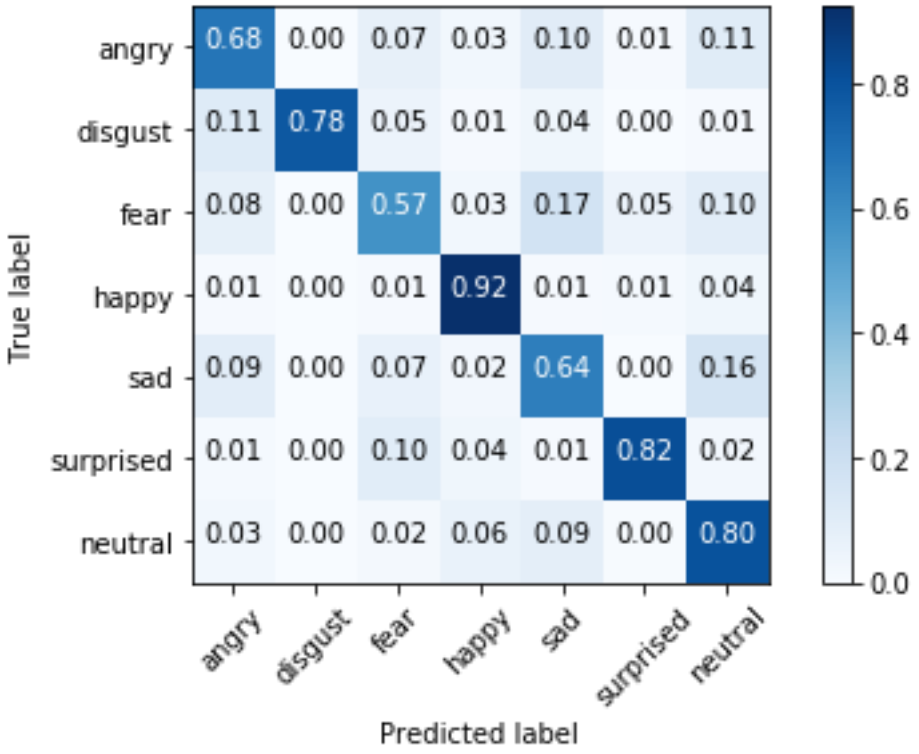
2. (1%) 承上題，請分別畫出這兩個 model 的訓練過程



3. (1%) 請嘗試 data normalization, data augmentation,說明實作方法並且說明實行前後對準確率有什麼樣的影響？

   用相同的 Model，分別測量使用原始資料、normalization(將 data scale 到-1~1)、normalization + augmentation(ImageDataGenerator)，分別得到 0.625、0.625、0.702 的準確度，可見 augmentation 對於提升 Model 的準確度有很大的幫助。

4. (1%) 觀察答錯的圖片中，哪些 class 彼此間容易用混？



   Sad、fear、neutra 這三個 class 相互的混淆程度相較其他顯得偏高。