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※以下實驗皆是使用10% training data 當作 validation，train到valid loss最低停止。

1. (1%)請比較有無normalize(rating)的差別。並說明如何normalize.
   (collaborator: NULL)
   latent dimension = 10，有bias

normalize rating	Private Score	Public Score
有	0.86584	0.86683
無	0.87561	0.87616

   normalize 演算法：

```
ave = numpy.average(rating)
std = numpy.std(rating)
rating = (rating - ave) / std
```

   因為rating的值其實並不大，以數學理論來說應沒有影響，不過實際跑有normalize rating的分數低了0.01，可能是因為normalize後機器fit得更好。

2. (1%)比較不同的latent dimension的結果。
   (collaborator: NULL)
   有bias，未normalize rating

latent dimension	Private Score	Public Score
8	0.87412	0.87105
16	0.87668	0.87490
32	0.88194	0.88156
64	0.89042	0.88825
128	0.90393	0.90128
256	0.92209	0.91859

   可發現latent dimension為個位數具有較佳表現，大於16的話表現會明顯變差。

3. (1%)比較有無bias的結果。
   (collaborator: NULL)
   latent dimension = 10，未normalize rating

bias	Private Score	Public Score
有	0.87561	0.87616
無	0.88062	0.87837

   結果稍稍變差，可見每部電影或每個使用者的評分或多或少會有一些bias。

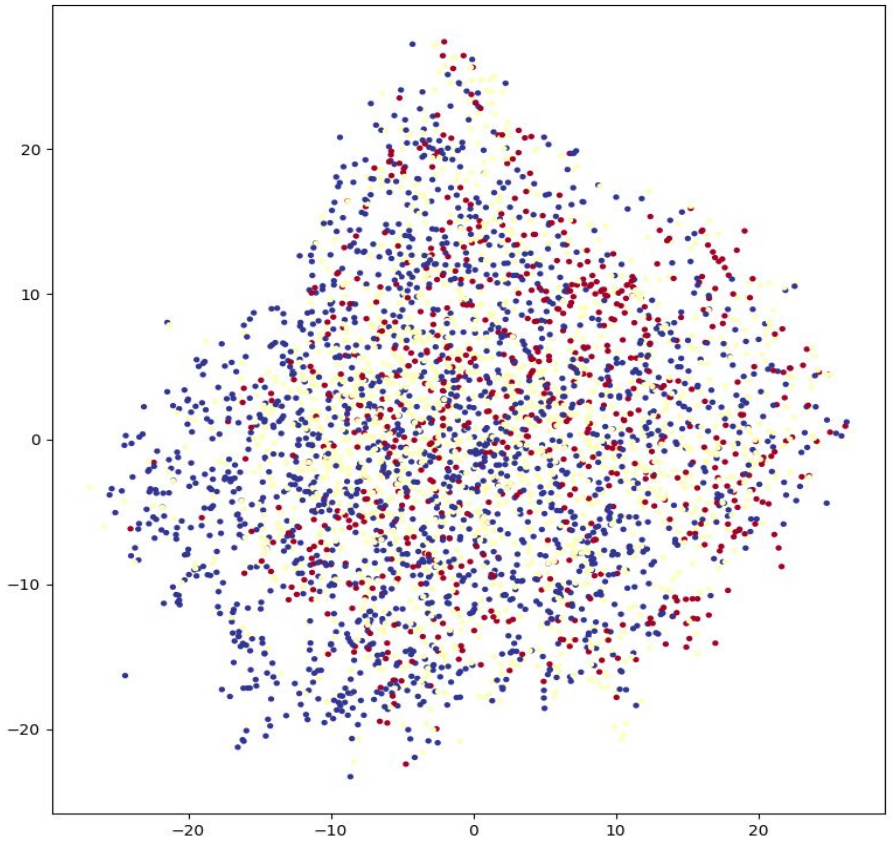
4. (1%)請試著用DNN來解決這個問題，並且說明實做的方法(方法不限)。並比較MF和NN的結果，討論結果的差異。
(collaborator: b04901146 - 黃禹傑)
輸入的資料同MF。
DNN model如下：

```
Layer (type)                 Output Shape              Param #     Connected to
==================================================================================
input_1 (InputLayer)         (None, 1)                 0
__________________________________________________________________________________
input_2 (InputLayer)         (None, 1)                 0
__________________________________________________________________________________
embedding_1 (Embedding)      (None, 1, 10)             60410       input_1[0][0]
__________________________________________________________________________________
embedding_2 (Embedding)      (None, 1, 10)             39530       input_2[0][0]
__________________________________________________________________________________
flatten_1 (Flatten)          (None, 10)                0           embedding_1[0][0]
__________________________________________________________________________________
flatten_2 (Flatten)          (None, 10)                0           embedding_2[0][0]
__________________________________________________________________________________
concatenate_1 (Concatenate)  (None, 20)                0           flatten_1[0][0]
                                                                   flatten_2[0][0]
__________________________________________________________________________________
dense_1 (Dense)              (None, 256)               5376        concatenate_1[0][0]
__________________________________________________________________________________
dropout_1 (Dropout)          (None, 256)               0           dense_1[0][0]
__________________________________________________________________________________
embedding_3 (Embedding)      (None, 1, 1)              6041        input_1[0][0]
__________________________________________________________________________________
embedding_4 (Embedding)      (None, 1, 1)              3953        input_2[0][0]
__________________________________________________________________________________
dense_2 (Dense)              (None, 1)                 257         dropout_1[0][0]
__________________________________________________________________________________
flatten_3 (Flatten)          (None, 1)                 0           embedding_3[0][0]
__________________________________________________________________________________
flatten_4 (Flatten)          (None, 1)                 0           embedding_4[0][0]
__________________________________________________________________________________
add_1 (Add)                  (None, 1)                 0           dense_2[0][0]
                                                                   flatten_3[0][0]
                                                                   flatten_4[0][0]
==================================================================================
Total params: 115,567
Trainable params: 115,567
Non-trainable params: 0
__________________________________________________________________________________
```

model	Private Score	Public Score
MF	0.87561	0.87616
DNN	0.86174	0.86050

結果進步很顯著，推測是因DNN較靈活，MF受到內積運算的限制，有些資訊無法包含。

5. (1%)請試著將movie的embedding用tsne降維後，將movie category當作label來作圖。
   (collaborator: NULL)
   分為三種，結果如下，右邊是mapping(紅→0、米→1、藍→2)。




```
'Action'      ] = '2'
'Adventure'   ] = '2'
'Animation'   ] = '2'
"Children\'s" ] = '2'
'Comedy'      ] = '2'
'Crime'       ] = '0'
'Documentary' ] = '1'
'Drama'       ] = '1'
'Fantasy'     ] = '1'
'Film-Noir'   ] = '0'
'Horror'      ] = '0'
'Musical'     ] = '2'
'Mystery'     ] = '0'
'Romance'     ] = '2'
'Sci-Fi'      ] = '1'
'Thriller'    ] = '0'
'War'         ] = '0'
'Western'     ] = '1'
```

6. (BONUS)(1%)試著使用除了rating以外的feature, 並說明你的作法和結果，結果好壞不會影響評分。
   (collaborator: NULL)
   將User的Gender、Age和Movie Genres的one-hot encoding整理成20維的向量，加入DNN model的Concatenate層，Keras model如下：

Layer (type)	Output Shape	Param #	Connected to
input_1 (InputLayer)	(None, 1)	0	
input_2 (InputLayer)	(None, 1)	0	
embedding_1 (Embedding)	(None, 1, 10)	60410	input_1[0][0]
embedding_2 (Embedding)	(None, 1, 10)	39530	input_2[0][0]
flatten_1 (Flatten)	(None, 10)	0	embedding_1[0][0]
flatten_2 (Flatten)	(None, 10)	0	embedding_2[0][0]
input_3 (InputLayer)	(None, 20)	0	
concatenate_1 (Concatenate)	(None, 40)	0	flatten_1[0][0] flatten_2[0][0] input_3[0][0]
dense_1 (Dense)	(None, 256)	10496	concatenate_1[0][0]
dropout_1 (Dropout)	(None, 256)	0	dense_1[0][0]
dense_2 (Dense)	(None, 1)	257	dropout_1[0][0]

Total params: 110,693
Trainable params: 110,693
Non-trainable params: 0

Kaggle Score比較：

model	Private Score	Public Score
原始DNN	0.86174	0.86050
加入其他info之DNN	0.87028	0.87071

推測是因為這些資訊對於rating並不具有重要的bias或關係，因此加了反而容易overfitting(多達20維的資訊)，結果稍稍變差。