```
# Imports
import tensorflow as tf
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from IPython.display import Image

# Movie ratings dataset
movieDict = {'movieID':[],'userID':[],'rating':[]}
with open('combined_data_1.txt', 'r') as inFile:
    curMovie = 0
    for line in inFile.readlines():
        if len(line.split(":")) == 2:
            curMovie = int(line.strip(':\n'))
        else:
            splitLine = line.split(",")
            lineVals = [int(splitLine[0].strip()),
int(splitLine[1].strip())]
            movieDict['movieID'].append(curMovie)
            movieDict['userID'].append(lineVals[0])
            movieDict['rating'].append(lineVals[1])

# Movie titles dataset
movieInfo = {'movieID':[], 'Year':[], 'Title':[]}
with open('movie_titles.csv', 'r') as movieInd:
    for line in movieInd.readlines():
        curLine = line.split(',')
        if(curLine[1].strip()=='NULL'):
            continue
        formattedLine = [int(curLine[0].strip()),
int(curLine[1].strip()), curLine[2].strip()]
        movieInfo['movieID'].append(formattedLine[0])
        movieInfo['Year'].append(formattedLine[1])
        movieInfo['Title'].append(formattedLine[2])

# Generate dataframe for movieInfo
titles_df = pd.DataFrame(movieInfo)
del movieInfo

titles_df.head()
```

	movieID	Year	Title
0	1	2003	Dinosaur Planet
1	2	2004	Isle of Man TT 2004 Review
2	3	1997	Character
3	4	1994	Paula Abdul's Get Up & Dance
4	5	2004	The Rise and Fall of ECW

```
# Generate dataframe for movieDict
movies_df = pd.DataFrame(movieDict)
del movieDict
```

```
movies_df.head()
```

```
   movieID   userID  rating
0        1  1488844       3
1        1   822109       5
2        1   885013       4
3        1    30878       4
4        1   823519       3
```

```
df = movies_df[:5000000] # Using 5 million ratings due to memory and
training time
users = df.groupby('userID') # Group ratings by userID

users.first().head()
```

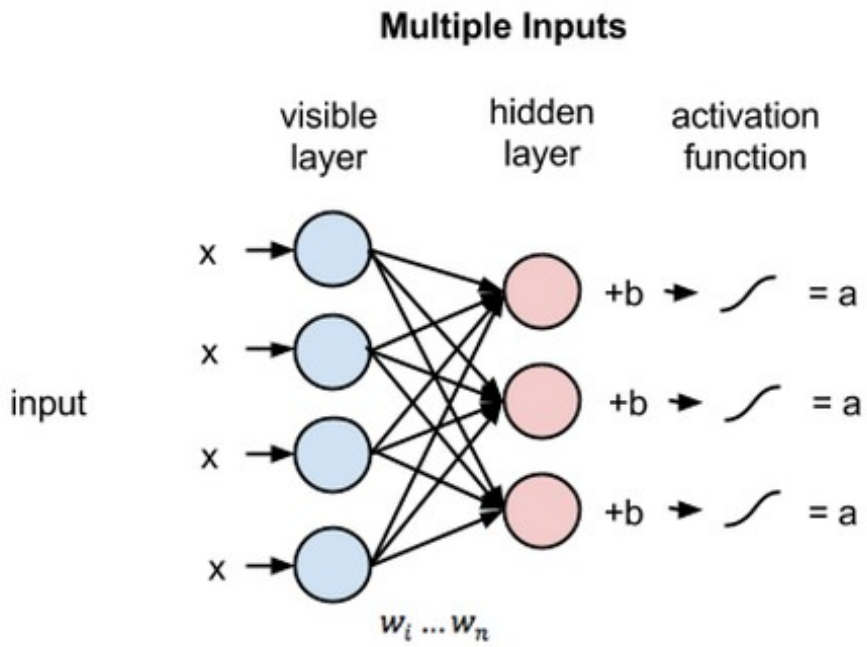
```
        movieID  rating
userID
6            30       3
7             8       5
10          175       3
25          178       3
33          197       4
```

```
# Generate a 2D list of all user ratings where each row is a unique
userID and the columns are
# the movie ratings at the corresponding movieID column index
num_users, total_users = 20000, 20000 # Using a smaller user sample
size due to memory and training time
ratings_list = []
for _, curUser in users:
    current_ratings = [0] * df['movieID'].nunique() # Initializing
array to all 0s for entries without ratings
    for _, movie in curUser.iterrows():
        current_ratings[movie['movieID']-1] =
round(movie['rating']/5.0, 1) # Normalize to between 0 and 1
    ratings_list.append(current_ratings)
    num_users -= 1
    if num_users == 0:
        break

# Initializing variables
visibleNodes = df['movieID'].nunique() # Number of visible variables
is the number of unique movies
visibleBias = tf.placeholder(tf.float32, [visibleNodes]) # Visible
biases have same dimensions as visible variables
visibleBias0, visibleBias1 = np.zeros([visibleNodes]),
np.zeros([visibleNodes]) # Before and after updates
hiddenNodes = 20 # Number of hidden variables (about 20 movie genres)
hiddenBias = tf.placeholder(tf.float32, [hiddenNodes]) # Hidden biases
have same dimensions as hidden variables
hiddenBias0, hiddenBias1 = np.zeros([hiddenNodes]),
```

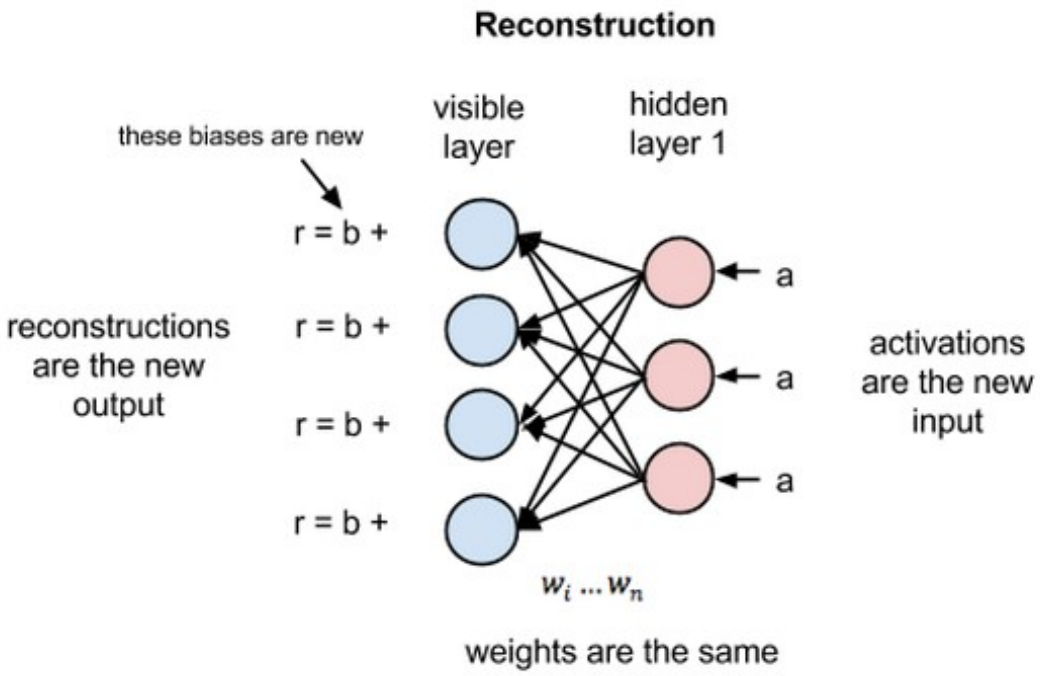
```
np.zeros([hiddenNodes]) # Before and after updates
weights = tf.placeholder(tf.float32, [visibleNodes, hiddenNodes]) #
Weights dimensions must match in matrix multiplication
weights0, weights1 = np.zeros([visibleNodes, hiddenNodes]),
np.zeros([visibleNodes, hiddenNodes]) # Before and after updates

Image(filename='Capture.png')
```




```
# Multiple Inputs Phase
visibleLayer = tf.placeholder(tf.float32, [None, visibleNodes]) #
Visible layer allocation
hiddenLayer = tf.nn.sigmoid(tf.matmul(visibleLayer, weights) +
hiddenBias) # Hidden layer = x * w + b
hiddenReLU = tf.nn.relu(tf.sign(hiddenLayer -
tf.random_uniform(tf.shape(hiddenLayer))))

Image(filename='Capture2.png')
```




```
# Reconstruction Phase
visibleRecon = tf.nn.sigmoid(tf.matmul(hiddenReLU,
tf.transpose(weights)) + visibleBias)
visibleReLU = tf.nn.relu(tf.sign(visibleRecon -
tf.random_uniform(tf.shape(visibleRecon))))
hiddenRecon = tf.nn.sigmoid(tf.matmul(visibleReLU, weights) +
hiddenBias)

#
https://en.m.wikipedia.org/wiki/Restricted_Boltzmann_machine#Training_
algorithm

# The positive gradient is defined as the outer product of the
training sample
# and the hidden activation vector
positive_grad = tf.matmul(tf.transpose(visibleLayer), hiddenReLU)

# The negative gradient is defined as the outer product of the
reconstruction
# of the training sample and the reconstruction of the hidden
activation vector
negative_grad = tf.matmul(tf.transpose(visibleReLU), hiddenRecon)

# Update steps
# Weights are updated by: learning rate*(pos_grad-neg_grad)
lr = 0.1 # Learning rate
update_weights = lr * (positive_grad - negative_grad) + weights
```

```
# Update visible and hidden biases: learning rate*(input-
reconstructed)
update_visibleBias = lr * tf.reduce_mean(visibleLayer - visibleReLU,
axis=0) + visibleBias # Take the mean to match dimensions
update_hiddenBias = lr * tf.reduce_mean(hiddenLayer - hiddenRecon,
axis=0) + hiddenBias

# Training
sess = tf.Session()
sess.run(tf.global_variables_initializer())
epochs = 10
batchsize = 100
for i in range(epochs):
    print("Epoch:", i+1, "of", epochs)
    for j in range(0, len(ratings_list), batchsize):
        batch = ratings_list[j:j+batchsize]
        weights1 = sess.run(update_weights, feed_dict={visibleLayer:
batch, weights: weights0, visibleBias: visibleBias0, hiddenBias:
hiddenBias0})
        visibleBias1 = sess.run(update_visibleBias,
feed_dict={visibleLayer: batch, weights: weights0, visibleBias:
visibleBias0, hiddenBias: hiddenBias0})
        hiddenBias1 = sess.run(update_hiddenBias,
feed_dict={visibleLayer: batch, weights: weights0, visibleBias:
visibleBias0, hiddenBias: hiddenBias0})
        weights0, visibleBias0, hiddenBias0 = weights1, visibleBias1,
hiddenBias1
```

```
Epoch: 1 of 10
Epoch: 2 of 10
Epoch: 3 of 10
Epoch: 4 of 10
Epoch: 5 of 10
Epoch: 6 of 10
Epoch: 7 of 10
Epoch: 8 of 10
Epoch: 9 of 10
Epoch: 10 of 10
```

```
# Pick a random user to recommend movies (or choose your own index)
rand_user = np.random.randint(total_users)
user = [ratings_list[rand_user]]

# Reconstruction for chosen user
hidden = sess.run(hiddenRecon, feed_dict={visibleReLU: user, weights:
weights0, hiddenBias: hiddenBias0})
visibleReconstruction = sess.run(visibleRecon, feed_dict={hiddenReLU:
hidden, weights: weights0, visibleBias: visibleBias0})

# Create the dataframe for the movies recommended
pd.set_option('mode.chained_assignment', None)
```

```
user_df = titles_df[:max(df['movieID'])]
user_df['Score'] = visibleReconstruction[0]
user_df = user_df.round(5).drop(['movieID','Year'],
axis=1).sort_values(by=['Score'], ascending=False)
user_df = user_df.rename_axis('movieID', axis='columns')

num_rec = 10 # How many movies to recommend
user_df.head(num_rec) # Display the top num_rec movies
```

movieID	Title	Score
570	American Beauty	0.63781
174	Reservoir Dogs	0.58579
311	High Fidelity	0.55313
481	Frida	0.49007
885	Ray	0.44611
797	Jaws	0.44463
240	North by Northwest	0.44173
787	Clerks	0.43447
328	Dogma	0.39544
719	Roger & Me	0.37253