Day 2

Please run the following code to update the recoflow package

In [89]:

```
!pip install recoflow --upgrade
import recoflow
```

```
Requirement already up-to-date: recoflow in /usr/local/lib/python3.6/dist-packages (0.0.7)
Requirement already satisfied, skipping upgrade: altair<4.0,>=3.2 in /usr/local/lib/python3.6/dist-packages
(from recoflow) (3.2.0)
Requirement already satisfied, skipping upgrade: pandas<0.26.0,>=0.25.1 in /usr/local/lib/python3.6/dist-pac
kages (from recoflow) (0.25.1)
Requirement already satisfied, skipping upgrade: scikit-learn<0.22.0,>=0.21.3 in /usr/local/lib/python3.6/di
st-packages (from recoflow) (0.21.3)
Requirement already satisfied, skipping upgrade: numpy<2.0,>=1.17 in /usr/local/lib/python3.6/dist-packages
(from recoflow) (1.17.2)
Requirement already satisfied, skipping upgrade: matplotlib<4.0,>=3.1 in /usr/local/lib/python3.6/dist-packa
ges (from recoflow) (3.1.1)
Requirement already satisfied, skipping upgrade: requests<3.0,>=2.22 in /usr/local/lib/python3.6/dist-packag
es (from recoflow) (2.22.0)
Requirement already satisfied, skipping upgrade: keras<3.0,>=2.3 in /usr/local/lib/python3.6/dist-packages
(from recoflow) (2.3.0)
Requirement already satisfied, skipping upgrade: entrypoints in /usr/local/lib/python3.6/dist-packages (from
altair<4.0,>=3.2->recoflow) (0.3)
Requirement already satisfied, skipping upgrade: six in /usr/lib/python3/dist-packages (from altair<4.0,>=3.
2->recoflow) (1.11.0)
Requirement already satisfied, skipping upgrade: jsonschema in /usr/local/lib/python3.6/dist-packages (from
altair<4.0,>=3.2->recoflow) (3.0.2)
Requirement already satisfied, skipping upgrade: toolz in /usr/local/lib/python3.6/dist-packages (from altai
r<4.0,>=3.2->recoflow) (0.10.0)
Requirement already satisfied, skipping upgrade: jinja2 in /usr/local/lib/python3.6/dist-packages (from alta
ir<4.0,>=3.2->recoflow) (2.10.1)
Requirement already satisfied, skipping upgrade: pytz>=2017.2 in /usr/local/lib/python3.6/dist-packages (fro
m pandas<0.26.0,>=0.25.1->recoflow) (2019.2)
Requirement already satisfied, skipping upgrade: python-dateutil>=2.6.1 in /usr/local/lib/python3.6/dist-pac
kages (from pandas<0.26.0,>=0.25.1->recoflow) (2.8.0)
Requirement already satisfied, skipping upgrade: scipy>=0.17.0 in /usr/local/lib/python3.6/dist-packages (fr
om scikit-learn<0.22.0,>=0.21.3->recoflow) (1.3.1)
Requirement already satisfied, skipping upgrade: joblib>=0.11 in /usr/local/lib/python3.6/dist-packages (fro
m scikit-learn<0.22.0,>=0.21.3->recoflow) (0.13.2)
Requirement already satisfied, skipping upgrade: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in /usr/local/lib/
python3.6/dist-packages (from matplotlib<4.0,>=3.1->recoflow) (2.4.2)
Requirement already satisfied, skipping upgrade: kiwisolver>=1.0.1 in /usr/local/lib/python3.6/dist-packages
(from matplotlib<4.0,>=3.1->recoflow) (1.1.0)
Requirement already satisfied, skipping upgrade: cycler>=0.10 in /usr/local/lib/python3.6/dist-packages (fro
m matplotlib<4.0,>=3.1->recoflow) (0.10.0)
Requirement already satisfied, skipping upgrade: urllib3!=1.25.0,!=1.25.1,<1.26,>=1.21.1 in /usr/local/lib/p
ython3.6/dist-packages (from requests<3.0,>=2.22->recoflow) (1.24.2)
Requirement already satisfied, skipping upgrade: idna<2.9,>=2.5 in /usr/local/lib/python3.6/dist-packages (f
rom requests<3.0,>=2.22->recoflow) (2.8)
Requirement already satisfied, skipping upgrade: chardet<3.1.0,>=3.0.2 in /usr/local/lib/python3.6/dist-pack
ages (from requests<3.0,>=2.22->recoflow) (3.0.4)
Requirement already satisfied, skipping upgrade: certifi>=2017.4.17 in /usr/local/lib/python3.6/dist-package
s (from requests<3.0,>=2.22->recoflow) (2019.6.16)
```

```
Requirement already satisfied, skipping upgrade: pyyaml in /usr/local/lib/python3.6/dist-packages (from kera
s<3.0,>=2.3->recoflow) (5.1.2)
Requirement already satisfied, skipping upgrade: keras-applications>=1.0.6 in /usr/local/lib/python3.6/dist-
packages (from keras<3.0,>=2.3->recoflow) (1.0.8)
Requirement already satisfied, skipping upgrade: h5py in /usr/local/lib/python3.6/dist-packages (from keras<
3.0,>=2.3->recoflow) (2.9.0)
Requirement already satisfied, skipping upgrade: keras-preprocessing>=1.0.5 in /usr/local/lib/python3.6/dist
-packages (from keras<3.0,>=2.3->recoflow) (1.1.0)
Requirement already satisfied, skipping upgrade: setuptools in /usr/local/lib/python3.6/dist-packages (from
jsonschema->altair<4.0,>=3.2->recoflow) (41.0.1)
Requirement already satisfied, skipping upgrade: pyrsistent>=0.14.0 in /usr/local/lib/python3.6/dist-package
s (from jsonschema->altair<4.0,>=3.2->recoflow) (0.15.4)
Requirement already satisfied, skipping upgrade: attrs>=17.4.0 in /usr/local/lib/python3.6/dist-packages (fr
om jsonschema->altair<4.0,>=3.2->recoflow) (19.1.0)
Requirement already satisfied, skipping upgrade: MarkupSafe>=0.23 in /usr/local/lib/python3.6/dist-packages
(from jinja2->altair<4.0,>=3.2->recoflow) (1.1.1)
WARNING: You are using pip version 19.1.1, however version 19.2.3 is available.
You should consider upgrading via the 'pip install --upgrade pip' command.
```

Data Preprocessing

In [2]:

```
import numpy as np
import pandas as pd
```

In [4]:

```
ratings = pd.read_csv("/tf/data/ratings.csv")
users = pd.read_csv("/tf/data/users.csv")
items = pd.read_csv("/tf/data/items.csv")
```

In [6]:

```
from recoflow.preprocessing import EncodeUserItem, StratifiedSplit
```

In [8]:

```
# Encoding the data
interaction, n_users, n_items, user_encoder, item_encoder = EncodeUserItem(ratings,
                                                                           "user_id",
                                                                           "movie_id",
                                                                           "rating",
                                                                           "unix_timestamp")
```

```
Number of users:  943
Number of items:  1682
```

In [18]:

```
train, test = StratifiedSplit(interaction, [0.8, 0.2])
train.shape, test.shape
```

Out[18]:

```
((80000, 7), (20000, 7))
```

In [46]:

```
min_rating = interaction.RATING.min()
max_rating = interaction.RATING.max()
min_rating, max_rating
```

Out[46]:

```
(1, 5)
```

Model - Deep Facorization

In [47]:

```
from keras.models import Model
from keras.layers import Embedding, Input, Dot, Add, Activation, Lambda, Concatenate, Dense, Flatten, Dropout
from keras.regularizers import l2
from keras.optimizers import Adam
```

In [48]:

```
Embedding?
```

```
Init signature:
Embedding(
    input_dim,
    output_dim,
    embeddings_initializer='uniform',
    embeddings_regularizer=None,
    activity_regularizer=None,
    embeddings_constraint=None,
    mask_zero=False,
    input_length=None,
    **kwargs,
)
Docstring:
Turns positive integers (indexes) into dense vectors of fixed size.
eg. [[4], [20]] -> [[0.25, 0.1], [0.6, -0.2]]

This layer can only be used as the first layer in a model.

# Example

```python
  model = Sequential()
  model.add(Embedding(1000, 64, input_length=10))
  # the model will take as input an integer matrix of size (batch, input_length).
  # the largest integer (i.e. word index) in the input should be
  # no larger than 999 (vocabulary size).
  # now model.output_shape == (None, 10, 64), where None is the batch dimension.

  input_array = np.random.randint(1000, size=(32, 10))

  model.compile('rmsprop', 'mse')
  output_array = model.predict(input_array)
  assert output_array.shape == (32, 10, 64)
```

Arguments
    input_dim: int > 0. Size of the vocabulary,
        i.e. maximum integer index + 1.
    output_dim: int >= 0. Dimension of the dense embedding.
    embeddings_initializer: Initializer for the `embeddings` matrix
        (see [initializers](../initializers.md)).
    embeddings_regularizer: Regularizer function applied to
        the `embeddings` matrix
        (see [regularizer](../regularizers.md)).
    activity_regularizer: Regularizer function applied to
        the output of the layer (its "activation").
        (see [regularizer](../regularizers.md)).
```

```
    embeddings_constraint: Constraint function applied to
        the `embeddings` matrix
        (see [constraints](../constraints.md)).
    mask_zero: Whether or not the input value 0 is a special "padding"
        value that should be masked out.
        This is useful when using [recurrent layers](recurrent.md)
        which may take variable length input.
        If this is `True` then all subsequent layers
        in the model need to support masking or an exception will be raised.
        If mask_zero is set to True, as a consequence, index 0 cannot be
        used in the vocabulary (input_dim should equal size of
        vocabulary + 1).
    input_length: Length of input sequences, when it is constant.
        This argument is required if you are going to connect
        `Flatten` then `Dense` layers upstream
        (without it, the shape of the dense outputs cannot be computed).

# Input shape
    2D tensor with shape: `(batch_size, sequence_length)`.

# Output shape
    3D tensor with shape: `(batch_size, sequence_length, output_dim)`.

# References
    - [A Theoretically Grounded Application of Dropout in
       Recurrent Neural Networks](http://arxiv.org/abs/1512.05287)
File:           /usr/local/lib/python3.6/dist-packages/keras/layers/embeddings.py
Type:           type
Subclasses:
```

In [49]:

```
def DeepMF(n_users, n_items, n_factors, min_rating, max_rating):

    # Item Layer
    item_input = Input(shape=[1], name='Item')
    item_embedding = Embedding(n_items, n_factors, embeddings_regularizer=l2(1e-6),
                               embeddings_initializer="glorot_normal",
                               name='ItemEmbedding')(item_input)
    item_vec = Flatten(name='FlattenItemE')(item_embedding)

    # Item Bias
    item_bias = Embedding(n_items, 1, embeddings_regularizer=l2(1e-6),
                               embeddings_initializer="glorot_normal",
                          name='ItemBias')(item_input)
    item_bias_vec = Flatten(name='FlattenItemBiasE')(item_bias)

    # User Layer
    user_input = Input(shape=[1], name='User')
    user_embedding = Embedding(n_users, n_factors, embeddings_regularizer=l2(1e-6),
                               embeddings_initializer="glorot_normal",
                               name='UserEmbedding')(user_input)
    user_vec = Flatten(name='FlattenUserE')(user_embedding)

    # User Bias
    user_bias = Embedding(n_users, 1, embeddings_regularizer=l2(1e-6),
                               embeddings_initializer="glorot_normal",
                               name='UserBias')(user_input)
    user_bias_vec = Flatten(name='FlattenUserBiasE')(user_bias)

    # Concatenation of Item and User & then Add Bias
    Concat = Concatenate(name="Concat")([item_vec, user_vec])
    ConcatDrop = Dropout(0.5)(Concat)

    # Use the Dense layer for non-linear interaction learning
    Dense_1 = Dense(32, name="Dense1", activation="relu")(ConcatDrop)
    Dense_1_Drop = Dropout(0.5)(Dense_1)
    Dense_2 = Dense(1, name="Dense2")(Dense_1_Drop)

    # Add the Bias
    AddBias = Add(name="AddBias")([Dense_2, item_bias_vec, user_bias_vec])

    # Scaling for each user
    y = Activation('sigmoid')(AddBias)
    rating_output = Lambda(lambda x: x * (max_rating - min_rating) + min_rating)(y)

    # Model Creation
```

```
    model = Model([user_input, item_input], rating_output, name="DeepFM")

    # Compile Model
    model.compile(loss='mean_squared_error', optimizer=Adam(lr=0.001))

    return model
```

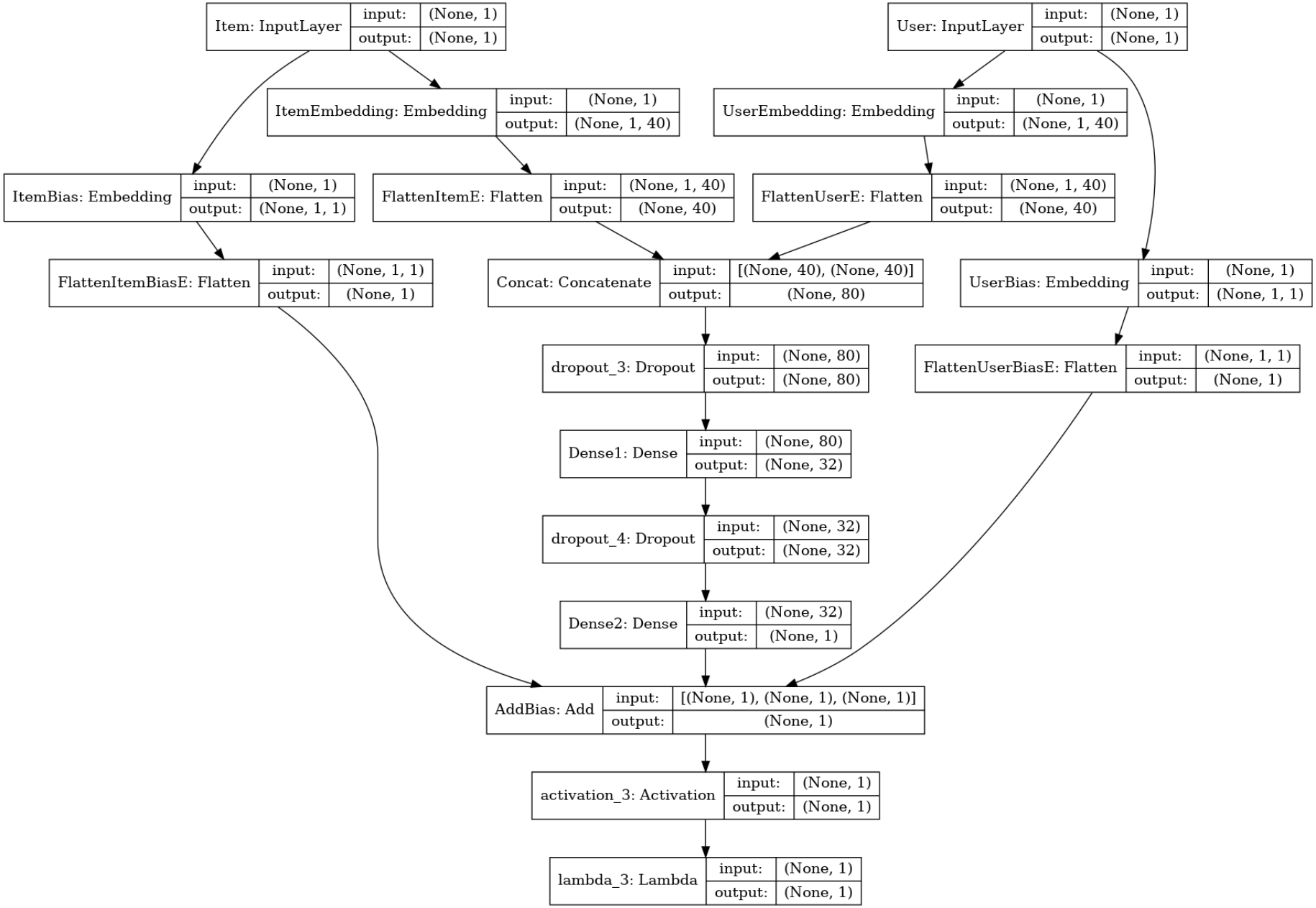
In [50]:

```
n_factors = 40
model = DeepMF(n_users, n_items, n_factors, min_rating, max_rating)
```

In [51]:

```
from keras.utils import plot_model
plot_model(model, show_layer_names=True, show_shapes=True)
```

Out[51]:


Item: InputLayer | input: (None, 1) | output: (None, 1)
User: InputLayer | input: (None, 1) | output: (None, 1)
ItemEmbedding: Embedding | input: (None, 1) | output: (None, 1, 40)
UserEmbedding: Embedding | input: (None, 1) | output: (None, 1, 40)
ItemBias: Embedding | input: (None, 1) | output: (None, 1, 1)
FlattenItemE: Flatten | input: (None, 1, 40) | output: (None, 40)
FlattenUserE: Flatten | input: (None, 1, 40) | output: (None, 40)
FlattenItemBiasE: Flatten | input: (None, 1, 1) | output: (None, 1)
Concat: Concatenate | input: [(None, 40), (None, 40)] | output: (None, 80)
UserBias: Embedding | input: (None, 1) | output: (None, 1, 1)
dropout_3: Dropout | input: (None, 80) | output: (None, 80)
FlattenUserBiasE: Flatten | input: (None, 1, 1) | output: (None, 1)
Dense1: Dense | input: (None, 80) | output: (None, 32)
dropout_4: Dropout | input: (None, 32) | output: (None, 32)
Dense2: Dense | input: (None, 32) | output: (None, 1)
AddBias: Add | input: [(None, 1), (None, 1), (None, 1)] | output: (None, 1)
activation_3: Activation | input: (None, 1) | output: (None, 1)
lambda_3: Lambda | input: (None, 1) | output: (None, 1)

In [52]:

```
model.summary()
```

Model: "DeepFM"

Layer (type)	Output Shape	Param #	Connected to
Item (InputLayer)	(None, 1)	0	
User (InputLayer)	(None, 1)	0	
ItemEmbedding (Embedding)	(None, 1, 40)	67280	Item[0][0]
UserEmbedding (Embedding)	(None, 1, 40)	37720	User[0][0]
FlattenItemE (Flatten)	(None, 40)	0	ItemEmbedding[0][0]
FlattenUserE (Flatten)	(None, 40)	0	UserEmbedding[0][0]
Concat (Concatenate)	(None, 80)	0	FlattenItemE[0][0] FlattenUserE[0][0]
dropout_3 (Dropout)	(None, 80)	0	Concat[0][0]
Dense1 (Dense)	(None, 32)	2592	dropout_3[0][0]
dropout_4 (Dropout)	(None, 32)	0	Dense1[0][0]
ItemBias (Embedding)	(None, 1, 1)	1682	Item[0][0]
UserBias (Embedding)	(None, 1, 1)	943	User[0][0]
Dense2 (Dense)	(None, 1)	33	dropout_4[0][0]
FlattenItemBiasE (Flatten)	(None, 1)	0	ItemBias[0][0]
FlattenUserBiasE (Flatten)	(None, 1)	0	UserBias[0][0]
AddBias (Add)	(None, 1)	0	Dense2[0][0] FlattenItemBiasE[0][0] FlattenUserBiasE[0][0]
activation_3 (Activation)	(None, 1)	0	AddBias[0][0]
lambda_3 (Lambda)	(None, 1)	0	activation_3[0][0]

Total params: 110,250
Trainable params: 110,250
Non-trainable params: 0

In [61]:

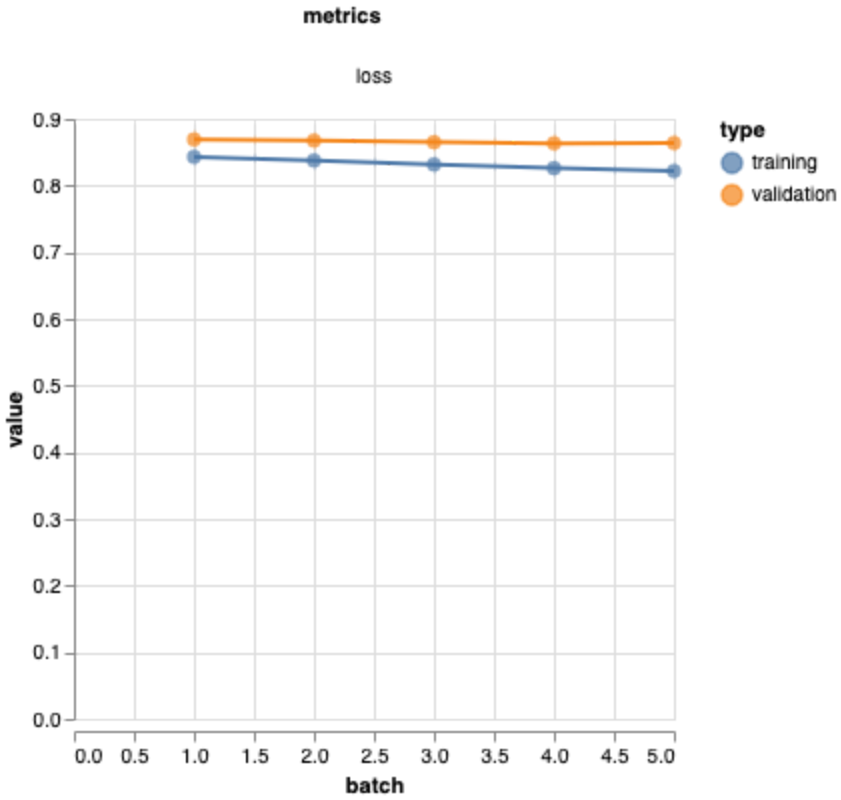
```
output = model.fit([train.USER, train.ITEM], train.RATING,
                   batch_size=32, epochs=5, verbose=1,
                   validation_data=([test.USER, test.ITEM], test.RATING))
```

```
Train on 80000 samples, validate on 20000 samples
Epoch 1/5
80000/80000 [==============================] - 5s 60us/step - loss: 0.8432 - val_loss: 0.8693
Epoch 2/5
80000/80000 [==============================] - 5s 60us/step - loss: 0.8378 - val_loss: 0.8677
Epoch 3/5
80000/80000 [==============================] - 5s 60us/step - loss: 0.8318 - val_loss: 0.8652
Epoch 4/5
80000/80000 [==============================] - 5s 60us/step - loss: 0.8262 - val_loss: 0.8635
Epoch 5/5
80000/80000 [==============================] - 5s 60us/step - loss: 0.8219 - val_loss: 0.8640
```

In [62]:

```
from recoflow.vis import MetricsVis
MetricsVis(output.history)
```

Out[62]:


metrics
loss
type
training
validation
value
batch
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0

In [63]:

```
from recoflow.recommend import GetPredictions

predictions = GetPredictions(model, interaction)
predictions.head()
```

Out[63]:

	USER	ITEM	RATING
0	195	241	4.077020
1	195	301	4.219788
2	195	376	2.237257
3	195	50	3.569890
4	195	345	3.739755

In [64]:

```
GetPredictions?
```

```
Signature: GetPredictions(model, data)
Docstring:
Get predictions for all user-item combinations

Params:
    data (pandas.DataFrame): DataFrame of entire rating data
    model (Keras.model): Trained keras model

Returns:
    pd.DataFrame: DataFrame of rating predictions for each user and each item

File:      /usr/local/lib/python3.6/dist-packages/recoflow/recommend.py
Type:      function
```

In [65]:

```
from recoflow.metrics import RatingMetrics
```

In [68]:

```
RatingMetrics(test, predictions)
```

Out[68]:

	MSE	RMSE	MAE
0	0.8619	0.9284	0.7355

Recommendations

In [75]:

```
from recoflow.recommend import ItemEmbedding, UserEmbedding
item_embedding = ItemEmbedding(model, "ItemEmbedding")
user_embedding = UserEmbedding(model, "UserEmbedding")
```

Getting Recommendation

- Given an Item, what are the similar Items
- Given a User, what items should I recommend

In [76]:

```

```

In [80]:

```
from recoflow.recommend import GetSimilar, ShowSimilarItems
similar_items = GetSimilar(item_embedding, k=5, metric="cosine")
similar_items
```

Out[80]:

```
array([[   0, 1518, 1638, 1514, 1622, 1428],
       [   1, 1678, 1509, 1204, 1363, 1435],
       [   2,  902, 1322, 1435, 1362, 1353],
       ...,
       [1679, 1602, 1431, 1556, 1454, 1551],
       [1680, 1599, 1610, 1631, 1155, 1235],
       [1681, 1121, 1351, 1658, 1640, 1593]])
```

In [85]:

```
ShowSimilarItems(0, similar_items, item_encoder, items, image_path='/tf/data/posters/')
```

In [91]:

```
recoflow.__version__
```

Out[91]:

```
'0.0.6'
```

In [93]:

```
from recoflow.metrics import RatingMetrics
```

For a user I want to find relevant

In [102]:

```
## For a user I want to find relevant
from recoflow.recommend import GetRankingTopK
GetRankingTopK
ranking_topk = GetRankingTopK
```

Ranking Top K

- Get all the predictions for all users
- Remove all the items the user has already seen (train)
- Sort the remaining data by predicted ratings
- Cut off at K

In [107]:

```
ranking_topk = GetRankingTopK(model, interaction, train, k=5)
```

In [108]:

```
ranking_topk.head()
```

Out[108]:

	USER	ITEM	RATING	rank
0	0	1448	4.681684	1
1	0	407	4.654933	2
2	0	482	4.587464	3
3	0	602	4.564211	4
4	0	317	4.539346	5

In [109]:

```
n_users * 5
```

Out[109]:

```
4715
```

In [111]:

```
ranking_topk.shape
```

Out[111]:

```
(4715, 4)
```

Model - Neural Collaborative Filtering

In [116]:

```
from recoflow.models import NeuralCollaborativeFiltering
```

In [118]:

```
NeuralCollaborativeFiltering??
```

```
Signature:
NeuralCollaborativeFiltering(
    n_users,
    n_items,
    n_factors,
    min_rating,
    max_rating,
)
Docstring: <no docstring>
Source:
def NeuralCollaborativeFiltering(n_users, n_items, n_factors, min_rating, max_rating):

    # Item Layer
    item_input = Input(shape=[1], name='Item')

    # Item Embedding MF
    item_embedding_mf = Embedding(n_items, n_factors, embeddings_regularizer=l2(1e-6),
                                  embeddings_initializer='he_normal',
                                  name='ItemEmbeddingMF')(item_input)
    item_vec_mf = Flatten(name='FlattenItemMF')(item_embedding_mf)


    # Item embedding MLP
    item_embedding_mlp = Embedding(n_items, n_factors, embeddings_regularizer=l2(1e-6),
                                   embeddings_initializer='he_normal',
                                  name='ItemEmbeddingMLP')(item_input)
    item_vec_mlp = Flatten(name='FlattenItemMLP')(item_embedding_mlp)


    # User Layer
    user_input = Input(shape=[1], name='User')

    # User Embedding MF
    user_embedding_mf = Embedding(n_users, n_factors, embeddings_regularizer=l2(1e-6),
                                   embeddings_initializer='he_normal',
                                  name='UserEmbeddingMF')(user_input)
    user_vec_mf = Flatten(name='FlattenUserMF')(user_embedding_mf)

    # User Embedding MF
    user_embedding_mlp = Embedding(n_users, n_factors, embeddings_regularizer=l2(1e-6),
                                  embeddings_initializer='he_normal',
                                  name='UserEmbeddingMLP')(user_input)
    user_vec_mlp = Flatten(name='FlattenUserMLP')(user_embedding_mlp)

    # Multiply MF paths
    DotProductMF = Dot(axes=1, name='DotProductMF')([item_vec_mf, user_vec_mf])
```

```
    # Concat MLP paths
    ConcatMLP = Concatenate(name='ConcatMLP')([item_vec_mlp, user_vec_mlp])

    # Use Dense to learn non-linear dense representation
    Dense_1 = Dense(50, name="Dense1")(ConcatMLP)
    Dense_2 = Dense(20, name="Dense2")(Dense_1)

    # Concatenate MF and MLP paths
    Concat = Concatenate(name="ConcatAll")([DotProductMF, Dense_2])

    # Use Dense to learn non-linear dense representation
    Pred = Dense(1, name="Pred")(Concat)


    # Item Bias
    item_bias = Embedding(n_items, 1, embeddings_regularizer=l2(1e-5), name='ItemBias')(item_input)
    item_bias_vec = Flatten(name='FlattenItemBiasE')(item_bias)

    # User Bias
    user_bias = Embedding(n_users, 1, embeddings_regularizer=l2(1e-5), name='UserBias')(user_input)
    user_bias_vec = Flatten(name='FlattenUserBiasE')(user_bias)

    # Pred with bias added
    PredAddBias = Add(name="AddBias")([Pred, item_bias_vec, user_bias_vec])


    # Scaling for each user
    y = Activation('sigmoid')(PredAddBias)
    rating_output = Lambda(lambda x: x * (max_rating - min_rating) + min_rating)(y)

    # Model Creation
    model = Model([user_input, item_input], rating_output, name="NeuralCF")

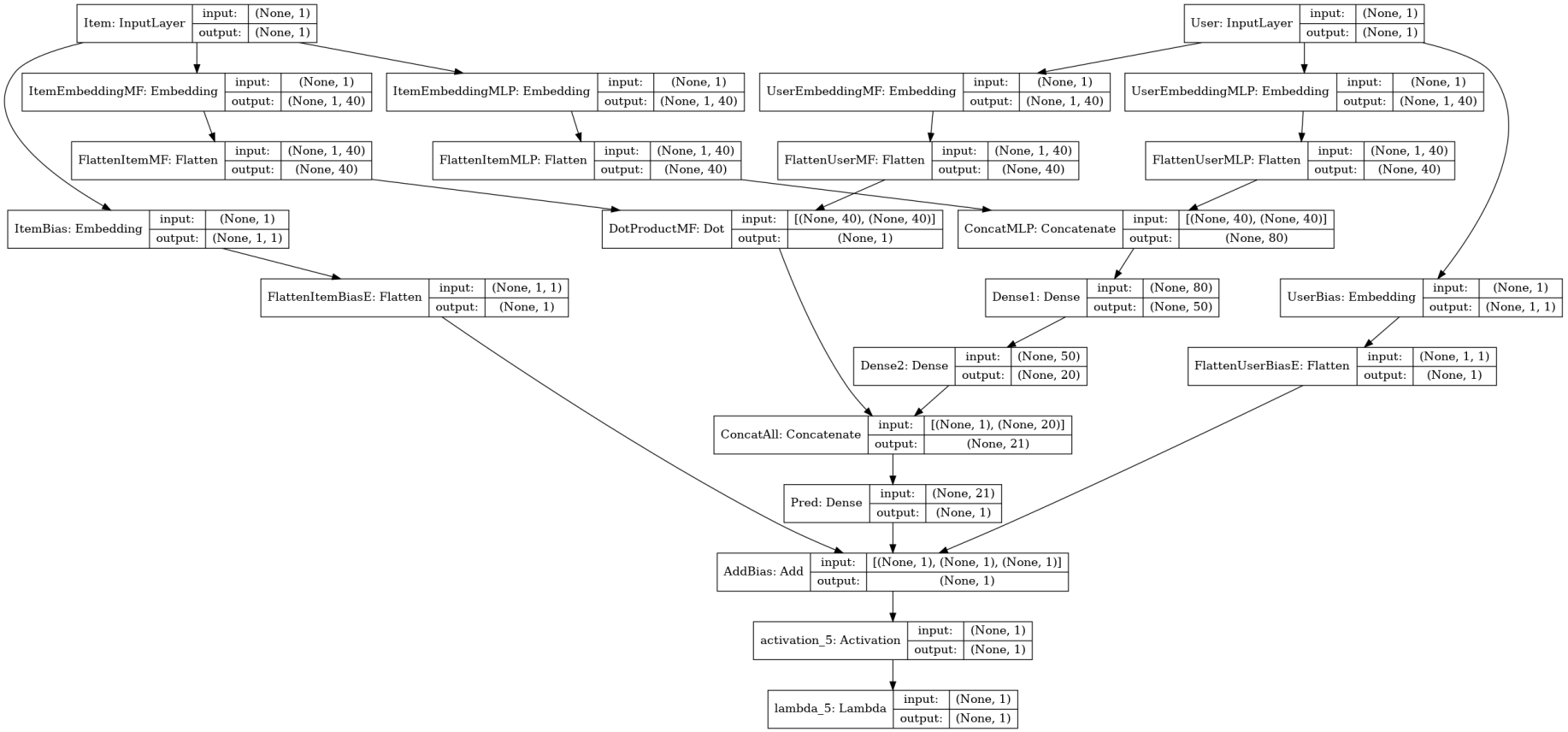
    # Compile Model
    model.compile(loss='mean_squared_error', optimizer="adam")

    return model
File:      /usr/local/lib/python3.6/dist-packages/recoflow/models.py
Type:      function
```

In [120]:

```
from recoflow.models import NeuralCollaborativeFiltering
ncf = NeuralCollaborativeFiltering(n_users, n_items, n_factors, min_rating, max_rating)
plot_model(ncf, show_layer_names=True, show_shapes=True)
```

Out[120]:



In [121]:

```
ncf.summary()
```

Model: "NeuralCF"

Layer (type)	Output Shape	Param #	Connected to
Item (InputLayer)	(None, 1)	0	
User (InputLayer)	(None, 1)	0	
ItemEmbeddingMLP (Embedding)	(None, 1, 40)	67280	Item[0][0]
UserEmbeddingMLP (Embedding)	(None, 1, 40)	37720	User[0][0]
FlattenItemMLP (Flatten)	(None, 40)	0	ItemEmbeddingMLP[0][0]
FlattenUserMLP (Flatten)	(None, 40)	0	UserEmbeddingMLP[0][0]
ItemEmbeddingMF (Embedding)	(None, 1, 40)	67280	Item[0][0]
UserEmbeddingMF (Embedding)	(None, 1, 40)	37720	User[0][0]
ConcatMLP (Concatenate)	(None, 80)	0	FlattenItemMLP[0][0] FlattenUserMLP[0][0]
FlattenItemMF (Flatten)	(None, 40)	0	ItemEmbeddingMF[0][0]
FlattenUserMF (Flatten)	(None, 40)	0	UserEmbeddingMF[0][0]
Dense1 (Dense)	(None, 50)	4050	ConcatMLP[0][0]
DotProductMF (Dot)	(None, 1)	0	FlattenItemMF[0][0] FlattenUserMF[0][0]
Dense2 (Dense)	(None, 20)	1020	Dense1[0][0]
ConcatAll (Concatenate)	(None, 21)	0	DotProductMF[0][0] Dense2[0][0]
ItemBias (Embedding)	(None, 1, 1)	1682	Item[0][0]
UserBias (Embedding)	(None, 1, 1)	943	User[0][0]
Pred (Dense)	(None, 1)	22	ConcatAll[0][0]
FlattenItemBiasE (Flatten)	(None, 1)	0	ItemBias[0][0]
FlattenUserBiasE (Flatten)	(None, 1)	0	UserBias[0][0]

```
AddBias (Add)                    (None, 1)             0           Pred[0][0]
                                                                   FlattenItemBiasE[0][0]
                                                                   FlattenUserBiasE[0][0]
__________________________________________________________________________________________________
activation_5 (Activation)        (None, 1)             0           AddBias[0][0]
__________________________________________________________________________________________________
lambda_5 (Lambda)                (None, 1)             0           activation_5[0][0]
==================================================================================================
Total params: 217,717
Trainable params: 217,717
Non-trainable params: 0
__________________________________________________________________________________________________
```